

**MINISTRY OF HEALTH OF UKRAINE  
NATIONAL PIROGOV MEMORIAL MEDICAL  
UNIVERSITY, VINNYTSYA**

**“Approved”**

Head of Admission Commission  
of VNMU n. a. M.I. Pirogov,  
Acting rector of IPEI

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**PROGRAM FOR  
CHEMISTRY ENTRANCE EXAMINATION  
(elective discipline)**

**Vinnytsya - 2023**

## EXPLANATORY NOTE

The main purpose of the entrance examination in chemistry is an objective and impartial assessment of the level of academic achievement of persons, who have decided to enter National Pirogov Memorial Medical University, Vinnytsya. The program of entrance tests in chemistry is developed on the basis of the State standard of basic and complete general secondary education, approved by the Cabinet of Ministers of Ukraine dated 23 November, 2011 №1392 and «Program of external independent assessment in chemistry» (order of the Ministry of Education and Science of Ukraine of 06/26/2018 № 695).

It focuses on the acquisition of subject skills by applicants and their achievement of certain learning outcomes. It is important not only for applicants to master chemical concepts, laws, but also the ability to explain chemical phenomena, draw oral conclusions about them, meaningful use of knowledge, formulation of evaluative judgments, identifying their own position in various life situations. The material of the program is divided into thematic blocks: «General Chemistry», «Inorganic Chemistry» and «Organic Chemistry», in which in the form of theoretical questions the content of the educational material, which must be owned by applicants. Theoretical questions fully correspond to the program in chemistry for entrance examinations to higher educational institutions of Ukraine (approved by the Ministry of Education and Science of Ukraine, 2011).

## 2. CONTENT OF THE PROGRAM

### Section 1. General chemistry

1. Subject and problems of chemistry. The place of chemistry among the natural sciences. Physical and chemical phenomena. Ecological problems of chemistry. The role of chemistry in environmental protection.
2. Atomic molecular theory. Molecules. Atoms. The law of constancy of the composition of substances. Relative atomic and relative molecular mass. The amount of substance. Mole. Molar mass. Avogadro's law and molar volume of gas.
3. Chemical element, simple and complex substances. Chemical formulas. Valency. Calculations of the mass fraction of a chemical element in a substance according to the formula. Establishing the simplest formula of a substance according to its composition.
4. The composition of atomic nuclei (protons and neutrons). The concept of proton and nucleon number, nucleon, nuclide. Isotopes. The essence of the phenomenon of radioactivity.
5. The concept of energy levels, sublevels, orbitals, paired and unpaired electrons. Forms of s- and p-orbitals, placement of p-orbitals in space. The sequence of electron filling of energy levels and sublevels in atoms of elements №1-20 and 26. Electronic and electron-graphical formulas of atoms and simple ions of elements № 1-20 and 26 in the ground and excited states. Valency states of elements.
6. Chemical bond, its types. Covalent bond (polar and nonpolar). Mechanisms of covalent bond formation (exchange and donor-acceptor) and its characteristics (multiplicity, energy, polarity). Electronic formula of molecules. Characteristics of

ionic, hydrogen and metallic bonds.

7. Crystalline and amorphous states of substances. Types of crystal lattices (atomic, molecular, ionic and metallic). Dependence of properties of substances on the type of crystal lattice.

8. Modern formulation of the periodic law of D.I. Mendeleev. Structure of the periodic table: large and small periods, groups and subgroups (main and secondary). Dependence of the properties of elements (atomic radius, electronegativity, metallic and nonmetallic properties) on their position in the periodic table. Families of chemical elements (alkali and alkaline earth metals, halogens, inert gases). Periodicity of changes in the properties of simple substances and compounds of elements. The meaning of the periodic law.

9. Chemical reaction, reaction scheme, chemical equation. External effects of chemical reactions. Classification of chemical reactions by type of reagent transformation (coupling, decomposition, substitution, exchange). Laws of conservation of mass of substances during chemical reactions and volume ratios of gases in reactions.

10. Thermal effects of chemical reactions, thermochemical equations. Exothermic and endothermic reactions.

11. Irreversible and reversible chemical reactions. Chemical equilibrium and conditions of its displacement. Le Chatelier principle.

12. The degree of oxidation of the element in the substance. Redox reactions. The concept of oxidant and reducing agent, oxidation and reduction processes. Electronic balance method.

13. Galvanic cell: definition, scheme of structure, principle of action, redox processes, application.

14. The rate of chemical reactions. Dependence of velocity on nature and concentration of reactants, surface area of reagents, temperature. Catalysts and catalysts.

15. Pure substances and mixtures. Classification of mixtures. The concept of dispersed systems. Colloidal and true solutions. Suspensions, emulsions, aerosols. Methods of separation of mixtures. Determination of the average molar mass of mixtures, mass and volume fractions of the components of the mixture.

16. The concept of solutions, solvent, solute, crystal hydrates. Solubility of substances and its dependence on the nature of substances, temperature and pressure. The mechanism of the dissolution process. Thermal effects upon dissolution. Saturated and unsaturated, concentrated and diluted solutions. Mass fraction of the substance in solution

17. Electrolytes and non-electrolytes. Electrolytic dissociation. Degree of dissociation. Strong and weak electrolytes. Properties of bases, acids and salts in the light of the theory of electrolytic dissociation. Hydrogen index (pH) and its value in acidic, alkaline and neutral environments. The color of the indicators (universal, phenolphthalein, methyl orange) depending on the pH of the medium.

18. Ion exchange reactions. Qualitative reactions for determination in solutions of chloride, sulphate, carbonate, silicate and orthophosphate ions, ammonium ions, iron (2+), iron (3+).

19. Hydrolysis of salts: definition, types, influence of temperature and pH. Coloring of indicators (universal, phenolphthalein, methyl orange) in solutions of various salts.

## Section 2. Inorganic chemistry.

1. Oxides: definition, names, classification, chemical properties of salt-forming oxides, extraction methods.
2. Basics: definition, names, classification, chemical properties, methods of extraction
3. Acids: definition, names, classification, chemical properties, extraction methods.
4. Salts: definition, names, classification, chemical properties and methods of extraction of medium and acid salts
5. The concept of amphotericity. Chemical properties and methods of extraction of amphoteric oxides and hydroxides. Genetic links between classes of inorganic compounds.
6. The position of metals in the periodic table. Features of the electronic structure of metal atoms. Metal connection. General physical properties of metals, dependence on their structure.
7. General chemical properties and methods of metal extraction. A number of activity of metals. Corrosion of metals and methods of corrosion protection.
8. Alkali metals: electronic structure, physical and chemical properties, distribution in nature, application. Basic compounds of alkali metals, their chemical properties and applications.
9. Alkaline earth metals: electronic structure, physical and chemical properties, application. The main compounds of alkaline earth elements, their chemical properties and applications. Water hardness and methods of its elimination.
10. Aluminum: electronic structure, physical and chemical properties, application. Basic aluminum compounds, their chemical properties and applications. Qualitative reaction on aluminum cations
11. Iron: electronic structure, physical and chemical properties, applications. Basic compounds of aluminum and iron, their chemical properties and applications. Qualitative reactions on iron cations. Iron alloys. Production of cast iron and steel.
12. General characteristics of non-metallic elements (place in the periodic table, features of the electronic structure of atoms). Physical properties of nonmetals. Phenomena of allotropy and adsorption. Oxidizing and reducing properties of non-metals. The use of non-metals.
13. Halogens. Chlorine: electronic structure, physical and chemical properties, applications and biological significance.
14. Hydrogen chloride and hydrochloric acid: physical and chemical properties, application. Qualitative reactions to chlorides.
15. Oxygen: electronic structure, allotropic modifications and their physical properties. Chemical properties, prevalence, application and biological significance of oxygen and ozone. Oxygen production in the laboratory and industry. Methods of collecting oxygen. Proof of oxygen. Oxidation (combustion, slow oxidation, respiration). Conditions of occurrence and cessation of combustion.
16. Sulfur: electronic structure. Allotropic modifications of sulfur and their physical properties. Chemical properties and applications of sulfur.
17. Hydrogen sulfide and sulfide acid: physical and chemical properties, application. Qualitative reactions to sulfides.
18. Sulfuric acid: physical and chemical properties, extraction and application.

Oxidizing properties of sulfuric acid. Qualitative reactions to sulfates

19. Nitrogen: electronic structure. Physical and chemical properties, application and prevalence of nitrogen in nature.

20. Ammonia: physical and chemical properties, applications. Qualitative reactions to ammonium ions.

21. Nitric acid: physical and chemical properties, extraction and application. Oxidizing properties of nitric acid. Qualitative reactions to nitrates

22. Phosphorus: electronic structure, allotropic modifications and their physical properties. Chemical properties and application of phosphorus. Features of orthophosphate acid. Mineral fertilizers.

23. Carbon: electronic structure, allotropic modifications and their physical properties. Coal. The concept of adsorption. Chemical properties and applications of carbon.

24. Oxides of non-metallic elements in the atmosphere. Greenhouse effect. Acid rains. Silicon (IV) oxide and modern silicate materials.

### Section 3. Organic chemistry.

1. The concept of organogenic elements, organic compounds (natural and synthetic) and organic chemistry. Nomenclature and classification of organic compounds. The phenomenon of homology: homologues, homologous series, homologous difference. Isomerism: definitions, structural isomers. Classification of chemical reactions in organic chemistry.

2. Theory of structure of organic compounds. Interaction of atoms or groups of atoms in molecules of organic compounds. Hybridization of electron orbitals of the carbon atom in organic compounds. Chemical bonds in molecules of organic compounds (simple, double, triple).

3. Alkanes. The general formula of alkanes, their nomenclature, isomerism, structure of molecules, physical and chemical properties, methods of extraction, application. The concept of cracking and isomerization.

4. Alkenes. General formula of alkenes, their nomenclature, isomerism; structure of molecules, physical and chemical properties, methods of extraction, application of ethene and propene; qualitative response to the double bond. The concept of polymerization, polymer, monomer, elementary unit, degree of polymerization.

5. Alkynes. General formula of alkynes, their nomenclature, isomerism; molecule structure, physical and chemical properties, methods of extraction, application of ethine; qualitative response to multiple communication.

6. Aromatic hydrocarbons (arenes). General formula of arenes, their nomenclature, isomerism; molecule structure, physical and chemical properties, methods of extraction, application of benzene; the concept of aromaticity.

7. Natural sources of hydrocarbons and their processing. Oil, natural and associated petroleum gases, coal, their composition; cracking and aromatization of oil and oil products. Detonation resistance of gasoline. Chemical processing of coal. Extraction of liquid fuel from coal and alternative sources.

8. Alcohols. Classification of alcohols. General formula, structure of molecules, nomenclature, isomerism, properties, methods of extraction and use of saturated monohydric alcohols. Alcohol has a detrimental effect on human health. Glycerin

(glycerol) as a representative of polyhydric alcohols; qualitative reaction to polyhydric alcohols.

9. Phenol. Phenol formula, molecule structure, properties, extraction, application; qualitative reaction to phenol.

10. Aldehydes. General formula of aldehydes, structure of molecules, nomenclature, properties, methods of extraction, application; qualitative reactions to the aldehyde group.

11. Carboxylic acids. Classification of carboxylic acids; functional group, general formula, structure of molecules, nomenclature, isomerism of monobasic carboxylic acids, their properties, application; methods of obtaining methane and ethanoic acids; distribution in nature of carboxylic acids. Soaps and synthetic detergents. Negative impact of synthetic detergents on the environment.

12. Esther. General formula of carboxylic acid esters, their classification, molecule structure, nomenclature, isomerism, properties, extraction, application, distribution in nature.

13. Fats: definition, classification, physical and chemical properties, extraction and biological role.

14. Carbohydrates. Classification of carbohydrates; composition, molecular formulas of glucose, fructose, sucrose, starch and cellulose; structural formulas of open forms of glucose and fructose molecules. Physical and chemical properties of glucose, fructose, sucrose, starch and cellulose. Glucose extraction, sucrose and starch production. Biological role of carbohydrates. Qualitative reactions for the determination of glucose and starch. The use of glucose, sucrose, starch, cellulose. The concept of artificial fibers.

15. Amines: definition, characteristic (functional) group of amines, classification, nomenclature, isomerism. Molecule structure, physical and chemical properties, application of methylamine and aniline.

16. Amino acids. Composition and structure of molecules, bipolar ion, general and structural formulas, characteristic (functional) groups, systematic nomenclature. The concept of amphoteric amino acids. Chemical properties and extraction of aminoethanoic acid. Peptide group. Peptides. Biological role of amino acids.

17. Proteins. The structure of proteins, their properties, applications, biological role. Denaturation and hydrolysis of proteins. Color reactions to proteins.

18. Synthetic macromolecular substances and polymeric materials based on them. Classification of macromolecular substances. Methods of synthesis of macromolecular substances (polymerization and polycondensation reactions). Plastics. Rubber, natural rubber. Synthetic fibers: physical properties and applications. The most common polymers and their applications. The value of natural and synthetic polymeric organic compounds

Head of examination commission  
Professor Melnyk A.V.

## ASSESSMENT OF EXAMINATION TASKS IN CHEMISTRY

to admit foreign citizens (English as medium of instruction) to study in 2023 for a master's degree (field of knowledge 22 Healthcare) in the speciality 221 «Dentistry», 222 «Medicine», 226 «Pharmacy, industrial pharmacy»

The chemistry exam paper contains **20 test tasks** of two levels of difficulty. The maximum number of points, that can be scored by correct completion of all the tasks is 60.

### Types of certification work tasks and scoring schemes for tasks completion

Task type	Scoring scheme
Tasks with one correct answer choice (№ 1–10).	<b>0</b> or <b>2</b> points: 2 points if the correct answer is given; <b>0</b> points if an incorrect answer is given or no answer to the task is given at all.
Tasks for establishing the correct matching (№ 11–20).	<b>0, 1, 2, 3</b> or <b>4</b> : 1 point for each correctly established matching; <b>0</b> points for the task, if no correct match is given.

Recalculation of the test points into a rating grade is carried out according to the table.

**Table of transfer of test points, received by applicants for the performance of the examination work in chemistry, into a rating grade (on 100-200 points scale)**

Test point	Rating grade 100-200	Test point	Rating grade 100-200	Test point	Rating grade 100-200	Test point	Rating grade 100-200
0	<i>Didn't pass</i>	16	117,0	32	155,0	48	182,0
1	<i>Didn't pass</i>	17	120,0	33	157,0	49	184,0
2	<i>Didn't pass</i>	18	123,0	34	159,0	50	186,0
3	<i>Didn't pass</i>	19	125,0	35	161,0	51	187,0
4	<i>Didn't pass</i>	20	128,0	36	163,0	52	189,0

5	<i>Didn't pass</i>	21	131,0	37	165,0	53	191,0
6	<i>Didn't pass</i>	22	133,0	38	167,0	54	193,0
7	<i>Didn't pass</i>	23	136,0	39	168,0	55	194,0
8	<i>Didn't pass</i>	24	138,0	40	170,0	56	196,0
9	<i>Didn't pass</i>	25	140,0	41	172,0	57	197,0
10	<i>Didn't pass</i>	26	143,0	42	174,0	58	198,0
11	100,0	27	145,0	43	175,0	59	199,0
12	104,0	28	147,0	44	177,0	60	200,0
13	107,0	29	149,0	45	178,0		
14	111,0	30	151,0	46	180,0		
15	114,0	31	153,0	47	181,0		