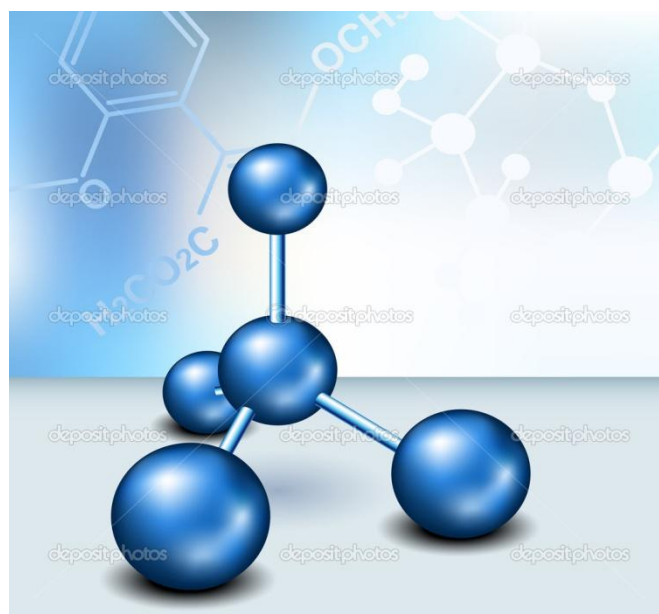**Orenburg State Medical University**

Department of Chemistry and Pharmaceutical Chemistry

Department of Foreign Languages

SYSTEMATIC COURSE
practical lessons in chemistry for foreign students

Orenburg, 2015

Authors:

Professor Krasikov S.I., Assistant Professor Sharapova N.V., Assistant Professor Zabolotnaya S.G., Assistant Kuzmicheva N.A., Assistant Karmanova D.S.

Consultant: Assistant Professor Korovina I.A.

Guidelines are intended for self-study and conducting practical task in chemistry for 1-st year students studying in medical educational institutions. Guidelines content are consistent with the program in chemistry, approved by the Ministry of Health of Russia.

The main purpose of teaching chemistry is the formation of the initial level of students' knowledge for successful study of chemical and special disciplines, a necessity to inculcate students with skills of chemical thinking, the ability to pre-see the possibility of interaction between substances and the nature of the products of their chemical transformations. Performing laboratory work contributes to deepening and assimilation of the theoretical material and the formation of experimental skills for practical work. These methodological guidelines are presented in the form of workbooks (module 1, module 2) and correspond to the curriculum subjects, as well as program requirements for chemistry is to educate students of higher medical education. Instructions correspond to the volume number of hours for studying this discipline in the curriculum.

Organizations of educational processes are carried out on credit-modular system in accordance with the terms of the Bologna process.

Contents

Introduction

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Module 1. General chemistry: Structure of matter. The doctrine of solutions.

1. Basic concepts and laws of chemistry.

2. The structure of compounds. Basic theoretical concepts about the structure of atom. Contemporary interpretation of the periodic law of D.I. Mendeleev on the basis of electronic theory of atom. Theory of chemical bond. Structure of molecule.

3. Classes and the nomenclature of inorganic compounds.

4. The doctrine of solutions. Preparation of solutions with a given mass fraction. Colligative properties of solutions. Osmose.

5. The buffer system.

Module 2. Biopolymers and their structural components.

6. Carbohydrates, structure and chemical properties. Monosaccharides, structure and chemical properties

7. Olygo-and polysaccharides, structure and chemical properties.

8. Higher fatty acids. Lipids. Phosphoglycerides.

9. The structure and chemical properties of α -amino acids.

10. Nucleic acids, composition, structure and biological significance.

Each lesson is organized according to the following plan: the relevance of the topic, general purpose, the concrete goal to be able to; literature (basis, additional); issues to be studied; questions for extracurricular self-study, standards of problem solving, task for the material, the algorithm of the laboratory work.

RULES AND SAFETY IN THE LABORATORY FOR INORGANIC CHEMISTRY

General rules

1. Laboratory course is permitted only when students are closely acquainted with the subject of work, learn theoretical material with the help of textbooks, manuals and lecture notes, record the equations of respective reactions in the laboratory magazine.

2. Duty of students is to receive the necessary work for the group equipment and reagents, and places them in the workplace.

3. In the chemical laboratory, it is permitted to work only when a white robe and cap are put on. Each student is given a permanent working place, which he or she should keep clean; do not clutter up foreign objects that are unrelated to what is being studied. Disorder and carelessness in carrying out experiments often lead to necessary repetition of the experiment.

4. When heating and boiling solutions, the tube must be pinch cocked and keep the tube so that its opening is directed in the opposite direction from those who work around.

5. You cannot lean over the test tube which is being heated or heating fluids so it does not hit in the face.

6. In those cases, if there is a need to check the smell of substances in the tubes there should be a slight movement of the palm of hand to direct the flow of air from the tube to him/her and gently sniff.

7. Reagents, distilled water, electrical energy in the laboratory should be used sparingly.

8. All the work with substances which are obtained during the interaction are harmful to the mechanism of organic gases or substances with an unpleasant smell, should be carried out in a specially reserved for this purpose rooms with forced ventilation, or under the hood. Categorically prohibits work with these substances at the work place.

9. Solutions, with compounds containing silver, mercury, lead and iodide ions should be poured into a separate bowl for further regeneration.

10. Categorically it is forbidden to perform experiments that are not related to the laboratory work.

11. After completion of work, clean the tubes, show your work, clean your desk, turn off heaters, electric lights, water, and wash your hands.

Rules for the treatment with reagents

- For experiments solutions and solids are taken in amounts required by the experimental method;
- Reagents remain in closed beakers with lids to prevent contamination;
- Solid reagents are selected carefully with a sPartula;
- Liquid reagents which are in the droppers, measure drops;

- The excess reagent should be spilled and poured into dishes from which it should be taken to prevent contamination of reagents;
- Concentrated solutions of acids and alkalis, toxic substances should be reserved closets where they are worked with.

Working with acids and bases

1. While working with concentrated acids and alkalis, one needs to be cautious and to ensure that they have not got on skin and clothes.

2. At the dilution of concentrated sulphuric acid, one should be careful and gradual but acid must be added to water, not vice versa. This is due to the fact that the dilution of sulphuric acid-slots causes a large amount of heat. Therefore, when water is added to the acid of the solution it can be sprayed, and can get on skin and clothing.

Working with harmful and poisonous substances

While working with harmful and toxic substances (cyanide, salts of barium, mercury, lead, arsenic, mercury metal, sulfide, etc.) it is necessary to ensure that hazardous or toxic substances are not included in the body through the gastrointestinal tract. Food consumoton in the laboratory is strictly prohibited. After working in the laboratory one must have a good wash of the hands. It is necessary to cylinders filled with mercury or its devices put on a special stand that in case of damage to the device main mass of mercury got on the stand rather than on a desktop or floor.

Working with flammable substances

1. While working with diethyl ether, alcohols, benzene and other combustible matter, or properties, their heat is carried out in a water bath in a flask with a reverse refrigerator.

2. In the laboratory these substances should be stored in tightly sealed jars of a small capacity.

3. Test tubes and beakers with combustible substances should be kept at a sufficient distance from the burners. After working with them switch off the burner, and only then, wash the dishes which contained these substances.

4. Combustible, flammable and volatile substances cannot be stored close to the flame, or very hot electric devices (thermostats, electronic, etc.).

5. Alkaline metals should always be kept in a layer of inert against water and moisture kerosene. Alkaline metals and crystalline alkali should be taken only with tweezers or special forceps. One should wear goggles or a mask. After the end of the experiment the remnants of these metals should be moved to a special dish.

Working with substances which form explosive mixture

1. It must be remembered that some gases (hydrogen, carbon disulfide, acetylene, carbon oxide), as well as volatile compounds (benzene, alcohols, hexane,

etc.), vaporize into air to form explosive mixtures with oxygen. So their pair does not accumulate in dangerous quantities in the laboratory; to work with these substances is necessary with under for strong extractor ventilation.

2. Without permission and relevant instructions of the teacher do not heat, do not put in shock substances which form explosive mixtures (chlorates, perchlorates, per-sulfate, etc.).

FIRST AID IN CASE OF ACCIDENTS

At the beginning of each semester the teacher must instruct a group of students on policy compliance rules work in the chemical laboratory and safety equipment. Students must confirm the knowledge of safety rules in their own signatures in a register. If the accident happens, first aid must be provided for a victim:

1. In case of contact of skin with acids, wash this place intensively with water and then 1% solution of ($NaHCO_3$). In case of contact with concentrated sulphuric acid before flushing the damaged skin should be wiped with dry swab.

2. If skin is damaged withalkaline solutions, wash this place with water, but in fact netir acetic acid, citric acid, or a saturated solution of boric acid.

3. If phenol, bromine, and similar substances are poured on skin, immediately wash the damaged area relevant organic solvents (alcohol, ether, etc.).

4. If poisoning by chlorine, bromine, oxides of nitrogen victim must breathe in fumes of dilute solution of ammonia and drink milk.

5. For cuts (a wound), they must be treated with alcoholic solution of iodine and tied.

6. After giving the first aid, there is an urgent need to send a person to the hospital.

MODULE 1.
GENERAL CHEMISTRY. STRUCTURE OF MATTER. THE DOCTRINE OF SOLUTIONS.

Topic 1: Introduction into to the study of General and inorganic chemistry. BASIC CONCEPTS AND LAWS OF CHEMISTRY.

1. Actuality of the topic: Knowledge and possession of the basic laws of chemistry will enable students dispensing chemistry to understand and master the techniques of quantitative research of chemical reactions, stoichiometric calculations of the weight and volume ratios between the reactants, calculations of chemical formulas and equations, the derivation of substances and the reactions that are needed to study these disciplines and in practical activities.

2. Key questions of the theme: Knowledge and possession of the basic laws of chemistry allow students dispensing chemistry to understand and master the quantitative methods of investigation of chemical reactions, stoichiometric calculations of the weight and volume ratios between the reactants, calculations of chemical formulas and equations, the derivation of substances and the reactions needed for studying these disciplines and in practical activities.

3. General aim: Learn basic concepts and laws of chemistry and apply them to solve relevant problems.

4. Actual aims and abilities: Do stoichiometric calculations of weight and volume ratios between the reactants, the calculations of chemical formulas and equations, the derivation of substance and complete the reactions.

5. The main question of the study:
5.1. The law of conservation of mass and energy as a quantitative mapping of constant motion of matter.
5.2. The law of constancy of composition and its modern interpretations.
5.3. Law of multiple relationships.
5.4. Avogadro's law and its consequences.
5.5. Application of the equation of state of ideal gas Mendeleev-Clapeyron to determine the molecular weights of substances.
5.6. Equivalent and the equivalent weight of the elements of simple and complex substances. Equivalent volume.
5.7. Equivalent and the equivalent weight of simple and complex substances in a chemical reaction. The law of equivalents.
5.8. Equivalent and the equivalent weight of the oxidant and reductant.

6. Questions for self study:

6.1. Application of the equation of state of ideal gases Mendeleev - Clapeyron equation to estimate the molecular weight substances (mol. weit of substances).

6.2. Equivalent and the equivalent weight of the oxidant and reductant.

7. Literature:

7.1. Lecture notes.

7.2. Grigorieva, V.V. and others. General Chemistry, 1991, p. 62-85.

8. Standards of solving tasks:

8.1. What data should be used to establish: the molar mass of substances in a gaseous state. A: You need to know the mass (m) a certain volume (V) gas under certain conditions, at room temperature (T) and pressure (P):

1. From the Clapeyron-Mendeleev: $M_x = \dfrac{mRT}{PV}$

Where:

R - universal gas constant (8,31 J/mol · K)

2. If we know the relative density of the gas, the molecular mass can be calculated according to the formula: $M_x = D * M$

Where:

Mx - molar mass of unknown gas;

D - Relative density of the unknown gas;

M - Molar mass of the known gas (usually M (H_2) = 2 g/mol or M (air) = 29 g/mol).

3. If a known mass (m) a certain volume (Vo) of gas under normal conditions:

$M_x = m_0 : \dfrac{V_m}{V_0}$

Where:

Vm - molar volume of any gas under normal conditions (22.4 L / mol).

8.2. What is the relationship between equivalent and molar mass of complex substances?

Answer: To calculate the equivalent mass of acids, hydroxides, oxides, of salts and use the formula: $E_q = \dfrac{M}{n \bullet B}$

Where:

M - molar mass (g / mol)

n - the number of atoms of metal (for salts), hydrogen, which can replace the metal (for acids), and hydroxogroup (for hydroxide);

B - Valence (or oxidation) of metal (for salts and oxides).

8.3. What is the essence of an electrochemical method of establishing an equivalent weight of electrolyte?

Answer: First find the mass of a simple substance, which is deposited on the electrode for electrolysis, for example, salts of a specific item. Next, the equivalent is calculated according to equation of Faraday: $E = \dfrac{m \bullet F}{Q}$

Where:
m - mass of the oxidized or reduced substance;
E - the equivalent of a chemical substance;
Q - the number of Coulomb electric current that passed through the solution;
F - Faraday constant (96,500 Kd)

9. Homework (must be performed in the laboratory notebook):
9.1. Under normal conditions, 500 ml of gas weighs 1,806, find it in the air density and molar mass.
9.2. 0,111 g of gas occupies a volume of 25 ml at 17°C and 101,463 kPa. Calculate the molar mass of gas.
9. 3. Calculate the equivalent weight of CaO, H_3PO_4, $Ba(OH)_2$, $Al_2(SO_4)_3$.
9.4. 1,6 g calcium and 2,65 g of zinc ousted from the acid the same quantity of hydrogen. Find the equivalent of zinc, if the equivalent of calcium is 20.
9.5. Calculate the equivalent weight of $KMnO_4$ as an oxidant which in acidic medium is converted into a salt of manganese (II)?

Topic 2: THE STRUCTURE OF COMPOUNDS

Part 1: BASIC THEORETICAL CONCEPTS ON THE STRUCTURE OF ATOM.

1. Actuality of the topic: Electronic theory of atomic structure explains the physical content of the periodic law of Mendeleev. Knowledge of the topic enables students to find any elements valence, oxidation state and to characterize the properties of that element.

2. Key questions of the theme: Electron theory of atomic structure explains the physical meaning of the periodic law of Mendeleev. Knowledge of the topic enables students to find any elements valence, oxidation states and to characterize the properties of this element.

3. General aim: values of quantum numbers and the rules and principles governing the sequence of filling of atomic orbitals for the electronic image and general: learn the basic of modern quantum-mechanical theory of atomic structure. Electrons apply the formula of atoms and ions of elements.

4. Actual aims and abilities: Learn examples of radiopharmaceuticals used for healing and disease diagnosis.

5. The main question of study:

5.1. The planetary model of atom and its contradiction. Experimental studies confirm the complex structure of atom. Bohr's postulates.

5.2. Wave-corpuscle duality of the electron, the equation of de-Broglie, Heisenberg's uncertainty principle. Motion of electrons in atom. Atomic orbitals.

5.3. Quantization of energy in the micro particles. Electronic energy levels. Quantum numbers: characteristics, importance (important, the orbital shape of s, p, d, f - orbitals, magnetic). The orientation of atomic orbitals, the spin quantum number.

5.4. Principles and rules of filling of atomic orbitals by electrons: the principle of lowest energy, the Pauli principle, Hund's rule and Klechkovskogo. Electric and electronic graphic formula of atoms and ions.

5.5. Natural and artificial radioactivity. Toxic effect of radionuclides, radiopharmaceuticals in the treatment and diagnosis of diseases.

6. Questions for self study:

6.1. Natural and artificial radioactivity. Toxic effect of radionuclides, radiopharmaceutical drugs for treatment and diagnosis of diseases.
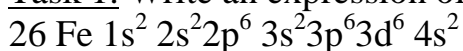
7. Literature:

7.1. Lecture notes.
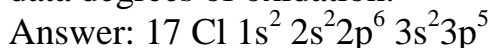
7.2. Glinka L.G. General chemistry. L.A.: 1986.

7.4. Olenin S., Fadeev, G.N. Inorganic Chemistry. G.: 1979. p.68-72, 76-80, 83-85, 91-93.
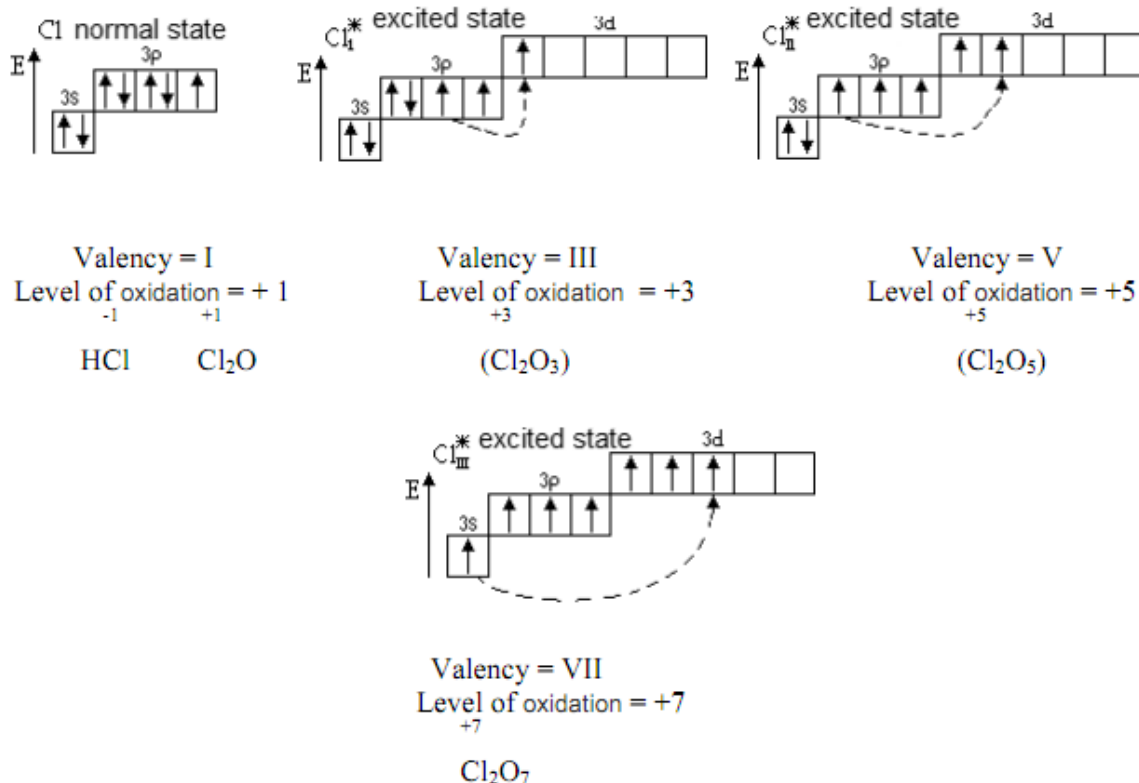
8. Standards of solving tasks:

Task 1. Write an expression of iron (Fe, z = 26).
26 Fe $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^6\ 4s^2$

Task 2. Write electro-graphical formula of chlorine in normal and excited states, to establish equivalency, the degree of oxidation and provide examples of compounds with data degrees of oxidation.
Answer: 17 Cl $1s^2\ 2s^2 2p^6\ 3s^2 3p^5$

Cl normal state
Valency = I
Level of oxidation = + 1
HCl ($^{-1}$)   Cl$_2$O ($^{+1}$)

Cl_I^* excited state
Valency = III
Level of oxidation = +3 ($^{+3}$)
(Cl$_2$O$_3$)

Cl_{II}^* excited state
Valency = V
Level of oxidation = +5 ($^{+5}$)
(Cl$_2$O$_5$)

Cl_{III}^* excited state
Valency = VII
Level of oxidation = +7 ($^{+7}$)
Cl$_2$O$_7$

9. Homework (must be performed in the laboratory notebook):

9.1. Leave e-formula of elements with atomic numbers 15, 34 and 53, determined to divide the family, emphasize the valence electrons and for the latter represent the electro-graphical formula in the normal and excited states, determine the valency, the degree of oxidation and provide examples of compounds with given degrees of oxidation.

9.2. Why is s-orbital full in the formation of the first electronic layer?

9.3. What determines the spin quantum number?

9.4. How many entries are the magnetic quantum number, if $l = 1$?

9.5. Complete the following table. The first two rows have been done for you. You may need to look at your periodic table.

Element	Symbol	Protons	Neutrons	Electrons
lithium	Li	3	7-3=4	3
carbon	C	6	12-6=6	6
		72		
				15
			0	
tungsten				

12

Part 2: STRUCTURE OF MOLECULE.

1. Actuality of the topic: Knowledge of this topic will allow students to provide the type and the strength of bonds in chemical compounds and their reactivity. This knowledge can help students understand the issue of sPartial structure and reactivity of chemical compounds in the study of inorganic, organic, biological, an analytic chemistry and other disciplines better.

2. Key questions of the theme:
2.1. Modern ideas about the nature of chemical bonds. Bond characteristics: energy, length, bond angle.
2.2. Covalent bond. The method of valence bond (VB). Two-electron chemical bond on Geytleru-London (on the example of education H_2).
2.3. Exchange and donor-acceptor mechanism of covalent bond formation.
2.4. Properties of covalent bond: saturation, direction, polarization ability.
2.5. Education σ and π bonds, of bonds in accordance with the method of OT.
2.6. Formation of the covalent bond in the excited atoms. Hybridization of atomic orbitals and the sPartial structure of molecules.
2.7. Determination of the valence of OT method.

3. General aim: Apply the method of valence bonds to determine the shapes of molecules and their polarity and molecular orbital method for determining the magnetic properties and staining substances. Analyze the advantages and disadvantages of these methods.

4. Actual aims and abilities: Depending on the type of intermolecular interaction explain the properties of substances in liquid, gaseous or liquid state.

5. The main question of the study:
5.1. Fundamentals of molecular orbitals (MOs) methods. Binding the gap-board and nonbonding molecular orbitals. Their energy and shape.
5.2. Energy diagrams of molecules that the formation of atoms of elements I and II periods of the periodic table of elements. Multiplicity of communications for the MO method.
5.3. Ionic bond and its properties: unsaturated, non-directional. Structure and properties of compounds with ionic bonds.
5.4. Metallic bond.
5.5. Intermolecular interaction and its nature. Orientation, induction and dispersion interaction.
5.6. Hydrogen bond and its types. The role of hydrogen bonding in biological systems.

6. Questions for self study:

6.1. Intermolecular interaction and its nature. Orientation, induction and the dispersion interaction.

7. Literature:
7.1. Lecture notes.

7.2. Levitin E.Y. and others. General and inorganic chemistry. Textbook. Vineyard: NEW BOOK, 2003 .- with. 61-98.
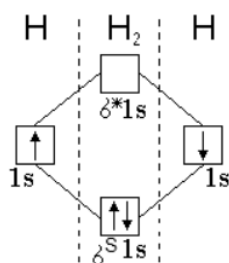
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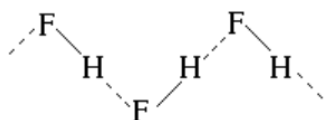7.5. Grigorieva, V.V. and others General Chemistry, 1991, p. 62-85.

8. Standards of solving tasks:
8.1. Write the energy diagram filling of the MO in the hydrogen molecule.
Solution:

8.2. Show the hydrogen bond between molecules of hydrogen fluoride.
Solution:

9. The task to consolidate the material:
9.1. Draw energy diagrams of the following molecules: F_2, N_2, NO, CO.

9.2. By the example of water molecules show schematically the formation of hydrogen bonds. What is the biological role of hydrogen bonding?
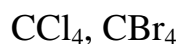
10. Additional Questions

1. Write electron dot formulas for each of the following:
  - chlorite ion
  - sulfur hexafluoride
  - BCl_4^+

2. Circle the most correct answer.
A. Which has the higher melting point?
  CCl_4, CBr_4
B. Which has the lower melting point?
  NaF, NaI

C. Which is harder?

CO_2, SiO_2

D. Which has the strongest intermolecular forces?

PCl_3, BCl_3, BH_3

E. Which has the higher melting point?

$MgCl_2$, BCl_3, BI_3

3. Make a sketch showing the structure of SiO_2.

4. Give formulas for the following compounds:

aluminum oxide, magnesium hydroxide, silver iodide, cobaltous phosphate, ferric arsenate, chromic perchlorate, lithium dihydrogen phosphate, cuprous hypoiodite, ammonium bromate, auric sulfite, cadmium nitride, ferrous sulfide, nickel nitrite, barium sulfate

5. Name the following compounds:

Rb_2O, K_3PO_3, $Ni(ClO_2)_2$, HgF_2, $PbCO_3$, $Mn(OH)_2$, $BaHPO_4$, $CsNO_3$, $Ca(HCO_3)_2$, $Fe(CN)_3$, H_3PO_2

Part 3: THEORY OF CHEMICAL BOND.

1. Actuality of the topic: Knowledge of the topic will allow students to provide the type and the strength of bonds in chemical compounds and their reactivity. This knowledge can help students understand the issue of sPartial structure and reactivity of chemical compounds in the study of inorganic, organic, biological, and analytic chemistry, and other disciplines better.

2. Key questions of the theme:

2.1. Modern ideas about the nature of chemical bonds. Bond characteristics: energy, length, bond angle.

2.2. Covalent bond. The method of valence bond (VB). Two-electronic chemical bond on Geytleru-London (on the example of education H_2).

2.3. Exchange and donor-acceptor mechanism of formation of a covalent bond.

2.4. Properties of covalent bond: saturation, direction, polarization ability.

2.5. Education σ and π bonds, bonds in accordance with the method of OT (OT-method).

2.6. Formation of the covalent bond in the excited atoms. Hybridization of atomic orbitals and the sPartial structure of molecules.

2.7. Determination of the valence of the OT method.

3. General aim: Learn the basic concepts of modern theory of chemical bonding.

4. Actual aims and abilities: Classify the types of chemical bonds to explain the properties of substances depending on the type of bond in the molecule.

5. The main question of the study:

5.1. Modern ideas about the nature of chemical bonds. Bond characteristics: energy, length, bond angle.

5.2. Covalent bond. The method of valence bond (VB). Two-electron chemical bond on Geytleru-London (on the example of education H_2).

5.3. Exchange and donor-acceptor mechanism of formation of a covalent bond.

5.4. Properties of covalent bond: saturation, direction, polarization ability.

5.5. Education σ and π bonds, of bonds in accordance with the method of OT.

5.6. Formation of the covalent bond in the excited atoms. Hybridization of atomic orbitals and the sPartial structure of molecules.

5.7. Determination of valence on the method of OT.

6. Questions for self study:

6.1. Formation of the covalent bond in the excited atoms. Hybridization of atomic orbitals and the sPartial structure of molecules.

7. Literature:

7.1. Lecture notes.

7.2. Levitin E.Y. and others. General and inorganic chemistry. Textbook. Vineyard: NEW BOOK, 2003 .- with. 61-98.

7.3. Glinka L.G. General chemistry. L.A.: 1986.

7.4. Olenin S., Fadeev, G.N. Inorganic Chemistry. G.: 1979. p.68-72, 76-80, 83-85, 91-93.

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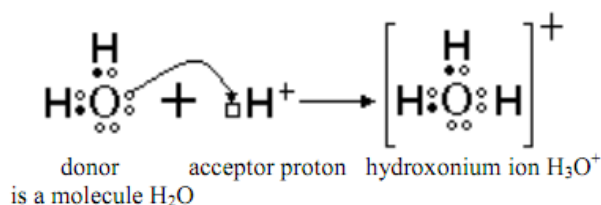## 8. Standards of solving tasks:

8.1. How many electron pairs are involved in the formation of a bond in a molecule of water?

Show e-formula. Answer: 2 (two).

8.2. Leave scheme for the formation of the cation hydroxal.

Answer:

8.3. Determine the type of hybridization of atomic orbitals, the sPartial structure and valence limited angle in the following molecules: H_2O, NH_3, CH_4, $BeCl_2$, BCl_3.

Answer:

H_2O: atom oxygenation in sp^3-hybridization state, the angular shape of the molecule, the angle of 104.5 D;

NH_3: Nitrogen atom in a state of sp^3-hybridization, pyramidal shape of the molecule, the angle of 107.3 D;

CH_4: carbon atom in a state of sp^3-hybridization, the tetrahedral shape of the molecule, the angle 109°28;

$BeCl_2$: beryllium atom in a state of sp-hybridization, the shape of the molecule is linear, angle 180°;

BCl_3: boron atom in a state of sp^2-hybridization, the shape of the molecule plane, the angle 120°.

9. Homework (must be performed in the laboratory notebook):

9.1. Determine the type of hybridization of atomic orbitals, the sPartial structure and valence limited angle in the following molecules: H_2S, PH_3, $SiCl_4$, $MgCl_2$, $AlCl_3$.

9.2. In what compounds there are only σ-bond (the answer motivate):

a) carbon dioxide;

b) in hydrogen chloride;

c) oxygen;

d) fluorine;

d) hydrogen.

9.3. If there are bond rotations of carbon atoms relative to each other but impossible.

Part 4: CONTEMPORARY INTERPRETATION OF THE PERIODIC LAW OF D.I. MENDELEEV ON THE BASIS OF ELECTRONIC THEORY OF ATOM.

1. Actuality of the topic: Knowledge of the periodic law and the structure of the periodic system is of great importance in the study of general chemistry and chemistry of elements. Ability to use the laws of the periodic system in periods and in groups allows students to characterize the properties of elements and their compounds.

2. Key questions of the theme: Knowledge of the periodic law and the structure of the periodic system is of great importance in the study of general chemistry and chemistry of the elements. Ability to use the laws of the periodic system the periods and in groups will allow students to characterize the properties of elements and their compounds.

3. General aim: Assimilate modern definition of periodic law and the physical meaning of the law of periodicity.

4. Actual aims and abilities: Interpret the frequency change of the atomic radius, ionization energy, electron affinity, electro negativity and chemical properties

of simple substances and compounds of elements based on the electronic structure of atoms.

5. The main question of the study:

5.1. Formulation of the periodic law of D.I. Mendeleev and the modern-formula of the periodic law. Law Moseley.

5.2. The structure of the periodic table of elements: time, group, subgroup, s, p, d, f - a family of elements.

5.3. Periodic behavior of the atomic properties of elements in a gaseous state as a function of changes in their electronic structure: the atomic radii, ionization energy, electron affinity, the relative electro negativity.

5.4. Metallic, nonmetallic and redox properties.

5.5. Internal and secondary periodicity.

5.6. Periodicity of chemical properties of elements and their compounds. The physical content of the periodic law.

6. Questions for self study:

6.1. Periodicity of chemical properties of elements and their compounds. The physical meaning of the periodic law.

7. Literature:

7.1. Lecture notes.

7.2. Levitin E.Y. and others. General and inorganic chemistry. Textbook. Vineyard: NEW BOOK, 2003 .- with. 61-98.

7.3. Glinka L.G General chemistry. L.A.: 1986.

7.4. Olenin S., Fadeev, G.N. Inorganic Chemistry. G.: 1979. p.68-72, 76-80, 83-85, 91-93.

7.5. Grigorieva, V.V. and others. General Chemistry, 1991, p. 62-85.

8. Standards of solving tasks:

8.1. For the elements of the III period taking consideration in to ascending serial number form higher oxides and indicate their acid-base character.

Na_2O; CaO; Al_2O_3; SiO_2; P_2O_5; Cl_2O_7

base   base   amf.   acid   acid.   acid

8.2. What kind of connection with hydrogenated and oxygenic form elements of the main

$$Э^{-2}H_2; \quad Э^{+4}O_2; \quad Э^{+6}O_3.$$

9. Homework (must be performed in the laboratory notebook):

9.1. Using the periodic law consider the formula of phosphorus compounds with hydrogen and oxygenic and give a general characterization of these compounds.

9.2. Using the periodic law give answers to questions such as:

a) some of the elements have a greater electro negativity of P and Cl? Why?

b) specify the nature of these chromium oxides: CrO, Cr_2O_3, CrO_3, and confirm the corresponding equations of reactions.

c) for the elements of the formula II period what causes higher oxides and specify their nature.

Topic 3: BASIC CLASSES OF INORGANIC COMPOUNDS.

1. The actuality of the topic: Representatives of the basic classes of inorganic compounds are widely used in medicine as medical products and chemicals. The study and knowledge of chemical properties is essential for further possible use of them for therapeutic purposes.

2. Key questions of the theme: Representatives of the basic classes of inorganic compounds are widely used in medicine as drugs and chemicals. Study and knowledge of chemical properties are essential for further possible use of them for therapeutic purposes.

3. General aim: Classify simple and complex matter depending on their composition and the presence of functional groups. Explain the chemical properties of substances with a certain class of chemical reactions.

4. Actual aims and abilities: Demonstrate knowledge of nomenclature of inorganic compounds with specific examples.

5. The main question of the study:
5.1. Simple matter: metals and nonmetals.
5.2. Complex substances: binary, tertiary, complex.
5.3. Oxides of: single, double, polymer. Peroxides and superoxide. Use of Nomenclature.
5.4. Hydroxides: basic, acidic, amphoteric. Nomenclature Application.
5.5. Acid. Ortho-, iso-and polyforms acids. Application.
5.6. Salt. Classification. Nomenclature. Application.
5.7. The dependence of acid-base forms and properties of oxides and hydroxides of the position of the elements that they constitute in the Mendeleev periodic table.

6. Questions for self study:
6.1. The dependence of acid-base forms and properties of oxides and bases from the position of elements which form in the periodic table of Mendeleev.

7. Literature:
7.1. Lecture notes.
7.2. Glinka L.G. General chemistry. L.A.: 1986.
7.3. Grigorieva V.V. and others. General Chemistry, 1991, p. 62-85.

8. Standards of solving tasks:

8.1. Give examples of oxides: a) acid b) basic c) amphoteric d) indifferent.

acid _____

basic _____

amphoteric _____

indifferent _____

8.2. Write IUPAC name of these substances:
a) acids: H_2SO_4 , H_3BO_3, H_2SO_3, H_2S.
b) the grounds of: $Fe(OH)_2$, $Fe(OH)_3$, $Cr(OH)_3$.
c) oxides: N_2O, NO, Mn_2O_7, N_2O_3.
d) salts: $Al_2(SO_4)_3$, $FeOHCl_2$, Na_3PO_4, $Ca\,(HCO_3)_2$.

8.3. Complete reaction equation:

$K_2O+ZnO=$_____

$CaO+Cl_2O_7=$_____

$Ca(H_2PO_4)_2+Al_2(SO_4)_3=$_____

8.4. Write the equation of dissociation of the following electrolytes: H_2SO_4, $Al_2(SO_4)_3$, H_3PO_4, $Cr(OH)_2Cl$.

8.5. Make the reactions necessary for the following transformations:
a) $Ba\rightarrow BaO\rightarrow BaCl_2 \rightarrow Ba_3(PO_4)_2\rightarrow BaSO_4$;
б) $Zn \rightarrow K_2ZnO \rightarrow ZnCl_2 \rightarrow Zn(OH)_2 \rightarrow Na_2[Zn(OH)_4] \rightarrow ZnSO_4$
в) $C \rightarrow CO\rightarrow CO_2 \rightarrow Na_2CO_3\rightarrow NaHCO_3 \rightarrow Na_2CO_3\rightarrow CaCO_3\rightarrow Ca(HCO_3)_2 \rightarrow CaCO_3$.

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QUESTIONS FOR SELF STUDY

Calculations of chemical equations.

</div>

1. Actuality of the topic: Ability to make calculations based on chemical equations needed to study the following disciplines of organic, analytical, physical, colloid chemistry, etc.

2. Key questions to the theme: Ability to make calculations based on chemical equations is needed to study the following disciplines of organic, analytical, physical, colloid chemistry, etc.

3. General aim: To be able to complete the reactions, pick the stoichiometric coefficients and do stoichiometric calculations of mass and volume of the reactants with the reactions using the law of conservation of mass of substances.

4. Actual aims and abilities: Do it stoichiometric calculations of weight and volume ratios between the reactants, the calculations of chemical formulas and equations.

5. The main question of the study:
5.1. What shows the chemical formula.
5.2. Structure of the chemical equation. Show the stoichiometric coefficients.
5.3. Calculating the number, masses and volumes of reagents for chemical equations.
5.4. The concept of: - the output of products of the reaction - the mass fraction (the main substance, a component in the mixture; dissolve substance in solution; element in the molecule) - volumetric particle - density.
5.5. Equivalent and the equivalent weight of the oxidant and reductant.
5.6. Equivalent and the equivalent weight of simple and complex substances in the chemical reaction. The law of equivalents.

6. Literature:
6.1. Lecture notes.
6.2. Levitin E.Y. and others. General and inorganic chemistry. Textbook. Vineyard: NEW BOOK, 2003, p.4-14.
6.3. Khomchenko G.P. Collection of problems in chemistry, 1993.

7. Examples of test control:
Task 7.1. Solution that contains silver nitrate weighing 25,5 g was added a solution that contains sodium sulphide, the mass of 7,8g. What mass of sediment isformed at the same time?
Solution:
Write the reaction equation:

$$2AgNO_3 + Na_2S = Ag_2S\downarrow + 2NaNO_3$$
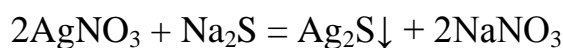
Determine the amount of the substance of silver nitrate and sodium sulphide:

$$v\,(AgNO_3) = \frac{m(AgNO_3)}{M(AgNO_3)} \quad ; \quad (AgNO_3) = \frac{25,5}{170}\,mol = 0,15\,mol;$$

$$v\,(Na_2S) = \frac{m(Na_2S)}{M(Na_2S)} \quad ; \qquad v\,(Na_2S) = \frac{7,8}{78}\,mol = 0,1\,mol.$$

From the reaction equation follows: for the reaction of silver nitrate with the amount of material 2 mols, 1 mol of sodium sulfide. Accordingly:

$$\text{If}\ \ v'\,(AgNO_3) = v\,(AgNO_3);\ v'\,(AgNO_3) = 0,15\,mol,\ then\ \ v'(\,Na_2S\,) = \frac{1}{2}\ v'\,(AgNO_3);$$

$$v'(\,Na_2S\,)\ =\ \frac{0,15}{2}\ mol\ = 0,075\ mol\ ;$$

Where: 0,075 mole - the amount of matter of sodium sulphide required for the reaction is taken in excess. Calculation of amount of substance and weight to the starting material to manufacture, using the mass and the amount of substance that is taken in the lack of, that is, silver nitrate. From reaction equation follows:

$$\frac{(AgNO_3)}{(Na_2S)} = \frac{2}{1}$$

Hence:

$$v(Ag_2S) = \frac{(Ag_2S)}{2}\ mol; \qquad v(Ag_2S) = \frac{0,15}{2}\ mol = 0,075\ mol$$

Determine the mass of silver sulphide:

$$m(Ag_2S) = v\,(Ag_2S) \times M\,(Ag_2S\,);\ \ m(Ag_2S) = 0,075 \times 248g = 18,6g.$$

Task 7.2. A mixture of copper and magnesium chips weighing 1,5 g was treated with excess of hydrochloric acid. The reaction released hydrogen volume of 560 ml (normal conditions). Identify the mass of copper particles in mixture.

Solution. Of the two metals, hydrochloric acid reacts only magnesium:
$$Mg + 2HCl = MgCl_2 + H_2$$
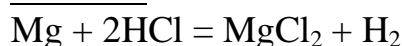
Determine the amount of hydrogen which include:
$$v\,(H_2) = V/V_m\ ;\ \ v\,(H_2) = 0,56l/22,4\ l/\,mol = 0,025\ mol.$$

From the reaction equation follows:
$$v\,(Mg) = v\,(H_2)\ ;\ v\,(Mg) = 0,025\ mol$$

We find the weight of magnesium:
$$m(Mg) = v\,(Mg) \times M(Mg)\,;\ \ Mg\,;\ m(Mg) = 0,025 \times 24g = 0,6g.$$

The mass of copper in the mixture will be:
$$m(Cu) = m_{(mixture)} - m(Mg);\qquad m(Cu) = (1,5 - 0,6)\ g\ =\ 0,9\ g.$$

We expect the mass fraction of copper in the mixture:

$$\omega(Cu) = \frac{m(Cu)}{m_{(mixture)}} = \frac{0,9}{1,5} = 0,6 \quad or \quad 60\%$$

Task 7.3. Determine the mass of salt that is obtained by mixing 40 ml of solution with mass fraction of nitric acid, 0,2 and density 1,12 g/ml with a solution volume of 36 ml of mass fraction of sodium hydroxide and 0,15 density1, 17 g/ml.

<u>Solution.</u> We introduce the notation: m_1 - mass; V_1 - volume; ρ_1 - density of a solution of nitric acid-slots; m_2 - mass; V_2 - volume; ρ_2 - density of sodium hydroxide; m_3 - density of sodium hydroxide; m_3 - density of sodium hydroxide; m_3 - mass of produced solution. We write the reaction equation:

$HNO_3 + NaOH = NaNO_3 + H_2O$
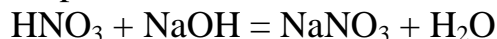
Determine the mass and the amount of substance in a solution of HNO_3:
$$m_1 = V_1 \rho_1 = 40 \times 1,12g = 44,8g;$$
$$m\,(HNO_3) = m_1\,\omega\,(HNO_3)\,; \quad m\,(HNO_3) = 44,8 \times 0,2\ g = 8,96\ g;$$

$$v\,(HNO_3) = m\,(HNO_3)/M(HNO_3)\,; \quad v\,(HNO_3) = \frac{8,96}{63}\ mol = 0,142\ mol.$$

Similarly, we can find the mass and the amount of the substance in a solution of sodium hydroxide:

$$m_2 = V_2\rho_2 = 36 \times 1,12\ g = 42,1\ g;$$
$$m\,(NaOH) = m_2\,\omega\,(NaOH);\ m\,(NaOH) = 42,1 \times 0,15g = 6,32\ g;$$
$$v\,(NaOH) = \frac{m(NaOH)}{M(NaOH)}\,; \quad v\,(NaOH) = \frac{6,32}{40}\ mol = 0,158\ mol.$$

From the reaction equation it follows that the nitric acid of 0,142 mole of a substance will react with sodium hydroxide, the amount of material 0,142 mol, respectively, NaOH taken in excess.

From the reaction equation it follows that:
$$v\,(NaNO_3) = v\,(HNO_3);\ v\,(NaNO_3) = 0,142\ mol\ .$$

To determine the mass of salt which was formed:
$$m\,(NaNO_3) = v\,(NaNO_3) \times M\,(NaNO_3);$$
$$m\,(NaNO_3) = 0,142 \times 85\ g = 12,1$$

The mass of the obtained solution is:
$$m_3 = m_1 + m_2;$$
$$m_3 = (44,8 + 42,1)\ r = 86,9\ g.$$
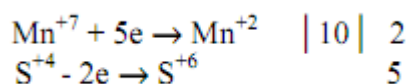
Define mass fraction of salt in the resulting solution:
$$\omega\,(NaNO_3) = \frac{m(NaOH)}{m_3}\,;$$
$$\omega\,(NaNO_3) = = 0,139\ or\ 13,9\%.$$

Task 7.4. A reaction of a sample of technical sodium sulphate spent weighing 9 g solution weight of 40 grams of mass part of potassium permanganate ($KMnO_4$) 7,9%. Determine the mass-equivalent fraction of Na_2SO_3 in the technical sulphite.

The reaction between potassium permanganate and sodium sulfite takes place in the presence of sulphuric acid.

Solution. Equation of the reaction:

$$5Na_2SO_3 + 2KMnO_4 + 3H_2SO_4 = 5Na_2SO_4 + 2MnSO_4 + K_2SO_4 + 3H_2O$$

$$Mn^{+7} + 5e \rightarrow Mn^{+2} \quad |\,10\,| \quad 2$$
$$S^{+4} - 2e \rightarrow S^{+6} \qquad\qquad\quad 5$$

Determine the weight and the amount of matter of potassium permanganate:

$$m(KMnO_4) = m(sol) \times \omega(KMnO_4); \; m = 40 \times 0,079g = 3,16 \text{ g};$$

$$v(KMnO_4) = \frac{m(KMnO_4)}{M(KMnO_4)}; \quad v(KMnO_4) = \frac{3,16}{158} \text{ mol} = 0,02 \text{ mol}.$$

From the reaction of the equation it follows that:

$$\frac{v(KMnO_4)}{v(Na_2SO_3)} = \frac{2}{5},$$

Location:

$$v(Na_2SO_3) = \frac{5}{2} v(KMnO_4); \quad v(Na_2SO_3) = \frac{5 \cdot 0,02}{2} \text{ mol} = 0,05 \text{ mol}.$$

The mass of Na_2SO_3, which is placed in the sample is:

$$m(Na_2SO_3) = v(Na_2SO_3) \times M(Na_2SO_3); \; m(Na_2SO_3) = 0,05 \times 126 \text{ g} = 6,3 \text{ g}.$$

We expect a mass of Na2SO3 in the technical sulphite:

$$\omega(Na_2SO_3) = \frac{m(Na_2SO_3)}{m}; \quad \omega(Na_2SO_3) = \frac{6,6}{9} = 0,7 \text{ or } 70 \%.$$

Task 7.5. To a solution in which the aluminum nitrate weighing 42,6g the solution that contains sodium carbonate was added, the precipitate mass of 37,2g calcined. Determine the mass of residue after calcined.

Solution. Aluminum nitrate - the salt of weak base and strong acid, sodium carbonate - the salt of strong base and weak acid, respectively, two salts in solution are subject to hydrolysis. When mixing the solutions is mutually enhanced hydrolysis, which in this case proceeds in full.

$$2Al(NO_3)_3 + 3Na_2CO_3 + 3H_2O = 2Al(OH)_3 + 6NaNO_3 + 3CO_2 \text{ (a)}$$
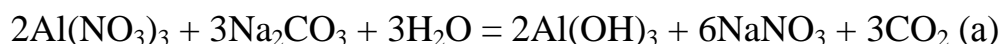
When calcined alumina precipitate is obtained:

$$2Al(OH)_3 = Al_2O_3 + 3H_2O \text{ (b)}$$

Quantities of materials:

$$\nu\,(Al(NO_3)_3) = \frac{m(Al(NO_3)_3)}{M(Al(NO_3)_3)} \quad ; \quad \nu\,(Al(NO_3)_3) = \frac{42,6}{213}\ mol = 0,2\ mol;$$

$$\nu\,(Na_2CO_3) = \frac{m(Na_2CO_3)}{M(Na_2CO_3)} \quad ; \quad \nu\,(Na_2CO_3) = 37,2/106\ mol = 0,35\ mol.$$

From (a) show that for the reaction with 0,2 mol of aluminum nitrate to 0,3 mole of sodium carbonate, sodium carbonate, respectively, taken in excess.

From equations we have (a)

$$\frac{\nu(Al(NO_3)_3)}{\nu(Al(OH)_3)} = \frac{1}{1}$$

From equations we have (b)

$$\frac{\nu(Al(OH)_3)}{\nu(Al_2O_3)} = \frac{2}{1}$$

so:

$$\frac{\nu(Al(NO_3)_3)}{\nu(Al_2O_3)} = \frac{2}{1}.$$

Hence:

$$\nu\,(Al_2O_3) = \frac{\nu(Al(NO_3)_3)}{2} \quad ; \quad \nu\,(Al_2O_3) = \frac{0,2}{2}\ mol = 0,1\ mol.$$

Determine the mass of aluminum oxide obtained after calcination:

$$m\,(Al_2O_3) = \nu\,(Al_2O_3) \times M\,(Al_2O_3)\ ;$$
$$m\,(Al_2O_3) = 0,1 \times 102\ g = 10,2\ g.$$

8. Homework (must be performed in the laboratory notebook):

8.1. A mixture of hydrogen and hydrogen chloride volume of 7 liters (standard conditions) was passed through silver nitrate solution, taken in excess, and received sediment mass was 28,7g. Determine the volume fraction of hydrogen in the mixture.

8.2. Calculate the mass of carbon dioxide (IV), which can be extracted from the interaction of calcium carbonate weighing 7 g of hydrochloric acid, weight 30 grams, in which the mass fraction of chlorine-hydrogen is 20%.

8.3. Calculate the mass of base formation interactions 34 silver nitrate and 21 g barium chloride.

Topic 4: SOLUTIONS.

Part 1: PREPARATION OF SOLUTIONS WITH A GIVEN MASS FRACTION.

1. Actuality of the topic: Examples of solutions. Here are some biological systems: blood plasma, lymph, intracellular fluid, gastric juice and so on. The forms of solutions are used in a lot of medicinal products.

2. Key questions of the theme:
2.1. Mass fraction (in %).
2.2. Molar concentration. Mole fraction.
2.3. Equivalence factor (acids, bases, salts, oxidants).
2.4. Molar mass of equivalent.
2.5. Molar concentration equivalent to (normal).
2.6. Molality concentration;
2.7. Titre solutions;
2.8. Recalculations of different ways of expressing solution concentration.

3. Literature:
3.1. Lecture notes.
3.2. Levitin E.Y. and others. General and inorganic chemistry. Textbook. Vineyard: NEW BOOK, 2003 .- with. 157-169.
3.3. Grigorieva V.V. and others. General Chemistry, 1991, p. 165-167.
3.4. Olenin S., Fadeev, G.N. Inorganic Chemistry, 1979, p.107-110.
3.5. Akhmetov, N.S. Total Inorganic Chemistry, 1988.

4. Standards of solving problems:
4.1. The calculation of the mass fraction of substances in solution.
Task. How many grams of boric acid and water is needed to prepare 250g of solution with mass fraction of 3% boric acid?
Solution: The formula for calculating the mass fraction:

$\omega = m_x/m_s \cdot 100\%$

Hence: $m_x = \dfrac{\omega \cdot m_s}{100}$; $m_{H3BO3} = \dfrac{3 \cdot 250}{100} = 7,5g$
water you need to take: $250 - 7,5 = 242,5g$

4.2. Calculation of the molar concentration of a solution.
Task. How many grams of sodium chloride is necessary for the preparation of 1L solution with $C_M = 2$ mol/l?
Solution: The formula for calculating the molar concentration:

$C_x = \dfrac{m}{Mx \cdot Vp}$, from: $m = C_M.M_x.V_p = 2 \cdot 58,5 \cdot 1 = 117g$

4.3. Calculation of the molar concentration equivalent.

26

Task. How many grams of $KMnO_4$ is required to prepare a 2l solution with C_H = 0,5 mol/l if the analysis are performed in acidic environment?

Solution:

$$C_m = \frac{m}{M_x \cdot f_{eqv.} \cdot V_p} \quad \text{from: } m = C_m\, M_x\, f_{equiv.x}\, V_p = 0,5 \cdot 158 \cdot \frac{1*2}{5} = 31,6g.$$

$$E_x = M_x \cdot f_{equiv.x}$$

4.4. Calculation of molality concentration.

Task. Calculate the molality concentration of the solution prepared with 2g of KOH and 200g of water.

Solution: The formula for calculating molality concentration:

$$b_x = \frac{m_x}{M_x \cdot m_{H2O}} \; ;$$

from: $\quad b_{KOH} = \dfrac{2}{56 \cdot 0,2} = 0,18$ mol/kg.

4.5. Calculation of titer.

Task. Calculate the titer of sulphuric acid, cw = 50% and ρ = 1,4 g/ml.

Solution: The formula for calculating the titer of the solution

$$T_x = \frac{\omega * \rho}{100}$$

from: $T_{H2SO4} = \dfrac{50 \cdot 1,4}{100} = 0,7$ g/ml.

4.6. Relationship of different ways of expressing concentration.

Task. Find the molar concentration equivalent of sulfuric acid solution with mass fraction of 10% (density 1,22, $f_{ekv.}$ = 1/2).

Solution: The formula for the transition from the mass of the particle to a molar concentration equivalent to:

$$C_x = \frac{\omega \cdot \rho \cdot 10}{M_x \cdot f_{eqv.}} = \frac{10 \cdot 1,22 \cdot 10}{98 \cdot 0,5} = 2,38 (mol/l)$$

5. Task for the material:

5.1. Calculate the mass of water that is needed to 50g of sodium chloride solution with mass fraction NaCl 2% for solution with mass fraction of NaCl 0,9%.

5.2. Mass fraction of sulfuric acid in solution 3,2%. Calculate the molar concentration equivalent of sulfuric acid in the solution (ρ = 1,02 g / ml).

5.3. For introducing in to the Partient general anesthesia using sodium oxybutyrate that comes in 10 ml vials in a mass fraction of substance 20%, weight 60 kg Partient. The drug must enter at the rate of 70 mg/kg. How many ml must enter into the Partient?

## Table regarding the expression of different methods of concentration

Method of assessing the content of the solute	ω	C_M, mol/l	C_H, mol/l	T, g/ml
Mass fraction, ω	—	$\omega = \dfrac{C_M \cdot M_x}{10 \cdot \rho}$	$\omega = \dfrac{C_M \cdot E_x}{10 \cdot \rho}$	$\omega = \dfrac{100 \cdot T}{c}$
Molar concentration, C_M	$C_M = \dfrac{10 \cdot \omega(\%) \cdot \rho}{M_x}$	—	$C_M = \dfrac{C_N}{Z}$	$C_M = \dfrac{1000 \cdot T}{M_x}$
Normality, C_N	$C_H = \dfrac{10 \cdot \omega(\%) \cdot \rho}{E_x}$	$C_N = Z \cdot C_M$	—	$C_H = \dfrac{1000 \cdot T}{E_x}$
Titer, T_x	$T_x = \dfrac{\rho \cdot c}{100}$	$T_x = \dfrac{C_M \cdot M_x}{1000}$	$T_x = \dfrac{C_N \cdot E_x}{1000}$	—

6. Laboratory work.

General rules of preparation of solutions.

Weigh the mass of material which is weighed on is hour-glass on the scale. Solvent measure with dimensional glass. Suspended matter is transferred to a volumetric flask. Remains of the substance on the hour glass wash away solvent from the measuring cup.

1._____

2._____

3. _____
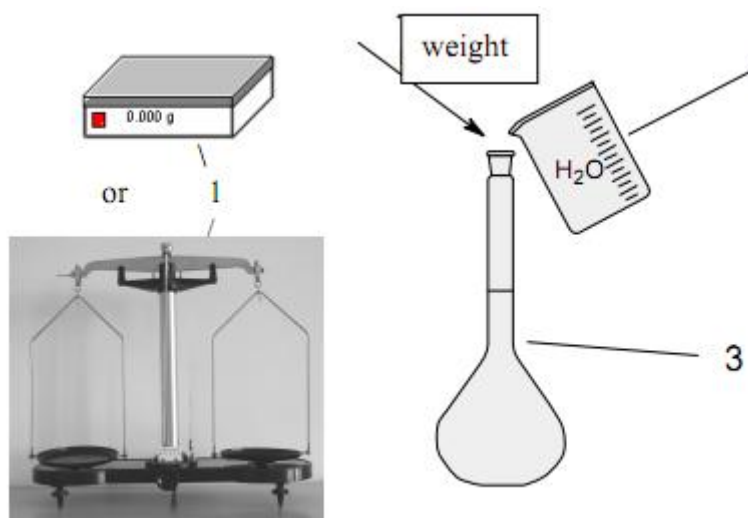
Experiment 1. **Preparation of solutions with a given mass fraction**.

In 135g of water dissolv 15g of salt. What is the mass fraction of salt (in %) in the solution?

Calculations:

$$\omega = \frac{m(salt)}{m(solution)} \cdot 100\% ; \qquad 1) m_{solution} = m_{H2O} + m_{salt} ; \quad m_{solution} = 135g + 15g = 150g ;$$
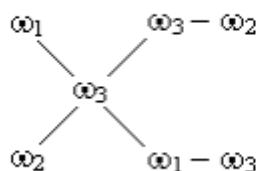
$$2) \omega = \frac{15}{150} \cdot 100 = 10\%$$

Experiment 2. **Preparation of solutions with a given mass fraction for mixing the two solutions.**

Calculate the volume of solution with mass fraction of sulfuric acid 56% ($\rho = 1,460$ g/ml) and water volume which are necessary for the preparation of 100 ml with a mass fraction of sulphuric acid 20% ($\rho = 1,143$ g/ml)

Solution: When mixing solutions use the "rule of the cross "diagonal scheme". In the center of the cross record the mass fraction of solution (w_3) which must be prepared. From left record the concentration of w_1 and w_2. Right record the difference between w_3 and w_2, w_3 and w_1.

The scheme has the general form: **In the example above:**

According to the scheme by 20g solution with $w = 56\%$, you must take 36g water and the weight of the solution is:

$$m = \rho \cdot V = 1,143 \cdot 100 = 114,3g,$$

That is $20 + 36 = 56$ according to the scheme

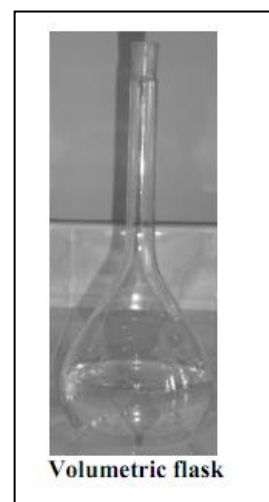Mass of sulphuric acid which is necessary to prepare the solution can be found in the proportion of:

114,3 g of 20% of solution is 56
Xg   20
Xg = 114,3 · 20/56 = 40,82 g

and the volume of the resulting solution: V= 28

$$V = \frac{m}{\rho} = \frac{40,82}{1,460} = 28 \text{ (ml)}$$

To prepare the solution to water:

$$m(\bar{H}_2\bar{O}) = V(H_2O) = 114,30 - 40,82 = 73,48 \text{ g (ml)}$$

Volumetric flask

Reliability of calculations and preparation of sulphuric acid test by determining the density of this solution which is set by using a hydrometer. The tabulated data according to on the density determine the concentration.

Experiment 3. Prepare 0,1 M solution of calcium chloride dissolving crystalohydrate.

Calculate the mass $CaCl_2 \cdot 6H_2O$ which is necessary for the preparation of 50 ml of 0,1 M solution.

Calculations:

$$M(CaCl_2)=111 \text{ g/mol}$$
$$M(CaCl_2 \cdot 6H_2O)=219 \text{ g/mol}$$
$$m(CaCl_2) = C_M \cdot V_{(l)} \cdot M = 0,1 \text{ mol/l} \cdot 0,05l \cdot 111 \text{ g/mol} = 0,555g$$

| 111 g/mol $CaCl_2$ | - | 219 g/mol $CaCl_2 \cdot 6H_2O$ |
| 0,555g | - | X |

$$X = 1,095g$$
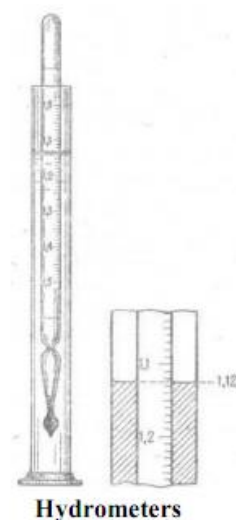
Hydrometers

To prepare 50 ml of 0,1 M solution of calcium chloride we must take 1,095 g crystalohydrate.

Experiment 4. <u>Preparation of solution cultivation of a more concentrated solution.</u>

How much salt solution with mass fraction of 18% is to be added to 46g of water to form a 15% solution.

Calculations:

Let m (solution salt 18%) = xg , then:
$$0,18x =(46 + x) \cdot 0,15$$
$$x = \quad 230$$

To prepare the 15% solution with W = 18% we should take 230g of 18% solution and 46g water.

Part 2: COLLIGATIVE PROPERTIES OF SOLUTIONS. OSMOSE.

1. Actuality of the topic: Osmosis and osmotic pressure plays an important role in osmoregulation - the aggregate of physical, chemical and biological processes that ensure constancy of the osmotic pressure of interstitial fluid, blood, lymph and distribution of water between the tissues and cells. Calculation of osmotic pressure is used in the manufacture of solutions for intravenous medications and eye drops.

2. Key questions of the theme:
2.1. The phenomenon of diffusion in solution. Semipermeable membrane. Osmose.
2.2. Osmotic law of Van't Hof equation for nonelectrolytes and electrolytes.
2.3. Isotonic coefficient, its relation with the degree of dissociation. Solutions: isotonic, hypotonic and hypertonic.
2.4. The biological significance of osmosis: isoosmosis, hemolysis, plasmolysis, turgor.

3. Literature:

3.1. Lecture notes.

3.2. Levitin E.Y. and others. General and inorganic chemistry. Textbook. Vineyard: NEW BOOK 2003 .- with. 170-176.

3.3. L.P. Gardening, V.G. Huhryansky, A.J. Tsyganenko. Biophysical Chemistry, 1985, p.

3.4. M.I. Ravitch-Scherbo, Vladimir Novikov. Physical and Colloid Chemistry, 1975, p. 37-44, 224-226.

3.5. Vladimir Grigoryev and others. General Chemistry, 1991, p. 167-174.

4. Standard test solution control.

Task: Calculate P_{osm}. sodium chloride solution with mass fraction 5,85% at 0° C. The degree of dissociation of sodium chloride 0,96, and $\rho = 1,04$ g / ml.

Solution: We translate the mass fraction in the molar concentration.

$$C = \frac{10 \cdot \omega(\%) \cdot \rho}{M} = \frac{10 \cdot 5,85 \cdot 1,04}{58,5} = 1 \, mol/l$$

Let's calculate the isotonic coefficient:

$$i = 1 + \alpha \, (n - 1) = 0,96(2-1) = 1,96$$

Osmotic pressure is calculated using the formula for the electrolytes:

$$Posm. = iCRT = 1,96 \cdot 1mol/l \cdot 0,082atm/mol \cdot K \cdot 273K = 4,36atm$$

5. Task for the material:

5.1. How many moles of nonelectrolyte are placed in 1 liter of solution at 0° C if Posm. = 1atm?

5.2. Is there an isotonic solution of urea and acetic acid by mass 0,6%, if the degree of dissociation of acetic acid is equal to 0,01, while the density of solutions - 1 g/ml.

5.3. Determine the molar concentration of sucrose solution which is isotonic relative to blood.

5.4. Calculate the isotonic coefficient of calcium chloride solution if the degree of dissociation of calcium chloride is equal to 68%.

6. Laboratory work.

Experiment 1. **Observation osmosis.**

Osmometer is filled with sugar which is colored magnet and is immersed in a vessel with water. Mark entry-level solution in osmometers, and then the level of solution in 0,5 hours to explain the phenomenon that you observe.
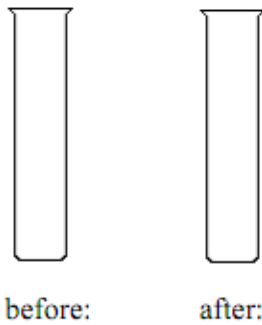
1. _____

2. _____

Conclusion: h - _____
_____
_____
_____

Experiment 2. **Getting inorganic semipermeable membrane.**

Add are poured 2 ml of copper sulphate; crystals of yellow blood salt in a test tube (not stirred). In 20 min. note the result. Write the reaction equation and explain what connection there is in a semipermeable membrane and why "cell" is growing.

Equation:_____
_____
_____

Conclusion: _____

before: after:

Topic 5: THE BUFFER SYSTEMS.

1. Actuality of the topic: Buffer systems support the constancy of the reaction environment of biological fluids in living organisms. Buffer systems are widely used for the practical creation of an environment with a certain pH.

2. Key questions of the theme:
2.1. Determination of buffer system.
2.2. The main types of buffer system.
2.3. Basic equations of the buffer systems. Formula Henderson-Hasselbach"s.
2.4. The mechanism of action of buffer system.
2.5. Buffer capacity. Factors on which it depends.
2.6. Buffer systems of the human body.
2.7. The biological significance of buffer systems.

3. Literature:
3.1. Lecture material.

3.2. M.I. Ravitch-Scherbo, Vladimir Novikov. Physical and Colloid Chemistry, 1975, p.90-97.

4. Standard test solution control.

4.1. Calculating pH of buffer system.

Task. Calculate the pH of buffer system which consists of 100 ml of dilute acetic acid, C = 0,1 mol/l and 200 ml of sodium acetate C = 0,2 mol/l, Kd (acid) = 1,75·10-5.

$$\text{Solution: pH} = -\lg K_d + \lg \frac{Cn_{(salt)} * V_{(salt)}}{Cn_{(acid)} * V_{(acid)}} = -\lg 1,75 \cdot 10^{5} + \lg \frac{V_{(salt)}}{V_{(acid)}} = 5,36.$$

4.2. Quantification of components for the preparation of buffer systems with a certain pH.

Task. Calculate the volume of sodium acetate C = 0,1 mol/l and the amount of acetic acid with C = 0,1 mol/l which must be mixed to prepare 3l of acetate buffer pH = 5,24 (Kd (acid) = =1,75·10-5).

$$\text{Solution: pH} = -\lg K_{\text{д}} + \lg \frac{Cn_{(salt)} * V_{(salt)}}{Cn_{(acid)} * V_{(acid)}} = \lg 1,75 \cdot 10^{5} + \lg \frac{V_{(salt)}}{V_{(acid)}} ;$$

$$\lg \frac{V_{(salt)}}{V_{(acid)}} = 5,24 - 4,76 = 0,48.$$

Antilog of 0,48 is equal to 3. [V (salt)] / [V (acid)] = 3/1. So you need 3 parts of salt solution and one part acid solution for the preparation of buffer systems with pH = 5,24. The volume of salt is: 3000 · 3/4 = 2250ml, and acid 3000 1/4 = 750ml.

5. Homework (must be performed in the laboratory notebook):

Task 1. Calculate the pH of buffer solution that contains 3,6 ml of ammonium chloride solution C = 0,2 mol/l and 2,6 ml of ammonium hydroxide solution C = 0,1 mol/l (Kd(NH$_4$OH)=1,8·10-5).

Task 2. Calculate the volume of acetic acid with C = 0,1 mol/l sodium acetate C = 0,1 mol/l which must be mixed to obtain 150 ml solution pH = 4,94. (Kd (CH$_3$COOH) = 1,75·10-5).

6. Laboratory work.

Experiment 1. **Preparation of buffer systems and the calculation of pH.**

№	Composition of buffer systems (ml) CH$_3$COOH : CH$_3$COONa	Colour	Approximate pH	Estimated pH
1	9,0 : 1,0			
2	1,0 : 9,0			

Add one drop of universal indicator in 1 ml solution obtained. Determine the approximate pH of a color table and calculate the pH with the formula:

$$pH(\text{solution№1}) = -\lg K_d + \lg \frac{C_{H_{(salt)}} \cdot V_{(salt)}}{C_{H_{(acid)}} \cdot V_{(acid)}} = -\lg 1,75 \cdot 10^{-5} + \lg \underline{\quad} =$$

$$pH(\text{solution №2}) = -\lg K_d + \lg \frac{C_{H_{(salt)}} \cdot V_{(salt)}}{C_{H_{(acid)}} \cdot V_{(acid)}} = -\lg 1,75 \cdot 10^{-5} + \lg \underline{\quad} =$$

Experiment 2. **Effect of acid and alkali on the pH of the buffer solution.**

Divide 9 ml of solution № 1 obtained in experiment № 1 equally into 3 tubes: in the first tube 3 drops of hydrochloric acid with C = 0,1 mol/l were added, the second - 3 drops of sodium hydroxide with C =0,1 mol/l. In each tube add 2 drops of methyl red indicator. Compare the color of the solution and draw conclusions.

Conclusion:

Experiment 3. **Effect of dilution on the pH of the buffer solution.**

In 2 tubes evenly divide the solution number 2 obtained in experiment number 1. In the first tube to 2 ml of water. To each tube add 2 drops of methyl red indicator. Compare the color and draw conclusions.

Conclusion:

Experiment 4.

Prepare 10 ml of acetate buffer with a calculated pH 5,24 and determine its approximate pH (see reference 4.2.).

Conclusion:

MODULE 2.
BIOPOLYMERS AND THEIR STRUCTURAL COMPONENTS

Topic 6. CARBOHYDRATES, STRUCTURE AND CHEMICAL PROPERTIES. MONOSACCHARIDES, STRUCTURE AND CHEMICAL PROPERTIES.

1. Actuality of the topic: Carbohydrates are widely spread in living nature they are contained in the cytomembranes. Carbohydrates are the source of energy for human organism. Besides, carbohydrates are the structural elements of nucleic acids, coenzymes, vitamins. Some of them are used as drugs.

2. General aim:
To make the conclusions on reactivity of monosaccharides according to their structure and composition.

3. Actual aims and abilities:
To distinguish the tautomeric forms of monosaccharides;
To learn the methods of monosaccharide determination in the biological liquids.

4. Literature:
4.1. Lecture.
4.2. Zurabyan S.E., Fundamentals of bioorganic chemistry, Moscow, 2004, pp. 225-238.

5. The main questions of the seminar:
5.1. What carbohydrate is.The classification of carbohydrates.
5.2. Glucose:
-non-cyclic form: Fisher projection, D- and L-configuration;
-cyclic form (pyranose and furanose): Heuorse`s projection, α- and β-anomers;
-conformation: α-D and β-D–configuration. Tautorotation (birotation).
5.3. Chemical properties of glucose: formation of helates, O– and N–glycosides, alkylation, acetylation.
5.4. The formulas to know: glucose, fructose, ribose, desoxyribose and their derivatives (glycone, glycarone, glycurone acids, glucosamine's, phosphor esters).
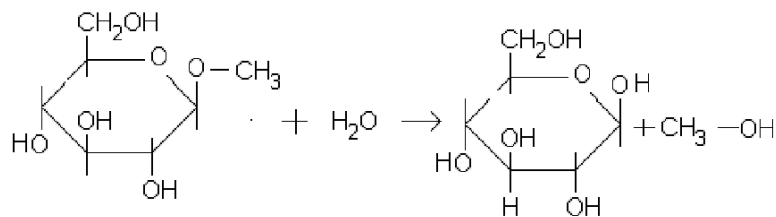

6. The questions for individual learning:
6.1. Ascorbic acid, structure, biological meaning.
6.2. Qualitative reactions on monoatomic alcohols and aldehyde group.
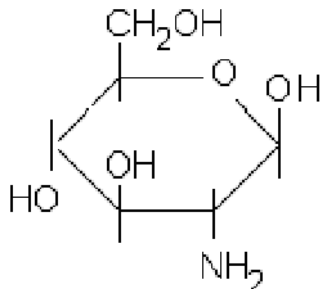6.3. Qualitative reaction on fructose (Selivanov's reaction).

7. Examples of tasks:
7.1. Write the hydrolysis scheme of O–methyl –β–D–glycopyranoside.

7.2. Write the formula of glucosamine.

8. Homework (must be performed in the laboratory notebook).

8.1. Write the equation of interaction between glucose and ethanol. Show the bond type and determine the product.

8.2. Write the equation of fructose alkylation with chloromethane. Show the bond type and determine the product.

9. Example of control test
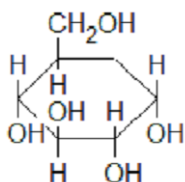
9.1. Write the α-D-glucopyranose formula.

9.2. Write the equation of interaction between α, D-fructofuranose and ethylamine. Determine the product and show the bond type.
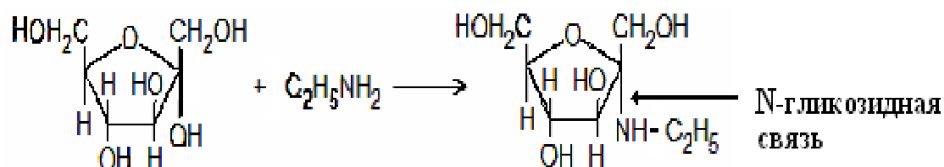
9.3. What is Trommer's reagent and what is it used for?

Answers:

9.1

9.2.

N-ethyl-α,D-fructofuranoside

9.3 $CuSO_4$+NaOH, is used for monosaccharide determination in bioliquids.

10. Laboratory work.

The algorithm of the experiments (must be performed in the laboratory notebook):

1. Demonstration of the presence of hydroxyl-groups in D-glucose.

2. Reduction of copper (II) hydroxide with glucose in alkaline medium (Tromer test).

3. Selivanov reaction for determination of fructose.

Detailed description of experiment:

Experiment 1. **Demonstration of the presence of hydroxyl-groups in D-glucose.**

Put 1 drop of glucose solution, 6drops of NaOH solution, 1 drop of $CuSO_4$ solution in to a test-tube. Note the results, write the reaction equation, make the conclusions.

Experiment 2. **Reduction of copper (II) hydroxide with glucose in alkaline medium (Tromer test).**

Add several drops of water to the solution that appeared in the first experiment. Heat the test-tube until boiling. Mark the results, write the reaction equation and make conclusions.

Experiment 3. **Selivanov`s reaction for fructose determination.**

Put the resorcinol crystal and 2 drops of HCl (conc.) Add 2 drops of fructose solution and heat until boiling. Mark the results, write the reaction equation and make conclusions.

Topic 7. OLYGO-AND POLYSACCHARIDES, STRUCTURE AND CHEMICAL PROPERTIES.

1. Actuality of the topic: combined hydrocarbons are spread in nature, olygo- and polysaccharides are among them. These hydrocarbons are contained in the cytomembranes, and they are also the source of energy in the organism (starch and glycogen). Some of them are used as blood substitutes (polyglycine), as loading of powders and tablets

2. General aim: to make conclusions about reactivity of combined hydrocarbons according to their structure and contents.

3. Actual aims and abilities:

To interpret the specialties of structure and conversion of oligosaccharides in Human organism.

To interpret the specialties of structure and conversion of homopolysaccharides in human organism as of energy source for living processes.

To explain the mechanism of heteropolysaccharides biological role in human organism.

4. Literature:
4.1. Lecture.
4.2. Zurabyan S.E. Fundamentals of bioorganic chemistry, Moscow, 2004, pp. 225-238.

5. The main questions of the seminar:
5.1. What disaccharides are. Classification of disaccharides according to their ability to oxydative-reductive reactions.
5.2. Saccharose structure, lactose structure: reductive abellies and oxy-groups (helates appearance, alkylation, acetylation).
5.3. Homopolysaccharides: starch, glycogen, cellulose, dextranes: composition, structure, primary and secondary structure, chemical properties, biological meaning.

6. The questions for individual learning:
6.1. Starch hydrolysis, qualitative reaction for starch determination.
6.2. Heteropolysaccharides: hyaluronic acid, heparin, chondroitin sulfate, their composition and the structure of disaccharide fragment, biological meaning.

7. Examples of tasks:
7. What are homopolysaccharides (examples)?

8. Homework (must be performed in the laboratory notebook)
8.1. Write the structural formula of lactose, show the bond type between two monosaccharide units.
8.2. Write the structure of cellulose disaccharide fragment and show the bond type between two monosaccharide units.

9. Examples of control test:
9.1. Write the structure of galactose and the scheme of its hydrolysis. What compounds are the reductors in this reaction?
9.2. Write the structure of disaccharide fragment of glucose and show the bond type.
9.3. Write the structure of completely acetylated disaccharide fragment of amilose.
Lactose, glucose and galactose are the reductors.

10. Laboratory work.
The algorithm of the experiments:
1. Demonstration of the presence of hydroxyle groups in saccharose.
2. Demonstration of absence of reductive abilities in saccharose.
3. Demonstration of saccharose hydrolysis.

4. Presence of reductive abilities in lactose.
5. Acidic hydrolysis of starch.

Detailed description of experiment:

Experiment 1. **Demonstration of the presence of hydroxyle groups in saccharose.**

Put 1 drop of saccharose solution and 6 drops of NaOH solution, 5-6 drops of water and 1 drop of copper sulfate solution in to the test-tube. Mark the results, write the reaction equation and make conclusions.

Experiment 2. **Demonstration of absence of reducing properties in saccharose.**

The solution received in the first experiment must be heated until boiling.

Mark the results, make the conclusions.

Experiment 3.. **Demonstration of saccharose hydrolysis.**

Put 1 drop of saccharose solution and 1 drop of HCl solution, 6 drops of water into a test-tube and boil for 1min. Hydrolysed solution put into two test-tubes. Add 6 drops of NaOH solution, 4-5 drops of water and 1 drop of $CuSO_4$ solution in to the first one and heat until boiling. Put the resorcinol crystal, 2 drops of HCl concentrated into the second one and heat until boiling. Mark the results, write the scheme and make the conclusions.

Experiment 4. **The reducing abilities of lactose.**

Put 1 drop of lactose solution, 4 drops of NaOH solution, 1 drop of $CuSO_4$ solution and heat until boiling. Mark the results, write the reaction equations and make conclusions.

Experiment 5. **Acidic hydrolysis of starch.**

Put 1 drop of starch gleu, 2 drops of sulfuric acid in the test-tube and put the test-tube into the boiling water. After 20 and 40 min. Make the qualitative reaction on the starch with one drop of hydrolysed solution. Mark the results, write the scheme of starch hydrolysis and make conclusions.

Topic 8. HIGHER FATTY ACIDS. LIPIDS. PHOSPHOGLYCERIDES.

1. Actuality of the topic:

Knowledge of the structure and chemical properties of lipids and their derivatives is necessary to understand the processes of lipids' metabolism in a human organism and the structure of biological membranes.

2. General aim:

To interpret the regularity of lipid metabolism in order to predict biochemical reactions which are accompanied and stimulated by lipids.

3. Actual aims and abilities:

3.1. To know the structure and chemical properties of lipids and their structural components.

3.2. To be able to use knowledge for understanding of the biological membrane structure and the regularity of the lipid metabolism as the basis of the metabolic changes in human organism.

4. Literature:

4.1. Lecture.

4.2. Zurabyan S.E. Fundamentals of bioorganic chemistry, Moscow, 2004, pp. 238-249.

5. The main questions of the seminar:

5.1. Lipids, saponification lipids (definition).

5.2. Higher fatty acids: saturated and unsaturated, sPartial structure of unsaturated acids, chemical characteristics.

5.3. Fats as triacylglycerols, their composition, structure, classification, chemical properties (hydrolysis, iodine number, peroxide oxidation).

5.4. Phosphoglycerols: composition, structure of phosphatidylcholine, phosphatidylcolamine, phosphatidylserine and their biological meaning.

6. The questions for individual learning:

6.1. Non Saponification lipids (definition).

6.2. Structure of cholesterine, bile acids.

7. Examples of task:
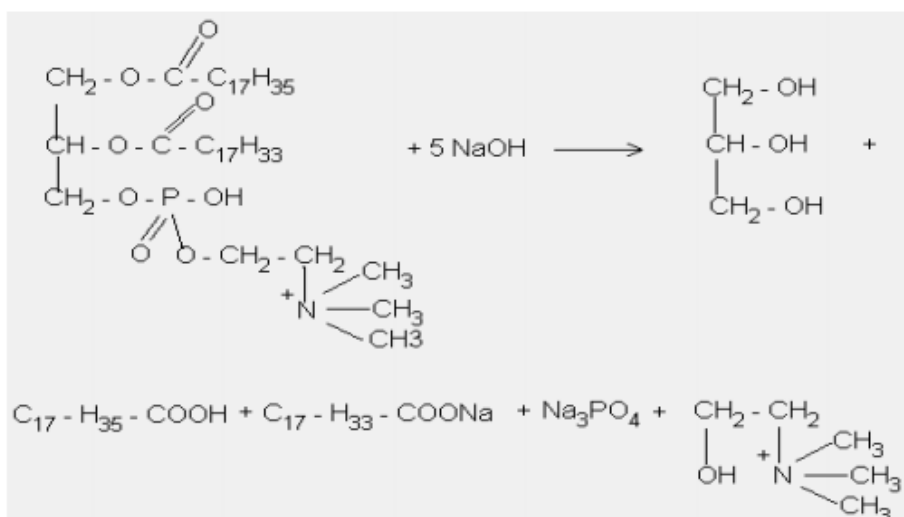
7.1. Write the configuration of oleic acid.

Answer:

7.2. Write the scheme of alkaline hydrolysis of 1 – stearoyl – 2 – oleinoyl – 3– phosphatidylcholine.

Answer:

8. Homework (must be performed in the laboratory notebook):
8.1. Write the reaction equation of alkaline hydrolysis of dioleoylstearine.
8.2. Write the structure of phosphatidylcholine.
8.3. Write the sPartial structure of unsaturated fatty acids: oleic and linoleic.

9. Example of control test:
9.1. Write structure and scheme of alkaline hydrolysis of tristearin.
Answers:
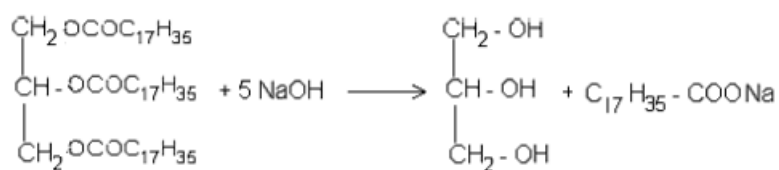
10. The Control Test:
Sample 1
1. Write the formation reaction of 1-O-palmitoyl-2,3-di-O- stearoyl glycerol 2. Write the configuration of linoleic acid.
3. Design the chemical method to distinguish between saturated and unsaturated fatty acids.
Sample 2
1. Write the formation reaction of fat containing one residue of linoleic acid and two molecules of palmitic acid.
2. Write the reaction equation of oxidation of oleic acid by potassium permanganate.
3. Call the products of hydrolysis of oil.
Sample 3
1. Write the reaction equation of interaction between iodine and trioleoylglycerol.
2. Write the differences between fat, oil and waxes.
3. What are the bile acids? Design their general formula.
Sample 4

1. Write the formation reaction of oil.
2. Write the configuration of linolenic acid.
3. What is hydrogenation of fats? Write the scheme of the reaction.

12. Laboratory work.
Experiment 1 **Formation of the fatty drop and its extraction.**
Detailed description:
On the filter paper put 3 separated drops of oil with sizes of 1 cm. Touch the center of the first drop with the tube that contains diethyl ether, the second with benzene and the third with water. Describe the results of the experiment and make the conclusions.

Experiment 2 **Extraction of free fatty acids from soap.**
Detailed description:
In the test tube put 5 drops of saturated soap solution and 1 drop of sulphuric acid. Point the effect, write reaction equation and make the conclusion.

Experiment 3 **Formation of unsolutable calcium salts (unsolutable soap).**
Detailed description:
In the test tube put 5 drops of soap solution and 1 drop of calcium chloride solution. Mix the test-tube. Point the effect, write reaction equation, and make the conclusion.

Experiment 4 **Unsaturated fatty acids reaction.**
Detailed description:
Put 5 drops of oil and 4 drops of bromine water into a test-tube and mix it. Point the effect, write reaction equation, and make the conclusion.

Topic 9. THE STRUCTURE AND CHEMICAL PROPERTIES OF α -AMINO ACIDS.

1. Actuality of the topic:
Amino acids are the sructural element of peptides and proteins. Understanding the structure and chemical properties of amino acids is necessary for realising their reactivity, conversions and biological significance in human organism.

2. General aim:
To use the knowledge of amino acids properties for explanation of structure and function of proteins in human organs.

3. Actual aims and abilities:
3.1. To interpret speciatiles of α -amino acids structure as the structural basis of proteins which have their function in human organism.
3.2. To make conclusions about α -amino acids' ways of conversion in human organism.

3.3. To predict appearance of proteins and other physiologically active compounds on the basis of reactivity and structure of amino acids, understand and predict degradation of aminoacids in human organism.

4. Literature:
4.1. Lecture.
4.2. Zurabyan S.E. Fundumentals of bioorganic chemistry, Moscow, 2004, pp. 211-218.

5. The main questions of the seminar:
5.1. Amino acids: definition, composition, structure.
5.2. Acid-base properties of amino acids.
5.3. Chemical reactions of amino acids by carboxy-group: ester and halogenanhydrydes formation. Biological meaning of these reactions.
5.4. Chemical reactions of amino acids by amino-group: N-acyl derivatives formation, interaction with nitrite acid, formaldehyde, phenylisothyocyanate. Biological significance of these reactions.
5.5. Decarboxylation of amino acids and biological meaning of biogen amines' formation.
5.6. Write down the Fischer projections for the following compounds:
a) L-glutaminic acid; b) L-threonine; c) L-tyrosine;
d) D-isoleucine; e) L-isoleucine.
5.7. Show the structure of cysteine and alanine according to the R, S-nomenclature.
5.8. Write down the proteinogenic amino acids which possess charge at pH = 7,4 (ionogenic amino acids).
5.9. Write the hydrophobic amino acids (aliphatic and aromatic).
5.10. Write the structures of amino acids at the pH = 1, pH = 7,4, pH = 10:
a) Ala; b) Glu; c) Asn; d) His; e) Arg; f) Tyr.
5.11. Write the oxidation reaction of cysteine.
5.12. Write down the reaction of methionine with:
a) acetic anhydride; b) ethanol in the H^+ presence; c) PCl_5.
5.13. Write down the schemas of biologically important reactions:
a) pyruvic acid with Glu;
b) α-oxoglutaric acid with Asp;
c) decarboxylation of His;
d) decarboxylation of 3,4-dihydroxyphenylamine;
e) decarboxylation of Glu;
f) oxidative deamination of Glu;
g) oxidative deamination of 3,4-dihydroxyphenylamine;
h) non-oxidative deamination of Asp;
i) hydroxylation of Phe;
j) hydroxylation of Tyr.

6. The questions for individual learning:
6.1. Classification of amino acids.
6.2. Decarboxylation of amino acids in human organism.

7. Examples of task:
7.1. What types of isomery are typical for α -amino acids.
Answer:

— isomery of amino-group location: α -amino acids and β-amino acids;
— carbon skeleton isomery: leucine-isoleucine;
— Enantiomery: D–methionine and L-methionine.

7.2. Explain the amino acids' amphotericity.
Answer:
Amphotericity is explained by the presence of carboxy-group and amonio-group in amino acids. Carboxy-group is the group with acidic properties, it dissociates with appearance of H^+-ion (or proton); amino-group is the group with basic properties because nitrogen has undivided electron pair. During solution of amino acid in water proton joins nitrogen, making bipolar ion that has carboxylate-anion and protonned amine group, and has positive charge. Amphoteric character of amino acids is also confirmed by their interaction with alkalines as well as with acids making salts.

8. Homework (must be performed in the laboratory notebook):
8.1. Write and learn 20 formules of aminoacids that form proteins; mark irreplaceable aminoacids.
8.2. Write the reaction of interaction between serine and ethanol equation.
8.3. Write the reaction of interaction between asparagine and phenylisothyocyanate equation.
8.4. Write down the Fischer projections for the following compounds:
a) L-glutaminic acid; b) L-threonine; c) L-tyrosine;
d) D-isoleucine; e) L-isoleucine.
8.5. Show the structure of cysteine and alanine according to the R, S-nomenclature.
8.6. Write down the proteinogenic amino acids which possess charge at pH = 7,4 (ionogenic amino acids).
8.7. Write the hydrophobic amino acids (aliphatic and aromatic).
8.8. Write the structures of amino acids at the pH = 1, pH = 7,4, pH = 10:
a) Ala; b) Glu; c) Asn; d) His; e) Arg; f) Tyr.
8.9. Write the oxidation reaction of cysteine.
8.10. Write down the reaction of methionine with:
a) acetic anhydride; b) ethanol in the H^+ presence; c) PCl_5.
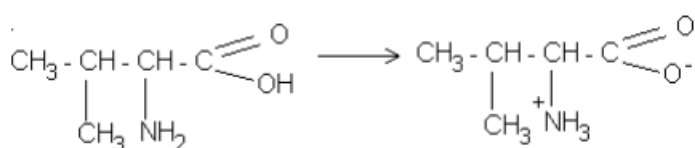8.11. Write down the schemas of biologically important reactions:
a) pyruvic acid with Glu;
b) α-oxoglutaric acid with Asp;
c) decarboxylation of His;

d) decarboxylation of 3,4-dihydroxyphenylamine;
e) decarboxylation of Glu;
f) oxidative deamination of Glu;
g) oxidative deamination of 3,4-dihydroxyphenylamine;
h) non-oxidative deamination of Asp;
i) hydroxylation of Phe;
j) hydroxylation of Tyr.

9. Example of control test:

9.1. Write the scheme of appearance of aminoacid – valine - bipolar ion. What pH does its isoelectrical point located in.
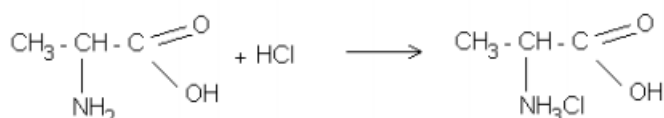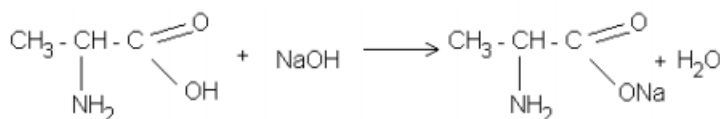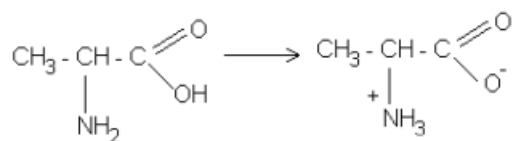
Answers:

$$CH_3-CH-CH-C{\overset{O}{\diagdown}}_{OH} \longrightarrow CH_3-CH-CH-C{\overset{O}{\diagdown}}_{O^-}$$
(with CH_3 and NH_2 substituents on the left; CH_3 and $^+NH_3$ on the right)

IEP is located in subacid medium.

9.2. Write the formulas of three possible alanine salts.

Answers:

$$CH_3-CH-C{\overset{O}{\diagdown}}_{OH} \longrightarrow CH_3-CH-C{\overset{O}{\diagdown}}_{O^-}$$
(with NH_2 on the left; $^+NH_3$ on the right)

$$CH_3-CH-C{\overset{O}{\diagdown}}_{OH} + NaOH \longrightarrow CH_3-CH-C{\overset{O}{\diagdown}}_{ONa} + H_2O$$
(with NH_2)

$$CH_3-CH-C{\overset{O}{\diagdown}}_{OH} + HCl \longrightarrow CH_3-CH-C{\overset{O}{\diagdown}}_{OH}$$
(with NH_2 on the left; NH_3Cl on the right)

10. The Control Test:

Sample 1
1. Write the structural formulas of aromatic amino acids.
2. Write the reaction equation between cysteine and methanol.
3. Write the scheme of decarboxylation of valine.

Sample 2
1. Write the structural formulas of heterocyclic amino acids.
2. Write the reaction equation between arginine and ethanol.
3. Write the reaction equation between alanine and phenylisothiocyanate.

Sample 3
1. Write the structural formulas of monoamino-monocarboxylic acids.
2. Write the reaction equation between lysine and formaldehyde.

3. Write the reaction equation between valine and nitrous acids.
Sample 4
1. Write the structural formulas of oxy amino acids.
2. Write the reaction equation between glycine and ethanol.
3. Write the scheme of decarboxylation of leucine

11. Laboratory work.
Experiment 1 <u>**Compairing of the aminoacids and their appropriate carbon acids power.**</u>
Detailed description:
Put into three test-tubes: into the first - 1ml of distilled water, the second -1ml of acetic acid, the third – 1ml of glycine. Add 2 drops of indicator methyl-red into each draw test-tube. Describe results, conclusions.
Experiment 2 <u>**Glycin and formaldehyde interaction.**</u>
Detailed description:
Put 5 drops of glycin solution and add 1 drop of methyl-red indicator. Note the color. Then add 6 drops of formaline. Describe results, write the reaction equation and make the conclusion.
Experiment 3 <u>**Glycin and nitrite acid interaction.**</u>
Detailed description:
Put 5 drops of glycine solution, 5 drops of $NaNO_2$ solution and 2 drops of CH_3COOH (conc.) into a test-tube. Write the reaction equation, describe the results, and make the conclusion.

Topic 10. NUCLEIC ACIDS, COMPOSITION, STRUCTURE AND BIOLOGICAL SIGNIFICANCE.

1. Actuality of the topic: Nucleic acids are the main carriers of the genetic information in the organism. The knowledge of the structure and chemical properties of nucleic acids and their monomers (nucleotides) is necessary for understanding of chemical principles of structural organization of nucleic acid macromolecules and nucleotide coenzymes for further learning of biochemistry and biology.

2. General aim: to fix the knowledge about the principles of the structure and learn about the principles of the biopolymer-cell components of the primary and secondary structures that is usefull for understanding their biological role.

3. Actual aims and abilities: to analyse the meaning of nucleotides for the construction of nucleic acids and the action of nucleotide coenzyme. To explain the role of vitamins in the formation of that reactions in the body.

4. **Literature**:
4.1. Lecture.

4.2. Zurabyan S.E. Fundamentals of bioorganic chemistry, Moscow, 2004, pp. 225- 238.

5. **The main questions of the seminar**:
5.1. Structural components of nucleic acids, chemical properties. Qualitative reaction.
5.2. Nucleosides: definition, structure, types of linkages, nomenclature, properties.
5.3. Nucleotides: difinition, structure, types of linkages, nomenclature, properties.
5.4. Nucleoside phosphate, the meaning of ATP. The role of nucleotides in the formation of coenzymes.
5.5. RNA and DNA: structure, types, types of linkages, complementary pairs. Biological significance of nucleic acids.
5.6. DNA duplex (Double spiral of DRA). Complementary pairs.

6. **The questions for individual learning**:
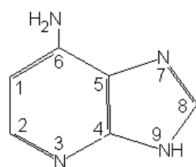6.1. Qualitative reaction on carbohydrate component and phosphoric acid.
6.2. Formation of N-glicosidic and ester bonds.
6.3. The action mechanism of coenzyme NAD^+.
7. **Examples of tasks**:
7.1. Write the structural formula of adenine and point out the pyrrol and pyridine nitrogen atoms.
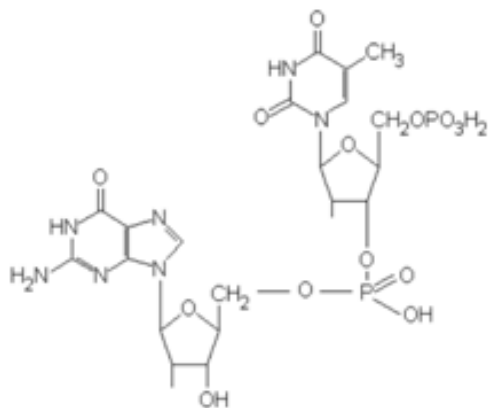Answer.

1,3,7 – pyridine nitrogen atom
9 – pyrrol nitrogen atom

7.2. Write the structure of DNA-GT fragment.
Answer.

8. **Homework (must be performed in the laboratory notebook)**
8.1 Write the structure of cytidine, deoxyguanosine. Point out the lactim-lactam tautomerization.
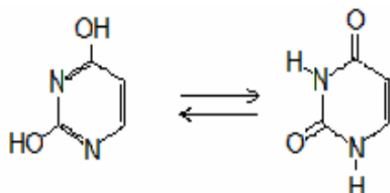
8.2. Write the structure of adenilic and thymidylic acid, point out the types of linkages.

8.3. Write the structure of the dinucleotides DNA: T-G.
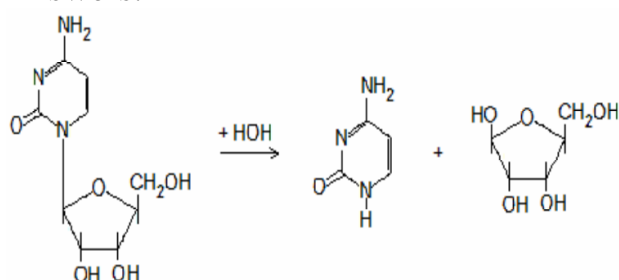
9. **Example of control test**:

9.1. Write the structure of lactim-lactam tautomerization of uracyl.
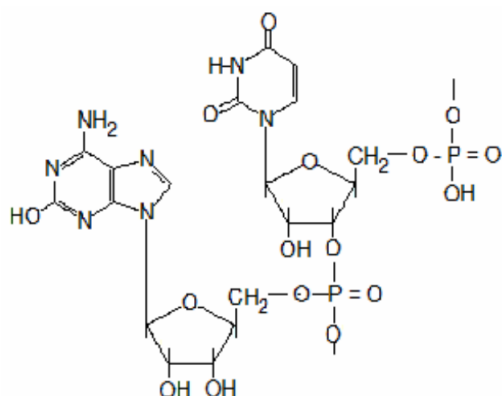
Answers.

9.2. Write the hydrolysis of cytidine.

Answers.

9.3. Write the structure of the dinucleotides RNA: guanine – cytosine.

Answers.

10. **Laboratory work.**

The algorithm of the experiments:

1. Benedict's reaction of carbohydrate skeleton detection.
2. Molybdenic probe for the phosphoric acid residue.
3. Dragendorff probe.

Detailed description of experiment:

Experiment 1 Benedict reaction of carbohydrate skeleton detection.

In the test tube add the aqueous solution of yeast, 6 drops of NaOH and 2 drops of copper sulfate. Heat the mixture. Note the result, write the reaction equation, and make conclusion.

Experiment 2 Molybdenic test for the phosphoric acid residue.

In the test tube add 5 drops of the aqueous solution of yeast and molybdenic probe ((NH_4)$_2$MoO$_4$ in itric acid). The mixture must be boiled for 5 min. Note the result, write the reaction equation, make conclusion.

Experiment 3 <u>Dragendorff test.</u>

In the test tube add 2 drops of the aqueous solution of yeast and 5-6 drops of Dragendorff reagent (BiI$_3$ + KI). Note the result, write the reaction equation, make conclusion.

QUESTIONS FOR BIOORGANIC CHEMISTRY MODULE

1. Hydrocarbons.

Monosaccharides: glucose, fructose, ribose, desoxyribose. Structure, isomery, properties: O-, N-glycosides formation, alkilation, acetylation of oxygroups, qualitative reactions.

2. Hydrocarbons.

Olygosaccharides: saccharose, lactose. Structure, bond types, sPartial structure, chemical properties: alkilation, acetylation of oxygroups, reductive properties, biological meaning.

3. Hydrocarbons.

Polysaccharides: starch (amylose, amylopectin), glycogen, cellulose. Contents, structure, bond types, spacial structure, chemical properties: alkilation, acetylation of oxygroups; qualitative ereaction for starch determination, biological meaning.

4. Saponifiable lipids.

Fats (triacylglycerides). Higher fatty acids: saturated and unsaturated, spacial structure of unsaturated acids, chemical properties (hydrolysis, iodine number, peroxide oxidation). Phosphoglycerols: composition, structure of phosphatidylcholine, phosphatidylcolamine, phosphatidylserine and their biological meaning.

5. Aminoacids as structural components of peptides and proteins.

The structure of carboxy and aminogroups, somery, chemical properties of aminoacids: acid base properties, IES, IEP; qualitative and quantitave reactions in aminoacid analysis. Aminoacid transformation in human organism: decarboxylation, oxydesamination, intramolecular desamination. Serine`s methabolism in human organism.

6. Nucleic acids.

The structural components of nucleic acids: nitrogen basis, hydrocarbons, phosphoric acid. Chemical properties, qualitative reactions. Nucleotides: structure, bond type, nomenclature, properties. Mononucleotides: structure, bond types, nomenclature, properties. RNA and DNA. The secondary structure of DNA, complementary bases. Biological meaning of nucleic acids. ATP, structure, bond types, biological meaning.