**Ministry of Health of the Republic of Uzbekistan**
**Ministry of higher and vocational education of the Republic of Uzbekistan**

# MANUAL ON THE GENERAL CHEMISTRY

**Tashkent - 2013**

**N.T.Alimhodzhaeva, H.N.Akbarhodzhaeva, A.D.Dzhuraev**

# MANUAL ON THE GENERAL CHEMISTRY

Tashkent - 2013

Reviewers: The dotsent of bioorganic and biological chemistry department TashMA Tajieva

Assistan Chairs of general chemistry TashPMI Aihojaev B.K.

N.T.Alimhodjaeva, H. N. Akbarhojaeva, A.D.Dzhuraev.
MANUAL ON THE GENERAL CHEMISTRY: the Manual for students of medical universities

In a management maintenances of laboratory researches at the rate of the general chemistry for students of medical institutes are resulted. For each employment the purposes and tasks of the given theme, the questions considered on employment, the importance of a studied theme, the information block on the given theme, training tasks with standards of their decision, situational tasks, questions, tasks and tests for revealing of mastering of the given theme, a technique of carrying out of laboratory works and a task for the independent decision are resulted.

The practical work is made according to the new program of teaching of a course «General chemistry» for students of medical institutes.

# THE FOREWORD

The chemistry belongs to number of fundamental general-theoretical disciplines. It is closely connected with other natural sciences: biology, geography, physics. Many sections of a modern chemical science have arisen on a joint of physical chemistry, biochemistry, geochemistry, etc. In modern chemistry independent sections, most important of which takes inorganic chemistry, organic chemistry, analytical chemistry, chemistry of polymers, physical chemistry and etc. were allocated many. The General chemistry considers the basic chemical concepts, and also the major laws connected with chemical transformations. The general chemistry includes bases from various sections of a modern science: physical chemistry, chemical kinetics, electrochemistry, structural chemistry and etc. Creation of theoretical base concerns the major functions of the general chemistry for successful mastering by special disciplines, in the second, development in students in the course of training of modern forms of theoretical thinking that ability to independent thinking, ability to think from a science position is extremely actual as among the requirements shown to the modern expert, of the first place necessity as a theoretical sight at studied objects and the phenomena is put forward, and, first, to be beyond a narrow speciality in the decision of complex tasks and acquisition of practical skills at performance of analyses of biological objects.

The chemistry role in medical education system is great enough. Studying of such important directions in medicine as molecular biology, genetics, pharmacology, quantum biochemistry, etc. it is impossible without knowledge of the theory of a structure of substance and formation of a chemical bond, chemical thermodynamics, the mechanism of course of chemical reactions and other questions.

One of sections of the general chemistry according to the program for medical institutes is the bioinorganic chemistry which has arisen on the basis of inorganic chemistry, biochemistry, biology, biogeochemistry.

The bioinorganic chemistry studies structure, transformation of the biomolecules containing ions of metals, their modeling. This science investigates mechanisms of participation of inorganic ions in course of biochemical processes.

Using achievements of bioinorganic chemistry, it is possible to explain behavior of chemical elements in biological systems.

Today, quite rightly saying of the great Russian scientist M.V. Lomonosov, "Medic without substantial knowledge of chemistry can not be perfect."

# INTRODUCTION

## The course of the general chemistry includes following basic sections:

1. Theoretical bases of bioinorganic chemistry in application to biological systems;
2. The chemistry of biogenic elements;
3. Bases of the qualitative and quantitative analysis of biological objects, medical products;
4. The superficial phenomens;
5. Dispersing systems;
6. Thermal effect of chemical reactions;
7. Chemical thermodynamics;
8. Chemical kinetics;

The present manual is made for the aid to the students of medical institutes studying the general chemistry. It is necessary for independent preparation of students for laboratory - practical training.

The purpose of the given grant consists in that on the basis of modern achievements to generate at students skills of qualitative and quantitative forecasting of products of transformation of substances in a live organism on the basis of studying of typical chemical reactions, and also to systematize knowledge of the major theoretical generalizations of chemistry; learn to use this knowledge for the phenomena occurring in a live organism in norm and a pathology.

As a result of mastering of a course of bioinorganic chemistry:

**The student should know**:

1. The doctrine about solutions, on which basis to estimate property not electrolytes and electrolytes for a prediction of influence of environment on a current of biochemical reactions (processes); ways of expression of structures of solutions; to be guided protolithic theory of acids and the bases, as a basis for consideration of the acid-bases of interactions in live organisms;
2. The basic concepts and the laws concerning thermodynamics of chemical processes, defining directions and depth of course of biochemical reactions;
3. Organic laws chemical kinetics in application to biological systems;
4. The basic laws of course of oxidation-reduction processes and processes of sedimentation for a prediction of probable products of transformation of substances in biochemical systems and medical products applied in medicine;
5. Substantive provisions of the theory of a structure and reactionary ability of complex connections for a prediction of formation of the most probable products in live organisms between ions of metals and bioligands for their use in medicine;
6. Typical properties of connections s, p, d elements in connection with their arrangement in periodic system of elements of D.I.Mendeleev for forecasting of transformation of chemical elements in biological systems.
7. Types of chemical reactions. Exothermal and endothermic reactions

As a result of mastering of a course of bioinorganic chemistry

**The student should be able**:

1. Independently to work with educational and reference books, to use their data for the decision of typical tasks in application to biological systems;
2. To choose conditions of carrying out of reactions for reception of concrete connections;
3. To predict possibility of realization of chemical reactions and to work out the equations of reactions of their course;
4. To own modern technics of laboratory chemical works for carrying out of the qualitative and quantitative analysis of medical preparations and biological objects;
5. To make abstracts to spent analyses and scientifically to prove the received experimental data in application to medical practice.

In a management the purposes and tasks of the given theme, the questions considered on employment, the importance of a studied theme, the information block on the given theme, training tasks with standards of their decision which are a rough basis of action at application of theoretical positions to specific targets, and also situational tasks, questions, tasks and tests for revealing of mastering of the given theme, a technique of carrying out of laboratory works and a task for the independent decision are resulted.

The basis of the given management included works which are used for a number of years in educational process in TashMA and TashPMI at studying of a course of the general chemistry. The practical work is made according to the program of teaching of a course, «the general chemistry» for students of medical institutes.

At management drawing up the special attention is given a medical bias of teaching of the general chemistry.

Authors will be grateful to readers for remarks and offers under the maintenance.

## Work rules in chemical laboratory

The technics of modern chemical researches is difficult and various. The initial stage of their carrying out is laboratory employment in the general chemistry on which elementary skills of work in chemical laboratory with chemical equipment are got, ware etc., to performance of simple experiments.

Each student working in chemical laboratory, should observe following rules of work strictly:

I. The workplace with which it is impossible to block up with unnecessary subjects is fixed To everyone working in laboratory, to put on a table portfolios, books, convolution etc. On a workplace it is necessary to keep order and cleanliness.

2. Before each laboratory work it is necessary to study a theoretical material concerning it, experiences to begin only after attentive acquaintance with the instruction (management) and finding-out of all not clear questions. All laboratory works to carry out individually.

3. Carefully to spend reactants, gas, water, the electric power. For experiences to take substance minimum quantities. It is impossible to return the reactants not spent or taken a lot of back in bottles. The rests of rare, expensive and poisonous connections to merge in the special vessels which are at the laboratorian.

4. All bottles with reactants and solutions after the use at once to close stoppers which cannot be confused. It is forbidden to carry away reactants of the general using on the place. It is not recommended to put a bottle with reactants on books and writing-books.

5. In laboratory it is necessary to work in dressing gowns, categorically it is forbidden to accept food, it is not authorized to smoke and loudly to talk.

6. Upon termination of work it is necessary to wash up the used ware, carefully to clean a workplace, to switch off gas, water, an electricity.

7. All data of the spent laboratory works it is necessary to write down in laboratory book. In it are brought: the theoretical material necessary for performance of given work, a technique of performance of laboratory work, supervision, the equation of reactions, calculations, answers to questions, decisions of the tasks, scientifically proved results of the analysis, the conclusions made on the basis of carried out research. The Log entry should be accurate and made so that the chemist not familiar with given work, having read it, could imagine clearly as experiences were spent, that in them was observed, to what conclusions the experimenter has come. It is necessary to fill laboratory book during carrying out of the analysis in process of its performance. To use any draught copies it is not authorized. Puttying or changing figures in the report of experiences is categorically forbidden.

## Rules under safety precautions at work in chemical laboratory

At performance of laboratory works in chemical laboratory it is necessary to observe safety precautions regulations

Laboratory works are usually spent behind a chemical table. The table should be pure. Before the beginning of carrying out of laboratory work it is necessary to be convinced available all reactants and ware.

To spend experience follows strictly in that sequence which is specified in its description. At heating it is impossible to hold test tubes and flasks an aperture to itself or working nearby; it is impossible to bend over a vessel aperture in which reaction proceeds.

Work with flammable substances to spend far from fire.

At ignition of benzene, ether, gasoline it is impossible to extinguish fire water, it is necessary to fall asleep fire sand.

To work with caustic, poisonous and odorous substances in an exhaust case. Under draught to pour the concentrated acids and alkalis. Their rests not to pour out at all in a bowl, and in specially taken away bottles. Under draught to carry out all reactions accompanied by allocation of poisonous gases or steams.

Hot devices and where to put on special supports.

At hit on the person and acid hands to wash off its strong stream of water from the crane, and then to wash out the amazed place the diluted solution of tea soda; at hit on an alkali skin carefully to wash out a place water, and then - the diluted solution of acetic acid.

At a burn hot subjects the burnt place to close a gauze impregnated with a weak solution of potassium permanganate. At cuts glass blood should be washed out a weak solution of permanganate potassium or spirit, a wound to grease with an iodine solution, to bandage.

To remember, that salts containing mercury, arsenic, barium, lead are poisonous; after their use carefully to wash hands.

At gas test on a smell a test tube to hold in the left hand so that the aperture was below level of a nose, the right hand to direct to itself a weak current of air.

It is necessary to remember well, that in chemical laboratory special attentiveness, conscientiousness and accuracy is required at performance of laboratory works. It will provide success in work.

Each student is supposed to carrying out of laboratory works only after studying of rules under safety precautions at work in chemical laboratory.

## WAYS OF EXPRESSION OF CONCENTRATION OF SOLUTIONS IN SI SYSTEM.

**The employment purpose**. To learn to carry out quantitative calculations for preparation of solutions of the various concentration necessary for the analysis of biological objects. To learn experimentally, to prepare the solutions of the set concentration used in medical practice.

**The importance of a studied theme**. Liquid solutions, first of all water solutions, are of great importance in biology and medicine. They are the internal environment of live organisms where the vital processes proceed, first of all, a metabolism. Biological liquids: blood plasma, a lymph, gastric juice, urine and other - represent difficult mixes of fibers, lipids, carbohydrates, the salts dissolved in water. Solubility of medical products in water is considered at their use for treatment. Solutions of medical products in medical practice are used always with numerical expression of their structure. Therefore the knowledge of units of measure of concentration of solutions is necessary for the doctor. Carrying out of quantitative calculations on preparation of solutions of the set concentration is very important in medical practice as in clinical, sanitary-and-hygienic and other analyses medical products are applied in the form of solutions of known concentration.

**Initial level of knowledge:**

1. Solubility of substances in water;
2. Concepts: the dissolved substance, solvent, a solution;
3. The chemical theory of formation of solutions of D.I.Mendeleev;
4. Concentration of solutions;
5. Solutions sated, nonsaturated, oversaturated, concentrated, diluted.

**Teaching material for self-preparation.**

1. A.V.Babkov, G.N.Gorshkova, A.M.Kononov. A practical work in the general chemistry with elements of the quantitative analysis. M, 1978, p. 32.
2. N.L.Glinka. The general chemistry. L, 1976, p. 213.
3. S.S.Olenin, G.N.Fadeev. Inorganic chemistry. M, 1979, p. 107.

**On employment following questions will be considered**:

1. Solutions, the concentration of solutions
2. Ways of expression of concentration of solutions:

   II.1. Mass fraction of component - ω (x), ω (x) %:

   Ii.2. Molarity share-n (x); a volume share - f (x);

   Ii.3. Molarity concentration- c(x);

   Ii.4. Molality concentration- в(x);

   Ii.5. Molarity concentration of equivalent c (f eq (x) x) = c($\frac{1}{z}x$)

   II. 6. The equivalence factor f eq (x) = ($\frac{1}{z}x$)

   II.7. An equivalent f eq (x) x = ($\frac{1}{z}x$)

II.8. Molarity weight of equivalent of M f eq (x) x = M ($\frac{1}{z}x$)

II.9. Quantity of substance of equivalent n (f eq (x)) = n ($\frac{1}{z}x$)

II.10.Titr of solution - t (x)

3. The decision of tasks on a theme.
4. Laboratory works

## THE INFORMATION BLOCK

### The basic terms and units of measure concentration of solutions in system SI.

*Solutions* is homogeneous systems, consisting of two and more components and products of their interaction**.** Are most significant - solutions of firm, liquid and gaseous substances in liquid solvents, usually in water.

Certain quantity of the dissolved substance containing in certain weight quantity or certain volume of a solution or solvent, name concentration of a solution.

In connection with introduction of the international system of units (SI) have occurred some changes in ways of expression of structure of a solution. In this system the basic mass unit, as is known, is the kg (kg), gramme (g), volume unit - liter (l), a milliliter (ml), a substance - unit of quantity mol.

**The quantity of substance of system - n (X) -** the dimensional physical size characterized by number of structural particles containing in system - atoms, molecules, ions, electrons, etc. the Unit of measure of quantity of substance is mol. This quantity of substance containing so much of real or conditional particles, how many atoms contains in 0,012 kg of an isotope of carbon with weight 12. For example: n (HCl) = 2mol or 2000 mol; n ($H^+$) = $3 \cdot 10^{-3}$ mol; n ($Mg^{2+}$) = 0,03 mol or 30 mmol

**The molar mass M(X) -** weight of one mol of substances of system, is the relation of weight of substance to its quantity. Units of measure - kg/mol,/mol

$$M(X)=\frac{m(x)}{n(x)},g/mol$$

*M(X)* - a molarity weight of substance X system;
*m(X)* - weight of substance X system;
*n(X)* - quantity of substance X system.
For example: M ($Cl_2$) =70,916 g/mol; M ($Ca^{2+}$) = 40,08 g/mol; M (NaCl) =58,50/mol

**Mass fraction of the component -** $\omega$*(X)* **-** the relative size representing the relation of weight of the given component, containing in system (solution), to a lump of this system (solution) (instead of concept percentage concentration). It is expressed in shares of unit and in percentage (%).

$$\omega(X)=\frac{m(x)}{m(s-n)}; \qquad \omega(\%)=\frac{m(x)}{m(s-n)}\cdot 100\%;$$

For example: *ω% (NaCl) =20 %; ω% (HCl) =37 %.*

**Molar (molality) share of component - *N (X)* -** the relative size equal to the relation of quantity of substance of a component, containing in the given system (solution), to total of substance of system (solution).

$$N(X) = \frac{n(X)}{n(p-p)};$$

The molar share is often designated by letter *N (X).*

**Component volume fraction - *f*(X) -** the relative size equal to the relation of volume of a component, containing in system (solution), to total amount of system (solution).

$$f(X) = \frac{V(X)}{V(s-n)};$$

**Molar concentration - c (x)** the relation of quantity of substance (X) in system (solution), to volume of this system (solution).

$$c(X) = \frac{n(X)}{m(s-n)} = \frac{m(X)}{M(X)\cdot m(s-n)}, \text{mol/l}$$

c *(HCl) = 0,1 mol/l;* *c* $(Cu^{2+})$ *= 0,2378 mol/l*

**Molaly concentration - b (x)** - the relation of quantity of substance (X), containing in system (solution), to weight of solvent.

$$в(x) = \frac{n(X)}{m(s-t)} = \frac{м(X)}{M(X)\cdot m(s-t)}, \text{mol/kg}$$

For example: *в (HCl) = 0,1 mol/kg.*

**The equivalence factor - *f eq (X)*=** $\frac{1}{z}$ **-** the dimensionless size designating, what share of a real particle of substance (X) is equivalent to one ion of hydrogen in the acid-basic reaction or to one electron in oxid-reduction reaction. The equivalence factor pays off on the basis stoichiometric the given reaction. For example:

$NaOH + \frac{1}{2} H_2SO_4 = \frac{1}{2} Na_2SO_4 + H_2O$; *f eq* (NaOH) =1, *feq* $(H_2SO_4) = \frac{1}{2}$

**Equivalent - *feq (X)*** - dimensionless size - the real or conditional particle of substance (X) which in given the acid - basic reaction incorporates to one mol of hydrogen either is somehow equivalent to it or is equivalent to one electrone in acid - regenerative reactions.

**Molar mass of equivalent - *M (feq (x)) =M*** $(\frac{1}{z}x)$ the weight of one asking mol of the substance equivalent, equal to product of the factor of equivalence on molar mass of substance:

$$M(feq(x)x) = M(\frac{1}{z}X) = f\ eq\ (x)\ M\ (x),\ \text{g/mol}$$

$$M(\tfrac{1}{2}H_2SO_4) = \tfrac{1}{2}M(H_2SO_4) = 49{,}0\ \text{g/mol}$$

**Quantity of substance of equivalent -** $\boldsymbol{n}$ ***(f eq (x) x) = n*** $(\frac{1}{z}x)$ **-** quantity of substance in which particles are equivalents:

$$n\,(\frac{1}{z}x) = \frac{m(X)}{M(\frac{1}{z}X)}, \text{ mol}; \qquad n\,(\frac{1}{Z}Ca^{2+}) = 0{,}5 \text{ mol}$$

**Molar concentration of equivalent-*c (f eq (x) x)=c*** $(\frac{1}{z}x)$ **-** the relation of quantity of substance of equivalent in system (solution) to volume of this system (solution):

$$c\,(f\,equ\,(x)\,x) = c(\frac{1}{z}x) = \frac{n(\frac{1}{z})}{V(s-n)} = \frac{m(X)}{M(\frac{1}{z}x)\cdot V(s-n)}\ mol/l = 0{,}1\ mol/l$$

**Titr of solution-** ***t (x)***-weight of substance (X), containing in I ml of solution:

$$t\,(x) = \frac{m(x)}{V(s-n)}\ \text{-}\ g/ml$$

$$t\,(HCl) = 0{,}003278\ g/ml$$

## Training tasks and standards of their decision

In the course of preparation for employment it is recommended to solve following tasks and to check up their decisions with the standard.

***Task №1.*** To calculate a mass fraction copper vitriol - $CuSO_4{\cdot}5H_2O$ and waterless sulphate of copper in a solution received by dissolution 50 g copper vitriol in 200 gr of water.

**Given:**

$m\,(H_2O) = 200{,}00g$

$m\,(CuSO_4{\cdot}5H_2O) = 50{,}00g$

$M\,(CuSO_4) = 342{,}16g/mol$

$M\,(CuSO_4{\cdot}5H_2O) = 25000\ g/mol$

---

$\omega\,\%\,(CuSO_4{\cdot}5H_2O) = ?$

$\omega\,\%\,(CuSO_4) = ?$

**The standard of decision:**

1. Find weight of a received solution:

$$m\,(s\text{-}n) = m\,(s\text{-}a) + m\,(H_2O) = 50{,}00\ g + 200{,}00\ g = 250{,}00g.$$

$$m\,(s\text{-}n) = 250{,}00g.$$

2. Find mass fraction $CuSO_4{\cdot}5H_2O$ in a solution:

$$\omega\ \%\ (CuSO_4{\cdot}5H_2O) = \frac{mCuSO_4 \cdot 5H_2O}{m(s-n)} \cdot 100\%$$

$$\omega\ \%\ (CuSO_4{\cdot}5H_2O) = \frac{50.00g}{250{,}0g} \cdot 100\% \frac{g \cdot \%}{g} = 20\%$$

3. Find weight of waterless salt in 50,00g copper vitriol. Molar mass of $CuSO_4{\cdot}5H_2O$ is equal 250,00 g/mol, Molar mass of $CuSO_4$ is equal 160,00g/mol. In I mol $CuSO_4{\cdot}5H_2O$ contains I mol $CuSO_4$. Thus, in I mol x 250,00 g/mol =250,00 g $CuSO_4{\cdot}5H_2O$ contains I mol x 160,00 g/mol = 342,16 g $CuSO_4$:

In 250,00 g $CuSO_4{\cdot}5H_2O$-160,00 g $CuSO_4$
In 50g---//----- - x g-----//--------

Make a proportion: 250,00: 160,00=50,00:x.
Solving it, we find weight of waterless sulphate of copper:

$$m(CuSO_4) = \frac{160{,}00 \cdot 50{,}00}{250{,}00} \frac{g \cdot g}{g} = 32{,}00g$$

Find a mass fraction of waterless salt:

$$\omega\ \%\ (CuSO_4) = \frac{m(CuSO_4)}{m(s-n)} \cdot 100\%$$

$$\omega\ \%\ (CuSO_4) = \frac{32{,}00g}{250{,}0g} \cdot 100\% = 12{,}80\%$$

*The answer:* $\omega\ \%\ (CuSO_4{\cdot}5H_2O) = 20\ \%$; $\omega\ \%\ (CuSO_4) = 25{,}60\ \%$

***Task №2*** How many ml of 96 % (weights) of solution $H_2SO_4$ ($\rho$ =1,84g/ml) it is necessary to take for preparation 2litres 0,1000 mol/l of solution $H_2SO_4$?

**Given:**
$\omega\ \%\ (H_2SO_4) = 96\ \%$;
$\rho = 1{,}84 g/ml$
$V\ (s\text{-}n) = 2{,}00 l$
$c\ (H_2SO_4) = 0{,}1000\ mol/l$
$M\ (H_2SO_4) = 98{,}0 g/mol$

---

$V\ (H_2SO_4) = ?$

**The standard of decision**:

1. Find weight $H_2SO_4$ containing in 2litres of a solution of molar concentration of 0,1000 mol/l. It is known, that

$$c\ (H_2SO_4) = \frac{m(H_2SO_4)}{M(H_2SO_4)V(s-n)}, \text{ then}$$

$$m\ (H_2SO_4) = c\ (H_2SO_4)\ M\ (H_2SO_4)\ V\ (s\text{-}n)$$

$$m\ (H_2SO_4) = 0{,}1000 \cdot 98 \cdot 2{,}00 \frac{mol \cdot g \cdot l}{l \cdot mol} = 19{,}60g$$

$$m\ (H_2SO_4) = 19{,}60g.$$

2. Find weight of 96 % (weights) of solution $H_2SO_4$ containing 19,60g $H_2SO_4$

$$\omega\ \%\ (H_2SO_4) = \frac{m(H_2SO_4)}{m(s-n)} \cdot 100\%$$

$$m\ (s\text{-}n) = \frac{19{,}6 \cdot 100\%}{96\%} = 20{,}42g$$

3. Find volume of solution $H_2SO_4$, knowing its density.

$$V\ (s\text{-}n) = \frac{m(s-n)}{p(s-n)}$$

$$V\ (s\text{-}n) = \frac{20{,}42}{1{,}84} \frac{g \cdot ml}{g} = 11{,}10ml$$

*The answer:* $V\ (H_2SO_4) = 11{,}10ml$

***Task №3***. Define molar concentration 200g an antiseptic of 2,0 % (weights.) spirit a solution brilliant [ethyl] green. M (brilliant [ethyl] green.) = 492g/mol; (ρ =0,80g/ml).

**Given:**

*m(s-n green)=200,00g*
*ω % (s-a) =2,0 %*
*ρ (s-n) =0,80g/ml*
*<u>M (s-a) =492,0g/mol</u>*
*c (s-a) =?*

**The standard of decision:**

1. Find weight of substance in 200,00 gr a solution of the diamond green.

$$m(s-ce) = \frac{200{,}00 \cdot 2{,}0}{100} \frac{g \cdot \%}{\%} = 4g$$

2. Find volume spirit a solution:

$$V\ (s\text{-}n) = \frac{m(s-n)}{p(s-n)}; \quad V\ (s\text{-}n) = \frac{200{,}00g \cdot ml}{0{,}80g} = 250{,}00ml = 0{,}25l$$

3. Find molar concentration c (s-ce) in a solution:

$$c\ (s\text{-}ce) = \frac{m(s-ce)}{M(s-ce) \cdot V(s-n)}; \ c\ (s\text{-}ce) = \frac{4}{492 \cdot 250{,}00} \frac{g \cdot mol}{g \cdot l} = 0{,}0325 mol/l$$

*The answer:* $c\ (s\text{-}a) = 0{,}0325mol/l$

***Task №4.*** The titer of solution NaOH widely used in the analysis of medical products, is equal to 0,003600g/ml. At interaction with sulfuric acid, it forms sour salt. What molar concentration of equivalent of a solution in its reaction with sulfuric acid; mass fraction NaOH (%) in a solution? Calculate awning NaOH, necessary for preparation 1,00 liter such solution.

**Given:**
*t (NaOH) =0,003800 g/ml*
*V (s-n) =1,00 l =1000ml*
*M (NaOH) =40,0 g/mol*
*ρ (s-n) =1,0g/ml*
*c (NaOH) =?* *m (NaOH) =?*
*ω % (NaOH) =?*

**The standard of decision:**

The equation of occurring reaction:

$$H_2SO_4 + NaOH = Na\,HSO_4 + H_2O$$

$$f\,eq\,(H_2SO_4) = 1; \quad f\,eq\,(NaOH) = 1.$$

Thus, in this case it is necessary to speak about molar concentration of solution NaOH.

1. Find weight NaOH necessary for preparation 1000ml of a solution:

$$t\,(NaOH) = \frac{m(NaOH)}{V(s-n)};$$

$$m\,(NaOH) = t\,(NaOH)\,V\,(s\text{-}n)$$
$$m\,(NaOH) = 0{,}003800 \cdot 1000 gml/ml = 3{,}8g$$

1. Find molar concentration of a solution:

$$c\,(NaOH) = \frac{m(NaOH)}{M(NaOH)\cdot V(s-n)}$$

$$c\,(NaOH) = \frac{3{,}8}{40\cdot 1}\frac{g\cdot mol}{g\cdot l} = 0{,}0950 mol/l$$

1. Find weight of 1 litre of a solution:

$$m\,(s\text{-}n) = \rho(s\text{-}n)\cdot V\,(s\text{-}n)$$

$$m\,(s\text{-}n) = 1000 \cdot 1{,}0\frac{g\cdot ml}{ml} = 1000g$$

4. Find mass fraction NaOH (%) in a solution:

$$\omega\,\%\,(NaOH) = \frac{m(NaOH)}{m(s-n)}\cdot 100\%$$

$$\omega\,\%\,(NaOH) = \frac{3{,}8\cdot 100}{1000}\frac{g\cdot \%}{g} = 0{,}38\%$$

*The answer*: *c (NaOH) =0,0950mol/l, ω % (NaOH) = 0,38 %, m (NaOH) =3,8g*

**Questions and tasks for self-checking of mastering of a theme:**

1. List ways of expression of concentration of solutions in SI.
2. What is mole fraction; a volume fraction?

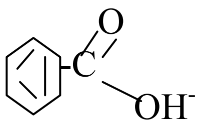
3. Calculate mole fraction of chloride of calcium in 10 % (weights.) solution $CaCl_2 \cdot 6H_2O$, widely used in medicine (ρ =1,007 g/ml).
4. To find a mass fraction (%) of glucose in a solution containing 280g waters and 40g of glucose.
5. For the medical purposes 85 % (weights are used.) a glycerin solution ($C_3H_8O_3$), (ρ =1,222 g/ml). Calculate mole fraction of glycerin and water in such solution.
6. In the biochemical analysis for sugar definition in blood it is necessary 45 % (weights.) solution $ZnSO_4 \cdot 7H_2O$. How many water and this salt is necessary for preparation 2кg a solution?
7. How many grammes of iodine and spirit (ρ =0,80 g/ml) are necessary for preparation 200,00g iodic tincture with a mass fraction of iodine of 5 %?

## Situational tasks

1. How many ml of 30 % (weights.) solution HCl (ρ=1,152 g/ml) it is necessary to take for preparation 1litrl 3 % (weights.) its solution used inside at insufficient acidity of gastric juice? What molar concentration and a titer of the received solution. (Solution standardization is made on NaOH).

2. Calculate molar concentration of physiological solution NaCl. How many waters should be added to 200 ml of 20 % of solution NaCl (ρ =1,012 g/ml) for preparation of a physiological solution of 5 l?

3. Nicotinic acid - vitamin PP - plays an essential role in organism ability to live, being prostatic group of some enzymes. Its insufficiency leads to development pellagrs at the person. Ampoules for the medical purposes contain 1 ml of 0,1 % (weights) nicotinic acid. Define molar concentration of equivalent and a titr of this solution




nicotinic acid.

Standardization is made on solution NaOH.

## Test questions

1 Calculate the factor of equivalence $H_2S0_4$ in the given reaction

$$H_2S0_4 + KOH = KHS0_4 + H_2O$$

a)1 b)2 c)1/2 d)1/3 e)3

2 Titr of solution NaOH 0,03600/ml Find molar concentration of the given solution.

a)9 mol/l b) 0,9 mol/l c) 0,09 mol/l d) 0,014 mol/l e) 1,14 mol/l

3 To what solution value $V_{solvent} < V_{crystallisation\ concerns}$.

a) the sated solution
b) nonsaturated solution
c) over-saturated a solution
d) the diluted solution

e) the concentrated solution

4 Find a mass fraction (%) of glucose in a solution containing 280 g waters and 40 g of glucose

a)24,6% b)12,5% c)40% d)15% e)8%

5 Define the factor of equivalence $H_2SO_4$ in given reaction

$$Mg(OH)_2 + 2H_2SO_4 = Mg(HSO_4)_2 + 2H_2O$$

a)2 b)1 c)1/2 d)4 e)3

6 Molaly concentration of substance in a solution is defined:

a) molaly substance number in 1 l of a solution
b) molaly substance number in 1 ml of a solution
c) molaly substance number in 1 kg of a solution
d) molaly substance number in 1 g a solution

7 How many kinds of modular conditions of a solution happen?

a)2 b)3 c)1 d)4

8. Specify concentrated solution NaOH:

a)0,36% b) 0,20% c)0,40% d) 36 %

9. Find molar concentration of physiological solution NaCl.

ω % (NaCl) =0,85 %

a) 1 mol/l b) 0,14 mol/l c) 1,5 mol/l d) 9,31 mol/l e) 10 mol/l

## LABORATORY WORK

### Preparation of solutions of the set concentration

There are three methods of preparation of a solution of the set concentration:

1. Dilute more concentrated solution
2. Use defined awning firm substance.
3. Use method fixanel.

1. *Preparation 0,1 molar solutions of sulfuric acid dilute more concentrated solution:*

1) In a beaker to pour a solution of sulfuric acid and by areometer to define density of the given solution. Then under the table to define a mass fraction of sulfuric acid in this solution.
2) To calculate, what volume of a solution with the given concentration is necessary for preparation of 100 ml 0,1 molar solutions.
3) To measure necessary volume of sulfuric acid in a small beaker and it is cautious by means of a funnel to pour it in 100 ml the measured flask half filled with distilled water. A mix in a measured flask to cool to a room temperature and cautiously to add water to a measured label. A measured flask densely to close a cover and after careful hashing to hand over to the laboratories.

1 *Preparation of a solution by a method of dissolution defined awning firm substance:*

1) To learn from the teacher a solution of what concentration it is necessary to prepare. Then to spend calculation: how many the salt gramme needs to be

dissolved for reception of a solution with the given concentration and to within 0,01g to weigh necessary quantity of salt.

2) To calculate necessary volume of water ($m_{water}$=$V_{water}$), to measure this volume by means of a measured flask or the cylinder, and to fill in it in a flask or a glass with salt.

3) To stir a solution a glass stick with a rubber tip before full dissolution of salt. If in the course of dissolution increase or temperature fall is observed, to wait, while the temperature of a solution will not reach the room.

4) To pour the received solution in the dry cylinder and by areometer to measure density of the received solution. Under the table to define the mass fraction of the dissolved substance corresponding to density.

5) To calculate the committed error under the formula:

$$\% \text{ an error} = (\cdot_{theor} - \omega_{practic}) \cdot 100 / \omega_{theor}$$

6) To calculate molar concentration of equivalent and molaly concentration of the received solution.

**Questions and tasks for the independent decision**

1. To prepare 500 ml of 0,1mol/l of a solution hydroxide sodium for an acid - basic of reaction with sulfuric acid from 10 % (weights.) a solution (ρ =0,960g/ml)

2. To prepare 250 ml 0,250 mol/l of a solution of sulfuric acid for an acid - basic of reaction about KOH from 4 % (weights.) a solution (ρ =1,025g/ml)

3. In neurosurgeryly practice for reduction of a hypostasis of a brain use a solution of 30 % (weights.) the urea, prepared on 10 % (weights.) a glucose solution. Calculate volume of a solution of the glucose, necessary for preparation 1 litr an urea solution (ρ $(NH_2)_2CO$), =1,216/ml

# INTRODUCTION IN THE TITRIMETRIC ANALYSIS

**The employment purpose**: To familiarize with bases of titrimetric analysis, as one of methods of the quantitative research applied in medical practice for the analysis of biological objects and medical products, and also for a sanitary estimation of environment.

**The importance of a studied theme.** The method titrimetric (volume) analysis has wide application in medical and biologic researches for an establishment of quantitative structure of biological objects, medicinal and pharmacological preparations.

Without knowledge of structure of various environments of live organisms are not possible understanding of essence of processes proceeding in them, working out scientifically - the proved methods of treatment. Diagnostics of set of diseases is based on comparison of results of analyses for the given patient with the normal maintenance of certain components in blood, urine, gastric juice, other liquids and organism tissue. Therefore to medical workers, especially doctors, it is necessary to know main principles and methods titrimetric the analysis.

**Initial level of knowledge**

1. Theory bases electrolytic dissociation of acids, bases, salts;
2. Types of chemical reactions (in the molecular and ionic form);
3. Ways of expression of concentration of solutions.

**Teaching material for self-preparation.**

1. V.N.Alekseev. The quantitative analysis. M, 1972, p. 193.
2. A A.Seleznev. Analytical chemistry. M, 1973, p. 164.
3. I.K.Tsitovich. A course of analytical chemistry. M, 1985.p.212.

**On employment following questions will be considered:**

1. Tasks of analytical chemistry
2. Essence of methods titrimetric the analysis
   2.1. The basic concepts: the solutions applied in titrimetric analysis
   2.2. An equivalence point
   2.3. Requirements to the reactions applied in titrimetric analysis
   2.4. Measuring ware: burette, pipettes, measured flasks, measured cylinders.
   2.5. A titration technique.
   2.6. Calculations in titrimetric method
   2.7. Classification of methods titrimetric analysis
3. Laboratory work

## THE INFORMATION BLOCK

Analytical chemistry - a science studying methods of definition of a qualitative and quantitative chemical compound of substances or their mixes. It shares on the qualitative and quantitative analysis. Methods of the qualitative analysis establish, the analyzed substance consists of what chemical elements, atoms, ions or molecules. Methods of the quantitative analysis establish quantitative parities of compound components of the given investigated connection.

The quantitative analysis is spent by various methods. Widespread chemical ways at which the quantity of substance is defined by quantity of the reagent spent for titration, by quantity of a deposition and etc. The most important are three methods: weight, titrimetric (volume) and colorimetrical.

The essence of the weight analysis consists that completely allocate a component of analyzed substance from a solution in the form of a deposition, last collect on the filter, dry up, to constant weight and weigh. Knowing weight of the received deposition, under the chemical formula of the last define the maintenance of a required component.

In titrimetric (volume) analysis quantitative definition of compound components of analyzed substance is spent by exact measurement of volume of a reactant of the known concentration entering chemical reaction with defined substance.

The colorimetricly method of the analysis is based on comparison of intensity of coloring of an investigated solution with the solution coloring which concentration is precisely known.

In the clinical analysis methods titrimetric the analysis as they do not demand the big expenses of time are most widely applied, are simple in performance and with their help it is possible to receive exact enough results.

The method of titrimetric analysis is based on exact measurement of volume of the reagent spent for reaction with defined substance of X. Process flowing of one solution, being in burette, to other solution for definition of concentration of one of them (at known concentration of another) is called as *titration.* The term «titration» is formed from a word a titer that means the reagent maintenance in grammes in 1,00 ml of a solution.

The solution of a reactant of precisely known concentration is called as *working titrate* or *a standard solution.* The solution with precisely known concentration can be received dissolution exact awning substances in known volume of a solution or a concentration establishment on other solution which concentration is in advance known. In the first case the solution with the prepared titr, in the second - with the established titer turns out.

For preparation of a solution with the set concentration only such substances which can be received in very pure kind are suitable, have constant structure, do not change on air and at storage. Many salts concern such substances (borax soap $Na_2B_4O_7{\cdot}10H_2O$, sodium oxalate $Na_2C_2O_4$, bichromate potassium $K_2Cr_2O_7$, chloride of sodium NaCl); oxalic acid $H_2C_2O_4{\cdot}2H_2O$ and some other. The substances meeting listed requirements, are called as *initial* or *standard*.

Exact definition of concentration of working solutions is one of the main preconditions of reception of good results of the volume analysis. Carefully prepared and checked up working solutions are stored in the conditions excluding change of concentration of a solution at the expense of evaporation, decomposition of substance or hit of pollution from environment. Concentration of working solutions periodically check on standard solutions.

For preparation the titrately solutions is possible to use also available in sale fixenal. These are the glass ampoules containing precisely given quantities of various firm substances or precisely measured volumes of liquids, necessary for preparation 1litr a solution with exact molar concentration of equivalent. For preparation of a solution from fixenal ampoule contents transfer to a measured flask on 1litrl then dissolve substance and lead up volume to a label.

During titration it is necessary to establish the moment of the termination of reaction, i.e. an equivalence point when quantities of reacting substances in a mix become equivalent. For this purpose In the titrimetric analysis indicators are used. As indicators are called the substances added in small quantity in solutions at titration and changing coloring in a point of equivalence.

For definition of the moment of equivalence besides coloring it is possible to use change and other properties of a solution, but physical and chemical measurements are thus necessary. The last find more and more wide application in the volume analysis.

In the titrimetric analysis such reactions which satisfy to following conditions are applied only:

1) Interaction between defined substance and a reactant should go in defined stereometrical parities;
2) Reaction between defined substance and a reactant should go with the big speed;
3) Chemical reaction between defined substance and a reactant should proceed completely, i.e. convertibility of reaction is not supposed;
4) Reaction between defined substance and a reactant should not be accompanied by any collateral reactions.

For exact measurement of volumes the measuring ware is used: burette, pipettes, measured flasks and measured cylinders.

Burette are intended for titration and exact volume of the spent reactant. These are the graduated glass tubes which bottom end is narrowed and supplied or polishing by the glass crane, or a rubber tube with a shutter of the ball type, connected to a pipette. Burette produce in capacity from 10,00 to 100,00 ml. To especially exact analyses apply microburette on 1,00 and 2,00 ml. Most often apply burette in capacity from 10,00 to 50,00 ml. Graduation burette begins from above, from it from top to bottom there are big divisions on 1,00 ml to the bottom label. The whole milliliters are divided into the tenth shares. The volume poured out of burette liquids is defined on a difference of levels before titration. Readout of level of a liquid are necessary for spending very precisely. Accuracy of readout is at a loss that in burette there is a concave meniscus. The visible form of a meniscus depends on illumination conditions, therefore at readout behind burette it is necessary to place a white paper closely. Eyes at readout should be at meniscus level. Filling burettes make by means of a funnel. From above burette close a cap that the dust has not got to it. Before filling by a solution burette it is necessary to rinse with the same solution three times.

Pipettes are applied when it is necessary from prepared solution to measure some exact volume of a liquid and to transfer it to other vessel. Pipettes represent glass tubes with expansion in the middle and small narrowing on the bottom end. On the top part the pipette capacity is specified. Pipettes produce in capacity from 1,00 ml to 100,00 ml. The graduated pipettes have divisions on 25,00, 10,00, 5,00, 2,00, 1,00 ml. To measurement of a thousand share of a milliliter apply also micropipettes on 0,20 and 0,10 ml. Pipettes store in special supports in vertical position. Fill a pipette with a solution by means of a rubber pear or involve a solution in a pipette a mouth through the top part of a tube. Last way is not recommended in view of possible hit of a liquid in a mouth. At filling of a pipette with a solution, last soak up a little above a label and then quickly clamp the top aperture an index finger that the liquid from a pipette has not poured out. The filled pipette raise a little so that the tip left only a solution, but not from a vessel from which take a solution. Then, holding an eye at label level, cautiously weaken pressure of a finger, slightly raising its end, and the liquid follows on drops. As soon as the bottom part of a meniscus will reach label lines, a pipette aperture densely close a finger and the measured liquid pour out in other vessel. Draining of a solution from a pipette make, concerning with a tip of a pipette of a wall of a vessel where merge a solution. Usually allow to a solution to merge freely or slow down speed of draining, closing a part of the top aperture of a pipette a finger. When all liquid will pour out, it is necessary to wait 20 - 30 seconds then to take out a pipette from a vessel. The droplet of the liquid which have remained on a tip of a pipette should not be blown, as it has been taken into consideration at pipettes. At work with a pipette before filling with last with a solution, it is necessary to rinse a pipette with the same solution some times.

After the termination of work the pipette needs to be washed out the distilled water.

Measured flasks apply basically to preparation of solutions of certain concentration. These are flat-bottomed vessels with a narrow and long neck. On a neck there is a label in the form of a ring, to which it is necessary to fill a flask (on a bottom edge of a meniscus of a liquid) to receive specified on a wide part of a flask volume. Measured flasks are calculated on volumes 50,00, 100,00, 200,00, 500,00, 1000,00, 5000,00 ml. The flask capacity is specified in an inscription on a flask. A flask close glass polishing a stopper. Fill a flask at first through the funnel inserted into it, and then from a pipette so that the bottom meniscus was opposite to line.

Measured cylinders are applied for measure off certain volumes of solutions when accuracy is not of great importance. They are convenient for mixing and dilute solutions of certain volume. On cylinder height there are divisions. At measure off the eye always should be flush with the bottom meniscus. For exact measurement of volumes measured cylinders do not use.

The ware intended for performance of chemical analyses, should be washed carefully up. It is among the major elements of work providing reception of exact results. Criterion of cleanliness of glasswares is flow downing the thaw of water from internal walls. If drops appear on walls at rinsing, that, starting to work, it is necessary to wash up ware anew. It is possible to apply special ruffs. After that ware fill with a chromic mix which oxidises traces of organic substances on glass, and maintain some time (to a half an hour). After ware washing the chromic mix gathers for a reuse. Having poured out a chromic mix in a modular bottle, ware rinse at first with water, and then distilled. If the ware be applied dry, it dry in special dryer cases.

Titration spend as follows:

1) Pure burette rinse 2-3 times with a small amount of a working solution for removal of the rests of water.
2) Strengthen burette vertically in a pad of a support and fill by the titrely solution to level a little above zero.
3) Solution part lower in the put glass for replacement of air from a rubber tubule and a pipette.
4) Lead up level of a liquid to zero line. On a tip burette should not remain solution drops (it remove a glass touch).

5) In a flask for titration measure a pipette an investigated solution.
6) Gradually pour out a liquid from burette in a flask to an establishment of a point of equivalence.
7) At readout of a liquid of eyes hold precisely at meniscus level. At the painted solutions readout make on the top meniscus, at unpainted - on bottom.
8) Upon termination of work burette fill with water above zero division and close from above a test tube.
9) At chemical analyses errors can be committed, some parallel measurements therefore are spent. Regular errors in titrimetrical analysis can arise because of wrong definition of concentration of working solutions, concentration change at storage, discrepancy of measured ware, a wrong choice of the indicator and etc.
10) Source of random errors are: discrepancy of filling burette before zero division, discrepancy of readout of volume on a scale burette, uncertainty of surplus of the regent after addition of last drop of a working solution at titration.

Calculations in the titrimetric analysis spend according to *the law of equivalents*: **at identical molar concentration of equivalent solutions co-operate among themselves in equal volumes. At various concentration volumes of solutions of co-operating substances inversely proportional to their concentration**:

$$V_1 \cdot c\ (1/Z\ X_1) = V_2 \cdot c\ (1/Z\ X_2)\ (1)$$

For both reacting substances product of molar concentration of equivalent of its solution on volume is size a constant. On the basis of the law of equivalents it is possible to carry out various quantitative calculations.

So, for example, knowing molar concentration of equivalent of one solution, and also the volumes of solutions spent for titration, it is possible to define molar concentration and a titr of other solution.

*For example:* 12,00 ml of a solution of alkali are spent for neutralization of a solution of sulfuric acid of 20,00 ml with molar concentration of equivalent 0,2000 mol/l. To calculate molar concentration of equivalent and a titr of sulfuric acid in this solution.

$$2\ NaOH + H_2SO_4 = Na_2SO_4 + 2\ H_2O$$

$$NaOH + \frac{1}{2}\ H_2SO_4 = \frac{1}{2} Na_2SO_4 + H_2O$$

From the equation it is visible, that the factor of equivalence $H_2SO_4$ is equal to l, and the factor of equivalence NaOH is equal 1. Substituting values in the formula (1) we will receive:

$$V(H_2SO_4) \cdot c(\frac{1}{2} H_2SO_4) = V(NaOH) \cdot c(NaOH)$$

$$c(\ c(\frac{1}{2} H_2SO_4) = \frac{V(NaOH) \cdot c(NaOH)}{V(H_2SO_4)};$$

$$c\left(\frac{1}{2}H_2SO_4\right) = \frac{0{,}200\,mol/l \cdot 12{,}00\,ml}{20{,}00} = 0{,}1200 mol/l$$

$$t(H_2SO_4) = \frac{c(\frac{1}{2}H_2SO_4)\cdot M(\frac{1}{2}H_2SO_4)}{1000} = \frac{0{,}1200\cdot 49}{1000}\frac{mol\cdot l}{mol\cdot ml} = 0{,}005880\, g/ml$$

Calculations in the titrimetric analysis should be spent with high degree of accuracy.

Volumes of solutions measure to within the 100-th shares of a milliliter, for example: V (HCI) =10,27 ml or V (NaOH) =22,82 ml. Concentration of solutions count to the fourth significant figure, for example:

*c (HCI) = 0,1025 mol/l*

*c (NaOH) =0,09328 mol/l*

*t (HCI) = 0,003600 g/ml*

Depending on reaction which underlies definition, methods of the volume analysis can be divided into following groups:

1) Methods of the acid-basic of titration or neutralization method
2) Oxidation methods - reduction or oxidimetry
3) Method of chelatometry
4) Sedimentation methods

## Training tasks and standards and their decisions

**Task №1**. In medicine potassium permanganate is applied as an antiseptic for externally to washing of wounds and a throat - 0,1-0,5 % a solution, for throat rinsing - 001 - 01 % a solution, for stomach washing - 0, 02 - 0,1 % a solution. To what of methods titrimetric analysis can take advantage for calculation the concentration of a solution of potassium permanganate if is available titrated solution of oxalic acids?

**The standard of decision:**

Potassium permanganate is an oxidizer, oxalic acid - a reducer. As reaction between these components - oxidation-reduction for definition of concentration of potassium permanganate can use a method of permanganatometry.

**Task №2.** Define molar concentration of equivalent, and a titer of chloride of hydrogen if 19,87 ml are spent for titration of this solution of 20,00 ml 0,1 mol/l of solution NaOH.

**Given:**

*V (HCl) = 20,00 ml*
*V (NaOH) = 19,87 ml*
*c (NaOH) = 0,1000 mol/l*

*M (HCl) = 36,5 g/mol*

*c (HCl) =?* *t (HCl) =?*

**The standard of decision.**

The equation of occurring reaction:

$$NaOH + HCl = NaCl + H_2O$$

Thus: *feq* (NaOH) = 1, *feq* (HCl) = 1.

1. Under the law of equivalents it is found molar concentration of solution HCl:

$$c\ (NaOH) \cdot V\ (NaOH) = c\ (HCl) \cdot V\ (HCl)$$

$$c(HCl) = \frac{c(NaOH) \cdot V(NaOH)}{V(HCl)}$$

$$c\ (HCl) = \frac{0.1000 \cdot 19{,}87}{20{,}00} \frac{mol \cdot ml}{l \cdot ml} = 0{,}09935 mol/l$$

2. Proceeding from value with (HCl), we will calculate a titr of this solution:

$$t\ (HCl) = \frac{c(HCl) \cdot M(HCl)}{1000}$$

$$t\ (HCl) = \frac{0{,}09935 \cdot 36{,}5}{1000} \frac{mol \cdot g}{l \cdot mol} = 0{,}003627 g/ml$$

*The answer*: *c (HCl)= 0,09935 mol/l; t (HCl)= 0,003627 g/ml*

## Questions for self-checking of mastering of a theme

1. To what requirements should satisfy the reactions applied in the titrimetric analysis?
2. Why burette and pipettes it is necessary to rinse before the use by a solution with which them will fill? Whether it is possible so to arrive with flasks for titration?
3. How it is necessary to arrive with the drop which has remained on a tip of a pipette in burette?
4. At titration the experimenter has fixed on burette such volumes of the solution of a reagent spent for titration: 15,27 ml, 18,17 ml and 12,89 ml. Whether these results are converging? Whether it is possible to take from them average arithmetic value for carrying out of calculations?

## Situational tasks

1. The maintenance of hydrochloric acid in gastric juice makes 0,4-0,5 %. Calculate, how many the ml 0,1 mol/l of solution NaOH is spent for titration of juice of 10,00 ml (p=1,000 g/ml).

2. In what cases the equivalence point lays at pH=7, at pH <7, at pH> 7?
The answer: At titration of strong acid by alkali the equivalent point coincides with a neutral point; at titration of weak acid by alkali the equivalent point lays at values

pH <7, at titration of the weak basis by strong acid the equivalent point lays above a neutral point.

3. Lead acetate - Pb $(CH_3COO)_2$ - is an astringent at inflammatory diseases of a skin. 0,5 % a solution are applied. Calculate weight of this substance for preparation of 0,5 % (weights) of a solution of 100 ml. What mass fraction of lead (%) in this solution? *p* =1/ml

## Test questions

1. What value of a titer of a solution t (HCl) reflects necessary degree of accuracy of definitions in titrimetric the analysis
a)0,03 g/ml b)0,003715 g/ml c)0,0037578 g/ml d)3,7 g/ml e) 0,0037 g/ml
2. What values of volumes are descending in titrimetric analysis?
a)2,51 ml; 10,52 ml; 8,78 ml b) 15,27 ml; 15,22 ml; 15,31 ml
c)5,73 ml; 7,02 ml; 15,76 ml d) 1,07 ml; 5,34 ml; 0,78 ml.
3. What measuring ware define volume titrated solution
a)Pipette b) measured flask c)burette d) flask
4. What reaction underlies the titration acid-basic?
a) Oxidation-reduction reaction
b) Neutralization reaction
c) Reaction of formation of complex connections
d) The reaction proceeding with allocation of heat
5. What solution is called titrated?
a) solution of unknown concentration
b) a freshly made solution
c) solution of a reactant of precisely known concentration
d) the solution, which concentration need to be defined

6. What is the equivalence point?
a)it is a point of the end of reaction b) it is a point of the beginning of reaction
c) interaction of two substances d) a point where volumes are equal

7. Calculations are based on what law in titrimetric the analysis?
a) the law of preservation of weight of substance b) the law of equivalents
c) the Ostwald law of cultivation d) Raul's law
8. Pipettes are applied to what purpose?
a) for measure off exact volume of a solution b)for titration
c) for preparation of solutions d) for dilute a solution
9. What is titer of the solution?
a)It is a quantity of grams of the dissolved substance in 1 l of a solution
b)It is a quantity of mols of the dissolved substance in 1 l of a solution
c)This quantity of mols of the dissolved substance in 1 kg of a solution
d)This quantity of grams of the dissolved substance in 1 ml of a solution
10. What substances are applied to definition of a point of equivalence?

a) indicators b) inhibitors c) promoters d) catalysts

## LABORATORY WORK.

### Technics of work as the laboratory measured ware used in the titrimetric analysis (on water).

The various measuring ware is applied to exact measurement of volume of solutions in the **titrimetric** analysis: burrete, pipettes, measured flasks and cylinders. In experiences with water it is necessary will learn to work correctly with it as the basic errors at carrying out of analyses a **titrimetric** method arise at wrong readout of volume of solutions.

### Tasks for the independent decision

1. In what units concentration of equivalent and a solution titer is expressed to a molar?
2. What value of a titer of a solution of hydrochloric acid reflects necessary degree of accuracy of definitions in the **titrimetric** analysis: 0,003 g/ml; 0,003715 g/ml; 0,00371578; 0,0037/ml
3. Define molar concentration of equivalent and a titer of solution $NH_3$ if 12,50 ml of solution HCI are spent for titration 10,00ml a solution, with molar concentration of equivalent 0,9510 mol/l.

## THEORETICAL BASES OF A METHOD OF THE ACID-BASIC TITRATION.

**The theme purpose**: To know the mechanism of change of coloring of the indicator and To learn to make its correct choice for carrying out of the analysis of biological liquids and medical products a method of the acid-base of titration, and also, using titration curves To learn to choose indicators correctly.

**The importance of a studied theme:** The knowledge of the theory of change of colouring of the acid-bases of indicators and a course of process of titration allows to choose correctly indicators for concrete titration that is important as reliability of received results of the analysis of biological objects and medical products depends on correctness of a choice of the indicator.

**Initial level of knowledge:**

1. Neutralisation reactions
2. Types of reactions of neutralisation
3. The law of action of weights
4. Chemical balance
5. Hydrolysis of salts
6. Hydrogen indicator - pH.

**Teaching material for self-preparation.**

1. V.N.Alekseev. The quantitative analysis. M, 1972, p. 238.
2. K.A.Seleznev. Analytical chemistry. M, 1973, p. 173
3. I.K.Tsitovich. A course of analytical chemistry. M, 1983, p. 228.
4. A.V.Babkov, G.N.Gorshkova, A.M.Kanonov. A practical work in the general chemistry with elements of the quantitative analysis. M, 1978, p. 98.

**On employment following questions will be considered**

1. Bases of the ionic theory of indicators
2. Concept and calculation pH indicators
3. An interval of transition of coloring of the indicator
4. Curve titration

4.1. A course of a curve of titration depending on force of co-operating acids and the bases

4.2. Titration jump

4.3 Point of equivalence

5.Indicator choice

## THE INFORMATION BLOCK.

### The acid-basic indicators.

In a method of the acid-basic of titration the end of chemical reaction is defined by means of indicators. Indicators change coloring of a solution depending on acidity and basicity of environment. Indicators can be one-color or two-colour. At one-colour indicators not dissociated molecules are colorless, and ions are painted. Two-colour indicators are characterized by that their not dissociated molecules are painted in one colour, for example in red, and ions - in other colour, for example in yellow. An example of one-colour indicators is phenolphthalein, timolftalein, two-colour - methyl-orange, metilred, neutral red, litmus, etc. According to the ionic theory the acid-basic indicators represent weak organic acids or the bases at which colouring of not ionised molecule sharply differs from colouring of its ion. In the titrimetric analysis the indicators which are weak organic acids are most often applied. The indicator as the weak electrolit, dissociates, and in a solution of such indicator is carried out balance:

$$HInd = H^+ + Ind^- \qquad (1),$$

Where *HInd* – is not dissociated molecule of the indicator, $Ind^-$ - it anion. Acid addition leads to increase in concentration of ions $H^+$ and balance according to the law of operating weights is displaced to the left, i.e. towards formation of not dissociated molecules; the solution gets colouring of not dissociated molecules of the indicator. On the contrary, if to a solution containing the indicator to flow alkali appearing in a solution hydroxyl ions will connect ions $H^+$ the indicator in not dissociated molecules of water; balance under the law of operating weights is displaced to the right, i.e. towards increase in a concentration solution anions, and solution colouring will be caused by colour of ions of the indicator. Thus, change of colouring of the indicator is connected with change pH a solution.

For constant of expression electrolyte dissociation fairly following expression:

$$K_{HInd} = \frac{c(H^+) \cdot c(Ind^-)}{c(HInd)} \quad (2)$$

$K_{HInd}$ there is a seeming constant of ionisation of the indicator.
Let's transform the equation (2):

$$\frac{c(HInd)}{c(Ind-)} = \frac{c(H^+)}{K_{HInd}}$$

Also we will solve it rather $c(H^+)$:

$$c(H^+) = \frac{K_{HInd} \cdot c(HInd)}{c(Ind^-)}$$

Whence**:**

$$\lg c(H^+) = \frac{-\lg K_{HInd} - \lg c(HInd)}{c(Ind-)}$$

And, hence,

$$pH = \frac{pK - \lg c(HInd)}{c(Ind^-)}$$

c (HInd) - the form of the indicator existing in the sour environment, we will designate it $c_{acid..}$;
c ($Ind^-$) - the form of the indicator existing in the alkaline environment, we will designate it $c_{bas..}$;
Thus:

$$pH = \frac{pK - \lg_{acid.f.}}{c_{bas.f.}} \quad (3)$$

pK = -lgK - an indicator indicator. The equation (3) expresses dependence between colouring of the indicator and size pH a solution. The less size pH, the at higher value pH it changes the colour under the influence of added acids and the bases.

If $C_{acid.f.} = C_{bas.f}$, *then* $\frac{C(acid.f.)}{C(bas.f)} = 1$

Hence, pH=pK, i.e. the indicator indicator specifies size pH at which 50 % of molecules of the indicator will be in the molecular form, and 50 % in the ionic form. At parity change $c_{acid.f.} = c_{b.f.}$ By addition of acid or alkali balance between these forms will change, that will result in colouring change. The eye of the person has the limited ability to perception of color and ceases to notice presence of one of the painted forms of the indicator if their concentration differ approximately in 10 times. Therefore indicator colouring changes not at any change pH, and in the certain interval of its values named an interval of transition of colouring of the indicator. It reaches usually one unit pH in that and other party from size pK the indicator, i.e. pH = pK $\pm$ 1. For example, an interval of change of colouring methyl-orange 3,1 - 4,4. In this interval indicator colouring passes from pink in yellow colour. At pH = 4,4 methyl-orange keeps yellow colouring, and at pH=3,1 - pink. Value pH at which titration with the given indicator comes to an end, is called as an indicator of titration and is designated pT. The titration indicator is calculated as a half-sum of values pH transition of colouring of the indicator from one form in another. **For example,**

$$pT(m - o) = \frac{(3,1 + 4,4)}{2} = 3,75$$

$$pT(ph - ph) = \frac{(8 + 10)}{2} = 9$$

In an ideal case titration comes to an end at value pH=pT.

The major indicators of a method of the acid-basic of titration have following intervals of transition of colouring and titration indicators:

| | Transition area | Indicator of titration (pT) |
|---|---|---|
| Methyl-orange | 3,1 - 4,4 | 4,0 |
| Methyl red | 4,4 - 6.2 | 5,5 |
| Phenolphthalein | 8,0 - 10,0 | 9,0 |
| Litmus | 5,0 - 8,0 | 7,0 |

## Curve titration. An indicator choice

It is known, that in a method of the acid-base of titration the equivalence point is defined on change of colouring of the added indicator. For correct selection of the indicator it is necessary to track, as acidity or alkalinity of solution in process of a current of process of neutralization changes. These changes pH a solution can be represented graphically.

It is convenient to express a course of process of titration by means of curves of titration which show a graphic representation of dependence of change pH environments from quantity of the added working solution. For reception of a curve of titration build the schedule in rectilinear axes of co-ordinates. On an axis of abscisses postpone quantity of milliliters of an added solution titrant, on an axis of ordinates - value pH environments

## Curve of titration of strong acid by the strong basis

Let's consider a case of acidimetrically titration of solution NaOH of 100,00 ml with molar concentration of equivalent 0,1000 mol/l, working solution HCl with molar concentration of equivalent 0,1000 mol/l.

If to 100,00 ml of solution NaOH with molar concentration of equivalent 0,1000 mol/l Titr of the solutionant, pH this solution = 13, pOH = 1 is not added. At addition of solution HCl of 90,00 ml with molar concentration 0,1000 mol/l concentration decrease in 10 times, and pH = 12, pOH = 2 (without taking into account for diluting). At addition 9,00 more ml (only 99,00 ml) solution HCl with molar concentration 0,1000 mol/l, concentration NaOH decrease in 10 times and pH = 11, pOH = 3. At the further addition of solution HCl with molar concentration 0,1000 mol/l we receive figures which it is brought in the table. Having noted the received values pH and number of milliliters titrant on the schedule, we will receive a titration curve.

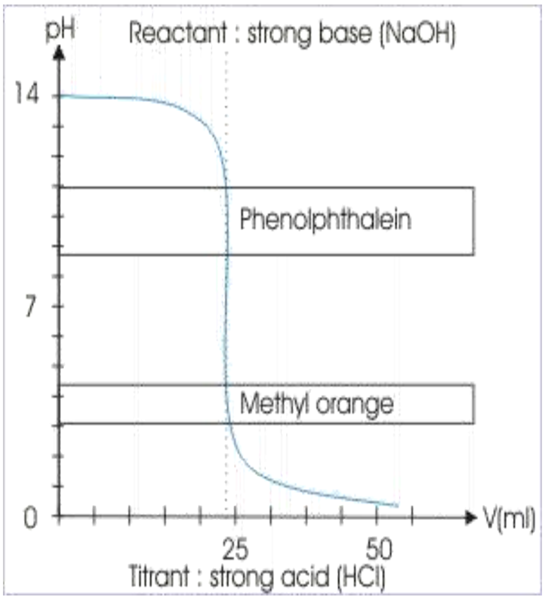
The analysis of a curve of titration of the strong basis by strong acid shows, that change of pH environments at first occur smoothly, environment remains alkaline, then there comes sharp change of size pH and environment from alkaline becomes sour, the further change pH occurs smoothly in the sour environment. The zone of sharp change of size pH is called as titration jump. On a curve of titration titration jump is observed at addition of a solution with molar concentration 0,1000 mol/l from 99,90 ml to 100,10 ml, in this interval there is a change pH environments from 10 to 4.

The equivalence point is in the middle of titration jump, at pH = 7. The curve of titration of strong acid the strong basis has a return appearance. It begins in the sour environment (titrating acid), titration jump is in the range from pH=4 to pH = 10, an equivalence point also is in the middle of titration jump, at pH=7.

The size of jump of titration depends on concentration titrable acid and a solution titrant. So, at solution titration acid with molar concentration of equivalent 0,0100 mol/l, a solution base the same concentration, titration jump decreases and is in the range from pH=5 to pH=9. The curve of titration strong acid is resulted by the strong basis on picture. 1.

Using a titration curve, choose the suitable indicator. For each case of titration those indicators which indicators of titration enter into jump limits pH on a curve are suitable only.

Strong acid the strong basis it is possible to apply any of four major indicators to titration (litmus, methyl orange, methyl red and phenolphthalein).



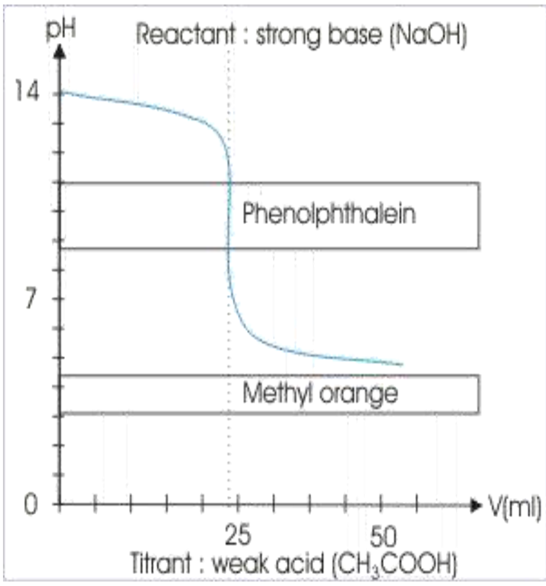

**Picture. 1**. A curve of titration of solution HCl with molar concentration of equivalent of 0,1000 mol/l solution NaOH molar concentration of equivalent 0,1000 mol/l.

## Curve of titration weak acid the strong basis

Character of a curve of titration changes at titration weak acid the strong basis. So, a curve of titration of a solution weak acid $CH_3COOH$ with molar concentration 0,1000 mol/l a solution of strong basis NaOH with molar concentration 0,1000 mol/l is resulted on picture. 2

Acetate of sodium $CH_3COONa$ formed as a result of titration is hydrolyzed with formation bases environments. Therefore the jump interval pH on a curve is shifted in bases the party from pH 7,8 to pH 10, and, the more poorly titrable acid, the it is more shift of a curve of titration and equivalence point.

For titration weak acid the strong basis the indicator phenolphthalein is suitable. Its indicator of titration pT =9 enters into limits of jump of titration. Other indicators (methyl orange, methyl red, litmus) in this case cannot be used, as their indicators of titration do not enter into a jump interval.



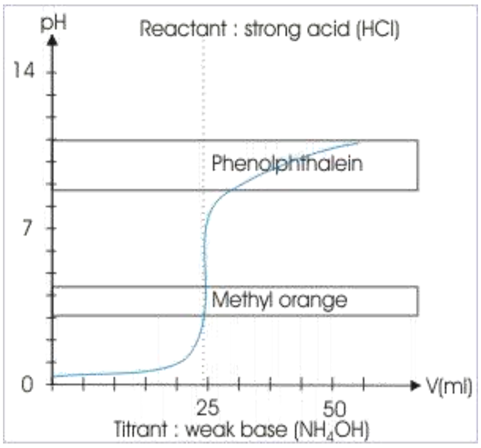

**Picture 2.** A curve of titration of solution $CH_3COOH$ with molar concentration of equivalent 0,1000 mol/l solution NaOH molar concentration of equivalent 0,1000 mol/l

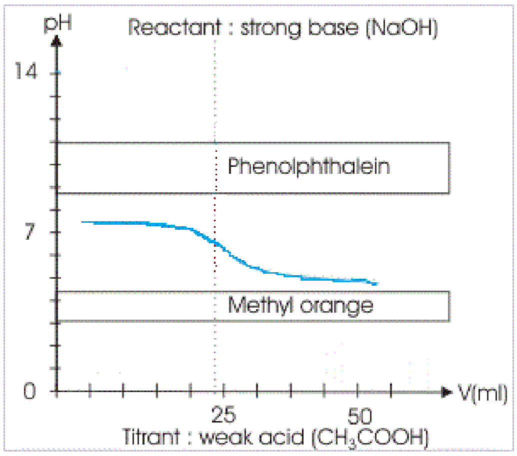
## Curve of titration of the weak basis strong acid

Curve of titration of solution $NH_4OH$ with molar concentration of equivalent 0,1000 mol/l solution HCl with molar concentration of equivalent of 0,1000mol/l. It is resulted on picture. 3.

Chloride of ammonium $NH_4Cl$ formed thus is hydrolyzed with formation acid environments. Therefore in this case the equivalence point should be in acid areas pH, i.e. at pH <7. Curve consideration confirms these assumptions. Really, at titration of the weak basis strong acid jump limits are stretched from pH 4 to pH 6,2. The equivalence point lays at pH 5,1.

In this case for titration indicators methyl orange (pT=4) and methyl red (pT=5) which indicators of titration enter into jump area are suitable. Application of litmus or phenolphthalein is impossible, as their indicators of titration far fall outside the limits jump. Titration weak acid the weak basis is impossible, as the curve of titration has no titration jump (picture. 4).




| | |
|---|---|
| **Picture 3.** A curve of titration of solution $NH_4OH$ with molar concentration of equivalent 0,1000 mol/l solution HCl with molar concentration of equivalent of 0,1000mol/l**.** | **Picture 4.** A curve of titration of solution $CH_3COOH$ with molar concentration of equivalent 0,1000 mol/l solution $NH_4OH$ with molar concentration of equivalent 0,1000 mol/l |

## Training tasks and standards of their decision

***Task №1*** Specify approximate value pH a solution if at presence phenolphthalein the solution is colorless, and at addition methyl red becomes red.

***The standard of decision***

1. Phenolphthalein has a transition interval at pH 8,0-10,0c change of colouring from colorless in the purple.
2. The methyl red has a transition interval at pH 6,8 8,4 with change of colouring from yellow in the red.
3. As the investigated solution at presence phenolphthalein is colorless, and in the presence of the methyl red has red colouring, that, obviously, its
4. Approximate value pH = 8,0-8,4.

***Task №2.*** Explain a course of a curve of titration hydroxide ammonium hydrochloric acid and choose the indicator for the given reaction at titration.

**The standard of decision**

1. Let's admit, to subtitle a solution (water) ammonia - hydrochloric acid - HCI. As a result of reaction:

$$NH_3 + HCl = NH_4Cl$$

Salt on which presence depends pH in an equivalence point turns out.
2. Consequent on hydrolysis the solution gets acid environment, and the equivalence point lays at pH <7.
3. On a curve of titration of the weak basis strong acid limits of jump of titration are stretched from pH 4 to pH 6,2.
Thus, for similar titration indicators - methyl orange (a transition interval pH 3,1 - 4,4) and methyl red (pH = 4,4 - 6,2) are suitable.

## Questions and tasks for self-checking of mastering of a theme

1. What indicators concern the acid-bases indicators?
2. What represent the acid-bases indicators?
3. What indicators are called as monochromatic, dichromatic?
4. What is the interval transition the colouring of indicator?
5. What is the index of indicator?
6. Express dependence between colouring of the indicator and size pH a solution.

## Situational tasks

1. Calculate an indicator of titration of the indicator bromine-thymoly dark blue which constant of ionization is equal $1{,}6 \cdot 10^{-7}$ (the acid indicator).

*2.* Specify approximate value pH to a biological liquid if at introduction - nitro phenol the solution is colorless, and at addition bromkrezoly dark blue - it is painted in dark blue colour. Interval transition of nitro phenol = pH 5,6 - 7,6 - colouring is change from colorless to yellow; a transition interval bromtimilly dark blue pH 3,8 - 5,4 and from yellow in dark blue.

3. Pick up the suitable indicator for titration acetic acid by hydroxide sodium.

## Test questions

1. What is the interval of transition of colouring of the indicator?
   a) Value pH at which 50 % of the indicator is in molecular, 50 % in the ionic form
   b) pH a solution at which indicator colouring passes value of an interval from one form in another;
   c) Graphic change pH a solution at titration;
   d) Sharp change pH a solution near to a point of equivalence from one drop of a working solution;
2. What is called as a titration curve?
   a) Value pH at which 50 % of the indicators are in molecular, and 50 % in the ionic form
   b) Value of an interval pH a solution at which indicator colouring passes from one form in another;
   c) Graphic change pH a solution at titration;

d) Sharp change pH a solution near to a point of equivalence from one drop of a working solution;

3. What is the titration jump?

a) Value pH at which 50 % of the indicators are in molecular, 50 % in the ionic form

b) Value of an interval pH a solution at which indicator colouring passes from one form in another;

c) Graphic change pH a solution at titration;

d) Sharp change pH a solution near to a point of equivalence from one drop of a working solution;

4. What indicators are called as one-colour?

a) Indicators at which both forms are painted

b) Indicators at which one form is painted;

c) Indicators at which both forms are colorless;

d) Indicators at which both forms have identical colouring.

5. What indicators are called as two-colour?

a) Indicators at which both forms are painted

b) Indicators at which one form is painted;

c) Indicators at which both forms are colorless;

d) Indicators at which both forms have identical colouring.

6. Specify the one-colour indicator?

a) Litmus b) phenolphthalein c) the methyl orange d) methyl red

7. What is the titration indicator?

A) Value pH at which 50 % of the indicator are in molecular, 50 % in the ionic form

b) Value of an interval pH a solution at which indicator colouring passes from one form in another;

c) Graphic change pH a solution at titration;

d) Sharp change pH a solution near to a point of equivalence from one drop of a working solution;

8. At what indicator the interval of change of colouring is in limits pH 3,1-4,4?

a)Litmus b) phenolphthalein c) the methyl orange d) methyl red

9. At what indicator the interval of change of colouring is in limits 8,2-10,00?

a) Litmus b) phenolphthalein c) the methyl orange d) methyl red

10. What indicator can be used at titration hydroxide ammonium hydrochloric acid?

a) Litmus b) phenolphthalein c) the methyl orange d) methyl red

## Tasks for the independent decision

1. What indicator should be applied at titration if titration jump is in value limits pH 5-9. 4-8, 6-10?

2. Where there is an equivalence point at titration strong acid the weak basis and what indicator can be used thus?
3. Where there is an equivalence point at titration weak acid the strong basis and what indicator can be used thus?
1. What interval of transition and pH at phenolphthalein?

## METHOD OF THE ACID-BASIC TITRATION. ALKALIMETRATION

**The employment purpose:** To learn on the basis of knowledge of laws of course of the acid-bases of reactions quantitatively to define the maintenance hydrochloric acid in biological objects and medical products.

**The importance of a studied theme.** The method of the acid-base of titration is applied in medical and biologic researches at carrying out of clinical analyses, in the sanitary-and-hygienic control of foodstuff, waters, the analysis of medical products. This method it is possible to establish the quantitative maintenance acid, the bases, and also salts which at hydrolysis form acid or bases environment. For example, by means of the titration acid-base carry out the analysis acidity gastric juice, urine, etc. biological liquids. Quantitatively analyze the medical products which are acids, for example, solutions hydrochloric, sulfuric, boric and many organic acid; in the sanitary-and-hygienic analysis carry out the analysis of foodstuff on them acidity, define rigidity of water etc.

**Initial level of knowledge.**

1) Neutralisation reactions;
2) Hydrogen indicator - pH;
3) Reactions of hydrolysis of salts;
4) The theory of indicators of a method of the acid-base of titration;
5) Definition of factors of equivalence;
6) Preparation of the titrable solutions.

**Teaching material for self-preparation:**


1. N.A.Alekseev. The quantitative analysis. M, 1972, p. 294
2. N.A.Selezneva. Analytical chemistry. M, 1973, p. 183
3. I.K.Tsitovich. A course of analytical chemistry. M, 1985, p. 249
4. A.V.Babkov, G.N.Goroshkova, A.M.Kononov. A practical work in the general chemistry with elements of the quantitative analysis. M, 1978, p. 109.


**On employment following questions will be considered:**

1. Theoretical bases of a method of the acid-base of titration:
2. Bases of laboratory work:

2.1. The equation of chemical reaction;
2.2. An indicator choice;
2.3. A technique of performance of work;
2.4. Settlement formulas;

2.5. Registering of the experimental data;
2.6. Conclusions from results of the analysis;
3. Application of a method of the acid-base of titration in medicine;
4. Laboratory work

## THE INFORMATION BLOCK.

### Methods of the acid-base of titration

At the heart of a method of the acid-base of titration the neutralization reaction lays, one of which products is water:

$$H^+ + OH^- \rightleftarrows H_2O$$

On this method it is possible, using a titrable solution any acid to spend quantitative definition bases (acidimetration) or, using titrable a solution base, quantitatively to define concentration acid (alkalimetration). The equivalence point in a method is defined by means of the acid-bases of indicators as in the course of the titration acid-base there is a change pH a solution, and the equivalence point lays at certain value pH, that depends on force co-operating acid and bases.

Indicator choice spends on a titration curve. In a method working solutions are solutions strong acid and bases. Often use a solution hydrochloric acid which standardization make on a standard solution tetraborat of sodium. The water solution of this salt owing to hydrolysis has bases reaction:

$$Na_2B_4O_7 + 7H_2O = 2NaOH + 4H_3BO_3$$

Therefore it is possible to subtitle acids:

$$NaOH + HCl = NaCl + H_2O$$

From the total equation:

$$Na_2B_4O_7 + 2HCl + 5H_2O = 2NaCl + 4H_3BO_3$$

Or

$$\frac{1}{2}\ Na_2B_4O_7 + HCl + 2{,}5H_2O = 2NaCl + 2H_3BO_3$$

It is visible, that as a result of reaction collects weak ortoboric acid, pH which solution it is equal 4,6. Hence, the equivalence point can be established on change of colouring of the indicator methyl orange at which the transition interval lays in a limit pH 3,0-4,4.

The solutions applied in a method, are of great importance in the clinical analysis and in medicine. So, the standardized solution hydrochloric acid is applied to the analysis of medical products of the bases, hydrolyzed salts etc.

In medical practice solution HCl of 8,2-8,4 % (weights.) it is applied inside at insufficient acidity gastric juice. Its quantitative analysis can be established, using a standard solution base, for example, NaOH or KOH.

The technique of carrying out of the analysis is similar set forth above.

### Training tasks and standards of their decision

***Task №1.*** Define molar concentration of equivalent, a subtitle of a solution hydrochloric acid, if for titration 20,00ml a solution tetraborat of sodium c ( $\frac{1}{2}$ $Na_2B_4O_7$) = 0,09528 mol/l it is spent 18,27 ml this solution.

***Given*:**
*V ($Na_2B_4O_7$)= 20,00ml*
*c ( $\frac{1}{2}$ $Na_2B_4O_7$)= 0,09528 mol/l*
*V (HCl) = 18,27 ml*
*M (HCl) = 36,5 g/mol*
*c (HCl) =?  t (HCl) =?*

**The standard of decision:**
The equation of occurring reaction:

$$\frac{1}{2} Na_2B_4O_7 + HCl + 2,5H_2O = 2NaCl + 2\ H_3BO_3$$

1. Under the equivalence law it is found molar concentration of solution HCl:

$$V\,(Na_2B_4O_7)\cdot c\,(\frac{1}{2}Na_2B_4O_7) = V\,(HCl)\cdot c\,(HCl)$$

$$c(HCl) = \frac{V(Na_2B_4Î_7)\bullet c(\frac{1}{2}N\alpha_2B_4O_7)}{V\,(HCl)}$$

$$c\,(HCl) = \frac{20.00\cdot 0.09528}{18{,}27}\,\frac{ml\cdot mol}{ml\cdot l} = 0{,}1043 mol/l$$

2. Proceeding from value with (HCl), we find a subtitle of this solution

$$t\,(HCl) = \frac{c(HCl)\cdot M(HCl)}{1000} = \frac{0{,}1043\cdot 36.5}{1000}\,\frac{mol\cdot g}{ml\cdot mol} = 0{,}003870 g/mol$$

*The answer*: *c (HCl) = 0,1043 mol/l, t (HCl) = 0,003870g/ml*

***Task №2***. Calculate awning $Na_2B_4O_7\cdot 10H_2O$ for preparation 500,00 ml 0,1000 mol/l of the solution necessary for the acid-base of titration hydrochloric acid on reaction:

$$Na_2B_4O_7 + 2HCl + 5H_2O = 4H_3BO_3 + 2NaCl$$

***Given:***
*V (s-n) = 500,00ml*
*c ($\frac{1}{2}$ $Na_2B_4O_7$) = 0,1000 mol/l*
*M ($Na_2B_4O_7$) = 381,4 g/mol*
*m ($Na_2B_4O_7$) =?*

**The standard of decision:**

1. The equations of occurring reaction*:*

$$\frac{1}{2} Na_2B_4O_7 + HCl + 2{,}5H_2O = NaCl + 2\ H_3BO_3$$

From the equation follows, that *feq* $(Na_2B_4O_7) = \frac{1}{2}$; *f eq (HCl) =1.*

Hence, the molar mass of equivalent $Na_2B_4O_7$ is equal:

$$M\ (\frac{1}{2} Na_2B_4O_7 \cdot 10H_2O) = feq\ (Na_2B_4O_7 \cdot 10H_2O) \cdot M\ (Na_2B_4O_7 \cdot 10H_2O)$$

$$M\ (\frac{1}{2} Na_2B_4O_7 \cdot 10H_2O) = (\frac{1}{2}) \cdot 381{,}4 g/mol = 190{,}7\ g/mol$$

2. Find number of mols $Na_2B_4O_7 \cdot 10H_2O$, containing in 0,5 l of its solution:

$n\ (Na_2B_4O_7 \cdot 10H_2O) = c\ (1/2Na_2B_4O_7 \cdot 10H_2O) \cdot V\ (s\text{-}n)$

$n\ (Na_2B_4O_7 \cdot 10H_2O) = 0{,}1000 \cdot 0{,}5\ \frac{mol \cdot l}{l} = 0{,}05 mol$

1. Proceeding from the found value n ($Na_2B_4O_7 \cdot 10H_2O$) and taking into consideration $M\ (1/2Na_2B_4O_7 \cdot 10H_2O)$, we will calculate awning this salt:

   $m\ (\frac{1}{2} Na_2B_4O_7 \cdot 10H_2O) = n\ (Na_2B_4O_7) \cdot M\ (\frac{1}{2} Na_2B_4O_7)$

   $m\ (\frac{1}{2} Na_2B_4O_7 \cdot 10H_2O) = 0{,}05 \cdot 190{,}7 \frac{mol \cdot l}{l} = 9{,}55 g$

   *Answer:* $m\ (1/2Na_2B_4O_7 \cdot 10H_2O) = 9{,}55g.$

## Questions and tasks for self-checking of mastering of a theme

1. What reactions underlie a method of the acid-base of titration?
2. How reactions of neutralization and hydrolysis reaction are connected among themselves?
3. What point of equivalence is established in a method of the acid-base of titration?
4. Name working solutions of a method?
5. Whether the method in the clinical analysis is applied?
6. How the solution volume hydroxide sodium, with molar concentration of equivalent 0,1500 is required on titration 10,00 ml hydrochloric acid, with molar concentration of equivalent 0,1520 mol/l?

## Situational tasks

1. The maintenance hydrochloric acid in gastric juice makes 0,4-0,5 % (weights.). Calculate, how many ml 0,1000 mol/l of solution NaOH it is spent for titration 10,00 ml gastric juice (ρ = 1,0 g/ml).

2. Quantitative definition of a solution boric acid, a mouth used for rinsing, washing of eyes spend an alkalimetricaly method. What molar concentration of a solution boric acid and its mass fraction in the given solution if for titration 2,00 ml $H_3BO_3$ it is spent 10,00 ml 0,1 mol/l of solution NaOH. M ($H_3BO_3$) = 61,83 g/mol, taking into consideration, that titrating not pure boric acid, and its glyceric complex, in which it titrating base as the one-basic acid.

3. Give an example the analysis of medical products by the method of the acid-base of titration.

## Test questions

1. What method it is possible to define quantity HCl in gastric juice?
a) acidimetration b) oxydimetria c) alkalimetration d) complexonometria
2. For what titration the indicator phenolphthalein is used?
a) $NH_3$+HCl b) $Na_2CO_3$ +$HNO_3$ c) $Na_3PO_4$+HCl d) HCOOH+NaOH
3. In what cases the equivalence point on a titration curve lays above a neutrality line
a) At titration strong acid the weak basis
b) At titration strong acid the strong basis
c) At titration weak acid base
d) At titration weak acid the weak basis
4. In what cases the equivalence point on a titration curve lays below a neutrality line
a) At titration strong acid the weak basis
b) At titration strong acid the strong basis
c) At titration weak acid base
d) At titration weak acid the weak basis
5. In what cases the equivalence point on a titration curve coincides with a neutrality line
a) At titration strong acid the weak basis
b) At titration strong acid the strong basis
c) At titration weak acid base
d) At titration weak acid the weak basis
6. What value pH has gastric juice?
a) 2-4 b) 0,9-2 c)4-6 d) 3-5
7. What value of concentration of solution HCl in titrimetric the analysis reflects necessary degree of accuracy?
a) 0,03 mol/l b) 0,1025 mol/l c) 0,09328 mol/l d) 0,081293 mol/l
8. With what accuracy measure volumes of solutions in titrimetric the analysis?
a) 10,25 ml; b) 11,252 ml; c) 11 ml; d) 12,5 ml
9. Under what formula define molar concentration HCl in an alkalimetric titration method?

a) $c\ (HCl) = c\ (\frac{1}{2}\ Na_2B_4O_7) \cdot V\ (Na_2B_4O_7)\ /\ V\ (HCl)$

b) $c\ (HCl) = c\ (\frac{1}{2}\ Na_2B_4O_7) \cdot V\ (HCl)\ /\ V\ (Na_2B_4O_7)$

c) $c\ (HCl) = c\ (\frac{1}{2}\ Na_2B_4O_7) \cdot V\ (HCl) \cdot M\ (HCl)\ /\ 1000$

d) $c\ (HCl) = m\ (HCl)\ /\ M\ (HCl) \cdot V$

10. What indicator is used at titration HCl by solution $Na_2B_4O_7$?
a) phenolphthalein b) litmus c) methyl-orange d) timolphtalein

## LABORATORY WORK №1

## "Definition of the general acidity gastric juice"

Change of concentration hydrochloric acid in gastric juice leads to diseases of a gastroenteric path. In norm pH = 0,9 - 1,8. Increase acidity - hyperclorhydria leads to a stomach ulcer, fall acidity - hypoclorhydria and full absence hydrochloric acid in gastric juice - achlorhydria lead to oncological diseases. Acidly reaction of gastric juice is caused by presence hydrochloric acid and acid-reaction phosphates, and at pathological processes - dairy acid and flying fat acids.

Set of all acid-reaction substances of gastric juice usually name the general acidity. Hydrochloric acid, connected with fibers and products of their digestion, name connected hydrochloric acid, and remained a lot of hydrochloric acid name free hydrochloric acid. At various diseases the maintenance in gastric juice hydrochloric acid can vary, that influences it fermentative activity. Therefore in clinical practice analysis methods acidity the gastric juice, playing the important role in diagnostics and treatment of many diseases of a gastroenteric path are widely used.

On the given employment will be spent the laboratory work on "Determination of total acidity of gastric juice"

***Work technique.*** To measure a pipette 20,00ml a standard solution tetraborat of sodium. To place it in a conic flask for titration, to add 1-2 drops of a solution methyl-orange and to subtitle a solution hydrochloric acid before transition of colouring from yellow in light pink from one drop acid. Titration to repeat 2 more times, from converging results to take an average arithmetic and to calculate concentration of a solution hydrochloric acid. Experimental data to bring in the table:

| № | $V(Na_2B_4O_7)$, ml | $c(1/2Na_2B_4O_7)$, mol/l | V(HCl), ml | C(HCl), mol/l | T(HCl) G/ml | Indicator |
|---|---|---|---|---|---|---|
| 1. | | | | | | M-o |
| 2. | | | | | | M-o |
| 3. | | | | | | M-o |

Calculations to make under the formula:

$$c(HCl) = \frac{V(Na_2B_4O_7) \bullet c(1/2N\alpha_2B_4O_7)}{V(HCl)}, \text{ mol/l}$$

$$t(HCl) = \frac{c(HCl) \cdot M(HCl)}{1000}, \text{ g/ml}$$

M (HCl) - molar mass HCl; M (HCl) = 36,5 g/mol

## LABORATORY WORK №2

## Quantitative definition acetic acid by the method of the alkalimetration

Acetic acid is weak acid, therefore it titrate by alkali

$$CH_3COOH+NaOH \rightleftarrows CH_3COONa+H_2O$$

As a result of reaction salt weak acid and strong the basis which easily is exposed to hydrolysis is formed:

$$CH_3COONa+H_2O=CH_3COOH+NaOH$$
$$CH_3COO^- +Na^+ + H_2O=CH_3COOH+Na^+ + OH^-$$
$$CH_3COO^- + H_2O=CH_3COOH+OH^-$$

Apparently, after hydrolysis acetic acid sodium environment will be bases. In this connection, as the indicator it is possible to choose phenolphthalein/f-f/.

For experience carrying out burette to fill with working solution NaOH and to establish a zero mark. In a conic flask to select a pipette 10,0 ml an investigated solution, to add 2 drops of the indicator phenolphthalein. Then the mix received in a flask to subtitle working solution NaOH before occurrence of weak pink colouring. Titration to repeat 3 times. For calculation awning “q”, normally and subtitle “T” to use arithmetic-mean value amount solution NaOH.
Given to bring in the table.

| № | $V_{CH3COOH}$, ml | Indicator, guttae f-f | $V_{NaOH}$, ml | $M_{CH3COOH}$, g | $c_{CH3COOH}$, mol/l | $t_{CH3COOH}$, g/ml |
|---|---|---|---|---|---|---|
| 1 | 10,0 | 2 | | | | |
| 2 | 10,0 | 2 | | | | |
| 3 | 10,0 | 2 | | | | |
| Medium average | | | | | | |

Calculations are conducted under formulas:

$$C_{(e)CH3COOH} = \frac{C(e)NaOH \cdot V(NaOH)}{V(CH_3COOH)}, g \cdot mol/l$$

$$T_{CH3COOH} = \frac{C(e)CH_3COOH \cdot M(CH_3COOH) \cdot F(CH_3COOH)}{1000}, g/ml$$

$$m = T_{CH3COOH} \cdot V_{CH3COOH}, g$$

## Tasks for the independent decision

1. Calculate pH a solution hydrochloric acid if for titration 10,00 ml a solution acid it is spent 8,40 ml tetraborat of sodium with molar concentration of equivalent 0,0955mol of/l.

2. Calculate molar concentration of equivalent and a subtitle of a solution chloric acid if on titration 20 ml methylate sodium, with molar concentration of equivalent 0,1150 mol of/l it is spent 19,60 ml a solution chloric acid.

## METHOD OF THE ACID-BASE OF TITRATION. ACIDIMETRATION

**The employment purpose:** To learn on the basis of knowledge of laws of course of the acid-bases of reactions quantitatively to define the maintenance of the bases in biological objects and medical products.

**The importance of a studied theme**. Ammonia is a disintegration product amino acid live organisms. Its part is allocated with urine in quantity 0,5-1,2g a day. At some diseases ammonia allocation increases. For the person ammonia is poisonous. Its maintenance in integral blood 0,05mg %. Quantitative definition of ammonia in biological objects characterizes presence or absence of pathological processes in an organism and has diagnostic value. The "liquid ammonia" applied in medicine, represents 10 % (weights.) solution $NH_4OH$.

**Initial level of knowledge.**

1) Neutralisation reactions;
2) Hydrogen indicator - pH;
3) Hydrolysis of salts;
4) The theory of a method of the acid-base of titration;

**Teaching material for self-preparation:**

1. I.K.Tsitovich. A course of analytical chemistry. M, 1985, p. 249
2. A.V.Babkov, G.N.Goroshkova, A.M.Kononov. A practical work in the general chemistry with elements of the quantitative analysis. M, 1978, p. 109.

**On employment following questions will be considered:**

1. A titer on defined substance:
2. Theoretical bases of laboratory work:
2.1. The equation of chemical reaction;
2.2. An indicator choice;
2.3. A technique of performance of work;
2.4. Settlement formulas;
2.5. Registering experimental data;
2.6. Conclusions from results of the analysis;
3. Application of the method of acid-base titration in the clinical analysis;
4. Laboratory work

## THE INFORMATION BLOCK

### Methods of the acid-base of titration

The standardized solution of hydrochloric acid can be used for quantitative definition of the bases and hydrolyzing salts. As an example we will consider definition $NH_3$ in water solutions. Interaction hydrochloric acid with ammonia (in a water solution) proceeds on the reaction equation:

$$NH_3 + HCl = NH_4Cl$$

$$f\,eq\,(NH_3) = 1, \quad f\,eq\,(HCl) = 1$$

The point of equivalence will be reached, when quantities of reacting substances will be equivalents, i.e.

$$n\,(NH_3) = n\,(HCl)$$

It is possible to express these magnitudes as follows:

$$n\,(NH_3) = \frac{m(NH_3)}{M(NH_3)}; \qquad c\,(HCl) = n\,(HCl) \cdot V\,(s\text{-}n)$$

*m* $(NH_3)$ -Weight $NH_3$, g
*M* $(NH_3)$ -Molar mass $NH_3$, a g/mol
*c (HCl)* -Molar concentration of a solution a mol/l
*V (s-n)* -Volume of solution HCl, ml.

Thus: $c\,(HCl) = \frac{m(NH_3)}{M(NH_3)} \cdot V\,(s\text{-}n)$

Let's transform the given equality:

$$\frac{m(NH_3)}{V(s-n)} = c\,(HCl) \cdot M\,(NH_3)$$

Also we will carry expression to 1 ml: $\frac{c(HCl) \cdot M(NH_3)}{1000}$, g/ml

c (HCl) - molar concentration of a solution hydrochloric acid, a mol/l, the size known for given definition.

$M(NH_3)$ - the molar mass $NH_3$, an equal 17g/mol. Having substituted these known sizes, it is possible to calculate t $(HCl/NH_3)$ which will have also constant value. If at ammonia definition in any object on titration of its solution it is spent V (HCl) ml, in titrable a solution weight of ammonia:

$$m\,(NH_3) = t(HCl/NH_3) \cdot V\,(HCl),\ g$$

## Training tasks and standards of their decision

***Task №1.*** Explain a course of a curve of titration hydroxide ammonium hydrochloric acid and a choice of the indicator for the given reaction at titration.

**The standard of decision**:

1. Let's admit, to subtitle a solution (water) ammonia - hydrochloric acid - HCI. As a result of reaction:

$$NH_3 + HCl = NH_4Cl$$

Salt $NH_4Cl$ on which presence depends pH in an equivalence point turns out.

2. Owing to hydrolysis $NH_4Cl$ the solution gets acid environment, and the equivalence point lays at pH = 5,1.

3. On a curve of titration of the weak basis strong acid limits of jump of titration are stretched from pH = 4 to pH 6,2.

Thus, for similar titration indicators - methyl orange (a transition interval pH 3,1 - 4,4) and methyl red (pH = 4,4 - 6,2) are suitable.

***Task №2.*** Awning 3,0g a technical hydrocarbonate of sodium it is dissolved in a measured flask on 250ml in water. On titration 10,00 ml this solution on reaction:

$$NaHCO_3 + HCl = NaCl + CO_2 + H_2O$$

It is spent 11,53 ml 0,1000 mol/l of a solution hydrochloric acid. To define molar concentration and a solution subtitle hydrocarbonate sodium. What mass fraction (%) $NaHCO_3$ in the sample?

**Given:**

*m (form) = 3,0g.*

*V (s-n) = 250,00ml*

*V ($NaHCO_3$) = 10,00 ml*

*V (HCl) = 11,53 ml*

*c (HCl) = 0,1000 mol/l*

*M ($NaHCO_3$) = 84,0 g/mol*

---

*c ($NaHCO_3$) =?   t ($NaHCO_3$) =?   ω % ($NaHCO_3$) =?*

***The standard of decision.***

1. Under the law of equivalents it is found molar concentration of solution $NaHCO_3$. According to proceeding chemical reaction *f equ* ($NaHCO_3$) = 1, *fequ* (HCl) = 1

$$c\,(HCl) \cdot V\,(HCl) = c\,(NaHCO_3) \cdot V\,(NaHCO_3)$$

$$c(NaHCO_3) = \frac{0{,}1000 \cdot 11{,}53}{10{,}00}\,\frac{mol \cdot ml}{l \cdot ml} = 0{,}1153\ mol/l$$

2. Proceeding from value C ($NaHCO_3$), we find a subtitle of solution $NaHCO_3$:

$$t\,(NaHCO_3) = \frac{c(NaHCO_3) \cdot M(NaHCO_3)}{1000}$$

$$t\,(NaHCO_3) = \frac{0{,}1153 \cdot 84{,}0}{1000}\,\frac{mol \cdot g}{l \cdot mol} = 0{,}009685\ g/ml$$

3. Find a mass fraction (%) $NaHCO_3$ in the sample: it is weight $NaHCO_3$ in 100g a solution (ρ = 1 g/ml).

$$\omega\,\%\,(NaHCO_3) = t\,(NaHCO_3) \cdot 100\% = 0{,}009685 \cdot 100\% = 0{,}968\,\%$$

$$\omega\,\%\,(NaHCO_3) = 0{,}968\,\%.$$

*The answer: c(NaHCO3) = 0,1153 mol/l, t($NaHCO_3$)=0,009685 g/ml*

***Task №3***. What a lot of hydroxide of sodium is necessary to take for preparation 500,00 ml a solution, for titration 20,00 ml which spent 18,50 ml 0,1000 mol/l of a solution of chamois acid.

**Given:**

*V (s-n) = 500,00ml*

$c(\frac{1}{2}H_2SO_4) = 0,1000\ mol/l$

*M (NaOH) = 40,0 g/mol*

*m (NaOH) =?*

***The standard of decision:***

Definition is based on chemical reaction:

$$2\ NaOH + H_2SO_4 = Na_2\ SO_4 + 2\ H_2O$$

$$NaOH + \frac{1}{2}H_2SO_4 = \frac{1}{2}Na_2\ SO_4 + H_2O$$

Thus, $f\ equ$ (NaOH) = 1, $f\ equ$ ($H_2SO_4$) = $\frac{1}{2}$

Under the law of equivalents it is found molar concentration of solution NaOH:

$$c\ (NaOH) = \frac{c(\frac{1}{2}H_2SO_4)\cdot V(H_2SO_4)}{V(NaOH)} = \frac{0.1000\cdot 18.50 mol\cdot ml}{20{,}00 l\cdot ml} = 0{,}09251 mol/l$$

1. Find weight NaOH in 500,00 ml or 0,5l solution:

$$m\ (NaOH) = c\ (NaOH)\cdot V\ (s\text{-}n)\cdot M\ (NaOH)$$

$$m\ (NaOH) = 0{,}09251\cdot 0{,}5\cdot 40\frac{mol\cdot l\cdot g}{l\cdot mol} = 1{,}85\ g$$

*The answer: m (NaOH) =1,85 g*

## Questions and tasks for self-checking of mastering of a theme

1. What is the solution subtitle on certain substance? In what cases at carrying out of analyses it is convenient to use this way of expression of concentration of a solution?
2. To calculate molar concentration of equivalent and a subtitle of solution NaOH if for titration 20 ml it is spent 17.80 ml solution HCI with molar concentration 0,1000 mol/l.
3. Why neutralization reactions between the weak bases and weak acids are not applied in titrimetric the analysis?
4. What versions of methods of the acid-base of titration are?

## Situational tasks

1. 10 % (weights.) an ammonia solution - "liquid ammonia" - apply to excitation of breath of patients at their deducing from an unconscious condition. Quantitative definition it spend an acidimetric method. For this purpose 5,00ml

a preparation plant with water in a measured flask in capacity 100ml. What molar concentration, mass fraction (%), and subtitle of the received solution if for its titration 10,00ml it is spent 14,00ml 0,1000mol/l of solution HCl?

2. Quantitative definition codeine - a preparation of calming action - spend solution HCl in the presence of methyl red, which interval of transition pH 4,2 - 6,3. Explain area pH a solution in which the point of equivalence of the given titration lays.

## Test questions

1. At what titration the equivalence point lays at pH> 7?
   a) $HNO_3$ + KOH → c) NaOH + HCl →
   b) $NH_3$ + HCl → d) HCOOH +NaOH →

2. Show an interval of change of colouring methyl-orange
   a) pH 8,2 – 9,8 b) pH 5,6-7,4
   c) pH 5,0-8,0 d) pH 3,1–4,2

3. At what titration the equivalence point lays at pH <7?
   a) HCOOH +KOH → b) $CH_3CH_2COOH$ + KOH →
   c) HCl + KOH → d) $NH_3$ + HCl →

4. At what titration it is used phenolphthalein?
   a) $NH_3$ + HCl → b) NaOH + HCl →
   c) $Na_3PO_4$ + HCl → d)HCOOH + NaOH →

5. At what titration the equivalence point lays at pH=7?
   a) $HNO_3$ + $NH_4OH$ → b) HCOOH + NaOH →
   c) $NH_3$ + HCl → d)$HNO_3$ + NaOH →

6. To what titration it is applied methyl-orange?
   a) $C_6H_5OH$ + NaOH → b) HCOOH + NaOH →
   c) $NH_3$ + HCl → d) $HNO_3$ + NaOH →

7. Choose the indicator for the given reaction: HCN + KOH →
   a) methyl-orange b) phenolphthalein
   c) litmus d) marked-red

8. What salt solution has high value pH?
   a) $(NH_4)_2CO_3$ b)$K_2CO_3$ c)$KNO_3$ d)KCl e) $NaNO_3$

9. What is a titration curve?
   a) Graphic presentation of change pH solution at titration
   b) Graphic presentation of change V solution at titration
   c) Graphic presentation of change C solution at titration.

10. At what titration the equivalence point lays at pH> 7?

a) $NH_4OH + HNO_3$ b) HCOOH + NaOH c) $NH_4OH + H_2SO_4$

d) $C_6H_5NH_2$ + HCl e) $Na_2CO_3$ + HCl

## LABORATORY WORK

### Control-analytical definition of weight of ammonia in solutions

***Work technique***. In a flask for titration to measure certain volume of ammonia (the teacher gives in the form of a control Task), to add 1-2 drops of a solution methyl-orange and to subtitle the standardized solution hydrochloric acid before transition of yellow colouring in light pink from 1 drop of a solution hydrochloric acid. Definition to repeat 2 more times, from the received results to take an average arithmetic and to calculate weight of ammonia. Experimental data to bring in the table:

| № | V($NH_3$), ml | V(HCl),ml | c(HCl), mol/l | t(HCl/ $NH_3$)g/ml | m($NH_3$), g | Indicator |
|---|---|---|---|---|---|---|
| 1. | | | | | | M-o |
| 2. | | | | | | M-o |
| 3. | | | | | | M-o |

Calculations to make under the formula:

$$m\ (NH_3) = t\ (HCl/NH_3) \cdot V\ (HCl)$$

t ($HCl/NH_3$) - a subtitle of solution HCl on ammonia:

$$t\ (HCl/NH_3) = \frac{c(HCl) \cdot M(NH_3)}{1000},\ g/ml$$

V (HCl) - the volume of solution HCl spent for titration of solution $NH_3$.

### Tasks for the independent decision

1. For what purposes count and build curve titration?
2. Where there is an equivalence point on titration jump?
3. In what cases the equivalence point on a titration curve coincides with a neutrality point; lays below a neutrality line; lays above a neutrality line?
4. The ammonia maintenance in a solution makes 0,4 - 0,5 % (weights.) calculate, how many ml solution HCl, with molar concentration 0,1025 mol/l it is spent for titration 20,00 ml an ammonia solution (ρ =1,0g/ml).

## METHODS OF ACID-REGENERATIVE TITRATION.

## PERMANGANATOMETRIC

**The employment purpose.** To learn on the basis of knowledge of laws of course of acid-regenerative reactions to spend quantitative definitions by a method of the permanganate metric  biological objects and medical products, and also objects of sanitary hygienic character.

**The importance of a studied theme.** Methods of acid-regenerative titration are widely applied in the clinical, sanitary-and-hygienic analysis of medical products. Using high acid ability of potassium permanganate, it is possible to spend with its help definition of reducers in biological objects. For example, a method of the permanganate metric  define the maintenance uric acid in urine, $Ca^{2+}$ in blood whey, sugar in blood, activity of enzyme catalase in blood, etc. acid properties $KMnO_4$ are used in medical practice at its application as an antiseptic external in water solutions for washing of wounds-0,1-0,5 of % (weights), for mouth and throat-0,01 rinsing-0,1 % (weights.) for stomach washing at poisonings-0,02-0,1 of % (weights).

## Initial level of knowledge

1. Laws of course of acid-regenerative reactions;
2. Drawing up of the equation of acid-regenerative reactions by a method of electronic balance.

## Teaching material for self-preparation

1. I.K.Tsitovich. The course of analytical chemistry. M, 1985, p. 271.
2. A.V.Babkov, G.N.Gorshkova, A.M.Kononov. A practical work in the general chemistry with elements of the quantitative analysis. M, 1978, p. 135
3. B.M.Alekseev. The quantitative analysis. M, 1972., p. 378

## On employment following questions will be considered:

1. Theoretical bases of methods of acid-regenerative titration.

2. Calculation of molecular weights of equivalent acid and reducers.

3. Theoretical bases of a method of the permanganatometric :
   3.1. Permanganate restoration in acid, bases and neutral environments
4. Theoretical bases of laboratory work:
   4.1. The equation of chemical reaction.
   4.2. A technique of performance of laboratory work.
   4.3. Settlement formulas.
   4.4. Registering experimental data.
   5. Application the method in medicine
   6.Laboratory work

## THE INFORMATION BLOCK.

## Method of the permanganatometric titration

The method of the permanganatometric is based on reaction acid reducers by potassium permanganate. Potassium permanganate shows acid properties in acid, neutral and alkaline environments.

$KMnO_4$ is strong oxidizer and in the acid environment is restored to $Mn^{+2}$

$$2KMnO_4+5K_2SO_3+3H_2SO_4=2MnSO_4+6K_2SO_4+3H_2O$$

$$\begin{array}{llll|l|l|l} Mn^{+7} & +5\bar{e} & \longrightarrow & Mn^{+2} & 5 & 10 & 2 \\ S^{+4} & -2\,\bar{e} & \longrightarrow & S^{+6} & 2 & & 5 \end{array}$$

In the alkaline environment $KMnO_4$ is restored to $Mn^{+6}$

$$2\,KMnO_4+K_2SO_3+2KOH=2K_2MnO_4+K_2SO_4+H_2O$$

$$\begin{array}{llll|l|l|l} Mn^{+7} & +1\bar{e} & \longrightarrow & Mn^{+6} & 1 & 2 & 2 \\ S^{+4} & -2\,\bar{e} & \longrightarrow & S^{+6} & 2 & & 1 \end{array}$$

In the neutral environment $KMnO_4$ is restored to $Mn^{+4}$

$$2\,KMnO_4+3K_2SO_3+H_2O=2MnO_2+3K_2SO_4+2KOH$$

$$\begin{array}{llll|l|l|l} Mn^{+7} & +3\bar{e} & \longrightarrow & Mn^{+4} & 3 & 6 & 2 \\ S^{+4} & -2\,\bar{e} & \longrightarrow & S^{+6} & 2 & & 3 \end{array}$$

In the titrimetric analysis oxidation spend in acid to environment in which are most shown acid properties of this substance. At titration an ion $Mn^{+7}$, entering into its structure and having crimson colouring, it is restored to almost colorless $Mn^{+2}$. After achievement of a point of equivalence the first superfluous drop $KMnO_4$ will paint a titrable liquid in light pink color that gives the chance to spend titration without indicators. In bases to environment or neutral in the course of restoration $Mn^{+7}$ dark-brown deposition $MnO_2$ or $K_2MnO_4$ which presence at a solution complicates an establishment of a point of equivalence drops out. As in acid-regenerative reaction by an equivalent name the quantity of substance equivalent to one electron, calculation of molar mass of equivalent acid and reducers are started with by number of the electrons got or lost by one molecule of substance. Thus, for a finding of equivalent weight oxyd a/reducer / it is necessary to divide its molar mass into number of the electrons got / by lost / one molecule of substance in considered reaction in which the substance participates.

Establishment of concentration of solution $KMnO_4$ spend a standard solution oxalic acid, interaction with which proceeds on the equation:

$$2\,KMnO_4+5H_2C_2O_4+3H_2SO_4=2MnSO_4+K_2SO_4+10CO_2+8H_2O$$

$$
\begin{array}{lll|c}
Mn^{+7} & +5\bar{e} \longrightarrow & Mn^{2+} & 2 \\
C_2O_4^{2-} & -2\bar{e} \longrightarrow & 2CO_2^{\ 0} & 5
\end{array}
$$

$$2Mn^{+7} + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 10CO_2$$

As as a result of reaction $Mn^{+7}$ attaches 5 electrons, its molar mass is equivalent is equal $\frac{1}{5}$ molar mass:

$$M\left(\frac{1}{5}KMnO_4\right) = \frac{158{,}03}{5} ==31{,}61 g/mol$$

Oxalic acid in the reaction gives two electrons, therefore molar mass of equivalent is equal to $\frac{1}{2}$ of molar mass:

$$M\left(\frac{1}{2}H_2C_2O_4\right) = \frac{126{,}07}{2} = 63{,}03 g/mol$$

In a case when at carrying out of definitions by a method of the permanganatometric there are collateral processes, apply methods of return titration.

For example, definition of molar concentration of equivalent and a subtitle of a solution of nitrite of sodium spend a method of return titration. The essence of a method of return titration consists that to acid solution taken a lot of, add the exact volume solution of nitrite sodium, and surplus of potassium permanganate to titer by standard solution of oxalic acid on reaction:

$$5NaNO_2 + 2KMnO_4 + 3H_2SO_4 = 5NaNO_3 + K_2SO_4 + 2MnSO_4 + 3H_2O$$

$$
\begin{array}{lll|c|c}
Mn^{+7} & +5\bar{e} \longrightarrow & Mn^{+2} & 5 & 2 \\
N^{+3} & -2\bar{e} \longrightarrow & N^{+5} & 2 & 5
\end{array}
$$

$$2KMnO_4 + 5H_2(C_2O_4)^{2-} + 3H_2SO_4 = 2MnSO_4 + K_2SO_4 + 10\ CO^0_2 + 8H_2O$$

$$
\begin{array}{lll|c|c}
Mn^{+7} & +5\bar{e} \longrightarrow & Mn^{+2} & 5 & 2 \\
(C_2O_4)^{2-} & -2\bar{e} \longrightarrow & 2CO^0_2 & 2 & 5
\end{array}
$$

## Training tasks and standards of their decision

***Task №1.*** Calculate awning oxalic acid, necessary for preparation 500,00 ml 0,0500 mol/l of the solution used for an establishment of concentration of a solution

**Given:**

*V (s-n) =500,00ml*

*$M (H_2C_2O_4 \cdot 2H_2O)$ =126,1g/mol*

$M (KMnO_4) = 158,0 g/mol$
$c (1/2\, H_2C_2O_4) = 0,0500 mol/l$
$m (H_2C_2O_4 \cdot 2H_2O) = ?$

***The standard of decision:***

1. Compose the equation of occurring reaction:

$$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 = 2MnSO_4 + K_2SO_4 + 10CO_2 + 8H_2O$$

$$\begin{array}{lll|c|c|c} Mn^{+7} & +5\bar{e} & \longrightarrow Mn^{2+} & 5 & & 2 \\ C_2O_4^{2-} & -2\bar{e} & \longrightarrow 2CO_2^{0} & 2 & 10 & 5 \end{array}$$

From the equation follows, that the molar mass of equivalent $H_2C_2O_4$ is equal:

$$M\left(\frac{1}{2} H_2C_2O_4 \cdot 2H_2O\right) = \frac{M(H_2C_2O_4 \cdot 2H_2O)}{2} = \frac{126,1}{2} = 63,0 \ g/mol$$

2. Find weight oxalic acid, consist in 500,00ml its solution:

$$m(H_2C_2O_4 \cdot 2H_2O) = \frac{M(\frac{1}{2} H_2C_2O_4 \cdot 2H_2O) \cdot c(\frac{1}{2} H_2C_2O_4) \cdot V(H_2C_2O_4)}{1000}$$

$$m(H_2C_2O_4 \cdot 2H_2O) = \frac{63,0 \cdot 0,050 \cdot 500,0}{1000} \frac{g \cdot mol \cdot l}{mol \cdot l} = 1,576 g.$$

*Answer:* $m (H_2C_2O_4 \cdot 2H_2O) = 1,581 g$

***Task №2.*** Define molar concentration of equivalent and a subtitle of solution $KMnO_4$ if 0,8g it have dissolved in 500,0ml waters in a measured flask and for titration 20,00ml solution 0,04741mol/l oxalic acid it is spent on the average 18,30ml solution $KMnO_4$.

**Given:**
$m (sample) = 0,8 g$
$V (s\text{-}n) = 500,00 ml$
$V (H_2C_2O_4) = 20,00 ml$
$c (\frac{1}{2} H_2C_2O_4) = 0,0474 mol/l$
$V (KMnO_4) = 18,30 ml$
$M (KMnO_4) = 158,01 g/mol$
$c (\frac{1}{5} KMnO_4) = ?$ $t (KMnO_4) = ?$

**The standard of decision:**

1. The equation of proceeding reaction:

$$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 = 2MnSO_4 + K_2SO_4 + 10CO_2 + 8H_2O$$

$$\begin{array}{llll} Mn^{+7} & +5\bar{e} \longrightarrow Mn^{2+} & 5 & \\ & & & 10 \quad 2 \\ C_2O_4^{2-} & -2\,\bar{e} \longrightarrow 2CO_2^{\,0} & 2 & \quad\;\; 5 \end{array}$$

$$M\left(\frac{1}{5}KMnO_4\right) = 31{,}61 g/mol$$

2. Under the law of equivalents it is found molar concentration of equivalent of a solution:

$$c\left(\frac{1}{2}H_2C_2O_4\right)\cdot V(H_2C_2O_4) = c\left(\frac{1}{5}KMnO_4\right)\cdot V(KMnO_4)$$

$$c\left(\frac{1}{5}KMnO_4\right) = \frac{c\left(\frac{1}{2}H_2C_2O_4\right)\cdot V(H_2C_2O_4)}{V(KMnO_4)}$$

$$c\left(\frac{1}{5}KMnO_4\right) = \frac{0{,}04741\cdot 20{,}0}{18{,}30}\ \frac{mol\cdot l}{l\cdot ml} = 0{,}05181 mol/l$$

3. Proceeding from value c($\frac{1}{5}$ $KMnO_4$), we will calculate a subtitle of it solution:

$$t\,(KMnO_4) = \frac{c\left(\frac{1}{5}KMnO_4\right)\cdot M\left(\frac{1}{5}KMnO_4\right)}{1000}$$

$$t(KMnO_4) = \frac{0{,}05181\cdot 31{,}61}{1000}\ \frac{mol\cdot g}{l\cdot mol} = 0{,}001638 mol/l$$

*The answer*: *c ($\frac{1}{5}$ $KMnO_4$) =0,05181 mol/l; t ($KMnO_4$) =0,001638g/ml*

**Questions and tasks for self-checking of mastering of a theme:**

1. In what essence permanganatometric titration?
2. Why in a method the indicator is not applied?
3. Calculate molar mass acid and reducers in following reactions:

2.1. $KMnO_4 + MnSO_4 + H_2O \longrightarrow MnO_2 + K_2SO_4 + H_2SO_4$

2.2. $KMnO_4 + FeCl_2 + HCl \longrightarrow MnCl_2 + FeCl_3 + KCl + H_2O$

2.3. $KMnO_4 + H_2O_2 \longrightarrow MnO_2 + KOH + O_2 + H_2O$

*The answer*: 2.1.M (1/3 $KMnO_4$) =52,67g/mol; M($\frac{1}{2}$ $MnSO_4$) =75g/mol

2.2. M ($\frac{1}{5}$ $KMnO_4$) =31,61g/mol; M ($FeCl_2$) =127g/mol

2.3. M ($\frac{1}{3}$ $KMnO_4$) =52,6g/mol; M ($\frac{1}{2}$ $H_2O_2$) =17g/mol

## Situational tasks

1. In medicine iron preparations, in particular $FeSO_4 \cdot 7H_2O$ apply to treatment of hypochromity anemia's of a various etiology. A dose for adults 0,3-0,5g a preparation 3-4 times a day. Calculate weight of iron in one tablet of a medical preparation «tablets BLO», containing 0,28g. $FeSO_4 \cdot 7H_2O$ What concentration should prepare solution $KMnO_4$ to analyses a solution received by dissolution of this tablet in a measured flask on 100,0 ml? What subtitle of the received solution?

2. To define mass fraction $H_2O_2$ in a selling medical preparation if 1,00ml $H_2O_2$ it is brought in a measured flask on 100,0ml and it is diluted by water to a label ($\rho$ $H_2O_2$) =1,0g/ml. At titration for everyone 20,00ml diluted solution $H_2O_2$ it is spent on the average 16,90ml 0,0198 mol/l of solution $KMnO_4$

## Test questions

1. To what ions it is restored $Mn^{+7}$ in bases to environment.
   1 $Mn^{+7} \rightarrow Mn^{2+}$
   2 $Mn^{+7} \rightarrow Mn^{+4}$
   3 $Mn^{+7} \rightarrow Mn^{+6}$

   a)1 and 2 b) 1,3 c) 3 d) 1

2 What indicator use in a method of the permanganatometric ?
   a) methyl-orange b) phenolphthalein
   c) starch d) is not used

3 What reaction are concerns to acid-regenerative reactions?
   a) $2Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$
   b) $6NaOH + Cr_2(SO_4)_3 \rightarrow 2Na_3[Cr(OH)_6] + 3Na_2SO_4$
   c) $Bi(NO_3)_3 + 2KOH \rightarrow Bi(OH)_2NO_3 + 2KNO_3$
   d) $4KMnO_4 + 4KOH \rightarrow 4K_2MnO_4 + O_2 + 2H_2O$

4. To what ions it is restored $Mn^{+7}$ in the neutral environment.
   1 $Mn^{+7} \rightarrow Mn^{2+}$
   2 $Mn^{+7} \rightarrow Mn^{+4}$
   3 $Mn^{+7} \rightarrow Mn^{+6}$

   a) 1 and 2 b) 1,3 c) 3 d) 1

5. Whether molar mass of equivalent $KMnO_4$ in different environments are identical?
   a)yes b)not c) at a low temperature d) at a high temperature

6. What element lowers degree acid in the given reaction?

$$3 As_2S_3 + 28HNO_3 + 4H_2O \rightarrow 6H_3AsO_4 + 9H_2SO_4 + 28NO$$

a) S b)As c)N d)As, S e) H

7. What role carries out $KMnO_4$ in acid-regenerative reactions?
a) acidity b) acidity and reducer
c) reducer d) both not acidity and not reducer.

8. What elements raise degree acid in the given reaction?

$$3As_2S_3 + 28HNO_3 + 4H_2O \longrightarrow 6H_3AsO_4 + 9H_2SO_4 + 28NO$$

a) As; N  b) As; S  c) S; N  d) As; H

9. Define molar mass of equivalent oxalic acid in the given reaction:

$$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \rightarrow 2MnSO_4 + K_2SO_4 + 10CO_2 + 8H_2O$$

a) M ($H_2C_2O_4$)  b) M (1/4 $H_2C_2O_4$)
c) M (1/2 $H_2C_2O_4$)  d) M (1/3 $H_2C_2O_4$)

10. What properties show $H_2O_2$ in chemical reactions?
a) Acidity  b) acidity and reducer
c) Reducer  d) donor of protons

## LABORATORY WORK №1

### Establishment of concentration of a solution of potassium permanganate

***Work technique*:** in a flask for titration to bring 10,00 ml solution $H_2SO_4$ (1:4), to add 2,00ml sated solution $MnSO_4$ (catalyst), to measure a pipette 20,00ml a standard solution oxalic acid to heat up to 70-80$^0$C and to subtitle solution $KMnO_4$ to occurrence from one drop of the light pink colouring which is not disappearing during 30 seconds Titration to repeat 2 more times. Experimental data to bring in the table. From converging results to take average arithmetic value and to calculate molar concentration of equivalent and a subtitle of a solution of potassium permanganate.

| № | V($H_2C_2O_4$), ml | c(1/2$H_2C_2O_4$), mol/l | V($KMnO_4$), ml | c(1/5$KMnO_4$), mol/l | t($KMnO_4$) g/mol |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |

Calculations to make under the formula:

$$c(1/5KMnO_4) = \frac{c(1/2H_2C_2O_4)\cdot V(H_2C_2O_4)}{V(KMnO_4)}, \text{ mol/l}$$

$$t(KMnO_4) = \frac{c(1/5KMnO_4)\cdot M(1/5KMnO_4)}{1000}, \text{ g/ml}$$

M (1/5$KMnO_4$) - molar mass of equivalent $KMnO_4$;
M (1/5$KMnO_4$) = 31,61 g/mol

## LABORATORY WORK № 2

### Definition of maintenance Fe (II) in salt of Mor $(NH_4)_2SO_4 \cdot FeSO_4 \cdot 6H_2O$

Definition of maintenance Fe (II) in salt of Mor is based that ion $Fe^{2+}$ oxidise in $Fe^{3+}$. In a flask for titration to pour 10 ml a solution of salt of Mor, to add as much 2н solution $H_2SO_4$. burette to fill 0,0196н with working solution $KMnO_4$. Titration to conduct on a cold before occurrence not disappearing poorly - pink colouring. Reaction between salt of Mor and $KMnO_4$ in acid is expressed to environment by the equation:

$$2KMnO_4+10\ (NH_4)_2SO_4\cdot FeSO_4+8H_2SO_4 = K_2SO_4+2MnSO_4+10(NH_4)_2SO_4+$$
$$+5Fe_2(SO_4)_3+8H_2O$$

$Mn^{7+}+5e = Mn^{2+}$ | 1 | 2   $f_{KMnO4} = 1/5$
$Fe^{2+} - Ie = Fe^{3+}$ | 5 | 10   $f_{FeSO4} = 1$

Titration to repeat three times. For calculation to use average value of volume $V_{KMnO4}$ spent for titration.

| № of test | Vsolution of salt of Mor, ml | $V_{H2\ SO4}$ ml | $V_{KMnO4}$ ml | $N_{FeSO4}$ g-equ/l | $T_{Fe(II)}$ g/ml | $P_{Fe(II)}$ % |
|---|---|---|---|---|---|---|
| 1<br>2<br>3 | | | | | | |
| **Mean average** | | | | | | |

At determination quantitative maintenance Fe (II) in salt of Mor it is necessary to remember, that Fe (II) in structure of salt of Mor enters in the form of $FeSO_4$, therefore normally an investigated solution it is calculated rather $FeSO_4$.

For example, if on titration 10 ml a solution of salt of Mor on average is spent 9,80 ml a solution $KMnO_4$, with molar concentration of equivalent 0,0196 mol/l then calculations are conducted under formulas: atomic mass Fe = 55,84.

$$c(FeSO_4) = \frac{c(KMnO_4)\cdot V(KMnO_4)}{\text{V(salt of Mor)}} = \frac{0{,}0196\cdot 9{,}8}{10}\ \frac{mol\cdot ml}{l\cdot ml} = 0{,}0192 mol/l$$

$$t(Fe(\text{II})) = \frac{c(FeSO_4)\cdot M(Fe)\cdot fequ(Fe)}{1000} = \frac{0{,}0192\cdot 55{,}84}{1000}\ \frac{mol\cdot g}{ml\cdot mol} = 0{,}00107 mol/l$$

The investigated solution of salt of Mor is prepared by dissolution awning 0,3456g to salt of Mor in a measured flask on 50 ml. Hence, in 50 ml a solution of salt of Mor contains Fe (II):

$$m(Fe) = t(Fe(\text{II}))\cdot 50ml = 0{,}00107 g/ml\cdot 50ml = 0{,}0536g.$$

Then, mass fraction (*w* %) P in awning 0,3456 g salts Mor will be:

$$w\%Fe(\text{II}) = \frac{0{,}0536 \cdot 100\%}{0{,}3456}\ \frac{g \cdot \%}{g} = 15{,}19\%$$

## LABORATORY WORK № 3

### Control-analytical definition of weight of peroxide hydrogen in the solution.

Peroxide hydrogen in reactions of oxidation -restoration with $KMnO_4$ shows properties of a reducer, and process proceeds on a following equation of reaction:

$$2KMnO_4 + 5H_2O_2 + 3H_2SO_4 \longrightarrow 2Mn\,SO_4 + K_2\,SO_4 + 5O_2 + 8H_2O$$

$$\begin{array}{llll|l|l} Mn^{+7} & +5\bar{e} & \longrightarrow & Mn^{+2} & 5 & 2 \\ (O_2)^{2-} & -2\,\bar{e} & \longrightarrow & O^0_2 & 2 & 5 \end{array}$$

***Work technique:*** the Flask for titration to fill with certain volume of solution $H_2O_2$ (the teacher gives in the form of examination), to add 3,0ml solution $H_2SO_4$/1:4/, to ad 2 ml $MnSO_4$ and to subtitle solution $KMnO_4$ before occurrence of not disappearing pink colouring. Titration to repeat two more times. Experimental data to bring in the table. From converging results to take average arithmetic value and to settle an invoice:

| № | $V(H_2O_2)$, ml | $c(1/5KMnO_4)$, mol/l | $V(KMnO_4)$, ml | $m(H_2O_2)$, g |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

Calculations to make under the formula:

$$m(H_2O_2) = \frac{M(1/2H_2O_2) \cdot V(KMnO_4) \cdot c(1/5KMnO_4)}{1000}$$

$c\ (1/5KMnO_4)$ -Molar concentration of equivalent of solution $KMnO_4$
$M\ (1/2\ H_2O_2)$ -Molar mass of equivalent $H_2O_2$
$M\ (1/2\ H_2O_2)$ -17g/mol

## LABORATORY WORK № 4

### Definition of an acidity waters (return titration)

In potable water reducers (acid iron, salts sulphureous, nitrogenous acid, organic acid) contain in insignificant quantity. Quality of water drinking water is supervised by sanitary inspection bodies. One of tests - test on acidity. Acidity it is expressed by number of milligrams of potassium permanganate, spent on acid substances in one liter of water. The essence of a method consists that potassium permanganate, being strong oxide, reacts with the reducers which are present at water under the following scheme:

$$Mn^{+7} + 5e = Mn^{+2}$$

Surplus brought $KMnO_4$ titrating oxalic acid:

$$2\ Mn^{+7} + 5\ C_2O_4^{2-} = 2\ Mn^{2+} + 10\ CO_2$$

Not entered reaction oxalic acid titrating potassium permanganate on the equation resulted above.

***Work technique:*** In a flask for titration place 100,00ml tap water, add 5,00 ml a solution diluted (1:3) a chamois acid, it is exact 10,00 ml a permanganate solution potassium with molar concentration of equivalent 0,0100 mol/l and shake up in a current of 10 minutes Then in a flask bring precisely 10,00 ml a solution oxalic acid with molar concentration of equivalent 0,0100mol/l and mix roundabout agitation.

The discolored solution titrate a permanganate solution potassium with molar concentration of equivalent 0,0100 mol/l before occurrence of is weak-pink colouring. Definition to repeat two more times, experimental data to bring in the table:

| № | $V(H_2O)$, ml | $c(1/5\ KMnO_4)$, mol/l | $V(KMnO_4)$, ml | $c(1/2H_2C_2O_4)$, mol/l | $x(H_2O)$ |
|---|---|---|---|---|---|
| 1<br>2<br>3 | | | | | |

From converging results to take average arithmetic value and to define acid waters under the following formula:

$$x = \frac{(V_1 - V_2)\cdot 0{,}32\cdot 1000}{V_3}$$

## METHODS OF ACID-REGENERATIVE TITRATION. IODOMETRY

**The employment purpose:** To learn on the basis of knowledge of laws of course of acid-regenerative reactions to spend quantitative definitions of medical products by a method of the iodimetry.

**The importance of a studied theme.** Methods of acid-regenerative titration are widely applied in the clinical, sanitary-and-hygienic analysis, the analysis of medical products.

Method of the iodimetry titration it is possible to spend definitions as reducers, and acid, that does this method rather widely applied in titrimetric the analysis.

This method define the maintenance aldehyde and ketone groups, acetone, quinone, antipyrine, peroxide hydrogen, free chlorine in water, copper/p/, nitrites in solutions, etc.

The iodate number is important for an estimation of food suitability of fats.

### Initial level of knowledge

1. Laws of course of acid-regenerative reactions.
2. Drawing up of acid-regenerative reactions by a method of electronic balance.

### Teaching material for self-preparation

1. I.K.Tsitovich. A course of analytical chemistry. M, 1985, p. 282
2. A.V.Babkov, G.N.Gorshkova, A.M.Kononov. A practical work in the general chemistry with elements of the quantitative analysis. M, 1976, p. 142
3. V.N.Alekseev. The quantitative analysis. M, 1972., p. 395.

### On employment following questions will be considered

1. Theoretical bases of a method of the iodimetry
   1.1. Iodimetrical definition of reducers
   1.2. Iodimetrical definition acid
2. Theoretical bases of laboratory work
   2.1. The equation of chemical reaction
   2.2. A principle of action of the indicator
   2.3. A technique of performance of laboratory work
   2.4. Settlement formulas
   2.5. Conclusions from results of the analysis
3. Laboratory work

## THE INFORMATION BLOCK

### Method of the iodimetryc titration

The method is based on the acid-regenerative processes connected with restoration $I_2$ to ions: $I^-$ or oxidation $I^-$ ions to $I_2$

$$I^0_2 + 2\bar{e} \longrightarrow 2I^-$$

$$2I^- - 2\bar{e} \longrightarrow I^0_2$$

Free iodine is rather weak oxidizer, and anion $I^-$ a strong reducer. In the titrimetric analysis a solution of iodine use for definition of reducers - direct titration, and solution KI - for definition acid a replacement method. The solution of iodine in the presence of starch gets dark blue colouring. Hence, in the first case at titration of a solution of a reducer by a solution of iodine in a point of equivalence the solution in the presence of starch from one superfluous drop of a solution of iodine gets dark blue colouring.

At definition oxidizers by a replacement method to solution of oxidizers add surplus KI. It will thus be allocated molecular iodine in equivalent quantity acidity.

It then define the standardized solution of thiosulfate sodium. Thus, quantity oxide calculate on volume $Na_2S_2O_3$ which is equivalent to quantity allocated $I_2$ under reaction:

$$H_2O_2+2KI+H_2SO_4=K_2SO_4+I_2+2H_2O$$

$$\begin{array}{ll|c|c} (O_2)^{2-} +2\bar{e} & \longrightarrow 2O^{-2} & 2 & 1 \\ 2I^- -2\bar{e} & \longrightarrow I^0_2 & 2 & 1 \end{array}$$

Iod, which educe in the reaction, titrate by standardized solution of natrium thiosulfate:

$$2Na_2S_2O_3+I_2= Na_2S_4O_6+2NaI$$

The indicator of a method of replacement also is the starch, forming with iodine mixed complex- adsorptive connection strongly dark blue color.

Definition of reducers by a method iodometry can be spent titration on a method of return titration. Thus to an investigated solution add much titrable a solution of iodine. With defined substance its equivalent quantity reacts. Surplus iodine to titer a working solution of thiosulfate sodium. Thus, knowing total iodine and not reacted surplus, count quantity iodine, equivalent to investigated substance.

## Training tasks and the standard of their decision.

***Task №1.*** Quantitative definition of arsenic anhydride ($As_2O_3$)spend by iodometry titration. This preparation is used as necrotic means at skin diseases, in stomatology, inside-at an anemia, an exhaustion, a neurasthenia. To define a mass fraction / % / $As_2O_3$ in a preparation, 1,40 g which have dissolved in a measured flask on 250,00 ml. On acid 25,00 ml the received solution it is spent on the average 24,10 ml 0,0980mol/l of solution $I_2$.

**Given:**
*m (preparation) =1,40g*
*V (s-n) =250,0ml*
*V* $(As_2O_3)$ *=25,00ml*
*V* $(I_2)$ *=24,10ml*
*c* $(1/2I_2)$ *=0,0980mol/l*
*M* $(As_2O_3)$ *=197,8 g/mol*
*ω %* $(As_2O_3)$ *=?*

**The standard of decision**:

The equation of proceeding reaction:

$$As_2O_3 + 2I_2 + 5H_2O = 2H_3 AsO_4 + 4HI$$

$$\begin{array}{lll|ll} 2As^{3+} - 4\bar{e} & \longrightarrow & 2As^{5+} & 2 & 1 \\ I_2^0 + 2\bar{e} & \longrightarrow & 2I^- & 1 & 2 \end{array}$$

$$2As^{3+} + 2I_2^0 \longrightarrow 2As^{5+} + 4I^-$$

Hence, the molar mass of equivalent arsenic anhydride is equal:

$$M(\frac{1}{4}As_2O_3) = \frac{M(As_2O_3)}{4} = \frac{197,82}{4} = 49,46 g/mol$$

The molar mass of equivalent iodine is equal:

$$M(\frac{1}{2}I_2) = \frac{M(I_2)}{2} = \frac{253,8}{2} = 126,9 g/mol$$

Under the law of equivalents it is found molar concentration of equivalent of solution $As_2O_3$:

$$c(\frac{1}{4}As_2O_3) \cdot V(As_2O_3) = c(\frac{1}{2}I_2) \cdot V(I_2)$$

$$c(1/4As_2O_3) = \frac{c(\frac{1}{2}I_2) \cdot V(I_2)}{V(As_2O_3)} = \frac{0.0980 \cdot 24,40}{25,00} \frac{mol \cdot ml}{l \cdot ml} = 0,09565 mol/l$$

We find a subtitle of the received solution:

$$t(1/4As_2O_3) = \frac{c(1/4As_2O_3) \cdot M(1/4As_2O_3)}{1000} = \frac{0.09565 \cdot 49,46}{1000} \frac{mol \cdot g}{mol \cdot ml} = 0,004731 g/ml$$

We find weight $As_2O_3$ in 250,00 ml a solution:

$$m\ (As_2O_3) = t\ (As_2O_3) \cdot V\ (s\text{-}n) = 0,00731 \cdot 250,0\ \frac{ghml}{ml} = 1,1827g.$$

We find a mass fraction (%) $As_2O_3$ in a medical preparation:

$$\omega\%(As_2O_3) = \frac{m(As_2O_3)}{m(farm.)} \bullet 100\% = \frac{1,1827 \cdot 100}{1,40} \frac{g\%}{g} = 84,48\%$$

*Answer:* $\omega\ \%\ (As_2O_3) = 84,48\ \%$

***Task №2.*** Calculate molar concentration of equivalent not dissolved and a subtitle of solution $H_2O_2$ applied as a disinfectant for washings and rinsing's, purulent wounds for titration 15,00 ml this solution it is spent on the average 13,80ml 0,0180 mol/l of a solution of thiosulfate sodium.

**Given:**

$V\ (H_2O_2) = 15,00ml$

$V\ (Na_2S_2O_3) = 13,80ml$

$c\ (Na_2S_2O_3) = 0,01800\ mol/l$

*M* $(H_2O_2)$ *= 34,0 g/mol*
*M* $(Na_2S_2O_3 \cdot 5H_2O)$ *= 248,21 g/mol*
*ρ (s-n) = 1,00 g/ml*
*ω %* $(H_2O_2)$ *=? c* $(1/2H_2O_2)$ *=?*

***The standard of decision***.

The equation of occurring reaction:

$$H_2O_2 + 2KI + H_2SO_4 = K_2SO_4 + I_2 + 2H_2O$$

$$\begin{array}{lcl|l} (O_2)^{2-} + 2\bar{e} & \longrightarrow & 2O^{2-} & 1 \\ 2I^{-} - 2\bar{e} & \longrightarrow & I_2^{0} & 1 \end{array}$$

$$(O_2)^{2-} + 2I^{-} \longrightarrow 2O^{2-} + I_2^{0}$$

Hence, the molar mass of equivalent peroxide hydrogen is equal:

$$M(1/2H_2O_2) = \frac{M(H_2O_2)}{2} = \frac{34}{2} = 17 g/mol$$

1. Under the law of equivalents it is found molar concentration of equivalent of solution $H_2O_2$

$$c\ (1/2\ H_2O_2) \cdot V\ (H_2O_2) = c\ (Na_2S_2O_3) \cdot V\ (Na_2S_2O_3)$$

$$c(1/2H_2O_2) = \frac{0{,}01860 \cdot 20{,}00}{1{,}00} \frac{mol \cdot ml}{l \cdot ml} = 1{,}76 mol/l$$

1. We find a subtitle of solution $H_2O_2$

$$t\ (H_2O_2) = \frac{c(1/2H_2O_2) \cdot M(1/2H_2O_2)}{1000} = \frac{0{,}01656 \cdot 17{,}0}{1000} \frac{mol \cdot g}{ml \cdot mol} = 0{,}0002815 g/ml$$

*Answer: c* $(1/2H_2O_2)$ *= 0,01656 mol/l, t* $(H_2O_2)$ *=0,00002815g/ml.*

**Questions and tasks for self-checking of mastering of a theme**

1. On what it is based iodimetry definition of reducers, acid?
2. What conditions should be observed at iodimetry definition?
3. Why at iodimetry definition acid use big surplus KI?
4. Ascorbic acid (vitamin C) contains in fresh vegetables, fruit, berries. It regulates acid-regenerative processes in an organism. Ascorbic acid it is not synthesized in a human body. The lack of vitamin C or its absence leads to development hypo-or an avitaminosis that the scurvy is the reason of occurrence of illness. Ascorbic acid enters into many polyvitaminic preparations. The analysis it spend by the method of iodimetry:

$$C_6H_8O_6 + I_2 \longrightarrow C_6H_6O_6 + 2HI$$

dehydroform

5. Calculate molar concentration of equivalent and a subtitle of a solution ascorbic acid if 1,20g its preparation it is dissolved in 100,00 ml waters. For titration 15,00 ml this solution in the presence of starch it is spent 21,00ml 0,09730 mol/l of a solution of iod.

*Answer:* c (1/2 $C_6H_8O_6$) =0,1362 mol/l, t ($C_6H_8O_6$) = 0,01199 g/ml

## Situational tasks

1. The iodine mass fraction in an aqueous-alcoholic solution of the iodine applied in medicine as an antiseptic makes 5 % (weights). Define molar concentration of equivalent of this solution (ρ =1,00 g/ml).

*2.* Quantitative definition of formaldehyde is based on
Reactions acid it to ant acid basely solution of iod:

$$HCHO + I_2 + 2NaOH \rightleftarrows HCOOH + 2Na\,I + H_2O$$

Definition spend in the way of return titration, to titr surplus added iodine a solution of thiosulfate sodium. To calculate a mass fraction / % / formaldehyde in formalin if 2,00 ml it is dissolved in a measured flask on 100,00 ml; for titration 10,00 ml this solution it is spent 40,00 ml 0,01940 mol/l of solution $I_2$.
Rest titration iodine has demanded 16,00 ml 0,01980 mol/l of solution $Na_2S_2O_3$. (ρ =1,00 g/ml).

## Test questions

1. What indicator is used in iodimetry titration?
a) Litmus b) marked the red c) methyl-orange d) starch
2. Quantity of what substances is defined by a method of direct titration?
a) acid b) acid and reducers c)reducers d) right answer is not present
3. Quantity of what substances is defined by a replacement method?
 a) acid c) acid and reducers
 b) educes d) right answer are not present
4. The quantity, what substances is defined in a method of return titration?
 a) acid c) ketones and aldehydes
 b) The bases d) the right answer are not present
5. In what organ is iodine collects?
 a) In bones c) in a thyroid gland
 b) In a liver d) in a pancreas
6. What concentration of a solution of iodine applied in medicine?
a) 2 %; b) 5 %; c) 10 %; d) 8 %
7. What function is carried out by molecular iodine?
a) acidity c) weak acidity
b) reducer d) weak reducer
8. What function is carried out by an ion iodine
a) acidity c) weak acidity

b) reducer d) weak reducer

9. To that the molar mass of equivalent $Na_2S_2O_3$ is equal in the following reaction:

$2Na_2S_2O_3 + I_2. \qquad 2NaI + Na_2S_4O_6$

a) M( $Na_2S_2O_3$) b) M(1/2 $Na_2S_2O_3$) c) M(1/3 $Na_2S_2O_3$) d) M(1/5 $Na_2S_2O_3$)10.

10. To that the molar mass of equivalent $I_2$ is equal in the following reaction

$2Na_2S_2O_3 + I_2. \longrightarrow 2NaI + Na_2S_4O_6$

a) M( $I_2$ ) b) M(1/2 $I_2$ ) c) M(1/3 $I_2$ ) d) M(1/5 $I_2$. )

## LABORATORY WORK № 1.

### Definition of molar concentration of equivalent and solution subtitle iodine

***Work technique:*** In a flask for titration to place 20,00 ml a standard solution of thiosulfate sodium and to subtitle its solution of iodine in the presence of 1,0 ml starch before occurrence of pale-dark blue colouring. To repeat titration of 2 more times. Given to bring in the table. To take average arithmetic value and to settle an invoice.

| № | V ( $Na_2S_2O_3$) ml | V($I_2$) ml | c(1/2$I_2$) | t($I_2$) | Indicator |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |

Calculations to make under the formula:

$$c(\tfrac{1}{2}I_2) = \frac{c(Na_2S_2O_3)\cdot V(Na_2S_2O_3)}{V(I_2)}$$

$$t = \frac{c(\frac{1}{2}I_2)\cdot M(\frac{1}{2}I_2)}{1000}$$

Aqua-spirits solution of iodine is used in medicine as an antiseptic.

## LABORATORY WORK №2

### Definition of weight ascorbic acid in water solutions

/ Control-analytical definition /

***Work technique:*** In a flask for titration to take certain volume of a solution ascorbic acid the/teacher gives in the form of examination/, to add 1,00 ml a solution of starch and to subtitle a solution of iodine before occurrence of dark blue colouring from one drop of a solution of iodine. Titration to repeat two more times. Experimental data to bring in the table. From converging results to take average arithmetic value and to make calculations. Given to bring in the table:

| № | $V(C_6H_8O_6)$ ml | V(amylum) ml | $V(I_2)$ ml | $m(C_6H_8O_6)$ | Indicator |
|---|---|---|---|---|---|
| 1<br>2<br>3 | | | | | Amylum |

Calculations to make on the equation:

$$m = (C_6H_8O_6) = \frac{c(1/2I_2)\cdot V(I_2)\cdot M(1/2C_6H_8O_6)}{1000}$$

Quantitative definition ascorbic acid is based on display of regenerative properties by it. iod from action ascorbic acid becomes colorless. Definition is spent on the basis of the following reaction:

$I_2 + C_6H_8O_6 \quad\quad 2HI + C_6H_6O_6$

Ascorbic acid regulates acid-regenerative processes in an organism. Its lack causes heavy disease - a scurvy. Ascorbic acid-vitamin C - widespread in the nature. Especially with it the flora is rich.

So, fresh vegetables - salad, cabbage, a beet, a potato, apples are rich with vitamin C. From berries - the black currant, a dogrose, a barberry, etc. a lot of vitamin C contains in needles, a nettle. This vitamin accelerates curling of blood and raises resistibility of an organism to infections.

## Methods of indirect titration

Sometimes in the volume analysis it is impossible to obtain exact given by direct titration of analyzed substance. In such cases apply one of following indirect methods: the return titrable and titration by a replacement method.

## LABORATORY WORK №3

### Control-analytical definition of weight peroxide hydrogen

### In a solution (a replacement method).

Weight definition peroxide hydrogen is based by a replacement method on reaction:

$$H_2O_2 + 2KI + H_2SO_4 = K_2SO_4 + I_2 + 2H_2\,O$$

$$(O_2)^- + 2\bar{e} \longrightarrow 2O^{-2} \quad | \; 2 \; | \; 1$$

$$2\,I^- - 2\bar{e} \longrightarrow I_2^0 \quad | \; 2 \; | \; 1$$

Allocated in reaction iodine to titer a solution of thiosulfate sodium:

$$2\,Na_2S_2O_3 + I_2^0 = Na_2S_4O_6 + 2\,NaI$$

$$2S_2O_3^{2-} - 2\bar{e} \longrightarrow 2\,S_4O_6 \quad | \; 2 \; | \; 1$$

$$I_2^0 + 2\bar{e} \longrightarrow 2\,I^- \quad | \; 2 \; | \; 1$$

***Work technique:*** IN a flask for titration to place certain volume peroxide hydrogen (the teacher gives in the form of examination), to add sulfuric acid ($H_2SO_4$) 3,0 ml, to flow 5,0 ml 5 % (weights.) a solution to 1-3 drops of 30 %

(mass.) a solution molibdat ammonium (catalyst). For full ending of reaction, the solution to leave for 5 minutes in a dark place, then allocated iodine to titer by the standardized solution of thiosulfate sodium in the presence of starch. When the solution will get straw-yellow colouring to add starch and to continue titration thiosulfate sodium. The appeared dark blue colouring of a solution should will become colorless from one drop thiosulfate sodium. Titration to repeat two more times. Experimental data to bring in the table. From converging results to take average arithmetic value and to calculate weight peroxide hydrogen in an analyzed solution.

| № | V($H_2O_2$) ml | V($Na_2S_2O_3$) ml | c($Na_2S_2O_3$) mol/l | m($H_2O_2$)₂ | Indicator |
|---|---|---|---|---|---|
| 1<br>2<br>3 | | | | | amylum |

Calculations to make under the formula:

$$m = (H_2O_2) = \frac{c(Na_2S_2O_3) \cdot V(Na_2S_2O_3) \cdot M(1/2H_2O_2)}{1000}, g$$

c ($Na_2S_2O_3$) - molar concentration of solution $Na_2S_2O_3$
M (1/2$H_2O_2$) - molar mass of equivalent $H_2O_2$
M (1/2$H_2O_2$) = 17,0 g/mol

Peroxide hydrogen it is widely applied in medical practice in the form of a solution to rinsing and greasing at inflammatory diseases of mucous membranes/stomatitis's, quinsy/, for treatment of purulent wounds. At skin diseases peroxide hydrogen apply in quality depigmentation means.

## LABORATORY WORK № 4

### Definition of molar concentration of equivalent and formaldehyde subtitle in a solution (return titration).

Definition of the maintenance of formaldehyde in a solution iodimetry is based by a method on reaction:

$$HCHO + I_2 + 3NaOH \longrightarrow HCOONa + 2Na\,I + 2H_2O$$

To a solution of analyzed substance add in notorious surplus exact volume titrable a solution of iod, and then this surplus to titer standardized solution $Na_2S_2O_3$

$$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$$

$$\begin{array}{lll|c|c} 2S_2O_3^{-2} - 2\bar{e} & \longrightarrow & S_4O_6^{2-} & 2 & 1 \\ I_2^0 + 2\bar{e} & \longrightarrow & 2I^- & 2 & 1 \end{array}$$

From the equation it is visible, that the molar mass of equivalent $I_2$ is equal.

$$M\ (1/2I_2) = \frac{M(I_2)}{2} = 127\ g/mol$$

***Work technique*****:** In a flask for titration to measure 5,00ml a formaldehyde solution, to add 20,00 ml titling a solution of iod, and then to add on drops solution NaOH with molar concentration 2,0 mol/l to straw-coloured colour. A flask to close glass and to sustain in darkness of 4-5 minutes. To add to a solution 3 ml HCl with concentration 2 mol/l and a mix to subtitle the standardized solution of thiosulfate sodium before pale yellow colouring of a solution; to add 2 drops of starch, the solution will be painted in dark blue colour and to continue to subtitle before disappearance of dark blue colourings from one drop. To measure exact volume of a solution thiosulfate the sodium, spent for titration. Titration to repeat two more times. Given to bring in the table. From converging results to take average arithmetic value and to make calculations.

| № | $V(CH_2O)$ ml | $c(1/2I_2)$ mol/l | C $(Na_2S_2O_3)$ mol/l | C$(CH_2O)$ mol/l | $t(CH_2O)$ g/ml |
|---|---|---|---|---|---|
| 1<br>2<br>3 | | | | | Amylum |

Molar concentration of equivalent of a solution of formaldehyde pays off under the formula:

$$c\ (CH_2O) = \frac{V(I_2)\cdot c(1/2\,I_2)\cdot V(Na_2S_2O_3)}{V(CH_2O)},\quad mol/l$$

$$t\ (CH_2O) = \frac{c(CH_2O)\cdot M(\frac{1}{2}CH_2O)}{1000},\ g/ml$$

Formaldehyde is widely applied in medicine as initial raw materials to reception of many medicinal substances. It of 40 % (weights) the solution is called as formalin. Operating on fiber, formalin does its dense, insoluble, and, the main thing, protects from rotting. Therefore it apply to conservation of anatomic preparations.

Formalin also is applied as a disinfectant to washing of hands, washing skin, at raised perspiration/0,5-1 % of weights. Solutions/, for disinfection of tools/0,5 % of weights. Solutions/, for syringings / 1:2000-1:3000/.

## Tasks for the independent decision

***Task №1***. Define molar concentration of equivalent of 3 % $H_2O_2$ for given reaction M $(H_2O_2)$ =34 g/mol: $H_2O_2+2KJ+H_2SO_4=K_2SO_4+J_2+H_2O$

***Task №2***. Aqua-spirits a solution of iodine 5 %/macc/apply as an antiseptic. What molar concentration of equivalent of this solution quantitatively analyzed by means of standardized solution $Na_2S_2O_3$?

## THE SEDIMENTATION METHOD. ARGENTOMETRIC.

**The employment purpose:** To learn a method of quantitative definition of ions of halogens.

**The importance of a studied theme:** Methods of quantitative definition of halogenid-ions are used in the clinical analysis of blood, urine, gastric juice, at the analysis various halogenids, containing in medical products etc. In sanitary - hygienic practice them use for quantitative definition of chlorine in drinking, natural and technical waters. Therefore the knowledge of quantitative definition halogenids - ions is of great importance for the future experts - of doctors.

**Initial level of knowledge.**

1. Salts, types of salts
2. Solubility of salts
3. Influence of various factors on solubility of salts
4. Electroliticaly dissociation of salts. Electrolits.

**Teaching material for self-preparation.**

1. V.N.Alekseev. The quantitative analysis. M: Chemistry, 1980.
2. V.P.Vasilev. Analytical chemistry. M: the Higher school. 1989.

**On employment following questions will be considered:**

1. Solubility product.
2. Solutions. The nonsaturated, sated, oversaturated solutions.
3. Theoretical fundamentals of the precipitation titration.
4. Quantitative methods of definition galogenids - ions. Methods Mor and Folgard.
5. The theoretical basis of laboratory work.
6. Laboratory work.

## THE INFORMATION BLOCK

According to the theory of solutions of strong electrolytes, badly soluble strong electrolits in a solution pass not in the form of molecules, and in a kind completely prodissociation ions. Therefore in the sated solutions of these connections, between ions of soluble substance and a firm phase there is a dynamic balance. For example, in sated solution AgCl, between ions and depositions AgCl balance is established:

$$AgCl \rightleftarrows Ag^{+} + Cl^{-}$$

For the given dynamic balance according to the law of operating weights the balance constant will be equal:

$$K = \frac{c(Ag^{+}) \cdot c\,(\mathrm{Cl})}{\mathrm{c\,(AgCl)}} \qquad [1]$$

As at the given temperature concentration of firm phase AgCl has constant value, therefore the equation [1] it is possible to write down in a kind

$$K·c(AgCl) = c(Ag^{+})\ c(Cl^{-})$$

As K·c (AgCl) has constant value, $c\ (Ag^{+})\ c\ (Cl^{-})$ will have too constant value:

$$c\ (Ag^{+})\ c\ (Cl^{-}) = const \qquad [2]$$

Hence, in the sated solutions of badly soluble electrolytes at certain temperature product of concentration of free ions has constant value. This value is called as *solubility product* ($sp_{AgCl}$). For the given electrolyte AgCl solubility product is equal:

$$c\ (Ag^{+})\ c\ (Cl^{-}) = SP_{AgCl} = 1,56 \cdot 10^{-10}$$

If product of concentration of ions badly soluble electrolytes is equal in a solution to product of solubility of the given electrolyte, in this case such solution will be called as the sated solution:

$$c\ (Ag^{+})\ c\ (Cl^{-}) = SP_{AgCl}$$

If product of concentration of ions in a solution badly soluble electrolytes is less products of solubility of the given electrolyte such solution is called as a no saturated solution:

$$c\ (Ag^{+})\ c\ (Cl^{-}) < SP_{AgCl}$$

In a return case the solution will be called as an over-saturated solution:

$$c\ (Ag^{+})\ c\ (Cl^{-}) > SP_{AgCl}$$

On the basis of these laws it is possible to define, in what case the deposition is formed or to define conditions of transition of a deposition in a solution. Using value of product of solubility, it is possible to calculate solubility of electrolytes, to define product of their solubility. Quantitative definition of investigated substance on a sedimentation method is based that at the moment of full sedimentation of quantity of the reacted substances are equivalent each other. Therefore, knowing volume wasting a working solution, it is possible to calculate quantity of the substance containing in the investigated solution. More often as a working solution $AgNO_3$ and a method in this case is used is called *argentometricaly.*

The given method allows to define the quantitative maintenance in investigated solutions halogenids - ions since ions $Ag^{+}$ with them forms difficultly soluble connections.

The equivalent point at titration is defined or on the termination of loss of a deposition, or by means of the indicator. Depending on environment of an investigated solution and presence at it of other ions quantitative definition halogenids spend methods Mor or Folgard.

At quantitative definition by the method of Mor as a working solution solution $AgNO_3$, as the indicator - $K_2CrO_4$ is used. The following reaction Thus proceeds:

$$NaCl + AgNO_3 = NaNO_3 + AgCl\downarrow$$
$$Ag^+ + Cl^- = AgCl\downarrow$$
$$K_2CrO_4 + 2AgNO_3 = Ag_2CrO_4\downarrow + 2KNO_3$$
$$CrO_4^{2-} + 2Ag^+ = Ag_2CrO_4\downarrow$$

Apparently from reaction, AgCl and $Ag_2CrO_4$_ - both almost insoluble substances. However in this case in the beginning in a deposition drops out AgCl (a deposition of white color), then drops out in deposition $Ag_2CrO_4$ (a deposition of brick-red color). This results from the fact that product of solubility AgCl ($1{,}25 \cdot 10^{-5}$ g-g/l) is less than at $Ag_2CrO_4$ ($6{,}5 \cdot 10^{-5}$ g-g/l).

Quantitative definition of halogenid-ions by the method of Mor is spent only in the neutral environment.

In case of the alkaline environment the deposition of brown color - $Ag_2O$ is formed;

$$2AgNO_3 + 2NaOH = Ag_2O\downarrow + 2NaNO_3 + H_2O$$

In case of the sour environment, formed deposition $Ag_2CrO_4$ will be dissolved, and to define an equivalent point of titration it is impossible:

$$Ag_2CrO_4 + 2HNO_3 = 2AgNO_3 + H_2CrO_4$$

In case of the ammoniac environment depositions AgCl and $Ag_2CrO_4$ are dissolved, forming ammoniac complex salts.

Besides, titration is necessary for spending at a room temperature since at rise in temperature solubility of deposition $Ag_2CrO_4$ will increase also sensitivity of the indicator to ions $Ag^+$ will decrease.

Besides these lacks at titration in a solution there should not be such ions, as $Ba^{2+}$, $Pb^{2+}$, $B^{3+}$, $PO_4^{3-}$ $CO_3^{2-}$ $CrO_4^{2-}$ $CN^-$ $CNS^-$.

Therefore at quantitative definition halogenid - rodanid ions the preference is given to the method of Folgard.

The given method is based on reaction of formation of an almost insoluble white deposition rodanid silver at interaction of ions of silver with rodanid ions:

$$Ag^+ + CNS^- = AgCNS\downarrow$$

The method of Folgard the quantity of halogenid-ions is defined by return titration. Thus solution $AgNO_3$ undertakes much. Chlorine ions completely contact silver ions:

$$Ag^+ + Cl^- = AgCl\downarrow$$

The ions which have remained a lot of silver titiring in the presence of the indicator ferroamonium alum ($NH_4Fe(SO_4)_2 \cdot 12H_2O$) a solution rodanid ammonium. At titration ions rodanid connect completely silver ions, forming white deposition AgCNS after ions $Ag^+$ completely drop out in a deposition, from one drop $NH_4CNS$ at the expense of interaction rodanid - ions with ions $Fe^{3+}$ present in ferroamonium alum the deposition of brick-red color - rodanid gland is formed:

$$Fe^{3+} + 3CNS = Fe(CNS)_3$$

Advantage of the given method consists that definition can be spent both in neutral, and in the sour environment, presence of any or other extraneous ions does not render undesirable influence on results of the analysis.

## Training tasks and the standard of their decision

***Task 1.*** To calculate molar equivalent concentration and a titr of solution $AgNO_3$ if 8,90 ml $AgNO_3$ are spent for titration of solution NaCl of 10 ml of 0,0900 M.

***Given:***
*V (NaCl) = 10 ml*
*c (NaCl) = 0,0900 mol/l*
*V ($AgNO_3$) = 8,90 ml*
*c ($AgNO_3$) =? t ($AgNO_3$) =?*

**The standard of decision**

Equivalent molar concentration is defined on the equation:

$$c(AgNO_3) = \frac{V(NaCl) \cdot c\,(\mathrm{NaCl})}{\mathrm{V(AgNO_3)}}, mol/l$$

$$c(AgNO_3) = \frac{10{,}00 \cdot 0{,}0900}{8{,}9} \frac{ml \cdot mol}{l \cdot ml} = 0{,}1011 mol/l$$

Titr of the solution is defined on the equation:

$$t(AgNO_3) = \frac{c(AgNO_3) \cdot M\ (\mathrm{AgNO_3})}{1000 g/ml}, mol/l$$

$$t(AgNO_3) = \frac{0{,}1011 \cdot 170}{1000} = 0{,}01719 g/ml$$

***Task 2.*** To define quantity NaCl in urine if 4,5 ml of solution $NH_4CNS$ are spent for titration of solution $AgNO_3$ of 9 ml of 0,01 M containing in 4 ml of investigated urine of 0,0198 M.

**Given:**
*V($AgNO_3$) = 9,00ml*
*c($AgNO_3$) = 0,0100 mol/l*
*V($NH_4CNS$) = 4,50 ml*
*c ($NH_4CNS$) = 0,0198 mol/l*
*n(NaCl) = ?*

***The standard of decision***

1. We will define $V_{AgNO3}$, spent for reaction with $NH_4CNS$

$$c_{NH4CNS} \cdot V_{NH4CNS} = c_{AgNO3} \cdot V_{AgNO3}$$

$$V(AgNO_3) = \frac{c(NH_4CNS) \cdot V(\mathrm{NH_4}CNS)}{c(AgNO_3)} = \frac{0{,}0198 \cdot 4{,}50}{0{,}0100} \frac{mol \cdot ml \cdot l}{l \cdot mol} = 8.91 ml$$

2. Define volume $AgNO_3$ which has reacted about chloride the ions which were present at a solution:

$$8 \; - 8{,}91 = 0{,}09 \text{ ml}$$

3. Will define concentration of an investigated solution:

$$c(NaCl) = \frac{c(AgNO_3) \cdot V(AgNO_3)}{V(NaCl)} = \frac{0{,}0100 \cdot 0{,}09}{4} = 0{,}0002 mol/l$$

4. Define a titer of an investigated solution

$$t(NaCl) = \frac{0{,}0002 \cdot 58{,}5}{1000} \frac{mol}{mg} \frac{g}{mol} = 0{,}0000117 g/ml$$

5. Define quantity of ions of chlorine which contains in 1300 ml of urine one days allocated in a current

$$m_{NaCl} = 0{,}0000117 \cdot 1300 = 0{,}015 \; g$$

Before the analysis urine has been diluted in 10 times, therefore

$$m_{NaCl} = 0{,}015 \cdot 10 = 0{,}15 \; g$$

Quantity NaCl, allocated together with urine from an organism of women and men, is defined as follows:

$$Q_{woman.} = t \cdot 1200 \cdot 10 = 0{,}0000117 \cdot 1200 \cdot 10 = 0{,}14 \text{ g}$$
$$Q_{man} = T \cdot 1300 \cdot 10 = 0{,}0000117 \cdot 1300 \cdot 10 = 0{,}15 \text{ g}$$

## Questions and tasks for self-checking of mastering of a theme

1. Value of a method of sedimentation
2. To write the equation of reaction and to explain a principle of action of the indicator at the method of Mor
3. To write the equation of reaction and to explain a principle of action of the indicator at the method of Folgard
4. To explain lacks of the method of Mor and advantages of the method of Folgard
5. To specify principles of impossibility of titration by the method of Mor in the alkaline and sour environment.

## Test questions

1. Find the formula of definition of a threshold of coagulation

$c_{def} = 100 \cdot c \cdot V$

$c_{def} = 1000 \cdot c \cdot V$

$c_{def} = 10 \cdot c \cdot V$

$c_{def} = 50 \cdot c \cdot V$

$c_{def} = 25 \cdot c \cdot V$

2. Coagulation is

a) Preparation process of colloidly solutions

b) Dissolution process of colloidly particles
c) Process of crushing of large particles
d) Association process of colloidly particles in large units
e) Settling out process of colloidly particles

3. Sedimentation is
a) Preparation process of colloidly solutions
b) Dissolution process of colloidly particles
c) Process of crushing of large particles
d) Association process of colloidly particles in large units
e) Settling out process of colloidly particles

4. Define coagulation kinds
a) Blacked out
b) Hidden, obvious
c) Blacked out, hidden, obvious
d) The visual
e) The stratified

5. Coagulation action of electrolits depends:
a) From size of a charge of an ion which has an identical charge with a charge b) colloidly particles
c) From size of a charge of an ion which is opposite to a charge colloidly particles
c) From action of radiant energy
d) From polarity of solvent
e) From temperature

## LABORATORY WORK

**Work 1.** *Definition of molar concentration of equivalent and a titr of solution $AgNO_3$ the method of Mor.*

In a flask for titration by a pipette to measure 5 ml of solution NaCl, to add 2-3 drops of indicator $H_2CrO_4$ and to titr solution $AgNO_3$ before occurrence of corporal colouring. Titration to repeat three times, given to write down in the table

| № | $V_{NaCl}$ | $c_{NaCl}$ | *Drops of inductor* | $V_{AgNO3}$ ml | $c_{AgNO3}$ ml | $T_{AgNO3}$ g/ ml |
|---|---|---|---|---|---|---|
| 1.<br>2.<br>3. | | | | | | |
| average value | | | | | | |

On average value define molar concentration of equivalent and a solution titr under formulas:

$$c(AgNO_3) = \frac{V(NaCl) \cdot c\,(\mathrm{NaCl})}{\mathrm{V(AgNO_3)}}, mol/l$$

$$t(AgNO_3) = \frac{c(AgNO_3) \cdot M\ (\mathrm{AgNO_3})}{1000 g/ml}, g/ml$$

***Work 2.*** Definition of chloride of sodium in urine the method of Folgard.

In a flask for titration to select 4 ml of urine. A solution to acidify 2 ml 4н solution $HNO_3$ with molar concentration of equivalent and by means of a pipette to flow 8 ml of solution $AgNO_3$. Then in the same flask to add 5 drops of indicator $NH_4Fe(SO_4)_2 \cdot 12H_2O$ (iron-ammonily alum), is formed a white deposition. Further to titr solution $NH_4CNS$ before occurrence of light pink colouring. In an equivalence point there will be a deposition of brick-red colour that will mean the titration end.

Titration to spend three times. Results to write down in the table:

| № | V urine, ml | $c_{AgNO3}$ G-g/l | Indicator | $c_{NH4CNS}$ G-equ/l | $V_{NH4CNS}$ ml | $t_{NaCl}$ G/ml | Q NaCl g |
|---|---|---|---|---|---|---|---|
| 1.<br>2.<br>3. | | | | | | | |
| Average value | | | | | | | |

On average value calculation (the decision of a task 2 see) is made

**Tasks for the independent decision**

1. Why at addition $AgNO_3$ to a solution containing ions $C1^-$ and $CrO_4^{2-}$ deposition AgCl in the beginning drops out?
2. What volume of 0,1 M $AgNO_3$ is necessary for sedimentation 0,2 g NaCl from its solution?
3. Titr of the solution is equal 0,0084/ml. What mass fraction (%) in 100 ml of this solution.
4. Define, in what direction reaction will go

$$PbCl_2 + K_2CrO_4 \rightleftarrows PbCrO_4 + 2KCl$$

SP ($PbCl_2$) = $1,6 \cdot 10^{-5}$ SP ($PbCrO_4$) = $1,6 \cdot 10$-$^{14}$

## COLLIGATIVITY PROPERTIES OF SOLUTIONS

**The employment purpose.** To familiarize with the phenomena based on collegiate properties of solutions. To learn to count quantitatively osmotic pressure of biological liquids and solutions of medical products, and also on the basis of knowledge of laws of the diluted solutions to define relative molecular weight inelektrolit.

**The importance of a studied theme.** The phenomena osmosis play the big role in a life of vegetative and animal organisms. Surfaces of cells and tissue of organisms, their covers possess properties of seminontight membranes.

Osmotic pressure in an organism is the important factor defining distribution of water between its various parts, its value is huge. At the person the constancy of osmotic pressure of blood and other biological liquids also is supported. It matters in limits 760-800kPa (7,7atm) at temperature $37.^0$

Into organism of human and animals is possible to enter into a human body in considerable quantities only isotonic solutions not to change value of osmotic pressure of biological liquids.

The criometrical method of the analysis is widely applied in medicine to definition of relative molecular weights of medical products, osmotic concentration, osmotic pressure of various biological liquids. This method is used also for degree and constant definition dissociation weak electrolyte, a constant of stability of the complex connections which are medical products.

**Initial level of knowledge**

1. Kinds of solutions
2. Electrolytes and inelectrolytes.
3. Boiling and freezing temperature
4. Ways of expression of concentration of solutions.

**Teaching material for self-preparation**

1. N.L.Glinka. The general chemistry. L, 1960, p. 215,227.
2. S.S.Olenin, G.N.Fadeev. Inorganic chemistry. M, 1979, p. 114
3. A.V.Babkov, G.N.Gorshkova, A.M.Kononov. A practical work in the general chemistry with elements of the quantitative analysis. M, 1978, p. 44
4. M.I.Ravich-Scherbo, V.V.Novikov. Physical and colloid chemistry. M, 1975, p. 37.

**On employment following questions will be considered**

1. Colligativity properties of solutions.
2. Osmosis and osmotic pressure. Law Vant-Goff.
3. Hypertensive, hypotonic and isotonic solutions.
4. Plazmoliz and haemoliz
5. Role osmosis and osmotic pressure in biological systems.
6. The phenomenon isoosmosis.
7. Raul's law and the consequences following from this law.
8. Definition of relative molar mass inelektrolit krioskope and ebulioskope method (the decision of tasks)
9. Laboratory work

## THE INFORMATION BLOCK

## Colligativity properties of solutions

Solutions have a number of properties which do not depend by nature dissolved substance, and depend only on its molar concentration. For infinitely diluted solutions which condition is close to a condition ideal, such properties are osmotic pressure, pressure decline of sated steam over a solution, rise in temperature of boiling and fall of temperature of freezing of solution. These properties usually name collegiate as all of them are caused by some general reasons.

Studying collegiate properties of the diluted solutions serves one of the most widespread ways of definition of molar mass of the dissolved substance, and also its degree dissociation or an association indicator.

Let's present the U-shaped tube supplied in the bottom of a seminontight partition (membrane) through which time molecules waters (solvent) can freely get, but not molecules or ions of the dissolved substance.

Let's fill the right knee of the device with pure solvent, and left a sucrose solution in water so that in the beginning liquid levels in both knees were identical. If there was no seminontight partition, at the expense of diffusion process of alignment of concentration of a solution in both parts of the device would begin. However in this case diffusion of molecules of sucrose in the right part of the device is interfered by a seminontight partition. Concentration alignment is carried out unilaterally only at the expense of slow transition of a part of molecules of water from the right part of the device in left, where concentration of the dissolved substance above. As a result liquid level in the right knee will start to decrease, and in left to increase, until some difference of hydrostatic columns will not established, answering to pressure $p_{osm.}$, at which this unilateral diffusion will stop.

Process of spontaneous transition (diffusion) of solvent through a nontight partition from that part of system, where concentration of the dissolved substance more low, in another where it above is called osmosis.

After a while speed of diffusion of water from the right knee in the left will be counterbalanced by speed of its return transition from the left part of the device in the right.

Pressure, which needs to be put to a solution to stop osmos, i.e. penetration into it through a seminontight partition of pure solvent, is called as osmotic pressure. The device measuring osmotic pressure name osmometr.

Vant-Goff the incorporated law for osmotic pressure in solutions has been offered: **osmotic pressure of the diluted solutions inelektrolit in direct ratio molar concentration (), to proportionality factor (R) and absolute temperature (T):**

$$p_{osm.} = cRT$$

where R - a gas constant, R=8,31litrl.kPa/molK

It can be applied to the diluted solutions of electrolytes with introduction correction multiplier - isotonic factor which shows, in how many time osmotic pressure of electrolyte more than osmotic pressure inelectrolit the same concentration:

$$i = p_{osm.el.} / p_{osm.unel.}$$

$$i = 1 + \alpha (n-1),$$

where α-degree dissociation of electrolytes,

n-number of ions in the solution.

The solutions having identical osmotic pressure, name isotonic. Otherwise solutions with the osmotic pressure equal to osmotic pressure of a solution, taken for the standard, are called *as isotonic*.

Solutions with osmotic pressure higher, than in the standard are called as *hypertensive*, with smaller pressure - *hypotonic*. Blood, a lymph, fabric liquids of the person represent water solutions of many substances. Their total osmotic pressure at 37$^{o}$C is equal 7,7 атм.

Such pressure has 0,86 % (weights.) solution NaCI which is called as a physiological solution and is isotonic to blood plasma.

If in the distilled water to place erythrocytes, there is a water moving, erythrocytes bulk up, it conducts to cover rupture erythrocytes. This process name *haemolis*. In strong solutions of salts it is marked, on the contrary, corrugation cells - *plazmoliz,* caused by water loss.

The human organism is characterized by the big constancy of some physical and chemical indicators of the internal environment, including osmotic pressure of blood. A constancy of this indicator name *isoosmos*. Infringement isoosmos appears pernicious for an organism much earlier, than comes plazmoliz or haemoliz cells.

In an organism the isoosmium support tissue of a liver, hypodermic cellulose, especially a kidney. It is regulated by nervous system and glands of internal secretion.

And animals it is possible to enter into a human body in considerable quantities (liters) only isotonic solutions which do not change osmotic pressure of an organism. Such solutions enter, for example, at heavy operations for compensation of losses of blood.

In surgery apply the hypertensive bandages representing gauze strips, moistened in hypertensive solutions NaCl and entered into purulent wounds; according to the phenomenon osmoses the current liquids goes on a gauze outside. It promotes clarification of a wound from pus, microorganisms and so forth

As a depletive use hypertensive solution $MgSO_4$ and $Na_2SO_4$. Laxative action of solutions of these salts speaks transition of considerable quantities of water from a mucous membrane in intestines gleam.

Small amounts of a hypertensive solution enter intravenously at a glaucoma caused owing to increase of intraocular pressure to "delay" superfluous quantity of a moisture from the forward chamber of an eye.

### Pressure of steam over a solution and Raul's law

Pressure of steam at which in the conditions of certain temperature there comes the dynamic balance characterized by equality of speeds of evaporation and condensation of a liquid, carries the name of pressure of sated steam.

Pressure of sated steam over liquid solvent (over water) above, than over a solution small volatility substances. This results from the fact that in the first case all surface of evaporation from a liquid phase is occupied only by solvent molecules, and in the second case the part of this surface is occupied by molecules of the dissolved substance which can keep nearby molecules of solvent forces of a chemical bond.

F.M.Raul (1886) has established the law:

**Relative pressure decline of steam of solvent over a solution to equally molaly share of the dissolved substance, i.e. the relation of quantity of mols of the dissolved substance to total quantity of mols of the dissolved substance and solvent:**

$$P_0 - P / P_0 = n/n+N$$

$P_0$ - pressure of sated steam over pure solvent;

P - pressure of sated steam over a solution;

n and N - number of mols of the dissolved substance and solvent in certain volume of a solution;

Raul's law, as well as law Vant-Goff, is fair only for ideal solutions.

For a solution of electrolytes the formula will be following:

$$P_0 - P / P_0 = i\ n/i\ n+N;$$

i - isotonic factor of Vant-Goff.

Rise in temperature of boiling of a solution - *ebullioscopy*, fall of temperature of crystallization of a solution - *cryoscopy*.

Boiling is a phase transition at which the conversion of liquid to vapour, the vapour bubbles are formed in the whole volume of the liquid.

Boiling point of the liquid is called the temperature at which the vapour pressure of the liquid on the outside as well. At this temperature, and the corresponding saturation vapour pressure equilibrium between the liquid and gas phases (evaporation rate equal to the rate of the reverse process of condensation). Both phases can exist for a long time.

The temperature at which this fluid boils in the face of pressure 101325 Pa is called the normal boiling point.

Freezing is a phase transition at which the conversion of the liquid into a solid, the particles which are formed in the whole volume of the liquid.

Freezing (crystallization) of the fluid is called the temperature at which the vapour pressure of the liquid is equal to the saturated vapour pressure of the drop out crystals of the solid phase. At this temperature, and the corresponding vapour pressure equilibrium between the liquid and solid phases (crystallization rate equal to the rate of melting) and both phases can coexist for a long time.

Saturated vapour pressure of the solution is less than for the pure solvent.

Boiling point of low-volatile substance is always higher than the boiling point of the pure solvent.

Crystallization temperature of solution of the substance is always lower than the crystallization temperature of the pure solvent.

From Raul's law the following corollary:

**Raising the boiling point, and lower the crystallization temperature of dilute solutins is directly proportional to molality of the solution.**

$$\Delta t_{boil.} = E\text{в}(x) \qquad \Delta t_{crys.} = K\text{в}(x)$$

*в(x)* - molality of the solution. E and K - ebullioscopy and cryoscopy constants whose values depend on the nature of the solvent.

For the calculation increase the boiling point and lower the freezing point of electrolytes should be introduced as an efficient isotonic Vant-Hoff factor (i).

$$t_{boil.} = i\,E\text{в}(x); \qquad t_{crys.} = i\,K\text{в}(x)$$

Raul's law is the basis of the experimental methods for the determination of molar mass of solutes through observation, arising from or increase the boiling point, or by lowering the freezing point of the solvent.

Methods ebullioscopy and cryoscopy widely used in physical and chemical studies of biological objects.

Knowing boiling point elevation certain molality, you can say in advance what will be the lowering of the temperature of crystallization, the relative reduction of the vapour pressure and the osmotic pressure of the resulting solution.

## The value of osmosis in medicine

Every living cell has a shell, or surface layer of protoplasm, with the property of semi-permeability. The shell is impermeable to the number of red blood cells cations, but she freely passes anions and water.

In medicine as therapeutic agents commonly used isotonic and hypertonic solutions. Isotonic solutions used for intravenous administration of drugs.

The closer the osmotic pressure of the solution introduced to the osmotic pressure of the blood, the less cause side effects. With loss of blood injected into the body isotonic solution. Usually after surgery can not drink a lot. Then drop method is introduced into the body isotonic solution. With cholera large fluid losses lead to thickening of the blood, which leads, in turn, to the death. In this disease, we recommend the introduction of a large number of isotonic solution. Hypertonic solutions are used in the treatment of inflammatory processes in the body. Inflammation - the accumulation of fluid. The introduction of a 40% solution of glucose helps drain fluid from the body. Trauma - injury, especially purulent, hypertonic saline treated. Fluid from the wound goes to bandage soaked hypertonic saline. Reyger-isotonic solution contains nutrients, similar in composition to the cell fluid. In solution Reyger isolated heart feels in your body.

Turning to the osmotic pressure in the body, it must be emphasized that the knowledge they need to understand the absorption of the products of digestion in the gastrointestinal tract, the process of movement of substances from the intercellular spaces and cavities to tissues and cells, etc.

The osmotic pressure of blood plasma at 370C (7.7) is equal to 7,5-8,2 bar.

Most of the osmotic pressure of the blood caused by sodium chloride. Part of the osmotic pressure of the blood caused by high-molecular compounds, especially proteins (albumin, globulin), is the *oncotic pressure*.

## Educational tasks and benchmark for their decision

***Task №1.*** The osmotic pressure of a solution of glucose at $37^0$C equals 760 kPa. Determine the volume of the solution, if you know the solution contains 1 mole of glucose.

**Given:**

n (gluc.) = 1,0 mol

$P_{osm}$. = 760 kPa

$t = 37^0C \quad T=310^0C$

R = 8,31 kPa / mol · K

---

V (solution) =?

**Standard of decision.**

By law, the Van't Hoff $\pi = c \cdot R \cdot T$

$$c = \frac{n(s-a)}{V(s-n}; \text{ thereby } \quad \pi = \frac{n(s-a)}{V(s-n)} \cdot R \cdot T$$

thereby

$$V_{s-n} = \frac{1 \cdot 8.31 \cdot 310}{760} \frac{моль \cdot l \cdot kPa \cdot K}{kPa \cdot mol \cdot K} = 3{,}389 l$$

*Answer: Vs-n = 3.4 l*

**Task № 2.** A solution containing 27g of solute in 750 g of benzene freezes at 3.50. Pure benzene freezes at 5.50. Cryoscopy constant of benzene 5.2. Determine the relative molecular mass of the substance in benzene.

**Given:**

m (s-a) = 27g

m ($C_6H_6$) = 750g

$t^0_{free(9s-n)} = 3{,}5^0$

$t^0_{freez(bensol)} = \_3{,}5^0$

K ($C_6H_6$) = 5,2 grad / mol

M (subs) =?

---

Standard solutions

1. Lowering the freezing point of the solution compared to pure benzene is:

$$\Delta t_{freez} = t_{freez(s\text{-}n)} - t_{freez(bensol)}$$

$$\Delta t_{freez} = 5{,}50^0 - 3{,}5^0 = 2{,}00^0$$

2. Proceeding from $\Delta t_{freez}$ of value, we calculate the relative weight of the substance dissolved in benzene as follows:

$$\Delta t_{freez} = K \cdot \frac{m(s-t) \cdot 1000}{M(s-a) \cdot m(C_6H_6)}$$

$$M(s-a) = K \cdot \frac{m(s-t) \cdot 1000}{m(C_6H_6) \cdot \Delta t_{freez}}$$

$$M(s-a) = 5{,}2 \cdot \frac{27 \cdot 1000}{750 \cdot 2{,}00} \frac{grad \cdot g \cdot g}{mol \cdot g \cdot grad} = 93{,}6 g / mol$$

*Answer: M (s-a) = 93.6 g / mol*

## Questions and tasks for self-learning the theme

1. What solutions are called colligative properties?
2. What is osmosis?
3. How is the osmotic pressure of dilute solutions of electrolytes and non-electrolytes?
4. Explain Raul's law.
5. What determines the change in the boiling point and freezing point of solutions in comparison with the pure solvent?
6. Is it possible to enter into the body in large amounts of hypertonic solution?
7. Raul's law as stated?
8. What is called the cryoscopy and ebullioscopy constant and what factors it depends?

## Situational tasks.

1. Are the 0.1 mol / L solutions of sugar and salt isotonic? Justify the answer.

2. In surgery apply "hypertonic dressing." This strip of gauze soaked in hypertonic NaCl solution and put into festering wounds. Calculate the osmotic pressure of 10% w / w / hypertonic solution of NaCl. ($\rho$=1,05 g/ml, $\alpha$=0,89, t = $37^0$C).). Explain what is the basis effect "hypertensive bandages."

3. Calculate the osmotic pressure of 0.85% / w. / Solution of NaCl, is completely dissociated at $37^0$C ($\rho$= 1.04 g / ml.) Is the solution isotonic with blood? What is the molar concentration of the solution?

4. Is it possible to be administered intravenously in large volumes (liters) 3% (by weight) solution of glucose ($\rho$ = 1,011 g / ml)?

5. 125 ml of a solution containing 1.5 g of sucrose, the osmotic pressure is equal to 83.14 kPa 120C. Determine the relative molecular mass of sucrose.

## Test questions

1. Parameter depends on what the value of osmotic pressure?
a) setting the vessel
b) the amount of solvent
c) the external pressure
d) temperature
2. What relation expresses the Van't Hoff?
a) the concentration of the gas solubility
b) the solubility of gases in liquids with temperature
c) the osmotic pressure of the number of solute
d) the solubility of gases from external pressures
3. Explain the phenomenon of plasmolysis in the body?
a) rupture of the cell wall due to the ingress of water
b) the migration of water molecules from the solution in the cell
c) the migration of water molecules from the cell into the solution
d) cell shrinkage due to water loss
4. Explain the phenomenon of hemolysis in the body?
a) rupture of the cell wall due to the ingress of water
b) the migration of water molecules from the solution in the cell
c) the migration of water molecules from the cell into the solution
d) cell shrinkage due to water loss
5. What is the answer, characterizes isotonic coefficient?
a) shows how many times the measured osmotic pressure exceeds the calculated value
b) for the electrolytes it is unity
c) shows the number of times the calculated osmotic pressure exceeds the observed
d) for non-electrolytes it is greater than one
6. In what units is measured osmotic pressure?
a) mol / L b) kPa c) kJ. d) kJ / mol
7. What concentration NaCl solution can be administered intravenously in large quantities?
A) 5% b) 0.86% c) 10% d) 20%
8. What organs are involved in maintaining isotonicity?
a) liver tissue, subcutaneous tissue, kidney
b) liver, kidney, heart
c) subcutaneous tissue, heart, lungs
d) the liver, kidneys, lungs
9. Specify the mathematical expression of the law of Raul
a) $P_0 – P/P_0 = n/n + N$
b) p = CRT
c) M = mRT / PV

d) PV = nRT
10. Specify hypertonic solution
a) 0.85% NaCI solution b) 10% solution in NaCI  c) 0.5% NaCI solution
d) 0.85% glucose
10. What is the osmotic pressure of blood at $37^0C$?
a) 2.9 - 3.9 kPa  b) 755 - 780 kPa   c) 70 - 120 kPa   d) 800 - 850 kPa

## Laboratory work № 1.

### Artificial cell growth'' Traube '' arborescence

In containers holding 10.0 ml poured almost to the top 5% - solution of CuSO4 and throw in a few crystals of ferrocyanide - hexacionly - (II) potassium ferrate. After a while watching bizarre formations which occur in the vessel. Crystals of $K_4[Fe(CN)_6]$, dissolved in solution react with CuSO4 by the equation:

$$2CuSO_4 + K_4[Fe(CN)_6] = Cu_2[Fe(CN)_6] + 2\ K_2SO_4$$

Resulting from the reaction film of  hexacionly - (II) ferrate copper crystals enveloped ferrocyanide with attached solution formed" artificial" cells capable of further growth, as its walls have a semi-permeable. The water molecule, penetrating into cells"" increases its volume, the film is broken, and the solution ferrocyanide pours out. Then the process is repeated again," cell" as it grows, forming a kind of shoots and branches.
Time - 10 minutes.

## Laboratory work № 2

### Study of osmotic properties of the plasma

***Experience 1***. For the experiment, take three tubes: first add 10 drops of isotonic NaCl, the second - 10 drops of a hypertonic solution of NaCl, in the third - 10 drops of hypotonic solution of NaCl. Then to make each 1 drop of blood. Watch occurring phenomenon. Justify  by scientific findings. Explain the solution can be injected into the body in large quantities (volume)? What solutions are unacceptable to introduce into the human body and what it can lead pathologies?

***Experiment 2.*** To 10 drops of isotonic NaCl solution in a test tube add 1 drop by 1 drop of blood, 0.5M $H_2SO_4$. Scientific support conclusions of the phenomena. The consequences may unreasonably large infusion of acid in a living organism.

***Experience 3***. Three tubes Add 10 drops of isotonic solution and 1 drop of blood. In the first test tube add 1 drop of 10% aqueous solution of NaCl, the second - 1 drop of 10% solution of CuSO4, leave the third tube for comparison.

Scientific basis of the phenomena. Based on the findings to make assumptions on the effect of copper ions in the blood and body through Wilson's disease.

### Tasks for independent decision

1. Is it possible to enter into the body in large amounts of hypotonic solution?
2. Calculate the osmotic pressure of 5% (mass). Glucose solution at $37^0$C (ρ= 1.04 g / ml.) Is the solution isotonic with blood? What is the molar concentration of the solution?

## THE ACID - BASE BALANCE.

**The employment purpose:** To learn to count and quantify experimentally determine the pH of solutions of biological fluids and medications.

**The importance of a studied theme.** The constancy of the hydrogen ion concentration is one of the essential constants of the internal environment of living organisms. For example, the pH of human blood is equal to 7,4 ± 0,04, gastric juice - 1,85 ± 0,15, saliva - 6,60 ± 0,30, urine - 5.0-8.0 etc.
Significant changes in the pH of biological systems, particularly blood, can lead to serious violations of life and, ultimately, death.

Changing the reaction of the medium to the acid side in a living organism is called acidosis, to alkaline –alkalosis. For life is dangerous and acidsis and alkalosis. pH deviation from the norm reduces enzyme activity by disrupting the normal course of reactions in cells, which could be the cause of some diseases. A number of diseases is a violation of the acid - base balance in the body. For example, if there is severe acidosis diabetes, cirrhosis of the liver - alkalosis.
Determination of pH of various body fluids is a necessity in the practice.

**Initial level of knowledge**

1. Basics of the theory of electrolytic dissociation.
2. Strong and weak electrolytes.
3. Ionic equilibration in electrolyte solutions.

**Training material for self-study**

1. N.L.Glinka. General chemistry., L., 1980, p.251.
2. S.S.Olenin, G.N.Fadeev. Inorganic Chemistry. Moscow, 1979, p.131.
3. I.K.Tsitovich. Course of analytical chemistry. Moscow, 1985, page 25.

**The lesson will focus on**

1. Fundamentals protolithic theory of acids and bases
2. The ionic product of water
3. pH value
4. The role of the concentration of hydrogen ions in the course of biochemical processes

. 5. Laboratory works

## THE INFORMATION BLOCK

## Fundamentals photolytic theory of acids and bases

According to this theory to the acid is a substance (or ions) capable of donating a proton, and to the grounds - a substance (or ions) that can connect them. And those and others call protolits. Since the return of the proton - a reversible process, then the resulting residue with base may again join the proton, and therefore form more acid:

$$\text{Acid} \rightleftarrows \text{base} + H^+$$

Protons in solutions do not exist independently, and pass only from the acid to the base. Therefore, the solution always takes two processes:

$$\text{Acid1} \rightleftarrows H^+ + \text{Base1}$$

$$\text{Base2} + H^+ \rightleftarrows \text{Acid 2}$$

Balance between them can be expressed by the equation:

$$\text{Acid1} + \text{Base1} \rightleftarrows \text{Acid2} + \text{Base2}$$

*For example:* $HCl + H_2O = H_3O^+ + Cl^-$

Thus, according to the protolytic theory of the source of acids and bases always get new acid and base, which in such a process called conjugated. Acids and bases can be neutral molecules, positive and negative ions:

| Acid | | Base |
|---|---|---|
| $HCl$ | $\leftrightarrow$ | $H^+ + Cl^-$ |
| $H_2O$ | $\leftrightarrow$ | $H^+ + OH^-$ |
| $NH_4^+$ | $\leftrightarrow$ | $H^+ + NH_3^o$ |

It should be remembered that in aqueous solutions hydrated all ions, including cations and hydrogen. Hydrated cations $H_3O^+$ hydrogen called hydroxonium - ions. Thus, the equation of dissociation of electrolytes more properly write this:

$$HCl + H_2O \leftrightarrow H_3O^+ + Cl^-$$
$$HCO_3^- + H_2O \leftrightarrow H_3O^+ + CO_3^{2-}$$

Often, however, to simplify the equations of the reaction $H^+$ write, and not $H_3O^+$. Depending on the conditions of some of the substances (or ions) can exhibit the properties of acids and bases. For example, water in contact with the acidic properties of NH3 shows:

$$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$$

acid base acid base

and the interaction with HCl carry out the function of base:

$$HCl + H_2O \leftrightarrow H_3O^+ + Cl^-$$

acid base acid base

Reaction of neutralization according protolytic theory considered as proton transfer from the acid to the base.

## The ionic product of water. pH value

Water, being a very weak electrolyte, very little dissociates into ions:

$$H_2O \leftrightarrow H^+ + OH^-$$

Constant of dissociation $H_2O$ is equal:

$$K_{diss.} = c(H^+)\cdot c(OH^-)/c(H_2O) = 1{,}8\cdot 10^{-16}$$

Considering the concentration of undissociated molecules of water with a constant value $(H_2O)$ = 55.55 mol / l), we can write the expression:

$$K\cdot c(H_2O) = c(H^+)\cdot c(OH^-) = 1{,}8\cdot 10^{-16}\cdot 55{,}55 = 10^{-14}$$

$$K_{H2O} = c(H^+)\cdot c(OH^-) = 10^{-14}.$$

$K_{H2O}$ - ionly product of water.

Thus, in water or in a dilute aqueous solution of the product of the concentration of $H^+$ and $OH^-$ is a constant. It has a value of $10^{-14}$ at $22^0$C. The reaction solution is characterized by the concentration of $H^+$.

Neutral solution: $c(H^+)=c(OH^-) = \sqrt{10^{-14}} = 10^{-7}$/ l

Acidic solutions: $c(H^+) > c(OH^-) > 10^{-7}$mol / l

Alkaline solution: $c(H^+) < c(OH^-) < 10^{-7}$mol/ l

More convenient and easy solution to characterize the response of pH-value: $pH = -lgC(H^+)$.

Neutral solution: pH = 7

Acidic solutions: pH <7

Alkaline solutions: pH> 7

The negative logarifm of the concentration of hydroxide ions is called Ron and $pOH = -lgc(OH^-)$. Consequently, pH + pOH = 14, hence pH = 14 - pOH, pOH = 14 - pH.

## Educational tasks and benchmark for their decision

***Task № 1.*** Compute c(H +) for solutions in which the $c(OH^-) = 10^{-4}$ mol / l and $c(OH^-) = 10^{-11}$ mol / l.

**Given:**

c (OH) = $10^{-4}$mol / l

c (OH) = $10^{-11}$*mol* / l

c (H +) =?

**Standard of decision:**

$$c(H^+)\cdot c(OH^-) = 10^{-14}$$

$c(H^+) = 10^{-14} / c(OH^-)$

1) $c(H^+) = 10^{-14} / 10^{-4} = 10^{-10}$ *mol/l*

$c(H^+) = 10^{-14} / 10^{-11} = 10^{-3}$ *mol/l*

**Task № 2**. Calculate the pH of the solution in which $c(H^+)$ is:
a) $2 \cdot 10^{-4}$ mol / l, b) $5 \cdot 10^{-6}$ mol /l; c) $9 \cdot 10^{-9}$ mol / l.

**Given:**
$c(H^+) = 2 \cdot 10^{-4}$ mol / l
$c(H^+) = 5 \cdot 10^{-6}$ mol / l
$c(H^+) = 9 \cdot 10^{-9}$ mol / l
pH?

**Standard solutions.**
$pH = - lg\ c(H^+)$
a) $pH = -lg(2 \cdot 10^{-4}) = 4 - 0,3 = 3,70$; $pH = 3,70$.
b) $pH = - lg\ (5 \cdot 10^{-6}) = 6 - 0,69 = 5,31$; $pH = 5,31$.
c) $pH = - lg\ (9 \cdot 10^{-9}) = 9 - 0,95 = 8,05$; $pH = 8,05$.

Issues and challenges for independent learning topics

1. What connections from the point of view of the theory are the protolytic bases, which - acids?
2. Indicate the pH and pOH in acidic, neutral and alkaline media?
3. What factors dependent ionic product of water?
4. Calculate the pH of distilled water at $25^0$C
5. What conclusions can be made about human health, if the pH of gastric juice in it was found to be 2.30?
6. Define $c(H^+)$ and $c(OH^-)$ in a patient in the urine pH is equal to 6.0.
7. Calculate $c(H^+)$ and the pH of the solution of hydrochloric acid 3% (by weight) used as a medicine at a reduced gastric acidity.

## Situational tasks

1.Calculate **$c(H^+)$** and the pH of the solution at **$c(OH^-)$** = **$10^{-5}$** mol / l.

2. $c(H^+)$ used in medicine preparation of sodium bicarbonate is $5 \cdot 10^{-2}$ mol / l. determine the pH of the solution.

3. Gastric pH and the patient's blood are respectively 3.0 and 8, respectively. Determine the $c(H^+)$ of gastric juice and blood.

## Test questions

1. Production of ion concentration of hydrogen and hydroxide ions is equal

a) 7 b) 14 c) $10^{-7}$ d) $10^{-14}$

2. How does change the concentration of hydrogen ions in water by adding acids?

a) the concentration of hydrogen ions increases;
b) the concentration of hydrogen ions is reduced;
c) the concentration of hydrogen ions does not change;
d) the concentration of hydrogen ions increases and then decreases;

3. Calculate the concentration of hydrogen ions in a 0.001 molar solution of HCl?

a) $10^{-2}$ b) $10^{-3}$ c) $10^{-4}$ d) $10^{-11}$

4. Calculate the concentration of hydroxide ions in a 0.001 molar solution of HCl?

a) $10^{-2}$ b) $10^{-3}$ c) $10^{-4}$ d) $10^{-11}$

5. Calculate the pH of a 0.01 molar solution of HCl?

a) 2 b) 3 c) 11 d) 12

6. Calculate the pOH of 0.01 molar solution of HCl?

a) 2 b) 3 c) 11 d) 12

7. According to the photolytic theory to bases include:

a) substances can attach the proton;
b) substance capable of donating a proton;
c) substances can attach as well as donating a proton;
d) a proton donor.

8. According to the protolytic theory to acids include:

a) substances can attach the proton;
b) a substance capable of donating a proton;
c) substances can attach as well as donating a proton;
d) proton acceptors.

9. Determine $c(OH^-)$ if $c(H^+) = 10^{-3}$.

a) $10^{-5}$ b) $10^{-11}$ c) $10^{-12}$ d) $10^{-6}$

10. Determine the pH if $c(OH^-)$ is $10^{-5}$:

a) 5 b) 9 c) 6 d) 10

# LABORATORY WORK.

## "The colorimetric determination the pH of the solutions"

## (Un-buffered method)

In determining the pH of the solutions used by un-buffered compartment Michaelis, which consists of:

1) four bottles with initial indicators nitro phenol;
2) universal indicator having the jump of pH (1-10) with the colour table;
3) four series of standards in sealed tubes;
4) porcelain cup or glass slide, glass rods and pipettes;
5) comparator with 6 pockets and tubes.

***Work performance.*** Determination of pH with test tubes Michaelis is as follows: 1) with a universal indicator and colour scale determine the approximate value of the pH of gastric juice. To do this, a few drops of gastric juice placed on a slide and moistened with the stain colour scale on which determine the approximate value of the pH of gastric juice;
2) out of the box Michaelis choose the indicator so that found the approximate pH of the solution was within the zone of colour change indicator;
3) in the tubes of the same diameter as the reference, pour 0.6 ml of gastric juice and add 0.1 ml of the selected indicator and mixed;
4) is inserted into the comparator, comparing colour tubes with gastric juice with test tubes - a reference containing the same indicator. The coincidence of the colour intensity indicates the equality of pH solutions and the standard. Similarly, you can determine the pH and to draw conclusions about the health of the patient.

## Tasks for independent decision

1. What conclusions can be made about human health, if the pH of gastric juice in it was found to be 0.5?
2. Determine the pOH of a solution if the $c(H^+) = 10^{-6}$.
3. Determine the pH of the solution, if pOH = 4.
4. What is the pH of the acetate buffer system?

## PROPERTIES OF THE BUFFER SOLUTION

**The employment purpose**: To learn to predict the mechanism of action of buffers in biological systems, as well as quantitatively calculated and experimentally determine the pH of the buffer solutions.

**The importance of a studied theme**. Knowledge of the properties of buffer systems and the ability to apply them to solve specific practical tasks in medical practice is essential, as these systems play an important role in maintaining the acid-base balance in the body. They regulate the acidity of the blood, cellular and extracellular fluid, etc., thus providing optimal conditions for the manifestation of the high activity of enzymes and hormones. The normal pH of blood in vivo 7.36. It supports both the bicarbonate buffer system, and powerful systems - haemoglobin and ox haemoglobin buffer, which constitute 75% of the buffer capacity of the blood. Ox haemoglobin-haemoglobin system supports constant pH of blood in the arteries. In urine, digestive juice important phosphate buffer.

**Initial level of knowledge**

1. The law of mass action;
2. Chemical equilibrium, chemical equilibrium shift.
3. The ionic product of water, the pH value;
4. The theory of strong and weak acids and bases.
5. Ways of expressing the concentration of solutions.

**Training material for self-study**

1. V.N.Alekseev. Quantitative analysis. Moscow, 1972, page 280
2. K.A.Seleznev. Analytical Chemistry., Moscow, 1973, p.30.
3. I.K.Tsitovich. Course of analytical chemistry. Moscow, 1985, page 31.
4. S.S.Olenin, G.N.Fadeev. Inorganic Chemistry. M, 1979, p.135.

The lesson will focus on
1. Buffering sistems
2. Henderson – Gasselbah's equation
3. Buffering mechanism
5. Buffering capacity and its significance
6. The value of the buffer systems in medicine
7. Laboratory works

## THE INFORMATION BLOCK

## BUFFER SYSTEMS

Buffer systems are called solutions that have the ability to maintain sufficient firmness constant concentration of hydrogen ions as the addition of a small amount of strong acid or alkali, and in breeding. They compositions are two basic types:
1) The systems consisting of a mixture of a weak acid and its salts;
2) Systems consisting of a mixture of a weak base and its salt.
For example:
$CH_3COOH + CH_3COONa$ - the first type;
$NH_4OH + NH_4CI$ - the second type;
$KH_2PO_4 + K_2HPO_4$ -third type;

pH of the buffer mixtures can be calculated from the equation of Henderson - Gasselbah.

$pH = pK_{a\text{-}d} - lg c_{(a\text{-}d)} / c_{(salt)}$ - for the acid buffer.
$pH = 14 - pK_{bas.} + lg\ c_{(bas.)} / c_{(salt)}$ - for alkaline buffer.

When added to the buffers of small amounts of highly acidic or alkaline pH of their almost constant as a strong acid (alkali) is replaced by an equivalent amount of a weak acid that is added alkali replaced by an equivalent amount of salt on the equation:

$$\begin{matrix} CH_3COOH \\ CH_3COONa \end{matrix} + HCl \longrightarrow \begin{matrix} \underset{increase}{CH_3COOH} \\ \underset{decrease}{CH_3COONa} \end{matrix} + NaCl$$

In this part of $CH_3COONa$ change to CH3COOH. Consequently, the hydrogen ions are fully bound in a weak acetic acid, and does not increase $c(H^+)$ and pH. And adding an alkali to the system:

$$\begin{matrix} CH_3COOH \\ CH_3COONa \end{matrix} + NaOH \longrightarrow \begin{matrix} \underset{decrease}{CH_3COOH} \\ \underset{increase}{CH_3COONa} \end{matrix} + H_2O$$

Hydroxyl ions are bound to the proton of acetic acid. The concentration $c(OH^-)$ is not increased, therefore the pH remains almost unchanged.

Dilution buffer systems up to 100 times their little effect on pH, since there is a reduction in the concentration of both components equally. As seen from the above equations, the value of a relationship with c(acid) / c (base) and the salt concentration does not change.

The ability of the buffer system to hold pH ultimately is limited ability and it determines by the amount added to it acidic or alkaline. It depends on the concentration of the buffer. The ability of the buffer system to counteract the displacement of reaction is measured by the buffer capacity. This milligram equivalent weight of a strong acid or alkali, which to be added to 1 litter of the buffer solution to displace the pH by one unit. Buffer capacity calculates by the formula: B=c/pH1-pH2, where c – concentration added acidic or alkaline, pH1 and pH2 – pH before and after addition a little of amount of acid or alkali. As the concentration of component buffer of acid (alkali) and salt increases the buffer capacity of the system. Thus, the pH of the buffer mixture depends only on the ratio of the components and Kdiss of weak acid or base, and the buffer capacity depends on the ratio of the components and their concentrations. In humans, the protein plays an important role buffer consisting of protein (Pt) and its salt, formed by a strong base:

Pt-COOH + Pt-COONa

Haemoglobin, ox haemoglobin and bicarbonate buffer perform an important role by maintaining of he pH of the blood $H_2CO_3 + NaHCO_3$

Phosphate buffer plays a major role in the he urine and juice of digestive glands - $NaH_2PO_4 + Na_2HPO_4$

Buffer systems are important for the normal functioning of the organism.

## Educational tasks and benchmark for their decision

**Task №1.** Determine the pH of the acetate buffer system consisting of 0.1 mol/ l acetic buffer system, which consist of 0.1 mol/l vinegar acid and 0.1 mol / l sodium acetate at the same ratio of components.

**Given:**

$c(CH_3COOH) = 0,1$ mol/l

$c(CH_3COONa) = 0,1$ mol/l

$K_{CH3COOH} = 1,8 \cdot 10^{-5}$

$pH = ?$

**Standard of decision**

By equation Henderson-Gasselbah:

$pH = pK_{a\text{-}d} - lg\ c_{a\text{-}d}/c_{salt}$

$pK = -lg\ 1,8 \cdot 10^{-5} = 5 - lg\ 1,8 = 4,75$

$pH = 4,75 - lg\ 0,1/0,1 = 4,75$

*Answer:* pH = 4.75

**Task №2.** Determine the pH of the acetate buffer system with the concentration of the components 0.1 mol / l after adding 0.01 mol / l solutions. HCl and NaOH. . K($CH_3COOH$)=1.8*10-5.

**Given:**

*c($CH_3COOH$) = 0,1 mol/l*
*c($CH_3COONa$)= 0,1 mol/l*
*c(HCl) = 0,01 mol/l*
*c(NaOH) = 0,01 mol/l*

---

*pH = ?*

**Standard of decision:**

1) After the addition of HCl acid concentration becomes equal to 0.11 mol / l, and salt - 0.09 mol / l

pH = 4,75 - lg 0,11 / 0,09 = 4,66; ΔpH = 4.75 - 4.67 = 0.09

2) After the addition of NaOH, the acid concentration becomes equal to 0.09 mol / L, and salt - 0.11 mol / l

pH = 4,75 - lg 0,09 / 0,11 = 4,88; ΔpH = 4.75 - 4.84 = - 0.13

*Answer:* After the addition of an acid pH buffer system will decrease by 0.09 units, and the addition of an alkali to increase the pH by 0.13 units.

***Task №3***. Determine the pH of the ammonia buffer system with concentration of the components of 0.5 mol / l after dilution with water to 100 times.

**Given:**

*c($NH_4OH$) = 0,5 mol/l*
*c($NH_4Cl$) = 0,5 mol/l*
*V($H_2O$) = 100ml*

---

*pH = ?*

**Standard of decision:**

After dilution with water the concentration of the components will be 0.005 mol / l.

*pH = 14 – pOH = 14 – 4,75 + lg 0,005/0,005 = 9,25*

*Answer:* pH = 9.25 after dilution with water to 100 times the pH buffer system does not change, because concentration of components is reduced by the same factor.

**Questions and tasks for self-learning of theme:**

1. Define and specify the composition of the buffer mixtures.
2. Provide a mechanism buffering phosphate and bicarbonate buffers.
3. Specify the components of the protein buffer.

4. In biological fluids - urine, juice digestive glands - is the action of phosphate buffer. Determine the pH of the phosphate buffer mixture consisting of a solution of 0.1 mol / l $NaH_2PO_4 + Na_2HPO_4$. At the same ratio of components $K_{H2PO4^-} = 6,8 \cdot 10^{-8}$
5. What is the buffer capacity and what factors it does depend on?
6. By what formula is defined buffer capacity?

## Situational tasks

1. In the blood, there is a large concentration of bicarbonate buffer. Calculate, how pH buffer system changes, which consisting of 0.1 mol / l $H_2CO_3$+$NaHCO_3$ at the same ratio of components on dilution with water to 100 times by adding 0.01 mol / l HCl and NaOH solutions to $K(H_2CO_3) = 4,5 \cdot 10^{-7}$.

## Test questions

1. What does a buffer system in the body?
a) remains constant osmotic pressure;
b) remains constant pH of body fluids;
a) reduces the pH of the blood;
d) increases the pH of biological systems.
2. Does the pH of the buffer system on the ratio of the components?
a) Yes; b) No; c) depends on the physical state;
d) depends on the nature of the components.
3. Indicate the most correct expression:
1. pH buffer systems depends on the ratio of the components.
2. buffer capacity depends on the ratio of the concentration of components.
a) 1; b) 1 and 2; c) 2 d) both statements are false.
1. By what formula defined buffer capacity?
a) $\beta = C_1 - C_2/pH_1 - pH_0$ b) $\beta = C/pH_0 - pH_1$
c) $\beta = C/pH_1 - pH_0$ d) $\beta = C_1 - C_2/ pH_0$

4. What per cent of the buffer capacity of the blood is bicarbonate buffer?
a) 50%; b) 75%; c) 25%; d) 100%.

5. Which biological fluids do have greatest phosphate buffer?
a) blood; b) the urine;
c) urine and juice digestive glands; d) digestive juice.

6. Determine the pH of the acetate buffer system, the concentration of the components of which are equal to 0.1 mol / l after dilution factor of 100.
a) 4,75; b) 4,95; c) 9,25; d) 9,55.

7. When you add HCl to ammonium buffer it interacts with:
a) $CH_3COOH$; b) $CH_3COONa$; c) NaCl; d) doesn't interact.

8. When you add NaOH to ammonium buffer it interacts with:
a) $CH_3COOH$; b) $CH_3COONa$;
c) NaCl; d) does not interact.

9. Will change the pH of the phosphate buffer system with the concentration of the components of 0.5 mol / l at a dilution factor of 10?
a) will not change; b) will not change significantly;
c) will increase in 2 times; d) will reduce in 2 times.

10. Which buffer system does maintain the pH of digestive organ?
A) bicarbonate; b) ammonia; c) phosphate; d) acetate.

# Laboratory work № 1.

## Preparation of buffer solutions, and the research of their properties.

For these experiments we used 0.1 mol / l solution $CH_3COONa$ and $CH_3COOH$.

### Experience № 1. Preparation of buffer solutions.

In seven identical test-tubes pour solutions of acetic acid and its salts in the amounts indicated in the table. Results of experiences we write down in the table:

| № of test tubes | Composition of the buffer mixture, ml. | | Calculate pH of the mixture. | The colour after adding the indicator. |
|---|---|---|---|---|
| | V ($CH_3COOH$ ) | V ($CH_3COONa$ ) | | |
| 1. | 9.0 | 1,0 | | |
| 2. | 7.0 | 3.0 | | |
| 3. | 5.0 | 5.0 | | |
| 4. | 3.0 | 7.0 | | |
| 5. | 1.0 | 9.0 | | |
| 6. | 0.5 | 9.5 | | |
| 7. | 0,2 | 9.8 | | |

Added to each tube three drops of methyl orange indicator, mix, noted in the table colouring buffer mixtures. Calculate the pH of each mixture.

### Experience № 2. Effect of dilution of the pH of the buffer solution.

In the test tube to prepare a buffer mixture consisting of 5.0 ml of acetic acid and an equal volume of a solution of its salt. Transfer to another tube 3.0 ml of this mixture and 6.0 ml diluted with water.

To each tube, add 2 drops of methyl red indicator. What is the colour of the solution? Draw conclusions on the impact of dilution on the pH of the buffer solution.

Experience number 3. Effect of acid and alkali on the pH of the buffer solution.
You should prepare a buffer solution of 10 ml in three test tube, which consisting of 5.0 ml $CH_3COOH$ and 5.0 ml of solution $CH_3COONa$.
Add to the first test tube 5 drops of HCl, and the second - 5 drops of NaOH (0.1 mol / l), in the third - 5 drops of distilled water and 2 drops each of methyl orange indicator. Note the colour of the solution. Draw conclusions about the impact of small amounts of acids and alkalis on the pH of the buffer solution.

## LABORATORY WORK № 2.

## Determination of buffer capacity of blood serum

The method works: Measure the glass 10.00 ml of serum and using a glass electrode pH - meter to determine the pH ($pH_o$). Pipette to measure out 3.0 ml HCl C (HCl) = 0.025 mol / l and pour into a glass. Determine the pH of blood serum after adding a solution of HCl ($pH_1$). These measurements made to the table and calculate the buffer capacity of the blood serum by the following formula:

$$\beta = \frac{V(HCl) \cdot C(HCl)}{V(buf.s - ms)\cdot)(pH_1 \cdot pH_0)}$$

| № | V(blood serum) | $pH_o$ | $pH_1$ | B(blood serum) |
|---|---|---|---|---|
| | | | | |

**Tasks for independent decision**

1. Explain the mechanism of action of ammonium buffer system.
2. Determine the pH of the buffer system consisting of 100 ml of acetate acid with molar concentration equivalent to 0.1 mol / l and 200 ml sodium acetate with molar concentration equivalent to 0.2 mol / l. K ($CH_3COOH$) = $1{,}75 \cdot 10^5$.
3. What the formula of ammonium buffer system is pH determined by?
4. How many grams of $NH_4CI$ to be added to 1 litre of 1.0 mol / l ammonium hydroxide to produce a buffer solution with pH = 9.5? Calculate the molar concentration of $NH_4CI$.

# THE COMPLEX COMPOUNDS

**Purpose of the lesson**. Learn a systematic approach to the identification of opportunities and the nature of the reaction products of complex formation. Learn to predict the formation of complex connections in biological systems

**The importance of a studied theme**. Many biochemical processes in living organisms occur with the participation of complex compound. Haemoglobin is a complex compound of iron, vitamin $\mathbf{B_{12}}$ - complex compound of cobalt and others. Complex processes should be considered in the use of drugs, as many of them, having in its composition metal – (complex forming) can form stable complexes with bio ligands of human body. Complex compounds are used in medicine as the remedies. For example, platinum compounds - anti-cancer drugs that slow the growth of malignant tumours. Relieves - $\mathbf{CuCl_2 \cdot 2B_6}$ - treats tuberculosis, hepatitis ferramid - iron complex with nicotinamide - anaemia of various aetiologies, koamid - cobalt complex with the amide of nicotinic acid - promotes healing of closed fractures, kobavit treats hepatitis, etc.

**The initial level of knowledge:**

1. Molecular and ionic equation for the reaction
2. Law of mass action
3. Chemical equilibrium
4. Hardness of water

**Training materials for self:**

1. S.S.Olenin, GN Fadeev Inorganic Chemistry, Moscow, 1979, page 94
2. IN Tsytovich course of analytical chemistry, Moscow, 1985, page 57,263
3. IA Alekseev quantitative analysis., MA. 1972, p 336
4. IA Seleznev Analytical Chemistry. M, 1973, page 222
5. AV Bobkov, G. Gorshkov, A. Kononov Workshop on general chemistry with elements of quantitative analysis. Moscow, 1989, page 231.

**The lesson will focus on**

1. Complexes.
2. Getting complexes
3. Coordination theory of the structure of complex connections of A.Verner
4. Classification of connections
5. Chelate intracomplex compounds
6. Equilibrium in solutions of complex compounds
7. Constant stability and instability of complex compounds
8. Scientific justification of direction of complex forming reactions
9. The value of the complex connections in medicine
10. Laboratory work.

## THE INFORMATION BLOCK

All chemical compounds meeting in the nature can be divided conditionally on two groups:

1. Simple binary connections or connections of the first order in which molecules atoms are connected ionic or covalently by communication.

For example: $H_2O$, $NH_3$, $H_2SO_4$, $Ca(NO_3)_2$ etc.

2. Difficult connections or connections of the higher order which are formed as a result of interaction of more simple molecules or connections of the first order. Them also name is the complex connections.

For example: $FeCl_3 + 6KCN \longrightarrow K_3[Fe(CN)_6] + 3KCl$

$FeCl_2 + 6KCN \longrightarrow K_4[Fe(CN)_6] + 2KCl$

$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]Cl + 2H_2O$

Connections are called as complex, in knots of which crystal lattice there are difficult particles (complex ions), consisting of the central atom and molecules surrounding it or ions-ligands.

Complex connections are capable to independent existence, both in a crystal, and in a solution:

$$K_3[Fe(CN)_6] \rightleftarrows 3K^+ + [Fe(CN)_6]^{3-}$$
$$K_4[Fe(CN)_6] \rightleftarrows 4K^+ + [Fe(CN)_6]^{4-}$$
$$[Ag(NH_3)_2]Cl \rightleftarrows [Ag(NH_3)_2]^+ + Cl^-$$

The structure of the complexes determines the coordination theory, created in 1893 by the Swedish scientist Alfred Werner. This theory includes the following:

1. Besides the main valences of atoms exist in the same side of valence, which manifest themselves in some reactions.

Saturation of the main valence is the basis of formation of connections of the first order, such as simple binary connections such as: HCl, $H_2O$, $NH_3$, $CaCl_2$, etc.

Saturation of side valences is the basis of formation of connections of higher order, such as product mix connections of the first-order type: $[NH_4]Cl$, $K_3[Fe(CN)_6]$, $K_4[Fe(CN)_6]$, $[Al(H_2O)]Cl_3$ and etc.

2. In complex connections central place of ion-complex forming or the central ion. As a rule, the central atom is a positively charged metal ion, except for connections $[NH_4]Cl$, where the central atom is $N^{-3}$.

3. Around the central atom are coordinated counter or polar molecules, called ligands (addends). Ligands are neutral molecules $NH_3$, $H_2O$, NO, CO, as well as anions (anions) $CN^-$, $CNS^-$, $NO_2^-$, $Cl^-$, $I^-$, $CO_3^{2-}$, $S_2O_3^{2-}$, hydroxide ions $OH^-$ and others.

4. Central atom or ion - is closely related to the complex forming ligands, and forms the inner sphere of the complex compound.

5. Outer coordination sphere are all the ions are not directly connected to the central atom and the outside of the inner coordination sphere.

Integrated group, carrying excess positive or negative charge (referenced to the right of the square bracket) is called a complex ion.

Depending on the charge of the complex ion can be positive, negative, and do not have a charge.

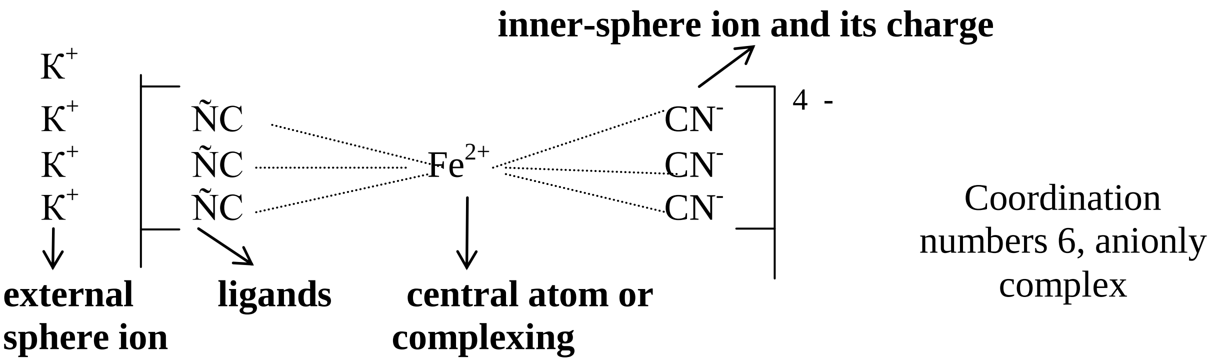
Charge of the complex ion (or neutral complex) is the algebraic sum of the charge of the central atom and the ligand charge.

6. The number of ligands around the central atom is coordinated is called the coordination number of the complex forming agent .Coordination number depends on the nature and geometry of the central atom and its surrounding ligands. It ranges from 1 to 12, the most common is a 6 and 4.

Coordnation numbers for some ions complex forming to the table:

| **Coordination number** | **2** | **4** | **6** | **8** |
|---|---|---|---|---|
| Ion-complexing | $Cu^{+}$<br>$Ag^{+}$<br>$Au^{+}$ | $Cu^{+}$, $Co^{2+}$<br>$Hq^{2+}$, $N{\cdot}Pb^{2+}$,<br>$Rt^{2+}$, $Zn^{2+}$ | $Fe^{2+}$, $Fe^{3+}$<br>$Co^{3+}$,$Cr^{3+}$<br>$Al^{3+}$,$M^{2+}$<br>$Pt^{4+}$ | $Ca^{2+}$<br>$Sr^{2+}$<br>$Ba^{2+}$ |

Therefore, knowing the charge of the ion –complex forming and of the ligands, the coordination number of the central atom, the outer-sphere ion and its charge can write complex compound structure.




<

**Classification of complex compounds**

I. Complex connections are classified according to the type of constituent ligands:

1) Complexes containing monodentantive molecular ligands. Representatives of this class of complex connections are:

a) hydrates - ligands are only water molecules (aqua - complexes) for example:
$[Ca(H_2O)_6]Cl_2$, $[Cr(H_2O)_6]Cl_3$

b) ammoniates - ligands are only molecules of ammonia. For example:
[Ag $[Ag(NH_3)_2]Cl$, $[Cu(NH_3)_4]SO_4$

c) metal carbonyls - ligands are molecules of carbon monoxide $[Fe(CO)_5]$, $[V(CO)_6]$.

2. Complexes containing ligands or ion acid complexes in which the ligands are anions (anions)

a) hydroxyl complexes - is ligands are hydroxyl groups. For example:
$[A1(OH)_6]Cl_3$, $[Zn(OH)_4]Cl_2$

b) acid complexes – ligands are anions $K_4[Fe(CN)_6]$

There are also complex, depending on the nature of the acid residue ftorocomplexes - $K_2[BeF_4]$, $Na_3[AlF_6]$, tsianocomplexes - $K_3[Fe(CN)_6]$ etc.

c) mixed complexes - connections that contain several different ligands.

*For example*: $[Pt(NH_3)_2Cl_2]$, $[Co(NH_3)_4(H_2O)_2]Cl_2$.

II. Complex compounds classified in charge of the complex ion.

If the charge of the complex ion positive - cationic complex $[Ag(NH_3)_4]Cl$, $[Cu(H_2O)_4]SO_4$.

If the charge of the complex ion negative - anionic complex $Na_2[K_2Br_4]$.

If the complex ion has a charge - neutral complex $[Pt(Me_3)_2Cl_2]$, $[Co(NO_6)(NH_3)_2]$

III. Cyclic complexes formed by polidentantive ligands, which form the group of so-called chelating complexes.

*For example*: tris (ethylenediamine) cobalt (III) chloride.

Typically, the chemical bond between the central atom and the ligands in complex connections due to donor-acceptor interaction. In these connections, the ligands are electron-pair donors, as they have free lone pair of electrons, and the central atom - acceptor of these couples, as it has to accommodate the free orbitals of these electrons.

## Chelate compounds

Particularly important place complex connections, since many metalloproteins, the protein of which is associated with metal ions, are built on this type.

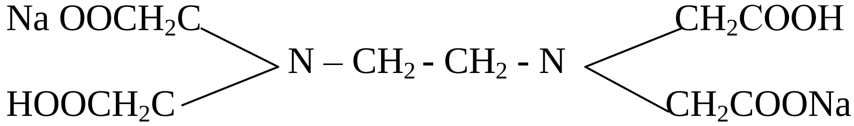
Chelate compounds are a type of circular or so-called chelate complexes. They are characterized by the donor-acceptors and polar covalent or ionic bonds between the ligands and complex forming.

Ligands being polidentantive contain simultaneously two or more groups:

1. Capable of forming covalent polar bonds due to the exchange reaction: $-COOH$, $-NH_2$, $-NH$, $-OH$, $-HS$ and others.

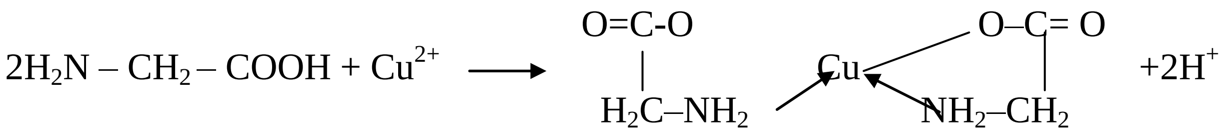
2. Donor electron pairs : N, >NH, >CO, - S – etc.

Ligands of chelate compounds are called complexones. These include aminopolycarboxylic acids and their derivatives, amino-acetic acid (glycine), ethylenediaminetetraacetic acid and its disodium salt, called trilon B.



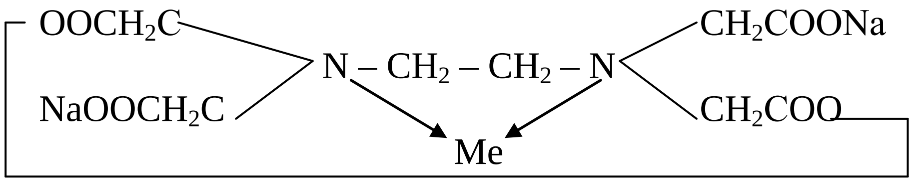

and others.

Consider the formation of chelate compound by the example of amino-acetic acid with the copper ion.




The resulting compound ion $Cu^{2+}$ with two acid residues amino-acetic acid is associated with four connections: two of them - the usual ionic bonds are formed as a result of substitution in the two carboxyl groups of the hydrogen ions on the ion $Cu^{2+}$ and the other two by the donor-acceptor interaction of the unshared electron pairs of the two amine H: N: H with the free orbitals of the copper ion. The first two links shown by solid line, and the other two - the arrow.

An example of chelate compounds are also complex-III (Trilon B) with metal ions




In chelate compounds metal ions through two different relationships are like claws clamped, and sometimes several of these claws in the transition of the complex compound in solution, they do not retain their former properties.

Chelate compounds complexion-III with different metals have different colours, so these connections have become important for analytical chemistry. On their application based method for the quantitative determination of metal ions, called complexometric method, introduced in 1945 year in analytical chemistry by scientist G.Shvartsenbach.

Complexometric method is widely used for the quantitative determination of cations of many metals $Ca^{2+}$, $Mg^{2+}$, $Sr^{2+}$, $Zn^{2+}$, $Ni^{2+}$, $Pb^{2+}$, $Cu^{2+}$, $Al^{3+}$, $Fe^{3+}$, etc., and indirectly for the analysis of some of the anions: $SO_4^{2-}$, $PO_4^{2-}$, $F^-$ etc.

Chelate compounds play an important role in the life of the organism, as the complex molecules of haemoglobin (Mg ≈ 67,000), is a transfer of diatomic oxygen from the lungs to the tissues, containing in the structure called the prosthetic (non-protein) groups, or gems, are chelate compounds .

Chlorophylls, which are of great importance for the life of plants, are also chelate compounds, which are complex forming are magnesium ions. Chelate compounds are also molecules of many enzymes, in which the role played by the complex forming atoms of metals such as iron, zinc, cobalt, molybdenum, copper and manganese.

## Balance in solutions of complex connections

In aqueous solutions the complex connections are dissociate. Initial dissociation occurs entirely on the type of dissociation of strong electrolytes:

$$[Ag(NH_3)_2]Cl \rightleftarrows [Ag(NH_3)_2]^+ + Cl^-$$

The dissociation of the inner coordination sphere is characterized by a balance between the complex species, the central ion and ligands, which obeys the law of mass action and is characterized by the equilibrium constant, called the constant instability of the complex ion:

$$[Ag(NH_3)_2]^+ \rightleftarrows Ag^+ + 2NH_3^0$$

$$Kunst. = \frac{c(Ag) \cdot c^2(NH_3^0)}{c([Ag(NH_3)_2])} = 6{,}8 \cdot 10^{-8}$$

Kunst. is a measure of the stability of the complex. The more stable the complex, the less the value of its constant instability. Is now often used to evaluate the stability of the complexes stability constant, reciprocal Kunst.:

$$\beta = \frac{1}{Kunst.}$$

The logarithm of this quantity is very convenient to compare stability of a number of complex connections, as it represents the integers:

$$lg\beta = \frac{1}{Kunst.}$$

Values Kunst, β , lgβ given in manuals. Using the value Kunst. coordination connections, we can predict the direction of reactions with the formation and breakdown of complex connections. The reaction is always directed toward the formation of connections with the lowest Kunst

*For example:* $K_{[Ag(NH2)2]-} = 1{,}5 \cdot 10^{-3}$
$K_{[Ag(H3)2]+} = 6{,}8 \cdot 10^{-8}$
$K_{[Ag(CN)2]-} = 1 \cdot 10^{-21}$

Since the $[Ag(CN)_2]^-$ - has the lowest Kunst The first two complexes interact with KCN to form cyanide connections from the equation:

$$[Ag(NO_2)_2]^- + 2CN^- \longrightarrow [Ag(CN_2)_2]^- + 2NO_2^-$$
$$[Ag(NH_3)_2]^+ + 2CN^- \longrightarrow [Ag(CN_2)_2]^- + 2NH_3^-$$

May also be a reaction:

$$[Ag(NO_2)_2]^- + 2NH_3 \longrightarrow [Ag(NH_3)_2]^+ + 2NO_2^-$$

And this compound with ammonia does not react as $K_{unst.\ [Ag(NO2)2]-}$ - less than $K_{unst.\ [Ag(NH3)2]+}$.

**Educational tasks and standards of their decision.**

***Task №1.*** Determine charges following complex ions enter including cationic, anionic and neutral complexes.

a)$[Co(NH_3)_5Cl]$ b) $[Cr(NH_3)_4\ PO_4]$ c) $[Ag(NH_3)_2]$

d) $[Cr\ (OH)_6]$ e) $[Co(NH_3)_3(NO_2)_3]$ f) $[Cu(H_2O)_4]$

**Standard of decision:**

a) Charge of the cobalt ion is +3, the ammonia charge is zero, the charge of the chloride ion -1. Find the algebraic sum of the charges of the ions within the domestic sphere: (+3) + (0) • 5 + (-1) = +2 charge of the complex ion +2, the cationic complex. -$[Co(NH_3)_5Cl]^{+2}$

*b) Cr = (+3),* $PO_4 = (-3)$

*(+3) + (0) 4 + (-3) = 0* *neutral* -$[Cr\ (NH_3)_4\ PO_4]$

*c) Ag = (+1),* $NH_3 = (0)$.

*(+1) + (0)·2 = +1* *cationic* -$[\ Ag\ (NH_3)_2]^+$

*d) Cr = (+3), OH = (-1)*

*(+3) + (-1)·6 = -3* *anionic* -$[Cr\ (OH)_6]^{3-}$

*e) Co= (+3),* $NH_3= 0$ $NO_2= (-1)$

*(+3) + (0)·3 + (-1)·3 = 0* *neutral* -$[Co(NH)_3(NO_2)_3]$

*f) Cu = (+2),* $H_2O = (0)$.

*(+2) + (0)·4 = +2* *cationic* - $[Cu\ (H_2O)_4]^{2+}$

***Task №2***. Set in what cases will the interaction between solutions of these substances. Write the reactions.

A) $K[Ag(CN)_2]^- + NH_3^0 \rightarrow$

B) $K[Ag(NO_2)_2]^- + NH_3^0 \rightarrow$

**Standard of decision:**

A) The constant instability of the ion complex $[Ag(NH_3)_2]^+$ is equal to $6,8\cdot10^{-8}$, ion of $[Ag(CN)_2]^-$ is $1,1x10^{-21}$. Thus, the complex $[Ag(CN)_2]^-$ stronger. Therefore, its interaction with NH3 will not happen.

B) The constant instability of the ion $Ag(NH_3)_2^+$ is $6,8x10^{-8}$, the ion $[Ag(NO_2)_2]^-$ - $1,5\cdot10^{-3}$, ion. In this case, a more stable complex $[Ag(NH_3)_2]^+$. Reaction between them is: $[Ag(NO_2)_2]^- + 2NH_3^0 = [Ag(NH_3)_2]^+ + 2NO_2^-$

***Task№ 3*** Calculate the concentration of Ag ions in a 0.1 M solution of $[Ag(NH_3)_2]NO_2$, contained in excess of 1.0 mol / l NH3.

**Given:**

$c[Ag(NH_3)_2]NO_3=0.1$ mol / l

$c(NH_3)=1,0$ mol / l

$K_{unst.}=9,3\cdot10^{-8}$

$c(Ag^+)=?$

**Standard of decision:**

The equation of dissociation of the complex compound in the solution:

$$[Ag(NH_3)_2]NO_3 = [Ag(NH_3)_2]^+ + NO_3^- \qquad (1)$$

$$[Ag(NH_3)_2]^+ = Ag^+ + 2NH_3^0 \qquad (2)$$

In excess NH3 equilibrium (2) shifts to the left and the amount of NH3, formed during dissociation (2) can be neglected, read from (NH3) = 1,0 mol / l.

$$\text{Kunst.} = \frac{c(Ag^+)\cdot c^2(NH_3^0)}{c([Ag(NH_3)_2]))}$$

From the expression is the concentration of $Ag^+$:

$$c(Ag^+) = \frac{K_{inst}\cdot c([Ag(NH_3)_2]^+)}{c^2(NH_3^0)} = \frac{9{,}3\cdot 10^{-8}\cdot 0{,}1}{1^2} = 9{,}3\cdot 10^{-9}\ mol/l$$

## Questions and tasks for self-control of the learning of theme

1. It is known that platinum coordination connections containing as ligands $Cl^-$ and $NH_3^0$ have antitumor activity, and the connections which are non-electrolytes.

Which of the following connections should possess antitumor activity?

1) $K_2[Pt(Cl_4)]$ ; 2) $[Pt(NH_3)_2Cl_2]$ ; 3) $[Pt(NH_3)_3Cl]Cl$ .

2. Write an expression for the constant instability of cobalt coordination connections, many of which are used in medicine as a model connections:

1) $(NH_4)_2[Co(SCN)_4]$; 2) $Na_3[Co(No_2)_6]$; 3) $[Co(NH_3)_6]Cl$ ;

3. Describe, in accordance with the coordination theory of A.Verner, the following complexes: $Na_3[Co(No_2)_6]$; $[Ag(NH_3)_2]Cl$; $Na_3[Co(No_2)_6]$

## Situational tasks

1. From a solution of the complex compound $PtCl_4 \cdot 6NH_3$ silver nitrate precipitates all the chlorine as silver chloride from salt solution $PtCl_4 \cdot 3NH_3$- only part of its constituent chlorine. Write coordinating formal's of salts, determine the coordination number of platinum in each.

2. Write the type of communication between the central atom and the ligands

3. Specify the central atom, its oxidation state, ligands, coordination number and the charge of the complex ion following compound $[Cu(NH_3)(OH)_2]$

## Test questions

1. Enter the charge of the complex ion $[Ag(SO_4)_2]$

a) 1 b) -3 c) +2 d) -2

2. Enter the anionic complex

a) $[Zn^{+2}(NH_3)_2Cl^-]$ b) $[Al^{+3}(NO_3^-)_5]$

c) $[Pb^{+4}(OH)_6]$ d) $[Cr^{+3}(H_2O)_5Cl]$

3. Name the complex compound $Na_2(Sn(OH)_4)$

a) geksogidroksostannat of (IV) sodium
b) geksogidroksostannat (VI) solution
c) tetragidroksostannat (II) sodium
d) geksogidroksostannit (VI) solution

4. Enter the charge of the complex ion [HgJ4]

a) +2 b) 3 c) -2 g) -3

5.Ligands - are:

a) an electron pair donor
b) electron pair acceptors
c) acid
d) ampholytes

6. Specify the coordination number of the central atom in the complex compound [Pt $(NH_3)_2Cl_2$]

a) 2 b) 3 c) 4 d) 5

7. Name the complex compound [Pt $(NH_3)_2Cl_2$]

a) dichlorplatinat b) chlordiaminoplatinat (II)
c) dichlordiaminoplatinat (II)
d) diaminochlorplatinat (II)

8. What is the charge of the complex forming agent and the coordination number in complexes [Pt$(NH_3)_3Cl_3$]Cl?

a) +2.4 b) +2.6 c) +4.4 d) + 6.6

9. What kind of data are complex connections respectively $Na_3$[Co$(NO_2)_6$], [Cr$(H_2O)_6$] $Cl_3$ , [Ag$(NH_3)_2$] Cl

a) acid complexs, ammonia complex,
b) aqua complex, acid complexes, ammonia, aqua complex
c) ammonia complex, acid complexs, aqua complex
d) acid complexs, aqua complex, ammonia complex

10.Determine complex forming, its oxidation state, ligands, coordination number of the central atom in the compound: [Pt$(NH_3)_2Cl_2$]

a) Pt, +4, $Cl^-$, 4
b) Cl, +4, $K^+$, 2
c) Pt, +2, $Cl^-$, ($NH_3$ 4
d) Cl, +2, $K^+$, 4

11.What chemical bond in the complex connection between the central atom and the ligands?

a) ion b) donor-acceptor c) polar covalent
d) non-polar covalent

## LABORATORY WORK.

## The formation of complex connections and investigation of their properties.

### Experience №1. The formation of the complex ion.

To a solution of salts of $Ag^+$, $Cu^{2+}$, $Zn^{2+}$ added to a solution of NaOH. The resulting hydroxide precipitates dissolve in excess reagent $NH_4OH$. Forms complexes - ammoniates corresponding cautions. To this solution was added a solution of alkaline complexes. Drop a metal hydroxide precipitation? Write the reactions of education ammoniates.

**Experience № 2. The formation of the complex anion.**

A) to the tube to make five drops of $Hg(NO_3)_2$, add 2 drops add KJ. Observe the formation of sludge. KJ to its complete dissolution. Write the equation for the reaction.

B) To a salt solution $Zn^{2+}$, $Al^{3+}$ , $Cr^{3+}$ add a solution of NaOH. Formed hydroxide precipitates dissolve in excess reagent. Write the equations of reactions of hydroxy.

**Experience №3. Shift the balance of the complexation reactions.**

A) In the test tube put 5 drops of $AgNO_3$ solution and 3 drops of NaCl. Write the equation of the reaction.

B) To the AgCl precipitate add 10 drops of $NH_4OH$. Write the equation of the reaction of dissolution.

C) to the solution add 10 drops of $HNO_3$. Write the equation of the reaction of the precipitate AgCl.

**Experience №4. Stability of the complex connections.**

To the solution $FeCl_3$ was added a solution of salt $NH_4SCN$. Note colour of the resulting solution. Add a solution of NaF. Explain what is happening phenomenon. $K_{unst.\ [Fe\ (SCN)6]3-} = 5{,}9 \cdot 10^{-4}$; $K_{unst.\ [Fe\ F6]3-} = 3{,}6 \cdot 10^{-7}$.

**Experience №5. Exchange reactions in solutions of complex connections.** To the solution was added a solution of $FeCl_3$ salt $K_4[Fe(CN)_6]$. Mark coloured precipitate formed, write the equation of reaction of their education. In a separate tube to mix a few drops of $K_4[Fe(CN)_6]$ and $K_3[Fe(CN)_6]$. Why in this case the precipitate formed?

## Tasks for independent decision

1. Write an expression for the constant instability of the following coordination connections $Na_3[Co(NO_2)_6]$; $K_4[Fe(CN)_6]$ ; $Na_3[Co(NO_2)_6]$.

2. Describe according the coordination theory of A.Verner following complexes $[Pt(NH_3)_3Cl_3]Cl$, $[Pt(NH_3)_2Cl_2]$.

3. Please indicate in which case there will be interaction between the solutions of these substances:

A) $K[Ag(CN)_2] + NH_3 \rightarrow$

B) $K[Ag(NO)_2] + NH_3 \rightarrow$

# METHODS OF COMPLEXOMETRIC TITRATION

**Purpose of lesson:** To learn from the knowledge of the reactions of complex patterns _ quantitatively determine the content of metal ions in biological liquids, in particular to determine the total water hardness.

**The importance of a studied theme.**

Complexometric titration methods are widely used in biomedical research in clinical, health and hygiene analysis, pharmaceutical and medical products. The method of determination of more than 80 elements. In living organisms, this method determines the presence of calcium, magnesium, and other cations in biological fluids, organs. In sanitary analysis it is used to determine the total water hardness. Reactions of complex forming using as chelating ligands complexions are used in medicine for the treatment of heavy metal poisoning by removing them from the body in the form of soluble complexes.

**Initial level of knowledge.**

1. Conditions of formation of complex connections;
2. Stability of complex ions;

2.1. Constant instability of complexes;

2.2. Determining the direction of complex formation reactions;

3. Hardness of water: temporary, permanent, general;
4. The methods of removal of temporary and permanent hardness of water.

**Training material for self-study:**

1..N.A.Alekseev. Quantitative analysis. Moscow, 1972, p 336

2.. N.A.Selezneva. Analytical chemistry. Moscow, 1973, str.222

3. I.K.Tsitovich. Course of analytical chemistry. M., 1985, str.263

4. A.V.Babkov, G.N.Gorshkova, A.M.Kononov. Workshop on General Chemistry with elements of quantitative analysis. Moscow, 1978, p.151.

**The lesson will include the following questions:**

1. The theoretical basis of the method of complexometric titration

1.1. equation of a chemical reaction;

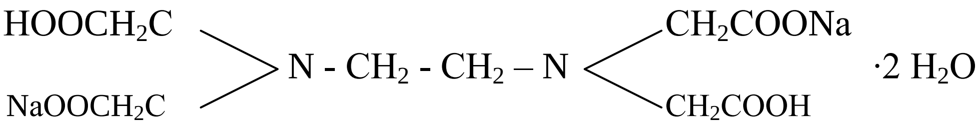
1.2. principle of the indicator.

2. Hardness of water and how to resolve it.
3. Chelation therapy.
4. Laboratory work.

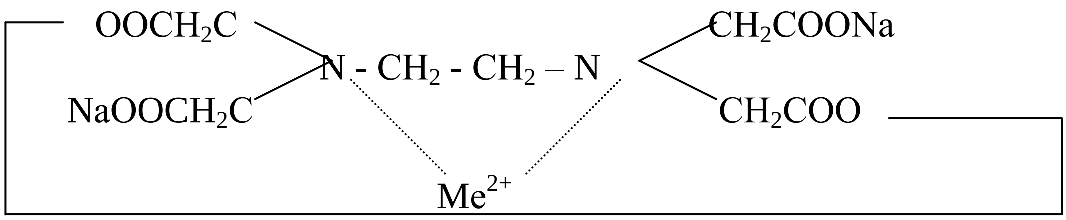
## THE INFORMATION BLOCK

### Method of the complexonometric titration.

At the heart of a method of complexonometric titration lays reactions of formation of chelate compounds of ions of metals with complexions, in particular, with most widely applied complexon III. Complexion III - EDTA - bisodium salt etilendiamintetra acetic acids:




Chelate compounds complexion III with ions of metals are formed at the expense of replacement of ions of hydrogen carboxyl groups and formation of coordination communication with atoms of nitrogen. Complex connections, as a rule, answer a parity metal: ligand = 1:1.




Complexion III forms with many cautions strong enough and soluble in water chelate compounds (salt) that allows to use it for their quantitative definition. The equivalence point in a method is defined by means of metals-indicators which are the organic dyes forming with cautions of metals painted complex connections, by less stronger, than complexes of the same cautions with complexion III. For example, the indicator at definition of ions of calcium and magnesium is weak organic acid eriochrom black T:

$$H_3Ind \rightleftharpoons H^+ + H_2Ind^- \rightleftharpoons 2H^+ + HInd^{2-} \rightleftharpoons 3H^+ + HInd^{3-}$$

pH <3 - red; pH 7-11 - dark blue; pH> 12 - yellow-orange.

At titration of salts complexion III at presence eriochrom black T following reactions proceed:

1. At pH = 10 eriochrom black T forms with ions $Ca^{2+}$ and $Mg^{2+}$ the painted cerise complex:

$$\underset{\text{dark blue}}{HInd^{2-}} + Ca^{2+} \rightleftharpoons \underset{\text{cherry red}}{CaInd^-} + H^+$$

2. At titration of salts of calcium and magnesium complexion III ions of metals in the subsequent form colorless strong complexes:

$$Ca^{2+} + [H\gamma]^{2-} \rightleftharpoons \underset{\text{colourless}}{[Ca\,\gamma]^{2-}} + 2H^+$$

3. When all free ions of calcium and magnesium will be connected complexion III in strong complexes, last will connect these cations from untoughness complexes $CaInd^-$, $Mg\,Ind^-$ in very strong complexes $[Ca\,\gamma]^2$, $[Mg\,\gamma]^2$:

$$[CaInd]^- + [H_2\gamma]^{2-} + OH^- \rightleftarrows [Ca\gamma]^{2-} + HInd^{2-} + H_2O$$

cherry red colourless dark blue

In an equivalent point the solution will change cerise coloring on dark blue with a greenish shade.

**Rigidity of water and ways of its elimination**

In the nature pure water does not meet: it always contains a considerable quantity of salts of calcium and magnesium. Rigidity of water - set of the properties caused by the maintenance in water cations of calcium $Ca^{2+}$ and cations of $Mg^{2+}$.

If concentration of these cations is great, water name rigid if it is small - soft. They give specific properties to natural waters. At washing of linen hard water worsens quality of tissue and demands the raised expense of soap which is spent for linkage cations of $Ca^{2+}$ and $Mg^{2+}$

$$2\ C_{17}H_{35}COO^- + Ca^{2+} = (C_{17}H_{35}COO)_2Ca \downarrow$$

$$2\ C_{17}H_{35}COO^- + Mg^{2+} = (C_{17}H_{35}COO)_2Mg \downarrow$$

Ions $Ca^{2+}$: and foam is formed only after full clearing of these cations. The truth some synthetic washing-up liquids well wash and in hard water as and calcium and magnesium salts are easily dissolved.

In hard water foodstuff hardly boils soft, and the vegetables welded in it are tasteless. Tea and its taste are very badly made lost. At the same time in sanitary - the hygienic relation these cations do not represent danger though at the big maintenance cations magnesium $Mg^{2+}$ water is bitterest on taste and renders indulgencing action on intestines of the person.

Hard water is unsuitable for use in steam coppers: the salts dissolved in it at boiling form a scale crust which badly spend warmth on walls of coppers. It causes the fuel over-expenditure, premature deterioration of coppers, and sometimes, as a result of an overheat of coppers and failure. Rigidity of water is harmful to metal designs, pipelines, casings of cooled cars. Cations of calcium $Ca^{2+}$ cause calcium rigidity, and cations magnesium $Mg^{2+}$ - magnesium rigidity of water. The general rigidity develops from calcium and magnesium, i.e. of total concentration in water cations $Ca^{2+}$ and $Mg^{2+}$.

Distinguish rigidity carbonate and non-carbonate. Carbonate rigidity, presence of that part cations $Ca^{2+}$ and $Mg^{2+}$ which is equivalent containing in water hydrocarbonate to ions $HCO_3^{-}$ is called. Differently, carbonate rigidity is caused by presence of hydrocarbonates of calcium and magnesium. At boilinghydrocarbonates collapse, and formed unsoluble carbonates drop out in a deposition, and the general rigidity decreases for value carbonate rigidity. Therefore carbonate rigidity name also time rigidity. At boilingcations calcium $Ca^{2+}$ are besieged in the form of a calcium carbonate:

$$Ca^{2+} + 2HCO_3^- = + H_2O + CO_2$$

And cations magnesium $Mg^{2+}$ - in the form of the basic carbonate or in a kind hydroxyde magnesium (at pH> 10,3):

$$2Mg^{2+} + 2HCO_3^- + 2OH^- = (MgOH)_2CO_3 + H_2O + CO_2$$

(Hydroxide-ions $OH^-$ are formed at the expense of interaction of ions $HCO_3$ with water:

$$HCO_3^- + H_2O = H_2CO_3 + OH^-).$$

Other part of rigidity remaining after boiling waters, is called uncarbonate. It is defined by the maintenance in water of sulphates and calcium and magnesium chlorides. At boiling these salts do not leave, and therefore non-carbonate rigidity name also constant rigidity.

Quantitatively rigidity of water is characterized by rigidity degree.

Let's consider the quantitative characteristic of rigidity of water. Degree of rigidity of water calculate differently. In its our country express number milliequivalents (meqv) cations $Ca^{2+}$ or 12,16 mg/l cations $Mg^{2+}$, containing in 1l waters. As 1 meqv to rigidity answers the maintenance of 20,04 mg/l cations $Ca^{2+}$ or 12,16 mg/l cations $Mg^{2+}$ according to definition, the general rigidity of water (in mekv/l) can be calculated under the formula

$$R = \frac{c(Ca^{2+})}{20{,}04} + \frac{c(Mg^{2+})}{12{,}16}$$

Where $c(Ca^{2+})$, $c(Mg^{2+})$ - concentration of ions $Ca^{2+}$ and $Mg^{2+}$, mg/l.

## The bases of the chelation therapy

Distribution of ions of metals in bioenvironments is defined as durability of formed complexes of metals with ligands, so concentration of these ligands. Coming, the metabolism, accumulation and allocation cations metals are regulated by special system of an elementary homeostasis. Infringement metall-ligandly a homeostasis is probably because of receipt cations toxic metals, because of deficiency or surplus cations biometals etc.

For maintenance metall-ligandly a homeostasis and allocation from an organism of ions of toxic metals in medicine there was the special direction concerning use complexions for linkage metall-ligandly of balance - chelation.

For example, at hit in an organism ions $Cd^{2+}$ with enzyme carboanhydraza form steadier complex connection and consequently supersede ion $Zn^{2+}$, a part of enzyme of an organism. As a result enzyme completely loses activity.

For deducing from an organism of an ion of a toxic element into an organism enter ligands which form steadier complexes with the last.

Ligands, applied in chelation are called as antidotes (antidote). They contain set of various functional groups which are capable to form with ions inorganic elements steady five-and six-member chelats. These properties of antidotes cause ability to formation of steady complex connections.

Clinical display of toxic action inorganic elements is shown within 8-12 hours after a sharp poisoning. Protective action of antidotes depends on speed of their introduction in an organism.

Such antidotes have found in medicine wide application as unitiol, dimercaprol (BAL), dimercaptoamberly acid, penicillaminum, aurintricarbonly acid, etilendiamintetracetic acid and it bisodium salt, pentacinum , etc.

In some cases for allocation from an organism of heavy metals use macrocyclic ligands, for example, criptands . Advantage of these antidotes consists that they form steady complex connections with certain metals-ions, i.e. their action is selective. For example, the antidot criptands with bioactive ions $Zn^{2+}$ and $Ca^{2+}$ does not form complex connections, and with ions inorganic elements, such as $Cd^{2+}$, $As^{3+}$, forms very steady complex connections and deduces them from an organism.

In medicine for treatment of the poisonings caused by increase in an organism of quantity of ions inorganic of elements, application simultaneously two and more various antidotes is possible.

## Training tasks and the standard of their decision

***Task №1.*** Constants of instability of complex ions $[Ca\ \gamma]^{2-} = 2x10^{-11}$, $[Mg\ \gamma]^{2-} = 2x10^{-9}$. Establish what of mentioned below reactions it is carried out first of all at titration $Ca^{2+}$ and $Mg^{2+}$ at joint presence at a solution. (To consider stability of complexes $Ca^{2+}$ and $Mg^{2+}$ with the indicator identical).

**The standard of decision**

The instability constant $[Ca\ \gamma]^{2-}$ is less, than $[Mg\ \gamma]^{2-}$ i.e. this complex ion stronger, and complexion III will co-operate first of all with $CaInd^-$, connecting

1. $Ca\ Ind^- + [H_2\ \gamma]^{2-} + OH^- \rightleftarrows [Ca\ \gamma]^{2-} + H\ Ind^{2-} + H_2O$
2. $Mg\ Ind^- + [H_2\ \gamma]^{2-} + OH^- \rightleftarrows [Mg\ \gamma]^{2-} + H\ Ind^{2-} + H_2O$

***Task №2.*** For titration of water of 50,00 ml at presence eriochrom black T it is spent 4,86ml 0,5050 mol/l of a solution complexion III. Calculate rigidity of analyzed water.

***Given:***

*V (compl.III) = 4,86ml*
*c (compl.III)= 0,05050 mol/l*
*V (H$_2$O) = 50,00 ML*

*R = ?*

***The standard of decision.***

Rigidity of water is defined under the formula:

$$R = \frac{c(complШ) \cdot V\ (komplШ)}{V\,(H_2O)} \cdot 1000$$

$$R = \frac{4{,}86 \cdot 0{,}05050}{50{,}00} \cdot 1000 = 4{,}9086 \text{mg/l}$$

*Answer: R = 4,91 mg/l*

***Task № 3.*** $ZnSO_4 \cdot 7H_2O$ possesses antiseptic action; 0,5 % (weights.) its solution is applied in the form of eye drops. Calculate volume 0,05000 mol/l of a solution complexion III, 20,00 ml of this solution spent for titration.

***Given:***

| | | |
|---|---|---|
| *ω % ($ZnSO_4 \cdot 7H_2O$)* | = | *0,5 %* |
| *c (compl. III)* | = | *0,0500 mol/l* |
| *V ($ZnSO_4$)* | = | *20,00 ml* |
| *M ($ZnSO_4 \cdot 7H_2O$)* | = | *287,54 g/mol* |
| *ρ* | = | *1,0 g/ml* |

*V (compl III) =?*

***The standard of decision.***

Complexion III forms with zinc ions chelate compounds with parity Me: ligand = 1:1.

1. As ρ = 100g/ml maintenance $ZnSO_4 \cdot 7H_2O$ in 20,00 ml we find a proportion:

100,00ml -0,5 $ZnSO_4 \cdot 7H_2O$
20,00 ml -X $ZnSO_4 \cdot 7H_2O$

$$x = \frac{20{,}00ml x 0{,}5g}{100{,}00ml} = 0{,}10g$$

1. Under the law of equivalents we define volume 0,5000 mol/l of a solution complexion III, spent for titration 0,10 g $ZnSO_4 \cdot 7H_2O$:

$$\text{V (compl.III)} = \frac{\text{m (ZnSO}_4 \cdot 7H_2O) \cdot 1000}{c(complIII) \cdot M(\text{ZnSO}_4 \cdot 7\text{H}_2\text{O})} \frac{g}{mol/l \cdot g/mol} = \frac{0{,}10 \cdot 1000}{287{,}3 \cdot 0{,}0500} = 6{,}96ml$$

*Answer:* V (compl III) = 6,96ml

**Questions and tasks for self-checking of mastering of a theme**

1. What class of connections concern complexions, and they are applied to what purposes?
2. Specify reactions which underlie complexonometrically definition of the general rigidity of water.
3. Specify a principle of action of metals-indicators.
4. Specify kinds of rigidity of water and ways of its elimination.
5. 4,58 ml are spent for titration of water of 50,00 ml at presence eriochrom black T 0,0511 mol/l of a solution complexion III. Calculate the general rigidity of analyzed water.

## Situational tasks

1. At hypertensive crises enter intramuscularly or intravenously 10-20ml 20-25 % (mac.) a solution of sulphate of magnesium $MgSO_4 \cdot 7H_2O$. Calculate volume of a solution 0,5235 mol/l complexion III, 2,00 ml of 20 % spent for titration (weights.) a solution of this substance. $\rho$ ($MgSO_4$) = 1,235g/ml
2. In medical practice the solution of chloride of calcium - $CaCl_2 \cdot 6\ H_2O$ is widely applied at various pathological conditions. Definitions of an ion of calcium in it spend method of complexonometrically in the presence of the indicator acid chrome dark blue. Calculate, what mass fraction (%) $CaCl_2 \cdot 6\ H_2O$ the solution is applied to intravenous introduction of a preparation, if 4,50 ml are spent for titration of 5,00 its ml 0,5028 mol/l of a solution III. $\rho$ ($CaCl_2 \cdot 6\ H_2O$) = 1,125 g/ml,

## Test questions

1. For what purpose in a method complexonometrically titration the ammoniac buffer is added?
a) For creation lightly acided environments
b) For creation of the acid environment
c) For creation of the alkaline environment
d) For creation it is weak - the alkaline environment
2. What salts cause time rigidity of water?
a) $CaCl_2$, $MgCl_2$
b) Ca $(HCO_3)_2$, Mg $(HCO_3)_2$
c) $CaSO_4$, $MgSO_4$
d) $CaSO_4$, $MgSO_4$, $MgCl_2$, $CaCl_2$
3. What salts cause constant rigidity of water?
a) $CaCl_2$, $MgCl_2$
b) Ca $(HCO_3)_2$, $Mg(HCO_3)_2$
c) $CaSO_4$, $MgSO_4$
d) $CaSO_4$, $MgSO_4$, $MgCl_2$, $CaCl_2$
4. How timely rigidity of water is eliminated?
a) boiling and addition $Ca(OH)_2$
b) Addition $Na_2CO_3$
c) Addition $Na_2CO_3$, NaOH, $Na_2R$
d)Addition $Na_2CO_3$ NaOH Ca $(OH)_2$ $Na_2R$
5. How constant rigidity is eliminated?
a) boiling and addition Ca $(OH)_2$
b) Addition $Na_2CO_3$
c) Addition $Na_2CO_3$ NaOH $Na_2R$
d) Addition $Na_2CO_3$ NaOH Ca $(OH)_2$ $Na_2R$
6. How the general rigidity is eliminated?

a) boiling
b) Addition $Na_2CO_3$
c) Addition $Na_2CO_3$ NaOH $Na_2R$
d) Addition $Na_2CO_3$ NaOH Ca (OH) $_2$ $Na_2R$

7. Quantity of that defines a method of complexonometric in live organisms?
a) Metals-ions
b) Acids
c) Bases
d) Salts

8. Specify the formula unitiola

a) HOOC-CH-CH-COOH
          |      |
         SH   SH

b) $CH_2$-CH-$CH_2$-$CO_3$Na
     |      |
    SH   SH

c) $CH_2$-SH
  |
  CH- SH
  |
  $CH_2$-OH

d) HS-C($CH_3$)- $CH_3$
           |
           CH-COOH
           |
           $NH_2$

9. Specify the formula of an antidot BALL

a) HOOC-CH-CH-COOH
          |      |
         SH   SH

b) $CH_2$-CH-$CH_2$-$CO_3$Na
     |      |
    SH   SH

c) $CH_2$-SH
  |
  CH- SH
  |
  $CH_2$-OH

d) HS-C($CH_3$)- $CH_3$
           |
           CH-COOH
           |
           $NH_2$

10. As connections which in medicine are applied to treatment of poisonings by heavy metals by their deducing from an organism in the form of solutions of complex connections are called
a) Complexons
b) Antidotes
c) Ingibitors
d) Promotors

## LABORATORY WORK.

### Control-analytically definition of the general rigidity of water

***Work technique:*** in a flask for titration to measure burette 100,00 ml of d water, to add 5,0 ml ammonia a buffer mix (pH=10), on a tip spatula - the indicator eriochrom black T (in a mix with dry NaCl) and to titr a standard solution complexon III before transition of wine-red colouring in dark blue (with a green shade). In the end of titration a solution complexon III to add slowly, on drops until the reddish shade will not disappear at all. Titration to repeat 2 more times, from converging results to take an average arithmetic and to calculate the general rigidity of water. Experimental data to bring in the table:

| №№ d. | V ($H_2O$), ml | V (compl.III), ml | c(compl.III), mol/l | The indicate |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| mean value | | | | |

The general rigidity of water ($Ca^{2+}$ and $Mg^{2+}$ on 1 l.) to calculate under the following formula in thousand shares of weight of equivalent:

$$R = \frac{c(complШ)\cdot V\,(complШ.)\cdot 1000}{V\,(H_2O)},\ mg\cdot eqv/l$$

## Tasks for the independent decision

1. What indicators are used in a method complexion
2. As the general rigidity of water is eliminated
3. 4,05 ml 0,05150 mol/l of a solution complexion III are spent for titration of water of 50,00 ml at presence eriochrom black T. Calculate rigidity of analyzed water.
4. For titration of water of 100 ml at presence eriochrom black T it is spent 8,55ml complexion III with molar concentration of equivalent 0,05420. Calculate the general rigidity of water.

## THE CHEMISTRY OF BIOGENIC ELEMENTS

**The employment purpose:** To acquaint students with section of bioinorganic chemistry - chemistry of biogenic elements. To acquaint with bases of the qualitative analysis.

**The importance of a studied theme.** The bioinorganic chemistry has arisen on a joint of inorganic chemistry, biology and biochemistry. The chemistry of biogene elements studying behavior of chemical elements in biological systems is one of sections of bioinorganic chemistry.

In a human organ the large quantity of chemical compounds is synthesised. The part of these connections is used as building materials for sources energy power and growth and development, other part in the form of a waste of this process provides to an organism, is deduced from an organism.

Six elements: carbon, oxygen, hydrogen, nitrogen, sulphur and phosphorus are synthesized in an organism as a result of its ability to live. Except these elements such vital elements participate in a metabolism (metabolism) as calcium, potassium, sodium, chlorine, magnesium, iron, fluorine being macrocells, and some microcells - a pine forest, aluminum, silicon, vanadium, chrome, manganese, cobalt, nickel, copper, zinc, iodine, bromine, strontium, molybdenum, etc.

Into a basis of live organisms enters more than 78 elements, and more than 99 % of weight of a human organ are necessary on a share of macrocells.

The majority of s-elements and d-elements are vital physiologically active biogene elements. There is a considerable quantity of medical products of s-elements I and II groups, and also d-elements, especially iron families.

Methods of the qualitative analysis are widely applied in medical practice to the analysis of biological objects: organs, tissue, biological liquids etc., medical products, sanitary-and-hygienic objects and a foodstuff.

**Initial level of knowledge**

1. Law of changes of properties of elements and their connections in connection with an arrangement in periodic system D.I. Mendeleev;
2. Electronic structure of atoms;
3. Types of chemical bonds in molecules;
4. Drawing up of the equations of chemical reactions in the molecular and ionic form.

**Teaching material for self-preparation**

1. N.L.Glinka chemistry, 1984, p. 543-652.
2. S.S.Olenin, G.N.Fadeev. Inorganic chemistry, M, 1979, p. 241-372
3. V.N.Alekseev the Course qualitative chemical half-microanalys, M, 1973, p. 121-344
4. K.A.Seleznev chemistry. M, 1973, p. 71-98
5. I.K.tsitovich the Course of analytical chemistry. M, 1985, p. 102-131.
6. H.H.Khakimov, A.Z.Tatar Periodic system and a biological role of elements, T, 1985, p. 16-64.

**On employment will be considered following questions:**

1. Chemistry of biogene elements - a basis of studying of a biological role of chemical elements in live organisms.
2. Biologically important s-elements.
3. Biologically important d elements
4. Biologically important p - elements.
5. Chemical properties s - elements.
6. Chemical properties d - elements
7. Chemical properties p - elements.
8. Application of connections s - p - and d - elements in medicine.

9. Bases of the qualitative analysis.
10. Analytical reactions on cations and aniones biogene s, d and p - elements.
11. Laboratory work

## THE INFORMATION BLOCK

The elements necessary for normal ability to live of an organism and making a basis of organic and inorganic connections is called as biogene elements.

The science which has arisen on the basis of biology, biochemistry and inorganic chemistry - bioinorganic chemistry is engaged in studying of the chemical reactions proceeding in an organism with participation of biogenic elements.

The biological role of elements is defined by their physicaly-chemical properties. Comparison of biological action of elements shows its certain interrelation with an arrangement in periodic table D.I. Mendeleyev. On degree of importance for ability to live they can be divided into three groups:

1. Biogene elements - the elements making a basis of live organisms, and the elements, which deficiency leads to pathological conditions. Them concern: H, O, N, C, P, S, F, Cl, I, Se, Na, K, Mg, Ca, Mn, Fe, Co, Cr, V, Cu, Zn, Mo, Ti, B, Si.
2. The elements which are not biogene, but a part of biogene medical products: Ag, Au, Al, Pb, Sb, Bi, Pt.
3. The elements which now are not a part of medical products.

Various organs keep in a human organ and accumulate certain elements in the certain quantities necessary for normal ability to live of given organ. The deviation from these norms leads to pathological conditions. Therefore introduction (or deducing) in a live organism of a necessary element is the important task of a medical science.

Now it is known more than 110 chemical elements, from them 92 elements meet in the nature. More than half from them are a part biological strainerem. 18 elements carry out the most important function in an organism. From them 6 elements (H, C, O, P, S, N) are a part some fibers, nucleinic acids and make a basis of ability to live of an organism. The others 12 elements (Na, K, Ca, Mg, Mn, Fe, Co, Cu, Zn, Mo, Cl, J) also participate in organism ability to live, from them 10 metals name biometals or life metals. These elements differ from each other both a structure of atoms and chemical properties, and their quantitative maintenance in an organism.

Elements with even serial numbers make more than 85 %, with odd - 15 % of weight of an organism.

In the course of ability to live vegetative and animal organisms acquire, accumulate and use various chemical elements.

The maintenance of chemical elements in an organism is influenced by following factors:

- Prevalence of elements in earth crust.
- Modular condition of their natural connections

- Solubility of natural connections of elements in water, etc.

Chemical elements get to a human organ from environment - air, soil, natural waters etc.

The structure of live organisms in considerable quantities includes only those elements, which most wide-spread in earth crust (oxygen, carbohydrates, hydrogen, nitrogen, calcium, magnesium, sodium, phosphorus, sulphur, chlorine).

Classification of biogene elements is spent to following signs:

On an electronic structure of atom

- Biogene s - elements. Them concern H, Li, Na, To, Mg, Ca, etc.
- Biogene p - elements. Them concern O, With, S, CI, P, In, etc.
- Biogene d - elements. Them concern Mn, Fe, Zn, With, Cu, Ni Cr, Mo, etc.

Depending on quantity of these elements in an organism them divide on:

- Macrobiogenly elements - the general maintenance in an organism of 0,01 % and more. Them concern About, C, H, N, S, P, Ca, Na, To, Mg, etc.
- Microbiogenly elements - the maintenance in an organism of $10^{-3}$-$10^{-5}$ %. Them concern Mn, Co, Cu, Mo, Zn, F, J, Br, etc.
- Ultramicrobiogenly elements - the maintenance in an organism less than $10^{-5}$ %. It Au, Se, Bi, Hg, etc.

On value of function carried out in an organism distinguish:

- The elements necessary for ability to live of an organism, which lack of an organism leads to serious pathologies. It is all macrobiogenly and some microbiogenly elements.
- Elements which can have the vital value. Elements which are available in biological systems concern them, but their participation in biochemical processes are not studied yet up to the end. Them concern Cr, Ni, Cd, etc.
- The elements, which biological value it is not revealed yet. They meet in an organism, but in what organs and tissue is not studied yet. Those concern them Tl, In, La, W, etc.

## Biologically important s – elements

S-elements of I group sodium and potassium are extremely important for normal ability to live of an organism. These are macrocells. They are distributed on all human organs. Sodium in the form of an ion is a part of various biomolecules. Together with ions potassium, calcium, magnesium, chlorine going for transfer of nervous impulses and a condition of muscles. Ions of sodium are a part of intercellular liquids, potassium - in structure of endocellular liquids. The shock at heavy burns is caused by loss $K^+$ from cells. Ions of sodium and kalii are responsible for maintenance of osmotic pressure on both parties of a cell. Cations sodium in a kind anti-ions in connections with phosphoric acid and organic acids support acid - the basic balance in organism bioliquids. Potassium it is necessary for functioning of enzymes, catalising Phospholiring carboxy groups or enolly anions, and also reactions eliminiritionly with formation enols.

Biogenic s-elements of II group magnesium and calcium are macrocells of a live organism. Exists about one and a half tens enzymes which are activated by ions $Mg^{2+}$. This element participates in the important reaction of transformation of system ADF in ATF. Magnesium has antiseptic, vasodilating an effect on an organism, lowers arterial pressure. In flora its role is great - it contains in a chlorophyll - about 2 % (weights).

The necessary quantity of salts of magnesium in an organism is created at the expense of fruit and vegetables. Especially a lot of magnesium contains in apricots, peaches, a cauliflower, a potato and tomatoes. The organism acquires no more 40%magnii, being in food as connections of this element are badly soaked up by intestines. The acquired magnesium collects in a liver, and then passes in muscles and bones. In muscles it strengthens processes of an exchange of carbohydrates, and in bones together with calcium is one of the major substances. At infringement all magnesium passes balance magnesium-calcify in muscles and bones, supersedes from them calcium and causes a rickets.

Magnesium participates in formation and disintegration of carbohydrates and fats. It carries out the big role in brain activity. Its lack causes convulsive attacks as a result of hypererethism of impellent and sensitive nerves, raises predisposition to heart attacks.

Calcium is a vital element. In an organism it is in a kind of ions and in the connected condition with fibers and lipids. Calcium ions get to an organism with vegetative food and milk.

Calcium makes about 2 % from weight of a organ of the person. The great bulk of calcium at the person is in bone and tooth tissue in the form of phosphate, a carbonate, fluoride. In tissue its concentration is small. In blood at normal growth and development of the person the maintenance of calcium within 9 - 11 mg of %. Reduction of this concentration is accompanied by increase of excitability of nervous system. The ionized calcium participates in process of curling of blood, in processes of reduction and a relaxation of muscles, etc. calcium Ions are extorted from the majority of cells. So, from mucous intestines calcium - the connecting fiber which synthesis depends on vitamin D is allocated and calcium - connecting fiber is similar with muscular. Vitamin D regulates a calcium exchange in an organism. At its introduction in an organism the maintenance calcium - the connecting fibers promoting soak up of calcium in intestines increases. The vitamin D lack worsens calcium mastering that leads to a rickets.

Ions $Ca^{2+}$ can be replaced with number ions alkaline metals, for example strontium ions. The last leads to heavy occupational diseases.

In considerable quantities calcium can have toxic an effect. At some pathological processes when the calcium exchange is broken, there can be an adjournment of its connections on walls of cells, blood vessels, joints, bones that leads to occurrence of a glaucoma, an atherosclerosis, urolithic illness, a gout.

## Biologically important d-elements

D-elements are physiologically active. Many of them are considered vital as stimulate process of haemoforming or make the expressed impact on it. They are a part some many enzymes, participate in bioredoks-processes in a live cell. Among them the important place belongs to transitive elements, i.e. elements which have blank d subtotals. Them concern Cn, Zn, Mn, Fe, C, Ni, Cr, Mo, etc.

Copper is a d-element of I group. It has the major value for organism ability to live. Its physiological depot is the bone liver, a brain. Copper in a small amount also contains in bones and a brain. Copper makes $1 \cdot 10^{-4}$ % (weights.) an organism. The daily requirement of an organism for copper makes 2 - 3 mg. From this quantity of 30 % it is acquired by an organism. In live cells copper almost entirely is in a complex with fiber.

Copper is a part some many fabric fibers and enzymes, for example, oxydase, tyrosinase, lactase, haemocianin, capable to transfer oxygen like haemoglobin.

Copper is a part some oxidation-reduction enzyme - cytochromoxydase, is a molecule integral part ceruloplasmin. Change of its maintenance leads to pathological conditions. So, Wilson's illness arises owing to accumulation of superfluous quantity of copper in a liver and a brain. At surplus of copper it is the blocked phermentativ process promoting transition of copper from plasma in ceruloplasmin. Thus coming copper in a liver and its inclusion in ceruloplasmin sharply decreases, and the quantity of the copper connected with albumin increases

Copper is an irreplaceable microcell. In a live organism copper shows specific action on processes haemoforming. Opinions are expressed, that it is necessary for transformation of inorganic iron in haemoglobin. Copper stimulates maturing reticulocytes and their transition in erythrocytes. Its lack of an organism conducts to development of a sharp anaemia, a diarrhoeia in chest children, to syndrome Menkes. Syndrome of Menkes at children is connected with genetically caused defect soaking up a copper ion. Its characteristic signs-intellectual backwardness, gypotermity, destruction of the ends of long bones, etc.

Along with that copper ions can participate in phermentativly processes in a role of a carrier of electrons, they can strengthen process of formation of complexes and preservation of tertiary structure of enzymes. Copper can inactivate enzyme, catalyzing insulin destruction - insulin’s.

Copper raises activity of some hormones, participates in fermentable oxidation, fabric breath, immune processes, pigmentation.

Zinc is biogenic d elements of 1 group. In a human organ contains $1 \cdot 10^{-3}$ % (weights) of zinc. The daily requirement of an organism for this element makes 10-15 mg. The zinc arriving in an organism together with food, is soaked up in the top departments of a thin gut. Then it arrives in a liver, there it is depositioned and spent necessarily.

The greatest quantity of zinc is found out in a mesh cover of an eye, in glands of internal secretion, a liver and muscles.

Cation zinc is cofactor variety of enzymes, for example, carboanhydrase, carboxypeptidase, alcogoldehydrogenase, etc. Zinc has normalising an effect on a sugar exchange, therefore is a part some insulin. The lack of zinc of a food leads to growth delay, loss of hair, oppression of sexual functions.

Zinc is an irreplaceable microcell for a life. Unactively participates in such vital processes as an exchange of carbohydrates, fibers and fats.

Zinc ions activate alkaline phosphotase. Believe, that the zinc ion keeps structure of enzyme and fixes the certain rests of amino acids. Zinc activates hormones of a hypophysis and also sexual hormones. Participates in haemopoesis and activity of glands of internal secretion, promotes removal from organism $CO_2$ Manganese is biogenic d - an element of VII group. In a human organ $1\text{-}10^{-3}$ % (weights contain.) manganese. From foodstuff especially rich with it a red beet, a tomato, a soya, peas, a potato.

Most of all manganese contains in muscles, a brain, kidneys, a liver, a thyroid gland, a spleen, bones etc. Daily requirement of the person for it nearby 6mg. Children require considerable quantities of this element as it promotes normal development and growth.

Manganese belongs to number of few elements, capable to exist in eight various conditions of oxidation, however in biological systems two are realised only: $Mn^{2+}$ and $Mn^{3+}$, sometimes $Mn^{4+}$. The probability of formation and existence in an organism anionly manganese forms is practically insignificant because of their very strongly pronounced oxidizing properties. $Mn^{2+}$ similarities with $Mg^{2+}$ can to replace it in complexes from DNA. Many complexes $Mn^{3+}$, for example $(Mn(C_2O_4)_3)^{3-}$oksalatnyj, are quite steady.

This element well influences growth and development, on processes of reproduction and cellular division, oxidizing phosphorylation in liver tissue, strengthens action of hormones (insulin, etc.) Photosynthesis in many plants is impossible in its absence. In blood of the person and the majority of animals contains about manganese 0,02mg/l. It in a combination to iron, copper and cobalt influences processes haemoforming, accelerates formation of antiorgans, neutralized harmful action of alien fibers. Manganese reduces the sugar maintenance in blood and favorably influences a condition sick of a diabetes. Besides, it renders lypotroply action and atherosclerosis development brakes. Manganese is necessary for activation of some enzymes, for example dehydrogenase and decarboxylasis. Without the enzymes containing manganese, specific metabolic processes, for example urine formation are impossible.

It is a part some such enzymes, as arginase, phosphotranspherase, as irreplaceable metallocomponents. Metallopherments, containing manganese, catalyst as hydrolytically, and oxidation-reduction processes. At its participation in an organism ascorbic acid (vitamin C) is synthesized.

Manganese plays a considerable role in a metabolism. It influences an exchange of vitamins $B_1$ and v in albuminous (raises disintegration of fabric fibers, lowers fat adjournment in an organism) and mineral (promotes mastering of phosphorus, calcium, iodine) an exchange. Its lack of a diet can cause pathological adiposity and infringement of process of ossification, promotes occurrence endomily a craw as participates in synthesis of hormones of a thyroid gland.

Also manganese participates in skeleton formation in immunity reactions, in haemopoesis and fabric breath.

The superfluous quantity of manganese operates as poison, causing various frustration of nervous system.

Iron, cobalt and nickel concern to d - to elements of family of iron. These elements are physiologically active and irreplaceable.

Iron - the most widespread element. In a human organ contains $1 \cdot 10^{-5}$ % (weights) of iron. Iron carries out the important function in physiology of plants, animals and the person the lack of iron at plants breaks a nitrogenous and mineral exchange, at animals causes microcytarly an anaemia, in the person - an alimentary anaemia - decrease in level of haemoglobin. It is the vital element. In a human organ gland contains 4-5 g. The depot core are erythrocytes, a liver, a spleen. Already that fact, that 60 - 72 % of iron containing in a human organ is in haemoglobin, testifies to its extremely important function in process haemoforming. In haemoglobin iron is in a kind chelatly a complex with protoporphyrin - haema. Haemoglobin carries out two biological functions: the atoms of iron connects molecules of oxygen and transfers from lungs to muscles where they are transferred to molecules mioglobin; after that haemoglobin uses some amino groups for linkage of molecules of carbonic gas and transfers them back to lungs.

Depending on connected liganda iron is in this or that valency condition: $Fe^{2+}$ - in haemoglobin, mioglobin; $Fe^{3+}$ - in catalase, oxydase.

Ferriferous fibers possess various action: haemoglobin transports oxygen, mioglobin reserves it in the connected kind, cytochrome-*c*-oxydase restores oxygen to water, cytochrome P catalisate oxidation by oxygen, in electron carrying over participate cytochromes *в* and *c*.

In the nature the big number of ferriferous fibers is known. They participate in oxidation-reduction reactions, carry out carrying over of electrons at photosynthesis, fixings of nitrogen, oxygen and etc. Fibers are called Ferrodoxyns. Into them enters from one iron to eight atoms connected through cysteinly the rests with polipeptid chains. Iron participates in process haemoforming, breath and oxidation-reduction reactions.

High biological activity cobalt possesses also. It is a vital microcell. Cobalt makes $1 \cdot 10^{-6}$ % (weights) of an organism. The depot core are a liver, kidneys, blood, a spleen, a pancreas, a hypophysis, a thyroid gland, eggs, a bone fabric. The daily requirement of an organism for cobalt makes about 0,001 mg. It is a part some vitamin $B_{12}$ - cianokobalamin. In vitamin $B_{12}$ it 4,0 % contain. Cobalt participates in synthesis of some enzymes (glycindipeptidase, holinisterase, acilase), a hormone of a thyroid gland, etc., stimulates process haemoforming, regulates a carbohydrate exchange.

He participates in haemoglobin synthesis, its lack causes a malignant anaemia. Cobalt participates in activation of many enzymes, is a part etanolaminoxydase, glycilglycinpeptidase, etc.

Cobalt salts strengthen accumulation nicotinamydum and pyridoxinum in an organism, positively influence an albuminous exchange, take part in a carbohydrate, mineral exchange. Surplus of cobalt in an organism lowers thyroid gland function, its surplus in soil, in a foodstuff influences distribution endomily a craw at the person and animals.

Nickel on the behaviour in biosystems is close to cobalt. In a human organ contains $1 \cdot 10^{-6}$ % (weights) of nickel. It concentrates in a liver, kidneys, a pancreas, a hypophysis, a skin, in a cornea of eyes. Now there are data about specific influence of nickel on Fermentativity processes its occurrence in structure urease, urea participating in splitting, for example, is revealed. Nickel activate enzyme angidrase, bb influences oxidising processes and a carbohydrate exchange. It is a part some insulin. There are sights about vital necessity of this element.

Chrome and molybdenum are physiologically active d-elements of VI group. Chrome widespread in vegetative and phauna, however about its physiological role now it is known a little. In a human organ contains $1 \cdot 10^{-5}$ % (weights) of chrome. It concentrates in hair and nails. Chrome takes part in a glucose exchange, influences carbohydrate balance at a diabetes. It is included into the active centre of enzyme tripsin and also activates oxidising processes. There are data about similarity of its biological action to manganese.

Molybdenum has physiological value both for plants, and for the person. In a human organ $1 \cdot 10^{-5}$ % of weights) molybdenum contain. It concentrates in a liver, kidneys, an adrenal gland, a pigmentary cover of an eye. At plants it promotes nitrogen mastering, is a part some enzyme nitratreductase. In an animal organism molybdenum is a part some fabric fibers and many enzymes: xantinoxydase, hydroginase, xantindehydrogenase, sulphitoxydase, aldegidoxydase. Molybdenum accelerates growth, its surplus leads molibdenly to a gout.

## Biologically important p - elements

Carbon - a basis of the organic world of all live organisms. In a human organ carbon arrives with a phytogenesis foodstuff, and also with potable water in the form of carbonates and bicarbonates. From an organism it is allocated basically with exhaled air (about 90 % of the carbon arriving in an organism daily with a natural foodstuff). Carbon - one of the major macrobiogenly elements. In a human organ 20,2 % (weights contain.) carbon. It is a part some fibers (about 52 %), molecules of DNA and the RNA (about 37 %), enzymes, hormones, vitamins. At the same time at long receipt in lungs of a coal dust there is a disease antracose. At expressed antracose there is an irritation of a fabric, and also blockade by dust particles of lymphatic system of lungs to infringement of a current of a lymph.

Nitrogen - one of the basic biogene macrocells. Such important parts of cells as protoplasm and a kernel, are constructed of albumens. Fiber cannot exist without nitrogen, and without fiber there is no life. Primary structural elements of fibers are the amino acids which name says that it nitrocontaining connections.

Into structure of fibers on the average enters 15 - 17 % of nitrogen. Catalysts of vital processes - enzymes, and also the majority of hormones and vitamins contain nitrogen. In a live organism constantly occurs both destruction of cells, and their reproduction (incessant disintegration and synthesis of fibers). Nitrogen makes approximately 3 % of weight of a organ of the person. The person receives nitrogen not from air, and from nitrocontaining food. Long exalbuminous a food inevitably leads to death. The requirement for fiber of the adult person who is engaged in brainwork, makes nearby 100g, physical - nearby 130-150g. The person receives this quantity with food at a normal food. Fibers of food before are acquired by an organism, are split to amino acids making them. The fund of amino acids is spent for biosynthesis of fibers and many other things connections, on power expenses and formation of end-products of the exchange which is subject to deducing. Functional groups of amino acids are widely involved in various reactions of a metabolism.

All antibiotics - the natural connections, capable to kill a microorganism or to suppress their development, also contain nitrogen.

Many medical preparations - amino acids, vitamins, hormones - contain nitrogen in such form in which it is necessary for ability to live.

Phosphorus, as well as the nitrogen, necessary element in live organisms. Its big quantity is in soil, from it it gets to plants, from them passes in a human organ and animals.

In a human organ contains about 1,16 % of phosphorus (-86 % is in a kind of difficultly soluble phosphate of calcium in bones and a teeth). Bones of the person consist basically from hydroxylapatit, enamel of a teeth contains hydroxylapatit with an impurity Phtorapatit. The phosphorus part is in soft tissue. Phosphoric acid and its connections take part almost in all physiological processes. Phosphate-ion plays the important role in formation of high-energy connections (for example, ATF), in a carbohydrate exchange, is a part of the RNA, phospholypids, is the predecessor in synthesis of genetically important connections (for example, DNA), takes part in creation of buffer capacity of liquids and organism cells.

Daily requirement of an organism for phosphorus-2,94g. Its big quantity arrives in an organism with such products, as milk, meat, a bird, fish, a flour, bread, vegetables etc. It is usually soaked up about 70 % of phosphorus consumed with food.

Oxygen is one of the most vital macrocells. In a human organ contains about 65 % (weights.) oxygen. It is the important component of carbohydrates, fats, the fibers, all organs, tissue, biological liquids, etc.

The adult person in a rest condition uses for breath nearby 0,5$m^3$ air at an o'clock, and only the fifth part of oxygen containing in this quantity of air, is kept in an organism. Other quantity of oxygen is necessary for maintenance parcial the pressure promoting diffusion through air cells.

The most widespread in a live organism oxygen connection is water. Water it not only environment in which vital processes proceed, and and substance which actively participates in reaction of hydrolysis and other vital processes.

Decrease in the maintenance of oxygen in an organism reduces its protective properties. Oxygen with coal acid (carbogen) raises respiratory and the vascular moving centres. It is applied in devices of a various design to maintenance of breath of divers, fire, in mining (in particular, saving) business, in medicine etc.

In a human organ 0,16 % (weights contain.) sulfurs. It is an irreplaceable component of live organisms which is a part some many fibers and the important amino acids which are a component of albuminous molecules. Sulphur is included also into structure of hormones, vitamins and nucleinic acids. In a live organism the sulphur which is a part sulphurocontaining of amino acids Phermentativity is oxidised to sulphates, acids and elementary sulphur are partially formed tiosulfats, politionises.

Fluorine a widespread element of earth crust. It meets basically in the form of connections. Minerals have the greatest value: fluor-spar (fluorite), criolit, Phtorapatit. In a human organ contains $1 \cdot 10^{-50}$ % (weights.) Fluorine, with food in an organism arrives nearby 1ml a day. The fluorine maintenance in potable water influences a condition of a teeth at the person and animals. The norm considers the maintenance 1mg fluorine in 1l waters; at the maintenance of less 0,5mg/l caries develops, and over 1,2mg/l is observed enamels, that is in both cases a teeth quickly collapses. Fluorine in an organism forms complex connections with calcium, magnesium and other elements - activators of fermental systems. Fluorine at introduction in an organism of considerable quantities replaces the iodine containing in a hormone tyroxin and by that oppresses thyroid gland activity. It depressing operates on many enzymes, influences an exchange of vitamins. Fluorine is a part neurolepticaly of preparations. For example, Phtorphenasinum it is effective at a schizophrenia with a long current of disease. Phtoracisinum antidepressive an effect has; Phtoriracilum, Phtoraphur, Phtorbenzoteph are used at malignant new growths; Phtorotan - means for removal of an inhalation narcosis; Phtorocort - the ointment applied externaly at inflammatory and allergic skin diseases. A mix of chloride and calcium fluoride in suspension gelatin fluorinates water.

Chlorine a-macrocell necessary for normal ability to live of an organism. Chlorine - active metalloid. It is gas it is yellow - green colour with a sharp suffocating smell. It causes irritation of mucous membranes of respiratory ways, burning in a mouth and cough, and inhalation of its big quantities can lead to death from an asthma as this element inhaled together with air, even in small quantities corrodes a mucous membrane of lungs (it becomes nontight for water, and blood plasma gets through it into alveoluses and there comes a hypostasis of lungs). Therefore maximum permissible concentration of chlorine in air - 0,001mg/l.

In a human organ $1 \cdot 10^{-2}$ % (weights contain.) chlorine. Mainly it is concentrated in an extracellular liquid, participates in formation of hydrochloric acid which makes 0,4 - 0,5 % of gastric juice and accelerates hydrolysis of fibers, provides high activity protoliticaly enzymes and possesses bactericidal properties. In a human organ 0,25 % anion chlorine contain approximately. It is necessary for maintenance of normal ability to live as creates the favorable environment for action protoliticaly enzymes of gastric juice, influences on electroconduction cellular membranes, takes part in formation of buffer system of blood, a aqua-salt exchange. The maintenance of hydrochloric acid in gastric juice deviates norm at various diseases, therefore with the diagnostic purpose it is necessary to define its quantity in gastric juice.

In the nature bromine meets basically in the form of bromides alkaline and alkaline elements together with chlorine connections, but in smaller quantities. Besides, it contains in sea, soil and underground waters. It is active metalloid, at a room temperature a mobile dark-brown liquid, easily evaporating, forms, red-brown steams with a sharp suffocating smell which cause strong burns of a skin and irritate mucous eyes, mucous membranes of respiratory ways. Inhalation of its steams dangerously. Organic connections of bromine (bromaceton, brombenzil-cianidum), causing strong lacrimation (lacrimators), are applied as poison gases of rarefying action.

Bromine is found out in many organs, but its most active action is shown in a hypophysis.

Bromine gets to an organism with food (7,5mg a day) and concentrates basically in soft tissue and blood. In a human organ $1 \cdot 10^{-4}$ % (weights contain.) bromine. It takes part in biosynthesis of sexual hormones and regulation of function of sexual glands. The basic positive function of bromine in a live organism - bromine, strengthening braking processes has salutary an effect on the central nervous system, therefore in medicine many salts and organic connections of bromine (carbromal, bromizoval, brotural, bromital, bromkafora), having calming and somnolent an effect find application.

In the nature iodine meets in a kind iodids sodium and calcium. To 0,3 % of iodine contains in the form of an impurity iodats in the Chilean saltpeter. Besides, iodine concentrates in various sea organisms. It receive from chisel waters and sea seaweed. It has one natural isotope $^{127}I$. Iodine - firm substance with weak metal shine. At heating it is sublimated without fusion, forming violet steam. At cooling of pair iodine crystallise, passing a liquid condition. It differs weak solubility. In field conditions iodine use for water disinfecting. Its solubility in water makes all 0,3g/l, therefore for reception of iodic water usually in water dissolve small amount KI.

In a human organ $1 \cdot 10^{-6}$ % (weights contain.) iodine. He plays the important role in metabolism regulation. In an organism iodine mainly collects in a thyroid gland (15mg from total - 25mg). With iodine are rich onions and sea fish. It an obligatory component tyroxin and triyodtyronin - the hormones developed by a thyroid gland. Superfluous long coming iodine in an organism at first brakes thyroid gland function, and it sharply reduces production of hormones, then its activity excessively increases, that can lead to development thyreotoxicose. Usually this disease the population of those districts in which air, water and food contain not enough iodine suffers.

Molecular iodine renders anti-microbly action, its solutions are used for processing of wounds, preparation of an operational field etc. Being soaked up, it actively influences a metabolism (in particular lypidly and albuminous), strengthens dissimilation process, influences thyroid gland function, participating in synthesis tyroxin. The daily requirement of an organism for iodine makes nearby 200 - 220mkg.

## Chemical properties of the biogene s - elements.

### S elements of 1 group and property of their connections.

S elements of 1 group - sodium, kalii, name alkaline metals. On an external electron sheath atoms of alkaline metals have on one electron - $nS^1$. In comparison with other elements they have the greatest radiuses of atoms and ions and the least value of energy of ionisation. These are chemically active metals, very strong reducers, show only positive degree of oxidation +1:

$Me^0 - 1\bar{e} \longrightarrow Me^+$

Their chemical activity grows from sodium to calii. They very much reactionly capable in relation to the electronegative elements, many difficult substances:

$2Na + O_2 = Na_2O_2$ $2K + S = K_2S$

$2K + Cl_2 = 2KCl$ $2K + NH_3 = 2KNH_2 + H_2$

$2 Na + 2H_2O = 2 NaOH + H_2$

With nonmetals they form ionic connections: NaCl, NaBr, $Na_2S$, etc. With hydrogen easily form hydrides:

$2K + H_2 = 2KH$

Oxydes alkaline metals - reactionly capablee substances which vigorously co-operate with water and form soluble in water hydroxydes - alkalis: $Na_2O + H_2O = 2 NaOH$. Salts of these metals are practically known for all acids. As a rule, it is connections with prevalence of ionic type the communications much soluble in water. The salts formed by weak acids, in water are hydrolyzed, creating the alkaline environment:

$Na_2CO_3 + H_2O \rightleftarrows NaHCO_3 + NaOH.$

**Calcium and magnesium** concern to biogene S to elements of II group. Magnesium a typical element, calcium - an alcalinly-ground element. On an external electron sheath atoms have 2 electrons - $nS^2$. They have strongly pronounced metal properties, conceding in activity only to alkaline metals. Are strong reducers, showing only positive degree oxidation+2:

$Me^0 - 2\bar{e} \longrightarrow Me^{2+}$ .

Calcium unlike magnesium, are characterised by rather big nuclear radius and low value of energy of ionisation. On air they quickly are oxidised, co-operate with many electronegative elements.

$2Ca + O_2 = 2CaO$ $3Ca + N_2 = Ca_3N_2$

$Ca + S = CaS$ $Ca + Cl_2 = CaCl_2$

Calcium directly co-operates with hydrogen:

$$Ca + H_2 = CaH_2.$$

Force of the bases increases among: $Mg(OH)_2 \longrightarrow Ca(OH)_2$. In this number solubility increases in water of these hydroxydes. On the contrary, if the majority of salts of magnesium soluble in water, at calcium soluble sour salts, chlorides, nitrates, and the majority of salts difficultly soluble.

Magnesium, unlike calcium, forms complex connection: $[Mg (H_2O)_6]^{2+}$.

## Chemical properties of d-elements

Copper concerns to d-elements of I group. An electronic configuration of its atom $3d^{10}4s^1$. Its chemical activity is insignificant. Copper is a weak reducer and is oxidised hardly. Electrons participate in formation of communication at atom of this element both external, and preexternal level. For copper characterised degrees of oxidation +2, +1.

At usual temperature halogens and oxygen on it operate. With hydrogen, nitrogen, carbon it directly does not co-operate. The acids which are not possessing oxidising properties, do not dissolve it. The concentrated and diluted acid $H_2SO_4$,concentrated and diluted $HNO_3$ cooperates with it very well:

$Cu+2H_2SO_4=CuSO_4+SO_2+2H_2O$

$Cu + 4HNO_{3\,(conc.)} = Cu(NO_3)_2+2NO_2+2H_2O$

$3Cu + 8HNO_3\ (_{sol}.) = 3Cu(NO_3)_2 + 2NO + 4H_2O$

---

Oxids and hydroxids of copper - is rather fragile connections, are insoluble in water. At heating hydroxid of copper decays:

$$Cu(OH)_2 \xrightarrow{t} CuO + H_2O$$

Copper is fine complexoforming, forming cation and anion complex connections with coordination number 4 and 6:

$Cu\ (H_2O)_6]^{2+}$; $[Cu\ (NH_3)_4]^{2+}$; $[Cu\ (H_2O)_4(NH_3)_2]^{2+}$; $[Cu\ (OH)_4]^{2}$

Well soluble salt of copper: chlorides, sulphates, nitrates, acetates.

---

**Chrome** concerns d-elements of VI group. An electronic configuration of its atom $3d^54s^1$. Chrome shows variable degree of oxidation +2, +3, +6. At communication formation electrons of external and preexternal level participate.

It is firm metal. At heating co-operates with many nonmetals:

$$4Cr + 3O_2 = 2Cr_2O_3$$

$$2Cr + 3Cl_2 = 2CrCl_3$$

At interaction with the diluted sulfuric acid supersedes hydrogen:

$$Cr + H_2SO_4 = CrSO_4 + H_2$$

Chemical properties of chrome are defined by its degree of oxidation.

$Cr^{2+}$ - a strong reducer.

$$CrCl_2 + O_2 + 4HCl = 4CrCl_3 + 2H_2O$$

| | | |
|---|---|---|
| $Cr^{+2} - 1e \rightarrow Cr^{3+}$ | 1 | 4 |
| $O_2^0 + 4e \rightarrow 2O^{-2}$ | 4 | 1 |

$Cr^{2+}$ - a weak reducer:

$$2NaCrO_2 + 3Br_2 + 8NaOH = 2Na_2CrO_4 + 6NaBr + 4H_2O$$

| | | |
|---|---|---|
| $Cr^{3+} - 3e \rightarrow Cr^{+6}$ | 3 | 2 |
| $Br_2^0 + 2e \rightarrow 2Br^-$ | 2 | 3 |

$Cr^{6+}$ - a strong oxidizer:

$$K_2Cr_2O_7 + 3H_2S + 4H_2SO_4 = Cr_2(SO_4)_3 + 3S + K_2SO_4 + 7H_2O$$

| | | | |
|---|---|---|---|
| $2Cr^{+6} + 6e \rightarrow 2Cr^{+3}$ | 6 | 3 | 1 |
| $S^{-2} - 2e \rightarrow S^0$ | 2 | 1 | 3 |

CrO, Cr (OH) $_2$-shows the basic properties:

$$Cr(OH)_2 + 2HCl = CrCl_2 + 2H_2O$$

$Cr_2O_3$, Cr (OH) $_3$-shows amphoteric properties:

$$Cr(OH)_3 + 3HCl = CrCl_3 + 3H_2O$$

$$Cr(OH)_3 + 3NaOH = Na_3[Cr(OH)_6]$$

$CrO_3$, $H_2CrO_4$, $H_2Cr_2O_7$- shows the acid properties:

$$H_2CrO_4 + 2NaOH = Na_2CrO_4 + 2H_2O$$

**Zinc** concerns to d-elements of 2 groups. An electronic configuration of its atom $3d^{10}4s^2$. It is last d-element in the period, has finished $d^{10}$ a configuration of a preexternal layer. It it differs from other d-elements and shows certain similarity to p-elements of the big periods. It shows positive degree of oxidation $M^{2+}$.

Zinc-heavy metal, a reducer. On air it is steady because of presence on a surface oxide films. At heating easily co-operates with many nonmetals:

$$2Zn + O_2 = 2ZnO$$

$$Zn + Cl_2 = ZnCl_2$$

In an electrochemical number of pressure zinc is located to hydrogen, therefore supersedes it from acids:

$$Zn+2HCl=ZnCl_2+H_2$$

Zinc at heating is dissolved in solutions of alkalis:

$$Zn+2NaOH+2H_2O=Na_2[Zn(OH)_4]+H_2$$

Forms oxids and hydroxids. Oxids and hydroxids of zinc show ampfoteric properties:

$$Zn(OH)_2+2HCl=ZnCl_2+2H_2O$$

$$Zn(OH)_2+2NaOH=Na_2[Zn(OH)_4]$$

$$Zn(OH)_2+2NaOH=Na_2ZnO_2+2H_2O$$

Zinc forms complex connections cation and anion type with coordination number 4 and 6:

$$[Zn(OH)_4]^{2-} \quad [Zn(NH_3)_6]^{2+} \quad [Zn(H_2O)^6]^{2+}$$

The majority of salts of zinc in water is marginally soluble. Chlorides, nitrates, sulphates are soluble. All salts in a water solution are exposed to hydrolysis and have the sour environment:

$$Zn(NO_3)+H_2O \leftrightarrow ZnOHNO_3+HNO_3$$

$$ZnOHNO_3+H_2O \leftrightarrow Zn(OH)_2+HNO_3$$

**Manganese** concerns to d to elements of VII group. An electronic configuration of its atom (n - 1) $d^5nS^2$. This element shows variable degree of oxidation. For manganese most typical degrees of oxidation +2, +3, +4, +6, +7. Electrons participate In communication formation both external, and preexternal levels.

As metal manganese is active enough. At heating easily co-operates with many nonmetals, the water, the diluted acids, allocating hydrogen:

$2Mn + N_2 = Mn_3N_2$

$Mn + O_2 = MnO_2$ $\qquad$ $Mn + 2HCl = MnCl_2 + H_2\uparrow$

Chemical properties of connections of manganese depend on degree of its oxidation.

So connections $Mn^{2+}$ are *reductants:*

$2MnSO_4 + 5PbO_2 + 6HNO_3 = 2HMnO_4 + 3Pb(NO_3)_2 + 2PbSO_4 + 2H_2O$

| | | | |
|---|---|---|---|
| $Mn^{2+} - 5e \longrightarrow Mn^{7+}$ | 5 | 2 |
| $Pb^{4+} + 2e \longrightarrow Pb^{2+}$ | 2 | 5 |

*Connections* $Mn^{4+}$ *weak reducers* -

$3MnO_2 + KClO_3 + 6KOH = 3K_2MnO_4 + KCl + 3H_2O$

| | | | | |
|---|---|---|---|---|
| $Mn^{4+} - 2e \longrightarrow Mn^{6+}$ | 2 | 1 | 3 |
| $Cl^{5+} + 6e \longrightarrow Cl^{-}$ | 6 | 3 | 1 |

*Connections* $Mn^{7+}$ *are strong oxidizers*

$2KMnO_4 + 5K_2SO_3 + 3H_2SO_4 = 6K_2SO_4 + 2MnSO_4 + 3H_2O$

| | | |
|---|---|---|
| $Mn^{7+} + 5e \longrightarrow Mn^{2+}$ | 1 | 2 |
| $S^{4+} - 2e \longrightarrow S^{6+}$ | 2 | 1 |

*Connections* MnO, $Mn(OH)_2$ *basic properties* -

$Mn(OH)_2 + 2HCl = MnCl_2 + 2H_2O$

*Connections* $Mn_2O_3$, $Mn(OH)_3$ *show amphoternly properties with prevalence of the basic character* :

$2Mn(OH)_3 + 3H_2SO_4 = Mn_2(SO_4)_3 + 6H_2O$

$Mn(OH)_3 + 3NaOH = Na_3MNO_3 + 3H_2O$

*Connections* $MnO_2$, $H_2MnO_3$ *show amorphous properties with prevalence of acid character*:

$H_2MnO_3 + 2NaOH = Na_2MnO_3 + 2H_2O$

$H_2MnO_3 + 4HCl = MnCl_4 \rightarrow MnCl_2 + Cl_2 + 2H_2O$

*Strengthening the basic properties* ←

$Mn(OH)_2$, $Mn(OH)_3$, $Mn(OH)_4$, $(H_2MnO_4)$, $HMnO_4$

*Strengthening the acid properties*. →

With increase in degree oxidations acid properties amplify and the basic properties weaken.

Manganese forms in all valency conditions numerous complex connections cationly and anionly types. Coordination numbers 6 are typical for it and 4:

$[Mn(H_2O)_6]^{2+}$, $[Mn(OH)_4]^{4-}$, $[Mn(CN)_6]^{4-}$, $[MnF_6]^{2-}$, $[MnF_6]^{4-}$, etc.

Neutral complexes - carbonils - $[Mn_2(CO)_{10}]$ are known.

Chlorides, sulphates, nitrates, manganese acetates, manganates, permanganates of alkaline metals easily soluble in water, not soluble hydroxydes, sulfids, carbonates, phosphates and others.

Salts of $Mn^{2+}$ in water solutions are hydrolyzed, permanganates alkaline metals to hydrolysis are not exposed.

**Iron, cobalt, nickel** concern to d elements of family of iron. An electronic configuration of atoms:

$Fe$-$3d^6 4S^2$; C - $3d^7 4S^2$; Ni - $3d^8 4S^2$.

These elements show oxidation degree:

Fe - +2, +3, +6

C - +2, +3

Ni - +2, +3

All elements have not finished 3d - half-level. Thus, in communication formation participate 4S and 3d - half-level. These are typical metals, average activity, unlike many are drawn by a magnet. In usual conditions they considerably do not react with nonmetals, but at heating are chemically active:

$3Fe + 2O_2 = Fe_3O_4$ $\quad$ $3\ Fe + N_2 = Fe\ _3N_2$

$Fe + S = Fe\ S$ $\quad$ $2Fe + 3Cl_2 = 2FeCl_3$

$2Fe + 3S = Fe_2S_3$

Iron at a heat co-operates with water:

$3\ Fe + 4\ H_2O = Fe_3O_4 + 4H_2$

It easily supersedes hydrogen from the diluted solutions of acids. Cobalt, nickel as less active, react with acids slowly:

$Fe + 2HCl = FeCl_2 + H_2\uparrow$

With the concentrated sulfuric acid iron does not co-operate.
Chemical activity falls among Fe - Co - Ni.

Chemical properties of connections of iron depend on degree of oxidation of elements:

*Strong reducers are connections* $Fe^{2+}$

$10FeSO_4 + 2KMnO_4 + 8H_2SO_4 = 5Fe_2(SO_4)_3 + 2MnSO_4 + K_2SO_4 + 8H_2O$

$2Fe^{2+} - 2e \longrightarrow 2Fe^{3+}$ | 2 | 5

$Mn^{7+} + 6e \longrightarrow Mn^{+2}$ | 5 | 2

*Oxidizers are connections* $Fe^{3+}$

$2\ FeCl_3 + 2KI = 2FeCl_2 + KCl + I_2$

$Fe^{3+} + 1e \longrightarrow Fe^{2+}$ | 1 | 2

$2I^- - 2e \longrightarrow I^{+2}$ | 2 | 1

*Strong oxidizers are connections* $Fe^{6+}$

$4K_2\ FeO_4 + 10H_2SO_4 = 2\ Fe_2(SO_4)_3 + 4K_2\ SO_4 + 3O_2 + 10H_2O$

$2Fe^{6+} + 6e \longrightarrow 2Fe^{3+}$ | 6 | 3 | 2

$2O^- - 4e \longrightarrow O_2^0$ | 4 | 2 | 3

*For connections* FeO, $Fe(OH)_2$ characterised the basic properties.

$Fe\ (OH)_2 + 2HCl = FeCl_2 + 2H_2O$

*Connections* $Fe_2O_3$, $Fe(OH)_3$ have the amphoternly properties with prevalence the basic properties:

$2Fe(OH)_3 + 3H_2SO_4 = Fe_2(SO_4)_3 + 6H_2O$;

$Fe(OH)_3 + 3NaOH = Na_3[Fe(OH)_6]$

*Connections* $FeO_3$, ($H_2FeO_4$) shows the acid properties:

$FeO_3 + Na_2O = Na_2FeO_4$

Connections $Co^{2+}$ are less strong reducers, than connections $Fe^{2+}$, $Fe(OH)_2$ this results from the fact that easily is oxidised air oxygen, Co $(OH)_2$ gradually, $Ni(OH)_2$ - is not oxidised.

Connections $Co^{3+}$ - stronger oxidizers, than $Fe^{3+}$:

$Co(OH)_3 + 3HCl = 2CoCl_2 + Cl_2 + 6H_2O$

$Co^{3+} + 1e \longrightarrow Co^{2+}$ | 1 | 2

$Cl^- - 2e \longrightarrow Co^0$ | 2 | 1

At action on hydroxid cobalt (III) oxygen-containing acids of salt of cobalt (III) it is not formed, and oxygen is allocated and salts of cobalt (II) turn out.

$4Co(OH)_3 + 4H_2SO_4 = 4CoSO_4 + O_2 + 10H_2O$

From hydrochloric acid hydroxid cobalt (III) allocates chlorine:

$2Co(OH)_3 + 6HCl = 2CoCl_2 + Cl_2 + 6H2O$

Unlike iron nickel with carbon oxid forms flying carbonyl of nickel Ni $(Co)_4$, decaying at heating with nickel allocation. Nickel forms the nickel oxid(II) or protoxide of nickel (II) NiO, nickel oxid (III) $Ni_2O_3$ and the bases corresponding to them; however one number of salts of nickel in which it is in degree of oxidation +2 is known only. Nickel salts mostly have green colour.

---

Like the majority of transitive metals, these elements are fine complexoforming. Complex connections are formed both with inorganic, and with organic ligands, both cationly, and anionly type, as a rule, with coordination number 6 and 4.

| | | | |
|---|---|---|---|
| $[Fe(H_2O)_6]^{2+}$ | $[Fe(H_2O)_6]^{3+}$ | $[Co(H_2O)_6]^{2+}$ | $[Ni(H_2O)_6]^{2+}$ |
| $[Fe(NH_3)_6]^{2+}$ | $[Fe(NH_3)_6]^{3+}$ | $[Co(NH_3)_6]^{2+}$ | $[Ni(NH_3)_6]^{2+}$ |
| $[Fe(CN)_6]^{4-}$ | $[Fe(SCN)_6]^{3-}$ | $[Co(OH)_4]^{2-}$ | $[Ni(CN)_4]^{2-}$ |
| $[Fe(CO)_5]$ | $[FeF_6]^{3-}$ | $[Co(SCN)_4]^{2-}$ | $[NiCl_4]^{2-}$ |
| | $[Fe(CN)_6]^{3-}$ | $[Co(NO_2)_6]^{3-}$ | |

Many complex connections have characteristic colouring that gives the chance to use them in the qualitative analysis for detection of these ions.

Characteristic property of iron is ability to form complexes with CO, having structure trigonal bipyramids with atom of iron in the centre: Fe + 5CO = [Fe (CO) $_5$].

Soluble salts of iron, cobalt, nickel are chlorides, sulphates, nitrates; insoluble - hydroxydes, sulfids, phosphates, carbonates, the basic salts and others. To hydrolysis most are exposed salt of ferro/III/:

$FeCl_3 + H_2O \rightleftharpoons Fe(OH)Cl_2 + HCl$

$Fe(OH)Cl_2 + H_2O \rightleftharpoons Fe(OH)_2Cl + HCl$

$Fe(OH)_2Cl + H_2O \rightleftharpoons Fe(OH)_3 + HCl$

## Chemical properties p elements

Nitrogen, phosphorus concern p-elements of V group. An electronic configuration of their atoms $nS^2np^3$. From them nitrogen and phosphorus - typical nonmetals. The steadiest degree of oxidation of elements are -3, +3 and +5; nitrogen can form connections and with other degrees of oxidation.

Nitrogen - gas, phosphorus - the firm substance. Electronic configuration of atom of nitrogen $2s^22p^3$. Its molecule consists of two atoms connected by threefold communication: one $\delta$ and two $\pi$ communications that does a nitrogen molecule rather rather strong. Therefore at a room temperature nitrogen co-operates only with lithium, and with all other elements it co-operates only at heats: typical nonmetals, at a heat incorporate to many metals, hydrogen, oxygen:

$6Li + N_2 = 2Li_3N$ $\qquad$ $N_2 + 3H_2 \rightleftharpoons 2NH_3$

$N_2 + O_2 \rightleftharpoons 2NO$

The important connection of nitrogen is **ammonia**.Ammonia - $NH_3$ - gas with a characteristic smell, attaching $H^+$, turns in cation ammonium - $NH_4^+$

Water solution of ammonia - $NH_4OH$.

Ammonia co-operates with metals, oxids metals, with acids, is a reducer:

$2NH_3 + 2Na = 2NH_2Na + H_2$

$2NH_3 + 3CuO = 3Cu + N_2 + 3H_2O$

$NH_3 + HCl = NH_4Cl$

$4NH_3 + 3O_2 = 2N_2 + 6H_2O$

$4NH_3 + 5O_2 = 4NO + 6H_2O$

$2NH_3 + AgCl = [Ag(NH_3)_2]Cl$

Ammonium salts are well soluble in water, are hydrolyzed, reactionly capable, easily decay:

$NH_4Cl \rightleftharpoons NH_3 + HCl$

$NH_4Cl + H_2O \rightleftharpoons NH_4OH + HCl$

Nitrogen forms some connections with oxygen. It is known five oxydes nitrogen: $N_2O$, NO, $N_2O_3$, $NO_2$, $N_2O_5$.

$N_2O_3$ Is anhydride of nitrogenous acid. $N_2O_3$ and $HNO_2$ are both oxidizers and reducers:

$H NO_2 + 2HI = I_2 + 2 NO + 2H_2O$

| | | | | |
|---|---|---|---|---|
| $N^{3+} + 2e$ | $\longrightarrow N^{2+}$ | 2 | 1 |
| $2I^{-} - 2e$ | $\longrightarrow I_2$ | 2 | 1 |

$HNO_2 + KClO = HNO_3 + KCl$

| | | | |
|---|---|---|---|
| $N^{3+} - 2e$ | $\longrightarrow N^{5+}$ | 2 | 1 |
| $Cl^{+} + 2e$ | $\longrightarrow Cl^{-}$ | 2 | 1 |

Nitrogenous acid is unstable: $2HNO_2 = NO + NO_2 + H_2O$

$NO_2$, $N_2O_3$ - acid oxyd, an oxidizer:

$2 NO_2 + 2NaOH = Na NO_3 + Na NO_2 + H_2O$

| | | |
|---|---|---|
| $N^{4+} - 1e$ | $\longrightarrow N^{5+}$ | 1 |
| $N^{4+} + 1e$ | $\longrightarrow N^{3+}$ | 1 |

$N_2O_5$ - acid oxyd, forming with water nitric acid - $HNO_3$. Nitric acid - strong acid, an oxidizer, completely dissociates:

$HNO_3 \rightleftarrows H^{+} + NO_3^{-}$

Depending on concentration $HNO_3$ and the nature of a reducer it can form various products: $NH_3$, $N_2$, NO, $N_2O_3$, $NO_2$

$HNO_3$ Oxidises the metals, and nonmetals:

$Cu + 4HNO_3$ (conc.)$= Cu(NO_3)_2 + 2NO_2 + 2H_2O$

| | | | |
|---|---|---|---|
| $N^{5+} + 1e$ | $\longrightarrow N^{+4}$ | 1 | 2 |
| $Cu^{0} - 2e$ | $\longrightarrow Cu^{+2}$ | 2 | 1 |

$S + 6HNO_3$ (conc.)$= H_2SO_4 + 6NO_2 + 2H_2O$

| | | | |
|---|---|---|---|
| $N^{5+} + 1e$ | $\longrightarrow N^{+4}$ | 1 | 6 |
| $S^{0} - 6e$ | $\longrightarrow S^{+6}$ | 6 | 1 |

$4Mg + 10HNO_3$ (del.)$= 4Mg(NO_3)_2 + N_2O + 5H_2O$

| | | | | |
|---|---|---|---|---|
| $2N^{5+} + 8e$ | $\longrightarrow 2N^{+1}$ | 8 | 4 | 1 |
| $Mg^{0} - 2e$ | $\longrightarrow Mg^{2+}$ | 2 | 1 | 4 |

$3P + 5HNO_3 + 2H_2O$ (delut.) $= 3H_3PO_4 + 5NO$

| | | | |
|---|---|---|---|
| $N^{5+} + 3e$ | $\longrightarrow N^{+2}$ | 3 | 5 |
| $P^{0} - 5e$ | $\longrightarrow P^{+5}$ | 5 | 3 |

Nitric acid salts - nitrates, nitrogenous - nitrites. The majority of nitrites in water soluble also are strongly hydrolyzed. Nitrates also soluble in water also are oxidizers.

Phosphorus is analogue of nitrogen. Its electronic formula $3s^2 3p^3$. However nonmetallic properties at phosphorus are expressed more poorly than at nitrogen. Therefore for phosphorus there is an oxidation degree-3, more often +5 less often.

---

Phosphorus incorporates to nonmetals and metals:

$2P+3S=P_2S_3$ $4P+5O_2=2P_2O_5$

$2P+3Ca=Ca_3P_2$ $2P+5Cl_2=2PCl_5$

Oxydes phosphorus $P_2O_3$ and $P_2O_5$ - acid Oxydes, to them correspond phosphoric $H_3PO_3$ and phosphoric acids. $P_2O_5$ can form 3 types of acids:

$P_2O_5 + H_2O = 2\ HPO_3$ - metaphosphoric
$P_2O_5 + 2H_2O = H_4P_2O_7$ - pyrophosphoric
$P_2O_5 + 3H_2O = H_3PO_4$ – ortophosphoric

It is most important ortophosphoric acid $H_3PO_4$. It is firm substance, average force acid, tribase , forms set of salts, as average, and sour.

$H_3PO_4+3NaOH=Na_3PO_4+3H_2O$
$H_3PO_4+2NaOH=Na_2HPO_4+2H_2O$
$H_3PO_4+NaOH=NaH_2PO_4+H_2O$

**Carbon** concerns to p - to elements of IV group. An electronic configuration of its atom $nS^2np^2$. Most typical its degree of oxidation +2, +4,-4. Carbon - typical nonmetal. Carbon possesses a unique electronic structure of atom: at it number of valency electrons in atom to equally number valency orbitals , that gives the chance realisation covalently communications with many elements, formation of practically infinite chains with various number of communications. Carbon - a basis of the organic world (its this property the science bioorganic chemistry considers).

Carbon rather inert, elements chemical activity amplifies with rise in temperature. It react with metals, nonmetals, with some connections, being a reducer:

$2C + O_2 = 2CO$
$Ca + 2C = CaC_2$
$C + 2H_2 = CH_4$
$C+ H_2O = CO + H_2$
$3C + 4H\ NO_3 = 3CO_2+ 4NO + 2H_2O$

Dioxyd $CO_2$ - gas, acid oxyd:

$CO_2 + H_2O = H_2CO_3$

$CO_2 + CaO = CaCO_3$

$H_2CO_3$ - weak two-basic, unstable acid, its salts are hydrolyzed:

$H_2CO_3 = CO_2 + H_2O$

$Na_2CO_3 + H_2O \rightleftarrows NaHCO_3 + NaOH$

Oxygen and sulphur are p-elements VI groups. An electronic configuration of their atoms $nS^2np^4$. Degree of oxidation of oxygen-2, sulphur shows oxidation degree-2, +4, +6. Oxygen and sulphur typical nonmetals.

Oxygen forms connections with all elements except helium, a neon and argon; sulphur less active nonmetal, also co-operates with many elements and connections:

$2H_2 + O_2 = 2H_2O$ $\quad$ $H_2 + S = H_2S$

$4Li + O_2 = 2Li_2O$ $\quad$ $S + O_2 = SO_2$

$4P + 5O_2 = 2P_2O_5$ $\quad$ $2S + 3O_2 = 2SO_3$

$4Al + 3O_2 = 2Al_2O_3$ $\quad$ $S + Cl_2 = SCl_2$

$4NH_3 + 3O_2 = 6H_2O + 2N_2$ $\quad$ $Cu + S = CuS$

$2SO_2 + O_2 = 2SO_3$ $\quad$ $2ZnS + 3O_2 = 2ZnO + 2SO_2$

$S + 6HNO_3 = H_2SO_4 + 6NO_2 + 2H_2O$

$4S + 8KOH = K_2SO_4 + 2K_2S + 4H_2O$

Oxygen - a strong oxidizer, it allotropicly modification is ozone - $O_3$, ozone shows still the big oxidising ability at the expense of atomic oxygen:

$O_3 \longrightarrow O_2 + O$

Oxygen forms numerous acid, amphoternse, the cores Oxydes and hydroxydes, oxygencontaining acids:

| | | |
|---|---|---|
| $Na_2O$ | $Al_2O_3$ | $SO_3$ |
| $NaOH$ | $Al(OH)_3$ | $H_2SO_4$ |
| *bas. properties* | *Amphoternly properties* | *Acid properties* |

The important hydrogen connection of sulphur is hydrogen sulfid. It is a reducer, gas with a characteristic smell, at dissolution in water forms the weak two-basic acid $H_2S$ which majority of salts are insoluble in the water, many have colouring:

$2H_2S + 3O_2 = 2H_2O + 2SO_2$ $\quad$ || $\quad$ $H_2S + Cu(NO_3)_2 = CuS\downarrow + HNO_3$

$H_2S + 4Br_2 + 4H_2O = H_2SO_4 + 8HBr$ $\quad$ black

Sulphur forms Oxydes $SO_2$ and $SO_3$ and acids corresponding to them - $H_2SO_3$ and $H_2SO_4$.

$SO_2$, $H_2SO_3$ have dual oxidation-reduction character:

$SO_2 + Br_2 + H_2O = H_2SO_4 + 2HBr$

$S^{+4} - 2e \longrightarrow S^{+6}$ | 2 | 1

$Br_2^0 + 4e \longrightarrow 2Br^-$ | 2 | 1

$SO_2 + 2H_2S = 3S + 2H_2O$

$S^{+4} + 4e \longrightarrow S^0$ | 4 | 2 | 1

$S^{-2} - 2e \longrightarrow S^0$ | 2 | 1 | 2

$H_2SO_3$ – Unstable acid: $H_2SO_3 \longrightarrow H_2O + SO_2\uparrow$

Sulfuric acid - $H_2SO_4$ - an oxidizer, its properties depend on concentration. Co-operates both with simple, and with difficult substances, all properties of acids are inherent in it:

$Zn + H_2SO_4$ (diluted.) = $ZnSO_4 + H_2$

$Zn + 2H_2SO_4$ (conc.) = $ZnSO_4 + SO_2 + 2H_2O$

$3Zn + 4H_2SO_4$ (diluted.) = $3ZnSO_4 + S + 4H_2O$

$S + 2\ H_2SO_4$ (conc.) = $3SO_2 + 2H_2O$

$H_2SO_4$ Forms set of soluble and insoluble salts.

Sulphur forms also thiosulphuric acid $H_2S_2O_3$ in which one atom of sulphur has oxidation degree - 2, another - +6. Thiosulphuric acid is unstable:

$H_2S_2O_3 + Cl_2 + H_2O = Na_2\ SO_4 + S + 2HCl$

Fluorine, chlorine, bromine, iod concern to p elements of VII group. Electronic structure of their atoms $nS^2np^5$. They show oxidation degrees:-1, +2, +3, +5, +7.

All halogens - typical nonmetals. In a subgroup of halogens from above in a bottom increases oxidising properties. Halogens are very active, co-operate with many elements simple and difficult connections:

$H_2 + Cl_2 = 2HCl$ $\qquad$ $H_2O + Cl_2 = HCl + HClO$

$2Na + Cl_2 = 2NaCl$ $\qquad$ $SiO_2 + 2F_2 = Si\ F_4 + O_2$

$P + Cl_2 = PCl_3$

Except HF, all galogenohydrargyrum acids concern strong acids, all properties of acids are inherent in them.

$4HCl + MnO_2 = Mn\ Cl_2 + Cl_2 + H_2O$

$4HI + O_2 = 2I_2 + H_2O$

Almost all metals form halogenides which find wide application. Aniones galogenids are also fine ligands:

$[Al\ Cl_4]^-$ $\quad$ $[Be\ F_4]^{2-}$ $\quad$ $[Hg\ Br_4]^{2-}$ $\quad$ $[Al\ F_6]^{3-}$

$[BF_4]^{4-}$ $\quad$ $[Si\ F_6]^{2-}$ $\quad$ $[I_3]^-$

Halogens form a number of oxygen connections which are unstable.

Them receive interaction of halogens with water and other connections:

$H_2O + Cl_2 = HCl + HClO$

Following oxygen acids of chlorine are known:

$HClO$ -------$HClO_2$-------$HClO_3$-------$HClO_4$

In this number oxidising properties weaken with increase in degree of oxidation of chlorine, force of acids increases.

*The strongest oxidizer*: HClO

*The strongest acid* - $HClO_4$

## Application of connections of elements in medicine

| | | |
|---|---|---|
| $Li_2CO_3$ | Lithium carbonate | It is used in psychiatric practice |

| | | |
|---|---|---|
| NaCl - 0,85 % (weights.) a solution | Physiological solution | Apply to intravenous injections at big hemorrhage |
| NaCl 3 %, 5 % (weights.) a solution | Sodium chloride | In surgical practice |
| $NaHCO_3$ | Lithium hydrocarbonate | It is applied to neutralisation of the raised acidity of gastric juice |
| $Na_2SO_4 \cdot 10H_2O$ | Sodium sulphate | It is applied as a depletive |
| NaBr, KBr | Bromides kalii and sodium | Demulcents |
| NaI, KI | Iodids kalii and sodium | It is applied at thyroid gland diseases |
| KCl | Chloride kalii | It is applied at aritmia of heart |
| $CH_3COOK$ | Acetate kalii | Diuretic |
| MgO | Oxyd magnesium | Possesses adsorbtionly, antacidly action, it is applied at disease of a gastroenteric path |
| $MgSO_4 \cdot 7H_2O$ | Magnesium sulphate | It is applied at a hypertension, an atherosclerosis, chronic coronary insufficiency, at skin diseases |
| $MgS_2O_3 \cdot 6H_2O$ | Tiosulfat magnesium | It is applied at a hypertension, an atherosclerosis, chronic coronary insufficiency |
| $3MgSiO_3 \cdot Mg(HSiO_3)_2$ | Silicate and magnesium hydrosilicate | It is applied to treatment of skin diseases |
| $CaCl_2 \cdot 6H_2O$ | Calcium chloride | It is applied at allergic skin diseases, a nephrite, bleedings; |
| $CaCO_3$ | Calcium carbonate | It is applied at the raised acidity of gastric juice; |
| $CaPO_3 – O – C_3H_5(OH)_2 \cdot nH_2O$ | | It is applied at a nervous breakdown; |

| | | |
|---|---|---|
| $CaSO_4 \cdot 1/2H_2O$ | Calcium sulphate | Plaster bandages; |
| $KMnO_4$ | Permanganate kalii | Antiseptic |
| $Na_2CrO_4$ | Chromat sodium | Radiolabeled Cr is used for diagnostic purposes in oncology. |
| Koamid | | Coordination connection of cobalt with amid nicotinic acid is a stimulator haemoforming. |
| Vitamin $B_{12}$ | | It is applied at treatment of a malignant anaemia. |
| Kobavit | | It is applied at hepatitis treatment, and also increases immune properties of an organism |
| Iron restored | | It is applied at treatment ferrodeficitly anemias. |
| Iron glycerophosphat | | At the same pathology |
| Iron lactat | | At the same pathology |
| $Fe\ SO_4 \cdot 7H_2O$ | | At the same pathology |
| Ferramid | | At the same pathology |
| Ferraceron | | At the same pathology |
| Ferrcophen | | At the same pathology |
| Haemostimulin | | At the same pathology |
| $Fe\ Cl_3 \cdot 6H_2O$ | | It is applied to a stop of bleedings. |
| $ZnSO_4 \cdot 7H_2O$ | Zinc sulphate | It is applied to treatment conjunctivitis, externaly |
| ZnO | Oxyd zinc | It is applied to treatment of skin diseases, externaly |
| $HgCl_2$ | Corrosive sublimate | It is applied to treatment of skin diseases |
| $Hg(CN)_2 \cdot HgO$ | | Disinfectant |
| HgO | Oxyd mercury | It is applied to treatment of skin diseases |

| | | |
|---|---|---|
| | | |
| $HgNH_2Cl$ | | It is applied to treatment of skin diseases |
| $Hg_2Cl_2$ | Kalomel | It is applied to cornea treatment (now inside it is not applied). |
| $CuSO_4 \cdot 5H_2O$ | Copper vitriol | It is applied to treatment conjunctivitis |
| $Cu\ Cl_2 \cdot 2B_6$ | | It is applied to treatment of a tuberculosis, a hepatitis, vitiligo |
| Citrat of copper | | It is applied to treatment of a tuberculosis, a hepatitis, vitiligo |
| $AgNO_3$ | Lapis | Possesses anti-inflammatory, cauterising, antiseptic and bactericidal action, it is applied externaly |
| $(Au – S – CH_2 – CHOH – CH_2\ SO_3)_2\ Ca$ | Krisanol | It is applied to treatment of a tuberculosis, lepra, lupus |
| $NH_4Cl$ | Ammonium chloride | Possesses diureticaction |

## Bases of the qualitative analysis

The analytical chemistry is the science developing theoretical bases and methods of the chemical analysis. A task of a course of analytical chemistry is the establishment of a chemical compound of substance or their mixes. As a rule, at first establish qualitative structure of substance, i.e. define, from what atoms, groups of atoms, cations and anions the given substance consists, and then establish quantitative structure, i.e. define in what quantitative parity there are components in the given substance.

The primary goal of the qualitative analysis is detection of separate elements or the ions which are a part of substance.

The qualitative analysis has huge value in medical practice for the analysis of biological objects, and also medical products.

In the qualitative analysis to definition of qualitative structure of substance apply various methods: chemical, physical and physical and chemical. These methods develop constantly and improved.

Chemical methods are based on use of chemical reactions, characteristic for a defined element or its connection with various substances which in this case are called as reactants (reagents) on a defined element or connection, and proceeding chemical reactions - analytical reactions. Thus as reagents apply substances at which interaction to analyzed substance there is any easily observable change: the deposition is formed, gas is allocated, solution colouring changes, there is a characteristic smell, etc.

Physical methods of the analysis are based on measurement of any parametre of the system which are function of structure.

Physical and chemical methods of the qualitative analysis are based on the supervision, any physical properties, characteristic for an opened element or its connection, for example radiation or absorption spectra (the spectral analysis), the form and colour of crystals (crystallochemicaly the analysis), character of the luminescence caused by action of ultra-violet beams (the luminescent analysis), fusion temperature (the thermal analysis), ability to be adsorbed on various sorts absorbers (chromatographicaly adsorbcionly analysis), etc.

In the given management chemical methods of the analysis are considered basically.

The analysis of investigated substance can be spent "wet" or "dry" by. In the first case analyzed substance dissolve in water or, in what or solvent then on the received solution operate with corresponding reactants. In the second case to the analysis subject solids. Thus definition of structure of substance is usually based on ability it to paint in characteristic colour a colourless flame of a torch or to give painted "pearls" at alloying with brown or the one-replaced phosphate of sodium in an ear of a platinum wire, etc.

Depending on quantity of analyzed substance distinguish:

1. The macroanalysis - for the analysis undertakes from 0,1 to 1g a solid.
2. Half-microanalysis - quantity of analyzed substance approximately in 20 - 30 times are less, than at the macroanalysis.
3. The microanalysis - quantity of analyzed substance approximately in 100 times is less, than at the macroanalysis.
4. Ultramicroanalysis - the quantity of analyzed substance approximately in 1000 times is less, than at the macroanalysis

The qualitative analysis of inorganic substances is in most cases reduced to the analysis "wet" by, i.e. water solutions of electrolits where the last are in the dissociated condition in the form of ions.

The reactions applied in the qualitative analysis should be sensitive and proceed quickly and full. Their important condition is: environment, temperature, concentration of a found out ion in a solution and other

To qualitative detection of ions apply reactions at which the deposition having certain colouring is formed, solubility, or solution colouring changes, gas with known properties etc. Such reactions and reactants applied thus is allocated are called as characteristic for the given ion. For example, calcium ions can be found out by training white crystally a deposition with oxalat ions:

$$Ca^{2+} + C_2O_4^{2-} \longrightarrow \downarrow CaC_2O_4$$

Characteristic reactant the given ions can be found out only at absence in a solution of other ions also reacting with this reactant.

The great value has specificity of reaction. Reaction which allows to find out ions in the presence of other ions is called as specific. The reactants causing these reactions, also are called as specific. For example, a specific reactant on an ammonium ion is alkali at which action on ammonium salts the ammonia defined on a smell and blue discoloration of a litmus paper is allocated:

$$NH_4Cl + KOH \longrightarrow NH_3\uparrow + KCl + H_2O$$

This reaction ammonium ions can be found out in the presence of other ions.

Reactions with which help from a mix of ions their group can be allocated, are called as group reactions, and the reactants causing such reactions - group reactants. For example, a group reactant on group of ions: Ag, Pb, Hg, Cn the hydrogen sulfid forming with all ions of this group depositions of sulfids, not soluble in the diluted acids is.

Opening of the ions which are in a mix with other ions is spent also by a fractional method of the analysis or on a regular course of the analysis.

Detection of ions by means of specific reactions in separate portions of the analyzed solution, made in any sequence, is called as the fractional analysis.

In a regular course of the analysis cations divide into analytical groups by consecutive application of group reactants. If within one group ions stir to opening each other them separate by means of corresponding reactions and then open each kind of ions characteristic reactions.

Thus, at the regular analysis along with reactions of detection of separate ions, it is necessary to resort also to reaction of their branch from each other.

The reactions giving similar effect only with limited number of ions, are called as selective or selective.

### Studying of private qualitative reactions cations biogene elements.

**Reactions of ions of sodium - $Na^+$.**

**Reactant hexahydroxostibat/V/kalii-** $K[Sb(OH)_6]$

Hexahydroxostibat/V/kalii-$K[Sb(OH)_6]$- in the neutral or is weak-alkaline environment forms with sodium salts a white crystal deposition - $Na[Sb(OH)_6]$

$$NaCl + K[Sb(OH)_6] = Na[Sb(OH)_6]\downarrow + KCl$$

$$Na^+ + [Sb(OH)_6]^- = Na[Sb(OH)_6]$$

Deposition formation is accelerated by solution cooling, hashing and a friction a glass stick about test tube walls. The investigated solution should not be sour as in the presence of free acids the white deposition of metaantimonic acid drops out:

$$K[Sb(OH)_6] + HCl = HSbO_3\downarrow + KCl + 3H_2O$$

**RESEARCH OF PROPERTIES OF A DEPOSITION. $Na[Sb(OH)_6]$**

1. The deposition is dissolved in water at heating.
2. The deposition is dissolved in solutions of caustic alkalis.

$Na[Sb(OH)_6]$ +2NaOH = $Na_3$ $[SbO_2(OH)_4]$ + 2 $H_2O$

$Na[Sb(OH)_6]$ +2$OH^-$ = $Na^+$ + $[SbO_2(OH)_4]^{3-}$ + 2 $H_2O$

**Reactions of ions kalii - $K^+$**

**Reactant hydrotartrat sodium** - $NaHC_4H_4O_6$

Hydrotartrat of sodium - $NaHC_4H_4O_6$ - in the neutral environment forms with salts kalii white cryptocrystalline deposition,

$KCl + NaHC_4H_4O_6 = KHC_4H_4O_6\downarrow + NaCl$

TO $^+$+ $HC_4H_4O_6^-$= $KHC_4H_4O_6\downarrow$

Deposition formation is accelerated by cooling, hashing and a friction a glass stick about test tube walls.

## RESEARCH OF PROPERTIES OF A DEPOSITION. $KHC_4H_4O_6$

1. The deposition is dissolved in water at heating.
2. The deposition is dissolved in solutions of strong acids.
   $KHC_4H_4O_6 + HCl = KCl + H_2C_4H_4O_6$
   $KHC_4H_4O_6$ + H $^+$ = TO $^+$+ $H_2C_4H_4O_6^-$
3. The deposition is dissolved in solutions of caustic alkalis
4. $KHC_4H_4O_6 + KOH = K_2C_4H_4O_6 + H_2O$
5. $KHC_4H_4O_6 + OH^- = K^+ + C_4H_4O_6^{2-} + H_2O$

**Reactant hexanitrocobalt/III/sodium** - $Na_3\,[Co\,(NO_2)\,_6]$

Hexanitrocobalt/III/sodium - $Na_3\,[Co\,(NO_2)\,_6]$ in the subacidic and neutral environment forms with salts kalii yellow crystal deposition $K_2Na\,[Co\,(NO_2)\,_6]$.

2 KCl + $Na_3\,[Co\,(NO_2)\,_6]$ = $K_2Na\,[Co\,(NO_2)\,_6]\downarrow$ + 2NaCl

2 To $^+$ + Na $^+$ + $[Co\,(NO_2)\,_6]^3$ = $K_2Na\,[Co\,(NO_2)\,_6]\downarrow$

Deposition formation is accelerated at a friction by a glass stick about walls of a test tube and at standing.

Reactions should be spent in the neutral or subacidic environment as in strongsourly to environment the reactant decays.

$Na_3\,[Co\,(NO_2)\,_6]$ + 3NaOH = Co $(OH)_3\downarrow$ + 6Na $NO_2$

Co $(OH)_3$ - a deposition of dark-brown colour.

**Reactions of ions of magnesium - $Mg^{2+}$.**

**Reactant - hydroxydes sodium, kalii -** NaOH, KOH

Caustic alkalis allocate from a solution of salts of magnesium white amphorly a deposition hydroxyd Mg $(OH)_2$:

$MgCl_2$ + 2 NaOH = Mg $(OH)_2\downarrow$ + 2 NaCl

$Mg^{2+}$ + 2ON $^-$ = Mg $(OH)_2\downarrow$

**RESEARCH OF PROPERTIES OF A DEPOSITION. Mg (OH) $_2$**

1. The deposition is dissolved in acids

$Mg(OH)_2 + 2HCl = MgCl_2 + 2H_2O$

$Mg(OH)_2 + 2H^+ = Mg^{2+} + 2H_2O$

2. The deposition is dissolved in salts amonium:.

$Mg(OH)_2 + 2NH_4Cl = MgCl_2 + 2NH_4OH$

$Mg(OH)_2 + 2NH_4^+ = Mg^{2+} + 2NH_4OH$

**Reaction of Petrashen.**

Solution iod (iodly water) in the presence of alkali gives a dark-brown deposition with magnesium salts.

In a test tube place 2-3 drops of iodic water, stir slowly the glass stick moistened in a solution of alkali before decolouration of a solution of iodine. At addition to the received mix of a drop of a solution of salt of magnesium form a dark-brown deposition.

$I_2 + 2NaOH \rightleftarrows NaIO + NaI + H_2O$

$MgCl_2 + 2NaOH = Mg(OH)_2\downarrow + 2NaCl$

Reaction of interaction of iodine with alkali is reversible, introduction in a mix of ions of magnesium displaces balance from right to left in consequence of formations of deposition Mg (OH) $_2$, molecular iodine which is adsorbed on white deposition Mg (OH) $_2$ is thus allocated, giving dark-brown colouring. Reaction it is impossible to spend a lot of alkali.

**Reactions cations calcium - $Ca^{2+}$.**

**Reactant sulfuric acid -** $H_2SO_4$

Sulfuric acid $H_2SO_4$ and its soluble salts form white crystal deposition $CaSO_4$ with calcium salts:

$CaCl_2 + H_2SO_4 = CaSO_4\downarrow + 2HCl$

$Ca^{2+} + SO_4^{2-} = CaSO_4\downarrow$

**RESEARCH OF PROPERTIES OF A DEPOSITION.** $CaSO_4$

1. The deposition is dissolved in water at heating.
2. The deposition is not dissolved in acids and caustic alkalis.

**Reactant oxalat ammonium - $(NH_4)_2C_2O_4$**

OXALAT ammonium - $(NH_4) C_2O_4$ - forms with calcium salts small-crystal white deposition $CaC_2O_4$

$CaCl_2 + (NH_4)_2C_2O_4 = CaC_2O_4\downarrow + 2NH_4Cl$

$Ca^{2+} + C_2O_4^{2-} = CaC_2O_4\downarrow$

Heating promotes faster sedimentation of a deposition.

**RESEARCHES OF PROPERTY OF DEPOSITION $CaC_2O_4$.**

1. The deposition is dissolved in mineral acids, but not dissolved in acetic acid unlike $BaC_2O_4$ and $SrC_2O_4$

$CaC_2O_4 + 2HCl = CaCl_2 + H_2C_2O_4$

$CaC_2O_4 + 2H^+ = Ca^{2+} + H_2C_2O_4$

**Reactions of ions of chrome - $Cr^{3+}$**

**Reactant - hydroxydes sodium and kalii - NaOH and the КОН**

Caustic alkalis at cautious addition allocate from solutions of salts of chrome III grey-green deposition hydroxyd chrome $Cr(OH)_3$:

$CrCl_3 + 3NaOH = Cr(OH)_3\downarrow + 3NaCl$

$Cr^{3+} + 3OH^- = Cr(OH)_3\downarrow$

**RESEARCH OF PROPERTIES OF DEPOSITION Cr (OH) $_3$**

Cr (OH) $_3$ possesses amphoternely properties.

1. The deposition is dissolved in mineral acids

$Cr(OH)_3 + 3HCl = CrCl_3 + 3H_2O$

$Cr(OH)_3 + 3H^+ = Cr^{3+} + 3H_2O$

2. The deposition is dissolved many caustic alkalis.

$Cr(OH)_3 + 3NaOH = Na_3[Cr(OH)_6]$

$Cr(OH)_3 + 3OH^- = [Cr(OH)_6]^{3-}$

3. $[Cr(OH)_6]^3$ emerald-green colours.

**Reactant a sodium hydrocarbonate** - $NaHCO_3$.

The sodium hydrocarbonate - $NaHCO_3$ allocates from chrome salts a green deposition hydroxyd chrome Cr (OH) $_3$:

$CrCl_3 + 3NaHCO_3 = Cr(OH)_3\downarrow + 3NaCl + 3CO_2\uparrow$

$Cr^{3+} + 3HCO_3^- = Cr(OH)_3\downarrow + 3CO_2\uparrow$

In water solutions $NaHCO_3$ is exposed to hydrolysis:

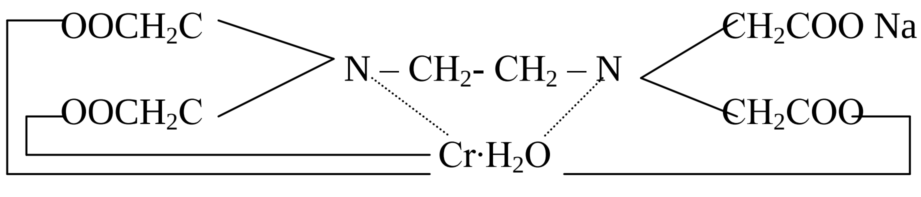
$NaHCO_3 + HOH \rightleftarrows NaOH + H_2CO_3$

$HCO_3^- + HOH \rightleftarrows OH^- + H_2CO_3$

Therefore in a water solution of this salt there are ions $HCO_3^-$, $OH^-$ and $CO_3^{2-}$. As Cr (OH) $_3$ less we will dissolve, than $Cr_2(CO_3)_3$ this connection and drops out in a deposition.

**Reactant complexon III** - Na $[H_2\gamma]$.

In subacidic complexon environment III form with cations chrome at heating complex connection of violet colour, obviously, such structure:




To a solution of salt of chrome it is necessary to add on 2-3 drops of solutions $CH_3COOH$ and $CH_3COONa$ for creation of the necessary environment and complexon III. At heating in 2-3 minutes characteristic violet colouring of a solution is formed.

**Reactions of ions of manganese** - $Mn^{2+}$

**Reactant - hydroxydes sodium and kalii - NaOH and KOH**

Caustic alkalis from solutions of salts of manganese allocate a white deposition hydroxyd manganese: $Mn(OH)_2$:

$MnCl_2 + 2NaOH = Mn(OH)_2\downarrow + 2NaCl$

$Mn^{2+} + 2OH^- = Mn(OH)_2\downarrow$

**RESEARCH OF PROPERTIES OF A DEPOSITION. Mn (OH) $_2$**

1. On air the deposition easily is oxidised passing from white in the dark-brown: $2Mn(OH)_2 + O_2 = 2MnO(OH)_2$
2. The deposition is dissolved in acids:
   $Mn(OH)_2 + H_2SO_4 = MnSO_4 + 2H_2O$
   $Mn(OH)_2 + 2H^+ = Mn^{2+} + 2H_2O$
3. The deposition is not dissolved many caustic alkalis.
4. The deposition is dissolved in ammonium salts:
   $Mn(OH)_2 + 2NH_4Cl = MnCl_2 + 2NH_4OH$
   $Mn(OH)_2 + 2NH_4^+ = Mn^{2+} + 2NH_4OH$

**Reactant oxalic acid - $H_2C_2O_4$**

Oxalic acid - $H_2C_2O_4^-$with $Mn(OH)_2$ forms a complex ion $[Mn(C_2O_4)_3]^{3-}$ is bright-pink colours. The detection technique consists in the following: to salt-manganese to add 2-3 drops of alkali KOH or NaOH, to mix contained in a test tube a glass stick before transition of white colouring of a deposition in dark-brown on reaction:

$2Mn(OH)_2 + O_2 = 2MnO(OH)_2\ (H_2MnO_3)$,

Then to flow a solution oxalic acids before deposition dissolution, thus the solution will be painted in is bright-pink colour:

$2H_2MnO_3 + 7H_2C_2O_4 = 2H_3[Mn(C_2O_4)_3] + 2CO_2 + 6H_2O$.

**Reactions of ions of iron - $Fe^{2+}$.**

**Reactant - hydroxydes sodium, kalii -** NaOH, KOH.

Caustic alkalis at action on solutions of salts $Fe^{2+}$ allocate white deposition Fe (OH) $_2$ which on air quickly changes the colour to dark green and red-brown:

$FeSO_4 + 2NaOH = Fe(OH)_2\downarrow + Na_2SO_4$

$Fe^{2+} + 2OH^- = Fe(OH)_2\downarrow$

**RESEARCH OF PROPERTIES OF A DEPOSITION. Fe (OH) $_2$**

1. On air the deposition easily is oxidised, passing in dark-brown Fe (OH) $_3$

$4Fe(OH)_2 + O_2 + 2H_2O = 4Fe(OH)_3$

2. The deposition is dissolved in mineral acids and in acetic acid:

$Fe(OH)_2 + 2HCl = FeCl_2 + 2H_2O$

$Fe(OH)_2 + 2H^+ = Fe^{2+} + 2H_2O$

3. The deposition is not dissolved many caustic alkalis.

**Reactant hexacianoferrat/III/kalii** - $K_3[Fe(CN)_6]$.

Hexaacianoferrat/III/kalii - $K_3[Fe(CN)_6]$ - forms with ions $Fe^{2+}$ in neutral or subacidic the dark-blue environment a deposition, so-called «trunbully blue» / - $Fe_3[Fe(CN)_6]_2$:

$3FeCl_2 + 2K_3[Fe(CN)_6] = Fe_3[Fe(CN)_6]_2\downarrow + 6KCl$

$3Fe^{2+} + 2[Fe(CN)_6]^3 = Fe_3[Fe(CN)_6]_2\downarrow$

### RESEARCH OF PROPERTY OF DEPOSITION $Fe_3[Fe(CN)_6]_2$

1. The deposition is not dissolved in acids.
1. The deposition decays caustic alkalis:

$Fe_3[Fe(CN)_6]_2 + 6NaOH = 3Fe(OH)_2\downarrow + 2Na_3[Fe(CN)_6]$

$Fe_3[Fe(CN)_6]_2 + 6OH^- = 3Fe(OH)_2\downarrow + 2[Fe(CN)_6]^{3-}$

2. **Reactions of ions of iron** - $Fe^{3+}$.

**Reactant - hydroxydes sodium, kalii -** NaOH, KOH.

Caustic alkalis at action on solutions of salts $Fe^{3+}$ give a red-brown deposition hydroxyd gland $Fe(OH)_3$:

$FeCl_3 + 3NaOH = Fe(OH)_3\downarrow + 3NaCl$

$Fe^{3+} + 3OH^- = Fe(OH)_3\downarrow$

### RESEARCH OF PROPERTY OF DEPOSITION $Fe(OH)_3$

1. The deposition is dissolved in mineral acids.

$Fe(OH)_3 + 3HCl = FeCl_3 + 3H_2O$

$Fe(OH)_3 + 3H^+ = Fe^{3+} + 3H_2O$

2. The deposition is not dissolved many caustic alkalis:

**Reactant hexacianoferrat/II/kalii** - $K_4[Fe(CN)_6]$.

Hexacianoferrat/II/kalii - $K_4[Fe(CN)_6]$ - forms with ions $Fe^{3+}$ a dark blue deposition, «the Berlin azure» / - $Fe_4[Fe(CN)_6]_3$:

$4FeCl_3 + 3K_4[Fe(CN)_6] = Fe_4[Fe(CN)_6]_3\downarrow + 12KCl$

$4Fe^{3+} + 3[Fe(CN)_6]^4 = Fe_4[Fe(CN)_6]_3\downarrow$

<u>Reaction should be spent in moderately sour solution for suppression of hydrolysis of salt of iron:</u>

$$Fe^{3+} + H_2O \overset{+HCl}{\rightleftarrows} [FeOH]^{2+} + H^+$$

### RESEARCH OF PROPERTY OF DEPOSITION $Fe_4[Fe(CN)_6]_3$

1. The deposition is not dissolved in acids.
2. The deposition decays caustic alkalis:

$Fe_4[Fe(CN)_6]_3 + 12NaOH = 4Fe(OH)_3\downarrow + 3Na_4[Fe(CN)_6]_4$

$Fe_4[Fe(CN)_6]_3 + 12OH^- = 3Fe(OH)_3\downarrow + 3[Fe(CN)_6]^{4-}$

**Reactant thiocyanide ammonium or kalii** - $NH_4SCN$, KSCN.

Thiocyanide kalii and ammonium $NH_4SCN$, К SCN - form with ions $Fe^{3+}$ a complex $[Fe(SCN)_6]^{3-}$, a painting solution in blood-red colour much:

$$FeCl_3 + 6\ KSCN \rightleftarrows K_3[Fe(SCN)_6] + 3KCl$$
$$Fe^{3+} + 6\ SCN^- \rightleftarrows [Fe(SCN)_6]^{3-}$$

PROPERTY RESEARCH $[Fe(SCN)_6]^{3-}$

Oxalic, wine, phosphoric acids, and also fluorides decolour a solution owing to formation of steadier complex connections of iron:

$$[Fe(SCN)_6]^{3-} + 6F^- = [Fe\ F_6]^{3-} + 6\ SCN^-$$

**Reactions of ions of cobalt - $Co^{2+}$**

**Reactant - hydroxydes sodium, kalii -** NaOH, КOH.

Caustic alkalis at cautious addition allocate from solutions of salts $Co^{2+}$ a dark blue deposition of basic salt CoOHCl:

$$Co\ Cl_2 + NaOH = CoOHCl\downarrow + NaCl$$
$$Co^{2+} + Cl^- + OH^- = CoOHCl\downarrow$$

At the further addition of alkali the basic salt passes in hydroxyd cobalt $Co(OH)_2$ - pink colour:

$$CoOHCl + NaOH = Co(OH)_2\downarrow + NaCl$$
$$CoOHCl + OH^- = Co(OH)_2\downarrow$$

RESEARCH OF PROPERTY OF A DEPOSITION $Co(OH)_2$

1. On air a deposition gradually turns brown owing to partial oxidation by its oxygen of air to hydroxyd cobalt/III/-

$$4Co(OH)_2+O_2+2H_2O= 4\ Co\ (OH)_3\downarrow.$$

2. The deposition is dissolved in acids:

$$Co(OH)_2+2HCl= CoCl_2+2H_2O$$
$$Co(OH)_2+2H^+= Co^{2+}+2H_2O$$

3. The deposition is dissolved much $NH_4OH$ with formation of complex connection of lurid colour:

$$Co(OH)_2 + 6\ NH_4OH = [Co(NH_3)_6](OH)_2 + 6H_2O$$
$$Co(OH)_2 + 6\ NH_4OH = [Co(NH_3)_6]^2 + 2OH^- + 6H_2O$$

4. The deposition is not dissolved many caustic alkalis.

**Reactant thiocyanide ammonium** - $NH_4SCN$.

Thiocyanide ammonium $NH_4SCN$ - forms with ions $Co^{2+}$ complex connection which in the presence of organic solvents, for example, acetone, passes in its layer (it from above, as easier water), painting in intensively-dark blue colour. Therefore for manifestation use sated solution $NH_4SCN$ in acetone:

$$CoCl_2 + 4\ NH_4SCN = (NH_4)_2[Co(SCN)_4] + 2\ NH_4Cl$$
$$Co^{2+} + 4SCN^- = [Co(SCN)_4]^{2-}$$

## Reactions of ions of nickel – $Ni^{2+}$

**Reactant - hydroxydes sodium, kalii -** NaOH, КОН.

Caustic alkalis besiege from solutions of salts $Ni^{+2}$ a deposition hydroxyd nickel of light green colour Ni $(OH)_2$:

$Ni(NO_3) + 2NaOH = Ni(OH)_2\downarrow + Na\,NO_3$

$Ni^{2+} + 2OH^- = Ni(OH)_2\downarrow$

**<u>RESEARCH OF PROPERTY OF DEPOSITION Ni $(OH)_2$</u>**

1.The deposition is steady on air

2. The deposition is dissolved in acids:

$Ni(OH)_2 + 2HCl = Ni\,Cl_2 + 2H_2O$

$Ni(OH)_2 + 2H^+ = Ni^{2+} + 2H_2O$

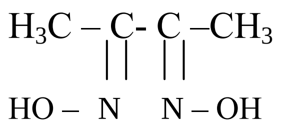
3. The deposition is dissolved much $NH_4OH$ with formation of complex connection of is bright-dark blue colour:

$Ni(OH)_2 + 6\,NH_4OH = [Ni(NH_3)_6](OH)_2 + 6H_2O$

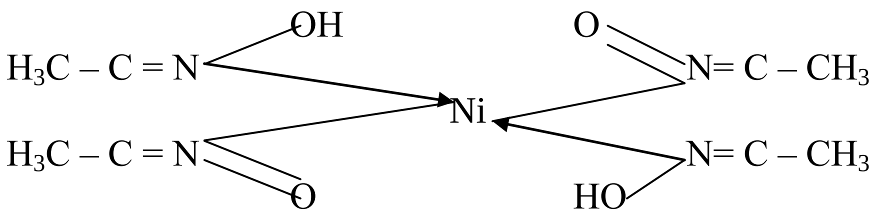
$Ni(OH)_2 + 6\,NH_4OH = [Ni(NH_3)_6]^{2+} + 2OH^- + 6H_2O$

The deposition is not dissolved many caustic alkalis.

**<u>Reactant dimethilglycoxynum. Reactant of Chugaev</u>**.




Dimethilglycoxynum forms with ions $Ni^{2+}$ in limits pH 5-10 crystal deposition of red-pink colour which is intracomplex salt:




Reaction spend at presence acetatly buffer mix with pH =5, 1 drop $CH_3COOH$ created by addition and 5 drops $CH_3COO\,Na$. Reaction can be spent and in the presence of $NH_4OH$, not supposing its surplus.

## Reactions of ions of zinc - $Zn^{2+}$

**Reactant-hydroxids of sodium and calii - NaOH, KOH.**

Caustic alkalis at cautious addition allocate from solutions of salt of zinc white amorphous deposit $Zn(OH)_2$:

$$ZnCl_2+2NaOH=Zn(OH)\downarrow +2NaCl\uparrow$$

$$Zn^{2+} +2OH^- =Zn (OH)_2\downarrow$$

## RESEARCH OF PROPERTIES OF DEPOSIT Zn (OH) $_2$

Zn (OH) $_2$ shows he amphoteric properties.

1. The deposit is dissolved in mineral acids:

$$Zn(OH)_2+2HCl=ZnCl_2 + 2H_2O$$

$$Zn(OH)_2 + 2H^+ = Zn^{2+} +2H_2O$$

2. The deposit is dissolved many alkalis:

$$Zn(OH)_2+2NaOH=Na_2[Zn(OH)_4]$$

$$Zn (OH)_2+2OH^- = [Zn(OH)_4]^2$$

Reactant - a sodium hydrocarbonate - $NaHCO_3$.

Sodium the hydrocarbonate and carbonates from solutions of salts of zinc allocate a white deposit-gidroksid of zinc $Zn(OH)_2$:

$$ZnCl_2+2NaHCO_3=Zn (OH)_2\downarrow + 2CO_2\uparrow + 2NaCl$$

$$Zn^{2+}+ 2HCO_3^- = Zn (OH)_2\downarrow + 2CO_2\uparrow$$

In water solution $NaHCO_3$ it is hydrolyzed:

$$NaHCO_3+H_2O\leftrightarrow NaOH+H_2CO_3$$

$$HCO_3^- + H_2O\leftrightarrow OH^- + H_2CO_3$$

Therefore at a water solution of this salt there are ions $Zn^{2+}$, $HCO_3^-$ $OH^-$ $CO_3^{2-}$ as Zn (OH) $_2$ less we will dissolve, than $ZnCO_3$ drops out in deposit Zn (OH) $_2$.

### Qualitative reactions on aniones biogene elements.

**Reactions a carbonate anions - $CO_3{}^2$.**

**Reactant barium chloride** - $BaCl_2$.

Chloride of barium $BaCl_2$ - allocates a white crystal deposition of a carbonate of barium $BaCO_3$ from solutions of carbonates.

$Na_2CO_3 + BaCl_2$ $BaCO_3 +NaCl_2$

**RESEARCH OF PROPERTIES OF DEPOSITION** $BaCO_3$.

1. The deposition is dissolved in mineral acids:
   $2H Cl = Ba Cl_2 + H_2O + CO_2$
   $BaCO_3 + 2H^+ = Ba^{2+} + H_2O + CO_2$
2. The deposition is dissolved in acetic acid:
   $BaCO_3 + 2CH_3COOH = Ba (CH_3COO)_2 + H_2O + CO_2$
   $BaCO_3 + 2CH_3COOH = Ba^{2+} + 2CH_3COO^- + H_2O + CO_2$

**Reactant sulfuric acid -** $H_2 SO_4$

The diluted sulfuric acid - $H_2SO_4$ - decomposes carbonates with allocation of carbonic gas $CO_2$. Last at reception in limy water causes its turbidity owing to formation of a white deposition of a carbonate of calcium $CaCO_3$.

$Na_2CO_3 + H_2SO_4 = Na_2SO_4 + H_2O + CO_2$
$CO_3^{2-} + 2H^+ = H_2O + CO_2$
$CO_2 + Ca (IT)_2 = CaCO_3 \downarrow + H_2O$

RESEARCH OF PROPERTIES OF DEPOSITION $CaCO_3$

1. At long reception $CO_2$ the deposition is dissolved:
   $CaCO_3 + CO_2 + H_2O = Ca (HCO_3)_2$
   $CaCO_3 + CO_2 + H_2O = Ca^{2+} + 2NSO3^-$

**Reactions of ions -** $PO_4^{3-}$
**Reactant barium chloride -** $BaCl_2$.

Chloride of barium $BaCl_2$ - allocates from solutions of hydrophosphates a white amorphous deposition hydrophosphatase barium $BaHPO_4$

$Na_2 HPO_4 + BaCl_2 = BaHPO_4 \downarrow + 2 NaCl$
$HPO_4^{2-} + Ba^{2+} = BaHPO_4 \downarrow$

At presence hydroxyd ammonium barium phosphate turns out:

$2Na_2 HPO_4 + 3BaCl_2 + 2NH_4OH = Ba_3 (PO_4)_2 \downarrow + 2NH_4Cl + 4 NaCl + 2H_2O$
$3Ba^{2+} + HPO_4^{2-} + 2NH_4OH = Ba_3 (PO_4)_2 \downarrow + 2NH_4^+ + 2H_2O$

**RESEARCH OF PROPERTIES OF DEPOSITION $BaHPO_4$.**

1. The deposition is dissolved in mineral acids:
   $BaHPO_4 + 2H Cl = BaCl_2 + H_3PO_4$
   $BaHPO_4 + 2H^+ = Ba^{2+} + H_3PO_4$
2. The deposition is dissolved in acetic acid:
   $BaHPO_4 + 2 CH_3COOH = Ba (CH_3COO)_2 + H_3PO_4$
   $BaHPO_4 + 2 CH_3COOH = Ba^{2+} + 2 CH_3COOH^- + H_3PO_4$

Reactant of magnesial mix **- $MgCl_2 + NH_4OH + NH_4Cl$**

Magnesium chloride at presence hydroxyd and ammonium chloride allocates from solutions of phosphates a white crystal deposition of double salt $MgNH_4PO_4$. Experience performance: to 3 drops of a solution $Mg Cl_2$ to add 2 drops of solution $NH_4OH$ and some drops of solution $NH_4Cl$ before dissolution of a dropping out deposition $Mg (OH)_2$, then 2-3 drops of solution $Na_2HPO_4$, drop out a deposition $MgNH_4PO_4$:

$$MgCl_2 + Na_2HPO_4 + NH_4OH = MgNH_4PO_4\downarrow + 2NaCl + H_2O$$
$$Mg^{2+} + HPO_4^{2-} + NH_4OH = MgNH_4PO_4\downarrow + H_2O$$

## RESEARCH OF PROPERTIES OF A DEPOSITION $MgNH_4PO_4$

1. The deposition is dissolved in mineral acids:

$$MgNH_4PO_4 + 3HCl = MgCl_2 + NH_4Cl + H_3PO_4$$
$$MgNH_4PO_4 + 3H^+ = Mg^{+2} + NH_4^+ + H_3PO_4$$

2. The deposition is dissolved in acetic acid:

$$MgNH_4PO_4 + 3CH_3COOH = Mg(CH_3COO)_2 + NH_4CH_3COO + H_3PO_4$$
$$MgNH_4PO_4 + 3CH_3COOH = Mg^{2+} + 3CH_3COO^- + NH_4^+ + H_3PO_4$$

**Reactions of ions $NO_2^-$**

**Reactant sulfuric acid** - $H_2SO_4$

The diluted sulfuric acid - $H_2SO_4$ - decomposes nitrites with liberation of gas of brown colour $NO_2$, well visible on a white background:

$$2KNO_2 + H_2SO_4 = K_2SO_4 + NO\uparrow + NO_2\uparrow + H_2O$$
$$2NO_2^- + 2H^+ = NO\uparrow + NO_2\uparrow + H_2O$$

Diluted $H_2SO_4$ on nitrats does not operate, them decomposes only concentrated $H_2SO_4$.

**Reactant iodid kalii** - KI

Iodid kalii - KI - in the sour environment is oxidised nitrites to free iod - $I_2$-.

Reaction performance: in a test tube to pour 2-3 drops of solution $KNO_2$, to add 2-3 drops solution $H_2SO_4$, 2-3 drops of solution KI, some drops of an aether. Allocated iod paints a radio layer in violet colour:

$$2KNO_2 + 2KI + 2H_2SO_4 = 2K_2SO_4 + 2NO + I_2 + 2H_2O$$
$$2I^- - 2\bar{e} \longrightarrow I_2^0 \quad |1$$
$$N^{3+} + \bar{e} \longrightarrow N^{2+} \quad |2$$
$$2I^- + 2N^{3+} \longrightarrow I_2 + 2N^{2+}$$

**Reactions of ions** - $NO_3^-$

**Reactant iron sulphate/II/**-$FeSO_4$

Iron sulphate - $FeSO_4$ - restores nitrates to oxyd nitrogen - NO which with $FeSO_4$ forms complex connection $[FeSO_4 \cdot NO]$ brown colour.

Reaction performance: in a test tube to pour solution $KNO_3$, to bring a little crystalls firm $FeSO_4$ and it is cautious on a wall of a test tube a capillary to lower a drop concentrated $H_2SO_4$.

$$2NaNO_3 + 6FeSO_4 + 4H_2SO_4 = 3Fe_2(SO_4)_3 + Na_2SO_4 + 2NO + 4H_2O$$
$$2Fe^{2+} - 2\bar{e} \longrightarrow 2Fe^{3+} \quad |3$$
$$N^{5+} + 3\bar{e} \longrightarrow N^{2+} \quad |2$$
$$6Fe^{2+} + 2N^{5+} \longrightarrow 6Fe^{3+} + 2N^{2+}$$
$$NO + Fe^{2+} + SO_4^{2-} = [Fe(NO)SO_4]$$

**Reactions of ions - $S^{2}$.**

**Reactant silver nitrate** - Ag $NO_3$

Silver nitrate - Ag $NO_3$ - forms with solutions of sulfids a grey deposition of sulfid of silver - $Ag_2S$

$2Ag\ NO_3 + Na_2S_3 = Ag_2S\downarrow + 2Na\ NO_3$

$2Ag^{+} + S^{2} = Ag_2S\downarrow$

**RESEARCH OF PROPERTIES OF DEPOSITION $Ag_2S$**

1. The deposition is not dissolved in the diluted hydrochloric acid.
2. The deposition is not dissolved in an ammonia solution.
3. The deposition is dissolved in the diluted nitric acid

   $3\ Ag_2S + 8H\ NO_3 = 6Ag\ NO_3 + 3\ S + 2\ NO + 4\ H_2O$

   $3\ Ag_2S + 8H^{+} + 2N_{O3}^{-} = 6Ag^{+} + 3\ S + 2\ NO + 4\ H_2O$

**Reactiv of cadmium nitrate** - Cd $(NO_3)_2$

Salts of cadmium with sulfids form a bright yellow deposition of sulfid of cadmium Cd S:

$Cd\ (NO_3)_2 + Na_2S = Cd\ S\downarrow + 2Na\ NO_3$

$Cd^{2+} + S^{2-} = Cd\ S\downarrow$

**RESEARCH OF PROPERTIES OF DEPOSITION CdS**

1. The deposition is dissolved in the diluted hydrochloric and sulfuric acids.

   $Cd\ S + 2HCl = CdCl_2 + H_2\ S$

   $Cd\ S + 2H^{+} = Cd^{2+} + H_2\ S$
2. The deposition is dissolved in the diluted nitric acid

   $3\ Cd\ S + 8H\ NO_3 = 3Cd\ (NO_3)_2 + 2NO + 3S + 4H_2O$

**Reactions of ions** $SO_4^{2-}$

**Reactant barium chloride** - $BaCl_2$.

Chloride of barium $BaCl_2$ allocates a white deposition of sulphate of barium Ba $SO_4$ from solutions of sulphates

$BaCl_2 + Na_2\ SO_4 = Ba\ SO_4\downarrow + 2\ NaCl$

$Ba^{2+} + SO_4^{2-} = Ba\ SO_4\downarrow$

**RESEARCH OF PROPERTY OF DEPOSITION Ba $SO_4$**

1. The deposition is not dissolved in mineral acids
2. The deposition is not dissolved many caustic alkalis.

**Reactions of ions** $SO_3^{2-}$

**Reactant barium chloride** - $BaCl_2$.

Chloride of barium $BaCl_2$ allocates a white deposition of sulphite of barium Ba $SO_3$ from solutions of sulphites

$BaCl_2 + Na_2\ SO_4 = Ba\ SO_3\downarrow + 2\ NaCl$

$Ba^{2+} + SO_3^{2-} = Ba\ SO_3\downarrow$

**RESEARCH OF PROPERTY OF DEPOSITION Ba $SO_3$**

1. The deposition is dissolved in mineral acids

$Ba SO_3 + 2H Cl = BaCl_2 + H_2O + SO_2$

$Ba SO_3 + 2H^+ = Ba^{2+} + H_2O + SO_2$

**Reactant permanganate kalii** - $KMnO_4$

Permanganate kalii $KMnO_4$ at addition to a solution of the sulphites, acidified by sulfuric acid, becomes colourless

$5K_2 SO_3 + 2 KMnO_4 + 3 H_2 SO_4 = 6K_2 SO_4 + 2Mn SO_4 + 3H_2O$

$S^{4+} + 2\bar{e} = S^{6+}$ | 5

$Mn^{7+} + 5\bar{e} = Mn^{2+}$ | 2

$5S^{4+} + 2Mn^{7+} = 5S^{6+} + 2Mn^{2+}$

**Reactions of ions** $S_2O_3^{2-}$

**Reactant barium chloride** - $BaCl_2$.

Chloride of barium $BaCl_2$ allocates from solutions of tiosulfats a white deposition of tiosulfat barium - $Ba S_2O_3$

$BaCl_2 + Na_2 S_2O_3 = Ba S_2O_3\downarrow + 2 NaCl$

$Ba^{2+} + S_2O_3^{2-} = Ba S_2O_3\downarrow$

**RESEARCH OF PROPERTY OF DEPOSITION** $BaS_2O_3$

1. The deposition is dissolved in mineral acids

$Ba S_2O_3 + 2H Cl = BaCl_2 + H_2S_2O_3$

$Ba S_2O_3 + 2H^+ = Ba^{2+} + H_2O + SO_2\uparrow + S\downarrow$

**Reactant sulfuric acid** - $H_2 SO_4$

At action by the diluted chamois of acid at boilingon tiosulfats the solution gradually grows turbid owing to allocation of elementary sulphur:

$Na_2 S_2O_3 + H_2 SO_4 = Na_2 SO_4 + SO_2\uparrow + S\downarrow + H_2O$

$S_2O_3^{2-} + 2H^+ = SO_2\uparrow + S\downarrow + H_2O$

**Reactions of ions** - $Cl^-$

**Reactant silver nitrate** - $Ag NO_3$

Nitrate of silver $AgNO_3$ allocates from solutions of bromides a cottage cheese white deposition of chloride of silver - AgCl

$AgNO_3 + NaCl = AgCl\downarrow + Na NO_3$

$Ag^+ + CL^- = AgCl\downarrow$

**RESEARCH OF PROPERTIES OF DEPOSITION AgCl**

1. The deposition is not dissolved in nitric acid.
2. The deposition is dissolved a lot of solution of ammonia.

$AgCl + NH_4 OH = [Ag (NH_3)_2] Cl + 2 H_2O$

$AgCl + NH_4 OH = [Ag (NH_3)_2]^+ + CL^- + 2 H_2O$

**Reactions of ions** $Br^-$

**Reactant silver nitrate** - Ag $NO_3$

Nitrate of silver $AgNO_3$ allocates from solutions of chlorides a yellowish deposition of bromide of silver - Ag Br

$AgNO_3$ + Na Br = Ag Br ↓ + Na $NO_3$

$Ag^+ + Br^- =$ Ag Br ↓

**RESEARCH OF PROPERTIES OF DEPOSITION Ag Br**

1. The deposition is not dissolved in nitric acid.
2. The deposition is partially dissolved a lot of solution of ammonia.

Ag Br + $2NH_4$ OH = [Ag $(NH_3)_2$] Br + 2 $H_2O$

Ag Br + $2NH_4$ OH = $[Ag (NH_3)_2]^+ + Br^-$ + 2 $H_2O$

**Reactant chloric water** - $Cl_2$

Chloric water $Cl_2$ in the sour environment from bromides allocates the free bromine having characteristic colouring.

Reaction performance: to a bromide solution to add 2-3 drops of a solution, $H_2SO_4$, 2-3 drops of a solution of chloric water, some drops of an aether or benzene to stir up test tube contents.

Elementary bromine paints an aether layer in yellow-orange colour:

2Na Br + $Cl_2$ = 2NaCl + $Br_2$

$2Br^- + Cl_2 = 2Cl^- + Br_2$

**Reactions of ions** $I^-$

**Reactant silver nitrate** - Ag $NO_3$

Nitrate of silver $AgNO_3$ allocates from solutions iodids a light yellow deposition iodid silver - Ag I

$AgNO_3$ + Na I = Ag I ↓ + Na $NO_3$

$Ag^+ + I^- =$ Ag I ↓

**RESEARCH OF PROPERTIES OF DEPOSITION** Ag I

1. The deposition is not dissolved in nitric acid.
2. The deposition is not dissolved a lot of solution of ammonia.

**Reactant the chloric water** - $Cl_2$

Chloric water $Cl_2$ in the sour environment from iodids allocates the free iodine having characteristic colouring.

Reaction performance: to a solution iodid to add 2-3 drops of a solution, $H_2SO_4$, 2-3 drops of a solution of chloric water, some drops of an aether or benzene to stir up test tube contents.

Elementary iod paints an aether layer in crimson-violet colour:

2Na I + $Cl_2$ = 2NaCl + $I_2$

$2 I^- + Cl_2 = 2 Cl^- + I_2$

**Training tasks and the standard of their decision**

***Task №1***. Why Mg $(OH)_2$ it is dissolved in ammonium salts?

***The standard of decision***

As is known, deposition Mg (OH) $_2$ is dissolved in ammonium salts. This results from the fact that concentration of ions It - decreases owing to formation light dissotiationly bases $NH_4OH$. Balance a deposition - a solution is broken towards deposition dissolution:

$$Mg(OH)_2 \rightleftarrows Mg^{+2} + 2OH^-$$
$$2NH_4Cl \rightleftarrows 2Cl^- + 2\ NH_4^+$$

***Task № 2.*** How to prepare chromokalily alum if as initial substance to take dichromat kalii? To find weight $K_2Cr_2O_7$ necessary for reception 1 kg of alum.

**Given:**

m (alum) = 1кg

M ($K_2Cr_2O_7$) =294 g/mol

M (alum) =499,09 g/mol

m ($K_2Cr_2O_7$)-?

***The standard of decision***

Chromokalily alum has formula $KCr(SO_4)_2 \cdot 12H_2O$

1. To receive chromokalily alum from $K_2Cr_2O_7$, it is necessary to restore $Cr^{6+}$ in $Cr^{3+}$. This process can be spent by means of various reducers: $SO_2$, HI, $H_2S$, etc. the most convenient chrome restoration by ethyl spirit as in this case it is not formed other inorganic ions is:

$3C_2H_5OH + K_2Cr_2O_7 + 4H_2SO_4 + 17H_2O = K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O + 3C_2H_4O$

2. On the reaction equation it is visible, that from 1 asking $K_2Cr_2O_7$ it turns out 2 asking $KCr(SO_4)_2 \cdot 12H_2O$, that is from 1mol $\cdot$ 294,10g/MOL = 294,10 g will turn out

2mol $\cdot$ 559,09g/mol = 1118,18 g $KCr(SO_4)_2 \cdot 12H_2O$. We will write down:

294,10g $K_2Cr_2O_7$--------------1118,18 g $KCr(SO_4)_2 \cdot 12H_2O$

X g $K_2Cr_2O_7$--------------1000 g $KCr(SO_4)_2 \cdot 12H_2O$

Makes a proportion:

294,10: 1000 = X: 1118,18

$$X = \frac{294{,}10 \cdot 1000}{1118{,}18} = 264g$$

*The answer:* m ($K_2Cr_2O_7$) =0,264 kg

**Questions and tasks for self-checking of learning of a theme**

1. As well as why the basic properties hydroxydes metals of the main subgroup of II group among Be (OH) $_2$ - Ca (OH) $_2$ - Sr (OH) $_2$ - Ba (OH) $_2$ ?
2. Strontium and especially, barium in considerable quantities cause in the person occurrence of fragility of bones. Explain, why these elements can replace a bio-element calcium in the bones consisting of phosphate and a carbonate of calcium?
3. What reaction to litmus will be had by solutions of salts $Na_2CO_3$, $CH_3COOK$?
4. Write the equation of oxidation-reduction reaction of oxidation $Mn^{2+}$ to $Mn^{7+}$.

**Situational tasks.**

***Task 1.*** In surgical practice hypertensive solution NaCl is widely applied 3, 5, 10 % (weights). How many salt grammes are necessary for preparation 1l. 10% a solution? On what its action is based?
(ρ =1,11 g/ml)
*The answer:* m (NaCl) = 111,0 Moistened, the tampon is put by solution NaCl on sites of the amazed skin on purpose soak up purulent liquids.

***Task 2.*** Copper sulphate - $CuSO_4 \cdot 5H_2O$ is used as knitting and an antiseptic at conjunctivitis. Calculate weight of a preparation for preparation of 0,25 % of a solution of 100,00 ml. What mass fraction of copper (%) in the given preparation?

*The answer:* m ($CuSO_4 \cdot 5H_2O$) = 0,25g. ω % (Cu) = 0,06 %.

## Test questions

1. What reagent is used for definition cation $Fe^{+3}$?
a) NaOH b) $NH_4SCN$ c) $K_3[Fe(CN)_6]$
d) $NH_4Cl$ e) HCl
2. What solution can be used as a physiological solution?
a) 3% NaCl b) 0,86% KCl c) 0,86% NaCl d) 0,9% $CaCl_2$
3. The lack of fluorine of an organism leads to following diseases:
a) Fluores b) caries c) anaemia d) hypoterios
4. Specify microbiogenly d - an element:
a) Ag b) Hg c) Cu d) Cd
5. In what organ iodine collects?
a) a bone b) a liver c) a thyroid gland d) nephrons
6. In what organ copper collects?
a) a bone b) a liver c) a thyroid gland d) nephrons
7. Surplus of iodine in an organism leads to occurrence:
a)Anemias b)caries c)hypoterios d)hyperterios
8. At addition to investigated solution $K_4[Fe(CN)_6]$, the dark blue deposition is formed. What ion is present at a solution?
a)$Sn^{2+}$ b)$Pb^{2+}$ c)$Fe^{+2}$ d)$Fe^{+3}$
9. Ions of sodium are a part:
a)Endocellular liquid
b)Extracellular liquid
c)Are not a part of cellular liquids
d)All answers are true
10. What element strengthens coagulability of blood?
a)Mg b)Ca c)Fe d)Co

## LABORATORY WORK

## Qualitative reactions on cations biogene elements.

***1 experience. Reaction to ions* - $Ca^{2+}$**

Reaction with oxalate sodium $Na_2C_2O_4$. To 5-6 drops of solution $CaCl_2$ to flow 5-6 drops of a solution of a reactant. The white deposition is formed.

***2 experience. Reaction to ions* - $Cr^{3+}$**

Reaction with caustic alkalis NaOH. To 5-6 drops of a solution of salt $Cr^{3+}$ to flow on drops solution NaOH before deposition formation.

***3 experience. Reaction to an ion* - $Fe^{3+}$**

Reaction with rodanidom ammonium $NH_4SCN$.

To 4-5 drops of solution $FeCI_3$ to add 4-5 drops of a solution of a reactant, blood-red colour is formed.

Reaction with Ferrocianid kalii (II) $K_4[Fe(CN)_6]$

To 4-5 drops of solution $FeCl_3$ to add 4-5 drops of a solution of a reactant, it is formed deposition the Berlin azure.

***4 experience. Reaction to an ion* - $Fe^{2+}$**

Reaction with Ferrocianid (III) kalii $K_3[Fe(CN)_6]$.

To 4-5 drops of solution $FeSO_4$ to add 4-5 drops of a solution of a reactant, the deposition turnubulity a blue is formed.

**5 *experience. Reaction to an ion* - $Mn^{2+}$**

Reaction with caustic alkalis.

To 4-5 drops of solution $Mn(NO_3)_2$ to add 4-5 drops of a solution of a reactant, the white deposition is formed.

***6 experience. Reaction to an ion* - $Zn^{2+}$**

Reaction with Ferrocianid kalii $K_4[Fe(CN)_6]$. To 4-5 drops of solution $ZnCl_2$ to add 4-5 drops of a solution of a reactant, the white deposition is formed.

$$2K_4[Fe(CN)_6] + 3ZnCl_2 \rightarrow 6KCl + K_2Zn_3[Fe(CN)_6]_2$$

***7 experience on an ion* - $Co^{2+}$**

Reaction with a carbonate of sodium $Na_2CO_3$. To 4-5 drops of solution $CoCI_2$ to add 4 - 5 drops of a solution of a reactant. The deposition of pink colour is formed.

### Tasks for the independent decision

1. Write the reaction equation, showing Amphoternly properties hydroxyd zinc.
2. At action on salt of chrome (III) sulfid of ammonium it is formed hydroxyd chrome. Explain this phenomenon. Write the reaction equation.
3. In what deposition $Mn(OH)_2$ is dissolved?

## INORGANIC ELEMENTS

**The employment purpose:** to acquaint students with chemistry inorganic elements, to study the general properties of elements inorganogens, their toxic influence on ability to live processes. To get skills of performance of qualitative reactions to ions inorganic elements.

**The importance of a studied theme.**

The chemistry inorganic elements studies the chemical reactions proceeding in a live organism with participation inorganic of ions. Toxic action of these elements in certain degree depends on a structure of their atom, set of their physical and chemical properties, ability to collect in those or other tissue and organs.

It is known, that ions inorganic elements contain in an organism in certain quantity, however neither the biological role, nor the maintenance form, features of their concentration in tissue and organs are unknown. Connections get to a human organ inorganic elements together with a foodstuff, food, air and water.

Surplus of these elements leads to serious pathologies. For treatment of the pathologies caused by toxic action of ions inorganic of elements, in clinical practice use a method chelation.

Methods of the qualitative analysis define presence of ions inorganic elements in biological liquids.

**Initial level of knowledge**

Law of changes of properties of elements and their connections in connection with an arrangement in periodic system D.I. Mendeleev;
Electronic structure of atoms;
Types of chemical bonds in molecules;
Drawing up of the equations of chemical reactions in the molecular and ionic form.

**Teaching material for self-preparation**

N.L.Glinka chemistry, 1984, p. 383-608.
S.S.Olenin, G.N.Fadeev. Inorganic chemistry, M, 1979, p. 314-336
V.N.Alekseev the Course qualitative chemical half-microanalys, M, 1973, p. 318-419,448.
K.A.Seleznev chemistry. M, 1973, p. 90,100,106,108,116,121.
I.K.Tsitovich the Course of analytical chemistry. M, 1985, p. 113.

**On employment following questions will be considered:**

Toxic action inorganic elements on a live organism and its consequence.
Application of connections inorganic elements as medical products in medicine.
Chemical properties inorganic elements and their connections.
Qualitative reactions on ions inorganic elements.
Laboratory work.

## THE INFORMATION BLOCK.

Inorganic elements are elements which contain in an organism in certain quantity, but their biological function is not studied, and the increase in their maintenance in an organism leads to serious pathologies.

inorganic elements it is possible to consider the given formulation conditional as revealing of biological functions and the vital properties inorganic elements can pull together them to a class of biogene elements.

To inorganic to elements barium, strontium, mercury, aluminium, lead, arsenic, bismuth, tin concern, etc.

**Barium.** In earth crust contains $5 \cdot 10^{-2}$ % (weights) of barium. In an organism the barium maintenance of slightly $1 \cdot 10^{-5}$ %.

Barium is found out in a pigmentary cover of an eye. The increase in its quantity in blood leads leycose. This element for the person is poisonous. In considerable quantities supersedes calcium from biomolecules.

Soluble salts of barium are toxic. It is known, that barium influences smooth muscles, reminding action of acetylcholin. It is revealed, that it raises blood pressure. In medicine from its salts barium sulphate is used. Because of bad solubility ($Sp_{BaSO4} = 0{,}87 \cdot 10^{-10}$) it is applied in radiodiagnosis as contrast substance.

The increase in the maintenance of barium in an organism leads to oncological diseases.

Toxicity of barium speaks possibility of formation of strong insoluble phosphate in a bone fabric, nervous cells and brain substance.

**Strontium.** In earth crust the maintenance of strontium of $4 \cdot 10^{-2}$ %; (weights). It contains in skeletons of the higher and lowest animals. To 5 % of strontium it is formed at explosions of nuclear bombs. Strontium represents the big danger since it is easy absorb soil, replacing calcium, and can get through plants to an organism of animals and the person. In an organism it is found out constantly. Strontium collects in more degrees in those organs which the rich man calcium and are poorer magnesium. Strontium can replace calcium in biosystems. Getting to an organism strontium replaces calcium in its phosphate which is a basis of a bone fabric and causes «a strontic rickets». To deduce from an organism strontium it is practically impossible also for a fabric are exposed to a constant "internal" irradiation which leads to a leukaemia.

**Cadmium.** In earth crust contains $5 \cdot 10^{-4}$ % (weights). If the cadmium maintenance in soil reaches 3 mg/kg its concentration in a biomass of plants will be not less than 0,4 mg/kg that can cause toxic effect in animals and the person. In a human organ contains $1 \cdot 10^{-4}$ % (weights) of cadmium. Cadmium connections are toxic for an organism. It is a microcell of vegetative and animal organisms. The biological role of cadmium is not revealed. Cases of replacement for cadmium of ions of zinc in carboxypeptidaza and in an alkaline phosphataza are known. Cadmium collects mainly in a liver and kidneys. Cadmium in a live organism shows both sinergism, and antogonism in operation: the zinc lack increases the cadmium maintenance in a liver and cortex substance of kidneys. Maximum permissible concentration of cadmium for an organism makes 70mkg. Its surplus raises a blood pressure, leads to a curvature and deformation of bones, as ions $Cd^{2+}$ supersede ions of biometals ($Ca^{2+}$, $Mg^{2+}$, $Zn^{2+}$) from less strong complexes, forming stronger communications with sulphurocontaining ligands fibers. It possesses also cancerogenic property as in growth tobacco cancels cadmium from soil and as a result in one cigarette its maintenance of 1,2-2,5 mkg. To lungs of the smoking person gets 0,1-2,5mkg cadmium.

Cadmium strengthens the phenomenon of zinc insufficiency at big horned cattle.

It ingibitor many enzymes, influences a carbohydrate exchange, regulates the sugar maintenance in blood.

**Mercury.** In earth crust contains $7 \cdot 10^{-6}$ % (weights) of mercury. In a human organ contains $1 \cdot 10^{-6}$ % (weights). Daily in a human organ together with food 0,02-0,05 mg of mercury arrive on the average. Complex connections of mercury are steadier, than kadmily, that leads to strong linkage of various enzymes with mercury (II) and to their inhibition. It speaks high toxicity of connections of mercury.

Owing to extremely high stability of complex connections of mercury with fibers and denaturation the squirrel under the influence of mercury salts, the last collect in a live organism and are difficultly deduced from an organism.

On modern representations, mercury and its organic connections are considered as fermental poisons which cause the strongest poisonings. Toxicity of mercury is caused by interaction with groups-SN cellular proteins. Metal mercury and its steams are very poisonous.

Mercury in environment is as in a kind of "inorganic connections», and in a kind of "organic connections», in a kind alcyll, aryll, alkoxyll connections. Are especially toxic methilhydrargyrum, ethilhydrargyrum, is less toxic - phenilhydrargyrum.

Mercury oppresses thyroid gland work. Introduction of superfluous quantity iodid leads to reduction of oppressing action of mercury as iodine connects surplus of mercury under the scheme:

$$HgI_2 + 2KI \longrightarrow K_2[Hg\ I_4]$$

Mercury ions strongly incorporate to fibers and form insoluble connections with albumin, causing frustration of intestines and also kidneys, as a result of a kidney lose ability to delete from blood disintegration products that can lead to death.

At a poisoning with mercury there is a strong pain in a gastroenteric path, there is a vomiting, the chair with blood is allocated, at a strong poisoning there is an ulcer in an intestines, a stomach, their rotting (necros) is observed. At a chronic poisoning loss of hair, eyebrows, eyelashes, a teeth is observed. Mucous membranes, nervous system are amazed, the metabolism, blood circulation is broken, etc. Therefore the mercury maintenance in air of the industrial enterprises should not exceed thyroid gland function $1 \cdot 10^{-5}$mg/l.

At a poisoning with mercury and its connections it is necessary to use milk and egg white as fibers besiege mercury in the field of a stomach.

**Aluminium.** This element makes $8{,}7 \cdot 10^{-5}$ % of weight of an organism. The daily requirement of an organism for aluminium makes 35-40mg a day. In an organism is in a kind of complex connections with oxyacids, polyphenols, carbohydrates, lipids etc.

It is a component of organs and tissue of the person, participates in construction of an epitelial and connecting fabric. The aluminium maintenance in air should not exceed 0,5mg/dm$^3$. Otherwise last breaks a metabolism of biologically active substances containing the rests of phosphoric acid. Aluminium is besieged in intestines by phosphates that lead to a rickets because of reduction of phosphorus owing to linkage of the last in lightly soluble aluminium phosphate. The greatest quantity of aluminium contains in a brain, lungs, a liver, a spleen, kidneys, bones.

Aluminium forms strong connections with fibers of a fabric that leads to metabolism infringement.

Aluminium reduces activity of such enzymes as lactatdehydrogenasa, the alkaline phosphataza, phosphohexoisomerasa, aldolasa and raises activity glutamataspartat - aminopherasa. It speaks replacement of ions of magnesium and calcium which are in the active centre of enzymes and are activators of the last.

Owing to high complexoforming abilities aluminium in considerable quantities brakes haemoglobin synthesis, blocking the active centres of the enzymes participating in process haemoforming.

Increase of the maintenance of aluminium in an organism leads to a neurotoxically poisoning.

Workers of nonferrous metallurgy, at persons occupied with manufacture of aluminium powder, extraction and smooth bauxites have a disease aluminos. Therefore maximum permissible norm in air of working premises 2mg/m$^3$. In the big doses aluminium preparations have irritating an effect on mucous membranes, small knitting, disinfectant property.

**Lead.** The lead maintenance in an organism makes $1\cdot10^{-4}$ % of weight of an organism. In air 0,01mg/m$^3$. The increase in the maintenance of acetate of lead to 145 mg/kg leads to a lethal outcome.

Lead is an element which contains in motor fuel, it collects and pollutes atmosphere. Pollution of atmospheric air by lead promotes its penetration into an organism. Lead in a significant amount is in soil.

Lead - poison for protoplasm of all cells of an organism. Through respiratory ways of pair lead collect in alveoluses, bronchiols and resolve in lungs.

The basic quantity of lead, getting to an organism, collects in red blood little organs and bones (~ 40-50 %).

The poisoning with lead ions leads to occurrence of stains on gums, to frustration of nervous system, infringement of function of kidneys, promotes anaemia development. Symptoms poisoning lead - weakness, an anaemia, dizziness, a faint, a paralysis, spasms.

Antidote at a poisoning with lead ions is egg white and ascorbic acid.

**Arsenic.** This element is poisonous for the person and live organisms. The maintenance in an organism makes $1\cdot10^{-6}$ % (weights). Is a toxic element. The maintenance in air should not exceed - 0,3 mg/m$^3$, in water - 0,05 mg/l. To atmosphere gets as a result of pollution by emissions of the industrial enterprises. With food to an organism gets nearby 1mg arsenic a day. Basically it concentrates in erythrocytes and a spleen, fibers of tissue. The deadly dose for the adult person makes 0,1-0,3g.

Connections As (III) - arsenites, make poisoning impact on tioly group at interaction with fibers and enzymes. They inhibitate-SH groups under the following scheme:

$$R - S - H + HO - As = O \longrightarrow R - S - As{-}OH + H_2O$$

Hydrogen replacement sulfhydrill groups arsenic leads to change conformation enzyme and loss of its activity. From arsenic connections by the most toxic action possesses arsin ($AsH_3$). This connection inhibitate activity

$$3Hb \cdot O_2 + 2AsH_3 \longrightarrow 3\ MetHb + 2HAsO_2 + 2H_2O$$

There of amplifies haemolysis of erythrocytes and there is a corking of channels of kidneys. The last weakens a channel of their bilious acids metabolites, that leads yellowing an organism.

Unlike listed arsenat of ions ($HAsO_4^{-2}$) inhibitate synthesis ATF.

Arsenat of ions weaken a metabolism of pyrograpely acids in mithochondries

It leads to infringement of a metabolism of carbohydrates, amino acids and lipids.

Also the increase in quantity of arsenic in an organism leads to disease of "black feet».

Being in the big doses poison, arsenic and its connections in small doses strengthen activity of cardiovascular system, haemoforming organs, influence the general tone of an organism.

**Bismuth.** Because it contains in potable water, in a human organ arrives with water and food about 20 mkg of bismuth a day. In an organism contains $1 \cdot 10^{-6}$ % (weights) of bismuth. It is revealed, that in liver, kidneys, glands of internal secretion of bismuth slightly.

Bismuth salts, getting to an organism, are easily hydrolyzed and form unsoluble connections. In a gastroenteric path bismuth ions form strong complex connections with ligands, containing an amino group, are not acquired by an organism and allocated from it. It toxic action of salts of bismuth which oppress amin - and carboxypolipeptidase speaks.

At penetration of soluble connections of bismuth into blood they are found out in plasma in connections with fibers.

The increase in ions of bismuth in an organism weakens warm activity, the excessive increase leads to defeat of the central nervous system.

The bismuth great bulk collects in kidneys and leads to infringement of its function. The increase in quantity of bismuth in an integument leads dermatites.

Soluble connections of bismuth are poisonous.

**Antimony.** In an organism $1 \cdot 10^{-6}$ % (weight) of antimony contain. On medical and biologic properties and pharmacological effect antimony is similar to arsenic, but its connections are less toxic. It is connected by small solubility of products of hydrolysis of salts of bismuth and thereof impossibility of absorption by walls of a digestive path. Antimony and its connections basically concentrate in a skeleton, a liver, kidneys and a spleen. A deadly dose for the person is 0,12g. Antimony.

**Tin.** This element makes $1 \cdot 10^{-4}$ % of weight of an organism. To an organism gets with food. With food the person receives about 1 mg of tin a day, at prevalence in food of tinned products this quantity increases for 38 mg.

The reason of a poisoning with tin is that it contains in gasoline in the form of Sn ($CrH_5$) and collects in a liver, lungs, kidneys, erythrocytes. Inorganic connections of tin are not so poisonous, but tinorganic connections are rather toxic.

In an organism tin basically concentrates in a liver, kidney, muscles, blood and lungs.

The poisoning with tin causes an anaemia, reduction of haemoglobin and red blood little organs.

Surplus of tin in an organism leads to defeat of a skin and the top respiratory ways, and also causes mental diseases. In particular at a poisoning with tin at 59 % of patients the encephalopathy is observed, at 38 % of patients intellectual backwardness is observed.

**Medical preparations of inorganic elements.**

| | | |
|---|---|---|
| $BaSO_4$ | Barium sulphate | It is applied at renthgenly inspections of a gullet, a stomach and intestines |
| BaS | Barium-sulfid | Means for removal of hair from a skin. |
| $^{89}Sr$ and $^{90}Sr$ | Strontium isotopes | It is applied in beam therapy at bone tumours |
| Cd | Cadmium | It is applied in stomatology. The Amal-dins containing cadmium, primenja-jutsja at sealing of a teeth |
| Al $(OH)_3$ | | Adsorbing means |
| KAl $(SO_4) \cdot 12H_2O$ | Alum | It is applied to treatment inflamely diseases of a skin and mucosa |
| $Al_2S_3$ | | It is applied as not fitting a prosthesis means in stomatology |
| Connections Sb | Self-antimony | It is applied to treatment leyshmanioses |
| $As_2S_3$ | | Not fitting a prosthesis means in stomatology |
| $Na_2HAsO_4 \cdot 7H_2O$ | | General consolidate and a tonic at an anaemia |
| Arsenic connections Aminarson Novarsenol | | Are applied to treatment amebios, a syphilis |

| | | |
|---|---|---|
| Miarsenol | | |
| Bi (OH) $_2$Na<br>BiOOH<br>$BiONO_3$ | | Are applied to treatment gastrici-intestinal diseases; in ointment at skin inflammations |
| Bismuth connections dermatol, bismoverol, biyohinol-kentabismol | | Are applied to treatment gastrici-intestinal diseases; in ointment at skin inflammations For syphilis treatment |
| $HgCl_2$ | Corrosive sublimate | It is applied to treatmen of skin disease |
| HgO,-$HgNH_2Cl$ | | It is applied to treatment of skin diseases |
| $Hg_2Cl_2$ | Kalomel | It is applied to treatment |
| PbO | Lead glet | In the form of a lead plaster used at pyoinflammatory diseases of a skin, furuncles |
| Alloy of tin with silver and gold | | It is used in stomatology |
| Connections of antimony $KC_4H_4O_6$ (SbO) $\cdot H_2O$ | | Emetic stone for gelmentos skin diseases |

## Chemical properties of inorganic elements.

**Barium** concerns to s-elements of II group of periodic system of D.I.Mendeleev. On an external electron sheath of its atom $6s^2$ electrons, giving it it turns to ion $Ba^{2+}$, than speaks its strongly pronounced metal properties.

Barium in the nature meets in various minerals in the form of sulphates, carbonates, silicates, alumosilicates. The major minerals of barium - barite $BaSO_4$, viterit $BaCO_3$, etc. In earth crust contains $5\cdot10^{-2}$ % (weights.).

Barium – malleable metal (t=710$^0$C, $t_{boil.}$ = 1696$^0$C). From 7 stable isotopes the most important are $^{140}$Ba with a half-life period 13,4 days and $^{133}$Ba with a half-life period 1,77 days. Barium possesses rather great volume and poorly expressed tendency, to polarisation, therefore does not form steady complex connections.

Barium is steady on air, it vigorously reacts with oxygen, therefore it store in hermetic vessels under a kerosene layer, petroley an aether or paraffin oil. On air shine of barium is lost owing to formation oxyd, peroxyd and nitride: BaO, $BaO_2$ and $Ba_3N_2$. Barium is chemically more active some calcium and reacts with nonmetals more vigorously, forming halogenides $BaG_2$ (G = F, Cl, Br, I).

Metal barium decomposes water:

$$Ba + 2H_2O = Ba(OH)_2 + H_2 + 387\ kJ$$

At usual temperature it reacts with dioxyd carbon:

$$5Ba + 2\,CO_2 = BaC_2 + 4BaO$$

Metal barium - a strong reducer.

Hydride of barium $BaH_2$ receive heating of metal barium in hydrogen atmosphere:

$$Ba + H_2 = BaH_2 + 230{,}1\ kJ$$

Oxyd barium BaO receive directly synthesis from elements or thermal decomposition of carbonates or nitrates:

$$BaCO_3 \xrightarrow{1350^0C} BaO + CO_2$$

Being dissolved in water, oxyd barium forms hydroxyd barium $Ba(OH)_2$- baritely water:

$BaO + H_2O = Ba\ (OH)_2$

$Ba\ (OH)_2$ - the strongest basis among elements II A groups, as barium - the most electropositive metal of the main subgroup of II group.

Peroxyd barium $BaO_2$ it is formed at direct interaction between oxygen and oxydom barium at heating:

$$2BaO + O_2 \xrightarrow{330^0C} 2BaO_2$$

$BaO_2$ in water is difficultly dissolve.

Soluble in water of salt of barium are exclusively toxic. A deadly dose - approximately 0,2g barium salts. Soluble salts of barium are applied to etching of rodents (rats, mice) from physiological point of view $BaCl_2$ are represented by strong warm poison! $BaCO_3$ and $BaSO_3$, soluble in hydrochloric acid of gastric juice, also are toxic. It is nontoxical only $BaSO_4$ as we will not dissolve in hydrochloric acid of gastric juice and consequently it is applied in rentgenology as control substance, does not pass X-rays and consequently it is applied to protection of facing of walls of x-ray chambers.

Barium salts co-operate with chromat kalii with formation of a deposition of yellow colour

$$Ba\,Cl_2 + K_2CrO_4 = \downarrow Ba\,CrO_4 + 2K\,Cl$$

$$Ba^{2+} + CrO_4^{2-} = \downarrow Ba\,CrO_4$$

At heating the yellow crystal deposition chromat barium $BaCrO_4$, soluble in nitric and hydrochloric acids, but insoluble in acetic acid is formed:

$$BaCrO_4 + 2HCl = Ba\,Cl_2 + H_2\,CrO_4.$$

In sulfuric acid the yellow deposition chromat barium passes in a white deposition of sulphate of barium:

$$BaCrO_4 + H_2\,SO_4 = \downarrow Ba\,SO_4 + H_2\,CrO_4.$$

Nitrates, halogenids, barium acetates well soluble in water, sulphates, carbonates, phosphates badly soluble.

**Strontium.** Strontium concerns s-elements of II group. Its electronic formula $5s^2$. It has strongly pronounced metal properties, little conceding to radium and barium. In earth crust contains $4 \cdot 10^{-20}$ % (weights) of strontium. It meets more often in calcii minerals, but strontic minerals are known also: celestin $SrSO_4$, stroncianit $SrSO_3$. Strontium has 4 stable isotopes: $^{84}Sr$, $^{86}Sr$, $^{87}Sr$, $^{88}Sr$. It is Most extended $^{88}Sr$ (82,56 %). It is Besides, received two artificial isotopes (β-radiation): $^{89}Sr$ with a half-life period 51 day and $^{90}Sr$ with a half-life period 27,7 years. Radioactive isotopes of strontium are very toxic.

Strontium easy metal (t=770$^0$C, $t_{boil.}$ = 1380$^0$C). Strontium easily loses the two s-electrons, existence only ion $Sr.^{2+}$ Strontium vigorously therefore is known co-operates with oxygen, therefore it store under a layer of paraffin oil, petroley an aether, kerosene etc. On air it quickly becomes covered by a film from oxydes (SrO, partially $SrO_2$) and nitride $Sr_3N_2$ which does not possess protective properties, at storage on air collapses.

Strontium - a strong reducer thanks to the big affinity to oxygen and halogens. It is dissolved in liquid $NH_3$, forming the solutions possessing metal conductivity. Strontium at heating with hydrogen easily forms hydride $SrH_2$:

$$Sr + H_2 = SrH_2 + 176 \text{ kJ},$$

Which decays water like calcium hydride:

$$SrH_2 + 2H_2O = Sr(OH)_2 + 2H_2$$

At heating strontium co-operates with oxygen, halogens, sulphur, nitrogen:

$$Sr + \frac{1}{2}O_2 = SrO + 589{,}1 \text{ kJ},$$

$$Sr + Cl_2 = Sr\,Cl_2 + 827{,}9 \text{ kJ}$$

$$Sr + S = SrS + 473{,}2 \text{ kJ}$$

$$3\,Sr + N_2 = Sr_3\,N_2 + 771{,}5 \text{ kJ}$$

Strontium quickly reacts with water:

$$Sr + 2H_2O = Sr(OH)_2 + H_2$$

It is easily dissolved in acids with formation of salt and hydrogen allocation. It reacts and with diluted $HNO_3$:

$$4Sr + 10\,HNO_3 = 4\,Sr(NO_3)_2 + NH_4NO_3 + 3H_2O$$

And slowly with concentrated $H_2SO_4$:

$$Sr + 2\,H_2SO_4 = \downarrow Sr\,SO_4 + SO_2 + 2H_2O.$$

Peroxyd strontium $SrO_2$ it is possible to receive direct interaction between oxygen (at a high pressure 200-250 atm and temperature 350-400$^0$C) and SrO:

$$O_2 + 2\,SrO = 2SrO_2$$

And also at interaction hydroxyd strontium with peroxydom hydrogen:

$$Sr(OH)_2 + H_2O_2 = SrO_2 + 2H_2O$$

Solubility of salts of strontium above, than barium, but more low, than calcium salts. Sulphate of strontium $Sr\,SO_4$ we will better dissolve, than $Ba\,SO_4$, but is worse, than $CaSO_4$. Well soluble halogenides (except $SrF_2$), nitrate, acetate, strontium chlorate.

Thanks to ability of flying salts of strontium to give bright karmin-red colour, they find application in pyrotechnics for fireworks, reception of red fires in alarm and lighting rockets. For this purpose are used nitrate $Sr(NO_3)_2$, oxalat $SrC_2O_4$ and carbonate $SrCO_3$.

**Cadmium (Cd).** Cadmium concerns d-elements of II group. An electronic configuration of atom $4d^{10}5s^2$. This element has a complete d-configuration and is last d-element in the period. Cadmium in a free condition in the nature does not meet. It meets in the form of minerals: grinokit CdS, otavit $CdCO_3$ and monteponit

CdO. In minerals of zinc, lead and polymetallic ores Natural cadmium Also contains consists of 8 isotopes.

Cadmium - heavy, soft metal ($t_{pl}$ = $778^0C$, $t_{boil.}$ = $321^0C$, density = 8,65 $g/sm^3$). It is malleable and viscous metal. On air its surface becomes covered by a protective film oxyd. At usual temperature cadmium with water does not react because of formation of protective film $Cd(OH)_2$, but at a heat it co-operates with water:

$$Cd + 2H_2O \longrightarrow Cd(OH)_2\downarrow + H_2$$

$Cd(OH)_2$ has poorly expressed amphoterly character. Hydroxyd cadmium it turns out as well as a result of exchange reactions between reactions of their salts and the basis. It is a white friable deposition. At heating cadmium on air or in oxygen is formed brown oxyd CdO. In the bases it practically we will not dissolve, it is slowly dissolved in diluted acids $HNO_3$, HCl and $H_2SO_4$ at heating:

$$3Cd + 8HNO_3 = 3Cd(NO_3)_2 + 2NO + 4H_2O$$

Cadmium co-operates with halogens, forming corresponding salts: $CdF_2$, $CdCl_2$, $CdBr_2$, $CdI_2$. It co-operates only with hydrogen and nitrogen, forming hydride $CdH_2$ and nitride $Cd_3N_2$.

At interaction of cadmium with sulphur cadmium sulfid is formed not soluble in water.

Cadmium connections possess the big propensity to complexoforming.

$$Cd(CN)_2 + 2KCN = K_2[Cd(CN)_4]$$

$$CdS + 4HCl = H_2[CdCl_4] + H_2S$$

$$CdS + 4KCN = K_2[Cd(CN)_4] + K_2S$$

All salts of cadmium are poisonous.

**Mercury.** Mercury also concerns d-elements of II group. An electronic configuration of its atom $5d^{10}6s^2$. Mercury in the nature is in a kind of minerals of cinnabar HgS, calomel $Hg_2Cl_2$, montroidit HgO, etc. In earth crust mercury is in a kind of 7 stable isotopes.

Mercury - brilliant silver-white liquid metal ($t_{freez}$ =-38,89$^0$S, $t_{boil.}$ = 356,95$^0$C, density = 13,595 $g/sm^3$). It has high affinity to an electron and the big electronegativity. For it formation iones $Hg^{2+}$ in which atoms of mercury keep covalently communication among themselves (for example, kalomel Cl - Hg - Hg - Cl, oxyd mercury (I) Hg - Hg is characteristic,

Nitrate of mercury (I) $Hg_2(NO_3)_2$). It dissolves many metals (Au, Ag, Sn, etc.), forming the alloys named amalgams. At usual temperature oxygen does not operate on mercury, but at heating of mercury with oxygen is formed its red oxyd HgO which at long heating breaks up again to mercury and oxygen:

$$2Hg + O_2 \underset{500^0C}{\overset{350^0C}{\rightleftarrows}} 2HgO$$

Oxyd mercury exists in $2^x$ updatings: yellow and red. Ozone oxidises mercury to protoxide mercury $Hg_2O$ of black colour. Oxyd mercury has the basic character, with water does not react (hydrates of mercury are unknown). Mercury being dissolved in acids, forms salts:

$$Hg + 4HNO_3 = Hg(NO_3)_2 + 2NO_2 + H_2O$$

$$6Hg + 8HNO_3 = 3Hg_2(NO_3)_2 + 2NO_2 + 4H_2O$$

Mercury among activity of metals is located after hydrogen, therefore does not supersede hydrogen neither from water, nor from acids. At action of solutions of the bases for salts of mercury instead of hydroxydes are allocated Oxydes: $Hg^{2+} + 2ON^- = HgO + H_2O$

It forms 2 numbers of connection: simple and complex, with degree of oxidation of mercury +2, and also connections in which structure are a steady complex from 2 atoms of mercury connected with each other in which these pair of atoms is as a whole two valency and, t.o., degree of oxidation of each atom of mercury is equal +1. Hence, mercury except normal connections of mercury (II) forms still original subconnections or connections of mercury (I). Connections of mercury (II) are easily restored before connection of mercury (I) and to metal:

$$Hg(NO_3)_2 + Hg = Hg_2(NO_3)_2$$

$$HgCl_2 + SO_2 + 2H_2O = Hg + H_2SO_4 + 2HCl$$

Metal mercury co-operates with halogens at usual temperature. Connections $Hg_2^+$ depending on conditions show regenerative and oxidising properties:

$$Hg_2Cl_2 + Cl_2 = 2HgCl_2$$

*Reducer*

$$Hg_2Cl_2 + SnCl_2 = 2Hg + SnCl_4$$

*Oxidizer.*

Galloidly mercury connections form numerous complex connections with galloidly connections of alkaline metals. For example, badly soluble in water iodid mercury (II) it is dissolved in a solution iodid kalii with formation tetraiod (II) hydrargyrat kalii:

$$Hg_2J_2 + 2KI = K_2[HgI_4].$$

Tetraiod (II) hydrargyrat copper and silver - $Cu_2[HgI_4]$ and $Aq_2[HgI_4]$ - the painted substances changing colour at certain temperature, in connection with with what apply them in termoscope.

**Aluminium**. Aluminium concerns p-elements of III group. An electronic configuration of its atom $3s^23p^1$. The steadiest degree of oxidation +3.

It is element very extended in the nature. On prevalence in earth crust Al occupies 3 place after oxygen and silicon. Aluminium is a part more than 250 mineralles, mainly alumosilicates, making an earth crust great bulk. The important mineral is: bauxite $Al_2O_3 \cdot xH_2O$, caolin $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, nephelin $Na_2O \cdot Al_2O_3 \cdot 2SiO_2$, etc. In a free condition in the nature aluminium does not meet Aluminium has 1 natural isotope $^{27}Al$. It is silver-white metal, easy (density of 2,7 g/sm$^3$), rather soft, very plastic, malleable and the viscous, best conductor of heat and an electricity after silver and copper, possesses enough good chemical stability.

On chemical properties aluminium not so active element. It easily co-operates with oxygen at a room temperature, but its surface becomes covered by protective film

$Al_2O_3$ and protects metal from the further oxidation. If to clear metal of a protective film it co-operates with water:

$$2Al + 6H_2O = 2\ Al(OH)_3 + 3H_2\uparrow$$
$$2Al + 3H_2O = Al_2O_3 + 3H_2\uparrow$$

Aluminium is dissolved in the diluted acids and solutions of alkalis:

$$2Al + 3H_2SO_4 = Al_2(SO_4)_3 + 3H_2\uparrow$$
$$2Al + 6HCl \longrightarrow 3AlCl_3 + 3H\uparrow$$
$$2Al + 6NaOH \longrightarrow 2Na_3AlO_3 + 3H_2\uparrow$$

Oxydes and hydroxydes aluminium show amphoterly characteristics

$$Al_2O_3 + 6HCl = 2AlCl_3 + H_2O$$
$$Al_2O_3 + 2\ NaOH = 2NaAlO_2 + H_2O$$

*Aluminate* Na

$$Al(OH)_3 + 3HCl = AlCl_3 + 3H_2O$$
$$Al(OH)_3 + NaOH = NaAlO_2 + 2H_2O$$

Salts $Al^{3+}$ and aluminates in solutions are strongly hydrolyzed. Aluminium does not co-operate with concentrated $HNO_3$. Metal aluminium, at heating co-operates with halogens, allocating heat and light considerable quantity and forming corresponding halogenides. At temperature 700-2000$^0$C it co-operates with sulphur, nitrogen and carbon and forms accordingly sulfid $Al_2S_3$, nitride AlN and carbide $Al_4C_3$.

Aluminium with many metals forms a considerable quantity of alloys. They differ among alloys of other elements ease (small relative density), high stability on air, in water and acids, durability, good electric properties and heat-conducting. Thanking these advantages aluminium widely used in all branches of technics.

**Tin and lead.** Tin and lead concern p-elements of VI group of periodic system of D.I.Mendeleeva. Their electronic formula Sn-$5s^25p^2$, Pb-$6s^26p^2$. It is rare and lightly soluble elements. Tin and lead have 10 and 4 isotopes accordingly. These are brilliant metals. Electronegativity of these elements decreases among Sn-Pb. In usual conditions tin can long time is on air without any changes, and lead becomes covered by a protective film oxyd. In water tin is steady, and lead is oxidised the oxygen dissolved in it. At heating Sn in the presence of oxygen it is formed $SnO_2$. At heating Pb on air at first it is formed yellow oxyd lead (II) PbO and bright red $Pb_3O_4$ (minium). Interaction of minium with nitric acid gives $PbO_2$:

$$Pb_3O_4 + 4HNO_3 = PbO_2\downarrow + 2\ Pb\ (NO_3) + 2H_2O$$

These elements form numerous simple and complex connections in which steady valency is 2. Connections $Sn^{2+}$ - strong reducers, and $Pb^{+4}$ - strong oxidizers.

Negative degree of an oxidizer tin and lead is shown only in connections with more electropositive elements:

$2Ca + Sn = Ca_2Sn$ (stanid calcium)

$2Mg + Pb = Mg_2Pb$ (plumbid magnesium)

At interaction $Ca_2Sn$ and $Mg_2Pb$ with hydrochloric acid more unstable and poisonous gases are formed:

$Ca_2Sn + 4HCl = 2\ CaCl_2 + SnH_4\uparrow$ (stanian)

$Mg_2Pb + 4\ HCl = 2\ MgCl_2 + PbH_4\uparrow$ (plumban)

Oxyd tin SnO and $SnO_2$ - amphoterns. SnO reacts with the hot concentrated alkalis, at alloying $SnO_2$ with oxids alkaline metals or with alkalis turn out metastannates, and in the presence of water - hexahydroxystannites:

$SnO_2 + K_2O = K_2 SnO_3$

$SnO_2 + 2KOH = K_2 SnO_3 + H_2O$

$K_2 SnO_3 + 3 H_2O = K_2 [Sn (OH)_6]$

PbO and $PbO_2$ - amphoterns though at PbO the basic properties are expressed more strongly, than at $PbO_2$ - acid. OXYD Sn (IV) and Pb (IV) very weak acids tin $H_2SnO_3$ and lead $H_2PbO_{3\ answer}$. Tin and lead form a considerable quantity of complex connections, and their connections tetragalogenids with galogenids alkaline metals and galogenids ammonium with coordination numbers 6 and 8 are steadier.

Lead ions are strong complexoforming, co-operate with sulfhydrilly groups of fibers and enzymes that leads to reduction of their activity.

**Arsenic, antimony and bismuth**. Arsenic, antimony and bismuth concern p-elements of V group. Electronic formula As-$4s^24p^3$, Sb-$5s^25p^3$, Bi-$6s^26p^3$.

Their maintenance in earth crust is insignificant. Usually in the nature they meet in the form of sulphidic ores and is more often accompany other metals in polymetallic ores. The basic minerals containing As, Sb, Bi are $As_2S_3$ - auripigment, FeAsS - arsenic pyrites (arsenopyrey); $Sb_2S_3$ - antimonic shine (antimonit), $Bi_2S_3$ - bismuth shine, etc. Considered elements can meet and in a free condition.

Arsenic and antimony exist in several allotropically updatings. The basic forms for arsenic are metal, grey and yellow; for antimony - yellow, black and explosive.

For As, Sb, Bi fall of stability of particles in which elements have positive oxidation degrees, in relation to a reducer with serial number growth is characteristic. So, arsenic has degree of oxidation +5 or +3, antimony basically +3 (it is rare +4) and bismuth more often +3 (only very strong oxidizers translate bismuth in a condition +5) more often.

In water and organic solvents elements of a subgroup of arsenic not soluble. In usual conditions on air antimony does not change, and arsenic and bismuth slightly are oxidised from a surface. At heating on air As, Sb, Bi; burn with formation oxydes type $E_2O_3$. Hydroxydes $E(OH)_3$ amphoterns, at $As(OH)_3$ prevails acid, and at $Bi(OH)_3$ - the basic character. Arsenic acid $H_3AsO_3$ exists only in a solution. $H_3SbO_3$ - stibium acid, a white deposition, its salts are called antimonits.

At acid dissociation from these acids the molecule of water can chip off and very weak acids are formed: metaarsenic $HAsO_2$ and metastibium $HSbO_2$. To the higher oxyds $As_2O_5$ and $Sb_2O_5$ corresponds arsenic $H_3AsO_4$ and antimonic $H_3SbO_4$ acids. Their salts are called arsenats and antimonats which are colourless and almost insoluble in water As, Sb, Bi with hydrogen do not react, their hydrogen connections $EN_3$ receive at acid action on connections As, Sb, Bi with metals.

$Ca_3As_2 + 6HCl = 3CaCl_2 + 2AsH_3\uparrow$

Gaseous hydrides: $AsH_3$ - arsin, $SbH_3$ - stelogin and $BiH_3$ - vismulin - are very unstable and poisonous. $AsH_3$ and $SbH_3$ very strong reducers.

With water As, Sb, Bi at usual temperature do not co-operate. They react only with acids showing oxidising ability:

$$2Bi + 6H_2SO_4 = Bi_2(SO_4)_3 + 3SO_2 + 6H_2O$$

As, Sb, Bi are dissolved in the concentrated nitric acid:

$$As + HNO_3 + H_2O = H_3AsO_3 + NO\uparrow$$
$$2\,Sb + 6HNO_3 = Sb_2O_3 + 6NO_2\uparrow + 3H_2O$$
$$Bi + 6HNO_3 = Bi(NO_3)_3 + 3NO_2\uparrow + 3H_2O$$

Sulfids As, Sb, Bi are painted also them often use in the qualitative analysis of these elements. Sulfids of arsenic $As_2S_3$ and $As_2S_5$ - yellow, sulfids of antimony $Sb_2S_3$ and $Sb_2S_5$ - orange, sulfid of bismuth $Bi_2S_3$ - black.

As, Sb, Bi it is easy connecting with halogens. From galogenids the greatest value have chlorides $AsCl_3$, $SbCl_3$, $BiCl_3$ and $SbCl_3$. With chlorides of some monovalent metals they form complex connections.

As, Sb, Bi are a part of soft alloys of nonferrous metals. They strongly lower their temperature of fusion, forming easy-to-melt alloys.

The majority of salts of these elements are toxic.

## QUALITATIVE REACTIONS TO IONS OF INORGANIC ELEMENTS: Ba, Sr, Hg, Cd, Al, Sb, Pb, As, Br, Sn.

**Reaction of cation barium** - $Ba^{2+}$

**Reactant sulfuric acid** - $H_2SO_4$

Sulfuric acid - $H_2SO_4$ and soluble sulphates form white crystal deposition $BaSO_4$ with barium salts:

$$BaCl_2 + H_2SO_4 \longrightarrow BaSO_4\downarrow + 2HCl$$
$$Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4\downarrow$$

**RESEARCHES OF PROPERTIES OF DEPOSITION $BaSO_4$.**

The deposition is not dissolved in acids and caustic alkalis.

**Reactant chromat kalii - $K_2CrO_4$.**

Chromat kalii $K_2CrO_4$ - form with barium salts yellow deposition $BaCrO_4$:

$$BaCl_2 + K_2CrO_4 \longrightarrow BaCrO_4\downarrow + 2KCl$$
$$Ba^{2+} + CrO_4^{2-} \longrightarrow BaCrO_4\downarrow$$

**RESEARCH OF PROPERTIES OF DEPOSITION $BaCrO_4$.**

The deposition is dissolved in strong acids, but we will not dissolve in acetic acid:

$$BaCrO_4 + 2HCl = BaCl_2 + H_2CrO_4$$
$$BaCrO_4 + 2H^+ \longrightarrow Ba^{2+} + H_2CrO_4$$

**Reactant dichromat potassium** $K_2Cr_2O_7$.

Dichromat kalii $K_2Cr_2O_7$ - forms with barium salts a yellow deposition chromat barium $BaCrO_4$. The reason of it consists in the following. In a water solution ions $Cr_2O_7^{2-}$are in balance with ions $CrO_4^{2-}$

$$Cr_2O_7^{2-} + H_2O \rightleftarrows 2CrO_4^{2-} + 2H^+$$

As chromat barium less we will dissolve, than dichromat in a deposition drops out $BaCrO_4$:

$$2BaCl_2 + K_2Cr_2O_7 + H_2O = Ba\ CrO_4\downarrow + 2KCl + 2HCl$$
$$Ba^{2+} + Cr_2O_7^{2-} + H_2O = Ba\ CrO_4\downarrow + 2H^+$$

For full sedimentation of ions $Ba^{2+}$ reaction should be conducted in the presence of sodium acetate. Reacting with the strong acid HCl allocated at reaction in which $BaCrO_4$ it is dissolved, it will replace its weak $CH_3OOH$, in which $BaCrO_4$ it is not dissolved:

$$HCl + CH_3COONa = NaCl + CH_3COOH$$

**Reaction cation strontium - $Sr^{2+}$.**

**Reactant sulfuric acid $H_2SO_4$.** Sulfuric acid - $H_2SO_4$ - and soluble sulphates form white crystal deposition $SrSO_4$ with strontium salts

$$SrCl_2 + H_2SO_4 = SrSO_4\downarrow + 2HCl$$
$$Sr^{2+} + SO_4^{2-} = SrSO_4\downarrow$$

**RESEARCH OF DEPOSITION $SrSO_4$**

The deposition is not dissolved in acids and caustic alkalis.

**Reactant plaster water** - $CaSO_4 \cdot 2H_2O$

The sated water solution of plaster forms white dregs with strontium salts $Sr\ SO_4$.

Solution heating accelerates dregs formation. The given reaction can will be applied to detection $Sr^{2+}$ only after branch $Va^{2+}$, giving similar effect:

$$SrCl_2 + Ca\ SO_4 = SrSO_4\downarrow + CaCl_2$$
$$Sr^{2+} + SO_4^{2-} = SrSO_4\downarrow$$

**Reaction of ions of mercury - $Hg^{2+}$.**

**Reactants hydroxydes sodium and kalii** - NaOH, KOH

Caustic alkalis at action on mercury salts allocate from a solution a yellow deposition oxyd mercury HgO:

$$Hg(NO_3)_2 + 2NaOH = HgO\downarrow + 2Na\ NO_3 + H_2O$$
$$Hg^{2+} + 2OH^- = HgO\downarrow + H_2O$$

**RESEARCH OF PROPERTIES OF DEPOSITION HgO**

1. The deposition is dissolved in mineral acids:

$$HgO + 2H\,NO_3 = Hg(NO_3)_2 + H_2O$$
$$HgO + 2H^+ = Hg^{2+} + 2H_2O.$$

2. The deposition is not dissolved many caustic alkalis.

**Reactant iodid kalii КI**

Iodid kalii besieges cations mercury in the form of a red-orange deposition iodid mercury $HgI_2$:

$$Hg(NO_3)_2 + 2KI = HgI_2\downarrow + 2\,KNO_3$$
$$Hg^{2+} + 2I^- = HgI_2$$

## RESEARCH THE PROPERTIES OF DEPOSITE OF $HgI_2$.

The deposition is dissolved a lot of reactant with formation of complex connection $K_2\,[HgI_4]$

$$HgI_2 + 2KI = K_2[HgI_4]$$
$$HgI_2 + 2I^- = [HgI_4]^{2-}$$

**Reaction of ions of mercury -** $Hg_2^{\ 2+}$.
**Reactant hydrochloric acid -** HCl.
Hydrochloric acid with ions $Hg_2^{2+}$ forms a deposition of white colour $Hg_2Cl_2$:

$$Hg_2(NO_3)_2 + 2\,HCl = Hg_2Cl_2\downarrow + 2H\,NO_3$$
$$Hg_2^{\ 2+} + 2Cl^- = Hg_2Cl_2\downarrow$$

## RESEARCH OF PROPERTIES OF DEPOSITION $Hg_2Cl_2$

1. The deposition is not dissolved in the diluted acids
2. The deposition is not dissolved much $NH_4OH$.

1. The deposition at action of surplus $NH_4OH$ blackens, owing to allocation of metal mercury.

$$Hg_2Cl_2 + 2NH_4OH = [NH_2Hg_2]Cl\downarrow + NH_4Cl + 2H_2O$$
$$[NH_2Hg_2]Cl \longrightarrow [NH_2Hg]Cl\downarrow + Hg\downarrow$$

**Reactant - metal copper - Cu**

On the cleared copper plate (a copper coin) to put 1-2 drops of solution $Hg_2(NO_3)_2$. After a while there is a brilliant metal stain from the allocated metal mercury:

$$Hg_2(NO_3)_2 + Cu \quad = \quad Cu(NO_3)_2 + 2Hg\downarrow$$
$$Hg_2^{\ 2+} + Cu \ = \quad Cu^{2+} + 2Hg\downarrow$$

## Reaction cations aluminium - Al

**Reactants hydroxydes sodium and kalii NaOH, КОН**

Caustic alkalis at cautious addition allocate from a solution of salt aluminium a white jellylike deposition hydroxyd aluminium $Al(OH)_3$;

$AlCl_3 + 2NaOH = Al(OH)_3\downarrow + 3NaCl$

$Al^{3+} + 3ON^- = Al(OH)_3\downarrow$

**RESEARCH OF PROPERTIES OF DEPOSITION $Al(OH)_3$**

$Al(OH)_3$ possesses atoroternily characteristically.

The deposition is dissolved in mineral acids:

$Al(OH)_3 + 3HCl = AlCl_3 + 3H_2O$

$Al(OH)_3 + 3H^+ = Al^{3+} + 3H_2O$

The deposition is dissolved many caustic alkalis

$Al(OH)_3 + NaOH = NaHO_2 + 2H_2O$

$Al(OH)_3 + 3H^+ = ALO2^- + 2H_2O$

**Reactant of sodium hydrocarbonate** - $NaHCO_3$

The hydrocarbonate of sodium and carbonates form with aluminium salts a white jellylike deposition hydroxyd aluminium $Al(OH)_{3:}$

$AlCl_3 + 3NaHCO_3 = Al(OH)_3\downarrow + 3NaCl + 3CO_2\uparrow$

$Al^{3+} + 3HCO_3^- = Al(OH)_3\downarrow + 3CO_2\uparrow$

In water solutions $NaHCO_3$ is exposed to hydrolysis:

$NaHCO_3 + H_2O \rightleftarrows NaOH + H_2CO_3$

At a solution of this salt there are ions OH - and $CO_3^{2-}$. Deposition $Al(OH)_3$ less we will dissolve, than $Al(CO_3)_3$, therefore and deposition Al (OH $_{3 \text{ drops out}}$

**Reactant alizarine red S** - $C_{14}H_5O_2(OH)_2SO_3Na$.

Alizarine red forms with aluminium salts forms a varnish of red-pink colour. Reaction is spent on a strip of a filtering paper: on a strip of a filtering paper to place a drop of a solution of salt of aluminium. A stain to process gaseous ammonia. For this purpose a filtering paper to place a paper over an aperture of a bottle with the concentrated solution of ammonia. A stain on periphery to lead round a capillary with alizarine and again to process gaseous ammonia. Against (alizarine colouring in the ammoniac environment) appears red-pink colouring. Alizarine red (1,2 dioxyantrohynon - 3 - sulfonat sodium) form intracomplex salt with aluminium.

**Reactions of an ion of lead** - $Pb^{2+}$

**Reactant of hydrochloric acid HCl.**

The diluted hydrochloric acid allocates from a solution of salts of lead white flakes seen a deposition of chloride of lead $PbCl_2$:

$Pb(NO_3) + 2HCl = PbCl_2\downarrow + 2HNO_3$

$Pb^{2+} + 2SL^- = PbCl_2\downarrow$

**RESEARCH OF PROPERTIES OF DEPOSITION $PbCl_2$**

1. The deposition is dissolved in boiling water
2. The deposition is not dissolved in acids
3. The deposition is not dissolved in caustic alkalis.

**Reactants hydroxydes sodium, potassium**: NaOH, KOH.

Caustic alkalis at cautious addition to lead salts allocate from a solution a deposition hydroxyd lead Pb (OH) $_2$:

$Pb(NO_3)_2 + 2NaOH = Pb(OH)_2\downarrow + 2NaNO_3$

$Pb^{2+} + 2OH^- = Pb(OH)_2\downarrow$

## RESEARCH OF PROPERTIES OF DEPOSITION $Pb(OH)_2$

Pb (OH) $_2$ possesses amphoteric properties.

The deposition is dissolved in mineral acids

$$Pb(OH)_2 + 2HNO_3 = Pb(NO_3)_2 + 2H_2O$$

$$Pb(OH)_2 + 2H^+ = Pb^{2+} + + 2H_2O$$

The deposition is dissolved many caustic alkalis:

$$Pb(OH)_2 + 2NaOH \;=\; Na_2[Pb(OH)_4]$$

$$Pb(OH)_2 + 2OH^- = [Pb(OH)_4]^2$$

**Reactant of iodid kalii - KI**

Iodid kalii - KI - forms with soluble salts of lead a yellow amorphous deposition iodid lead - $PbI_2$:

$$Pb(NO_3)_2 + 2KI = PbI_2\downarrow + 2KNO_3$$

$$Pb^{2+} + 2I^- = PbI_2\downarrow$$

**Research of properties of deposition** $PbI_2$

The deposition is partially dissolved a lot of reactant

$$PbI_2 + 2KI = K_2[PbI_4]$$

$$PbI_2 + 2I^- = [PbI_4]^{2-}$$

The deposition is dissolved in boiling water

The deposition is dissolved at boiling in the diluted acetic acid. If then a solution slowly to cool, the deposition will be now will be allocated in the form of brilliant golden-yellow crystals. It is one of beautiful reactions of the qualitative analysis.

**Reactions of an ion of arsenic - $As^{3+}$**

**Reactant tiosulfat sodium $Na_2S_2O_3$**

Tiosulfat sodium in sour (HCl) environment forms with arsenic salts a yellow deposition of sulfid of arsenic $As_2S_3$.

Reaction performance: in a test tube to bring 2-3 drops of solution $Na_2AsO_3$, 1 drop of solution HCl and 2-3 drops of solution $Na_3S_2O_3$. A mix to finish to boiling. In 2-3 minutes the deposition is formed:

$2Na_3AsO_3 + 3Na_2S_2O_3 + 6HCl = As_2S_3\downarrow + 3Na_2SO_4 + 6NaCl + 3H_2O$

$2ASO_3^{3-} + 3S_2O_3^{2-} + 6H^+ = As_2S_3\downarrow + 3SO_4^{2-} + 3H_2O$

## RESEARCH OF PROPERTIES OF DEPOSITION $As_2S_3$

1. The deposition is dissolved in solutions of caustic alkalis:

$$As_2S_3 + 6NaOH = Na_3AsO_3 + Na_3AsS_3 + 3H_2O$$

$$As_2S_3 + 6OH^- = AsO_3^{3-} + AsS_3^{3-} + 3H_2O$$

$Na_3AsS_3$ is called tiosalt. These are salts corresponding tioacid. Tioacids are similar to oxygen acids of the same elements with that only a difference, that in them atoms of oxygen are replaced by atoms of sulphur:

$H_3AsO_3$ - arsenic acid, $H_3AsS_3$ - tioarsenic acid.

2. The deposition is dissolved in sulphurous alkalis $Na_2S$, $K_2S$

$$As_2S_3 + 3Na_2S = 2Na_3\,AsS_3$$

$$As_2S_3 + 3S^{2-} = 2AsS_33^-$$

3. The deposition is dissolved in an ammonium carbonate

$$As_2S_3 + 3\,(NH_4)\,_2CO_3 = (NH_4)\,_3AsO_3 + (NH_4)\,_3\,AsS_3 + 3CO_2\uparrow$$

$$As_2S_3 + 3_{SO32}{}^- = AsO_3^{3-} + AsS_3^{3-} + 3CO_2\uparrow$$

**Reactions of an ion of bismuth - $Bi^{3+}$**

**Reactants hydroxydes sodium and kalii - NaOH, КОН**.

Caustic alkalis form with bismuth salts a white deposition hydroxyd bismuth – $Bi\,(OH)\,_3$:

$$Bi\,(NO_3)\,_3 + 3NaOH = Bi\,(OH)\,_3\downarrow + 3NaNO_3$$

$$Bi^{3+} + + 3OH^- = Bi\,(OH)\,_3\downarrow$$

**RESEARCH OF PROPERTIES OF DEPOSITION $Bi(OH)_3$:**

The deposition is dissolved in mineral acids:

$$Bi\,(OH)\,_3 + 3HNO_3 = Bi\,(NO_3)\,_3 + 3H_2O$$

$$Bi\,(OH)\,_3 + 3H^+ = Bi^{3+} + 3H_2O$$

The deposition is not dissolved many caustic alkalis.

**Reactant chloride of tin (II) - $SnCl_2$**

Chloride of tin (II) in strongly alkaline environment restores from salts $Bi^{3+}$ to metal bismuth which is allocated in the form of a black deposition. Reaction performance: to a solution of salt $SnCl_2$ to add solution NaOH, white deposition $Sn\,(OH)\,_2$ is formed. Last possesses amphoteric properties. To dissolve it it is a lot of NaOH. Then to add a solution of salt of bismuth. Thus from action NaOH white amorphous deposition $Bi\,(OH)\,_3$ which instantly blackens in consequence of allocation of small shattered restored metal bismuth is allocated:

$$SnCl_2 + 2NaOH = Sn(OH)_2\downarrow + 2NaCl$$

$$Sn(OH)_2 + 2NaOH = Na_2[Sn(OH)_4]$$

$$Bi(NO_3)_2 + 3NaOH = Bi(OH)_3\downarrow + 3NaNO_3$$

$$2\,Bi(OH)_3 + 3Na_2[Sn(OH)_4] = 2Bi\downarrow + 3Na_2[Sn(OH)_6]$$

**Reactions of an ion of cadmium - $Cd^{2+}$**

**Reactant hydrogen sulfid - $H_2S$.**

Hydrogen sulfid in the acetic environment with cations $Cd^{2+}$ forms a yellow deposition of sulfid of cadmium CdS:

$$CdCl_2 + H_2S = CdS\downarrow + 2HCl$$

**RESEARCH OF PROPERTIES OF DEPOSITION CdS**

1. The deposition is not dissolved in the diluted hydrochloric acid.

2. The deposition is dissolved in the warm diluted nitric acid.
3. The deposition is dissolved in the concentrated acids.

**Training tasks and the standard of their decision**

***Task № 1.*** How many metal lead it is possible to receive from 25 g the lead shine, containing 6 % of impurity:

**Given:**
m (ores) = 25g
W (impurity) = 6 %
m (PbS) = 239,25 g/MOL
m (Pb) = 207,19 g/m

m (Pb)-?

***The standard of decision.***

The equation of occurring reactions:

$$2\ PbS + 3O_2 = 2PbO + 2SO_2$$
$$2PbO + 2C = 2Pb + 2CO$$

We find weight of an impurity in lead shine

25g (ores) -100 %

x -6% $x = \frac{25 \cdot 6}{100} = 1{,}5$

m (impurity) = 1,5g.

We find weight pure PbS:

m (PbS) = 25g. (Ores) - m (impurity) = 25g - 1,5g = 23,5g.

We find weight of the lead received from 23,5g PbS. On the equation of reactions it is visible, that 1 mol PbS forms 1 mol Pb. From here, 1 mol · 239,25g/MOL = 239,25g PbS forms 1 mol x a 207,19g/MOL 207,19 Pb. We will write down:

239,25g PbS -207,19g Pb.

23,5g PbS -xg Pb

We make a proportion: 239,25: 207,19 = 23,4: x

$$x = \frac{207{,}19 \cdot 23{,}5}{239{,}25} = 20{,}35$$

The answer:

m (Pb) = 20,35g.

***Task № 2***. In what of the diluted solutions of salts (concentration are identical) pH more low: Zn $(NO_3)_2$ or Hg $(NO_3)_2$

***The standard of decision***

$M(NO_3)_2 + H_2O \longrightarrow M(OH)NO_3 + HNO_3$; M-Zn; Hg

The given equilibrium process depends from dissociation ion of $M(OH)^+$:

$$M(OH)^+ \rightleftarrows M^{2+} + OH^-$$

Which qualitative characteristic is time $K_{diss}$. And, than above its value process dissociation goes that more full. It is known, that $K_{diss}$. ([Zn (OH)] $^+$) = $4\cdot10^5$; Kdiss. ([HgOH] $^+$) = $5\cdot10^{-11}$Kdiss. ([Zn (OH)] $^+$)> Kdiss. ([HgOH] $^+$), hence, pH salt Hg $(NO_3)_2$ has less, than Zn $(NO_3)_2$ and consequently hydrolysis of salt Hg $(NO_3)_2$ proceeds in more degrees, than $Zn(NO_3)_2$.

**Questions and tasks for self-checking of mastering of a theme**

1. In medical practice chloric connections of mercury are used

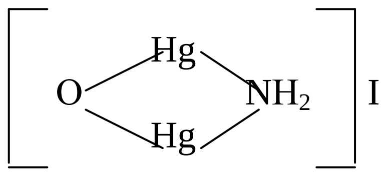
$HgCl_2$ - corrosive sublimate

$Hg_2Cl_2$ - kalomel

Whether it is possible qualitative to establish by subject to each preparation. The answer confirm with the equation of reactions.

2. The Alkaline solution tetraiodomercurat II kalii $K_2[HgI_4]$ + KOH is used in the analysis of medical preparations for detection of ion $NH_4^+$ in medical preparations.

Mix $K_2[HgI_4]$ + a KOH named reactant Nesler, with ions $NH_4^+$ forms a red-brown deposition:



Write the equation of reaction of this reactant with $NH_4Cl$ which has diuretically action.

3. On what application Al $(OH)_3$ inside for treatment of the gastroenteric diseases accompanied by raised acidity of gastric juice is based? How you think, why in a considerable quantity the preparation is dangerous for accepting inside?

5. Barium salts are toxic for the person. Why in medical practice it is used $BaSO_4$ at radiological inspections gastrici - an intestinal path?

## Situational tasks

***Task 1***. Children's powder contains: oxyd zinc-1 a part, starch - 2 parts, talc - 8 parts. What mass fraction (%) of these components in a powder?

***Task 2.*** Lead acetate - Pb $(CH_3COO)_2$ - is an astringent at inflammatory diseases of a skin. 0,5 % a solution are applied. Calculate weight of this substance for preparation of 0,5 % (weights) of a solution of 100 ml. What mass fraction of lead (%) in this solution: $p$ =1g/ml

## Test questions

1. Specify inorganic elements
A) O, Cu, Hg
B) Al, Ba, As
C) Al, Hg, Fe
D) Cu, Fe, Na

2. What connection is a reagent on cation lead?
A) NaCl
B) KOH
C) NaOH
D) KI

3. What connection possesses rentgenocontrasting property and is applied in rentgenology?
A) $CaSO_4$
B) $BaSO_4$
C) $Na_2SO_4$
D) $K_2SO_4$

4. Specify connection which is applied in medicine to a plaster bandage?
A) $BaSO_4$
B) $CaSO_4$
C) $CaSO_4 \cdot 0,5H_2O$
D) $CaSO_4 \cdot 2H_2O$

5. Specify a number of p-elements?
A) Al, Pb, Hg
B) Hg, Au, Ag
C) Al, As, Pb
D) Pb, Au, Hg

6. What connection of arsenic is applied in stomatology?
A) $AsH_3$
B) $As_2S_3$
C) $As_2O_3$
D) $Na_2AsO_3$

7. What of following elements possesses the most expressed cancerogenic property?
A) $Ca^{+2}$ B) $Cu^{+2}$ C) $Ni^{+2}$ D) $Ba^{+2}$

8. $As_2O_3$ it:
A) basic oxyd

B) acid oxyd
C) amphoterly oxyd
D) indefferently oxyd

9. What element causes necros?
A) As B) Ba C) Ni D) Li

10. Specify a reagent on cation $Bi^{3+}$
A)$SnCl_2$ B) $Na_2S_2O_3$. C) $H_3 AsO_3$ D) KI

## LABORATORY WORK

***Experience 1.*** Reaction on cation $Ba^{2+}$. Reactiv - chromat kalii $K_2CrO_4$
In a test tube to place 5 drops $BaCl_2$, 3-5 drops $CH_3COONa$, 3 drops of solution $K_2CrO_4$. There is deposition $BaCrO_4$ of yellow colour. The deposition is dissolved in strong acids, and in $CH_3COOH$ is not dissolved. Write the reaction equation write in a molecular and ionic kind.

***Experience 2.*** Reaction to ions $Hg^{2+}$. A reactant - kalii iodid KI.
To 3-5 drops Hg $(NO_3)_2$ to add 3-5 drops of solution KI. There is deposition $HgI_2$ of red-brown colour. The deposition is dissolved in considerable quantity KI, are formed complex connection. Write the reaction equation in a molecular and ionic kind.

***Experience 3.*** Reaction on cation aluminium. Reactivalisarin red S in the basic environment.

On a filtering paper to put 1 drop of solution $AlCl_3$ and to take 1-2 minutes over the concentrated solution of ammonia. It is formed $Al(OH)_3$. On a stain in the filter to put 1 drop of alizarine, and again to take over the concentrated solution of ammonia. There is «an aluminium varnish» red-pink colour.

***Experience 4.*** Reaction on cation $Pb^{2+}$. Reactiv - kalii iodid KJ.

In a test tube where is Pb $(CH_3COO)_2$ to add 3-5 drops KJ. Yellow amorphous deposition $PbJ_2$ is formed. The deposition is partially dissolved in considerable quantity KJ, in hot water, acetic acid. Write the reaction equation in a molecular and ionic kind.

***Experience 5.*** Reaction to ion $Sn^{2+}$. A reactant nitrate of bismuth Bi $(NO_3)_3$.

To solution $SnCl_2$ to add solution NaOH, there is deposition Sn $(OH)_2$. Sn $(OH)_2$ - amphoterly, therefore, at addition excess quantities NaOH, it is dissolved. To a colourless solution to add solution Bi $(NO_3)_3$ before occurrence of a black deposition. Free bismuth is allocated. Write the reaction equation in a molecular and ionic kind.

***Experience 6.*** Reaction on cation $As^{3+}$. Reactiv - sodium tiosulfat $Na_2S_2O_3$.

In a test tube to pour 2-3 drops of solution $Na_3AsO_3$, 3-5 drops HCl and 2-3 drops of solution $Na_2S_2O_3$ and a test tube to take over a spirit-lamp before boiling. There is deposition $As_2S_3$ of yellow colour. The deposition is dissolved in solution $Na_2S$. Write the reaction equation in a molecular and ionic kind.

***Experience 7.*** Reaction on cation $Bi^{3+}$. Reactant $SnCl_2$.

On a solution of salt $SnCl_2$ to add NaOH. There is white deposition

$Sn(OH)_2$. It is dissolved in considerable quantity NaOH. To a colourless solution to add $Bi(NO_3)_3$ before occurrence of a black deposition. Free bismuth is allocated. Write the reaction equation in a molecular and ionic kind.

### Questions and tasks for the independent decision

1. In medical practice as an antiseptic it is applied dichlorid mercury. At carrying out of the qualitative analysis of this preparation iodid kalii has formed a red-orange deposition, a soluble a lot of reactant. Draw a conclusion on what ion of mercury $Hg^{2+}$ or $Hg_2^{2+}$ is a part of a preparation. Write the equation of occurring reaction.

2. Whether the constant of product of solubility $SrSO_4$ is equal $3{,}6x{\cdot}10^{-7}$ .

Is deposition $SrSO_4$ . formed if to mix equal volumes 0,002 mol/l of solutions $SrCl_2$ and $K_2SO_4$.Write the reaction equation in an ionic and molecular kind.

3. All connections of mercury are extremely poisonous. As is known, metal mercury is widely used in thermometers which it is wide wide-spread in any bioclinical laboratory and in a life. At casual splitting the thermometer mercury spreads (metal mercury - a liquid) and it necessarily should be removed. Explain with what help of a reactant it is possible to remove it, write the equation of occurring chemical reaction.

4. $As_2O_3$ despite poisonous, in small doses it is applied in medicine, for example, in stomatology for necrolisation pulps. Why this connection does not cause a poisoning of the person.

## ELECTRIC CONDUCTIVITY OF SOLUTIONS.

## CONDUCTIVITY METERLY TITRATION

**The employment purpose:** To acquaint students with electric conductivity of biological liquids and the tissue which are present at a human organ. To acquaint with conduct metrical titration and it’s use in medicine.

**The importance of a studied theme** Biological tissue and liquids contain a significant amount of electrolytes and possess enough high electro conductivity. Besides it movement of skeletal muscles, heart reduction, excitation and braking of cells of the central nervous system, distribution of impulses on nerves are accompanied by the electric phenomena. Therefore knowledge of electric-conducting solutions is necessary for the doctor, especially they are necessary for diagnostics of some diseases of heart, a brain and skeletal muscles, this knowledge is necessary in physiotherapy.

**Initial level of knowledge**

1. Electro conductivity
2. Electrolytes and un electrolytes
3. Resistance and specific resistance of a conductor

**Teaching material for self-preparation**

1. M.I.Ravich-Scherbo, V.V. Novikov. Physical and colloid chemistry. M. 1975, chapter III, 1-6.
2. L.I.Antropov. Theoretical electrochemistry., 1984, a part 1 and 2.
3. J. Plembek. Electrochemical methods of the analysis.M.Mir, 1985, chapter 4.

**On employment following questions will be considered:**

1. Degree and a constant of ionization of weak electrolyte
2. Specific electric conductivity of solutions of electrolytes and its dependence on concentration
3. Molar electric conductivity of electrolyte
4. Law Kolraush
5. Conductivity meterly titration
6. Laboratory work

## THE INFORMATION BLOCK

### Degree and ionization constant

All bio liquids an organism along with un electrolytes necessarily is contained by electrolytes. We will remind, that electrolytes name substance, melts or which solutions spend an electric current Solutions of electrolytes, unlike metals are conductors of the second sort since their electric conducting it is caused by ions, instead of electrons.

Electrolytes in solutions in full or in part dissociate on ions. Strong electrolytes in solutions are ionized completely:

$$MA \rightarrow M^{+} + A^{-}$$

Weak - partially:

$$MA \rightleftarrows M^{+} + A^{-}$$

Process of ionization of weak electrolyte characterize ionization degree α:

*α = the number of pro dissociating molecules/the general number of molecules*

Degree of ionization of electrolyte decreases at increase in its concentration. In the size characterizing position of balance of process of ionization of weak electrolyte and not dependent on concentration, the ionization constant is:

$$K = \frac{C(M^{+}) \cdot C(A^{-})}{C(MA)}$$

The ionization constant has physically - chemical sense only concerning weak electrolytes. We will notice, that division of electrolytes on weak and strong is conditional since depends not only by nature the substance, but also by nature solvent. In one solvent the given electrolyte will be strong, in other - weak.

Communication between degree of ionization and ionization constant is described by V.Ostvalda's equation (1888):

$$K = \frac{\alpha^2 c}{1-\alpha}$$

For very weak electrolytes α<1, the size α in a denominator can be neglected, since 1 - α ≈ 1, and the equation will be transformed to more simple: $K \approx \alpha^2 \cdot c$

Whence $\alpha \approx \sqrt{K/c}$

The law of cultivation Ostvald says: Degree dissociation weak binary electrolytes inversely proportional to a root square of their concentration or are directly proportional to a root of square their cultivation.

## Specific electric conductivity of a solution of electrolyte

Ability of electrolytes to spend an electric current depends on quantity of carriers of a current and their electric mobility U:

$$U = \frac{V}{E}, \frac{sm^2}{(V \cdot s)}$$

Where V - speed of ions, sm/s;

E - intensity of electric field, see/V

Specific electric conductivity $\Re$characterizes the quantity of electricity which is passing through $1 sm^2$ of a solution for 1 second at a gradient of potential, equal 1 V/sm:

$$\Re = 10^{-3} \cdot \alpha \cdot c(1/z\ X) \cdot F \cdot (U_+ + U_-),\ Om^{-1} sm^{-1},$$

where α - degree of ionization of electrolyte;

$c(\frac{1}{z}X)$ - molar concentration of equivalent of substance X, mol/l;

F – constant of Faradey, 96500 Kl/mol;

$U_+ + U_-$ - electric mobility of cations and anions accordingly, sm / (V.s);

$10^{-3} sm^3/dm^3$ - translation factor.

Specific electric conductivity can be calculated, if resistance of solution R and its geometrical parameters is known:

$$\Re = \frac{1}{R} \cdot \frac{L}{S}, \text{ where } H = \frac{1}{R} \cdot \frac{L}{S}$$

S - They are of cross-section section of the solution which is between two parallel electrodes, $sm^2$;

L – Distance between electrodes

This, $\Re$ - electric conductivity of a solution of electrolyte with the area of cross-section section equal 1 $sm^2$, and the prisoner between two parallel electrodes, spaced from each other on 1 see

## Molar electric conductivity of electrolyte.

## Law of Kolraush

The size of molar electric conductivity $\Lambda_c$, pays off on the equation:

$$\Lambda_c = 1000 \cdot \frac{\Re}{c}(\frac{1}{z}X), \frac{sm^2}{(Om \cdot mol)}, \lambda_c = 1000 \cdot \frac{H}{c}(\frac{1}{z}X)$$

She allows to reveal in more obvious form dependence of electric conductivity on character of intrinsic interaction (for strong electrolytes) and from ionization degree (for weak electrolytes).

With cultivation increase $\Lambda_c$ increases, reaching the maximum value which is called as limiting molar electric conductivity. The further decrease in concentration does not lead to change $\Lambda_c$. A solution for which $\Lambda_c = \Lambda_{max}$, is called as extremely diluted. In such solution the weak electrolyte is ionized on 100 % ($\alpha$ =1), and in a solution of strong electrolyte there are no all kinds of intrinsic interaction.

In 1879 F.Kolraush has established the law according to which in extremely diluted solutions of electrolytes ions spend an electric current independently from each other:

$$\Lambda_{max} = \lambda_+ + \lambda_-$$

Where $\lambda_+$ and $\lambda_-$ = limiting molar electric conductivity cation and anion accordingly.

Limiting molar electric conductivity of an ion can be calculated from parity: $\lambda = F \cdot u$

## Ionic force of a solution Activity of ions

Change of molar electric conductivity of strong electrolyte at change of its concentration specifies what not all ions which are present at a solution are active. It, by the way, extends not only on the phenomena of carrying over of electricity, but also on all physically - chemical processes, including and chemical reactions. Thus, the structure of solutions of electrolytes should be characterized not the analytical concentration connected with a technique of preparation of a solution, and the effective concentration named activity. Activity **and** is connected with concentration a parity: **a=f·c**, where

**f** - Activity factor.

There are two different approaches to definition of dimension of activity. According to one of them activity is dimensionless size, in this case dim f = dim 1/c, l/MOL is units of measure. Other approach assumes, on the contrary, that the activity factor is dimensionless, in that case dim a = dim c.

Activity of an ion depends on intensity of electric field existing in a solution which is quantitatively characterized by ionic force of a solution I:

$I = 0{,}5\Sigma c_j \cdot Z_j^2$, where

c - molar concentration of an ion in a solution, mol/l;

Z - an ion of charge.

Ionic force of a solution is additive size; it means that each electrolyte brings the contribution to size 1 irrespective of others. In some cases ionic force of a solution count, substituting in not molar, but molar concentration ($1_m$). As in the diluted solutions $c \approx c_m$, values 1 and $1_m$ also are close to each other.

For the diluted solutions the activity factor can be calculated on equation Debay-Hukkel:

$Lgf = -0,5z^2\sqrt{1}$.

At concentration reduction f-> and, hence, a-> c. As in solutions of weak electrolytes ionic force low, for them, as well as for the diluted solutions of strong electrolytes, it is possible conditionally, to accept, that $a \approx c$.

Character of stirring influence of ions can be considered on examples of carrying over of an electricity in solutions.

As is known, ions in water solutions are surrounded by dipoles of molecules of water: they create a hydraulic cover. Because of an electrostatic attraction ions in a solution are surrounded by the ions of an opposite charge forming ionic atmosphere.

At the directed movement in electric field the ion is braked because the molecules of the water forming hydraulic covers of opposite charged ions, create a counter stream of solvent, i.e. hydrodynamic resistance. This effect has received the name of electro photometric braking.

Ions forming ionic atmosphere, are located around opposite charged ion in regular intervals. At imposing on a potential difference solution there is opposite directed tendency in moving cations and anions, that leads to infringement of uniformity of an arrangement of ions in ionic atmosphere; cations, for example, will mainly be behind moving to the anode anion. It also leads to delay of speed of its moving, i.e. physically to reduction of electric mobility. This effect has received names relaxation braking.

## Conductivity masterly

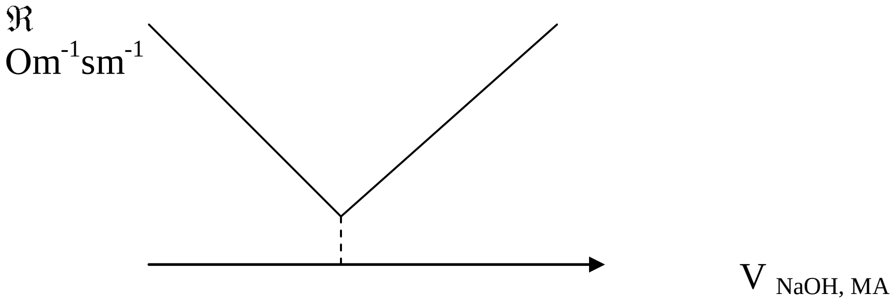
Conductivity masterly name the physical and chemical method of the analysis based on measurement of electric conductivity of conductors of the second sort. Conductivity masterly use for definition of concentration of electrolytes. Distinguish direct and indirect conduct metrical methods.

At direct measurements preliminary is under construction gravely the schedule expressing dependence of resistance from concentration R=f (c) on which then definition the concentration of electrolytes in investigated solutions is spent. Such measurements are spent for an estimation of the total maintenance of electrolytes, for example, at the analysis of waters of mineral sources, sewage of the industrial enterprises, at quality assurance of water of the economic appointment distilled and deionisationly of water.

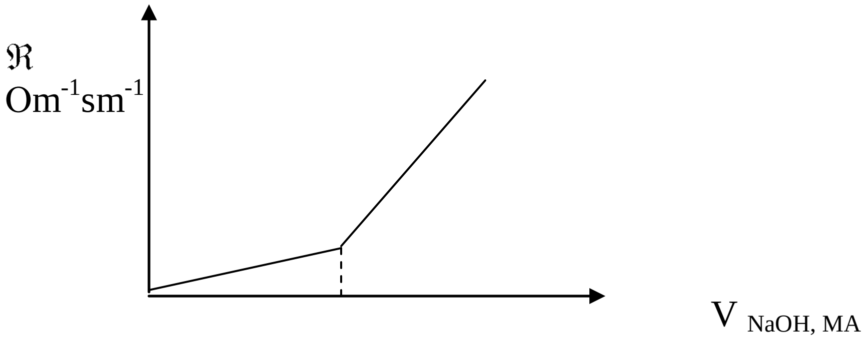
At indirect conduct metrical measurements to destination resistance of a solution find, for example, a point of equivalence in the course of titration. Titration with conduct metrical indication of a point of equivalence is used when application of the usual indicator is impossible (the muddy, intensively painted solutions etc.). Besides, this method allows to use widely various types of the reactions accompanied by change electric-conducting of analyzed solutions, to define a final point of titration on crossing of two straight lines and accordingly to calculate an equivalence point, to make the differentiated titration of mixes of electrolytes and thus to construct conduct metrical curve titration.

Curve conduct metrical titration reflects change of specific electro conductivity of a solution at additions titrant. For construction conductivity masterly a curve use values of specific electro conductivity of the solution, received by measurements after addition every portion titrant.

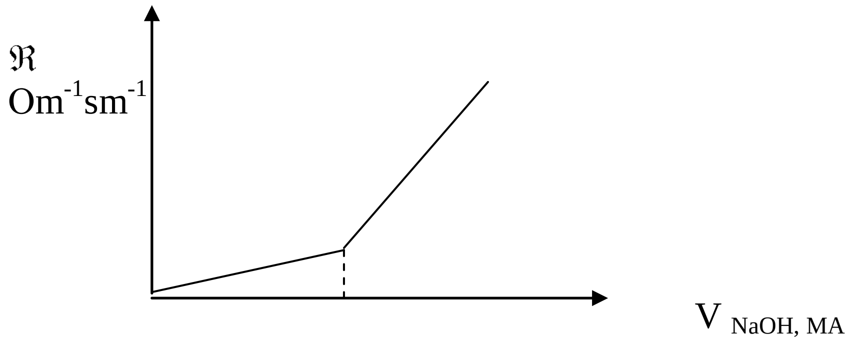
At titration of strong acid by the strong basis very mobile ions of hydrogen are replaced with less mobile ions of metals. Therefore electro conductivity of a solution goes down to a minimum in an equivalently point, and at the further titration at the expense of surplus of ions of metals and mobile ions OH electro conductivity increases.




At titration of weak acid by the strong basis electro conductivity of a solution raises at the expense of replacement light-dissociation acids completely dissociated salt a little. Electro conductivity raises gradually to an equivalent point, and then is sharp at the expense of accumulation of ions of metal and OHof ions in a solution.




At titration of a mix of strong and weak acids strong acid, and then weak acid in the beginning will be neutralized. Therefore electro conductivity of a solution goes down in the beginning to a minimum in an equivalent point of strong acid, and then gradually increases to an equivalent point of weak acid, after full neutralization of weak acid electro conductivity sharply increases.




## Situational tasks

***Task №1***. Calculate limiting molar electric conductivity of bromide of lithium at 298 K.

***The standard of decision:***

Limiting molar electric conductivity of ions $Li^+$ and $Br^-$ count under the formula: $\alpha$ =F*U, thus electric mobility of ions is equal: U ($Li^+$) = $4{,}01 \cdot 10^{-4} sm^2$

U (Br-) = 8,12 $sm^2$

$\lambda$ (Li +) = U (Li +) F=$4{,}01 \cdot 10^{-4} \cdot 96500 = 38{,}7\ sm^2 \cdot Om^{-1} \cdot mol^{-1}$

$\lambda$ (Br-) = U (Br-). F=$8{,}12 \cdot 10^{-4} \cdot 96{,}500 = 78{,}4\ sm^2 \cdot Om^{-1} \cdot mol^{-1}$

Limiting molar electric conductivity of bromide count under the formula:

$$\lambda_{max} = \lambda_+ + \lambda_-$$

$\lambda_{max}$ (Li Br) = $\lambda$ ($Li^+$) + $\lambda$ (Br-) = 38,7+78,4=117,1 $sm^2 \cdot Om^{-1} \cdot mol^{-1}$

***Task №2.*** Specific electric conductivity of solution of proponly acids with concentration c($C_2HCOOH$) =$7{,}8 \cdot 10^{-3}$mol $dm^{-3}$ is equal $1{,}21 \cdot 10^{-4} Om^{-1}\ sm^{-1}$. Calculate degree and an ionization constant a proponly acids (T=298).

***The standard of decision:***

Molar electric conductivity at the given concentration count under the formula:

$$\lambda_c = ℜ/C \cdot 10^3 = 1{,}21 \cdot 10^{-4}/7{,}8 \cdot 10^{-3} \cdot 10^3 = 15{,}5\ sm^2 \cdot Om^{-1} \cdot mol^{-1}$$

Under law Kolraush find limiting molar electric conductivity, thus

$$\lambda_{H^+} = 349{,}8\ sm^2 \cdot Om^{-1} \cdot mol^{-1}$$

$$\lambda_{C2H5COO} = 35{,}8\ sm^2 \cdot Om^{-1} \cdot mol^{-1}$$

$\lambda_{max} = \lambda\ (_{H^+}) + \lambda\ _{(C_2H_5COO^-)} = 349{,}8+35{,}8=385{,}6\ sm^2 \cdot Om^{-1} \cdot mol^{-1}$

Ionization degree of propyonly acids in a solution of the specified concentration count under the formula:

$\alpha = \lambda_c / \lambda_{max} = 15{,}5\ sm^2 \cdot Om^{-1} \cdot mol^{-1}/385{,}6\ sm^2 \cdot Om^{-1} \cdot mol^{-1} = 0{,}04$ or 4 %

$K = \alpha^2 c/1-\alpha = (4{,}02 \cdot 10^{-2})^2 \cdot 7{,}8 \cdot 10^{-3}/1-4{,}02 \cdot 10^{-2} = 1{,}31 \cdot 10^{-5}$

***Task 3.*** In quality of plasma replacing solution used a solution of Ringer-Lokk having the writing:

| | |
|---|---|
| *V (NaCl)* | *0,9g* |
| *KCl* | *0,02g* |
| *$CaCl_2$* | *0,02g* |
| *$NaHCO_3$* | *0,02g* |
| *$C_6H_{12}O_6$* | *0,1g* |

Water for injections to 100 ml.

Calculate ionic force of this solution and activity of an ion of sodium.

**The standard of decision**

Let's calculate molar concentration of electrolytes under the formula:

$c (x) = m (x)/M (x) \cdot V$

$C (NaCl) = 0,9/58,5 \cdot 0,1 = 0,154$ mol/l

$C (KCl) = 0,02/74,5 \cdot 0,1 = 2,68 \cdot 10^{-3}$ mol =0,00268 mol/l

$C (CaCl_2) = 0,02/111 \cdot 0,1 = 1,8 \cdot 10^{-3}$ mol =0,0018 mol/l

$C (NaHCO_3) = 0,02/84 \cdot 0,1 = 2,38 \cdot 10^{-3}$ mol =0,00238 mol/l

Let's calculate total concentration of chloride-ion $c (C1^-)$

$C (C1^-) = C (NaCl) + C (KCl) + 2C (CaCl_2) = 0,154 + 0,00268 + 2 \cdot 0,0018 =$

$= 0,160$ mol/l

and total concentration of ions of sodium:

$C (Na^+) = C (NaCl) + C (NaHCO_3) = 0,154 + 0,00235 = 0,156$ mol/l

Concentration of other ions are equal to concentration of electrolytes which structure includes these ions: ionic force of a solution it is counted on the equation:

$I = 1/2 [C (Na^+) + C (K^+) + C (Ca^{2+}) \cdot 2^2 + C (Cl^-) + C (HCO_3^-)] = ½ (0,156 + 0,00268 + 0,00180 \cdot 4 + 0,160 + 0,00235) = 0,164$ mol/l

The received value of ionic force corresponds to value I for blood plasma.

$f(Na^+) = 0,72$

$a = f \cdot c = 0,72 \cdot 0,156 = 0,112$

## Questions and tasks for self-checking of mastering of a theme

1. Result expression of a constant of ionization for weak acid and the weak basis (at your choice).

2. How the constant of ionization of weak electrolyte is connected with degree of its ionization?

3. How change specific electric conductivity of a solution of electrolyte with concentration increase? Explain character of dependence.

4. How change molar electric conductivity of electrolyte with cultivation increase? Explain character of dependence.

5. Formulate law Kolraush.

6. Why the behavior of ions in solutions of electrolytes is more precisely defined by their activity, instead of concentration?

7. How is defined the factor of activity of an ion in a solution?

8. In what the essence electroforetic and relaxation braking of ions consists?

## Test questions

1. Specify the formula of definition of molar electro conductivity

A) $\Re$=K/R B) $\lambda$=1000/C·$\Re$

C) $\lambda$=K·$\lambda$ D) $\lambda$=1/p

E) $\lambda$=1000/C

2. Specify the formula of definition of limiting molar electro conductivity

A) $\lambda_\infty=\lambda_k-\lambda_a$ B) $\lambda_\infty=\lambda_k/\lambda_a$

C) $\lambda_\infty=\lambda*K$ D) $\lambda_\infty=\lambda_k+\lambda_a$

E) $\lambda_\infty=\lambda_a/\lambda_k$

3. On what factors is depends the ionic force of a solution?

A) Charge of each of present ions
B) Temperature
C) Concentration of each of present ions
D) Factor of activity of each of present ions
E) Isotonic factor of each of present ions

4. For what purposes electro conductivity is used
1. For degree definition dissociation
2. The Express train diagnostics
3. For measurement of potentials
4. For measurement EDS
5. For constant measurement dissociation electrolytes

A) 1,2,3 B) 4,5,6 C) 1,2,6 D) 2,3,4 H) 3,4,5

5 In what case for definition of concentration of solutions use conductivity masterly titration?
A) For research of electrolytes
B) For research un electrolytes
C) For research of the painted solutions

D)For research of muddy solutions
H)For research of the muddy and painted solutions

## Laboratory work

**Work 1.Definition the degree and constant of dissociation 0,01n a solution of weak electrolyte.**

Having filled with an investigated liquid a vessel to make measurement of resistance $R_x$ with the help reohordly bridge R-38. For this purpose it is necessary:

1. To bring to nests of charging of the device pressure of an alternating current 127 or 220 V with frequency of 50 Hz, the "charging" switch to put in position «∞».
2. To connect electrodes electroliticalycells to clips «$R_x$».
3. To establish the switch of a shoulder of comparison in position «zero installation» and, having established the switch «galv» in position is exact, rotation of the proof-reader to establish an arrow of a galvanometer in zero position.
4. To establish the switch «galv» in position "roughly" and to counterbalance the bridge rotation of handles of a shoulder of comparison and reheard, and then to translate the switch «galv» in position "precisely" and handle rotation reohordpre-balance the bridge.
5. To make readout of values of resistance of a comparative shoulder «R» and relations «m» (on a scale) to define value of measured resistance under the formula:

$$R_x = m\,R,\ \text{Om}$$

| № | Capacity of using liquid, ml | R Om | m A | $R_x$, Om | $\Re$, $Om^{-1}sm^{-1}$ | λ, $Om^{-1}sm^2$. g-equ$^{-1}$ | A | K |
|---|---|---|---|---|---|---|---|---|
| 1. | 50 | | | | | | | |
| 2. | 50 | | | | | | | |
| 3. | 50 | | | | | | | |
| Average value | | | | | | | | |

To calculate value $\Re$, λ, α, To under the formula:

$$\Re = K / R_x,\ Om^{-1}sm^{-1}$$

$$\lambda = 1000 / C \cdot \Re,\ Om^{-1}sm^2.\ g\text{-}ekv^{-1}$$

$$\alpha = \lambda / \lambda_\infty;\ K = C\alpha 2 / 1\text{-}\alpha = c \cdot \lambda\ 2 / \lambda_{\alpha}(\lambda_\infty - \lambda),$$

Where: $\Re$ - specific electro conduction, $Om^{-1}sm^{-1}$
$R_x$ - resistance of weak electrolyte, the Ohm
K - a constant of electroliticaly cells
λ - molar electro conduction at the given cultivation, $Om^{-1}$ $sm^2$. g-ekv$^{-1}$
$\lambda_\infty$- molar electro conductivity at infinite cultivation, $Om^{-1}$ $sm^2$. g-ekv$^{-1}$

$\lambda_\infty = \lambda_K + \lambda_a$

$\lambda_K$, $\lambda_a$ - accordingly limiting mobility cation and anion,

c - normally of solution;

α - degree dissociation;

K- a constant dissociation

**Work 2.Quantitative definition of concentration of a solution by a method of conductivity masterly titration.**

In a vessel for definition electric-conducting to pour 40 ml of an investigated solution. To measure initial resistance by reochordly bridge R-38.Then from burettes to an investigated solution to flow a working solution in the portions on 1 ml. After addition every portion to measure resistance. Results of titration to write down in the table

| № | Investigated solution, ml | Vworking. s-n, ml | R, Om | M | $R_x$, Om $R_x$=R | ℜ, $Om^{-1}sm^{-1}$ | Equivalence point, ml | N, g-equ/l |
|---|---|---|---|---|---|---|---|---|
| | | NaOH | | | | | | |
| 1. | | 1 | | | | | | |
| 2. | | 3 | | | | | | |
| 3. | HCl | 4 | | | | | | |
| 4. | | 5 | | | | | | |
| 5. | | 6 | | | | | | |
| 6. | | 7 | | | | | | |
| | | NaOH | | | | | | |
| 1. | | 1 | | | | | | |
| 2. | | 3 | | | | | | |
| 3. | $CH_3COOH$ | 4 | | | | | | |
| 4. | | 5 | | | | | | |
| 5. | | 6 | | | | | | |
| 6. | | 7 | | | | | | |
| | | HCl | | | | | | |
| 1. | | 1 | | | | | | |
| 2. | | 3 | | | | | | |
| 3. | $NH_4OH$ | 4 | | | | | | |
| 4. | | 5 | | | | | | |
| 5. | | 6 | | | | | | |
| 6. | | 7 | | | | | | |

On received given to construct a curve in co-ordinates ℜ - $V_{wor}$ on which to define an equivalence point. Then to calculate concentration of an investigated solution under the formula:

$$C(t/z) = V_{wor} \cdot N_{wor} / V_{invest}, \text{ g-equ/l}$$

**Tasks for the independent decision**

1. Calculate molar electric conductivity of chloride of ammonium in 12 %-s' water solution (ρ =1,109 g/ml). Specific electric conductivity of this solution is equal 0, 01041$om^{-1}sm^{-1}$.

2. Calculate degree and a constant of ionization of oil acid if its specific electric conductivity with concentration 0,0156 mol/l is equal $1{,}81*10^{-4} om^{-1}sm^{-1}$

3. Calculate ionic force of plasmoreplacingsalt solution «trio salt» having the following prescribe:

NaCl 0,5g
KC1 0,1g
$NaHCO_3$ 0,4g
Water for an injection to 100 ml.

## POTENTIONITY METERLY DEFINITION OF PH BIOLIQUIDS

**The employment purpose** To learn to define pH bio liquids by method of potentiality masterly.

**The importance of a studied theme:** the organ temperature, certain osmotic pressure, and also value pH various bio liquids are a basis of a constancy of an organism. For example, pH blood =7,4±0,04, gastric juice - 1,85±0,15, a saliva - 6,60±0,30 etc.

Considerable change pH biological systems, first of all blood, leads to serious pathological processes.

Definition pH blood, urine, gastric juice has great value in medicine at diagnostics of various diseases.

Definition pH bio liquids a method of potentiality masterly - exact and reliable definition. This technique can be used in those cases when it is impossible to define pH bio liquids in other ways, for example, pH the blood, the painted and muddy solutions etc.

The potentiality masterly method of definition pH has found wide application in biochemical analyses.

**Initial level of knowledge**

1. Potential.
2. A potential difference.
3. Galvanic cages.
4. Constants and variable sources of a current.

**Teaching material for self-preparation**

1. M.I.Ravich-Scherbo, V.V. Novikov. Physical and colloid chemistry M, 1975, p. 59-75.
2. Lensky A.S. introduction in bioinorganic and biophysical chemistry M, 1989, p. 234-235.

**On employment following questions will be considered**

1. The potentials formed on border metal - water, metal - a solution of its salt.

2. The galvanic cell device. Element Jacobi - Daniel.
3. Dependence of electrode potential by nature metal, concentration, temperature. Equation of Nernst
4. Kinds of electrodes: comparison electrodes (standard electrodes), definition electrodes, ion selectivity electrodes. Electrodes of the first and second sort.
5. Memorably and diffusion potentials and their biological value.
6. Oxidation-reduction systems and their biological value.
7. Potentiality masterly definition pH solutions.
8. Laboratory work.

## THE INFORMATION BLOCK

If a metal plate to ship in water or a solution of its salt at the expense of destruction of a crystal lattice the small part of an ion of metal will pass in water or in a solution. As a result of it metal gets some negative charge, and adjoining to it the sheet of water or a solution is charged positively for the account cations, kept by a negative charge of metal. On border has undressed metal - water or metal - the solution is formed a double electric layer. The arisen potential interferes with the further transition of ions of metal in water or in a solution. In a case when metal is placed in a solution of own salt to transition of ions of metal in a solution same ions already available in a solution in which result ions of metal from a solution will be a part again of a crystal lattice of metal will to counteract.

If in the system consisting of metal, lowered in a solution of the salt, process of transition of ions of metal in a solution metal gets negative charge if return process prevails, that is sedimentation process cations on metal gets a positive charge prevails. In each case between a surface of metal and adjoining the potential difference arises a sheet of water or a solution. This difference electrically potentials, or potential jump on border metal - a solution name electrode potential.

The arisen potentials limit process of the further transition of ions from metal or on metal. On the basis of it for each metal and certain concentration of its salt values of electrode potential are calculated. In table 1. Standard (normal) electrode potentials of some metals are resulted. The metals located among hydrogen are charged negatively, and below hydrogen - is positive.

**Values of standard electrode potentials of metals at $25^0$C**

| **Electrode (metal / an ion)** | **$E_0$, in** | **Electrode (metal / an ion)** | **$E_0$, in** |
|---|---|---|---|
| $Li/Li^+$ | -3.02 | $Pb/Pb^{2+}$ | -0.126 |
| $K/K^+$ | -2.92 | $H_2/H^+$ | ±0.000 |
| $Na/Na^+$ | -2.713 | $Cu/Cu^{2+}$ | + 0.34 |
| $Al/Al^{3+}$ | -1.66 | $Ag/Ag^+$ | +0.80 |
| $Mn/Mn^{2+}$ | -1.05 | $Hg/Hg^+$ | +0.799 |

| | | | |
|---|---|---|---|
| $Zn/Zn^{2+}$ | -0.763 | $Hg/Hg^{2+}$ | +0.854 |
| $Fe/Fe^{2+}$ | -0.441 | $Pt/Pt^{2+}$ | +1.20 |
| $Ni/Ni^{2+}$ | -0.23 | Au/Au + | +1.70 |

The potential which has arisen on a metal plate, the salt of the same metal shipped in a solution with activity of ions of the given metal of 1 g-g/l, at comparison with potential of the hydrogen electrode which potential it is considered to be equal 0 name normal electrode potential. The sizes of electrode potential depends by nature metal, concentration or are more exact than activity of ions of metal in a solution and from temperature.

**The galvanic cell device**

The device consisting of two electrodes, lowered in a salt solution in which chemical energy turns in electric and back is called as a galvanic cell.

Galvanic cages can consist from:

1. From two electrodes differing on value of electrode potential-Zn | $Zn^{2+}$ (-0,762) and Cu | $Cu^{2+}$ (+ 0,34)
2. From two various electrodes having identical value of electrode potential Cu | $Cu^{2+}$ (+ 0,34) and Au | $Au^{+}$ (+1,70)
3. From two identical electrodes lowered in a solution of salt of different concentration.

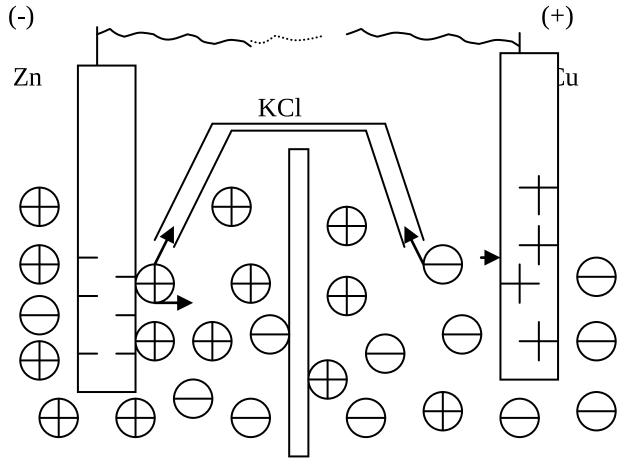
Last name a concentration galvanic cell. Electrode, lowered in a solution with more concentration of salt, will be positive in relation to an electrode placed in a solution with smaller concentration Charges of electrodes can be and identical on a sign, but owing to a difference of concentration of salt their size will be different, as it is required for occurrence.

In first two cases for electromotive power occurrence (E.D.S.) the absolute size of a potential difference of two electrodes, instead of signs on their charges matters only.

Element Jacobi - Daniel consists of the copper and zinc electrodes shipped in solutions of corresponding salts. As zinc among standard electrode potentials is located to hydrogen, and copper after hydrogen the zinc electrode is charged negatively, and a copper electrode - is positive. Solutions are connected glassily by a tubule filled with an agar, containing KCl. At short circuit of an external chain electrons from zinc pass to a copper electrode and join ions of copper besieging on it. The zinc electrode will be gradually dissolved, and a copper electrode on the contrary, to be allocated from a solution on an electrode. Formed surplus of ions $Zn^{2+}$ in the left part of an element to diffundirate through a tubule filled with an agar, containing KCl, in the right part, and $SO_4^{2-}$ - in left, it is mutual neutralists.

As source of electric energy chemical reaction of replacement of copper by zinc serves in an element:

$$Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$$




The electrode potential is defined V.G. Nernst's by formula:

$$E=E^{o} + (RT/nF)\ \ln a_{Me}^{+n}$$

Where E - electrode potential for the given electrode.
$E^{o}$ - the potential of a normal electrode corresponding to potential of an electrode at $a_{me}^{+n}$, an equal 1 mol/l.
R - the gas constant equal 8,31 D zh/hailstones a mol
T - solution temperature on Calvin
n - a charge of an ion of metal in a solution
F – number Faraday equal 96500 Ki/MOL.
$a_{me}^{+n}$ - Activity of an ion of metal in a solution in a mol/l.

Galvanic cages happen reversible and irreversible. So for example if in Daniel's galvanic cell - Jacobi electric current to start up in the opposite direction it will cause return processes on electrodes: zinc will be allocated on an electrode, and copper to be dissolved, the system will revert to the original state. Elements in which current passage in the opposite direction causes return processes, name reversible. If an element from a copper and zinc electrode to lower in sulfuric acid at its work zinc will be dissolved, and on a copper electrode hydrogen will be allocated. At a return direction of a current copper will be dissolved, on a zinc electrode hydrogen will be allocated. Such electrodes name irreversible.

Electrodes not always represent the plate of metal shipped in a solution of salt. Sometimes instead of a salt solution use the paste containing necessary salt (in calomel electrodes); apply gas electrodes, in which the role of a metal plate carries out adsorbed on an indifferent plate (gold, platinum) gas - in hydrogen and oxygen electrodes etc.

All these electrodes work on the basis of an exchange of ions between a plate and a solution and are called as reversible rather anion or cation (looking that exchanges). Distinguish electrodes of the first sort, reversible concerning one of ions, and electrodes of the second sort, reversible concerning both kinds of ions of a solution.

## Comparison electrodes

Electrodes which under the influence of external factors do not change value of electrode potentials called the comparison electrodes.

Now any ways for an estimation of absolute values of electrode potentials does not exist. Are for this purpose limited to an establishment of their absolute size by comparison with potential of the standard electrode which value is conditionally accepted for zero.

As a standard electrode usually accepts the hydrogen electrode which potential is conditionally accepted for zero. To it compare potentials of other electrodes. After definition of size of potentials electrodes also can use as standard (them name in such cases more often comparison electrodes).

As comparison electrodes apply normal electrodes. These are electrodes in which activity of ions in a solution of salt of corresponding metal is equal 1 g-g/l.

The normal hydrogen electrode belongs to reversible electrodes of the first sort as it is reversible rather only one of ions in a solution - hydrogen. This electrode represents in the most simple form a tube with one closed end into which the platinum delay in the platinized platinum plate welded on it (i.e. by platinum, electroliticaly spongy platinum covered with a layer is entered that increases a surface of contact of metal with hydrogen). The tube is filled with a solution of acid with activity of ions of the hydrogen, equal unit. Then the closed knee let in pure hydrogen under the pressure of 1 atm. Gas rises upwards, creates in the end of a knee a gas vial and is adsorbed on platinum. The electrochemical scheme of a hydrogen electrode registers: (Pt) $H_2 \mid 2H^+$

At $a_{H^+}$ = 1 g-g/l and pressure $H_2$=1 atm the potential of a hydrogen electrode conditionally is accepted equal to zero. The hydrogen electrode is very exact, but is very sensitive to working conditions, and also preparation and its application is connected with technical difficulties, therefore use other electrodes is more often.

Chlorargentumly electrode consists from silvery a wire covered with salt AgCl and shipped in solution KCl. It does not contain some mercury, work with which is not absolutely safe (mercury is toxic).Electrochemically the scheme chlorargently an electrode is expressed: Ag | AgCl | KCl. Value of its potential depends on activity of ions of chlorine. The potential of chlorargently an electrode at $a_{Cl^-}$ = 1 and at $25^0$C is equal +222 mв.

Calomel the electrode represents system on which bottom some drops of mercury and crushed $Hg_2Cl_2$ (calomel) shipped in concentrated solution KCl contain. The electrochemical scheme Calomel an electrode is expressed: Hg | $Hg_2Cl_2$ | KCl. Value of potential of this electrode also depends on activity of ions of chlorine (concentration KCl) and is equal +246 mB.

## Definition electrodes

Electrodes which can change value of potential under the influence of environment components name definition electrodes.

**The glass electrode** represents a glass tubule with a ball on one end in the thickness about 0,01mm. A tubule fill with a liquid with constant pH (for example, 0,1 M HCl) and place there an auxiliary electrode (it name also an internal electrode) - chlorargentumly. The potential of a glass electrode depends on activity of ions of hydrogen in a solution and is defined under formula Nernst.

The glass electrode can use in the big interval of values pH - from-2 to 12.

**An chynhydronely electrode**. This electrode represents the platinum delay lowered in a glass with the investigated solution, containing in equimolar quantity hynon ($C_6H_4O_2$) and hydrohynon$C_6H_4$ $(OH)_2$. The system hynon- hydrohynon concerns to redox systems and consequently hynon is oxidized, and hydrohynon - restoreredox the form.

The hingidronely electrode can serve both a comparison electrode, and a definition electrode. This electrode is very simple in work.

Its lacks consist that it gives exact evidences only at pH solutions less than 8; presence at solutions of oxidizers, reducers and some salts also stirs to its correct work. Because of it the hingidronely electrode is inapplicable for studying of many biological liquids where it is necessary to give preference to more perfect and universal glass electrode.

## Ion selectivity electrodes

Electrodes which change values of potential depending on concentration of the certain ions which are in system ($Li^+$, $Na^+$, $To^+$, $Ca^{2+}$, $NH_4^+$, $Ag^+$, $Cu^{2+}$, $S^{2-}$ $CN^-$). Are called ion selectivity. Use of these electrodes allows to define concentration of various ions in bios stems.

## Membranly and diffusion potentials and their biological value.

At contact of solutions different concentration the dissolved substance to diffundirate in a solution with smaller concentration. If ions electrolytes possess different speed of diffusion more mobile ions gradually appear ahead less mobile. As a result of it less concentrated solution find potential with a sign on a charge of "fast" ions, and more concentrated - potential with a sign on a charge of "slow" ions. On border of section of solutions arises diffusion potential which brakes "fast" ions and accelerates slow, that is averages speeds of movement of ions.

Diffusion the potential can strongly increase, if solutions of electrolytes of different concentration to divide membranly, nontight only for ions with what or one charge.

This property of membranes explain that free carboxyl groups of such membranes having a negative charge, draw and pass only cations and push away anions. However there are membranes nontight only for anions, for example, a cover erythrocytes. Probably, that there, selectivity of a membrane is caused by positively charged amino groups. Occurrence membranly potential is connected not only with features of chemical structure and a structure of membranes, but also with possible discrepancy of the sizes of ions and a time in a membrane.

Membranly potentials very proof also remain within several months.

Diffusion and membranly potentials have very much great value in medicine, they arise in biological objects. At damage of a blanket or covers of cells selectivity of their permeability and electrolytes is broken begin diffundirate in a cell or from it, depending on a concentration difference, thus arises diffusion potential. It value reaches 30-40 mv. Gradually with end of process of diffusion the potential decreases to 0. As a rule, the damaged fabric is charged negatively in relation to the intact.

## Oxidation-reduction systems and their biological value.

The systems containing mixes of oxidized and restored forms of the same substance, for example, $Fe^{3+}$ and $Fe^{2+}$, $Cu^{2+}$ and $Cu^{+}$ and etc. Name oxidation-reduction or redoks-systems.

The redoks-system causes potential occurrence on the indifferent electrode placed in it - platinum or gold to a plate. The reason of its occurrence can be considered on example of system $Pt|FeCl_3|FeCl_2$

In this system the following reaction proceeds:

$$Fe^{3+} + 1e^{-} \longrightarrow Fe^{2+}$$
$$Fe^{2+} - 1e^{-} \longrightarrow Fe^{3+}$$

If in a solution the maintenance of oxidized form $Fe^{3+}$ there is a restoration process prevails, metal accepts one electron at an electrode and turns in $Fe^{2+}$ and the electrode losing an electron gets a positive charge. At surplus of restored form $Fe^{2+}$ there is an oxidation process, metal gives one electron and turns in $Fe^{3+}$, and the electrode is charged negatively. As a result balance of reaction is displaced in right or a left-hand side new balance will not be established yet. Thus on electrodes there is a potential difference named in redoks-potential. The Redoks-potential is defined by equation of Pitters:

$$E = E^0 + \frac{RT}{nF}\ln\frac{c(oxidised)}{c(restored)}, \text{ where}$$

$E^0$ - Normal redoks-potential; n - number of the electrons lost by one molecule or one ion of the restored form at its transition in the oxidizing form; with (oxidized) and with (restored) - concentration (is more exact than activity) corresponding forms of substance, R - the universal gas constant is equal 8,31zh/grad·mol, T - absolute temperature, F - number Faradey equal 96500 Kl/MOL. Substituting value R and F in the above-stated equation and passing from the natural logarifm in decimal at $25^0$C it is received a following equation:

$$E = E^0 + \frac{0{,}0591}{n}\lg\frac{c(oxidised)}{c(restored)}$$

If an electrode to place in the system containing equal concentration of oxidized and restored forms of substance the formed potential is called as normal redoks-potential $E^0$.

Oxidation-reduction potentials have great value in human physiology. Such systems concern their number in blood and tissue, as gem/gemmating and cytochromes in which contain two-and trivalent iron; the ascorbic acid which is in oxidized and restored forms; system of glutation; cystin and cystein, etc.

## Potentiality masterly definition pH solutions

This method is based on definition EDS of a galvanic cell. This method use for definition pH various systems, and also in the diagnostic purposes.

Definition pH a solution is reduced to an establishment of potential of an electrode of the definition shipped in the investigated solution and based on dependence of size of potential from pH. Potential size define on EDS a chain made of an electrode with known potential (normal hydrogen, chlorargentumly, Calomel) and a definition electrode.

EDS chains measure by a compensatory method, i.e. comparison with EDS the normal element Veston having constant EDS, equal at $20^{0}$C 1,0183 century

Potentiality masterly definition pH solutions have great value at research of the muddy and painted biological liquids.

In chemical and biochemical laboratories now pH define by means of the semi-automatic and automatic rn-metres working on a principle of a compensatory method of definition EDS.

Convenience, accuracy, reproducibility of result, control possibility pH without influence of an electrode on a solution, possibility of automation of process of the measurement, all it has caused wide application pH-metric in microbiological researches, a chemically-pharmaceutical industry, in micro analytical researches etc.

## Training tasks and the st andard of their decision

*Task 1.* At immersing of a platinum electrode in a solution containing ions $Fe^{3+}$ and $Fe^{2}$ at temperature 298K its potential became equal 0, 783 century Define a parity of ions of iron in this solution.

*The standard of decision:*

For definition of a parity of ions we will take advantage the equation of Piters:

$$E = E^{0} + 0{,}0591 \lg \frac{c(Fe^{3+})}{c(Fe^{2+})}$$

$$\lg \frac{c(Fe^{3+})}{c(Fe^{2+})} = \frac{e - e^{0}}{0.0591}$$

$$\lg \frac{c(Fe^{3+})}{c(Fe^{2+})} = \frac{0.783 - 0.77}{0.0591} = 0.2034$$

$$\frac{c(Fe^{3+})}{c(Fe^{2+})} = anti\lg \cdot 0.2034 = 1.597 \approx 1.6$$

The answer: $Fe^{3+}$ ions in a solution in 1,6 times more, than $Fe^{2+}$ ions.

**Questions and tasks for self-checking of mastering of a theme**

1. Explain the mechanism of formation of oxidation-reduction potential.
2. Than electrodes of definition and comparison electrodes differ?
3. How the redoks-potential changes at soluble?

**Situational tasks**

**Task 1.** Advantage of a method potentiality meter.

**Task 2.** Application pH - meter in medicine?

**Test questions**

1. What electrode concerns comparison electrodes?

a) Hydrogen electrode b) ion selectivity

b) Glass electrode d) hingidronely electrode

2. What electrode concerns definition electrodes?

a) Hydrogen electrode b) Calomel electrode

c) Glass electrode d) ion selectivity

3. What basis of a method is made by definition EDS of galvanic cages?

a) Electroosmosisb) Oxydimetricaly c) Chromatographically

d) Potentiality merely

4. Specify the scheme of oxidation-restoration of the given reaction:

$$Fe + Cd(NO_3)_2 \rightarrow Fe(NO_3)_2 + Cd$$

a) $Fe/Fe(NO_3)_2$ /KCl /$Cd(NO_3)_2$/Cd b) $Fe/Cd(NO_3)_2$/ KCl /$Cd/Fe(NO_3)_2$

c) $Cd/Cd(NO_3)_2$/ KCl /$Fe(NO_3)_2$ d) $Cd(NO_3)_2/Fe(NO_3)_2$/ KCl /Cd/Fe

5.Make the oxidation-reduction scheme for the given reaction:

$$Zn^0+Fe^{2+} \rightarrow Fe^0+Zn^{2+}$$

a) $Fe^0/Fe^{2+}$/ KCl /$Zn^{2+}/Zn^0$ b) $Zn^{2+}/Zn^0$ / KCl / $Fe^{2+}$/ $Fe^0$

c) $Zn^{2+}/Fe^{2+}$/ KCl /$Zn^0/Fe^0$ d) $Fe^0/Fe^{2+}$/ KCl /$Zn^0/Zn^{2+}$

6. What organ has the least electro conduction?

a) heart b) blood c) skin d) liver

7.Of what the concentration element consists?

a)From two identical electrodes

b)From two identical electrodes lowered in solution $H_2SO_4$

c)From two identical electrodes lowered in a solution of own salt identical concentration

d)From two identical electrodes lowered in a solution of own salt various concentration

8.At the heart of a diagnostic method of electro cardiographicaly measurement of following sizes lays:

a)Pressure b)Temperature c)Bio potential

d) electro conduction

9. Specify an electrode which is reversible both on cation and on anion:

a) comparisonity b) normally

c) ion selectivity d) indicatory

10.Specify the electrochemical scheme chlorargently an electrode:

a)Ag/AgCl; KCl b)Hg/$Hg_2Cl_2$; KCl c)Ag/$AgNO_3$; $HNO_3$
d)AgCl/$AgNO_3$; KCl

## LABORATORY WORK

### Definition of pH bio liquids by method of potentiality masterly.

***Experience 1:*** In a glass for definition twice fillurinas pour urinalysis, lower an electrode and define approximate value pH. For this purpose press a

pH-metrly key, where value pH = 1-19. Then for exact definition pH press a key of the necessary range. After the termination of work the device switch off, electrodes leave in the distilled water. On the basis of data define the diagnosis.

***Experience 2:***For definition take 3 different gastric juice. Define pH on the above-stated way. On the basis of value pH gastric juice establish the diagnosis; normal concentration HC1, hyperchlorhydria or hypochlorhydria.

It is known, that at increase of acidity of gastric juice apply solution $NaHCO_3$, and at fall - ascorbic acid.

Not removing electrodes from a glass, to a solution where increase acidity add $NaHCO_3$, where lower acidity ascorbic acid before achievement pH norms of gastric juice.

***Experience 3:*** To blood whey in a glass add blood and define pH. Then add solution HCI. At what value pH begins chemical haemolysis? To draw a conclusion. The same experience make with solution NaOH.

**Tasks for the independent decision**

1. What is the electrode and how there is its potential?
2. As it is a defined E.D.S.of galvanic cage?
3. It is possible to make of what elements redox system?

## DISPERSE SYSTEMS.
## METHODS OF RECEPTION AND STABILITY OF THE COLLOIDLY SOLUTIONS.

**The purpose of employment:** Mastering by skills of reception liophobscolloids and acquaintance with their properties. Mastering by skills of clearing colloidal solutions and biologically important solutions.

**The importance of a studied theme:**

Blood, lymph, spinal liquid, protoplasm of cells, etc. biological liquids are colloidal systems and contain in colloidal a condition a number of substances, for example, phosphates, fats, lipids that it is necessary to consider at studying of properties of these liquids. Besides, some medical products represent colloidal solutions, for example, portage, kollargol. Many foodstuffs, washing-up liquids and others are also colloidal systems. All it demands enough detailed studying of properties and reception methods colloidal solutions.

**Initial level of know ledge.**

1. Solutions. Homogeneous and heterogeneous solutions;
2. The formation mechanism colloidal solutions;
3. Drawing up of the molecular and ionic equations of reactions

**Teaching material for self-preparation**


1. M.I.Ravich-Scherbo, V.V.Novikov. Physical and colloid chemistry. M, 1975, p. 178-179.
2. JU.G.Frolov. A course of colloidal chemistry’s, 1989, p. 14-16.
3. H.M.Rubina, etc. the Practical work on physical and colloidal chemistry. M, 1972, p. 121-126.


**On employment will be considered following questions:**

1. Classification of disperse systems
2. Ways of reception colloidal solutions
3. Clearing methods colloidal solutions
4. Structure of micelle
5. Laboratory work.

## THE INFORMATION BLOCK

The systems comprising the smallest weighed particles, are called as disperse. Disperse systems consist at least of two phases. One of them is utter and is called as the dispersive environment. Other phase disunity and distribution in the first; it name a disperse phase.

Depending on the size of particles of a disperse phase, disperse systems share on 3 groups:

1). Crudely dispersion systems - the size of particles from 0,1mk and above ($10^{-4}$-$10^{-7}$m) (suspensions, emulsum, powders, etc.)

2). Colloidal systems - the size of particles from 0,1 to 1 mmk ($10^{-7}$-$10^{-9}$m).

3).True or molecular-ionic systems, the size of particles no more 1mmk (not bolee10-9m).

Among disperse systems in medicine have colloidal solutions.

On a modular condition of disperse zoles environment share on 3 groups:

1) Liozoli - The dispersive environment liquid,
2) Aerosols - the dispersive environment gaseous,
3) Firm zoli - the dispersive environment firm.

The important property colloidal solutions are interaction of a disperse phase with the dispersive environment. In dependent from it distinguish liophylly and liophoblyzoles.

Colloids which particles have the big affinity to solvent are called liophylly. Liophyllycolloids are formed spontaneously as in their molecules are available ionnogenly (polar) and unionnogenly (not polar) groups which at dissolution hydra titrate (solvates). Solutions of fiber, gelatin concern them, pepsin and other high-molecular substances.

In liophobscolloidly solutions between molecules of a disperse phase and the dispersive environment there is no chemical affinity, therefore the third substance participates in their formation - the electrolyte named the stabilizer. One of stabilizer ions is selectively adsorbed by the Panetta-faience rule on a surface un deluded in deposition water, informing it the charge with the same name and stability.

### The reception methods of colloidal solutions

As the characteristic sign distinguishing colloidal solutions from true, their heterogeneity serves. Really, the sizes colloidal particles in comparison with the sizes of molecules of solvent are so great, that between them the interface is formed.

As interface is called the interface separating one phase from another**.**

Actually colloidal systems represent the micro heterogeneous systems consisting of the dispersive environment and a dispersive phase. These systems are formed under following conditions:

The sizes dispergiruely substances should be finished till the sizes colloidal particles;

Stabilizers (ions of electrolytes) which on an interface of phases form an ionic layer and hydraulic a cover providing preservation colloidal of particles in a suspension are necessary;

The disperse phase should possess bad solubility at least at reception water proofzoles.

Thus, particles get electric a charge and hydraulic a cover that interferes with their loss in a deposition.

Colloidal solutions occupy on the sizes of the particles intermediate position between crudely dispersion and molecular-disperse systems. For their reception it is used two methods: *smashing* - dispergiration larger particles to desirable degree of the dispersion answering to size colloidal of particles, and *integration* - association in units of molecules or ions to the particles which are coming nearer in the sizes to particles colloidal of systems.

**Dispersive methods**. *Mechanical methods*. The cars working by a principle shock grind and grinding are applied to crushing of substances. Dispersion degree at such processing nevertheless remains rather low - diameter of particles nearby 50-60mk.

*Ultrasonic method*. For dispergiration substances recently it is more often used ultrasonic method which is accompanied by occurrence of the breaking off forces conducting to crushing of substances.

*Method peptisation*.Peptisation is a process of transition of substance of gel in zoles under influence peptisators. Peptisation basically are exposed friable fresh forming depositions hydroxides metals, for example Al (OH) $_3$Fe (OH) $_3$, Zn (OH) $_{2,}$ etc.

Peptisation can occur in consequence of removals from a solution koagulationly the ions causing integration of particles or adsorption peptisator, accompanied by formation of a double electric layer and occurrence solvatly covers on colloidal particles. Peptisators serve, mainly electrolytes which promote des aggregation depositions.

*Dissolution method, or method spontaneous dispergiration*. This method can be used for reception of solutions of high-molecular substances from firm polymers dispergirationm them in corresponding solvents.

The method spontaneous dispergirationfirm substance in the liquid environment leads to formation dysphasic steady colloidal systems. Self-dispergiration it is made without external mechanical influences on this process.

**Condensational methods**. At the heart of the majority condensational reception methods colloidal solutions various chemical reactions lay: oxidations, restoration, reaction of exchange decomposition, hydrolysis, etc.

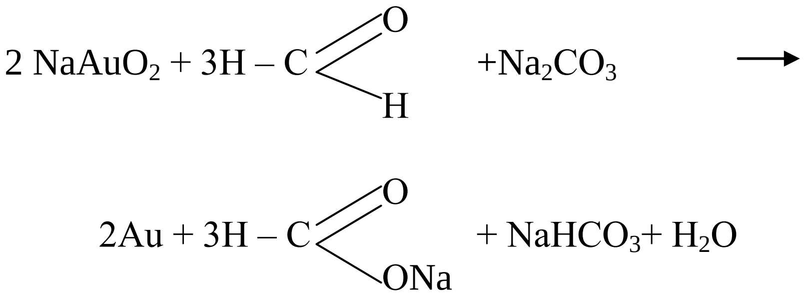
*Oxidation method*. As a result of oxidation reaction can be received colloidal solutions, for example:

$$2H_2S + SO_2 \longrightarrow 3S + 2H_2O$$

Formed atoms of neutral sulphur then spontaneously are condensed in colloidal sulphur particles.

*Restoration method*. Restoration is a reaction of joining of electrons by ions which, turning then in atoms is condensed in colloidal particles. As reducers the substances possessing weak restoring properties (formalin, gaseous hydrogen, etc.) are usually used.

$$Ag_2O + H_2 \longrightarrow 2Ag + H_2O$$



*Method of exchange decomposition*. This method is based on reaction, as a result which the new almost insoluble substance is formed, capable will remain in high dispersion condition in the presence of a number of corresponding favorable conditions. Testing reception reaction of zole silver chloride is

$$AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$$

Or zole barium sulphate

$$BaCl_2 + K_2SO_4 \longrightarrow BaSO_4 + 2KCl$$

*Hydrolysis method*. This method is used at reception zolesfrom salts when as a result of hydrolysis reaction badly soluble substances are formed, for example:

$$FeCl_3 + 3H_2O \longrightarrow Fe(OH)_3 + HCl$$
$$Fe(OH)_3 + HCl \longrightarrow FeOCl + 2H_2O$$

Partially forming in reaction chloroxyd gland dissociates on ions

$$FeOCl \rightleftarrows FeO^+ + Cl^-$$

Which provide ionogenly a layer round particles Fe (OH) $_3$ and keep them in a suspension?

*Method of replacement of solvent*. The method is based on allocation of the dissolved substance from a solution in a kind high-dispersion an insoluble phase by solvent replacement. Molecules of the dissolved substance which are in a condition of molecular dispersion in one solvent, getting to conditions of bad solubility at solvent replacement, start to be condensed in larger colloidal particles.

*Electric method*. This method is offered by Bredig (1898)

It is possible to use for preparation hydrozoles precious metals. This method is based on reception of an electric arch between the electrodes consisting from dispergiruely of precious metal (silver, platinum, gold). Under the influence of a heat there is an evaporation of a material of electrodes in the dispersive water environment. Then metal steams are condensed in colloidal particles, forming corresponding zoles. Process occurs at cooling.

## Clearing methods colloidal solutions.

At reception high-firmcolloidly solutions it is necessary to get rid of various impurities, surplus of electrolytes etc.

Removal of impurity colloidal solutions spends following methods:

*Dialysis* - clearing process zolesfrom impurity of electrolytes containing in them. It is carried out very simply in devices dialisators, animal seminontight membrane animal, vegetative or artificial origins. Molecules or ions pass in solvent, balance between their concentration on either side of a membrane will not be established yet, updating all time solvent achieve full clearing zolefrom electrolytes and un electrolytes. The usual dialysis lasts very long and a lot of time demands. With a view of dialysis acceleration apply an electro dialysis.

*Electro dialysis.* At reception a constant electric current through dial sly a liquid ions move to corresponding electrodes and are carried away by water that promotes clarification colloidal solution.

*Ultra filtration* - a method of branch of a disperse phase from the disperse environment filtering colloidal solutions through the special filters which are not passing colloidal particles. At an ultra filtration the disperse phase remains on the filter. At an ultra filtration use special filters (for example, polyetilenor the filtering paper impregnated colloid as colloidal particles easily pass through a time usual filltrly papers. For acceleration of process of an ultra filtration him spend under pressure for what from the vessel (receiver) located under the filter pump out air.

*Compensatory dialysis and vividialysis.* The essence of a compensatory dialysis consists that the liquid in dialysator is washed not by pure solvent, and solutions of defining substance with various concentration. This method is applied to research of biological liquids more often. He allows defining concentration of those or other low-molecular substances which are in colloidal solutions. Approximately lifetime clearing of blood by a method is based on the same principle vividialysis.

## Structure the micelle of colloidal particles

The structure colloidlyconnections is convenient for considering on a structure example colloidal particles AgI. Formation reaction colloidal particles AgI proceeds under the following scheme:

$$AgNO_3 + KI = AgI + KNO_3$$

Ions $Ag^+$ and $I^-$ in almost insoluble connection AgI form a crystal lattice. New forming particles AgI have in the beginning an amorphous structure, then gradually crystallize. If initial substances ($AgNO_3$ and KI) are taken in reaction in equivalent quantity particles - crystals grow, reaching the considerable size surpassing the sizes colloidal of a particle and quickly drop out in a deposition. In a case when one of initial reagents is taken much, the size of formed particles AgI will correspond to the sizes colloidal particles as the reagent taken in superfluous quantity will serve as the stabilizer informing stability colloidal to particle AgI. At surplus KI in a solution concentration of ions$K^+$ and $I^-$ will increase. According to rule Panet - Faience, construction of a crystal lattice can go only at the expense of the ions which are a part of this crystal lattice. Therefore, ions $I^-$will continue to complete a crystal lattice of a kernel, informing it a charge defining so-called electro thermodynamic potential or E-potential. These ions also name potention-definingions. The size of electro thermodynamic potential for the majority colloidal particles is equal 1 century of the Particle with such rather high charge draw opposite charged ions which have remained in a solution $K^+$ (anti-ions). Adsorption processanti-ionswill begin. Thus between the adsorbed ions and free ions dynamic balance will be established. The basic part anti-ions, adsorbed on a kernel colloidal particle, together with potention-definingions forms adsorbcionly layer. A kernel and adsorbcionlylayer form a granule. The granule has electric potential of the same sign, as E-potential, but its size less and depends on quantity anti-ions in adsorbcionly layer. So, if 90 their % are adsorbed, the granule potential will make 10 % from E-potential. The granule potential is called as electro kinetic or delta-potential (ζ-potential). Kinetic it name because it can be found out and measured at movement of particles in electric forces of an attraction near to a granule, forming diffusion layer. The granule together with a diffusion layer forms micelle.

The thickness a diffusion layer is various, so depends on ionic force of a solution: the ionic force above, the a thickness of a layer is less. Concentration anti-ions in diffusion layer decreases in a direction to periphery; according to it the particle potential decreases also, falling on border diffusionlyis layer to zero.

Thus, micelle always electro neutrally. If to move in adsorbcionlya layer a considerable quantity anti-ions, for example 95 % ζ - the potential measured on a surface of a granule, will decrease to 5 % from value E-potential. The E-potential size, depend from quantity potential-defining of ions, will not vary.

The structure micelle AgI much KI is possible express the plan

$$\left\{ \underbrace{[AgI]_m}_{nucleus} \cdot \underbrace{nI^- \cdot (n-x)K^+}_{adsorbcionly\ stratum} \right\}^{-} \cdot \underbrace{xK^+}_{diffusionly\ stratum}$$

← Granule →

← Micelle →

Stability colloidal solutions are caused by stabilizer presence, i.e. electrolytes, and depend on size of a charge of a granule (ζ - potential). The above this potential, the there are forces of mutual pushing away of the particles, interfering their association at the collisions observed as a result of Brown movement more strongly. Colloidlymicell AgI much $AgNO_3$ it is possible to present a structure as follows:

$$\left\{ \underbrace{[AgI]_m}_{nucleus} \cdot \underbrace{nAg^+ \cdot (n-x)NO_3^-}_{adsorbcinly\ stratum} \right\}^{+} \cdot \underbrace{xNO_3^-}_{diffusionly\ stratum}$$

← Granule →

← Micelle →

Potention-definingions are I - and anti-ions - K +. If all anti-ionsK +from diffusion a layer will move in adsorbcionly, then ζ - the potential will decrease to zero and the granule becomes electro neutral (or is electric):

$$[AgI]_m \cdot nI^- \cdot (n-x)K^+$$

**Training tasks and the standard of their decision**

***Task 1.*** How it turns out micelle$As_2S_2$?

***The standard of decision:***

This micelle receive reception current $H_2S$ through a solution arsenic acids:

$$2H_3AsO_3 + 3H_2S \rightarrow As_2S_3 \downarrow + 6H_2O$$

As the stabilizer serves $H_2S$

$$H_2S \rightarrow H^+ + HS^-$$

It is as a result formed micelle.
$[(As_2S_3)_m \cdot NHS^- \cdot (n\text{-}x) H^+]^{X-} \cdot xH^+$
As on reception conditions surplus $H_2S$ the granule of sulphurous arsenic is charged always negatively is used.

***Task 2.*** To a product of burning 37,5 coals containing 80 % of carbon are added alkalis before formation of average salt. To the received salt it is added 1 l $CaCl_2$ with molar concentration 0,5 mol/l. Whether it is formed at this reaction colloidal connection? To write a structure micelle received colloidal connections and to specify a granule charge.

***The standard of decision:***
Reaction proceeds under the following scheme:

$$C \xrightarrow{O_2} CO_2 \xrightarrow{2NaOH} Na_2CO_3 \xrightarrow{CaCl_2} CaCO_3 + 2\,NaCl$$

1. The maintenance acarboin coal is defined:

3,75 - 100 %
x - 80% x = 3 g carbon

2. How many it makes mol's

$n = \frac{m}{M} = \frac{3}{12} = 0.25$ mol Carbon
From 0,25 mol of carbon 0,25 mol $Na_2CO_3$ is formed.
In one litre 0,5 molar solutions $CaCl_2$ contain

$$n = C \cdot V = 0.5 mol/l \cdot 1l = 0,5 \text{ mol } CaCl_2$$

0,25 mol $Na_2CO_3$interact about 0,5 mol $CaCl_2$. On the equation of reaction 1 mol $Na_2CO_3$ co-operates with 1mol $CaCl_2$

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$$

Hence, $CaCl_2$ it is taken much and consequently it is formed colloidly a solution. The structure micellzole is a lot of it $CaCl_2$ the following:

$$\{m(CaCO_3)\, nCa^{2+}\, (n-x)Cl^-\}^{x+}\, xCl^-$$

Charge of a granule the positive.

**Questions and tasks for self-checking.**

1. What is the dispersive phase and the dispersive environment?
2. Classification of disperse systems by the size of particles.
3. Write a structure micellcolloidly particle $BaSO_4$ formed a lot of $Na_2SO_4$.
4. What conditions of existence colloidal solutions?
5. What distinctive signs colloidal solutions?

**Situational tasks.**

***Task 1.*** Write formation reaction zolehydroxyd gland.

***Task 2.*** Show the structure micellcolloidlyparticles AgC1, formed is a lot of on reaction:

$$AgNO_3 + KCl \longrightarrow AgCl + KNO_3$$

Specify ions forming diffusion a layer

**Test questions.**

1. On what of clarification methods the device «Artificial kidney» is based:
a)Dialysis b) electro dialysis c)vive dialysis d)ultra filtration

2. Specify the sizes of particles colloidal systems:
1) $10^{-7}$ - $10^{-9}$ m 2) $10^{-4}$ - $10^{-7}$ m 3) $10^{-9}$m 4) 1-100 mmk 5) 1-50 mmk
a)1,2,3 b)2,3,4 c)1,4 d)2,4
3. Specify adiphilly molecule.
a) Toluene b) NaCl c) HOOC-COOH d) $CH_3$-CH($NH_2$)-COOH
4. The charge of an ion causing coagulation according to rule Gardi.
a) It is equal to a charge colloidal particle
b) It is more than charge colloidal particles
c) It is opposite to a charge colloidal particle
d) It is equal to a charge of the ion defining potential
5. What organ possesses the highest electro conduction?
a) Heart b) skin c) liver d) blood
6. The system consisting of a liquid disperse phase is called:
a) Suspension b) emulous c)aerosol d) liozoles
7. Find the answer where aerosols are resulted:
1) Water 2) a fog 3) turbidity 4) a dust 5) milk
a)1,2,3 b)2,3,4 c)2,4 d)3,4
8.Defineliozoles.
a)Water b)Water solution of NaCl c)sugar solution
d)solution of Fe $(NO_3)_3$
9.Micell consists from:
a)Granules b) diffusion and adsorbcionly layer c)granule and diffusion layer
d)nucleus and adsorbcionly layer

10. The granule consists from:
a)adsorbcionly layer b)diffusion and adsorbcionly layer c)nucleus and diffusion layer d)nucleus and adsorbcionly layer

## LABORATORY WORK

### Experience 1. Reception zolehydroxyd gland a hydrolysis method

Place in a test tube of solution *$FeCI_3$*of 1 ml of 2 %, add 10.0 ml distillation waters. A mix shake up and heat up to boiling. Explain the occurring phenomena. Write the formula micelle hydroxide gland. Take in other test tube of the received solution of 2,0 ml zole and add some drops 0,1 mol/ Explain the observable phenomena. A solution zole hydroxyd gland keeps for following experiences.

### Experience 2.Reception zoles of the Berlin azure.

2.1. To 2,0 ml of 0,1 % of solution $K_4$ *[Fe (CN)* $_6$] add 4 drops of solution $FeCl_3$ $_{\text{of 2 \%}}$. A mix shakes up. Pay attention to coloring of the received product. Write the formula micellformed zole to the Berlin azure.

2.2. To 2,0 ml of solution $FeCl_3$ add 5 drops of 0,1 % of solution $K_4$ *[Fe (CN$_6$)]*.A mix shake up. Pay attention to coloring of the received product. Write the formula micelle formed zole to the Berlin azure. In what difference of formulas received zoles? Specify charge signs colloidal particles. Solutions keep for following experience.

### Experience 3. Definition of a sign on a charge colloidal particles a method capillarisation.

Take 3 leaflets of a filtering paper. On the first leaflet put 1 drop zolehydroxyd gland, on the second - 1 drop zole to the Berlin azure (1), on the third - 1 drop zole to the Berlin azure (2). After soaking up the thaw will turn out certain stains. To draw true conclusions from the occurring phenomena, consider following positions: positively charged zoles give painted in the centre and colorless along the edges of a stain; negatively charged zoles give in regular intervals to edges the painted stains. This phenomenon speaks that paper negatively charged in relation to water adsorbs positive particles and does not adsorb the negative. On the basis of the given position define signs on a charge of particles investigated zoles and draw conclusions.

### Experience 4. Clearing zolesby dialysis

In acolloidly sack to pour hot zolesFe $(OH)_3$. Hang up sack on a glass stick and to ship in a glass with the hot distilled water. The raised temperature promotes process acceleration. Through 10-15 mines to define presence of ions $CI^-$with help of solution $AgNO_3$ and absence of coloring in water washing a sack. To note on coloring, whether have passed micelle Fe $(OH)_3$ through a membrane.

**Questions and tasks for self-preparation:**

1. What is a lyphoblyand liophyllycolloidly solution?
2. Name two ways of reception colloidal solutions.
3. Specify dispersive ways of reception colloidal solutions.
4. What condensation ways of reception colloidal solutions you know?
5. Of what components consists micelle?

## STABILITY OF COLLOIDLY SYSTEMS AND SOLUTIONS OF BIOPOLYMERS

**The employment purpose**. To familiarize with stability of disperse systems and solutions of biopolymers.

**The importance of a studied theme.** Animal and vegetative tissue contain high-molecular connections (fibers, a glycogen, starch, cellulose), solutions which possess many properties colloids. Colloidal-chemical processes underlie a food and development of animal and vegetative organisms. Many medical products are made in a kind colloids, for example, widespread drops in a nose - kollargol, protargol - represent silver in colloidal a condition, they are protected by a gelatin small amount.

The phenomenon colloidal protection has the big physiological value. So, fibers of blood protect fat droplets, cholesterol and a number of other waterproof substances. Decrease in degree of this protection leads to adjournment, for example, cholesterol and calcium in walls of vessels. Fall of protective properties of fibers can lead to loss of salts of uric acid, to formation of stones in kidneys, a liver, etc. Therefore colloid protection has the big physiological value.

**Initial level of knowledge**

1. Disperse systems
2. Colloidal solutions. Kinds colloidal solutions
3. The Structure colloid particles

**Teaching material for self-preparation**


1. V.N.Zaharchenko. Colloid chemistry. M.:High school, 1989.
2. M.I.Ravich-Scherbo, V.V.Novikov.Physical and colloid chemistry. M.:High school, 1975, part2, head3, $2-11.
3. E.D.Schukin, A.V.Pertsov, E.A.Amelina.A course of colloidly chemistry. Moscow State University M.: 1982.
4. J.G.Frolov. A course of colloidly chemistry. M.:Chemistry, 1982.
5. Zontag К, Shtrenge K.Koagulation and stability of disperse systems. L.:Chemistry, 1973.


**On employment following questions will be considered**

1. Principal views of stability of colloid-disperse systems

2. Coagulation. The coagulation mechanism. Slow and fast coagulation
3. A coagulation Threshold, its definition. Coagulation ability of electrolytes
4. Rule of Shulce and Gardi
5. Peptisation, kinds and mechanisms
6. Stability of solutions of biopolymers
7. Laboratory work

## THE INFORMATION BLOCK

## STABILITY OF DISPERSE SYSTEMS

For disperse systems thermodynamic non-uniformity because of the presence of surplus of the free superficial energy connected with strongly developed interface of phases and great value of an interphase tension on an interface of phases is characteristic. It leads to basic instability liophobs disperse systems, including liophobszoles and emu tasks, and to spontaneous course in them of the processes conducting to reduction of free superficial energy, and division of systems into macrophages, i.e. to their destruction. Nevertheless, disperse systems exist, they possess certain stability.

Speed of course of processes of destruction of disperse systems and their stability depend on structure of a phase of environment, from degree of dispersion and concentration of a disperse phase.

Condition sedimentation stability is the small size of particles of a phase - such that gravity did not exceed increase of entropy of system because of brounly movement of particles. Thus, a major factor sedimentation stability - entropily.

Entropy the factor promotes to some extent and aggregate stability of systems since thermal movement does termo dynamic unprofitable integration of particles. In liophobs disperse systems major factors of aggregate stability are electrostatic (presence of a double electric current) and adsorbtion-solvatly barriers on border of section of phases.

Infringement of aggregate stability of disperse system i.e. aggregation of particles of a phase at them cohere, name coagulation. This process is characteristic for liophobszoles. While aggregation processes do not lead to loss sedimentation to stability (particles become larger, but in the sizes there is no abroad a colloid-disperse condition), outwardly coagulation is shown in color change zole.

Coagulation product zole at this stage is actually zoles, but with larger particles.

In process of integration of particles the system starts to lose and sedimentation stability - appears turbidity, and then the deposition drops out. Coagulation is not always accompanied sedimentation by system stratification: aggregation can lead to formation of a continuous spatial grid of the particles filling all volume of system, i.e. to formation of disperse-connecting system-gel.

Infringement of aggregate stability emulsum is merge of particles of a phase-koalestantion.

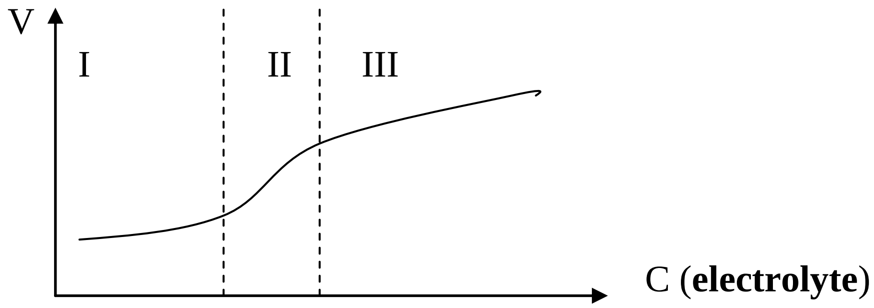
Coagulation can be caused concentration change zole (both diluted, and concentration), temperature change, mechanical influence, an irradiation, a long dialysis or particles etc. the greatest interest is represented by coagulation under the influence of electrolytes.

**Coagulation the liophobszoles electrolytes**

Coagulation action of electrolyte depends on size of a charge of the ions which sign on a charge is opposite to a charge sign colloidal particles, i.e. coincides with a charge sign anti-ions. With charge increase coagulation an ion coagulation electrolyte action sharply increases.

Coagulation zoles in the presence of electrolyte is shown only after achievement of some critical concentration of an ion in the ashes $_{\text{dispute}}$ named a threshold of coagulation. The size, return to a coagulation threshold, is called coagulation as ability. The relation of sizes coagulation abilities one - and tricharger ions makes two-1:60:700, i.e. is approximately proportional to the sixth degree of a charge coagulation an ion (a rule Schultz-Gardi).

On rice the kinetic curve of coagulation liophobszoles is presented by electrolyte.




**Dependence of speed of coagulation on concentration the added electrolyte**

The piece I corresponds to the latent coagulation proceeding without external displays; a piece II - the slow coagulation which speed depends on concentration of the added electrolyte, a piece III - the fast coagulation which speed does not depend on concentration of electrolyte.

According to the modern theory electrolitly coagulations addition of electrolyte causes infringement of balance of the forces stabilizing and destabilizing system. Destabilize colloid-disperse system of force of intermolecular interaction, stabilize - forces of electrostatic pushing away and anti-connection pressure. Electrolyte addition in system leads to compression diffusion a layer micelle and to zeta-potential reduction. The scope of forces of electrostatic pushing away is narrowed, simultaneously with it decreases and anti-connection pressure. It allows particles of a disperse phase to approach more close to each other as a result of Brown movement thanks to what possibility of aggregation of particles sharply amplifies.

Stability falling zole is expressed especially, than the double electric layer, i.e. than above concentration of electrolyte and than above a charge coagulation an ion is more strongly compressed.

At coagulation zoles by mixes of electrolyte the additivity phenomena (for example, KCl+NaCl), antagonism ($CaCl_2$+NaCl), synergism ($CaCl_2$+LiCl) can be observed.

It is noticed, that the size of a threshold of coagulation is influenced by a way of addition of electrolyte to zole. If the electrolyte is added gradually, small portions the size of a threshold of coagulation, as a rule, increases: zoles as though "gets used" to action of the external destabilizing factor. This phenomenon has received the accustoming name zoles («colloidal immunity»).

Infringement of stability of colloid-disperse systems of an organism can occur at receipt of some substances. So, for example, formed at hydrolysis of salts of bismuth (III) connection is in blood in a colloid-disperse condition. Displacement of available balance between a disperse phase and the disperse environment can lead to development of a colloidly-plasticly shock.

## Peptisation

Process desegregation particles, return to coagulation process, is called <u>peptisation</u>.

In system the balance establishment between processes of aggregation and desegregiration phase particles is possible. To this condition there corresponds certain concentration of particles in free dispersion system, equilibrium in relation deposition.

Peptisation it is especially probable, than less time has passed from the moment of coagulation since eventually in coagulate accretion of particles of a phase and in this case coagulation begins accepts irreversible character. Peptisation is possible to cause washing up coagulate from the electrolyte which have caused coagulation, water (concentration of electrolyte becomes less $C_{threshold}$) or addition of the electrolyte containing potential defining ions. The mechanism of potentisationis consists in increase in forces of pushing away of particles at the expense of expansion diffusion a layer and zeta-potential increase, as leads desegregation.

For example, at peptisation a depositionhydroxyd gland (III) solution of chloride of iron (III) occurs adsorption of ions $Fe^{3+}$ on deposition particles (by a rule of selective adsorption of Panetta-faience); micelle received zolewill have a following structure:

$$\{m\ Fe(OH)_3 \cdot n\ Fe^{3+}\ 3(n-x)\ Cl^-\}^{3x+} \cdot 3x\ CL^-$$

In this case the mechanism of adsorbtionly peptisation is realized.

The mechanism of chemical peptisation consists that at electrolyte addition there is its interaction to a deposition part, is as a result formed peptisator which ions are adsorbed on deposition particles, giving to them a charge. An example chemical peptisation is peptisation a deposition of hydras oxide gland (III) hydrochloric acid. There is chemical reaction HCl to a deposition part:

$$Fe(OH)_3 + H^+ \rightleftarrows Fe(OH)^+_2 + H_2O$$

$$Fe(OH)^+_2 \rightleftarrows FeO^+ + H_2O$$

And then adsorption of ions peptisator on deposition particles.

The possible formula micelle received zole:

$\{mFe(OH)_3 \cdot nFeO^+\ (n-x)\ Cl^-\}^{x+} \cdot XCL^-$

Peptisation it is possible to spend also solutions of FAS. Molecules of FAS, being adsorbed on deposition particles, raise affinities of a disperse phase to the dispersive environment according to an alignment rule polar of Rebinder, i.e. raise somewhat liophyllyliophoblyzole.

To accelerate process peptisation it is possible rise in temperature and hashing.

## Training tasks and the standard of their decision

**Task 1.**«Definition of a threshold of coagulation by known quantity of the electrolyte necessary for addition to colloidal for a solution». Coagulation $10 sm^3$hydrozolehydroxyd gland (III) has come at addition to it of 2 $sm^3$ of a solution of sulphate of sodium with C (1/2 $Na_2SO_4$) =0,0025 $mol.dm^{-3}$. Calculate a threshold of coagulation and coagulation ability of electrolyte.

**The standard of decision**

For calculate the threshold of coagulation $C_{threshold}$ use the equation:

$$C_{threshold} = c(X) \cdot V(el)/V(zoles) + V(el),$$

Where **c(x)** - concentration of ions coagulator in a mol/l.

c ($SO_4^{2-}$) == 1/2c (1/2 $Na_2SO_4$) =$2,4 \cdot 10^{-3}$ a mol/l:2=$1,25 \cdot 10^{-3}$ a mol/l.

$C_{threshold} = 1,25 \cdot 10^{-3}$ A mol/l·0,002l/0,010l+0,002l. = $2,08 \cdot 10^{-4}$ mol/l.

Size of a threshold of coagulation often express in a mol/l, $c_{por}$=0,208 mmol/l. Coagulation ability is equal 1/0,208 mmol/l=4,8 l/mmol.

**Task 2.**«Scoping of the electrolyte necessary for coagulation zole, on known value of a threshold of coagulation».

Coagulation threshold zole silver aluminum ions is0,186 mmol/l. What volume 28 %-s' solutions of sulphate of aluminum (square of 1,33 g/ml) is required for coagulation 2lzole?

**The standard of decision**

Let's calculate molar concentration 28 %-s' (ω =0,28) a solution of sulphate of aluminum under the formula:

c=1000 · ω · ρ/M (X) =1000ml/l·0,28·1,33g/ml/342,15 g/mol=1,09 a mol/l

As c ($Al^{3+}$) = 2c ($A1_2 (SO_4)_3$),

Concentration of an ion coagulator will be equal 2·1,09 MOL/l=2,18 a mmol/l mol/l=2180.

The equation for calculation of a threshold of coagulation we will transform as follows: $C_{threshold}$ [V (zoles) +V (el)] =c (x) ·V (el), whence

V (el) =$C_{threshold}$ ·V (zoles)/with (x)-$C_{threshold}$;

V (el) =0,186 mmol/l·2l/2180 mmol/l - 0,186 mmol/l = 1,7 · $10^{-4}$ = 0,17 ml

The answer: for coagulation 0,17 ml of a solution of sulphate of aluminum are required.

**Task 3.** «Charge definition of colloidal particles on comparison of sizes of a threshold of coagulation by different electrolytes».

**Task №1 (straight line).**

Thresholds of coagulation for some hydrozole are equal $C_{threshold}$ ($CaC1_2$) = 0,3mol/$dm^3$, $C_{threshold}$ ($Na_2SO_4$) = 0,029mol/$dm^3$. What charge on a sign is born by particles zole?

Possible variant of the decision.

Coagulation ability of sulphate of sodium in relation to zole above, than coagulation ability of chloride of calcium. By a rule Schultz coagulation ability of electrolyte that more than is more charge coagulation than an ion. At $Na_2SO_4$ a charge anions more than at $CaC1_2$. Means, coagulation ions are anions. Hence, according to rule Gardi, particles zole are charged positively.

**Task №2 (return).**

Zolesofiodid silver, received on reaction: KI+$AgNO_3$ = AgI+$KNO_3$ at some surplus К1, coagulation solutions of sulphate of sodium and calcium acetate. At what electrolyte coagulation ability is more?

*The answer:* As the stabilizer zole is К1 micelle has a structure:

$\{m (AgI)\ NI^{-} (n-x)\ K^{+}\}^{X-} \cdot xK^{+}$;

The granule is charged negatively. Hence, coagulation ions are cations electrolytes. So, the charge of ion $Ca^{2+}$ is more than charge of ion $Na^{+}$, coagulation ability of acetate of calcium more than sodium sulphate.

**Task №3.**

What zoles: hydroxide gland (111), iodid silver (at surplus $AgNO_3$), iodid silver (at surplus K1), it is necessary to note, that there was a mutual coagulation?

*The answer:* Mutual coagulation zoles is possible at mixing zoles with opposite signs on a charge of granules.

Granules zolehydroxydgland (111) are charged positively (see lab.work.). Granules zoleiodid silver (at surplus $AgNO_3$) (potential defining ions $I^-$) - it is negative. Hence, mutual coagulation is possible at draining zoles:

Hydroxyl gland (111) and iodid silver (at surplus K1) and

iodid silver (at surplus $AgNO_3$) and iodid silver (at surplus K1).

**Questions and tasks for self-checking of mastering of a theme:**

1. On what factors depends coagulation ability of electrolyte?
2. Formulate rule of Gardi and Schultz.
3. What phenomenon name peptisation?
4. Than it is possible to cause peptisation a deposition?
5. What properties the deposition that it it was possible to peptisate should possess?
6. What phenomenon is called as coagulation?
7. In what coagulation signs are expressed?
8. What Influence of factors it is possible to cause coagulation liophobszoles?
9. That name a coagulation threshold? In what units its size is expressed?
10. What is coagulation ability of electrolyte?

**Situational tasks:**

1. At displacing what colloidly solutions coagulation will be observed?

A. $[m(As_2S_3)nHS^-(n-x)H^+xH^+$

$[m(BaSO_4)nSO_4^{2-}2(n-x)H^+]^{-2x}2xH^+$

B. $[m(As_2S_3)nHS^-(n-x)H^+xH^+$

$[m(As_2S_3)nAsO_3^{-3}3(n-x)Na^+]^{-3x}3xNa^+$

C. $[m(As_2S_3)nHS^-(n-x)H^+xH^+$

$[m(AgCl_4)nAg^+(n-x)NO_3^-]^{+x}xNO_3^-$

**Test questions**

1. Define the formula of definition of a threshold of coagulation

A) $C_{threshold} = 100 \cdot C \cdot V$

B) $C_{threshold} = 1000 \cdot C \cdot V$

C) $C_{threshold} = 10 \cdot C \cdot V$

D) $C_{threshold} = 50 \cdot C \cdot V$

E) $C_{threshold} = 25 \cdot C \cdot V$

2. Coagulation is
a) Preparation process of colloidal solutions
b) Dissolution process of colloidal particles
c) Process of crushing of large particles
d) Association process of colloidal particles in large units
e) Dependence of properties colloidal systems from value of free superficial energy
3. Sedimentation is
a) Preparation process of colloidal solutions
b) Dissolution process of colloidal particles
c) Process of crushing of large particles
d) Association process of colloidal particles in large units
e) Settling out process of colloidal particles
4. Define coagulation kinds
a) Blacked out
b) Hidden, obvious
c) Blacked out, hidden, obvious
d) The visual
e) The stratified
5. Coagulation action of electrolytes depends from
a) From size of a charge of an ion which has an identical charge with a charge colloidal particles
b) From size of a charge of an ion which is opposite to a charge colloidal particles
c) From action of radiant energy
d) From polarity of solvent
e) From temperature
6. The charge of an ion causing coagulation according to rule Gardi.
a) It is equal to a charge colloidal particle
b) It is more than charge colloidal particles
c) It is opposite to a charge colloidal particle
d) It is equal to a charge of the ion defining potential
7. In what cases it is necessary to accelerate process of coagulation of blood?
a) Bad coagulability of blood
b) Very good coagulability of blood
c) At high arterial pressure
d) At a heat organs

## LABORATORY WORK

**Experience 1. Definition of a threshold of coagulation zolehydroxide gland**

In three test tubes to pour on 10 ml zolehydroxide gland. In the first to pour on drops from a pipette before turbidity of a solution of chloride sodium of 2 M, in the second - 0,01 M a sulphate solution kalii. After addition of each 3-4 drops of a test tube to stir up and mark in each case quantity of milliliters of the electrolit necessary for weak turbidity of a solution and calculate a coagulation threshold under the formula:

$C_{threshold.} = 100 \cdot C \cdot V$, mmol/l

Where C - molar concentration, V - the least number of milliliters of the solution, necessary for coagulation zole. Obtained given to bring in the table. Compare coagulation action of ions and check up performance corrected Schultz - Gardi.

| The electrolyte name | Concentration of electrolyte, mol/l | Volume of electrolyte for coagulation, ml | $C_{threshold}$ |
|---|---|---|---|
| NaCl<br>$K_2SO_4$<br>$K_3[Fe(CN)_6]$ | 2<br>0,1<br>0,001 | | |

**Experience 2.Protective action of gelatin.**

In 2 test tubes pour on 5 ml zole the Berlin azure, then in the first - 1ml the distilled water, and in the second - 1mlfresh made 0,5 %-s' solutions of gelatin and mix. In both test tubes pour on 1 ml of a solution of nitrate of aluminum of 0,02 M, shake up and after a while on absence sedimentation in the second test tube are convinced of protective action of gelatin.

**Experience 3.Stability of solutions hydrophilic BMB to electrolytes.**

In one test tube to pour 5 ml zoles the Berlin azure, in another - 5 ml of 0,5 %-s' solutions of gelatin. From addition of several drops of the sated solution of sulphate of ammonium zoles the Berlin azure koagulate whereas the gelatin solution does not change.

**Experience 4.Infringement of stability of a solution of polymer.**

To take 5 test tubes, to number them and in everyone to pour on 5 ml of a solution of polymer and sediment as it is specified in the table.

| № test tubes | V solution of polymer, ml | V sediment, ml | Supervision and conclusions |
|---|---|---|---|
| 1<br>2<br>3<br>4 | 5<br>5<br>5<br>5 | 0,5<br>1,0<br>1,5<br>2,0 | |

| | | | |
|---|---|---|---|
| 5 | 5 | 2,5 | |

After vigorous stirring put test tubes in a support and through 5 mines note degree of infringement of stability of polymer. Fill the table.

**Tasks for the independent decision**

1. Coagulation of 1,5 l zole gold sulfide has come at addition of a solution of chloride of sodium of 570 ml with concentration 0,2 mol/l. Calculate a coagulation threshold zole sodium ions.
2. Coagulation of 650 ml zole gold sulfid has come at addition of a solution of sulphate of chrome of 1,18 ml with concentration 0,025 mol/l. Calculate a coagulation threshold zole sulphates-ions.
3. Coagulation of 4 l zolehydroxyd gland (111) has come at addition of 10 %-s' solutions of sulphate of magnesium of 0,91 ml (p=1,1 g/ml). Calculate a coagulation threshold zole sulphates-ion.
4. The coagulation Threshold zolehydroxyd aluminum dichromate-ions is equal 0,63 mmol/l. What volume of 10 %-s' solutions dichromatkalii (p=1,07 g/ml) is required for coagulation of 1,5 l zole?
5. To what electrode will move at electrophorus v-laktoglobulin in the buffer solution containing equal concentration hydro phosphate and dihydrophosphat -ions if at pH=5,2fiber remains on start?

## THE SUPERFICIAL PHENOMENA.ADSORBTION.

## QUALITATIVE EXPERIENCES ON

## ADSORBTIONS. THE CHROMATOGRAPHY.

**The employment purpose:** to acquaint students with the superficial phenomena, in particular a superficial tension, the phenomenon of adsorbtion and chromatographically.

**The importance of a studied theme:** All biological processes proceed through internal and external surfaces of cells, tissue, blood vessels and organs of live organisms, therefore studying of the superficial phenomena and the mechanism of their course is for physicians rather necessary.

**Initial level of knowledge**

1. Homogeneous and heterogeneous systems;
2. The active centers of firm substance.
3. Adsorption , ion its, their application.

**Teaching material for self-preparation**

1. P.M.Marshev the Practical work on physical and colloidly chemistry. M, 1967, p. 95-96, works 50,52.
2. M.I.Ravich-Scherbo, V.V.Novikov. Physical and colloid chemistry, M, 1975, p 153-161.

3. JU.G.Frolov colloidly chemistry, M, 1989, p. 25-50

**On employment following questions will be considered:**

1. Adsorption , absorption, desorption , elution .
2. Chemical and physical adsorption .
3. Adsorption on border of sections of phases a firm organ-gas, a firm organ-liquid.
4. Selective adsorption .The Panetta-faience rule.
5. Adsorption in medicine.
6. Laboratory work.

## THE INFORMATION BLOCK

In the heterogeneous systems consisting of two and more phases, the phenomena proceeding on an interface of phases have great value.

Absorption of gases or liquids firm substances or liquids proceeds on various mechanisms. These processes are called sorption . Absorbing substances are called as the sorbents, absorbed substances are called sorbets or sorbtivs. Depending on type sorption happens four kinds: adsorption , absorption, haemosorbtion and capillary condensation. Adsorption name the phenomenon of accumulation of one substance on a surface of another. Its accumulation in other substance name absorption. Adsorption represents reversible process. Process return adsorbtion s, caked desorbtion . At adsorption there can be a chemical interaction adsorbent and adsorptive, for example:

$$CO_2 + CaO \rightarrow CaCO_3.$$

Such adsorption is called haemosorbtion . Condensation of steams in capillaries of a firm sorbent is called as capillary condensation.

Studying of adsorption protecting on border of sections of phases is practically important:

1. The Firm organ-gas and a firm organ-liquid;
2. The Liquid-gas and a liquid-liquid.

Adsorption protecting on a surface of firm organs, is process spontaneous and speaks presence of surplus of free superficial energy for the account disbalance communications in a crystal lattice (the active centers), capable to interaction with atoms or molecules from environment. In molecule liquids in substance inside layers test an identical attraction in all directions from the next molecules; the molecules which are in a blanket, from air are not valid almost attractions and accordingly have disbalanceforces which are called as superficial energy.

Adsorption depends on temperature, surface size adsorbent, concentration adsorptive, the chemical and physical nature adsorbent and adsorptive etc.

The adsorption going on border of section of phases a firm organ-gas, firm a teldo-liquid qualitatively and quantitatively define:

1. On concentration change adsorptive;
2. On change of a superficial tension.

The substances raising a superficial tension of a solution are called superficially-inactively as substances, for them d $\delta$ / dc> 0. Substances with an asymmetrical structure the molecules consisting of polar and not polar groups, lower a superficial tension of solutions. Such substances are called as surface-active (FAS-facially active substance), for them d $\delta$/dc <0. For adsorption from water solutions the great value has presence at molecules of substance polar (hydrophilic) and not polar (waterproof) groups. The molecules possessing simultaneously both kinds of groups, are called diphylly .

In solutions superficial energy can go down or increase at the expense of change of concentration of particles in a liquid blanket. Gibbs has been established it, that distribution of substance dissolved in a liquid occurs so that the maximum reduction of a superficial tension was reached. He has offered the equation defining size of adsorption G:

$$G = - C/RT \cdot \Delta\delta / \Delta C = - C/RT \cdot (\delta_2 - \delta_1) / C_2 - C_1,$$

The equation shows size of surplus of the substance collecting on a blanket, in comparison with the maintenance of this substance in a liquid. Hence, adsorption G depends on sizes of superficial activity $\Delta\delta / \Delta C$ and concentration of substance.

The adsorption accompanied by accumulation of substance in a blanket, name positive. As its limit full saturation of a blanket by adsorbed substance serves. Thus the superficial tension decreases, i.e. $\Delta\delta$ <0,> 0. If the dissolved substance increases a superficial tension it will be pushed out from a blanket inside adsorbent. Such adsorption name negative. In this case $\Delta\delta$> 0 and G<0.

Adsorption process in solutions happens three kinds:

Additively adsorption -adsorption of components of a solution is estimated them sorbtionly by ability so at adsorption from the solutions containing a mix of many components, substances are adsorbed in the quantities proportional adsorbtionly to ability of each of them.

Antagonistically adsorption - one substances interfere with adsorption of other substances.

3. Sinergisticallyadsorbtion - substances mutually strengthen adsorption .

The sorbents, capable to exchange ions, are called ionites anddivide on 3 kinds:

Cationits - acid sorbents (for example: silicogel , cellulose, alumni -silicates) co-operate with adsorbent by cationly an exchange.

2. Anionits - the cores adsorbent (for example: Al $(OH)_3$, Fe $(OH)_3$) co-operate by anionly an exchange.

3. Amphoternly ionits - sorbents on structure approached to $H^+SO_3^-$ - R - $N^+(CH_3)_3OH^-$ (R-organic polymer) co-operate with sorbat and cationly (at the expense of$H^+$), and anionly (forOH -) an exchange.

Selective adsorption as selecting necessary adsorbent it is possible to take strictly certain substances from difficult mixes has great value.

One of examples of selective adsorption is ionic. According to the Paneta-faience rule, on firm adsorbent the ions which are a part adsorbent, or having the general with adsorbent group are mainly adsorbed.

Selective adsorption by the nature is chemical sorbtion and proceeds at the expense of interaction of valence forces, is accelerated by rise in temperature.

So on particles Fe $(OH)_3$, formed on reaction:

$Fe(NO_3)_3 + 3NaOH \rightarrow Fe(OH)_3\downarrow + 3NaNO_3$

Are adsorbed or ions $OH^-$, or ions $Fe^{3+}$. Selective adsorption depends on size of a charge of an ion, degree of hydration and from radius.

In a human organ the phenomena of selective adsorption of toxins and other substances are often observed by various tissue and cells. So, for example, toxins of activators of a tetanus, a botulism and others amaze first of all cells of the central nervous system, and toxins of activators of a dysentery - vegetative nervous system; at a typhus vessels of a skin, a brain and partly heart etc. are amazed mainly

The chromatography is a physical and chemical method of division of a mix of the substances, based on various distribution of components of a mix between two phases, one of which is motionless, with the big surface of contact, and another represents the mobile stream filtered through a motionless phase.

The chromatography happens following kinds:

1. Adsorbtionly chromatography. This kind of a chromatography is based on selective adsorption of substances by that or other adsorbent .
2. Ions-exchange chromatography. In its basis the exchange of ions between a solution and adsorbent lays.
3. A distributive chromatography. At this method distinctions in distribution of substances between not mixing up liquids are used. These distinctions are defined by law Nernst: at constant temperature the parity of concentration of the substance distributed between two not mixing up liquids (phases), is constant size:

$$C_1 / C_2 = K.$$

The distributive chromatography shares on following kinds:

1.Extractionly method of a distributive chromatography.
2.Paper chromatography
3.Gelfiltrationly or a method molecular strainer
4.Thin-layer chromatography
5.Gas chromatography.

The Chromatography method of research is used for an establishment amino acidly structure of hydrolysis and primary structure of fibers; in studying amino acidly structure of plasma and other biological environments, at quantitative definition of vitamins, hormones and other biologically active connections.

**Training tasks and the standard of their decision**

***Tasks 1.*** What ions will be adsorbed on firm adsorbent $Ca_3(PO_4)_2$

***The standard of decision:***

By the Paneta-Faience rule on firm adsorbent those ions which are a part adsorbent or having the general with adsorbent group will be mainly adsorbed.

Hence on particles $Ca_3 (PO_4)_2$, formed at reaction $CaCl_2 + H_3PO_4$ions $Ca^{2+}$, -are adsorbed or ions $PO_4^{3-}$.

**Questions and tasks for self-checking of mastering of a theme**

1. What is the adsorption and association ?
2. What is called desorption and elusion?
3. Name the reasons of occurrence of the superficial phenomena.
4. What is the superficial energy and units of its change?

**Situational tasks.**

***Task 1.*** Rule of Djuklo-Traube and its mathematical expression.

***Task 2.*** On what adsorption are based actions of poisonous substances or the toxins which entered to the organism?

**Test questions.**

1.Specify equation Gibbs for adsorbtion :
A)$G=C/RT+\Delta\delta/\Delta C$ B)$G= -C/RT\Delta\delta/\Delta C$ C)$G=RT/C\Delta C/\Delta\delta$D)$G=C/RT\Delta\delta/\Delta$
2. What of the mentioned below phenomena concern process sorbtion?
A)Adsorbtion B)Haemosorbtion C)Capillary condensation
D)All answers are true
3. Specify sorbents:
1.C (ac) 2. CaO 3. $CO_2$ 4. $H_2O$
A)1,2 B)2,3 C)3,4 D)2,4
4. Specifydiphyllymolecules:
A)$CH_3$-COOH B)HOOC-COOH C)$CH_4$D)$H_2O$
5. Specify hydrophylly group in a molecule of oil acid:
$CH_3$-$CH_2$-$CH_2$-CO,OH
A) –$CH_3$ B)$CH_3$-$CH_2$- C)$CH_3$-$CH_2$-$CH_2$-
D) –COOH
6. What ions are adsorbed in particle AgCl?
A)$Na^+$ B)$Cu^{2+}$ C)$Cl^-$ D)$J^-$
7. The following reaction concerns what process:
$CaO + CO_2=CaCO_3$
A) Adsorbtion B) Absorption C) Haemosorbtion D) Desorbtion
8. What increase in concentration of ions leads to formation of stones
In kidneys and uric ways?
A)$Na^+$, $Ca^{2+}$,$PO_4^{3-}$ B)$K^+$,$Ca^{2+}$,$PO_4^{3-}$,C)$Mg^{2+}$,$Ca^{2+}$
D)$Mg^{2+}$, $Ca^{2+}$, $PO_4^{3-}$, $C_2O_4^{2-}$
9. Essence adsorbtionly a chromatography:
A) Ionic exchange between a solution and adsorbent
B) Various distributions of substances of solvent
C) Selective adsorption of substances in adsorbent
D) Division of substances in a gaseous condition
10. Specify chromatography kinds:

A) Adsorbtionly B) Ions-exchange
B) Distributive C) All answers are true

## LABORATORY WORK.

## QUALITATIVE STUDYING OFADSORBTION

### Experience 1.Adsorbtion on firm adsorbent.

Place in each of five test tubes on 2,0 ml of strongly diluted solutions of fucsin. Copper sulphite, dichromatkalii, hydroxyd iron (III), the Berlin azure. In each test tube to bring on 0,2g the pounded activated coal. Carefully shake up contents within 5 minutes and filter. Explain the observable phenomena. Whether it is possible to establish on coloring of filtrates what solution of connection was in a test tube?

### Experience 2.Influence of solvent on adsorption

There are 2 solutions of fucsin (1 and 2), differing the solvent nature. In one test tube place 2,0 ml of a solution №1, in another - 2,0 ml of a solution №2. Bring in each test tube on 0,2g the activated coal, 5 mines shake up contents, then filter. Explain the observable phenomena. Establish water and spiritusfucsin solutions. Whether there are distinctions in their adsorption ?If the answer affirmative, explain for what reason.

### Experience 3.Haemosorbtion heavy metals

3.1. Bring in 2 test tubes on 2.0 ml of whey of blood, add on 2 drops of blood. In the first test tube add 1.0 ml of a solution №3, in the second 1,0 ml of a solution №4. Explain the observable phenomena. Establish which of the added solutions is a solution of salt $Na^{+}$, and which - a solution of salt $Pb^{2+}$. Ions of heavy metals, co-operating with uniform elements of blood by haemosorbtion, influence on physically - chemical properties of their membranes, since these ions completing with phospholipids bio membranes.
Place in a test tube of whey of blood of 2.0 ml, add 2 drops of blood, 1.0 ml 0,1 mol/l of a solution complexion - Ш and 1,0 ml of a solution of salt $Pb^{2+}$ (you have established the given solution in the previous experience). Explain the observable phenomena. Why in this case haemosorbtion it is not carried out? Whether it cancomplexon - III to be entered into a live organism as a reagent preventing haemosorbtion blood by heavy metals?

**Questions and tasks for the independent decision.**

1. Than physical adsorption differs from the chemical?
2. Name the factors influencing size of adsorption .
3. The qualitative method of definition of adsorption .

4. Name quantitative methods of an estimation of adsorption . What ions will be adsorbed on firm adsorbent $BaSO_4$?

## ADSORBTIONLY BALANCE ON A MOTIONLESS INTERFACE.

## ADSORBTION OF ACETIC ACID ON COAL.

**The employment purpose.** To acquaint students with adsorption process, to show an adsorption role in live organisms.

**The importance of a studied theme.** The phenomenon of adsorbtion underlies many major biological processes proceeding in an organism. So, for example in a human organ the phenomenon of selective adsorption of toxins and other substances is often observed by various tissue and cells.

Interaction of enzymes with the substrata, necessary for course fermentative reactions, also is adsorbtionly process. Therefore the knowledge of the phenomenon of adsorbtion is necessary for the doctor.

**Initial level of knowledge.**

1. Adsorbtion .Adsorbtion kinds.
2. Adsorbent, Adsorbtiv.

**Teaching material for self-preparation.**

1. V.C.Zaharchenko. Colloid chemistry.M: the Higher school, 1989, gl III, C.63.
2. M.I.Ravich-Scherbo, V.V. Novikov. Physical and colloid chemistry.M: the Higher school, 1975, a part II, gl.II.
3. E.D.Schukin, A.V.Pertsov. Colloid chemistry.M: the Moscow State University, 1982, gl. III.

**On employment following questions will be considered:**

1. The adsorption Theory on firm organs. Adsorbent, adsorptive, adsorbtionly balance.
2. The Factors defining size of adsorption on a motionless interface.
3. An adsorption Is other. The equation of an isotherm of adsorption Lengmura. Adsorbtionly balance in ability to live.
4. Laboratory work

## THE INFORMATION BLOCK.

Adsorption on a motionless interface submits, basically, to the same laws, as adsorption on mobile surfaces.

For the first time ability of firm organs to adsorb on the surface other substances has been experimentally shown K.Sheele (1773g).

The adsorption reason on a surface of firm organs is uncompensationforce fields of the molecules which are in zones of deformation of crystal structures. Such zones name the active centers. Distinguish physical and chemical adsorption (haemosorbtion). Physical adsorbtion is caused by forces of intermolecular interaction (forces Van-der-Vaalsa and in some cases at the expense of formation of hydrogen communications); it passes, as a rule, on the active centres which are in hollows of a microrelief of a surface.

The centers of chemical adsorbtion are basically on micro relief ledges; at haemosorbtion chemical bonds between the atoms which are a part of the active center, and atoms of adsorbed substance are established.

Distinctions between physical adsorbtion andhaemosorbtion consist in the following:

1. Warmth haemosorbtion (80-800 kdzh/MOL) much more warmth of physical adsorbtion (8-20 kdzh/MOL); on the values of warmth haemosorbtion are close to warmth of usual chemical reactions.
2. Haemosorbtion is specific process, while physical adsorbtion - process nonspecific.
3. With increase in temperature the size of physical adsorbtion decreases, and the size haemosorbtion - increases.

## Equation of Lengmur

Adsorption on firm adsorbentx is described I.Lengmjura's by equation

$$a = a_{max} * c / \alpha + c$$

$\alpha$ - a constant equal to the relation of constants of speeds desorption and adsorption s, dimensional concentration

$a_{max}$ - size of limiting adsorption . It is reached at employment of all centers adsorbent

Both constants are defined experimentally.

The given equation has been deduced for gas adsorption on firm adsorbent. During the initial moment of time of contact adsorptive and adsorbent speed of adsorption is maximum, and desorption is equal 0. In process of filling of the active centers with molecules adsorptive speeds of these processes are leveled up to achievement of dynamic balance.

Equation Lengmur is carried out only for adsorbcionly balance. At an equation conclusion following assumptions have been made:

- Energy of adsorption of all molecules adsorptive on the active centres is identical
- Molecules adsorptive do not move on a surface adsorbent and do not co-operate among themselves.

Equation Gibbs cannot be used for adsorption definition on a motionless interface because of impossibility of experimental definition in this case a superficial tension.

Size of adsorption from solutions on firm adsorbent experimentally define on change of concentration of a solution after adsorption end.

$$a = (C_o - C) * V / m$$

a - adsorption size, mol.g$^{-1}$ (quantities of the substance absorbed by a mass unit adsorbent)

$C_o$ – and C –accordingly initial and equilibrium concentration of a solution, mol.dm$^{-3}$

V – volume from which adsorption was spent. Dm$^{-3}$

m - weight adsorbent, g

## Adsorbtionly balance in ability to live

Adsorption underlies many major biological processes. Processes of absorption of various substances by cells and organism tissue, Interaction of enzymes begin with adsorbtion with the substrata, necessary for course phermentativly reactions, also is adsorbtionly process,

Adsorbtion is the basic physical and chemical mechanism of work of immune system. Process offormation of a complex begins with it an antigene-antiorgan, Modelling of natural mechanisms detoxication in various sorbtion devices with use of carbon sorbents, immunosorbents, ionochanging pitches, etc., is called haemosorbtion. It is used for removal from blood of various toxic substances, viruses, bacteria.

At contact of blood to a haemosorbent the competition for the active centres between the substances which are subject to removal and substances which presence provides vital functions is observed. Use of not specific sorbents does procedure haemosorbtion practically uncontrollable since thus leave and toxics, and the substances which are in plasma in norm. Progress in this method of treatment is connected now with creation high-specific sorbents on concrete metabolits, ions, toxins.

Other important task haemosorbtion is creation of the sorbents compatible to blood (haemojoint sorbents). Contact of haemosorbents, to blood makes approximately 4-5 hours; it is enough this time, that at use of haemoincompatible sorbents destruction erythrocytes, leukocytes, formation of blood clots has begun. Reception of sorbents compatible to blood is based often on updating alien for an organism of a surface by fibers and anticoagulants; fixation of modifiers is carried out so that the quantity of their active superficial groups as much as possible remained. In some cases for reception of haemocompatible sorbents the conclusion of granules of a sorbent in the capsules made of synthetic or natural biologically compatible materials is used: albumins, nitroacetylcellulose, etc.

At allergic conditions there is a necessity of removal from a blood channel of the antiorgans causing inadequate reaction of an organism on some substances. The activated coal with the fixed antigene is for this purpose used. The received sorbents with the fixed antigenes of a house dust, a grass of timopheevka - the most widespread allergens. Antisomalyimmunosorbents are used for selective extraction of microbic toxins.

## Types of the sorbents used for removal Various substances.

| Substance | The Sorbent |
|---|---|
| Phenol, heparin | Anionits with quartalammonily and phosphonily bases |
| Bilirubin | Active coals |
| Ions kalian | Cationits, alum silicates, circonysilicates |
| Ammonium ions | Phosphoroxyly cationits |
| Creatin | Alumosilicates, modified by salts of nickel, copper, zinc, cobalt |
| Cholesterol | Carbon sorbents, macroporous anionits, biospecific sorbents. |

The silicate matrix with entered into its structure amino - or carboxy groups, modified at pH 3,5 - 4,5 protein And, shows high sorbtionly activity at removal from plasma of blood IgG sick of AIDS.

To haemosorbtion the method lymphosorbtion is close.

In medicine therapy is widely applied to removal of toxins and undesirable substances from a gastroenteric path adsorbtionly . Such adsorbent as hydroxyd aluminium, oxyd magnesium, are a part of preparations «Almagel », «Phosphalugel », etc. the Activated coal is applied for a long time as a sorbent of gases (at meteorism ), toxins (at food poisonings), alcaloids and salts of heavy metals (at poisonings).

It is necessary to mean, that on any objects coming to contact with biological liquids of an organism, arise adsorbtionly salts of fibers or other FAS. Negative consequences such established balance are possible at use insufficiently biologically compatible materials of which artificial limbs are made, contact lenses, details of devices of artificial blood circulation etc.

## Training tasks and the standard of their decision

**Task 1.** It is experimentally established, that the maximum size of adsorbtion ofFAS (M=60u.e.) some adsorbentm makes $5{,}0\cdot10^{-3}$ mol $2^{-1}$; the size $\alpha$ is equal 0,06 mol$\cdot$dm$^{-3}$. How many gp. Substances it was adsorbed from a solution with equilibrium concentration 0,1mol $\cdot$dm$^{3}$ in two grammes of data adsorbent?

***The standard of decision***

On equation Lengmur count size of adsorbtion ofFAS:

$$a=a_{max}c / \alpha + c=5{,}0\cdot10^{-3}\text{mol}\cdot g^{-1}\cdot0{,}1\text{mol}\cdot dm^{-3}/0{,}06\text{mol}\cdot dm^{-3}+0{,}1\text{mol}\cdot dm^{-3}=3{,}1\cdot10^{-3}\text{mol}\cdot g^{-1}.$$

The quantity of the adsorbed substance on adsorbent in weight 2gwill be twice more: $3{,}1\cdot10^{-3}$mol $\cdot g^{-1}\cdot$2g. = $6{,}2\cdot10^{-3}$mol . The weight of the adsorbed substance will be equal:

m (FAS) =V (FAS) ·M (FAS) =$6.2\cdot10^{-3}$mol. 60 a mol-1=0,37g.

The answer:

The weight of the adsorbed substance is equal 0,37

**Task №2.** 60 $sm^3$ of a solution of acetic acid with concentration 0,1moldm$^{-3}$have shaken up with 2 g adsorbent. After achievement of balance test of a solution in volume 10sm3titrate a solution hydroxyl sodium c=0,05 moldm$^{-3}$. For titration 15,0 $sm^3$ titrantare spent. Calculate size of adsorption of acetic acid.

***The standard of decision***

Equilibrium concentration of acetic acid is equal (by results of titration):

c ($CH_3COOH$) =c (NaOH) ·V (NaOH)/V ($CH_3COOH$) =0,05mol.dm$^{-3}$ · 15,0 $sm^3$/10,0 $sm^3$ = 0,075 mol.dm$^{-3}$.

Size of adsorbtion and count on:

a=($c_o$-c) ·V/m = (0,1-0,075) mol.dm-3·0,05dm-3/2g=6,25·10-4mol.g$^{-1}$.

The answer:

a ($CH_3COOH$) =6,25·10$^{-4}$mol.g$^{-1}$.

**Questions and tasks for self-checking of mastering of a theme:**

1. How it is experimentally possible to define adsorption from solutions firm adsorbent ?
2. Result examples most often used in practice adsorbentoв
3. Write equation Lengmur and open sense of sizes entering into it
4. In what units the adsorption size on firm adsorbent is expressed?

## Situational tasks

1. The maximum size of adsorption ofFAS (M=60 c.u.) adsorbent makes 5,0·10$^{-4}$ mol. A it is equal 0,06 mol·dm$^{-3}$. Equilibrium concentration is equal 0,1 mol·dm$^{-3}$. Weight adsorbent 5 calculate weight (gp) the adsorbed substance.

## Test questions:

1. Find mathematical expression for equation Gibbs:

A) -dc/dτ=kc B) p=icRT

C) G=-c/Rт*Δτ/ΔC D) $\varphi=\varphi_0$+RT/nFlg$C_{oxi}/C_{res}$

E) G=c/Rт

2. Find mathematical expression for Friendlich's equation

A) x/m=kp B) x/m=kp$^{1/n}$

C) G=C/$R_T$ D) A=σ*S

E) G=X/S

3. Specify, what such adsorbent?

A) Substance which is absorbed

B) Absorbed substance

C) Substance which absorbs other substance

D) The substance which is installing electrical equipment

E)Substance, dissociation on ions

4. Specify, what such haemosorbtion?

A) It when one substance is absorbed by other substance

B) This accumulation of substance on a surface of other substance

C) It is process, return to adsorption process

D) Adsorbcionlyprocess which is accompanied by chemical bond formation between adsorptive and adsorbent

E) It dissociation substances

5. Define process hydrolytically adsorptions

A) Ions $H^+$ or $OH^-$exchange

B) Ions $Na^+$ $CI^-$exchange

C) Ions $Na^+$ or $K^+$exchange

D) CO or $CO_2$exchange

6. Define the process accompanied at positive adsorption

A) Increase in a superficial tension

B) Reduction of superficial energy

C) Reduction of a superficial tension

D) Increase in superficial energy

7) Define the process accompanied at negative adsorption

A) Increase in a superficial tension

B) Reduction of superficial energy

C) Reduction of a superficial tension

E) Increase in superficial energy

## LABORATORY WORK

### Isotherm of acetic acid on coal

a) In four pure and dry bottles with the ground in cover to bring on 0,5g the activated coal and by means of a pipette to pour on 15ml a solution of the acetic acid specified in the table normally (0,025; 0,05; 0,1; 0,2н). Bottles to close a stopper and to leave for 20-25 minutes from time to time stirring up. Then, solutions of acetic acid to filter through a filtering paper in separate four cone. Filtrates are used for definition of equilibrium concentration (C) a solution of acetic acids (point B).

b) To define initial concentration $C_o$a solution of acetic acid. For this purpose a pipette on 10ml to select solutions of acetic acid of the above-stated concentration, to transfer to four flasks, to add on 2-3 drops of the indicator phenolphthalein andto titr about, 1н solution NaOH before occurrence of bledon-pink color. The quantity of the alkali which have left on titration of a solution of acetic acid to write down in the table expressing concentration in volume 0,1н NaOH on 100ml a solution of acetic acid.

| № Bottles | Concentration of acetic acid, mol/l | Quantity ml 0,1m NaOH on 100ml a solution of acetic acid | | | Quantityad sorb. substances, x mmol | Specific adsorbtion, x/т mmol/g |
|---|---|---|---|---|---|---|
| | | $C_0$1 | C 1 | $C_0 - C$ 1 | | |
| 1 | 0,025 | | | | | |
| 2 | 0,05 | | | | | |
| 3 | 0,1 | | | | | |
| 4 | 0,2 | | | | | |

For example, if on titration 10ml 0,025M a solution of acetic acid it is spent 2,5ml; 0,05M - 5,3ml; 0,1M - 10,5ml and 0,2M - 20,6ml 0,1M solution NaOH then initial concentration of solutions of acetic acid $C_0$will be accordingly equal - 25ml, 53ml, 105ml and 206ml. The received figures to write down in the table.

c) To define equilibrium concentration (C) a solution of acetic acid, i.e. concentration of acetic acid after adsorption by coal (point A).For it to select a pipette 10ml a solution of acetic acid (from a filtrate after adsorption by the activated coal) to transfer in separate pure cone to add on 2-3 drops of the indicator phenolphthalein and to titr 0,1M solution NaOH before light pink coloring of a solution. The quantity of the alkali which have left on titration of a solution of acetic acid to write down in the table, expressing concentration in volumes 0,1M NaOH on 100 ml of a solution of acetic acid. The received figures to write down in the table.

d) For each concentration under the formula to define quantity of the adsorbed acetic acid

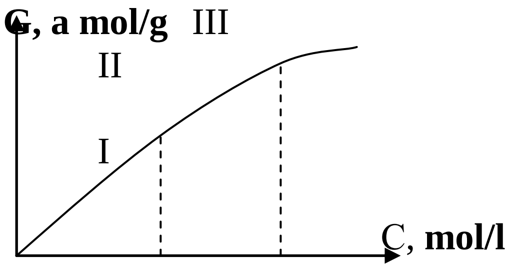
$$x = \frac{(C_0 -)\,V}{100}, \text{ mmol}$$

Where x - quantity of acetic acid adsorbed 1gadsorbent, g

$C_0$andC - initial and equilibrium concentration

V - volume of a solution of the acetic acid taken for adsorption , ml

On graph paper to construct an adsorption isotherm. For this purpose on an axis abscises to postpone values of initial concentration specified in the table, a mol/l, and on an axis of ordinates - values of specific adsorption x/m a mol. Received isotherm of adsorption should have the following appearance




**Questions and tasks for the independent decision**

1. Adsorbtion on an interface firm substance-solution
2. What is called as an adsorbtion isotherm?
3. Friendlich's equation, Lengmur and Gibbs
4. An adsorbtion role in live organisms
5. Superficially active and superficially inactive substances

## DEFINITION OF THERMAL EFFECT OF REACTION.

**The employment purpose:** to discuss with students thermodynamics and consequence laws following of them. To learn to define quantitatively thermal effect of chemical reactions.

**The importance of a studied theme**: live organisms are open system which exchange various substances and energy with environment. Studying of power of biochemical reactions is necessary for understanding of mechanisms of transformation of various substances in vital energy.

Definition warm forming abilities of foodstuff gives the chance to establish necessary diets under various conditions of their work and a life. Disease of the person is accompanied by change of thermodynamic sizes, first of all temperatures. Disease is always accompanied by increase in entropy of system. It is established, that value of entropy increase during the period embryogenesis , at processes of regeneration and growth of malignant new growths.

**Initial level of knowledge**

1. Exothermic and endothermic reactions
2. Thermal effect of reaction
3. The thermochemical equations of reactions

**Teaching material for self-preparation**

1. S.S.Olenin, G.N.Fadeev inorganic chemistry. M., 1979, p. 26.
2. A.V.Babkov, G.N.Gorshkova, A.M.Kononov. A practical work in the general chemistry with elements quantity the analysis. M., 1978, p. 51.

**On employment following questions will be considered:**

The basic concepts of thermodynamics
Thermal effect of reaction
The thermochemical equations of reactions
Gess`s law
Consequence from Gess's law
Calculations of thermal effects of chemical reactions
Bases of carrying out of work
The calorimeter scheme
Technique of carrying out of experience
Settlement formulas
Registration of experimental data
Revealing of results of experience
Power of chemical processes in biology and medicine
The decision of tasks on a theme

## THE INFORMATION BLOCK

All processes important in chemistry - chemical reactions, reactions dissociation, dissolution and crystallization - are accompanied by various energy effects. The latent energy of substance can be allocated in the form of mechanical, light, electric or thermal energy. Often there is also a return process of transition of various kinds of energy in the latent energy of substance. Mechanical, electric and light energy in turn easily passes in warmth, therefore for the power characteristic of chemical processes it is the most expedient to measure thermal effects of reactions. The size of thermal effect depends by nature occurring process, a condition of the received and initial substances and conditions of course of process.

The equation of reactions in which the thermal effect is underlined, are called as the thermochemical equation. In these equations it is necessary to specify a modular condition of initial substances and reaction products, applying a following symbol:

G - gaseous; l- liquid; c - crystal; f - firm; d - dissolved.

For comparison of power effects of reactions corresponding thermochemical calculations can be carried to 1 moll of substance and to standard conditions [pressure 101 325 Pa, temperature $25^0$C (298,15 K)

$H_2(g) + ½\ O_2(g) = H_2O(l) + Q$

Thermal effects of chemical reactions are calculated on the basis of Gess's law according to which the thermal effect of process depends only on an initial and final condition of initial substances and end-products and does not depend on a process way, i.e. from number and character of intermediate stages. Using Gess's law, it is possible to calculate thermal effect of any stage of process if thermal effects of other stages and process as a whole are known. It is partial expression of the law of conservation of energy. For calculates it is possible to use warmth as formations, and substance combustion, if its conditions same. So at burning of one asking glucose in one stage it is allocated 2881,2 kJ heat if glucose combustion in a human organ occurred in one stage, it would be lost from surplus of energy. Actually process occurs through a number of intermediate stages, on each of which the insignificant quantity of energy, but under Gesso's law total of the warmth allocated at all stages of oxidation of glucose is allocated, there will be same, i.e. 2881,2 kJ/MOL.

A number of consequences from which two have the greatest value follows from Gesso's law.

The thermal effect of reaction is equal to the sum of warmth of formation ($\Delta H_{form}$) products of reaction minus the sum of warmth of formation of initial substances.

The thermal effect of reaction is equal to the sum of warmth of combustion ($\Delta H_{cgop}$) initial substances minus the sum of warmth of combustion of products of reaction.

As warmth of formation of difficult substance is called the standard thermal effect $\Delta H^0_{form}$ - formations 1 its moll from simple substances under standard conditions (pressure - 101325 Pa, temperature - $25^0$C (298,15K).

As warmth of combustion of substance is called the standard thermal effect $\Delta H_{cgop}$ reactions of its combustion in oxygen.

Thermochemical methods are of great importance in medicine. The energy necessary for live organisms for full filament of work, maintenance of a constant organ temperature etc. turns out for the account exothermic reactions of oxidation proceeding in cells. The stock of oxidized substances (carbohydrates, fats) constantly renews at food intake. The diets necessary for the person at various working conditions and a life, are defined with the account warm forming abilities of foodstuff.

Definition of thermal effects of reactions spend in devices - calorimeters. Quantity of warmth define on the general thermal capacity of all parts of a calorimeter and change of temperature in the course of chemical reaction. Weight of reacting substances and water select so that temperature change was insignificant, and process could be considered as the isothermal. Having counted the quantity of warmth falling to 1 mol of reacting substance or products of reaction, define its thermal effect.

**Training tasks and the standard of their decision**

***Task №1.*** Process of dissolution of some waterless salts can be considered as proceeding in two stages: process of hydration of salt (going usually with heat allocation) and hydrate dissolution. To calculate warmth of hydration of waterless salt $MgCl_2$ if it is known, that

$\Delta H^0_{sol}$ ($MgCl_2$) = - 150,5 kJ/MOL, and $\Delta H^0_{sol}$ ($MgCl_2 \cdot 6H_2O$) = - 12,3 kJ/MOL.

**GIVEN:**

$\Delta H^0_{sol}$ ($MgCl_2$) = - 150,5 kJ/MOL

$\Delta H^0_{sol}$ ($MgCl_2 \cdot 6H_2O$) = - 12,3 kJ/MOL.

$\Delta H^0_{hydrotation}$ =?

***The standard of decision:***

1.We work out the equation of hydration $MgCl_2$:

$MgCl_2 + nH_2O \rightarrow [Mg\ (H_2O_6)\ ]^{2+} + 2CL^{-}$ (n 6) aq

$\Delta H^0_{sol}\ (MgCl_2) = -\ 150{,}5$ kJ/MOL

2.It is possible to present the given process thus:

$MgCl_2 + 6H_2O \rightarrow MgCl_2{\cdot}6H_2O\ \Delta H^0_{hydro} =?$

$Mg6H_2O + aq \rightarrow [Mg\ (H_2O_6)\ ]^{2+} + 2Cl\ aq\ \Delta H^0_{sol} = -\ 12{,}3$ kdzh/MOL

3.From Gesso's Law follows:

$\Delta H^0_{sol}\ (MgCl_2) = \Delta H^0_{hydro} + \Delta H^0_{sol}\ (MgCl_2{\cdot}6H_2O)$

Thus:

$\Delta H^0_{hydro} = -\ 150{,}5$ kJ/MOL - (-12,3 kJ/MOL) = - 138,2 kJ/MOL

The answer:

$\Delta H^0_{hydro} = -\ 138{,}2$ kJ/MOL

***Task №2.*** Warmth of formation peroxide hydrogen cannot be defined by practical consideration as at interaction of hydrogen with oxygen in usual conditions water is formed. However it is possible to measure warmth of decomposition $H_2O_2$ on $H_2O$ and $O_2$ and warmth of formation $H_2O$.

**GIVEN:**

$\Delta H^0_{destr}\ (H_2O_2)\ (l) = -\ 98{,}2$ kJ/MOL

$\Delta H^0_{form}\ (H_2O)\ (l) = -\ 286{,}0$ kJ/MOL

$\Delta H^0_{form}\ (H_2O_2)\ (l) =?$

***The standard of decision:***

We work out the equation of reaction of formation $H_2O_2$ (l):

$H_2\ (g) + O_2\ (g) = H_2O_2\ (l)$

We work out the equation of reaction of formation $H_2O$ (l):

$H_2\ (g) + 1/2O_2\ (g) = H_2O\ (l)\ \Delta H^0_{form} = -\ 286{,}0$ kJ/MOL

3. We work out the equation of reaction of decomposition $H_2O_2$ ():

$H_2O_2\ (l) = H_2O\ (l) + 1/2O_2\ (g)\ \Delta H^0_{destr} = -\ 98{,}2$ kJ/MOL

$H_2O\ (l) + 1/2O_2\ (g) = H_2O_2\ (l)\ \Delta H^0_{destr} = +\ 98{,}2$ kJ/MOL

4. Combining these equations, under Gesso's law it is found required size:

$H_2O\ (l) + 1/2O_2\ (g) = H_2O_2\ (l)\ \Delta H^0_{destr} = 98{,}2$ kJ/MOL

$H_2\ (g) + 1/2O_2\ (g) = H_2O\ (l)\ \Delta H^0_{form} = -\ 286{,}0$ kJ/MOL

$H_2\ (g) + O_2\ (g) = H_2O_2\ (l)\ \Delta H^0_{form} =?$

Thus:

$\Delta H^0_{destr}\ (H_2O_2)\ (l) = \Delta H^0_{form}\ (H_2O)\ () + \Delta H^0_{form}\ (H_2O_2)\ (l)$

$\Delta H^0_{form}\ (H_2O_2)\ (l) = \Delta H^0_{delut}\ (H_2O_2)\ () + \Delta H^0_{form}\ (H_2O)\ (l)$

$\Delta H^0_{form}\ (H_2O_2)\ (l) = -\ 98{,}2$ kJ/MOL + (-286 kJ/MOL) = - 187,8 kJ/MOL

$\Delta H^0_{form}\ (H_2O_2)\ (l) = -\ 187{,}8$ kJ/MOL.

**Questions and tasks for self-preparation**

1. What is the thermochemical equations of reaction?
2. How Gesso's law is formulated?

Whether 3. It is possible to spend arithmetic actions with thermochemical reactions?

**Situational tasks:**

***Task 1.*** Gesso's law in medical and biologic researches is how much important?

**Test questions.**

1. Enthalpy what formations of substance it is equal to zero?
a) $H_2O_2$ b)$H_2SO_4$ c)$O_2$ d) $CaSO_4$
2. Define change of energy Gibbs for the following reaction:
$NO + ½ O_2 = NO_2$
$\Delta G^0(NO_2)$= -57,3kJ/moll $\Delta G^0(NO)$= - 72,9kDj/moll
a) –57,3kJ/moll b) –72,9kJ/moll c) –35,6kJ/moll
d) 25,2kJ/moll
3. Specify an equilibrium condition of system:
a) $\Delta H>T\Delta S$ b) $\Delta H<T\Delta S$ c) $\Delta H=T\Delta S$ d) $\Delta G=\Delta H$
4.When Gesso's law has been opened:
a)1830g. b)1840g. c)1850g. d)1860g.
5.What parity characterizes an equilibrium condition of system?
a) $\Delta H>T\Delta S$ b) $\Delta H<T\Delta S$ c) $\Delta H=T\Delta S$ d) $\Delta G=\Delta H$
6.Process proceeds spontaneously in a case:
a)$0=\Delta G=\Delta H - T\Delta S$ b) $0<\Delta G=\Delta H - T\Delta S$
c)$0>\Delta G=\Delta H - T\Delta S$ d) only in the presence of enzymes
7.Define value of energy Gibbs for reaction:
$½ H_2S_{(g)} + ½ Cl_{2(g)} \rightarrow 2HCl_{(g)} + S_{(f)}$
$\Delta G_{HCl(g)}$ = -95,36kJ/moll $\Delta G_{H S (g)}$ = -33,83kJ/moll
a) –1571kJ b) –157,1kJ c) – 129,2kJ d) – 61,53kJ
7. Specify standard conditions:
a)P=1013,25kPa T=298,15$^0$K b)P=1atm. T=293$^0$K
c)P=1013,25kPa T=22$^0$C d)P=1013,25kPa T=295$^0$
8. Specify the thermochemical equation of reaction of formation Ammonia:
a)$3H_{2(g)} + N_{2(g)} = 2NH_{3(g)}$ + 91,608kJ
b)$3/2H_{2(g)} + ½ N_{2(g)} = NH_{3(g)}$ + 45,804kJ
c)$3/2H_{2(g)} + ½ N_{2(g)} = NH_{3(g)}$ + 91,608kJ
d)$3H_{2(g)} + N_{2(g)} = 2NH_{3(g)}$ - 91,608kJ
9. Specify mathematical expression of the first law of thermodynamics:
a)$Q=\Delta U-A$ b)$Q=\Delta U+A$ c)$Q=\Delta H-A$ d) $Q=\Delta U+H$
10. Entropy is measured in what units?
a)kJ b)kPa c)kJ/moll·K d)kPa/mol

## LABORATORY WORK.

***Experience 1.*** Definition of warmth of the neutralization allocated at interaction of the one-basic strong acid by alkali.

For work performance use a calorimeter. In a dry and pure internal glass of a calorimeter place by means of a pipette of solution NaOH of 25.00 ml of 1 M and write down thermometer indications ($t^0C$), in other glass measure 25,00 ml of solution HCl of 1 M and take its temperature. Then at a working mixer through a funnel pour in an alkali solution in a solution of acid and for removal of indications place in a calorimeter. Measure the heat after mixing of solutions ($t^0C$). Definition spend on two times and data write down in the table.

Density of solutions accept in equal 1g/sm$^3$ a specific thermal capacity of solutions accept equal to a water thermal capacity.

Quantity of allocated warmth calculate under the formula:

$Q = (m_{bas} + m_k) \cdot (t_2 - t_1) \cdot 4{,}184$ kJ

$m_{bas}$ - weight of the basis

$_{Mk}$ - weight of acid

$t_1$ - Reference temperature

$t_2$ - Final temperature

| Experience | Temperature, $t^0C$ | | q , kJ | Q , kJ/MOL |
|---|---|---|---|---|
| | | | | |
| 1 | | | | |
| 2 | | | | |
| Average | | | | |

The thermal effect of reaction of neutralization is calculated under the formula:

$$Q = qm / 1000M, \text{ a kJ/MOL}$$

q - quantity of warmth

Q - quantity of the warmth allocated at neutralization of one moll of acid, one moll of alkali

m - the weight of acid containing in 25,00 ml 1 M of solution HCl

M - molar weight HCl

***Experience 2.*** Definition of warmth of hydration $Na_2CO_3$.

In the weighed calorimetric glass pour 50,00 ml (50) waters and in 5 minutes measure and write down temperature ($t_1$). Then give 4 g crushed $Na_2CO_3$ and add in a glass with water at constant hashing by a mixer before full dissolution. Mark the maximum temperature of a solution ($t_2$). Experience is repeated by two times and write down results.

Warmth of hydration of salt pays off under the formula:

$Q_{(г)} = C\,(m\,(Na_2CO_3) \cdot m\,(H_2O))\Delta\,t\,M/\,m\,(Na_2CO_3) \cdot 1000$
$m\,(H_2O)$ - weight of water in a calorimeter, g

$m\,(Na_2CO_3)$ - weight $Na_2CO_3$, g

$M\,(Na_2CO_3)$ - relative molar weight $Na_2CO_3$

**Questions and tasks for the independent decision.**

1. It is known, that end-products of transformation of fibers in an organism are water, dioxide of carbon and urea. Whether in organism warmth of transformation of fiber differs from warmth of combustion of fiber?
2. Why crystalloid hydrates are dissolved with absorbtioning warmth, while corresponding waterless salts - with allocation?
3. Warmth of reaction of clearing to exhaust makes 66,94 kJ/MOL. How many warmth it will be allocated at clearing of 1 kg 85 %-s' to exhaust?

## DEFINITION OF THERMAL EFFECT OF REACTION.

**The employment purpose:** to discuss with students thermodynamics and consequence laws following of them. To learn to define quantitatively thermal effect of chemical reactions.

**The importance of a studied theme**: live organisms are open system which exchange various substances and energy with environment. Studying of power of biochemical reactions is necessary for understanding of mechanisms of transformation of various substances in vital energy.

Definition warm forming abilities of foodstuff gives the chance to establish necessary diets under various conditions of their work and a life. Disease of the person is accompanied by change of thermodynamic sizes, first of all temperatures. Disease is always accompanied by increase in entropy of system. It is established, that value of entropy increase during the period embryogenesis , at processes of regeneration and growth of malignant new growths.

**Initial level of knowledge**

1. Exothermic and endothermic reactions
2. Thermal effect of reaction
3. The thermochemical equations of reactions

**Teaching material for self-preparation**

1. S.S.Olenin, G.N.Fadeev inorganic chemistry. M., 1979, p. 26.
2. A.V.Babkov, G.N.Gorshkova, A.M.Kononov. A practical work in the general chemistry with elements quantity the analysis. M., 1978, p. 51.

**On employment following questions will be considered:**

The basic concepts of thermodynamics
Thermal effect of reaction
The thermochemical equations of reactions
Gess`s law
Consequence from Gess's law
Calculations of thermal effects of chemical reactions
Bases of carrying out of work
The calorimeter scheme
Technique of carrying out of experience
Settlement formulas
Registration of experimental data
Revealing of results of experience
Power of chemical processes in biology and medicine
The decision of tasks on a theme

## THE INFORMATION BLOCK

All processes important in chemistry - chemical reactions, reactions dissociation, dissolution and crystallization - are accompanied by various energy effects. The latent energy of substance can be allocated in the form of mechanical, light, electric or thermal energy. Often there is also a return process of transition of various kinds of energy in the latent energy of substance. Mechanical, electric and light energy in turn easily passes in warmth, therefore for the power characteristic of chemical processes it is the most expedient to measure thermal effects of reactions. The size of thermal effect depends by nature occurring process, a condition of the received and initial substances and conditions of course of process.

The equation of reactions in which the thermal effect is underlined, are called as the thermochemical equation. In these equations it is necessary to specify a modular condition of initial substances and reaction products, applying a following symbol:

G - gaseous; l- liquid; c - crystal; f - firm; d - dissolved.

For comparison of power effects of reactions corresponding thermochemical calculations can be carried to 1 moll of substance and to standard conditions [pressure 101 325 Pa, temperature $25^0$C (298,15 K)

$$H_2(g) + ½\ O_2(g) = H_2O(l) + Q$$

Thermal effects of chemical reactions are calculated on the basis of Gess's law according to which the thermal effect of process depends only on an initial and final condition of initial substances and end-products and does not depend on a process way, i.e. from number and character of intermediate stages. Using Gess's law, it is possible to calculate thermal effect of any stage of process if thermal effects of other stages and process as a whole are known. It is partial expression of the law of conservation of energy. For calculates it is possible to use warmth as formations, and substance combustion, if its conditions same. So at burning of one asking glucose in one stage it is allocated 2881,2 kJ heat if glucose combustion in a human organ occurred in one stage, it would be lost from surplus of energy. Actually process occurs through a number of intermediate stages, on each of which the insignificant quantity of energy, but under Gesso's law total of the warmth allocated at all stages of oxidation of glucose is allocated, there will be same, i.e. 2881,2 kJ/MOL.

A number of consequences from which two have the greatest value follows from Gesso's law.

The thermal effect of reaction is equal to the sum of warmth of formation ($\Delta H_{form}$) products of reaction minus the sum of warmth of formation of initial substances.

The thermal effect of reaction is equal to the sum of warmth of combustion ($\Delta H_{cgop}$) initial substances minus the sum of warmth of combustion of products of reaction.

As warmth of formation of difficult substance is called the standard thermal effect $\Delta H^0_{form}$ - formations 1 its moll from simple substances under standard conditions (pressure - 101325 Pa, temperature - $25^0$C (298,15K).

As warmth of combustion of substance is called the standard thermal effect $\Delta H_{cgop}$ reactions of its combustion in oxygen.

Thermochemical methods are of great importance in medicine. The energy necessary for live organisms for full filament of work, maintenance of a constant organ temperature etc. turns out for the account exothermic reactions of oxidation proceeding in cells. The stock of oxidized substances (carbohydrates, fats) constantly renews at food intake. The diets necessary for the person at various working conditions and a life, are defined with the account warm forming abilities of foodstuff.

Definition of thermal effects of reactions spend in devices - calorimeters. Quantity of warmth define on the general thermal capacity of all parts of a calorimeter and change of temperature in the course of chemical reaction. Weight of reacting substances and water select so that temperature change was insignificant, and process could be considered as the isothermal. Having counted the quantity of warmth falling to 1 mol of reacting substance or products of reaction, define its thermal effect.

**Training tasks and the standard of their decision**

***Task №1.*** Process of dissolution of some waterless salts can be considered as proceeding in two stages: process of hydration of salt (going usually with heat allocation) and hydrate dissolution. To calculate warmth of hydration of waterless salt $MgCl_2$ if it is known, that

$\Delta H^0_{sol}$ ($MgCl_2$) = - 150,5 kJ/ mol, and $\Delta H^0_{sol}$ ($MgCl_2 \cdot 6H_2O$) = - 12,3 kJ/ mol.

**GIVEN:**

$\Delta H^0_{sol}$ ($MgCl_2$) = - 150,5 kJ/ mol

$\Delta H^0_{sol}$ ($MgCl_2 \cdot 6H_2O$) = - 12,3 kJ/ mol.

$\Delta H^0_{hydrotation}$ =?

***The standard of decision:***

1.We work out the equation of hydration $MgCl_2$:

$MgCl_2 + nH_2O \rightarrow [Mg (H_2O_6) ]^{2+} + 2CL^{-}$ (n 6) aq

$\Delta H^0_{sol} (MgCl_2) = - 150,5$ kJ/ mol

2.It is possible to present the given process thus:

$MgCl_2 + 6H_2O \rightarrow MgCl_2{\cdot}6H_2O$ $\Delta H^0_{hydro}$ =?

$Mg6H_2O$ + aq $\rightarrow [Mg (H_2O_6) ]^{2+}$ + 2Cl aq $\Delta H^0_{sol} = - 12,3$ kdzh/ mol

3.From Gesso's Law follows:

$\Delta H^0_{sol} (MgCl_2) = \Delta H^0_{hydro} + \Delta H^0_{sol} (MgCl_2{\cdot}6H_2O)$

Thus:

$\Delta H^0_{hydro}$ = - 150,5 kJ/mol - (-12,3 kJ/ mol) = - 138,2 kJ/ mol

The answer:

$\Delta H^0_{hydro}$ = - 138,2 kJ/ mol

***Task №2.*** Warmth of formation peroxide hydrogen cannot be defined by practical consideration as at interaction of hydrogen with oxygen in usual conditions water is formed. However it is possible to measure warmth of decomposition $H_2O_2$ on $H_2O$ and $O_2$ and warmth of formation $H_2O$.

**GIVEN:**

$\Delta H^0_{destr} (H_2O_2)$ (l) = - 98,2 kJ/ mol

$\Delta H^0_{form} (H_2O)$ (l) = - 286,0 kJ/ mol

$\Delta H^0_{form} (H_2O_2)$ (l) =?

***The standard of decision:***

We work out the equation of reaction of formation $H_2O_2$ (l):

$H_2$ (g) + $O_2$ (g) = $H_2O_2$ (l)

We work out the equation of reaction of formation $H_2O$ (l):

$H_2$ (g) + 1/2$O_2$ (g) = $H_2O$ (l) $\Delta H^0_{form}$ = - 286,0 kJ/ mol

3. We work out the equation of reaction of decomposition $H_2O_2$ ():

$H_2O_2$ (l) = $H_2O$ (l) + 1/2$O_2$ (g) $\Delta H^0_{destr}$ = - 98,2 kJ/ mol

$H_2O$ (l) + 1/2$O_2$ (g) = $H_2O_2$ (l) $\Delta H^0_{destr}$ = + 98,2 kJ/ mol

4. Combining these equations, under Gesso's law it is found required size:

$H_2O$ (l) + 1/2$O_2$ (g) = $H_2O_2$ (l) $\Delta H^0_{destr}$ = 98,2 kJ/ mol

$H_2$ (g) + 1/2$O_2$ (g) = $H_2O$ (l) $\Delta H^0_{form}$ = - 286,0 kJ/ mol

$H_2$ (g) + $O_2$ (g) = $H_2O_2$ (l) $\Delta H^0_{form}$ =?

Thus:

$\Delta H^0_{destr} (H_2O_2)$ (l) = $\Delta H^0_{form} (H_2O)$ () + $\Delta H^0_{form} (H_2O_2)$ (l)

$\Delta H^0_{form} (H_2O_2)$ (l) = $\Delta H^0_{delut} (H_2O_2)$ () + $\Delta H^0_{form} (H_2O)$ (l)

$\Delta H^0_{form} (H_2O_2)$ (l) = - 98,2 kJ/ mol + (-286 kJ/ mol) = - 187,8 kJ/ mol

$\Delta H^0_{form} (H_2O_2)$ (l) = - 187,8 kJ/ mol.

**Questions and tasks for self-preparation**

1. What is the thermochemical equations of reaction?
2. How Gesso's law is formulated?

Whether 3. It is possible to spend arithmetic actions with thermochemical reactions?

**Situational tasks:**

***Task 1.*** Gesso's law in medical and biologic researches is how much important?

## Test questions

1. Enthalpy what formations of substance it is equal to zero?

a) $H_2O_2$ b)$H_2SO_4$ c)$O_2$ d) $CaSO_4$

2. Define change of energy Gibbs for the following reaction:

$NO + ½ O_2 = NO_2$

$\Delta G^0(NO_2)$= -57,3kJ/moll $\Delta G^0(NO)$= - 72,9kDj/moll

a) –57,3kJ/moll b) –72,9kJ/moll c) –35,6kJ/moll

d) 25,2kJ/moll

3. Specify an equilibrium condition of system:

a) $\Delta H>T\Delta S$ b) $\Delta H<T\Delta S$ c) $\Delta H=T\Delta S$ d) $\Delta G=\Delta H$

4.When Gesso's law has been opened:

a)1830g. b)1840g. c)1850g. d)1860g.

5.What parity characterizes an equilibrium condition of system?

a) $\Delta H>T\Delta S$ b) $\Delta H<T\Delta S$ c) $\Delta H=T\Delta S$ d) $\Delta G=\Delta H$

6.Process proceeds spontaneously in a case:

a)$0=\Delta G=\Delta H - T\Delta S$ b) $0<\Delta G=\Delta H - T\Delta S$

c)$0>\Delta G=\Delta H - T\Delta S$ d) only in the presence of enzymes

7.Define value of energy Gibbs for reaction:

$½ H_2S_{(g)} + ½ Cl_{2(g)} \rightarrow 2HCl_{(g)} + S_{(f)}$

$\Delta G_{HCl(g)}$ = -95,36kJ/moll $\Delta G_{H\ S\ (g)}$ = -33,83kJ/moll

a) –1571kJ b) –157,1kJ c) – 129,2kJ d) – 61,53kJ

7. Specify standard conditions:

a)P=1013,25kPa T=298,15$^0$K b)P=1atm. T=293$^0$K

c)P=1013,25kPa T=22$^0$C d)P=1013,25kPa T=295$^0$

8. Specify the thermochemical equation of reaction of formation Ammonia:

a)$3H_{2(g)} + N_{2(g)} = 2NH_{3(g)}$ + 91,608kJ

b)$3/2H_{2(g)} + ½ N_{2(g)} = NH_{3(g)}$ + 45,804kJ

c)$3/2H_{2(g)} + ½ N_{2(g)} = NH_{3(g)}$ + 91,608kJ

d)$3H_{2(g)} + N_{2(g)} = 2NH_{3(g)}$ - 91,608kJ

9. Specify mathematical expression of the first law of thermodynamics:

a)$Q=\Delta U-A$ b)$Q=\Delta U+A$ c)$Q=\Delta H-A$ d) $Q=\Delta U+H$

10. Entropy is measured in what units?

a)kJ b)kPa c)kJ/moll·K d)kPa/mol

## LABORATORY WORK.

***Experience 1.*** Definition of warmth of the neutralization allocated at interaction of the one-basic strong acid by alkali.

For work performance use a calorimeter. In a dry and pure internal glass of a calorimeter place by means of a pipette of solution NaOH of 25.00 ml of 1 M and write down thermometer indications ($t^0C$), in other glass measure 25,00 ml of solution HCl of 1 M and take its temperature. Then at a working mixer through a funnel pour in an alkali solution in a solution of acid and for removal of indications place in a calorimeter. Measure the heat after mixing of solutions ($t^0C$). Definition spend on two times and data write down in the table.

Density of solutions accept in equal $1 g/sm^3$ a specific thermal capacity of solutions accept equal to a water thermal capacity.

Quantity of allocated warmth calculate under the formula:

$Q = (m_{bas} + m_k) \cdot (t_2 - t_1) \cdot 4{,}184$ kJ

$m_{bas}$ - weight of the basis

Mk - weight of acid

$t_1$ - Reference temperature

$t_2$ - Final temperature

| Experience | Temperature, $t^0C$ | | q , kJ | Q , kJ/mol |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| Average | | | | |

The thermal effect of reaction of neutralization is calculated under the formula:

$$Q = qm / 1000M, \text{ a kJ/mol}$$

q - quantity of warmth
Q - quantity of the warmth allocated at neutralization of one moll of acid, one moll of alkali
m - the weight of acid containing in 25,00 ml 1 M of solution HCl
M - molar weight HCl

***Experience 2.*** Definition of warmth of hydration $Na_2CO_3$.

In the weighed calorimetric glass pour 50,00 ml (50) waters and in 5 minutes measure and write down temperature ($t_1$). Then give 4 g crushed $Na_2CO_3$ and add in a glass with water at constant hashing by a mixer before full dissolution. Mark the maximum temperature of a solution ($t_2$). Experience is repeated by two times and write down results.

Warmth of hydration of salt pays off under the formula:

$Q_{(r)} = C\ (m\ (Na_2CO_3) \cdot m\ (H_2O))\Delta\ t\ M/\ m\ (Na_2CO_3) \cdot 1000$
m ($H_2O$) - weight of water in a calorimeter, g

m ($Na_2CO_3$) - weight $Na_2CO_3$, g

M ($Na_2CO_3$) - relative molar weight $Na_2CO_3$

**Questions and tasks for the independent decision.**

1. It is known, that end-products of transformation of fibers in an organism are water, dioxide of carbon and urea. Whether in organism warmth of transformation of fiber differs from warmth of combustion of fiber?
2. Why crystalloid hydrates are dissolved with absorbtioning warmth, while corresponding waterless salts - with allocation?
3. Warmth of reaction of clearing to exhaust makes 66,94 kJ/MOL. How many warmth it will be allocated at clearing of 1 kg 85 %-s' to exhaust?

## KINETIC OF CHEMICAL REACTIONS.

**The employment purpose:** To learn the system approach to definition of possibility of course of chemical reactions. To predict the mechanism and a direction of course of reactions in biological systems. Experimentally to investigate influence of various factors on speed of chemical reactions and a balance condition.

**The importance of a studied theme:** Studying kinetic and mechanisms of course of chemical reactions and ability to apply them to biological systems is necessary for physicians as some biochemical reactions proceed in time and are kinetic. Action of medical products is carried out under laws chemical kinetic. Processes proceeding in biological objects, belong to open systems in which constantly there is a metabolism and energy to an environment. Biochemical reactions in these systems are multistage. For example, reactions of hydrolysis of fibers, carbohydrates, transformation mono sugars in $CO_{2,}$ etc. the Most part of biochemical reactions of a cell proceeds with participation of radicals and ions. These reactions differ in the high speeds. The choice of a way of chemical transformations in a live organism is defined by concrete conditions of a metabolism in it.

Chemical reactions in bio systems are carried out by means of biological catalysts - enzymes. Biocatalysts differ high specificity and an orientation of actions. They are the fibers, many of them contain ions of metals. So hydrolase contain zinc, calcium, magnesium, manganese; oxidase - iron, copper, molybdenum, cobalt. At replacement of one metal with another in structure of metal enzyme activity of the last changes and often falls. Decrease in activity of enzymes owing to change of structure of fibers leads to illnesses which are called Phermenthopaties or enzymophaties. All of them are hereditary. For example, albinism results from decrease in activity of enzyme tyrosine, catalyzing transformation tyrosine cells in melanin.

The majority of chemical reactions is reversible, including many major biochemical processes proceeding in live organisms.

We will result some of them:

Function of hemoglobin of blood consists in carrying over of oxygen by blood from lungs to tissue and cells of a live organism. In general it is possible to present this process so:

In lungs where concentration of oxygen is high, balance of the given process is displaced in the right party. In cells concentration of oxygen is much less, therefore the given balance is displaced to the left, that leads to constant maintenance of cells with oxygen.

Catalytically action of enzymes occurs on reversible process. For example, carbohydras contains in the active Centre in quality coenzymes $Zn^{2+}$:

$F \rightleftarrows AF + Zn^{2+}$

F-enzyme carbohydras;

AF-Apo ferment.

At deficiency of zinc the given balance is displaced to the right, and activity of enzyme decreases. Introduction of ions of zinc displaces balance to the left thanks to what concentration carbohydras increases also activity of enzyme is restored.

**Initial level of knowledge**

1. Homogeneous and heterogeneous reactions.
2. Concept about speed of chemical reactions.
3. Reactions proceeding between molecules and ions.

**Teaching material for self-preparation**

1. N.L.Glinka. The general chemistry. L, 1984, p. 215.
2. S.S.Olenin, G.I.Fadeev, Inorganic chemistry. M, 1979, p. 32.
3. A.S.Lensky Introduction in bioinorganic and biophysical chemistry. M, 1989, p. 56-90.

**On employment following questions will be considered:**

1. Speed of chemical reactions
2. Dependence of speed of chemical reactions on various factors
3. The nature of reacting substances
4. Concentration of reacting substances
5. Temperature
6. Catalyst Presence
7. Enzymes - biocatalysts
8. Chemical balance

9. The Conclusion of a constant of chemical balance
10. Influence of external factors on a balance condition. Principle Le-Shatele.
11. Balance in biochemical reactions

## THE INFORMATION BLOCK.

### Chemical kinetic.

Chemical kinetic studies: 1) definition of speed of reaction and its dependence by nature, concentration of substances, temperature and presence of the catalyst and 2) revealing of the mechanism of reaction, i.e. number of stages and the nature, intermediate substances formed in these stages.

Speed of chemical reaction is characterized by change of concentration of reacting substances (or reaction products) for a time unit: $V = \frac{t_1 - t_2}{t_1 - t_2} = \pm \frac{\Delta C}{\Delta t}$

Speed of reaction depends on many factors.

**Influence of concentration of reacting substances:**

At increase in concentration of reacting substances the number of their collisions that leads to increase in speed of reaction increases. Influence of concentration on speed of chemical reaction expresses the law of action of weights: at constant temperature speed of chemical reaction is directly proportional to product of concentration of reacting substances:

$2CO + O_2 \longrightarrow 2CO_2$

$V = K \cdot C^2 (CO) \cdot C(O_2)$

K - a constant of speed, a constant, it is speed of reaction at concentration of the reacting substances equal to unit, K - depends by nature reacting substances and temperature, but does not depend on concentration of substances.

At heterogeneous reactions of concentration of the substances which are in a firm phase, usually do not change during reaction and consequently do not join in the equation of the law of action of weights.

For example

$C + O_2 \longrightarrow CO_2$

$V = K \cdot C(O_2)$

### Influence of temperature on speed of reaction.

Rise in temperature leads to increase in speed of reaction that is connected with growth of a constant of speed of reaction. In turn the constant of speed of reaction depends on energy of activation.

That molecules could enter chemical interaction, they should possess some superfluous kinetic energy in comparison with average energy of molecules which is called as energy of activation. The molecules possessing such energy, are considered as the active. During chemical reaction the power barrier in which top connection - the activated complex is formed intermediate during reaction is always broken. Energy of activation is that power barrier which separates the activated complex from substances entering reaction. In case of very big energy of activation there will be few molecules, capable to break a power barrier and speed of reaction will be insignificant.

Dependence of a constant of speed of reaction on energy of activation/E, the DJ/moll / is expressed by equation Arrhenius:

$$K = z \cdot p \cdot l^{-Ea/Rt}$$

Z - number of collisions of molecules in a second in volume unit;
l - the basis of the natural logarithm / e=2,716 …/;
R - universal gas constant / =8,314 DJ/MOL · To/;
T - absolute temperature, K;
P - steric multiplier connected with orientation of facing molecules.

Other expression of equation Arrhenius is known also:

$$\lg\frac{K_2}{K_1} = \frac{Ea}{2.303}\cdot\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Ea - energy of activation;
$K_1$, $K_2$ - constants of speed of reaction at initial/$T_1$/and set/$T_2$/to temperature.

Speed of chemical reactions, as a rule, at rise in temperature increases. By rule Vant-Goff, at rise in temperature on everyone $10^oC$ speed of reaction increases in 2-4 times. This increase is called as temperature factor of reaction.

$$v = \frac{v_t + 10^0}{v_t} = \frac{K_t + 10^0}{K_t}\,\frac{v_{t2}}{v_{t2}} = \sqrt{\frac{t_2 - t_1}{10}}$$

$v_{t2}K_t$ - Speed of reaction at initial ($T_1$) and set ($T_2$) temperatures.

Rise in temperature conducts to increase of number of the active molecules possessing a sufficient stock of energy at which impact there is a reaction certificate.

For finding-out of the mechanism of chemical reactions it is necessary to define a reaction order experimentally.

The reaction order specifies dependence of speed of reaction on concentration.

**Reactions of a zero order.**

As reaction of a zero order is called the reaction which speed does not depend on concentration of reacting substances. For example,

$CaCo_3 \rightleftarrows CaO + CO_2$

Speed of this reaction does not depend on concentration of reacting substances. V=K, where K - a constant of speed of reaction.

The heterogeneous reactions proceeding on a surface of firm substance concern reactions of a zero order. Speed of such reactions is very small.

**Reactions of the first order.**

As reaction of the first order is called the reaction which speed depends on concentration of one component.

Speed of reaction depends only on concentration.

**Reactions of the second order.**

Reactions of the second order can be two types

1) $2\,O_2 \longrightarrow 2O + O_2$

2) $H_2$ 2H

**Simple reactions**

Elementary reactions classify on number of molecules which participate in one elementary chemical certificate.

Reactions in which there is a transformation of one molecule are called as monomolecular:

Reactions in which the elementary certificate is carried out at collision of two molecules are called as biomolecule:

In three molecular reactions the elementary certificate is carried out at collision of three molecules:

**Difficult reactions**

Difficult reactions : continue able , parallel, interfaced, reversible and chain reactions

Reactions which proceed through a number of consecutive stages are called as consecutive:

$$C_{18}H_{32}O_{16} + H_2O \longrightarrow C_{12}H_{22}O_{11} + C_6H_{12}O_6$$
$$C_{12}H_{22}O_{14} + H_2O \longrightarrow 2C_6H_{12}O_6$$

Reactions at which the same initial substances simultaneously react, forming different products in several directions are called as parallel:

$$6KClO_3 \longrightarrow \begin{cases} 2KCl + 3O_2 \\ 3\,KClO_4 + KCl \end{cases}$$

Two reactions, one of which are called as interfaced, being spontaneous, causes (induces) course in the same system of the second chemical reaction which are not carried out for lack of first.

For example, benzene in a water solution is not oxidized peroxide hydrogen, but at salt addition (II) occur its transformation into phenol and biphenyl:

$$6FeO + 2H_2CrO_4 = 3Fe_2\,O_3 + Cr_2\,O_3 + 2H_2O$$
$$6HJ + 2H_2CrO_4 = 3J_2 + Cr_2\,O_3 + 5H_2O$$

Both reactions of oxidation proceed with participation of the general intermediate free radical HO.

Reactions which go both in direct, and in the return directions are called as reversible:

The number of active molecules can be increased not only heating, but also quantum or oscillatory energy (light, x-ray, radioactive, ultrasonic etc.).

The reactions proceeding under the influence of light, are called as photochemical. The big number of the various reactions proceeding in a human organ concerns photochemical processes.

In a skin of the person under the influence of ultra-violet beams of a sunlight vitamin D possessing anthracitic activity is synthesized.

The most important photochemical process proceeding in green parts of plants - photosynthesis.

Photosynthesis is a source of replenishment of stocks of atmospheric oxygen in an organism of plants which serve as nutrient for animals and the person.

The essence of photochemical action of light consists in excitation of molecules or atoms of reacting substances under the influence of photons.

Dependence between quantity of the absorbed energy at photochemical reaction and quantity of the reacted substance is expressed by the law of photochemical equivalence of Einstein according to which each molecule reacting under the influence of light, absorbs one quantum of the radiation causing reaction.

For the kinetic characteristic of photochemical reaction the concept of a quantum exit is entered.

Where - number of the absorbed molecules, - number of the absorbed quanta of light.

As a rule, the quantum exit should be equaled to unit, but there are reactions at which it is more or less units.

With a quantum exit many important reactions proceed. For example: a primary step of reaction of formation of ozone is absorption of quantum of radiant energy by an oxygen molecule:

**Active molecule**

Having absorbed one quantum of energy of activation, the oxygen molecule enters reaction with other molecules of oxygen:

Speed of photochemical reactions depends on concentration of transformed substances and temperature and is proportional to quantity of the absorbed energy of radiation.

- Natural photochemical reactions have positive influence on an organism. For example, under the influence of solar beams pro vitamin D passes in vitamin D that stimulates process of regeneration of a bone fabric.
- Ultra-violet beams perniciously operate on a bacterium that is used for sterilization inject only solutions.
- Photochemical reactions are stimulators of biochemical reactions that is used for preventive maintenance and treatment of some diseases in the form of solar baths.

Photochemical reactions depending on frequencies of radiations can negatively influence an organism. For example, the beams allocated at radioactive disintegration of an isotope along with positive influence on process of decomposition of malignant tumors. Also negatively operate on biochemical reactions in which result there is a radiation sickness. The most evident indicator of the last is reduction of number of leukocytes in blood.

Reactions at which the chain of consistently repeating reactions is carried out, each of which leads to formation of an active particle, are called as chain reactions.

The majority of photochemical reactions concerns chain reactions: burning and oxidation processes, cracking, polymerization. The modern theory of chain reactions is developed by I.I. Sechenov.

In all chain reaction distinguish three stages:

1.Chain origin.

2.Chain development.

3.Chain breakage.

Chain reaction example is synthesis hydrochloric under the influence of light.

At an irradiation for short time of a gas mix of hydrogen and chlorine there is an explosive reaction and is formed hydrochloric. This process occurs in three stages.

The first - chain origin: under the influence of light in reactionary system there are active particles.

The second stage - chain development. Formed atoms of chlorine react with molecules of hydrogen with allocation of a radical (atom) of hydrogen which in turn co-operates from one of chlorine molecules.

The third stage - breakage of chains, recombination radicals (atoms) - leads to disappearance of active particles, i.e. to the termination of chain process.

Recombination atoms goes with allocation of a considerable quantity of energy.

In chain reactions by active particles can be both free atoms, and free radicals.

## Catalysis. Enzymatic catalysis.

Speed of chemical reaction increases in the presence of catalysts. The reactions proceeding with participation of catalysis, are called catalytically. The phenomenon of change of speed of reaction under the influence of catalysts is called cataclysm.

Various inorganic and organic substances can be catalysts. Their weight in reaction is small, and as a rule, remains to invariable reaction by the end. Catalysts not only accelerate chemical reaction which in their absence proceeds rather slowly, but can cause reactions, without them considerably not passing. Their characteristic property consists that they not passing. Their characteristic property consists that they are not consumed during reaction and consequently do not join in the total equation of process.

Absence of influence on chemical balance appears second their distinctive ability.

Distinguish homogeneous catalyze when both the catalyst, and reacting substances are in one phase, both heterogeneous, and contact catalyze at which the catalyst usually is the firm substance in a gaseous or liquid reactionary mix.

Homogeneous catalyze:

/ reacting substances and the catalyst are in one phase - gas/.

Heterogeneous catalyze:

/ reacting substances - gaseous, the catalyst - firm substance/.

In homogeneous catalyze all weight of the catalyst therefore increase in speed of reaction in direct ratio its concentration takes part.

As a whole the mechanism of action of catalysts consists that it reacts with one of initial substances with formation of the intermediate product which is rather reactionary-capable. Thus energy of activation decreases in comparison with the basic:

A+C=AC - Very slowly

A+K=AK-K - the catalyst

AK+C=AC+K.

When intermediate connection of the catalyst with one of initial substances (i.e. AK) co-operates with the second initial substance - with higher energy of activation, reduction of speed of course of reaction is observed. In such cases catalyze and the catalyst is called as negative. If the negative catalyst contains in the system, it is called inhibitor.

Catalysts can increase speed of one reaction, several reactions, specifically operate on certain process, defining an exit of products of reaction. For example, ethyl spirit at heating can decay two ways depending on the applied catalyst.

Thus it is possible to achieve reception of a necessary product.

In live organisms it is carried out Enzymatic catalyze. Enzymes are biocatalysts, they are albumin connections. Enzymes catalyst thousand chemical reactions in organisms. Their role as biocatalysts of biochemical transformations is similar to a role of catalysts in other chemical reactions. Upon termination of reaction enzyme as the catalyst remains in a free kind in the initial form. Enzymatic reactions usually carry to heterogeneously - catalytically reactions.

Quantitative studying enzymatic reactions spends Enzymatic kinetic - one of the important areas of a science in whom wide application was found by mathematical methods. It has huge practical value for biochemistry.

Enzymes is high-specific also possess high catalytically effect. In catalytically the certificate their certain part - the active Centre of enzymes participates only. It is the part of an albumin molecule formed several amino-acid by rests, containing - and other groups. The active Centre directly co-operates with a substratum, forming enzyme-substratly complex which co-operating with other reagent, forms a reaction product.

The enzymes containing in quality coenzymes ions of metals, are called metal enzymes. Ions of metals are capable to carry out three tasks: they or form the connecting bridge for substratum and enzyme linkage, or represent catalytically group. Metals-ions promote giving to enzymes optimum conformation for display high catalytically to activity. Cofactors, rather strongly connected in an albumins molecule of enzyme, usually name simply groups, and poorly connected - co Enzymes.

At metal enzymes activity depends on presence of an ion of metal and at its removal catalytically activity of enzyme disappears.

For example, at removal of an ion of zinc enzyme carbohydrase loses the activity. If into system to enter necessary quantity of ions of zinc, for example, in the form of salt, activity of enzyme is restored.

Thus, the metal ion is necessary for display catalytically for activity of enzyme. We will result some examples metal enzymes and reactions, catalyzing them:

Ferriferous enzymes

2. $2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$

3 4-ferrotsitohrom C + $O_2$ ⟶ 4-ferritsitohrom C + $2H_2O$

5. 4-trimetilaminobutirat + 2-okiibutirat $Fe^{2+}$. O ⟶ 3-hydroxi - 4-trimetilbutirat + succinat + $CO_2$ + $Fe^{2+}$.

6. 2 - ascorbat + $O_2$ 2 ⟶ dihydroascorbat + $H_2O$.

7. tyrosin + dihydroxyphenilalanin + $O_2$ ⟶ dihydroxyphenilalanin + dioxyphenilalanin + $O_2$

## Chemical balance

As is known, all reversible reactions up to the end do not go. At their current speed of direct reaction decreases, return - increases. During the certain moment they decreases equally and then there comes chemical balance. The quantitative characteristic of chemical balance is the constant of chemical balance. We will deduce it for reaction of synthesis of ammonia.

$$N_2(g) + 3H_2(g) \rightleftarrows 2NH_3$$

$$\upsilon_1 = K_1 \cdot C(N_2) \cdot C^3(H_2)$$

$$\upsilon_2 = K_2 \cdot C^2(NH_3)$$

In a balance condition: $\upsilon_1 = \upsilon_2$

$K_1 \cdot C(N_2) \cdot C^3(H_2) = K_2 \cdot C^2(NH_3)$

$$\frac{K_1}{K_2} = \frac{C^2(NH_3)}{C(N_2) \cdot C^3(H_2)}; \quad \frac{K_1}{K_2} = K_m$$

$K_m$ - a balance constant.

Concentration of the substances entering into expression of a constant of balance, are called as equilibrium concentration.

Balance constant - a constant at the given temperature, expressing a parity between equilibrium concentration of products of reaction and initial substances. The more it, the above an exit of products of reaction

$$aA + bB + \ldots \rightleftarrows cC + dD + \ldots$$

$$K_m = \frac{C^c(C) \cdot C^d(D) \cdot \ldots}{C^a(A) \cdot C^d(B) \cdot \ldots}$$

Km expression does not include concentration of firm substances. At change of conditions of course of reaction chemical balance is broken. As a result of primary course of reaction in one of possible directions the condition of new chemical balance differing from the initial is established. Process of transition from one equilibrium condition to new is called as displacement of chemical balance. The direction of this displacement submits to principle Le-Shatele: « If on the system which is in a condition of chemical balance to have any influence balance will be displaced in such direction, that the had influence decreases ». The increase in concentration of initial products leads to displacement of balance towards formation of products of reaction and on the contrary, the increase in concentration of products of reaction leads to balance displacement in the opposite direction; rise in temperature displaces a condition of chemical balance aside endothermic reactions; pressure increase - in a direction of reduction of the general number of molls of gaseous substances; removal from system of one of reaction products conducts to displacement of balance towards direct reaction etc. the Catalyst does not influence value of a constant of balance. The constant of balance of chemical reaction is connected with standard change of energy Gibbs:

$$\Delta G_т = -2,3 \cdot R \cdot T \cdot lgK_т$$

At 298 K ($25^0$) equation it will be transformed to a kind:

$$\Delta G_{298} = -5,69 lgK_{298},$$

Where $\Delta G_{298}$ it is expressed in a kHz/mol.

Thus, from these equations it is visible, that at $\Delta G^0$ <0, lgK> 0, i.e. 1. It means, that at $\Delta G^0$ <0 balance is displaced towards direct reaction and the exit of products is rather great; at $\Delta G^0$> 0, lgK <1 exit of products of direct reaction is small.

**Training tasks and the standard of their decision**

***Task № 1***. In how many time will increase Speed of reaction at rise in temperature from $20^0$C to $75^0$C?

**Given:**

$\nu$ =2,8

$t_1 = 20^0C$

$t_2 = 75^0C$

$\frac{\vartheta_{t1}}{\vartheta_{t2}} =$ ?

***The standard of decision***

1. We will designate speed of reaction at $t_1$ - $\upsilon_{t1}$, at $t_2$ - $\upsilon_{t2}$ $\upsilon$

2. Rise in temperature

$\Delta t = t_1 - t_2 = 75^0C - 20^0C = 55^0C$

3. On the basis of rule Van-Goff we will write down:

$$\frac{\vartheta_{t1}}{\vartheta_{t2}} = \nu^{t1-t2/10} \qquad \frac{\vartheta_{t1}}{\vartheta_{t2}} = 2.8^{55/10} = 2.8^{5.5}$$

Logarithm the given expression:

$$\lg\frac{\vartheta_{t1}}{\vartheta_{t2}} = 5,5 \cdot \lg 2,8 = 5,5 \cdot 0,447 = 2,458$$

From here $\frac{\vartheta_{t1}}{\vartheta_{t2}} = 287$

The answer:

Speed of reaction will increase in 287 times.

***Task № 2.*** Speed of chemical reaction $2NO + O_2 = 2NO_2$ at concentration of reacting substances C (NO) =0,3 moll/l and C ($O_2$) = 0,15 moll/l has made 1,2 $10^{-9}$ MOL/l*sec. Find value of a constant of speed of reaction.

**Given:**

C (NO) = 0,3 mol/l;

C ($O_2$) = 0,15 mol/l;

ύ = 1,2 * $10^{-3}$ moll/l. s;

K =?

**The standard of decision**

Under the law of action of weights: ύ = $K \cdot C^2 (NO) \cdot C(O_2)$

From here K= $K = \frac{\vartheta}{C^2(NO) \cdot C(O_2)}$

$$K = \frac{1{,}2 \cdot 10^{-3} mol/l^2 \cdot l}{0{,}3 \cdot 0{,}3 \cdot 0{,}15\ l \cdot c \cdot mol^3 \cdot mol} = 8{,}9 \cdot 10^2 \frac{l^2}{mol^2 \cdot c}$$

Answer: $K = 8{,}9 \cdot 10^2 \frac{l^2}{mol^2 \cdot c}$

***Task №3.*** Explain, what substances are called as negative catalysts and inhibitors, in what their difference.

***The standard of decision.*** Negative catalysts are substances which are used for delay of undesirable processes or for giving to reactions of quieter character. For example, at synthesis of chloride hydrogen from hydrogen and chlorine the negative catalyst is oxygen. In difference of these substances inhibitors are a part of reaction products. For example, inhibitor iron corrosion there can be a calcium hydro carbonate - $Ca(HCO_3)_2$, under which action on a metal surface forming insoluble film of a carbonate of iron.

***Task №4***. In system: $A_{(g)} + B_{(g)} \rightleftarrows C_{(g)}$ equilibrium concentration C(A) = 0,216 moll/l, C(B) = 0,12 moll/l, C(C) = 0,216 moll/l; find a constant of balance of reaction and initial concentration of substances A and B

**Given:**

C(A) = 0,216 moll/l
C(B) = 0,120 moll/l
C(C) = 0,216 moll/l
$K_T$ =?
c ($A_o$) = ?,  C ($B_o$) = ?

***The standard of decision***

The constant of balance of the given reaction under the law of action of weights is expressed by the equation:

$$K_m = \frac{C(C)}{C(A) \cdot C^2(B)}$$

Substituting in this equation the given tasks, we find numerical value $K_T$:

$$K_m = \frac{0{,}216}{0{,}6 \cdot 0{,}12^2} = 2{,}5$$

$K_T$ = 2,5

According to the equation of reaction from 1 asking substances A and 2 molls of substance B it was formed I moll of substance of C.Po data of task, in each liter of system 0,216 molls of substance C were formed at wasting 0,216 molls of substance A and 0,216·2=0,432 asking substances of B

Thus, initial concentration of substances A and B are equal:
C ($A_0$) = 0,06 moll/l + 0,216 moll/l of =0,276mol/l
C ($C_0$) = 0,12 mol/l +0,432 mol/l = 0,552 mol/l
The answer:
$K_T$ = 2,5  C ($A_0$) = 0, 276 moll/l  c($B_0$) = 0,552 moll/l

**Questions and tasks for self-checking of mastering of a theme**

1.Why rise in temperature conducts to increase of speed of chemical reaction?
2.Balance in system was established at concentration of hydrogen 0,024 moll/l, iodine - 0,005 moll/l , Iodide hydrogen - 0,09 moll/l. Define initial concentration iodine and hydrogen.
3. In how many time changes speed of the reaction which temperature factor is equal 2, at rise in temperature on $10^0$C?
4. Than increase of speed of reaction speaks at introduction in catalyst system: reduction of energy of activation; increase in average kinetic energy of molecules; increase of number of collisions; growth of number of active molecules?
5. What enzymes are metal enzymes? What role of ions of metals in metal enzymes?
6. Than specificity of action of enzymes is caused?

**Situational tasks**

***Task 1***. At heating of a mix of gaseous hydrogen and iodine to $420^0C$ following equilibrium concentration of reagents were established:
C ($H_2$) - $2 \cdot 10^{-3}$ moll/l, C ($J_2$) - $2{,}5 \cdot 10^{-4}$ moll/l, C (HJ) - $5 \cdot 10^{-3}$ moll/l. What value of constants of balance $K_c$ and $K_p$ under these conditions?

***Task 2.*** Dioxide nitrogen - brown gas with a characteristic smell, for the person is poisonous. Is the important product at nitric acid reception, therefore at work with it is necessary to consider its poisoning action. It turns out on reaction:

$$2NO_{(g)} + O_{2(g)} \rightleftarrows 2NO_{2(g)}$$

Find value of a constant of chemical balance if the mix containing 4 asking oxide of nitrogen and 2 asking oxygen has originally been prepared, and by the moment of approach of balance there were 20 % of initial quantity of nitrogen.

## Test questions

1. Positive catalyze directs reaction on a way:
   a) With low activation a barrier
   b) With high activation a barrier
   c) Does not influence
2. In how many time increases speed of reaction at rise in temperature with $10^0C$ to $30^0C$ at $\gamma$ =4?
 a) 5 b) 16 c) 64 d)8
**3.** In what party balance of the following reaction will be displaced at pressure increase twice - $2NO + Cl_2 = 2NOCl$?
   a) to the right b)to the left c)pressure does not influence
   d) Balance will not be displaced.
**4**. In how many time increases speed of homogeneous chemical reaction at rise in temperature on $20^0C$? (gamma=4)
   a ) In 24 times b)in 4 times c)in 8 times d)in16 times
**5.** How the substances which addition activates catalysts are called?
   a) Reagents b) promoters c) catalytically poisons
   d) Enzymes
**6.** In how many time increases speed of reaction at rise in temperature from $15^0C$ to $35^0C$ if the temperature factor is equal 3?
 a) 5 b)16 c)12 d)9
**7.** How the catalyst which is slowing down chemical transformation is called?
   a) auto catalyst b)the positive catalyst
   c) inhibitor d)the heterogeneous catalyst
**8**. At what pH enzyme pepsin shows the greatest activity?
a) pH = 1-2,2 b) pH = 2,2–3 c) pH = 1–3,5 d) pH = 10,0-10,2
**9.** What reactions proceed faster?

a)In homo systems b)in hetero systems
c)The one-phasic d)multiphasic

**10**. In what party and in how many time changes speed of chemical reactions at increase in pressure of system in 3 times in the following reaction:

$3H_2 + N_2 = 2NH_3$

a) to the left in 8 times b)to the right in 81 times
c) to the left in 81 times d)to the left in 4 times

## LABORATORY WORK №1

***Experience 1.*** **Influence of temperature on speed of reaction.**

In two test tubes on 15 drops put solution *HCL*. One test tube heat up. In both test tubes add metal zinc. Compare and explain a difference of allocation of hydrogen.

In two test tubes bring on 5 drops $CrCl_3$ complexion (Ш) and $CH_3COONa$. One test tube heat up to boiling. Explain and compare speed of change of color of a solution in test tubes.

***Experience 2.*** **Dependence of speed of reaction on the catalyst.**

In 2 test tubes bring on 10 drops $H_2C_2O_4$ and 8 drops of solution $H_2SO_4$. In one test tube add some crystals $MnSO_4$. In two test tubes add on 5 drops of solution $KMnO_4$. Compare in both test tubes speed of disappearance of color of a solution and define role $MnSO_4$.

***Experience 3***. **Influence on speed of reaction of the nature of substance.**

In a test tube №1 pour 2 ml $CH_3COOH$, №2 - 2 ml *HCl*. To them add metal zinc. Define intensity of allocation of hydrogen. Write the reaction equation. Explain the reason of different speed of process.

### Qualitative experiences on chemical balance.

***Experience 1.*** **Influence of temperature on chemical balance.**

**1.1.** At interaction iodine with starch the substance of dark blue coloring of difficult structure – iodine starch is formed. Reaction exothermic , it is possible to present its balance conditionally the scheme:

$$\text{Iodine + starch} \rightleftarrows \text{Iodine starch+Q.}$$

In two test tubes to pour on 4-5 drops of a solution of starch and to add on 1 drop of the diluted solution iodine. The solution will be painted in dark blue color. To heat up one of test tubes and to observe coloring change. Then to cool a test tube water from under the crane. What will occur to solution coloring? To give an explanation to experience.

**1.2.** In two test tubes to pour on 5-7 ml distillationly waters, on 2-3 drops phenolphtalein and on 1 drop of the concentrated solution of ammonia.

One test tube to leave for comparison, another to heat up. Heating promotes allocation of ammonia from a solution and by that to balance shift:

$$NH_3 + H_2O \rightleftarrows NH_4OH \rightleftarrows NH_4^+ + OH^-$$

Explain change of coloring of a solution of ammonia at heating.

***Experience 3*. Influence of reaction of environment on chemical balance.**

In an alkaline solution the chrome ion (YI) exists in the form of painted in yellow color chromate - an ion. In process of fall pH occurs protonation an ion and in the sour environment the dichromate ion - orange color is formed.

To pour in a test tube of 10 % of a solution of 2-3 ml. To this solution on drops to add the concentrated solution of alkali, to observe coloring change. When the solution becomes yellow, to add the concentrated sulfuric acid on drops. To observe coloring change.

Explain the occurring phenomenon.

***Experience 4.* Displacement of balance under the influence of formation light dissociation substances.**

In a test tube to bring 4-5 ml of a solution of chloride of magnesium and slowly to flow a solution hydroxide sodium before deposition formation. To shake up a deposition, suspension to pour in other two test tubes.

The first test tube to leave for comparison, in the second to flow hydrochloric acid before deposition dissolution, in the third to flow a solution of chloride of ammonium before deposition dissolution. To explain dissolution hydroxide magnesium in hydrochloric acid and in ammonium chloride.

**Tasks for the independent decision**

**1**. Prove difference of chemical catalysts from enzymes.

**2**. As a result of consumption of a considerable quantity of alcohol some enzymes of the person lose active conformation. Offer the possible mechanism of this phenomenon at molecular level.

**3**.Enzymes alcohol dehydrogenase translates ethylene glycol in poisonous oxalate - an ion, and ethanol - in acetate - an ion. Size $K_1/K_2=K$ for balance E + is much less for ethylene glycol in comparison with "K" for ethanol. Knowing it, explain, why at a poisoning ethylene glycol enter intravenously ethanol. The last half reduces a deadly outcome.

# THE APPLICATION

**Table 1.**

## Solubility of some salts at various temperatures

**(1 g of waterless substance in 100g waters)**

| | substance | $0^0C$ | $10^0C$ | $20^0C$ | $30^0C$ | $40^0C$ |
|---|---|---|---|---|---|---|
| 1. | $AgNO_3$ | 122 | 170 | 222 | 300 | 376 |
| 2. | $CuSO_4\cdot5H_2O$ | 14,3 | 17,4 | 20,8 | 25 | 28,5 |
| 3. | $HgCl_2$ | 4,3 | 5,6 | 6,6 | 8,3 | 9,9 |
| 4. | KCl | 27,6 | 31,0 | 34,0 | 37,0 | 40,0 |
| 5. | $NH_4Cl$ | 29,4 | 33,3 | 37,2 | 41,4 | 45,8 |
| 6. | NaCl | 35,7 | 35,8 | 36,0 | 36,3 | 36,6 |
| 7. | $Ca(HCO_3)_2$ | 14,2 | - | 14,3 | - | 14,5 |
| 8. | $Li_2\ SO_4$ | 26,2 | - | 25,7 | - | 24,5 |
| 9. | $Mg\ SO_4\cdot H_2O$ | - | - | 38,6 | 37,8 | 36,3 |

**Table 2.**

## Warmth of combustion of some organic substances

| Substance | Aggregate state | Warmth of combustion kDj/mol | Substance | Aggregate state | Warmth of combustion kDj/mol |
|---|---|---|---|---|---|
| $CH_4$ | g | -882 | $C_6H_6$ | C | -3170 |
| $CO(NH_2)_2$ | cr | -634 | $C_6H_{12}O_6$ | C | -3170 |
| $C_2H_4$ | g | -1390 | $C_6H_{12}O_6$ | cr | -2810 |
| $C_2H_5OH$ | C | -1370 | $CH_3COOH$ | C | -872 |

**Table 3.**

Warmth of dissolution in water of some inorganic substances.

| Substance | $\Delta H^0$ dissolution kDj/mol | Substance | $\Delta H^0$ dissolution kDj/mol |
|---|---|---|---|
| $Al_2(SO_4)_3$ | -350,5 | $MgCl_2\cdot6\ H_2O$ | -12,3 |
| $CaCl_2$ | -75,3 | $Na_2CO_3$ | -23,6 |
| $C\ aCl_2\cdot6\ H_2O$ | -19,1 | $Na_2CO_3\cdot10\ H_2O$ | -67,5 |
| $CuSO_4$ | -66,5 | $Na_2\ SO_4$ | -2,3 |
| $CuSO_4\cdot5\ H_2O$ | -11,6 | $Na_2\ SO_4\cdot10\ H_2O$ | -79,1 |
| KCl | -16,7 | $Zn\ SO_4$ | -77,6 |

**Table 4.**

## Thermodynamic properties of some connections applied in medicine.

$\Delta H^0_{298}$ – standard warmth of formation of substance kDj/mol
$\Delta G^0_{298}$ – Gibbs's energy at formation of difficult substance from simple kDj/mol
$\Delta S_{298}$ – standard entropy of substance Dj/molK

The reductions accepted in the table:

cr-crystalline state
g- gaseous state
ag – quantity of substance in water solutionope

| **Substance or ion** | Aggregate state | **$\Delta H^0_{298}$ –** | **$\Delta G^0_{298}$** | **$\Delta S_{298}$** |
|---|---|---|---|---|
| C | Graphite | 0 | 0 | 5,7 |
| C | Diamond | 1,9 | 2,9 | 2,4 |
| CO | G | -111 | -137 | 198 |
| $CO_2$ | G | -394 | -394 | 214 |
| $CO_2$ | Ag | -413 | -386 | 121 |
| $H_2CO_3$ | Ag | -700 | -623 | 187 |
| $HCO_3^-$ | Ag | -691 | -587 | 95 |
| $CO_3^{2-}$ | Ag | -676 | -528 | -53 |
| $Ca^{2+}$ | Ag | -543 | -553 | -55 |
| CaO | Cr | -636 | -604 | 40 |
| $Ca(OH)_2$ | Cr | -987 | -897 | 76 |
| Ca $SO_4$ | Cr | 1430 | -1320 | 107 |
| $CaSO_4 \cdot 2\ H_2O$ | Cr | -2020 | -1790 | 194 |
| $CaCl_2$ | Cr | -795 | -750 | 114 |
| $CaCl_2$ | Ag | -877 | -815 | 55 |
| $CaCl_2 \cdot 6\ H_2O$ | Cr | -2600 | - | - |
| $Cl_2$ | G | 0 | 0 | 223 |
| HCl | G | -92,3 | -95,3 | 187 |
| HCl | Ag | -167 | -131 | 55 |
| $CuSO_4 \cdot 3\ H_2O$ | Cr | -1680 | -1400 | 225 |
| $CuSO_4 \cdot 5\ H_2O$ | Cr | -2280 | -1880 | 306 |
| $H_2O$ | C | -286 | -238 | 70 |
| $H_2O$ | G | -242 | -229 | 189 |
| $H_2O_2$ | J | -188 | -118 | - |
| $H_2O_2$ | Ag | -191 | - | - |
| KVr | Ag | -372 | -385 | 183 |
| KCl | G | -216 | -235 | 240 |
| KCl | Ag | -419 | -414 | 158 |
| KJ | Ag | -307 | -334 | 212 |
| $KMnO_4$ | Cr | -814 | -714 | 172 |
| $MgCl_2 \cdot 6\ H_2O$ | Cr | -2500 | -1280 | 366 |

**Table 5.**

# Properties of some indicators

| **Indicator** | **Interval of change of coloring of the indicator** | **PK indicator** | **Colouring of the indicator** | |
|---|---|---|---|---|
| | | | **Acid form** | **Alkaline form** |
| Methyl orange | 3,1 | 4,0 | Red | Yellow |
| Red methyl | 4,2-6,2 | 5,5 | Red | Yellow |
| Litmus | 5,0-8,0 | 7,0 | Red | Blue |
| n-nitrophenol | 5,6-7,4 | 6,5 | Colourless | Yellow |
| Neutral Red | 6,8-8,0 | 7,5 | Red | Yellow |
| Fenolftalein | 8,2-9,8 | 9,0 | Colourless | Crimson |
| Timolftalein | 9,3-10,5 | 9,9 | Colourless | Blue |

**Table 6.**

# Ways of expression of concentration of solutions

| Name | Unit of measure | Settlement formulas |
|---|---|---|
| Molarly concentration c(X) | Mol/l | $C(X)=\frac{n(X)}{V(solution)}=\frac{m(X)}{M(X)V(solution)}$ |
| Equivalent molarly concentration $C(\frac{1}{z}x)$ | Mol/l | $C(\frac{1}{z}x)=\frac{C(\frac{1}{z}x)}{V(solution)}=\frac{m(X)}{M(\frac{1}{z}X)\cdot V(solution)}$ |
| The molal concentration | Mol/kg | $в(X)=\frac{n(X)}{m(solution)}=\frac{m}{M(X)\cdot m(solution)}$ |
| Mass fraction of a component ω | | $\omega=\frac{m(X)}{m(solution)}$ |
| Mass fraction of a component as a percentage ω % | | $\omega\%=\frac{m(X)}{m(solution)}\cdot 100\%$ |
| Molarly share of a component N | | $N=\frac{n(X)}{n(solution)}$ |
| Volume fraction of a component γ | | $\varphi=\frac{V(X)}{V(solution)}$ |
| Titr T(x) | g/ml | $T(X)=\frac{m(X)}{V(solution)}$ |

**Table 7.**

**Krioskopic and ebullioscopic constants of some solvents**

| Solvent | К, grad, kg/mol | E, grad kg/mol |
|---|---|---|
| Aqua | 1,86 | 0,52 |
| Benzol | 5,12 | 2,57 |
| NitroBenzol | 6,9 | 5,27 |
| Acetic acid | 3,9 | 3,1 |

**Table 8.**

## The constants of solubility of difficultly-solubility connections

| Substance | $К_{sol.}$ | Substance | $К_{sol.}$ |
|---|---|---|---|
| AgBr | $5{,}3\cdot10^{-13}$ | $Sr_3(PO_4)_2$ | $1{,}0\cdot10^{-31}$ |
| AgSCN | $1{,}1\cdot10^{-12}$ | $Co(OH)_3$ | $2{,}0\cdot10^{-16}$ |
| $Ag_2CrO_4$ | $1{,}1\cdot10^{-12}$ | CuS | $6{,}3\cdot10^{-36}$ |
| AgCl | $1{,}78\cdot10^{-10}$ | $Cu(OH)_2$ | $5{,}0\cdot10^{-20}$ |
| $Ag_2Cr_2O_7$ | $1{,}1\cdot10^{-10}$ | $Cr(OH)_3$ | $6{,}3\cdot10^{-31}$ |
| AgJ | $8{,}3\cdot10^{-17}$ | $Fe(OH)_2$ | $1{,}0\cdot10^{-15}$ |
| $Ag_2S$ | $6{,}3\cdot10^{-50}$ | $Fe(OH)_3$ | $3{,}2\cdot10^{-38}$ |
| $Al(OH)_3$ | $1{,}0\cdot10^{-32}$ | $Hg_2Cl_2$ | $1{,}3\cdot10^{-18}$ |
| $BaCO_3$ | $5{,}1\cdot10^{-9}$ | HgS | $4{,}0\cdot10^{-53}$ |
| $BaC_2O_4$ | $1{,}1\cdot10^{-7}$ | Mg $CO_3$ | $4{,}0\cdot10^{-5}$ |
| Ba $CrO_4$ | $1{,}2\cdot10^{-10}$ | $Mg(OH)_2$ | $6{,}0\cdot10^{-10}$ |
| $Ba_3(PO_4)_2$ | $6{,}0\cdot10^{-39}$ | $Mg_3(PO_4)_2$ | $1{,}0\cdot10^{-23}$ |
| $BaSO_4$ | $1{,}1\cdot10^{-10}$ | $Mn(OH)_2$ | $4{,}5\cdot10^{-13}$ |
| $CaCO_3$ | $4{,}8\cdot10^{-9}$ | MnS | $2{,}5\cdot10^{-10}$ |
| $Ca_2$ $C_2O_4$ | $2{,}3\cdot10^{-9}$ | Pb $Cl_2$ | $1{,}6\cdot10^{-5}$ |

| | | | |
|---|---|---|---|
| $Ca\ SO_4$ | $9{,}1\cdot10^{-6}$ | $Pb\ CrO_4$ | $1{,}8\cdot10^{-14}$ |
| $Ca_3(PO_4)_2$ | $2{,}0\cdot10^{-29}$ | $PbJ_2$ | $1{,}1\cdot10^{-9}$ |
| $CdS$ | $1{,}1\cdot10^{-29}$ | $Pb(OH)_2$ | $1{,}1\cdot10^{-27}$ |
| $Pb\ SO_4$ | $1{,}6\cdot10^{-8}$ | $PbS$ | $2{,}5\cdot10^{-27}$ |
| $Sr\ CO_3$ | $1{,}1\cdot10^{-10}$ | $Zn(OH)_2$ | $7{,}1\cdot10^{-18}$ |
| $Sr\ CrO_4$ | $3{,}5\cdot10^{-5}$ | $ZnS$ | $1{,}6\cdot10^{-24}$ |
| $Sr\ C_2O_4$ | $5{,}5\cdot10^{-8}$ | $Zn\ CO_3$ | $1{,}4\cdot10^{-11}$ |

**Table 9.**

# Constants of dissociation of some acids and bases

| acid | К | pК |
|---|---|---|
| $H_2SO_4$ | $K_1=1{,}4\cdot10^{-2}$<br>$K_2=6{,}0\cdot10^{-8}$ | 1,85<br>7,20 |
| $H_2S$ | $K_1=1{,}0\cdot10^{-7}$<br>$K_2=2{,}5\cdot10^{-13}$ | 6,99<br>12,60 |
| $H_2CO_3$ | $K_1=4{,}5\cdot10^{-7}$<br>$K_2=4{,}8\cdot10^{-11}$ | 6,32<br>10,35 |
| $H_3PO_4$ | $K_1=7{,}1\cdot10^{-3}$<br>$K_2=6{,}2\cdot10^{-8}$<br>$K_3=5{,}0\cdot10^{-13}$ | 2,15<br>7,21<br>12,0 |
| $H_2C_4H_4O_6$ | $K_1=1{,}3\cdot10^{-3}$<br>$K_2=3{,}0\cdot10^{-5}$ | 2,89<br>4,52 |
| $CH_3COOH$ | $K_1=1{,}74\cdot10^{-2}$ | 4,76 |
| $H_2C_2O_4$ | $K_1=5{,}6\cdot10^{-2}$<br>$K_1=5{,}4\cdot10^{-5}$ | 1,25<br>4,27 |
| $NH_4OH$ | $1{,}76\cdot10^{-5}$ | 4,75 |
| $H_2O$ | $1{,}8\cdot10^{-15}$ | 15,74 |
| $Ca(OH)_2$ | $K_2=4{,}0\cdot10^{-2}$ | 2,40 |
| $Cu(OH)_2$ | $K_2=7{,}9\cdot10^{-14}$ | |
| $Mn(OH)_2$ | $K_1=3{,}0\cdot10^{-4}$ | |
| $Zn(OH)_2$ | $K_1=4{,}4\cdot10^{-5}$<br>$K_2=1{,}5\cdot10^{-9}$ | 4,36<br>8,83 |

**Table 10.**

# Constants of instability of some complex ions

| Complex ion | $K_{instability}$ | Complex ion | $K_{instability}$ |
|---|---|---|---|
| $[Ag(CN)_2]^-$ | $1{,}4\cdot10^{-20}$ | $[Co(NH_3)_6]^{3+}$ | $6{,}17\cdot10^{-36}$ |
| $[Ag(NH_3)_2]^+$ | $5{,}75\cdot10^{-8}$ | $[Fe(CN)_6]^{4-}$ | $1{,}0\cdot10^{-24}$ |
| $[Ag(NO_2)_2]^-$ | $1{,}48\cdot10^{-8}$ | $[Fe(CN)_6]^{3-}$ | $1{,}0\cdot10^{-31}$ |
| $[Ag(SCH)_2]^-$ | $5{,}37\cdot10^{-9}$ | $[Fe(SCH)_6]^{3-}$ | $5{,}99\cdot10^{-4}$ |
| $[Ag(S_2O_3)_2]^{3-}$ | $3{,}47\cdot10^{-14}$ | $[HgBr_4]^{2-}$ | $1{,}0\cdot10^{-21}$ |
| $[Cu(NH_3)_4]^{2+}$ | $9{,}33\cdot10^{-13}$ | $[HgJ_4]^{2-}$ | $1{,}5\cdot10^{-30}$ |
| $[Co(NH_3)_4]^{2+}$ | $4{,}07\cdot10^{-9}$ | $[Ni(NH_3)_4]^{2+}$ | $3{,}4\cdot10^{-8}$ |
| $[Co(NH_3)_6]^{2+}$ | $8{,}51\cdot10^{-6}$ | $[Zn(NH_3)_4]^{2+}$ | $2{,}0\cdot10^{-9}$ |
| $[Co(SCH)_4]^{2+}$ | $6{,}31\cdot10^{-3}$ | $[Zn(SCH)_4]^{2-}$ | $2{,}0\cdot10^{-4}$ |

**Table 11.**

## The maintenance of chemical elements in a live organism

| Percentage | Elements |
|---|---|
| 10 | O(62); C(21); H(10) |
| 1-10 | N(3) Ca(2) P(1) |
| 0,01-1 | K(0,23) S(0,16) Cl(0,1) Na(0,08) Mg(0,027) Fe(0,01) |
| $10^{-3}$ – $10^{-2}$ | Zn Sr |
| $10^{-4}$ – $10^{-3}$ | Cu Cd Br Si Cs |
| $10^{-5}$ – $10^{-3}$ | J, Sn |
| $10^{-5}$ – $10^{-4}$ | Mn V B Si Cr Al Ba |
| $10^{-6}$ – $10^{-3}$ | Mo Pb Ti |
| $10^{-7}$ – $10^{-4}$ | Be Ag |
| $10^{-6}$ – $10^{-5}$ | Co Ni La Le As Hg Bi |
| $10^{-7}$ – $10^{-5}$ | Se Sb U |
| $10^{-7}$ – $10^{-6}$ | Th |
| $10^{-12}$ – $10^{-4}$ | Ru |

**Table 12.**

## Prevalence of chemical elements in crust

**(on decades of V.I.Vernadsky)**

| Decade | % | Elements |
|---|---|---|
| I. | >10 | O(49,13) Si(26,00) |
| II. | 1-10 | Al(7,45), Fe(4,20), Ca(3,25), Na(2,40), K(2,35), Mg(2,35), H(1,00) |
| III. | $10^{-1}$-1 | Ti(0,61), C(0,35), Cl(0,20), P(0,10), S(0,10), Mg(2,35), H(1,00) |
| IV. | $10^{-2}$ – $10^{-1}$ | F, Ba, N, Sr, Zr, V, Ni, Zn, B, Cu, Sr |
| V. | $10^{-3}$ – $10^{-2}$ | Pb, Li, V, Be, Ce, Co, Th, Nb, Pb, Ga, Mo, Br<br>U, Vb, Dy, Gd, Sm, Er, La, Sn |
| VI. | $10^{-4}$ – $10^{-3}$ | Sc, W, Cs, Cd, As, Pr, Hf<br>Ar, Zr, Ag, Tu, Ao, Tb, J, Ge |
| VII. | $10^{-5}$ – $10^{-4}$ | Se, Sb, Nb, Ta, Eu, Jn, Bi, Tl, Ag |
| VIII. | $10^{-6}$ – $10^{-5}$ | Pd, Pt, Ru, Os, Po, Au, Kh, Gr, Te, He |
| IX. | $10^{-7}$ – $10^{-6}$ | Ne, Re, Tc |
| X. | $10^{-8}$ – $10^{-7}$ | Kr |
| XI. | $10^{-9}$ – $10^{-8}$ | Xe |
| XII. | $10^{-10}$ – $10^{-9}$ | Ra |
| XIII. | $10^{-11}$ – $10^{-10}$ | Pa |

**Table 13.**

## Radiuses of some atom and ions (pm)

| Atom, ion | Kernel charge | Atom | ion | Atom, ion | Kernel charge | Atom | ion |
|---|---|---|---|---|---|---|---|
| $H_3$ $H^-$ | 2 | 53 | 208 | Li $Li^+$ | 3 | 155 | 60 |
| He | 1 | 93 | - | Be $Be^{2+}$ | 4 | 112 | 31 |
| V, $V^{3+}$ | 5 | 98 | 20 | Zn $Zn^{2+}$ | 30 | 138 | 74 |
| C, $C^{4+}$ | 6 | 91 | 15 | Ga $Ga^{3+}$ | 31 | 141 | 62 |
| N, $N^{3-}$ | 7 | 92 | 171 | Ge $Ge^{4+}$ | 32 | 137 | 53 |
| O, $O^{2-}$ | 8 | 73 | 140 | As $As^{5+}$ | 33 | 139 | 47 |
| F, $F^-$ | 9 | 72 | 136 | Se $Se^{2-}$ | 34 | 140 | 198 |
| Ne | 10 | 71 | - | Br $Br^-$ | 35 | 114 | 195 |
| Na, $Na^+$ | 11 | 190 | 95 | Kr | 36 | 112 | - |
| Mg $Mg^{2+}$ | 12 | 160 | 65 | Rd $Rd^+$ | 37 | 246 | 148 |
| Al $Al^{3+}$ | 13 | 143 | 50 | Sr $Sr^{2+}$ | 38 | 215 | 113 |
| Si $Si^{4+}$ | 14 | 132 | 41 | V $V^{3+}$ | 39 | 178 | 93 |
| P, $P^{3-}$ | 15 | 128 | 212 | Zr $Zr^{4+}$ | 40 | 160 | 80 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| S $S^{2-}$ | 16 | 127 | 184 | Nb $Nb^{5+}$ | 41 | 146 | 70 |
| Cl $Cl^{-}$ | 17 | 99 | 181 | Mo $Mo^{5+}$ | 42 | 139 | 62 |
| Ar | 18 | 98 | - | Ru $Ru^{3+}$ | 44 | 134 | 69 |
| K $K^{+}$ | 19 | 235 | 133 | Rh $Rh^{2+}$ | 45 | 134 | 86 |
| Ca $Ca^{2+}$ | 20 | 197 | 99 | Pd $Pd^{2+}$ | 46 | 137 | 86 |
| Sc $Sc^{3+}$ | 21 | 162 | 87 | Ag $Ag^{+}$ | 47 | 144 | 126 |
| Ti $Ti^{4+}$ | 22 | 147 | 68 | Cd $Cd^{2+}$ | 48 | 154 | 97 |
| V $V^{5+}$ | 23 | 134 | 59 | In $In^{3+}$ | 49 | 166 | 81 |
| Cr $Cr^{6+}$ | 24 | 130 | 52 | Sn $Sn^{2+}$ | 50 | 162 | 112 |
| Mn $Mn^{7+}$ | 25 | 135 | 56 | Sb $Sb^{5+}$ | 51 | 159 | 62 |
| Fe $Fe^{2+}$ | 26 | 126 | 76 | Te $Te^{2+}$ | 52 | 160 | 221 |
| Co $Co^{2+}$ | 27 | 125 | 74 | J $J^{-}$ | 53 | 133 | 216 |
| Ni $Ni^{2+}$ | 28 | 124 | 72 | Xe | 54 | 131 | - |
| Cu $Cu^{2+}$ | 29 | 128 | 69 | Cs $Cs^{+}$ | 55 | 267 | 169 |
| Ba $Ba^{2+}$ | 56 | 222 | 135 | Pt $Pt^{2+}$ | 78 | 139 | 96 |
| La $La^{3+}$ | 57 | 187 | 115 | Au $Au^{+}$ | 79 | 146 | 137 |
| Ta $Ta^{5+}$ | 73 | 149 | 73 | Hg $Hg^{2+}$ | 80 | 157 | 110 |
| W $W^{6+}$ | 74 | 141 | 68 | Ta $Ta^{3+}$ | 81 | 171 | 95 |
| Os $Os^{4+}$ | 76 | 135 | 69 | Pb $Pb^{2+}$ | 82 | 175 | 120 |
| Ir $Ir^{4+}$ | 77 | 136 | 66 | Bi $Bi^{3+}$ | 83 | 170 | 120` |

**Table 14.**

# Energy of ionization of some atoms..

| Atom | 1 | Atom | 1 |
|---|---|---|---|
| Hydrogen | 1312 | Sodium | 496 |
| Helium | 2372 | Magnesium | 738 |
| Lithium | 520 | Aluminium | 578 |
| Beryllium | 899 | Silicon | 786 |
| Bor | 801 | Phosphorus | 1012 |
| Carbon | 1088 | Sulfur | 1000 |
| Nitrogen | 1402 | Chlorine | 1251 |
| Oxygen | 1314 | Argon | 419 |
| Fluorine | 1681 | Potassium | 590 |
| Neon | 2081 | Strontium | 549 |
| Scandium | 633 | Yttrium | 600 |
| Titan | 658 | Zirconium | 660 |
| Vanadium | 650 | Niobium | 664 |
| Chrome | 653 | Molybdenum | 685 |
| Manganese | 717 | Technetium | 702 |
| Temir | 762 | Ruthenium | 711 |
| Cobalt | 759 | Rhodium | 720 |
| Nickel | 737 | Palladium | 804 |
| Mies | 745 | Kumush | 731 |
| Rukh | 906 | Indy | 558 |
| Gallium | 579 | Cadmium | 868 |
| Germany | 762 | Kalay | 709 |
| Margimush | 947 | Antimony | 834 |
| Selenium | 941 | Tellurium | 869 |
| Bromine | 1142 | Iodine | 1008 |
| Krypton | 1351 | Xenon | 1170 |
| Rubidium | 403 | | |

**Table15.**

## Solubility of salts and the bases in water at 220C.

| 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | 15. | 16. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1d | 6b | - | - | 1d | 4b | 1d | - | 1d | 5b | 1d | 1 | - | 5b | Aluminum |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Ammonium |
| 5b | 1 | 3a | 4b | 2a | 5g | 4b | 1 | 4d | 1 | 2a | 1 | 1 | 1 | 4b | Barium |
| 4b | 1d | 5b | - | 5d | 1d | 4b | 1d | 5b | 4b | 5b | 1d | 1 | - | 5b | Bismuth |
| - | 1- | 4d | 4b | 5a | 1 | 4b | 1 | 4b | 1 | 4b | - | 1 | - | - | Temir (II) |
| 1 | 1d | 5b | - | 5b | 1d | 1 | - | - | - | 5b | 1d | 1d | 4b | 5b | Temir (III) |
| 1 | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Potassium |
| 3a | 1 | 4a | 4b | 3a | 3g | 5b | 1 | 4a | 1 | 3a | 1 | 1 | - | 4b | Calcium |
| 4b | 1 | 4a | 4b | 5b | 1 | 5b | 1 | 5a | 1 | 5b | 1 | 5b | 5b | 5b | Cobalt |
| 1 | 1 | 4a | 2b | 3a | 1 | 4b | 1 | 4a | 4 | 5a | 1 | 1 | 1 | 4b | Magnesium |
| - | 1 | 4a | - | 5a | 1 | 4b | 1 | 4a | 1 | 5a | 1 | 2 | 4b | 4b | Manganese |
| 2b | 1 | 5b | - | 5v | 1 | 4b | 1 | 4a | 1 | 5a | 1 | 1 | 5b | 5b | Mies (II) |
| 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Sodium |
| 4b | 1 | 5a | 4b | 5v | 1 | 5b | 1 | 4a | 1 | 5b | 1 | 1 | 5b | 5b | Nickel |
| - | 1d | - | - | 5b | 1d | - | - | - | 3b | 5b | 5d | 1 | - | - | Tin |
| 3b | 5v | 5v | - | 5v | 4v | 5b | 1d | 4b | 5v | 5b | 1v | 3v | 4b | 4b | Simob (I) |
| 3b | 2 | 5b | - | 5b | - | 5v | 2g | 5b | 5v | 5a | 3v | 2 | 5b | 5b | Simob (II) |
| 4b | 5g | 5b | 4b | 5v | 3b | 4b | 1 | 4a | 5g | 4a | 5b | 1 | 4b | 5b | Silver |
| 5b | 3b | 5b | 4b | 5v | 4g | 4b | 1d | 5a | 4a | 4a | 3b | 1 | 4b | 5b | Lead |
| 3a | 1 | 5a | 4b | 1 | 4g | 4b | 1 | 4a | 1 | 3a | 1 | 1 | 3b | 3b | Strontium |
| 4d | 1d | 5b | - | 2- | 1d | 3 | 1d | - | 1d | 5a | 1d | 1d | - | 4b | Chrome (III) |
| 3b | 1 | 5a | - | 5b | 1 | 4b | 1 | 4a | 1 | 5b | 1 | 1 | - | 5b | Zinc |
| Chromate | Chloride | Phosphate | Sulphite | Sulfide | Sulphate | Oxalate | Nitrate | Carbonate | Iodide | Hydroxide | Bromide | Acetate | Arsenite | Arsenate | |

# THE MAINTENANCE.