THE BUDGETARY INSTITUTION OF HIGHER EDUCATION OF THE KHANTY-MANSIYSK AUTONOMOUS OKRUG-UGRA
"Surgut State University"

Approved by:
Deputy Chairman of the Admissions Committee, the First Vice Rector
_____ I.N. Danilenko
«30» октября 2023

ENTRANCE EXAM PROGRAM
ON THE GENERAL EDUCATION SUBJECT "CHEMISTRY"

for applicants to study in educational programs of higher education - bachelor's and specialty programs

Surgut
2023

The program is compiled in accordance with the requirements of the federal state educational standard of secondary general education and the federal state educational standard of basic general education.

The entrance test program was approved at a meeting of the Academic Council of the Institute of Nature and Technical Sciences on October 25, 2023, Protocol No. 9.

Content

I. GENERAL PROVISIONS

1. This program is compiled in accordance with the requirements of the federal state educational standard of secondary general education and the federal state educational standard of basic general education and determines the general content of the entrance exam for applicants to study in educational programs of higher education - undergraduate programs and specialty programs at the budgetary institution of higher education "Surgut State University" (hereinafter referred to as the University).

2. The entrance exam is aimed at assessing the knowledge of applicants acquired during the development of secondary general education programs and basic general education programs, and at selecting among applicants the most capable and prepared for mastering bachelor's and specialty programs at the University.

3. The entrance exam is carried out within the framework of several competitions (in the relevant areas, forms and basics of education) and is taken once.

4. The entrance exam is conducted in English.

5. The entrance exam is conducted in person and (or) using remote technologies (subject to the identification of applicants when passing the entrance tests).

6. The duration of the entrance exam is 120 minutes.

II. CONTENTS OF SECTIONS

Section I. Fundamentals of theoretical chemistry

Subject and tasks of chemistry. Chemical and physical phenomena. The relationship of chemistry with other natural disciplines. Basic provisions of atomic-molecular teaching. Substances with molecular and non-molecular structure. Atoms, molecules, ions. Relative atomic and relative molecular mass. Mol. Amount of substance. Molar mass. Chemical transformations. Law of conservation of mass and energy. The law of constant composition of matter. Stoichiometry.

Avogadro's law and consequences from it. Molar volume of gas. Normal conditions. Absolute and relative gas density. Average molar mass of a gas mixture. Volume ratios of gases during chemical reactions. Clayperon-Mendeleev equation.

Chemical element. The structure of the nuclei of atoms of chemical elements. Isotopes. Stable and unstable nuclei. Radioactive transformations, nuclear fission and nuclear fusion. Half life.

Simple substance, complex substance. Phenomena of allotropy and isomerism. Signs of chemical elements and chemical formulas. Valence and oxidation state of an atom.

The structure of the electronic shells of atoms. Energy levels and sublevels, atomic orbitals. Quantum numbers. Paired and unpaired electrons. Basic patterns of electron placement in atoms of elements of small and large periods. Electronic configurations of atoms in the ground and excited states, Pauli's principle, Hund's rule. s-, p-, d- and f-elements.

Discovery of the periodic law by D.I. Mendeleev and creation of the periodic system of elements. Modern formulation of the periodic law. Reasons for the periodicity of the properties of elements. The meaning of the periodic law. Periods, groups and subgroups in the periodic table. Connexion between the properties of elements and their compounds with their position in the periodic table. Metals and non-metals.

Types of chemical bonds: covalent (polar and non-polar), ionic, metallic, hydrogen (intermolecular and intramolecular). σ- and π-Bonds. Mechanisms of covalent bond formation (using unpaired electrons and donor-acceptor type). Binding energy. Ionization potential, electron affinity, electronegativity. Covalence capabilities of atom.

Orbital hybridization model. Relation of electron structure of molecules to their geometric structure (using the example of compounds of elements of the 2nd period).

Crystalline and amorphous substances. Main types of crystal lattices.

Classification of chemical reactions according to various criteria: by changes in the oxidation states of atoms, by the number and composition of the initial and resulting substances, by the type of breaking of covalent bonds (by mechanism), by thermal effect, and by reversibility.

Redox reactions. Reduction and oxidation processes. Reducing and oxidizing agents.

Thermal effect of a chemical reaction. Heat of formation and heat of combustion of a substance. Thermochemical reaction equations. Thermal effects when dissolving various substances in water.

The rate of chemical reactions. Homogeneous and heterogeneous reactions. Dependence of the reaction rate on the nature of the reactants, concentration, temperature, contact surface. Kinetic equation of reaction, rate constant. Catalysis

and catalysts. Homogeneous and heterogeneous catalysis. Inhibitors. Enzymes as biocatalysts.

Chemical balance. Equilibrium constant, degree of conversion. Shift in the position of chemical equilibrium under the influence of various factors: concentration of reactants, pressure, temperature. Le Chatelier's principle.

Solutions. Solutions concentrated and diluted, saturated and unsaturated. The dependence of the solubility of substances on their nature, pressure and temperature. Processes that occur when various substances are dissolved in water. Solubility coefficient. Methods of expressing the composition of a solution (mass fraction, molar concentration). Colloidal systems, reasons for their stability. Coagulation. Coarsely dispersed systems (suspensions and emulsions).

Electrolytic dissociation. Degree of dissociation. Strong and weak electrolytes. Ionic reaction equations. Conditions for the occurrence of chemical reactions in electrolyte solutions. Properties of acids, bases and salts in the light of the theory of electrolytic dissociation.

Section II. Fundamentals of Inorganic Chemistry

Main classes of inorganic substances.

Oxides, classification of oxides. Methods for producing oxides. Their physical and chemical properties.

Bases, their classification, methods for producing and chemical properties. Alkalis. Amphoteric hydroxides.

Acids, their classification, methods for producing, physical and chemical properties.

Salts, their classification, nomenclature, methods for producing and chemical properties. Hydrolysis of salts. Crystal hydrates.

Metals, their position in the periodic table. General physical and chemical properties of metals. Electrochemical voltage series of metals. Alloys. Corrosion of metals and its prevention. The main methods of obtaining metals.

Alkali metals, their general characteristics. Occurrence in nature, methods of production, physical and chemical properties. The most important compounds of alkali metals, their applications. Sodium and potassium hydroxides, their producing, properties and applications. Potash fertilizers.

General characteristics of the elements of the main subgroup of group II of the periodic table, their oxides and hydroxides. Calcium, its occurrence in nature, production, physical and chemical properties. The most important calcium

compounds, their producing, properties and applications. Water hardness and ways to eliminate it.

Aluminum. Occurrence in nature, producing, physical and chemical properties, application. Aluminum oxide, hydroxide and salts. Complex aluminum compounds. Ideas about aluminosilicates.

Metals of the secondary subgroup of group VIII (iron, nickel, platinum). Their electronic structure. Iron, its occurrence in nature, producing, physical and chemical properties, application. Oxides, hydroxides and salts of iron, their producing and properties. Nickel and platinum, their physical and chemical properties, application.

Metals of secondary subgroups (copper, zinc, titanium, chromium, manganese). Their electronic structure, occurrence in nature, producing, physical and chemical properties. Oxides, hydroxides and salts of these elements.

Hydrogen, its general characteristics, occurrence in nature. Isotopes of hydrogen. Methods for producing hydrogen in the laboratory and in industry, physical and chemical properties, application.

Halogens, their general characteristics. Halogen compounds in nature. Producing of halogens. Application of halogens and their compounds. Chlorine. Producing of chlorine in the laboratory and in industry. Its physical and chemical properties. Producing, properties and use of hydrogen chloride, hydrochloric acid and its salts. Compounds with positive oxidation states of chlorine.

General characteristics of the elements of the main subgroup of group VI of the periodic system. Sulfur, its occurrence in nature, producing, allotropy, physical and chemical properties, application. Sulfur oxides, their producing and properties. Hydrogen sulfide and sulfides, their producing and properties. Sulfuric acid, its electronic structure, producing, physical and chemical properties, application. Salts of sulfuric acid. Sulfurous acid and its salts.

Oxygen. Its presence in nature. Allotropy of oxygen. Producing and properties of ozone. Oxygen production in the laboratory and in industry. Its physical and chemical properties. The role of oxygen in nature, its use.

Water. The structure of the water molecule and hydronium ion. Physical and chemical properties of water. Hydrogen and metal peroxides, their producing and properties.

General characteristics of the elements of the main subgroup of group V of the periodic system. Phosphorus, its occurrence in nature, its production. Allotropy of phosphorus, physical and chemical properties, application. Phosphides and

phosphine. Phosphorus(III) and (V) oxides. Phosphorus halides. Ortho-, meta- and diphosphoric acids. Their preparation and chemical properties. Salts of phosphoric acid. Phosphorus fertilizers.

Nitrogen, its general characteristics, occurrence in nature, producing. Electronic structure of the nitrogen molecule. Physical and chemical properties of nitrogen. Nitrides. Ammonia, the structure of its molecule, producing, physical and chemical properties, application. Nitrogen oxides and nitric acid. The structure of the nitric acid molecule, its producing and chemical properties, application. Properties of nitric acid salts. Nitrogen fertilizers.

General characteristics of the elements of the main subgroup of group IV of the periodic table of elements. Silicon, its occurrence in nature, producing, physical and chemical properties, application. Silicon(IV) oxide and silicic acid, their chemical properties. Silicic acid salts.

Carbon. Its general characteristic is being in nature. Allotropy of carbon. Producing of carbon, its physical and chemical properties, application. Carbon oxides and carbonic acid. Their producing and properties. Salts of carbonic acid, their producing, properties and use.

Qualitative reactions to inorganic substances and ions.

Section III. Basics of organic chemistry

Theory of the chemical structure of organic compounds A.M. Butlerov. Dependence of the properties of organic compounds on their structure. Types of isomerism. Electronic nature of chemical bonds in organic compounds. Types of covalent bond cleavage in reactions of organic compounds. Free radicals.

Homologous series of saturated hydrocarbons (alkanes). Their electronic structure, isomerism, nomenclature. Conformations. Methods for obtaining alkanes, their physical and chemical properties, application.

Cycloalkanes, their structure, isomerism, nomenclature. Methods for producing and chemical properties of cycloalkanes.

Ethylene hydrocarbons (alkenes). Their electronic structure, isomerism, nomenclature. Geometric isomerism. Producing, physical and chemical properties of alkenes. Markovnikov's rule. Application of alkenes.

Alkadienes. Electronic structures, isomerism, nomenclature. Producing, chemical properties and use of alkadienes.

Alkynes. Electronic structure, isomerism, nomenclature. Acidic properties of alkynes. Methods for producing, physical and chemical properties of alkynes. Application.

Aromatic hydrocarbons (arenes). Electronic structure of the benzene molecule. Isomerism and nomenclature of benzene homologues. Producing of benzene and its homologues. Chemical properties of aromatic hydrocarbons. Orienting effect of substituents on the benzene ring. Mutual influence of atoms in a molecule using the example of toluene. Styrene Application of aromatic hydrocarbons.

Halogen derivatives of various classes of hydrocarbons. Their methods for producing and chemical properties.

Natural sources of hydrocarbons: oil, natural and associated gas, coal. Processes occurring during their processing.

Alcohols. Their classification, isomerism, nomenclature. Electronic structure of the ethyl alcohol molecule. Homologous series of saturated monohydric alcohols, methods of their producing, physical and chemical properties, application. Polyhydric alcohols, methods of their producing, chemical properties and applications.

Phenols. Electronic structure of phenol. Methods for producing phenol, its physical and chemical properties. Mutual influence of atoms in a phenol molecule. Comparison of the properties of phenol with the properties of alcohols. Application of phenol.

Ethers, their structure and methods for producing.

Carbonyl compounds. Aldehydes and ketones. Electronic structure of the carbonyl group. Isomerism and nomenclature of aldehydes, their methods Carbonyl compounds. Aldehydes and ketones. Electronic structure of the carbonyl group. Isomerism and nomenclature of aldehydes, their methods for producing, physical and chemical properties. Application.

Carboxylic acids. Electronic structure of the carboxyl group. Dependence of the strength of carboxylic acids on the structure of the organic radical. Nomenclature and isomerism of monobasic carboxylic acids. Methods for producing carboxylic acids, their physical and chemical properties. Application. Unsaturated carboxylic acids (acrylic, methacrylic). Oxalic acid.

Esters, their structure and nomenclature. Producing of esters, their physical and chemical properties, application. Fats as representatives of esters, their role in

nature, fat processing. Carboxylic acids that are part of fats (stearic, palmitic, oleic, linoleic and linolenic). Soaps and other cleaning products.

Nitro compounds. Nitromethane and nitrobenzene.

Carbohydrates. Classification of carbohydrates. Monosaccharides (glucose, fructose, ribose and deoxyribose), their structure. Cyclic forms of monosaccharides. Physical and chemical properties of glucose, its application. Disaccharides: cellobiose, maltose and sucrose, their structure and properties. Polysaccharides (starch and cellulose). Their structure, occurrence in nature, biological role, chemical properties and application. Dextrins.

Amines, their electronic structure, isomerism, nomenclature. Producing of amines, physical and chemical properties. Amines as organic bases. Comparison of the basic properties of various amines and ammonia. Manifestation of the mutual influence of atoms in the aniline molecule.

Hydroxy acids. Lactic acid. Optical isomerism.

Amino acids. Their isomerism and nomenclature. Producing, physical and chemical properties of amino acids. a-Amino acids that make up proteins (glycine, alanine, valine, phenylalanine, tyrosine, serine, cysteine, glutamic acid, lysine, tryptophan). Peptides. Primary, secondary and tertiary structure of protein. Properties of proteins.

Nitrogen-containing heterocyclic compounds. Pyridine, pyrrole, pyrimidine, purine. Nitrogen bases that make up nucleic acids (uracil, thymine, cytosine, adenine, guanine). Nucleosides and nucleotides, their structure. Structure of nucleic acids., physical and chemical properties. Application.

Carboxylic acids. Electronic structure of the carboxyl group. Dependence of the strength of carboxylic acids on the structure of the organic radical. Nomenclature and isomerism of monobasic carboxylic acids. Methods for producing carboxylic acids, their physical and chemical properties. Application. Unsaturated carboxylic acids (acrylic, methacrylic). Oxalic acid.

Esters, their structure and nomenclature. Producing of esters, their physical and chemical properties, application. Fats as representatives of esters, their role in nature, fat processing. Carboxylic acids that are part of fats (stearic, palmitic, oleic, linoleic and linolenic). Soaps and other cleaning products.

Nitro compounds. Nitromethane and nitrobenzene.

Carbohydrates. Classification of carbohydrates. Monosaccharides (glucose, fructose, ribose and deoxyribose), their structure. Cyclic forms of monosaccharides.

Physical and chemical properties of glucose, its application. Disaccharides: cellobiose, maltose and sucrose, their structure and properties. Polysaccharides (starch and cellulose). Their structure, occurrence in nature, biological role, chemical properties and application. Dextrins.

Amines, their electronic structure, isomerism, nomenclature. Producing of amines, physical and chemical properties. Amines as organic bases. Comparison of the basic properties of various amines and ammonia. Manifestation of the mutual influence of atoms in the aniline molecule.

Hydroxy acids. Lactic acid. Optical isomerism.

Amino acids. Their isomerism and nomenclature. Producing, physical and chemical properties of amino acids. a-Amino acids that make up proteins (glycine, alanine, valine, phenylalanine, tyrosine, serine, cysteine, glutamic acid, lysine, tryptophan). Peptides. Primary, secondary and tertiary structure of protein. Properties of proteins.

Nitrogen-containing heterocyclic compounds. Pyridine, pyrrole, pyrimidine, purine. Nitrogen bases that make up nucleic acids (uracil, thymine, cytosine, adenine, guanine). Nucleosides and nucleotides, their structure. Structure of nucleic acids.

General concepts of the chemistry of high-molecular compounds: monomer, polymer, structural unit, degree of polymerization, stereoregularity of the polymer. Polymerization and polycondensation reactions. Polymers obtained by polymerization reaction (polyethylene, polypropylene, polyvinyl chloride, polymethyl methacrylate). Rubbers. Natural and synthetic rubbers. Vulcanization of rubbers. Polymers obtained by polycondensation reaction. Phenol-formaldehyde resins. Synthetic fibers nylon and lavsan. Artificial fibers (silk acetate). Biopolymers.

Qualitative reactions to various classes of organic substances.

Section IV. Main types of calculations

Calculation of the molar mass of a substance based on its formula or relative and absolute density (for gases).

Calculation of the amount of a substance based on its mass or volume (for gases).

Bringing the volume of gas to normal conditions.

Determination of mass fractions of elements in a substance based on its formula.

Determination of the formula of a substance based on elemental analysis data.

Calculation of solution composition (mass fractions of dissolved substances or their molar concentrations).

Stoichiometric calculations using equations of chemical reactions in moles (in volumes for reactions involving gases).

Finding coefficients in the equations of redox reactions using the electronic balance method.

The simplest thermochemical calculations.

Determination of the rate of a chemical reaction by the change in the amount of a substance over a certain time interval, according to the kinetic equation of the reaction, recalculation of the reaction rate with a change in temperature (using the Van't Hoff equation).

III. LIST OF RECOMMENDED LITERATURE

1. Gabrielyan O.S. Chemistry. Advanced level. Grade 11. / O.S. Gabrielyan, S.A. Sladkov, I.G. Ostroumov - M.: Education, 2021. - 432 p.

2. Egorov A.S. Chemistry tutor / A.S. Egorov, K.P. Shatskaya, N.M. Ivanchenko - M.: Phoenix, 2020. - 763 p.

3. Eremin V.V. Chemistry: In-depth preparation course for the Unified State Exam / V.V. Eremin, R.L. Antipin, A.A. Drozdov, E.V. Karpova, O.N. Ryzhova - M.: Eksmo, 2020. - 608 p.

4. Kuzmenko N.E. The beginning of chemistry. Modern course for applicants to universities / N.E. Kuzmenko, V.V. Eremin, V.A. Popkov. - M.: Laboratory of Knowledge, 2020. - 707 p.

5. Novoshinsky I.I. Chemistry: textbook for 10 (11) grade. Advanced level. / I.I. Novoshinsky, N.S. Novoshinskaya. - M.: LLC "Russian Word - Textbook", 2021. - 440 p.

6. Khomchenko G.P. A manual on chemistry for applicants to universities / G.P. Khomchenko.-M: New wave, 2021. - 480 p.

7. Khomchenko I.G. Collection of problems in chemistry for applicants to universities 2020 / I.G. Khomchenko, G.P. Khomchenko. - M: New Wave, 2020. - 278 p.

8. Chernikova, N.Yu. Problems on the basics of general chemistry for independent work with answers and solutions: textbook / N. Yu. Chernikova, E. V. Meshcheryakova. - St. Petersburg: Lan, 2021. - 304 p.

9. Chernikova, N.Yu. Chemical minimum: textbook / N. Yu. Chernikova. - St. Petersburg: Lan, 2019. - 316 p.