Ministry of Education and Science of Ukraine

V.N. KARAZIN KHARKIV NATIONAL UNIVERSITY

School of Chemistry

APPROVED:

Head of the admissions committee of

V.N. Karazin Kharkiv National University

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“_____” _____ 2023 y.

PROGRAM

OF ENTRANCE EXAM IN CHEMISTRY

(in oral form)

for obtaining “Master’s degree”

in medical science

Kharkiv 2023

1. General chemistry

1.1 The main chemical definitions. Substance

Definitions of substance, physic body, material, simple compound, complex compound, chemical compounds, chemical reaction, chemical formula, scheme of the reaction, chemical equation, relative atomic (molecular) mass, molar mass, quantity of substance; names and composition of some mixtures of substances; methods to separate mixtures; units of measure of mass, volume, quantity of substance,density, molar mass, molar volume, values of temperature and pressure, that corresponds to standard conditions, molar volume of gas; Avogadro low, Avogadro number, average relative mass of air.

1.2 Chemical reactions

The lows of mass conservation, proportions of gases volume at chemical processes, Le-Chatelier principle; the internal effects, followed by chemical reactions, definitions of oxidizer, reducing agent, oxidation, reduction, catalyst, chemical equilibrium;types of chemical reactions.

1.3 Periodic low and periodic table of chemical elements by D. Mendeleev

Periodic low (modern definition), structure of the long and short types of periodic table, groups of the most important elements, position of metallic and non metallic elements in the periodic table.

1.4 Structure of atom

Composition of atom; definitions of nucleon, nuclide, isotopes, photonics number, nucleonic number, orbital, energetic level, electronic shell, coupled (single) electron, phenomena of radioactivity, forms of s- and p-orbitals, position of p-orbitals in space, order of energetic level in atom.

1.5 Chemical bond

The main types of chemical bond (ionic, covalent, hydrogen, metallic); types of crystalline lattices, definition of electronegativity, oxidation number, multipliness of covalent bond, polarity of covalent bond.

1.6 Solutions

Components of solutions: solvent, dissolved substance, crystalline hydrate, electrolyte, non electrolyte, degree of electrolyte dissociation, color of the indicators (universal, lacmus, phenolphtalein, methylorange) in acidic, neutral and alkaline medias; structure of molecule of water; nature of the processes of solution and electrolyte dissociation.

2. Inorganic chemistry

2.1. The main classes of inorganic compounds

2.1.1 Oxides

Definition, names, classification, properties, methods to obtain.

2.1.2. Bases

Definition, names, classification, properties, methods to obtain.

2.1.3 Acids

Definition, names, classification, properties, methods to obtain.

2.1.4 Salts

Definition, names, classification, properties, methods to obtain.

2.1.5 Amphoteric compounds

Definition of amphoterism; chemical properties, methods to obtain amphoteric oxides and hydroxides.

2.2. Metallic elements and their compounds. Metals.

2.2.1 General information about metallic elements and metals.

Position of metallic elements in the periodic table; peculiarities of electronic structure of the atoms of metallic elements; peculiarities of metallic chemical bond; general physical properties; general chemical properties; general methods to obtain; corrosion, ways to prevent corrosion; names and formulas of the most important compounds of metallic elements; alloys (cast iron, steel). Systematization of information about metals and compounds of metallic elements.

2.2.2. Alkaline and earth-alkaline metals.

Chemical properties; methods to obtain; names and formulas of the most important compounds; hardness of water; using of the most widely distributed sodium, potassium, calcium compounds; chemical properties of the most widely distributed potassium fertilizers.

2.2.3. Aluminum and compounds of aluminum

Chemical properties; methods to obtain; names and formulas of the most important compounds; using of the most widely distributed aluminum compounds.

2.2.4. Iron and ferrum compounds.

Chemical properties; methods to obtain; names and formulas of the most important compounds; using Iron and of the most widely distributed ferrum compounds.

2.3. Non metallic elements and their compounds. Non metals.

Systematization of information about non metals and compounds of non metallic elements.

2.3.1. Non metallic elements

Non metallic elements (hydrogen, halogens, oxygen, sulphur, nitrogen, phosporus, carbon, silica); electronic formulas of the atoms of nonmetallic elements; electronic formulas and names of the simple and most widely distributed complex compounds of non metallic elements; phenomena of allotropy and allotropic modifications; phenomena of absorption; chemical properties of the simple and most widely distributed complex compounds of non metallic elements; physical properties of the simple and most widely distributed complex compounds of non metallic elements; methods to obtain of the simple and most widely distributed complex compounds of non metallic elements in laboratory and in industry; the most important brunches of using of simple and most widely distributed complex compounds of non metallic elements; qualities reactions to determine simple and complex ions of non metallic elements.

2.3.2. Hydrogen. Compounds of hydrogen.

Electronic formula of hydrogen atom; chemical formula of the simple compound of hydrogen; physical properties of hydrogen and water; chemical properties of hydrogen and water; methods to obtain hydrogen in laboratory and in industry; methods of purification of water; the most important brunches of using of hydrogen and water; proof of hydrogen existence.

2.3.3. Halogens compounds

Electronic formulas of Fluorine and Chlorine atoms; chemical formulas of the simple compound of halogens (fluorine, chlorine, bromine, iodine); chemical properties and names of the most widely distributed compounds of halogens, physical properties of the most important compounds of halogens (hydrogen chloride,halogenides of metallic elements); chemical properties of chlorine and hydrogen chloride; methods to obtain of chlorine and hydrogen chloride in laboratory and in industry; the most important brunches of using of chlorine and hydrogen chloride, chlorides; qualities reactions to determine halogenide-ions.

2.3.4. Oxygen subgroup

Electronic formulas of oxygen and sulphyr atoms; allotropic modifications of oxygen and sulphyr atoms; chemical formulas of the simple compounds of Oxygen (Oxygen, ozone), and suplhur and the most widely distributed compounds of oxygen and sulphyr; physical and chemical properties of oxygen and sulphyr compounds (Oxygen, ozone, sulphur, sulphur (IV) oxide, sulphur (VI) oxide, sufuric acid, sulphates); methods to obtain Oxygen, ozone, sulphur, sulfuric acid in laboratory and in industry; conditions of sulfuric acid manufacturind; the most important brunches of using of Oxygen, sulphur, sulphur (IV) oxide, sulphur (VI) oxide, sulfuric acid, sulphates; qualities reactions to determine sulphate ions.

2.3.5. Nitrogen subgroup

Electronic formulas of nitrogen and phosphorus atoms; allotropic modifications of phosphorus; chemical formulas of the simple compounds of nitrogen and phosphorus (white and red), the most widely distributed compounds of nitrogen and phosphorus, the most widely distributed fertilizers, contains nitrogen and phosphorus; physical and chemical properties of nitrogen and phosphorus compounds (nitrogen, white and red phosphorus, nitrogen (IV) oxide, phosphorus (V) oxide, ammonia, ammonia salts, nitric acid, nitrates, phosphoric acid, phosphates); methods to obtain nitrogen, phosphorus, ammonia, nitric acid, phosphoric acid, in laboratory and in industry ; conditions of ammonia manufacturind; the most important brunches of using of nitrogen, phosphorus, phosphorus (V) oxide, ammonia, nitric acid, nitrates, phosphoric acid, phosphates; qualities reactions to determine phosphate-,ammonia-and nitrate ions.

2.3.6. Subgroup of Carbon

Electronic formulas of carbon and silica; allotropic modifications of carbon; definition of absorption, absorption properties of carbon; chemical formulas of simple carbon and silica compounds and the most widely distributed compounds of carbon and silica; physical and chemical properties of simple compounds of carbon and silica (carbon (II) oxide, carbon (IV) oxide, carbonates, silica (IV) oxide, silica acid, silicates); methods to obtain carbon, silica, carbon (II) oxide, carbon (IV) oxide in laboratory and industry; the most important brunches of using of carbon, diamante, graphite, carbon (II) oxide, carbon (IV) oxide, carbonates, hydrogenharbonates, silica (IV) oxide, silica acid, silicates; qualities reactions to determine carbonate-and silicate-ions.

3. Organic Chemistry

3.1 Theory of organic chemistry. Overview of organic compounds and organic chemistry; nature compounds and synthetic organic compounds.

Structural theory of organic compounds. Electronic structure of Carbon atom in its ground state and excited state. Chemical bond types in organic molecules. Hybridization of electronic orbitals of Carbon; sp^3, *sp*-, *sp* hybridization types. σ– i π– bonds. Classification of organic compounds. Homology, homologs, homologous series, homological difference; classes of organic compounds; general formulas of homologous series and classes of organic compounds. Primary (secondary,

tertiary, quaternary) Carbon atom. Nomenclature of organic compounds. Isomerism and isomers; structural isomers and stereoisomers. Influence of atoms or atom groups on electronic density distribution in organic molecules. Acidity and basicity of organic compounds. Classification of chemical reactions in organic chemistry. Chemical safety with dangerous influence of organic compounds on environment and on human health due to manufacture, storage, transportation, use and waste management.

3.2. Hydrocarbons

Classification, general formulas of homologous series, structure, nomenclature, isomerism of hydrocarbons.

3.2.1. Alkanes

General formula, nomenclature, isomerism, structure, physical and chemical properties, preparation methods; cracking of alkanes, isomerization.

3.2.2. Alkenes

General formula, nomenclature, isomerism, structure, physical and chemical properties, preparation of alkenes; double bond test reaction; polymerization and polymers, monomer, repeat unit, degree of polymerization.

3.2.3. Alkynes

General formula, nomenclature, isomerism, structure, physical and chemical properties, preparation methods, practical use of alkynes; test reaction on triple bond.

3.2.4. Aromatic hydrocarbons (arenes)

General formula, nomenclature, isomerism, structure, physical and chemical properties, preparation methods, practical use of aromatic hydrocarbons; aromaticity.

3.2.5. Natural sources and industrial transformation of hydrocarbons

Natural gas, petroleum; cracking and aromatization of oil products, detonation resistance of petrol; coal composition; problem of obtaining liquid fuels from coal and from alternative sources..

3.3. Oxygen-containing compounds

Classification of oxygen-containing compounds; functional groups of different classes of oxygen-containing compounds; nomenclature of oxygen-containing compounds. Hydroxy derivatives of hydrocarbons. Classification of hydroxy derivatives of hydrocarbons.

3.3.1. Alcohols

Classification of alcohols. General formula, structure, nomenclature, properties, preparation methods. Occurrence of saturated alcohols in nature. Influence of alcohols on human health.
Glycerol (glycerin) as an example of compound with multiple hydroxyl groups (“polyols”). Test reactions of polyols. Phenol. Structure, properties, preparation methods, practical use; test reaction on phenol.

3.3.2. Aldehydes

General formula, structure, nomenclature, properties, preparation methods, practical use, natural occurrence; test reaction on aldehyde functional group.

3.3.3. Carboxylic acids

Classification, general formula, structure, nomenclature, isomerism, properties, preparation

methods, practical use, natural occurrence of carboxylic acids; structure and properties of soap and detergents; environmental impact of detergents.

3.3.4. Esters. Fats

Classification, general formula, structure, nomenclature, isomerism, properties, preparation methods, practical use, natural occurrence of carboxylic acid esters; biological function of fats

3.3.5. Carbohydrates

Composition, empirical formulas and structural formulas of glucose, fructose, sucrose, starch, cellulose. Classification, structure, physical and chemical properties, preparation, practical use, biological function of carbohydrates; test reactions for determination of glucose and starch. Practical use of glucose, sucrose, starch, cellulose. Synthetic fibers.

3.3.6. Amines

General formulas, structure, nomenclature, isomerism, properties, preparation methods, practical use, natural occurrence of amines.

3.3.7. Amino acids

Structure, nomenclature, isomerism, physical and chemical properties, preparation methods, practical use, biological function of amino acids. Amphoteric properties of amino acids, dipolar ion, di-, tri- and polypeptides.

3.3.8. Proteins.

Structure, properties, practical use, biological function of proteins; test reaction on proteins.

3.3.9. Synthetic polymers and polymeric materials

Classification of polymers; synthesis of polymers; structure and properties of polymers; thermoplastic materials and plastics; domestic and industrial use polymers.

4. Calculation in Chemistry

4.1. Solution for tasks by chemical formula

Units of molar mass, molar volume, amount of substance, values of molar volume under normal conditions, Avogadro constant, formula for amount of substance, number of particles in given amount of substance, mass concentration of element in the compound, relative gas density, mass (volume) concentration in the mixture. Expression for quantitative composition of solution.

4.2. Quantitative composition of solutions

Definition of mass concentration, solution mass.

4.3. Solution for tasks by reaction equations

Algorithms of solution tasks by reaction equations; definitions: reaction yields, reagent excess.

Evaluation criteria

For evaluation of calculated problem, following factors are taken into account:

1) general understanding of the logic of solving the problem;

2) correctness of chemical compounds' formula, valence and oxidation state, ions' charges;

3) knowledge of main chemical properties for basic classes of chemical compounds (organic and inorganic);
4) correct writing of chemical reaction equations, including red-ox reactions;
5) correct writing of structural formula (firstly organic compounds);
6) correct use of chemical nomenclature, skills in naming compounds by structural formula and writing structure by name;
7) correct calculations – skills in calculation of amount of substance, molecular mass, mass concentration, molar concentration, skills in using ideal gas laws for volume, pressure and relative density calculations;
8) correct arithmetic calculations;
9) correct use of dimension of quantities.

Characteristics of the work (answer)	Grade
Correct answer received. All the key points of the solution are substantiated	**5**
The logically correct solution sequence is given. Some of the key points are insufficiently substantiated or not substantiated. 1–2 errors or typos in calculations or transformations are possible, which slightly affect the correctness of further solving. The answer received may be incorrect, or incomplete, or only a part of the task is solved correctly. Errors were corrected during the oral interview.	**4**
The logically correct solution sequence is given. Some of the key points of the solution may not be sufficiently substantiated. Errors in calculations or conversions that do not affect the correctness of the answer are present. The answer received may be incorrect or incomplete. Errors were corrected during the oral interview.	**3**
Some steps are omitted in the correct solution sequence. The key points of the solution are not substantiated. There are errors in calculations or transformations that affect further solving. The answer received is incomplete or incorrect. Errors were partially corrected during the interview.	**2**
There are only some steps in the solution sequence. The key points of the solution are not substantiated. The answer received is incorrect or the task is not completely solved. Errors were not corrected during the oral interview.	**1**
The participant did not start solving the task, or the entries do not meet the above criteria. No correct answer was given during the oral interview.	**0**

The maximum number of points for completing all tasks is 40 points.
If the entrant scored at least 4 points, the total number of points is transferred to the 100-200 scale in accordance with Table 7 of Appendix 5 to the "Procedure for transferring test scores from the chemistry of the national multi-subject test to the 100-200 scale".

Literature

1. Bettelheim F.A. Introduction to General, Organic, and Biochemistry, 10th Ed. – Cengage Learning, 2013 (in internet).
2. Bettelheim, W.H. Brown, M.K. Campbell, Sh.O. Farrell, O. Torres. Introduction to General, Organic and Biochemistry, 10th Edition. – 2013 (or previous years of the edition – 2010, 2007), Belmont: Brooks/Cole, Cengage Learning.
3. Carey F. A. Organic Chemistry, 5th Edition, The MgGraw-Hill, 2004. (http://www.chem.ucalgary.ca/courses/350/Carey5th/Carey.html).
4. Encyclopedia of Biological Chemistry, Volumes 1-3. Elsevier Inc. 2004.
5. 4. H. A. Fawre, W. H. Powell. Nomenclature of Organic Chemistry (IUPAC recommendations and preferred names), 2014, International Union of Pure and Applied Chemistry

Chairman of the subject examination commission
and interview commissions Tetiana CHERNOZHUK

It is approved at the meeting of the admissions committee of
V.N. Karazin Kharkiv National University

Protocol № 3 dated 3th April 2023

Responsible Secretary
of the admissions committee Sergii ELTSOV