Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"

APPROVED
Vice Rector for Academic Affairs

A.A. Voronov

Work program of the course (training module)

course:	General Chemistry/Общая химия
major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия
	Phystech School of Biological and Medical Physics
	кафедра физической химии
term:	2
qualification:	Bachelor

Semester, form of interim assessment: 3 (fall) - Exam

Academic hours: 120 AH in total, including:
- lectures: 30 AH.
- seminars: 30 AH.
- laboratory practical: 60 AH.

Independent work: 75 AH.

Exam preparation: 30 AH.

In total: 225 AH, credits in total: 5

Number of course papers, tasks: 2

Authors of the program:

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The program was discussed at the кафедра физической химии 04.06.2020

Annotation

The training course is organized so that students are ready to take other courses of the chemical cycle at the end of it. The course consists of lectures, workshops and seminars, and is designed according to the modern scheme without losing the fundamental nature of the old courses, while getting rid of their heaviness. The course is aimed at creating students ' modern ideas about the structure of matter, the relationship of the structure and properties of substances with the nature of the chemical bond and the position of their constituent elements in the Periodic table; acquaintance with the principles that determine the properties of chemical reactions; description of the most important properties of inorganic compounds and the patterns of their changes depending on the position of their constituent elements in the periodic table.

1. Study objective

Purpose of the course

The main goal is theoretical and practical development of the main sections of General chemistry, taking into account modern trends in the development of chemical science. This will allow:

- to understand the logic and possibilities of chemistry, especially the chemical approach to the study of the world;
- understand and use the language of chemical formulas and equations;
- predict the structure and properties of substances, their ability to interact with other substances;
- to understand the driving forces of chemical reactions, especially their course and ways to manage them.

The course of General chemistry is designed to form students studying in the direction of "Biotechnology" ideas about the basic concepts and laws of chemistry, chemical reactions and properties of inorganic substances. The course represents the basics of chemical literacy, shows the place of chemistry in modern natural science, especially the chemical approach to the study of the world, gives an idea of the methodology and approaches of chemistry to the study of chemical properties of matter, makes it clear that chemistry, being closely related to physics and biology, is an independent science.

In the study of this course, the student for the first time receives information about the quantum theory of the electronic structure of atoms and molecules, on the basis of which the chemical properties of matter are explained. Therefore, students must accept this information without the justification that they will later receive in the study of General and theoretical physics. This once again demonstrates that chemistry, based on fundamental physical laws, is an independent scientific discipline, which has the subject of its study of the structure, properties and transformations of matter.

The course consists of lectures, seminars and laboratory work. This enables the full development of the curriculum and the active use of knowledge in the further study of disciplines such as chemical physics, biochemistry and biophysics.

Tasks of the course

The objectives of General chemistry course is to study:

- modern ideas about the structure of the substance, the relationship of the structure and properties of substances from the position of their constituent elements in the Periodic table and the nature of the chemical bond
- basic principles determining the properties of chemical reactions, kinetic and thermodynamic approaches to the description of chemical processes in order to optimize the conditions for their practical implementation
- the most important properties of inorganic compounds and patterns of their changes depending on the position of their constituent elements in the Periodic table.

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators

Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
Pro.C-1 Plan and conduct scientific experiments (in a selected subject area) and/or theoretical (analytical and simulation) research	Pro.C-1.7 Follow the basic rules of conduct in a modern scientific laboratory
Pro.C-2 Analyze research data and make scientific conclusions	Pro.C-2.3 Make scientific claims with supporting evidence for a professional audience in verbal and written form, state scientific problems and propose solutions
	Pro.C-2.2 Define key parameters of the studied phenomenon and make relevant numerical estimates
Pro.C-3 Select the necessary devices, tools, and research methods for problem-solving in a selected subject area	Pro.C-3.1 Apply functional principles and operating ranges of scientific equipment

3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

- basic concepts of chemistry: substance, chemical element, atom, molecule, relative atomic and molecular masses, ion, allotropy, isotopes, chemical bond, electronegativity, valence, oxidation degree, mole, molar mass, molar volume, solutions, electrolyte and nonelectrolyte, electrolytic dissociation, acid, base, oxidation and reduction, thermal reaction effect, chemical reaction rate, catalysis, chemical equilibrium;
- basic laws of chemistry: the law of conservation of mass and energy, multiple ratios, constancy of composition, volume ratios; kinetic and thermodynamic law of acting masses;
- General information about the chemical element (name, chemical symbol, relative atomic mass);
- the position of the chemical element in the Periodic system (serial number, period, group, subgroup);
- structure of the element atom (nucleus charge; number of protons and neutrons in the nucleus; number of electrons;
- electronic configuration, electron distribution over energy levels, sublevels and atomic orbitals;
- properties of a simple substance formed by this element (metal, nonmetal, aggregate state under normal conditions, type of chemical bond in the substance);
- higher oxide and its corresponding hydroxide (formulas, valence and oxidation state of the element in the compound), their acid-base properties;
- hydrogen compound (formula, valence and oxidation state of the element in the compound); other compounds of the element (formula, cationic or anionic form).

be able to:

- call inorganic substances by "trivial" or international nomenclature;
- determine: the valence and oxidation degree of chemical elements, the type of chemical bond in the compounds, ion charge, the nature of the medium in aqueous solutions of inorganic compounds, oxidative and reducing properties of the compound;
- make structural formulas of molecules and predict their geometry;
- to characterize: elements in periods and groups according to their position in the Periodic table of D. I. Mendeleev; General chemical properties of metals, nonmetals, main classes of inorganic compounds;
- explain: the dependence of the properties of substances on their composition and structure; the nature of the chemical bond (ionic, covalent, metallic), the dependence of the rate of chemical reaction and the position of chemical equilibrium on various factors;
- write the equations and diagrams of chemical reactions and lead the stoichiometric calculations;
- perform a chemical experiment to recognize the most important inorganic substances and obtain the simplest substances;
- to conduct an independent search for chemical information using various sources (scientific publications, computer databases, Internet resources).

master:

- methods for determining the possibility of chemical transformations in different conditions and assessing their consequences;
- theoretical methods of describing the properties of simple and complex substances based on the position of their constituent elements in the Periodic system of chemical elements;
- methods of safe handling of combustible and toxic substances;
- basic skills of working with laboratory equipment;
- methods of preparation of solutions of a given concentration.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Subject and tasks of chemistry, basic concepts and laws of chemistry.	2	2	4	4
2	The structure of the atom and the periodic law.	2	2		4
3	Chemical bonds. Types of chemical bond.	2	2		4
4	Fundamentals of chemical thermodynamics and kinetics, equilibrium.	2	2	8	8
5	Solutions. Methods of concentration expression, colligative properties of solutions.	2	2	4	4
6	Solutions, electrolytic dissociation	2	2	4	4
7	Acid-base equilibria in solutions.	2	2	8	8
8	Redox reactions.	2	2	4	8
9	Chemistry of hydrogen and halogens.	2	2	4	4
10	Chemistry of chalcogens.	2	2	4	4
11	Chemistry of pnictogens and nonmetals in13 and 14 groups of the Periodic table of elements.	2	2	4	4
12	Chemistry of alkaline and alkaline earth metals and metals of main subgroups.	2	2	4	4
13	Chemistry of coordination compounds.	2	2	4	8
14	Chemistry of transition metals.	4	4	8	7
AH in total		30	30	60	75
Exam preparation		30 AH.			
Total complexity		225 AH., credits in total 5			

4.2. Content of the course (training module), structured by topics (sections)

Semester: 3 (Fall)

1. Subject and tasks of chemistry, basic concepts and laws of chemistry.

Chemistry as one of the natural Sciences. Interrelation of chemistry, physics and biology. Features of chemistry as a science. Structure and language of chemistry. Substance. Classification of chemicals. Chemical element. Atom, atomic number, relative atomic mass, isotopes. Prevalence of chemical elements in nature. Periodic table of chemical elements. D. I. Mendeleev's table structure, groups, periods and blocks. Metals and nonmetals. Chemical compounds and their characteristics: structure, composition, property. Simple and complex connections. Stoichiometric relations, empirical and molecular formula of the compound. Valence of elements. Non-stoichiometric compounds. Allotropes and polymorphs. The main classes of inorganic compounds: oxides, acids, bases, salts, binary compounds. Transformation of chemical compounds. Reaction equations. Stoichiometric calculations on reaction equations. Chemical variable. Formal recording and reaction mechanism. Energy curve of chemical reaction. An elementary act of chemical reaction.

2. The structure of the atom and the periodic law.

Hydrogen-like atoms and ions. Electronic energy levels, wave functions, spatial distribution of electron density, radial and angular dependence of wave functions. The quantum number of the electron. Many-electron atoms. One-electron approximation. Effective charge. Hydrogen-like orbitals. Principles of filling orbitals. Diagram of the energy levels of the atom. Periodic properties of elements: atomic and ionic radii, ionization energy and electron affinity, electronegativity on Milliken

3. Chemical bonds. Types of chemical bond.

Formation of chemical bonds between atoms. Covalent bond. Valence. Octet rule. Lewis Structures. Resonance structure. Formal charge and oxidation state of the element in the compound. Chemical bond characteristics-bond order, length, energy, polarity. Geometry of molecules. Model of repulsion of electronic pairs of valence orbitals and its limitations. Theory of hybridization and directionality of bonds. Electronic states of the molecule. Molecular orbitals method. Electronic configuration of the molecule. Molecular orbitals method in the approximation of LCAO. Correlation diagrams, linking, non-binding and loosening orbitals, communication order. Electronic structure of diatomic molecules. The concept of the construction of MO heteronuclear diatomic molecules. Intermolecular interaction. Hydrogen bond, its nature, properties and role in liquids, molecular crystals and macromolecules. Van der Waals bond, various types of dipole-dipole interactions.

4. Fundamentals of chemical thermodynamics and kinetics, equilibrium.

Classification of chemical reactions. Stoichiometric description of the chemical reaction. Energy curve of elementary chemical reaction. Direct and reverse reactions. The first law of thermodynamics and its application to chemical reactions. Enthalpy. Heat of chemical reactions at constant volume and at constant pressure. Thermochemical equations of reactions. Hess's Law. Enthalpy of formation, combustion, dissolution. Thermochemical cycles. Entropy. The second law applies to chemical processes. Gibbs energy, enthalpy and entropy factors. Reversible reaction. Chemical equilibrium-definition and General properties. Equilibrium constant and its relation to thermodynamic functions. Le Chatelier Principle. Thermodynamic reference data on individual substances and chemical reactions.

Characteristic times of chemical reactions. Energy barrier of chemical reaction. Activation of the reagents. The concept of the mechanism of chemical reaction. The rate of chemical reaction and its dependence on various factors. The law of acting masses. Rate constant. Arrhenius equation. The limiting stage of a complex reaction. Catalysis, its role in chemistry. The main mechanisms of catalysis. General properties of catalysts.

5. Solutions. Methods of concentration expression, colligative properties of solutions.

Solutions, their classification. Methods of expressing the composition of the solution-molar and mass fraction, molar concentration. Polar and nonpolar solvents. Solubility and its dependence on temperature and pressure. The difference between the properties of solutions from the properties of individual substances. Colligative properties of electrolyte and nonelectrolyte solutions. Osmotic pressure. Raoult's Law. Isotonic coefficient. Increasing the boiling point and lowering the freezing point of solutions from the standpoint of colligative properties.

6. Solutions, electrolytic dissociation

Electrolytic dissociation, electrolytes and nonelectrolytes. Strong weak electrolytes. Degree of dissociation, dissociation constant. Dissociation of acids, bases and salts. Interaction between ions in solution, ion equations of reactions. Ion binding, direction of ion exchange reactions.

7. Acid-base equilibria in solutions.

Acids and bases according to Arrhenius. Strong and weak acids and bases. Acidity and basicity constants. Step dissociation on the example of phosphoric acid. Brensted acidity, conjugate acids and bases. Water as acid and base. Autoionization of water, hydroxonium ion. the pH of the solutions. Calculation of pH solutions of weak acids and bases. Hydrolysis of salts. Buffer solution. Lewis acids and bases. Solubility product.

8. Redox reactions.

Concepts of oxidation and reduction. Typical reducing agents and oxidizers. Preparation of equations of redox reactions: methods of electronic and electron-ion balance. Redox potentials. Conjugate oxidizers and reducing agents. nernst equation. The Latimer Diagram. The relationship of EDS with the thermodynamic properties. Chemical current sources, their classification. Electrolysis of solutions and melts.

9. Chemistry of hydrogen and halogens.

The position of hydrogen and Halogens in the Periodic table. Typical properties and oxidation States of Halogens. Feature of hydrogen. Hydrogen isotopes; preparation and properties. Hydronium ion. Hydrides. Industrial and laboratory methods for producing hydrogen and Halogens. Chemical and physical properties of Halogens. Hydrogen halides. Interaction of Halogens with water. Oxygen compounds of Halogens. Preparation and chemical properties of oxygen-containing compounds of Halogens.

10. Chemistry of chalcogens.

General characteristics of the elements of the group 16 of the Periodic table of elements. Distinctive properties of oxygen and ozone. Chemical properties of simple substances. Chalcogenides-preparation and chemical properties. Hydrogen compounds of the chalcogens. Oxides and oxygen acids of sulfur and selenium. Preparation and chemical properties of oxygen-containing compounds of sulfur, selenium and tellurium.

11. Chemistry of pnictogens and nonmetals in13 and 14 groups of the Periodic table of elements.

General characteristics of the elements of the group 15 Periodic table of elements. Typical oxidation States of nitrogen, phosphorus, arsenic and antimony compounds. Hydrogen compound pnictogens – methods of getting and chemical properties. Ammonium salt. Oxides 15 of the group of the Periodic table of elements. Preparation and chemical properties of oxygen acids of nitrogen and phosphorus, arsenic and antimony. Carbon, silicon and boron. Features of the structure, physical and chemical properties. Carbon oxides, carbonic acid and carbonates. Silicon and boron oxides, silicates, borates.

12. Chemistry of alkaline and alkaline earth metals and metals of main subgroups.

Position of metals in the Periodic table of elements. General physical and chemical properties of metals of main subgroups. Preparation and chemical properties of alkaline and alkaline earth metals. Alkalis are chemical properties. Basic properties of p-metals. Features of aluminum chemistry: interaction with water, alkalis and acids, reducing properties. Chemical properties of tin and lead.

13. Chemistry of coordination compounds.

Concept of complex connection. Werner coordination theory. Types of Central atoms and ligands. Geometric structure, coordination numbers and isomerism of complexes. Crystal field theory. Spectra, coloring and magnetic properties of complexes. Stability of complexes in solutions. Conditions of formation and destruction of complex compounds. The instability constant of complex compounds. Typical complex compounds of chromium, iron and cobalt.

14. Chemistry of transition metals.

Position of d-metals in the Periodic table. Electronic configuration of transition metals. Three rows of transition metals. Features of metals of the first transition series. Basic chemical properties: interaction with Halogens, oxygen, dissolution in acids. Transition metals of the second and third rows. Typical oxidation States and chemical properties. Features of molybdenum chemistry: change in redox and acid-base properties when changing the degree of oxidation. Chemistry of f-elements. Lanthanides and actinides. Basic properties and oxidation state.

5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

Computerized laboratories equipped with a projector.
Laboratory tables in laboratory rooms equipped with fume hoods.
Laboratory equipment for chemical analysis and synthesis of inorganic substances.
Chemical reagent.

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

Recommended additional literature:

1. Atkins P., Overton T., Rourke J., Weller M., Armstrong F., Hagerman M. Shriver and Atkins' Inorganic Chemistry. – 5th Edition – W. H. Freeman and Company, 2010. – 824 p.
2. Petrucci R.H., Herring F.G., Madura J.D., Bissonnette C. General Chemistry: Principles and Modern Applications. – 11th Edition. - Pearson Canada Inc., 2017. - 1496 p.

Additional literature

Recommended additional literature:

1. Linus Pauling. General chemistry. — Dover Publications, 1988. — 992 p.
2. Greenwood N.N., Earnshaw A. Chemistry of the Elements. Second Edition. — Butterworth-Heinemann, 1997. — 1359 p.
3. Atkins P., Jones L., Laverman L. Chemical Principles: The Quest for Insight. – W. H. Freeman and Company, 2013. – 1129 p.

7. List of web resources that are necessary for the course (training module) mastering

Not used

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

MS Office software package.

9. Guidelines for students to master the course

The student studying the discipline, on the one hand, must master the General conceptual apparatus, and on the other hand, must learn to apply theoretical knowledge in practice.

As a result of studying the discipline, the student must know the basic definitions of the discipline, be able to apply the knowledge to solve various problems.

Successful completion of the course requires:

- attendance of all classes provided by the curriculum of the discipline;

introduction of abstract classes;

- intense independent work of the student.

Independent work includes:

- reading recommended literature;
- study of educational material, preparation of answers to questions intended for self-study;
- solving problems offered to students in the classroom;
- preparation for performance of tasks of the current and intermediate certification.

The indicator of possession of the material is the ability without notes, to answer questions on the topics of discipline.

It is important to achieve an understanding of the material being studied, not its mechanical memorization. If you find it difficult to study certain topics, questions, you should seek the advice of the teacher.

Intermediate control of students ' knowledge in the form of solving problems in accordance with the subject of classes is possible.

SUPPLEMENT

Assessment funds for course (training module)

major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия Phystech School of Biological and Medical Physics кафедра физической химии
term:	2
qualification:	Bachelor

Semester, form of interim assessment: 3 (fall) - Exam

Authors:

K.O. Znamenkov, candidate of chemical sciences, associate professor
S.V. Silkin, candidate of chemical sciences, senior professor
V.V. Sudin, assistant

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
Pro.C-1 Plan and conduct scientific experiments (in a selected subject area) and/or theoretical (analytical and simulation) research	Pro.C-1.7 Follow the basic rules of conduct in a modern scientific laboratory
Pro.C-2 Analyze research data and make scientific conclusions	Pro.C-2.3 Make scientific claims with supporting evidence for a professional audience in verbal and written form, state scientific problems and propose solutions
	Pro.C-2.2 Define key parameters of the studied phenomenon and make relevant numerical estimates
Pro.C-3 Select the necessary devices, tools, and research methods for problem-solving in a selected subject area	Pro.C-3.1 Apply functional principles and operating ranges of scientific equipment

2. Competency assessment indicators

As a result of studying the course the student should:

know:

- basic concepts of chemistry: substance, chemical element, atom, molecule, relative atomic and molecular masses, ion, allotropy, isotopes, chemical bond, electronegativity, valence, oxidation degree, mole, molar mass, molar volume, solutions, electrolyte and nonelectrolyte, electrolytic dissociation, acid, base, oxidation and reduction, thermal reaction effect, chemical reaction rate, catalysis, chemical equilibrium;
- basic laws of chemistry: the law of conservation of mass and energy, multiple ratios, constancy of composition, volume ratios; kinetic and thermodynamic law of acting masses;
- General information about the chemical element (name, chemical symbol, relative atomic mass);
- the position of the chemical element in the Periodic system (serial number, period, group, subgroup);
- structure of the element atom (nucleus charge; number of protons and neutrons in the nucleus; number of electrons;
- electronic configuration, electron distribution over energy levels, sublevels and atomic orbitals;
- properties of a simple substance formed by this element (metal, nonmetal, aggregate state under normal conditions, type of chemical bond in the substance);
- higher oxide and its corresponding hydroxide (formulas, valence and oxidation state of the element in the compound), their acid-base properties;
- hydrogen compound (formula, valence and oxidation state of the element in the compound); other compounds of the element (formula, cationic or anionic form).

be able to:

- call inorganic substances by "trivial" or international nomenclature;
- determine: the valence and oxidation degree of chemical elements, the type of chemical bond in the compounds, ion charge, the nature of the medium in aqueous solutions of inorganic compounds, oxidative and reducing properties of the compound;
- make structural formulas of molecules and predict their geometry;
- to characterize: elements in periods and groups according to their position in the Periodic table of D. I. Mendeleev; General chemical properties of metals, nonmetals, main classes of inorganic compounds;
- explain: the dependence of the properties of substances on their composition and structure; the nature of the chemical bond (ionic, covalent, metallic), the dependence of the rate of chemical reaction and the position of chemical equilibrium on various factors;
- write the equations and diagrams of chemical reactions and lead the stoichiometric calculations;
- perform a chemical experiment to recognize the most important inorganic substances and obtain the simplest substances;
- to conduct an independent search for chemical information using various sources (scientific publications, computer databases, Internet resources).

master:

- methods for determining the possibility of chemical transformations in different conditions and assessing their consequences;
- theoretical methods of describing the properties of simple and complex substances based on the position of their constituent elements in the Periodic system of chemical elements;
- methods of safe handling of combustible and toxic substances;
- basic skills of working with laboratory equipment;
- methods of preparation of solutions of a given concentration.

3. List of typical control tasks used to evaluate knowledge and skills

Examples of the tasks for ongoing control:

1. Among these sets of quantum numbers, specify the one that correctly determines the orbital of the atom:

n l ml

1 1 0

2 1 0

2 0 1

A) Determine the chemical element having only one electron at this sublevel.

B) Write the full electronic configuration of the atom of this element.

2. Build a scheme of molecular orbitals for the molecule C2.

A) for particles C2, C2 -, C22-calculate the multiplicity of the bond.

B) Arrange the specified particles in order of increasing the inter-nuclear distance.

C) Specify which of these particles are paramagnetic.

D) Give an example of a heteroatomic particle isoelectronic ion C22- and consisting of atoms of elements of the second period.

3. Describe the Structure of the BrF5 molecule in terms of the Gillespie model, specify the coordination polyhedron of the Central atom.

4. When heated NOCl reaction takes place

2NOCl (g.) = 2NO(g.)+Cl2(g.)

At a temperature of 450 C in the system equilibrium was established, which corresponds to the following values of partial pressures of components p(NO)=0.589 ATM, p(Cl2)=0.294 ATM, p (NOCl)=0.117 ATM. The total volume of the system was 1 liter.

When the system was cooled to 300 C, the system volume decreased to 710 ml (p=1 ATM).

Considering that dH0 and dS0 are independant on temperature,

A) determine the eqiulibrium conctant Kp of the reaction at a temperature of 450 C,

B) determine the dG0 at a temperature of 450 C.

C) how does entropy change (increase or decrease) during this reaction? Give a reasonable answer.

G) determine the sign of the enthalpy (dH0) of this process.

D) draw schematically the dependence dG0 for this reaction temperature.

5. How many gram of Na2S *9H2O should be taken to get 100 g of 0.78% aqueous solution? Determine the pH value of the solution (d=1G/cm3) at 25oC. Ka (HS-)=10-13. Protolytic reaction of S2-ion proceeds only on the first stage. Write the equation of this reaction in ionic form. Determine the freezing point of the solution. Consider the salt dissociation complete. K(H2O)=1.86.

6. Using the electron-ion balance method, write the equations of the following reactions:

1) PbO2 + HCl = Cl2 + …

2) Na2S2O3 + Cl2 + H2O = Na2SO4 + …

3) KNO3 + Al + KOH + H2O = NH3 + K[Al(OH)4]

7. 1) Using Latimer diagram (pH=14)

0.37V 0.29V 0.68V 0.42V 1.36V

ClO4- -------> ClO3- ----------> ClO2- ----------> ClO- ----------> Cl2 -------> Cl-, determine

a) thermodynamic possibility of the disproportionation of ClO2- with the formation of Cl- and ClO3- at pH=14. Answer confirm the calculation of the EMF of the reaction. Write the equation of possible reaction;

b) whether KOCl to interact in solution with KI at pH=9 and temperature of 250C, if E^o (IO3-/I-) = 0.26 V? Write the equation of possible reaction. Answer confirm the calculation of the EMF of the reaction. Consider the activity of all other substances involved in the reaction, except OH -, equal to 1.

8. Four tubes without labels contain solutions of the following compounds:Na2SiO3, NaBr, Na2SO3, Na3PO4.

Using the characteristic reactions for each anion, determine the contents of each tube. Write the equations of all your proposed reactions and their conditions.

9. Suggest a method for producing and separating SOCl2, using as the only sources of sulfur and chlorine crystalline sodium sulfate and potassium chlorate, respectively. Write the equations of all your proposed reactions and specify the conditions for their conduct.

10. Give the names of the complexes, specify the Central atom and its coordination number

1) [Cr(CO)6]

2) K3[AlF6]

3) [Ni(NH3)4]J2

11. (a) for complex octahedral ions [CrF6]3-and [MoF6]3-

1) specify the complete electronic configuration of the central ions (1s2 2s2 2p6 ....);

2) draw, observing the scale, the splitting diagrams of d-orbitals of central ions and the distribution of electrons in these orbitals;

3) specify for which of these ions, the magnitude of the energy splitting is larger, explain why;

4) calculate the crystal field stabilization energy (CFSE) for each complex ion;

5) based on points 3) and 4) explain which of these ions is thermodynamically more stable;

6) calculate the magnitude of effective magnetic moment (mu eff.) (pure spin component) of the [CrF6]3- ion.

b) Draw all possible geometric isomers of the octahedral complex [V (H2O)4Br2]+.

12. Write the equations of chemical reactions and specify the conditions for their conduct:

NH4VO3 → X1 → VOCl3 → VOCl2 → V2O3 → (NH4)3VF6

Xi -a substance that contains vanadium

13. At your disposal there is an aqueous solution of a mixture of the following compounds:

Al2(SO4)3, MgSO4, Na2SO4

Divide this mixture is chemically and highlight each ingredient in the individual mind.

14. During the calcination of the black metal oxide A containing 20% of oxygen by mass at high temperature forms a red-brown compound V. the Substance A dissolves in ammonia with the formation of deep blue solution of the substance S. When you make the solution With a powder of metallic copper and a long exposure without access of air becomes colorless, this gives a solution of compound D. the gradual addition of the solution D concentrated hydrochloric acid a white precipitate falls, which then dissolves, forming a solution E. This solution can absorb a certain amount of carbon monoxide, when it passes forming a substance F. Determine the substance A-F, write the equations of all reactions and specify the conditions for their conduct.

4. Evaluation criteria

Example of the exam task:

Example 1

1. Covalent bond. Valence. Octet rule. Lewis Structures. Resonance structure. Formal charge and oxidation state of the element in the compound. Chemical bond characteristics-bond order, length, energy, polarity.

2. Brensted acidity, conjugate acids and bases. Water as acid and base. Autoionization of water, hydroxonium ion. the pH of the solutions. Calculation of pH solutions of weak acids and bases. Hydrolysis of salts. Buffer solution.

3. Identify an unknown substance and propose chemical equations according to the scheme

$Na \rightarrow X \rightarrow Na_2CO_3 \rightarrow Y \rightarrow Na_2S$

Example 2

1. The rate of chemical reaction and its dependence on various factors. Law of mass action for elementary reactions. Rate constant.

2. Regularities of changes in radii, metallic properties, as well as acid-base and redox properties of oxides and hydroxides of elements in the side subgroups.

3. Will it form a precipitate when draining equal volumes of 0.01 M sodium chloride solution and 0.002 M lead nitrate? Ion product of $PbCl_2 = 2*10-5$

Example 3

1. Entropy. The second law in applies to chemical processes. Gibbs energy, enthalpy and entropy factors.

2. Aluminum: being in nature, obtaining, interacting with water, alkalis and acids, reducing properties. Diagonal similarity with beryllium.

3. Identify an unknown substance and propose chemical equations according to the scheme

$CuSO_4 \rightarrow Cu_2O \rightarrow X \rightarrow CuCl \rightarrow Y \rightarrow Cu$

Example 4

1. Arrhenius acids and bases. Strong and weak acids and bases. Acidity and basicity constants. Polybasic acids and bases.

2. Properties of Co and Ni – preparation, stable oxidation states, acid-base and redox properties of compounds.

3. Propose chemical method for separation the alloy of zinc and tin and receive each metal in the individual state.

Assessment excellent 10 points-exposed to the student who showed a comprehensive, systematic, in-depth knowledge of the curriculum discipline, showing interest in the subject area, demonstrated the ability to confidently and creatively apply them in practice in solving specific problems, free and correct justification of decisions.

Assessment excellent 9 points-exposed to the student, who showed a comprehensive, systematic, in-depth knowledge of the curriculum discipline and the ability to confidently apply them in practice in solving specific problems, free and correct justification of decisions.

Assessment is excellent 8 points-exposed to the student, who showed a comprehensive, systematic, in-depth knowledge of the curriculum discipline and the ability to confidently apply them in practice when solving specific problems, the correct justification of the decisions, with some shortcomings.

Score well 7 points is assigned to the student if he knows the material, competently, and essentially presents it, is able to apply the acquired knowledge in practice, but has not been properly justifies the results obtained.

Score well 6 points is assigned to the student if he knows the material, competently, and essentially presents it, is able to apply the acquired knowledge in practice, but admits in the answer or in the task some inaccuracies.

Score well 5 points is assigned to the student if he basically knows the material, competently, and essentially presents it, is able to apply the acquired knowledge in practice, but admits in the answer or in the task of quite a number of inaccuracies.

The satisfactory rating of 4 points is assigned to the student who showed the fragmented, piecemeal nature of the knowledge is not enough for the correct formulation of the basic concepts, disorders of logical sequence in the presentation of program material, but he mastered parts of the curriculum necessary for further learning, and can apply the knowledge modeled in the standard situation.

Rating satisfactory 3 points - is given for student, who showed the fragmented, piecemeal nature of knowledge makes a mistake in the formulation of the basic concepts of violation of logical sequence in the presentation of program material, has little major parts of the curriculum necessary for further studies and work applies the knowledge gained even in the standard situation.

Assessment unsatisfactory 2 points-exposed to the student who does not know most of the basic content of the curriculum discipline, makes blunders in the wording of the basic principles and does not know how to use the knowledge in solving typical problems.

Assessment unsatisfactory 1 point-exposed to the student who does not know the basic content of the curriculum discipline, makes gross errors in the wording of the basic concepts of discipline and does not have the skills to solve typical practical problems.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

In the theoretical part of the course, an oral exam is conducted with the affixing of the grades "excellent", "good", "satisfactory", "unsatisfactory", as well as the corresponding score in a ten-point scale. During the oral examination, the student is given one academic hour (45 minutes) to prepare. Questioning of the student on the ticket at the oral exam is carried out until the examiner is convinced of the objectivity of the assessment, but should not exceed one astronomical hour.