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

APPROVED
Head of the Phystech School of Aerospace Technology
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Work program of the course (training module)

course: Selected Sections of General and Bioorganic Chemistry/Избранные главы общей и органической химии
major: Applied Mathematics and Physics
specialization: Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии
Phystech School of Aerospace Technology
Chair of Logistics Systems and Technologies
term: 2
qualification: Master

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

Academic hours: 75 AH in total, including:
lectures: 15 AH.
seminars: 45 AH.
laboratory practical: 15 AH.

Independent work: 60 AH.

In total: 135 AH, credits in total: 3

Author of the program: T.M. Vasileva, doctor of technical sciences, associate professor

The program was discussed at the Chair of Logistics Systems and Technologies 09.02.2022

Annotation

The course presents the basics of chemical science, shows the place of chemistry in modern natural science and in modern high-tech technologies. The course discusses approaches to solving various particular problems of the physico-chemical direction.

The laboratory workshop allows the student to master modern research methods necessary for further work in scientific laboratories.

1. Study objective

Purpose of the course

- formation of modern scientific ideas about the essence of chemical phenomena;
- creation of solid knowledge of fundamental concepts, laws, laws of general chemistry, chemical properties of elements and their compounds;
- formation of ideas about the place of chemistry in modern high-tech technologies and approaches to solving various particular problems of the physico-chemical direction;
- acquisition of the ability to use the acquired knowledge, skills and abilities in the field of professional activity related to plasma physics and chemistry, aerospace technologies and other fields.

Tasks of the course

- formation of ideas about the main objects of chemistry and chemical processes, the relationship of composition, structure, properties and reactivity of chemicals;
- formation of knowledge of the basic laws of chemistry and chemical properties of elements and their compounds, the understanding and application of which will improve existing and develop new approaches in the field of aerospace technologies;
- formation of ideas about the relationship of chemical phenomena, the simplest methods of chemical research;
- obtaining knowledge based on specific ideas about the studied substances and their transformations, understanding the basics of chemistry;
- acquisition of the ability to analyze chemical phenomena, highlight their essence, compare, generalize, draw conclusions, use the laws of chemistry when comparing and analyzing various phenomena;
- formation of skills for solving problematic and situational tasks;
- acquisition of skills in the application of chemical laws to solve specific problems with quantitative calculations and the use of educational and reference literature;
- formation of practical skills in setting up and performing experimental work;
- formation of skills for studying scientific chemical literature.

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 Gain fundamental scientific knowledge in the field of physical and mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of physical and mathematical sciences
Gen.Pro.C-3 Select and/or develop approaches to professional problem-solving with consideration to the limitations and specifics of different solution methods	Gen.Pro.C-3.1 Analyze problems, plan research strategy to achieve solution(s), propose, and combine solution approaches
	Gen.Pro.C-3.2 Employ research methods to solve new problems and apply knowledge from various fields of science (technology)
	Gen.Pro.C-3.3 Gain knowledge of analytical and computational methods of problem-solving, understand the limitations of the implementation of the obtained solutions in practice
Pro.C-3 Use research and testing equipment	Pro.C-3.1 Understand the operating principles of the equipment and specialized software

Pro.C-3 Use research and testing equipment (devices and installations, specialized software) in a selected subject field	Pro.C-3.2 Conduct an experiment (simulation) using research equipment (software)
	Pro.C-3.3 Evaluate the accuracy of the experimental (numerical) results

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 general chemistry;
- the structure of the Periodic system of elements of D.I. Mendeleev and the main characteristics of the element resulting from it;
- thermodynamic and kinetic patterns that determine the flow of chemical processes;
- methods for describing chemical equilibria;
- theoretical foundations of general chemistry, electronic structure of the atom, fundamentals of the theory of chemical bonding in compounds of different types;
- structure and chemical properties of the main classes of inorganic compounds;
- properties of water and aqueous solutions of strong and weak electrolytes, ways of expressing the concentration of substances in solutions;
- basic laws of chemical processes used in modern high-tech technologies and especially in the field of aerospace technologies;
- laboratory equipment of the experiment;
- safety precautions and rules of work in the chemical laboratory.

be able to:

- analyze chemical phenomena, highlight their essence, compare, generalize, draw conclusions, use the laws of chemistry in the study and comparison of various phenomena;
- apply the basic laws of chemical thermodynamics and kinetics in solving professional problems;
- predict the possibility of chemical processes and describe their kinetics;
- determine the chemical properties of elements and their compounds by the position of the element in the Periodic Table;
- find and use reference data of various physico-chemical quantities when solving chemical or related professional tasks;
- present experimental research data in the form of graphs, tables and a completed research protocol.

master:

- methods of chemical calculations, analysis of patterns of chemical processes based on thermodynamic calculations, determination of the main kinetic parameters of chemical reactions;
- skills of independent work with educational, scientific and reference literature; to search and make generalizing conclusions;
- skills of safe work in a chemical laboratory and skills of practical work on setting up an experiment;
- skills of making reports on the results of the experiment.

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	Basic concepts and laws of general chemistry		3		
2	The structure of the atom	2	3		
3	Frequency of properties of elements and their compounds	2	3		
4	Chemical bonding and structure of molecules	2	3		

5	The main classes of inorganic compounds		3	3	
6	The main classes of organic compounds		3		
7	Chemical thermodynamics	2	3	3	
8	Chemical equilibrium	2	3		
9	Chemical kinetics	2	3	3	
10	Electrochemistry and redox reactions		3	3	
11	Organic polymers		3		
12	Biopolymers		3	3	
13	Chemical problems of processing products of renewable natural resources		3		
14	Chemical problems of obtaining and converting energy in rocket technology	1	3		
15	Chemical bases of creation of new functional materials	2	3		60
AH in total		15	45	15	60
Exam preparation		0 AH.			
Total complexity		135 AH., credits in total 3			

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

Semester: 3 (Fall)

1. Basic concepts and laws of general chemistry

The subject of chemistry. Substances are simple and complex. Chemical formulas, the concept of a mole. Relative atomic mass. The main types of chemical reactions, examples. Stoichiometry of chemical reactions.

2. The structure of the atom

Basic concepts of the electronic structure of the atom: quantum numbers and atomic orbitals, forms of atomic orbitals. Electronic configurations of atoms: rules for filling electronic shells.

3. Frequency of properties of elements and their compounds

Periodicity of properties of elements and their compounds: D.I. Mendeleev's periodic system of elements, the basic information contained in it, the relationship of the periodic system of elements with the structure of atoms. The periodicity of the physical properties of the elements: atomic and ionic radii, ionization energy of the atom and electron affinity. Electronegativity. Periodic classification of elements: metals, nonmetals, metalloids. Frequency of chemical properties of elements and their compounds: basic patterns. The concept of the degree of oxidation of elements, stable oxidation states.

4. Chemical bonding and structure of molecules

Types of chemical bonds: ionic, metallic, covalent. Mechanisms of formation and main characteristics (length, energy, bond angle, dipole moment of coupling). Specific properties of the covalent bond are saturation and directivity. The theory of repulsion of electron pairs of valence orbitals (OEPVO). Elements of the valence bond method: the concept of hybridization of atomic orbitals. Polar and nonpolar molecules, the dipole moment of the molecule.

Hydrogen bonding and intermolecular interactions.

Properties of substances and materials with different types of chemical bonds.

5. The main classes of inorganic compounds

There are four main classes of inorganic compounds: oxides, bases (hydroxides), acids, and salts.

6. The main classes of organic compounds

The main classes of organic compounds. Marginal and unsaturated hydrocarbons. The homological series of methane. Aromatic hydrocarbons. The main functional derivatives and their characteristic groups.

7. Chemical thermodynamics

Energy of chemical processes. I-th and II-th laws of thermodynamics, enthalpy of chemical reaction. Exo- and endothermic reactions. Thermochemical equations. The concept of entropy. Energy effects of chemical reactions. Hess's law and its application. Standard enthalpy of formation and combustion of chemical compounds. Thermal effects of chemical and physico-chemical processes (dissolution, phase transitions, etc.).

Spontaneous chemical processes, conditions of their occurrence. Isobaric-isothermal potential. The Gibbs equation. Factors determining the direction of chemical reactions, the influence of temperature. Reversible and irreversible reactions.

8. Chemical equilibrium

Equilibrium processes. The concept of chemical equilibrium, its criteria, chemical equilibrium in gaseous systems and solutions. Homogeneous and heterogeneous systems, equilibrium in heterogeneous systems. Isotherm of a chemical reaction. Chemical equilibrium constant. Chemical equilibrium shift: influence of concentration, temperature and pressure. The Le Chatelier principle.

9. Chemical kinetics

Kinetics of homogeneous reactions. The theory of the rate of chemical reactions: the concept of the rate of chemical reactions, the kinetic equation of a chemical reaction, the law of acting masses. Dependence of the chemical reaction rate on concentration. The rate constant of the chemical reaction, the order and the molecular nature of the chemical reaction. Methods for determining the order of a chemical reaction. Mechanisms of chemical reactions, simple and complex reactions (sequential, parallel). Kinetics of complex reactions.

The effect of temperature on the rate of chemical reactions. Arrhenius equation, its analysis. Activation energy, the rate of the limiting stage of a chemical reaction. Determination of activation energy based on experimental data.

Catalysts and catalysis. Homogeneous and heterogeneous catalysis.

10. Electrochemistry and redox reactions

Redox reactions (OVR). Conjugated oxidizer-reducing agent pairs. Redox properties of elements and their compounds depending on the position of the element in the periodic table. The most important oxidizing agents and reducing agents. Redox duality. Redox reactions in electrochemical systems. Galvanic cells. Standard redox potentials, methods of their determination. Thermodynamics in galvanic cells, the Nernst equation. Calculation of the EMF of a galvanic cell.

11. Organic polymers

Concepts of monomers and polymers. Polymerization reactions. Examples of polymers. The molecular weight of polymers. Basic properties of physico-chemical properties of polymers.

12. Biopolymers

Biopolymers and their natural raw materials sources.

Proteins: primary, secondary, tertiary and quaternary structure of proteins. Basic physical and chemical properties, research methods.

Carbohydrates: mono-, oligo- and polysaccharides. Cellulose, starch, chitin and chitosan, etc. Lignin. Structure, physico-chemical properties of polysaccharides. Methods of studying the structure and properties of polysaccharides, directions of practical use.

13. Chemical problems of processing products of renewable natural resources

Renewable natural resources, examples. Chemical approaches to the creation of new high-tech materials based on biopolymers. Chemical processing of cellulose and chitin: hydrolysis and problems of its waste disposal.

Alternative fuel sources. Synthetic liquid fuels and biofuels, methods and high-tech approaches to the production of biofuels.

14. Chemical problems of obtaining and converting energy in rocket technology

Rocket fuels: liquid rocket fuels, their chemical composition, main characteristics and related design features of rocket engines. The most common oxidizing agents and combustible. Solid and hybrid rocket fuels.

Autonomous chemical current sources for rocket technology, aviation and the submarine fleet. Fuel cells, types, device and principle of operation on the example of a hydrogen-oxygen fuel cell. Advantages and difficulties of using fuel cells. Modern batteries.

15. Chemical bases of creation of new functional materials

Basic concepts: Phase states of matter, phase equilibria and phase transitions. Solid solutions, alloys. Liquid crystals. Non-stoichiometric compounds.

Functional materials: systematics and classification by composition, structure and functional properties, principles of production and design, physical properties and practical applications. Structural materials and composites: distinctive features, basic quality criteria, mechanical properties. Hybrid materials: natural and artificial hybrid materials, the main approaches to obtaining and application areas. Nanomaterials: basic concepts, dimensional effects, reactivity, carbon nanomaterials (nanotubes, fullerenes, graphene), nanocatalysts, nanocomposites. Promising materials of aerospace engineering.

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

Lecture classes: a specialized audience equipped with presentation and multimedia equipment, posters, a periodic system of elements; a set of electronic presentations / slides.

Laboratory work is carried out in classrooms with exhaust ventilation, equipped with special furniture and various chemical utensils, visual tables. When conducting experiments, teachers and a training engineer are present in the classroom.

The student's independent work is ensured by the availability of all course manuals on the website of the Department of General Chemistry, as well as the availability of textbooks and methodological literature in the MIPT library and in the laboratory workshop of the department, Internet access.

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

Main literature

1. Ахметов Н.С. Общая и неорганическая химия. − М.: Высшая школа, 2009.
2. Практический курс общей химии / под ред. В.В. Зеленцова. − М.: МФТИ, 2010.
3. Снигирева Е.М., Зеленцова С.А. Справочник физико-химических величин. − М.: МФТИ, 2007.

Additional literature

1. Артеменко А.И. Органическая химия. − М.: Высшая школа, 2004.
2. Алекин О.А., Ляхин Ю.И. Химия океана. – Л.: Гидрометеоиздат, 1984.
3. Берзин Б.Д., Берзин Д.Б. Курс современной органической химии. – М.: Высшая школа, 1999.
4. Беркут В.Д. Неравновесные физико-химические процессы в гиперзвуковой аэродинамике. – М.: Энергоатомиздат, 1994.
5. Буданов В., Ломова Т., Рыбкин В. Химическая кинетика. Вольхин В.В. Общая химия. Основной курс. – СПб.: Издательство «Лань», 2014.
6. Вольхин В.В. Общая химия. Основной курс. – СПб.: Издательство «Лань», 2008.
7. Вольхин В.В. Общая химия. Специальный курс. – СПб.: Издательство «Лань», 2008.
8. Вольхин В.В. Общая химия. Избранные главы. – СПб.: Издательство «Лань», 2008.
9. Глинка Н.Л. Общая химия. – М.: Интеграл-пресс, 2005.
10. Глинка Н.Л. Задачи и упражнения по общей химии. – Л.: Химия, 1999.
11. Коровин Н.В. Общая химия. − М.: Высшая школа, 1998.
12. Леенсон И.А. Как и почему происходят химические реакции Элементы химической термодинамики и кинетики. – Долгопрудный: Издательский дом «Интеллект», 2010.
13. Пармон В.Н. Термодинамика неравновесных процессов для химиков. С приложением к химической кинетике, катализу, материаловедению и биологии. – Долгопрудный: Издательский дом «Интеллект», 2015.
14. Пушкарев А.И., Ремнев Г.Е. Прикладная плазмохимия. – Томск: Издательство Томского политехнического университета, 2011.
15. Штиллер В. Уравнение Аррениуса и неравновесная кинетика. – М.: Мир, 2000.
16. Atkins P., de Paula J. Physical chemistry. – Oxford University Press, 2006.
17. Chang R. Physical Chemistry for the Biosciences. – University Science Books, 2005.
18. Fridman A. Plasma chemistry. Cambridge university press, 2011.
19. McMurry J. Fundamentals of Organic Chemistry. – Cole, Cengage Learning, 2011.

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)

Microsoft Office. Internet access.

9. Guidelines for students to master the course

1. At lectures, students are recommended to have its electronic version posted by the teacher on the website of the Department of General Chemistry.

2. In practical classes, teachers analyze the main issues of the theoretical part of the course, solutions to typical problems, approaches to the compilation of equations of chemical reactions. For each of the topics studied in the general chemistry course, students perform control work. In the same classes, teachers give personal assignments for advanced students.

3. Laboratory work contains a variety of research elements and is carried out with the participation and supervision of teachers. After completing the laboratory work, students hand over the practical and theoretical parts of the work to the teacher.

ORGANIZATION OF INDEPENDENT WORK OF STUDENTS

Mandatory ongoing independent work is aimed at deepening and consolidating the student's knowledge, developing practical skills, and includes:

• work with lecture material;
• preparation for laboratory classes;
• preparation for control works;
• work with additional literature.

To implement independent work, students are provided with information resources (textbooks, reference books, textbooks). The student has the opportunity to prepare for the lesson in advance, try to answer control questions, solve typical control tasks.

Control of students' independent work and evaluation of its results are carried out by the teacher during laboratory hours when the student performs laboratory and control work. The points received by the student, based on the results of the work, form an assessment of the student's academic performance in the discipline. The arithmetic mean of the sum of the points received determines the student's grade when receiving a differentiated credit.

It is possible to organize additional independent work of the student, aimed at deepening and consolidating knowledge, developing analytical skills on the problems of the discipline. Evaluation of the results of additional independent work is carried out during contact hours with the teacher. The points received for this type of work are taken into account when receiving a differentiated credit. Additional independent work includes writing an abstract on a given topic related to the chemical problems of modern aerospace technologies.

SUPPLEMENT

Assessment funds for course (training module)

major:	Applied Mathematics and Physics
specialization:	Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии
	Phystech School of Aerospace Technology
	Chair of Logistics Systems and Technologies
term:	2
qualification:	Master

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

Author: T.M. Vasileva, doctor of technical sciences, associate professor

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of physical and mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of physical and mathematical sciences
Gen.Pro.C-3 Select and/or develop approaches to professional problem-solving with consideration to the limitations and specifics of different solution methods	Gen.Pro.C-3.1 Analyze problems, plan research strategy to achieve solution(s), propose, and combine solution approaches
	Gen.Pro.C-3.2 Employ research methods to solve new problems and apply knowledge from various fields of science (technology)
	Gen.Pro.C-3.3 Gain knowledge of analytical and computational methods of problem-solving, understand the limitations of the implementation of the obtained solutions in practice
Pro.C-3 Use research and testing equipment (devices and installations, specialized software) in a selected subject field	Pro.C-3.1 Understand the operating principles of the equipment and specialized software
	Pro.C-3.2 Conduct an experiment (simulation) using research equipment (software)
	Pro.C-3.3 Evaluate the accuracy of the experimental (numerical) results

2. Competency assessment indicators

As a result of studying the course the student should:

know:

- basic concepts of general chemistry;
- the structure of the Periodic system of elements of D.I. Mendeleev and the main characteristics of the element resulting from it;
- thermodynamic and kinetic patterns that determine the flow of chemical processes;
- methods for describing chemical equilibria;
- theoretical foundations of general chemistry, electronic structure of the atom, fundamentals of the theory of chemical bonding in compounds of different types;
- structure and chemical properties of the main classes of inorganic compounds;
- properties of water and aqueous solutions of strong and weak electrolytes, ways of expressing the concentration of substances in solutions;
- basic laws of chemical processes used in modern high-tech technologies and especially in the field of aerospace technologies;
- laboratory equipment of the experiment;
- safety precautions and rules of work in the chemical laboratory.

be able to:

- analyze chemical phenomena, highlight their essence, compare, generalize, draw conclusions, use the laws of chemistry in the study and comparison of various phenomena;
- apply the basic laws of chemical thermodynamics and kinetics in solving professional problems;
- predict the possibility of chemical processes and describe their kinetics;
- determine the chemical properties of elements and their compounds by the position of the element in the Periodic Table;
- find and use reference data of various physico-chemical quantities when solving chemical or related professional tasks;
- present experimental research data in the form of graphs, tables and a completed research protocol.

master:

• methods of chemical calculations, analysis of patterns of chemical processes based on thermodynamic calculations, determination of the main kinetic parameters of chemical reactions;
• skills of independent work with educational, scientific and reference literature; to search and make generalizing conclusions;
• skills of safe work in a chemical laboratory and skills of practical work on setting up an experiment;
• skills of making reports on the results of the experiment.

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

3. Перечень типовых контрольных заданий, используемых для оценки знаний, умений, навыков

EXAMPLE OF A CONTROL TASK ON THE TOPIC ENERGY OF CHEMICAL PROCESSES

1. The thermodynamic equations of chemical reactions for obtaining HBr(g) are given:

a) H2(g) + Br2(g) → 2HBr(g), ΔHº = -72 kJ/mol;

b) 1/2H2(g) + 1/2Br2(g) → HBr(g), ΔHº = -21 kJ/mol;

c) H(g) + Br(g) → HBr(g), ΔHº = -336 kJ/mol;

d) 1/2H2(g) + 1/2Br2(g) → HBr(g), ΔHº = -36 kJ/mol.

Which of the given values of ΔHº can be taken as the standard enthalpy of formation of HBr(g)? Explain why other of the specified values are not equal to the desired value.

2. Determine the standard enthalpy change ΔHº298 of the methane combustion reaction:

CH4(g) + 2O2() Gorenje→ CO2(g) + 2H2O(g),

if the enthalpy of formation of CO2(g), H2O(g) and CH4(g) are -393.5, -241.8 and -74.9 kJ/mol, respectively.

3. Determine the enthalpy of hydration of Na2CO3•H2O to Na2CO3•10H2O if 10.5 kJ/mol is released when the first crystallohydrate is dissolved, and 67 kJ/mol of heat is absorbed when the second one is dissolved.

4. Determine the double bond energy C = C if the enthalpy of the reaction is known:

C2H4(g) + H2(g) = C2H6(g) ,□ ΔHº □ -137 kJ / mol

and the average binding energies: EC-H = 412 kJ/mol, EC C = 348 kJ/mol and EN-H = 430 kJ/mol.

5. The chemical reaction is given:

CaCO3 (k) = CaO (k) + CO2 (g).

Determine the direction of this reaction at temperatures of 700 and 1000 ° C. If the direction of the reaction changes with increasing temperature, give an estimate of the temperature at which the reaction direction changes. The values of ΔHºobr, 298 and ΔSºobr, 298 for CaCO3(k), CaO(k) and CO2(g) are taken from the reference literature, do not take into account the dependence of thermodynamic functions on temperature.

EXAMPLE OF A CONTROL TASK ON THE TOPIC CHEMICAL KINETICS AND CHEMICAL EQUILIBRIUM

1. How will the reaction rate of 2NO(g) + O2(g) → 2NO2(g) change if

a) increase the pressure in the system by 3 times;

b) reduce the volume of the system by 3 times;

c) increase the concentration of NO by 3 times.

2. It is established that for the reaction A + 2B → 3C + D, the kinetic equation of the reaction has the form a = k[A][B]. What is the dimension of the reaction rate constant. Determine the order of reaction and the rate of expenditure/ formation for substances A and C.

3. The decomposition reaction of gaseous acetaldehyde (CH3COOH) was carried out at a temperature of 518 ° C and an initial pressure of 363 Torr. After 5% of the substance reacted, the reaction rate was 1.07

Torr/s. After 20% of the substance reacted, the reaction rate became 0.76 Torr/s. Determine the order of the reaction.

4. The rate constant of the decomposition reaction of some substance is 2.80 •10-3 dm3/mol • s at 30 ° C and 1.38•10-2 dm3/mol•s at 50 °C. Find the activation energy and the pre-exponential factor A for a given reaction.

5. The standard Gibbs energy change for the A + B ↔ AB reaction at 298 K is -8 kJ/mol. The initial concentrations of substances A and B are equal to 1 mol/l. Find the equilibrium constant and the equilibrium concentrations of A, B and AB.

4.3. EXAMPLE OF A CONTROL TASK ON ELECTROCHEMISTRY AND REDOX REACTIONS

1. Which of the listed ions can be reducing agents: Fe2+, Sn2+, Pb4+, Tl3+, Ge4+? Explain the answer.

2. Determine the oxidizer and reducing agent in the following transformations:

a) 2Al + 6HCl → 2AlCl3 + 3H2O;

b) HI + H2SO4(conc.) → I2 + SO2 + H2O;

c) 5KNO2 + 2KMnO4 + 3H2SO4 → 5 KNO3 + 2MnSO4 + K2SO4 + 3H2O.

3. For the galvanic cell:

(–) Ni Ni2+ Sn2+ Sn (+)

a) write the equation of reactions occurring on the electrodes, the equation of the total reaction of the process and the Nernst equation for it;

b) calculate the E of the element and estimate the order of the equation;

c) in which direction will the process proceed if aNi2 + = 1 mol / l, aSn2+ = 10-4 mol / l?

4. Make up the circuits of galvanic cells in which reactions occur:

a) Zn +2Fe3 + → Zn2 + + 2Fe2+;

b) Cd + CuSO4 → CdSO4 + Cu.

EXAMPLE OF A CONTROL TASK ON THE MAIN CLASSES OF INORGANIC AND ORGANIC COMPOUNDS

1. Determine the number of boron atoms contained in sodium tetraborate Na2B4O7 weighing 40.4 g.

2. Lithium reacts with water to form hydroxide and hydrogen gas:

2Li(tv) + 2H2O(w) → 2LiOH(p-r) + H2(g).

How many grams of lithium are needed to get 7.79 g of H2?

3. How do the acid-base and redox properties of higher oxides and hydroxides of elements change with the increase in the charge of their nuclei: a) within the period; b) within the group.

4. Which of the listed compounds will NaCl table salt react with in an aqueous solution: a) Cu(OH)2; b) H2SiO3; c) AgNO3; d) CO2.

5. Explain the reasons for the diversity of organic compounds. Why do the structural isomers of C5H12 pentane have different boiling points? Draw two possible structural isomers of C5H12.

AN EXAMPLE OF A CONTROL TASK FOR THE TOPIC STRUCTURE OF MATTER

1. What is the maximum number of electrons an atom can contain in an electron layer with the main quantum number n = 4?

2. Write electronic configurations:

a) Sn, Sn2+, Sn4+;

b) Mn, Mn2+;

c) Cu, Cu2+; Cr, Cr3+;

d) S, S2−.

3. How does the value of the first ionization potential of the elements of the second period change with the growth of the ordinal number? How can we explain that the first ionization potential of the Be atom is greater than that of the Li and B atoms?

4. Determine the type of connection in the following connections: a) CC bond in H3CCH3; b) KI bond in KI; c) NB bond in H3NBCl3; d) ClO bond in ClO2.

5. Describe the spatial structure of the nonpolar molecule BeCl2. Which atomic orbitals of beryllium are involved in the formation of Be–Cl bonds?

6. The dipole moments of H2O and H2S molecules are 1.84 and 0.94 D, respectively. Which molecule is more polar? Indicate the directions of the dipole moments of the bonds in these molecules.

7. What kind of interactions between particles lead to the transition to the condensed state of He, N2, HI, Cl2, BF3, H2O?

EXAMPLE OF A TEST CONTROL ON THE TOPIC CHEMICAL PROBLEMS OF PROCESSING PRODUCTS OF RENEWABLE NATURAL RESOURCES

1. The property of cellulose underlying its chemical processing:

a) decomposition without air access;

b) gorenje;

c) esterification;

d) hydrolysis.

2. What substances are classified as heteropolysaccharides:

a) cellulose;

b) chitin;

c) chitosan;

d) starch.

3. Acetate fiber obtained by chemical modification of cellulose is called:

a) natural;

b) artificial;

c) synthetic;

d) natural.

4. Ethanol obtained by the chain of transformations:

Cellulose → Glucose → Ethanol

is called:

a) food;

b) hydrolysis;

c) synthetic;

d) artificial

5. By hydrolysis of 250 kg of sawdust, the cellulose content of which is 45%, 62 kg of glucose was obtained. Determine the mass fraction of the glucose yield from the theoretically possible.

a) 98.1%;

b) 56.7%;

c) 49.6%;

d) 30.5%.

6. Give examples of high-tech materials based on biopolymers that are promising for use in astronautics.

EXAMPLE OF A CONTROL TASK ON THE TOPIC CHEMICAL PROBLEMS OF OBTAINING AND CONVERTING ENERGY IN ROCKET TECHNOLOGY

1. Which fuel, according to its energy intensity per 1 g, is better to use in rocket engines: liquid hydrazine N_2H_4 or gaseous borane B_5H_9? Gorenje reaction equations:

$N_2H_4 + O_2 = N_2 + 2H_2O$;

$2B_5H_9 + 12O_2 = 5B_2O_3 + 9H_2O$.

For substances N_2H_4 (w), H_2O (w), B_5H_9 (g), B_2O_3 (cr), the enthalpy of formation (DHcobr) is 50.4; -241.8; 62.5; -1273.8 kJ/mol, respectively.

2. The volume of gaseous (at flame temperature) combustion products of rocket fuel based on the mass of fuel should be as large as possible. Calculate the volume (reduced to n.o.) of combustion products of 100 g of a mixture of NH_4NO_3 and $(CN_3H_6)NO_3$, counting water as steam. In which direction will the volume of gases change at the flame temperature (the pressure is considered atmospheric)? The ratio of the components of the mixture is such that when it burns, all nitrogen turns into N_2, hydrogen into H_2O, and carbon into CO_2.Gorenje

3. Specify in which of the above reactions hydrazine N_2H_4 serves as an oxidizer, and in which – a reducing agent:

a) $N_2H_4 + 4AgNO_3 + 4KOH = N_2 + 4Ag + 4KNO_3 + 4H_2O$;

b) $N_2H_4 + Zn + 2KOH + 2H_2O = 2NH_3 + K_2[Zn(OH)_4]$.

How does the degree of nitrogen oxidation change in each case?

4. Hydrogen-oxygen fuel cell: device, operating principle, reactions occurring.

4. Критерии оценивания

Оценка	Баллы	Критерии
Excellent	10	- systematic, in-depth and complete knowledge of all sections of the curriculum, as well as on the main issues beyond its limits; - accurate use of scientific terminology (including in a foreign language), stylistically competent, logically correct presentation of the answer to the questions; - perfect knowledge of the tools of the discipline, the ability to use it effectively in the formulation and solution of scientific and professional tasks; - expressed ability to independently and creatively solve complex problems in a non-standard situation; - complete and in-depth assimilation of the main and additional literature recommended by the curriculum of the discipline; - the ability to navigate theories, concepts and directions in the studied discipline and give them a critical assessment, use scientific achievements of other disciplines; - creative independent work in practical, laboratory classes, active participation in group discussions, a high level of task performance culture.
	9	- systematic, deep and complete knowledge of all sections of the curriculum; - accurate use of scientific terminology (including in a foreign language), stylistically competent, logically correct presentation of the answer to the questions; - possession of the tools of the discipline, the ability to use it effectively in the formulation and solution of scientific and professional tasks; - the ability to independently and creatively solve complex problems in a non-standard situation within the framework of the curriculum, full assimilation of the main and additional literature recommended by the curriculum of the discipline; - the ability to navigate the main theories, concepts and directions of the discipline being studied and give them a critical assessment; - independent work in practical, laboratory classes, creative participation in group discussions, a high level of task performance culture.
	8	- systematized, in-depth and complete knowledge on all the issues raised in the scope of the curriculum;

		- the use of scientific terminology, stylistically competent, logically correct presentation of the answer to questions, the ability to draw informed conclusions; - possession of the tools of the discipline (methods of complex analysis, information technology techniques), the ability to use it in the formulation and solution of scientific and professional tasks; the ability to independently solve complex problems within the curriculum; - assimilation of the main and additional literature recommended by the curriculum of the discipline; - the ability to navigate the main theories, concepts and directions of the discipline being studied and to give them a critical assessment from the standpoint of state ideology (in the disciplines of the socio-humanitarian cycle); - active independent work in practical, laboratory classes, systematic participation in group discussions, a high level of task performance culture.
Good	7	- systematic, deep and complete knowledge of all sections of the curriculum; - the use of scientific terminology (including in a foreign language), linguistically and logically correct presentation of the answer to questions, the ability to draw informed conclusions; - possession of the tools of the discipline, the ability to use it in the formulation and solution of scientific and professional tasks; - assimilation of the main and additional literature recommended by the curriculum of the discipline; - the ability to navigate the main theories, concepts and directions of the discipline being studied and give them a critical assessment; - independent work in practical, laboratory classes, participation in group discussions, a high level of task performance culture.
	6	- sufficiently complete and systematized knowledge in the scope of the curriculum; - the use of the necessary scientific terminology, stylistically competent, logically correct presentation of the answer to questions, the ability to draw informed conclusions; - possession of the tools of the discipline, the ability to use it in solving educational and professional tasks; the ability to independently apply standard solutions within the framework of the curriculum; - assimilation of the basic literature recommended by the curriculum of the discipline; - the ability to navigate the basic theories, concepts and directions of the discipline under study and give them a comparative assessment; active

		independent work in practical, laboratory classes, periodic participation in group discussions, a high level of culture of task performance.
	5	- sufficient knowledge in the scope of the curriculum; - the use of scientific terminology, stylistically competent, logically correct presentation of the answer to questions, the ability to draw conclusions; - possession of the tools of the discipline, the ability to use it in solving educational and professional tasks; - the ability to independently apply standard solutions within the framework of the curriculum; - assimilation of the basic literature recommended by the curriculum of the discipline; - the ability to navigate the basic theories, concepts and directions of the studied discipline and give them a comparative assessment; - independent work in practical, laboratory classes, participation in group discussions, a high level of task performance culture.
Satisfactory	4	- sufficient knowledge within the educational standard; - assimilation of the basic literature recommended by the curriculum of the discipline; - the use of scientific terminology, stylistic and logical presentation of the answer to questions, the ability to draw conclusions without significant errors; - possession of the tools of the discipline, the ability to use it in solving standard (typical) tasks; - ability to solve standard (typical) tasks under the guidance of a teacher; - the ability to navigate the main theories, concepts and directions of the discipline being studied and to evaluate them; - work under the guidance of a teacher in practical, laboratory classes, an acceptable level of task performance culture.
	3	- insufficient amount of knowledge within the educational standard; - knowledge of the part of the main literature recommended by the curriculum of the discipline; - the use of scientific terminology, the presentation of the answer to questions with significant linguistic and logical errors; - poor knowledge of the tools of the discipline, incompetence in solving standard (typical) tasks; - inability to navigate the basic theories, concepts and directions of the discipline being studied;

		- passivity in practical and laboratory classes, a low level of task performance culture.
Unsatisfactory	2	- fragmentary knowledge within the educational standard; - knowledge of individual literary sources recommended by the curriculum of the discipline; - inability to use the scientific terminology of the discipline, the presence of gross stylistic and logical errors in the answer; - passivity in practical and laboratory classes, a low level of task performance culture.
	1	- lack of knowledge and competencies within the educational standard or refusal to answer.

5. Методические материалы, определяющие процедуры оценивания знаний навыков и (или) опыта деятельности

Differentiated credit in the discipline is carried out based on the results of current academic performance. The student's score is defined as the arithmetic mean of the sum of the points received by the student during laboratory and control work.

When receiving a differentiated credit, points for additional independent work of a student (writing an abstract on a given topic related to chemical problems of modern aerospace technologies) can be taken into account.

During the differentiated test and the defense of the abstract, students can use the discipline program, as well as reference literature.