

MINISTRY OF EDUCATION AND SCIENCE OF THE RUSSIAN FEDERATION

Federal State Autonomous Educational Institution of Higher Education

"Crimean Federal University named after V. I. Vernadsky"

Head of entrance commission

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**THE PROGRAM
OF ENTRY TEST IN**

CHEMISTRY

Simferopol' 2021

THE PROGRAMM OF ENTRY TEST

1. GENERAL CHEMISTRY

Basic concepts of chemistry. Matter.

To know: Matter, physical body, elementary substance (metal, nonmetal), compounds, the chemical element; the smallest particles of matter – atom, molecule, ion (cation, anion). The composition of the substance (qualitative, quantitative). The valence of a chemical element. Chemical (empirical, simple, true) and graphic (structural) formulas. A physical phenomenon. Relative atomic and molecular masses, molar mass, number of moles of a substance. The unit number of moles, molar mass, molar volume; the values of temperature and pressure under normal conditions, molar volume of gas. Avogadro's law; Avogadro's number; the average relative molecular mass of gas mixture, air. Mass fraction of element in a compound.

To be able to: Compose the formulas of compounds according to the valence of the elements. Write chemical and graphic (structural) formulas of substances. Distinguish between a physical body and a substance; simple and complex substances, elements and elementary substances; metal and non-metals; atoms, molecules and ions (cations, anions); physical and chemical properties of matter; physical and chemical phenomena; the simplest and true formula of a compound. Determine the valence of the elements in binary compounds. Analyze the qualitative (elemental) and quantitative composition of the substance by its chemical formula.

Chemical reaction.

To know: What a chemical reaction is, the scheme of reaction, the chemical equation. The laws of conservation of mass of substances in a course of chemical reactions, the volume ratios of gases in chemical reactions. External effects that accompany chemical reactions. The concept of oxidizing agent, reducing agent, oxidation, reduction. The types of chemical reactions. The rate of chemical reactions. Catalyst.

To be able to: Write the scheme of reactions, chemical equations. Differentiate between the types of reaction according to the number of particles of reactants and products (combination reaction, decomposition, ionic exchange, substitution), the change in the oxidation numbers of the elements (redox reaction), heat effect (exothermic, endothermic reaction), the direction of the reaction (reversible, irreversible). Determine oxidizing and reducing agents, the oxidation and reduction processes in redox reaction. Analyze the effect of reagent concentration, size of the contact surface, temperature, catalyst on the rate of chemical reactions. Apply the law of conservation of mass of substance to convert the scheme of redox reaction in chemical equations.

The periodic law of D.I. Mendileev and the periodic system of chemical elements.

To know: The periodic law (modern definition). The structure of different variants of the periodic table; periods, groups, subgroups (main, side). Ordinal (atomic) number of an element, the position of metallic and nonmetallic elements in the periodic table, periods and groups; alkali, alkaline earth metals, noble gases, halogens.

To be able to: Distinguish between periods, groups, main and side subgroups, metallic and non-metallic elements in the periodic table. Determine the element type (metallic or non-metallic element), the maximum value of its valence, the type of the simple substance (metal or nonmetal), the chemical nature of the oxides, hydroxides, compounds of elements with hydrogen according to its position in the periodic table. Analyze changes of properties of elementary substances within groups and periods.

The structure of an atom.

To know: Composition of an atom (nucleus, electron shell). The concept of nucleon, nuclide, isotope, proton number, nucleon number, orbital, energy level and sublevel, paired and unpaired electrons, the radius of an atom (atomic ion); normal and excited state of the atom. The

space. The sequence of filling the electron energy levels and sublevels in atoms of elements N° 1-20, and electronic graphic formula of atoms and ions of elements N° 1-20.

To be able to: Write the electronic and graphic formulas of atoms and ions of elements N° 1-20, atoms of nonmetallic elements of the 2nd and 3rd periods in the excited state. Determine the composition of the nucleus (number of protons and neutrons in the nuclide) and electron shells (energy levels and sublevels), atomic number of elements N° 1-20. Compare radius of atoms and ions. Analyze the changes in the atomic radius within periods and subgroups.

Chemical bond.

To know: The main types of chemical bond (ionic, covalent, hydrogen, metallic). Characteristics of covalent bond (multiplicity, energy, polarity). Types of crystal lattice (atomic, molecular, ionic, metallic); the dependence between the physical properties of the substance and the type of its crystal lattices. The electronic formula of the molecule. The electronegativity of an element. The oxidation state of the element in the compound.

To be able to: Make the electron formula of molecules, the chemical formulas of the compounds according to the oxidation states of elements, ion charge. Distinguish between a valence and oxidation state of an element. Calculate the oxidation state of the element in the compound. Identify multiplicity, polarity or non-polarity of covalent bond. Predict the type of chemical bond in a compound, the physical properties of the substance according to the type of crystal lattice.

Solutions.

To know: Solutions and mixtures (suspension, emulsion, foam, aerosol). Mass and volume (for gas), the proportion of the substances in the mixture. Methods of separation of mixtures (sedimentation, filtration, centrifugation, evaporation, distillation). Concepts of solution, solvent, solute, electrolytic dissociation, electrolyte, non-electrolyte, the degree of electrolytic dissociation, ionic and molecular equation. Mass fraction of solute in a solution. The structure of the water molecule; hydrogen bonding in water. The color of indicators (universal litmus, phenolphthalein, methylorange) in acidic, alkaline and neutral medium. Ion exchange reactions between the electrolytes in the solution.

To be able to: Make the scheme of electrolytic dissociation of bases, acids, salts; ionic-molecular equations molecular equations, ionic-molecular equations. Distinguish between solutions: dilute, concentrated, saturated, unsaturated; electrolytes and nonelectrolytes, strong and weak electrolytes. Determine the possibility of occurrence of ionic exchange reaction between the electrolytes in the solution. Analyze the dependence between composition of a substance, temperature, pressure (for gases) and its solubility in water; mechanisms of formation of ions of electrolytes, ionic and molecular structure when dissolved in water. Apply knowledge to select the separation method of components in homogeneous and heterogeneous mixture.

2. INORGANIC CHEMISTRY

The main classes of inorganic compounds.

Oxides.

To know: Definition, nomenclature, classification of oxides, chemical properties of salifiable (salt-forming) oxides, methods of oxides obtaining.

To know: Write chemical formulas of oxides; chemical reactions equations that describe the chemical properties of salt-forming oxides (interaction with water, oxides, acids, bases), methods of their obtaining (interaction of elementary and complex substances with oxygen, decomposition of some insoluble acids, bases and salts with heating). Name oxides according to their chemical formulas. Indicate formulas of oxides among other classes of inorganic compounds studied. Distinguish between salifiable (acidic, basic, amphoteric) and nonsalifiable oxides. Compare chemical properties of basic, acid and amphoteric oxides (to describe zinc and aluminum oxides as examples). Establish the dependence between properties of oxides, type of element and chemical bond in compound.

Bases.

To know: Definition (general and from the point of view of the electrolytic dissociation), naming, classification, chemical properties, methods of obtaining.

To be able to: Write chemical formulas of bases, reactions equations that characterize the chemical properties of alkali (interaction with acid oxides, acids and salts in solution) and insoluble bases (interaction with acids, decomposition under heating), methods of obtaining (reactions of alkali and alkaline earth (excluding magnesium) metals with water, and basic oxides of alkaline alkaline-earth elements with water) and insoluble bases (interaction of salts with soluble bases in solution). Name the bases according to their chemical formulas. Distinguish between formulas of bases and other compounds studied. Compare chemical properties of soluble and insoluble bases.

Acids.

To know: Definition (general and from the point of view of the electrolytic dissociation), naming, classification, chemical properties, methods of obtaining.

To be able to: Write chemical formulas of bases, reactions equations that characterize the chemical properties of acid (interaction with metals, basic oxides, bases and salts in solution) and methods for their preparation (interaction of acid oxides with water, non-metals with hydrogen, acids with salts). Name the acids according to their chemical formulas. Identify the acids formulas among the formulas of other compounds studied. Find the valence of the acid residue according to the formula. Distinguish acid by their composition (oxygen containing, oxygen-free), the ability to electrolytic dissociation (strengths, weaknesses) and basicity.

Salts.

To know: Definition (general and from the point of view of the electrolytic dissociation), naming, classification, chemical properties, methods of obtaining.

To be able to: Write chemical formulas of normal and acid salts; equations that characterize the chemical properties of salts (interaction with metals, acids (hydrochloric acid, sulfuric acid, nitric acid), alkalis, salts in solution) and methods of their obtaining (interaction of acids with metals, basic oxides with acids, acid with basic oxides, bases with acids, acids with salts, bases with salts, acid oxides with basic oxides, salts with salts, salts with metals, metals and non-metals). Name normal and acid salts according to their chemical formulas. Distinguish between formulas of normal/acid salts and formulas of other compounds studied. Differ medium salts from acid salts.

Amphoteric compounds

To know: The phenomenon of amphoterity (for example oxides and hydroxides); chemical properties, methods of preparation of amphoteric hydroxides)

To be able to: Write reactions equations that characterize the chemical properties of aluminum and zinc oxides and hydroxides (interaction with acids, alkalis) and methods of their obtaining (interaction of salt of these elements with alkali in solution, aluminates and zincates with acids).

Genetic links between the classes of inorganic compounds

To be able to: Equate reactions between various inorganic compounds. Compare the chemical properties of oxides, bases, acids, amphoteric hydroxides, salts. Establish links between composition and chemical properties of oxides, acids, bases, amphoteric hydroxides, salts.

Metallic elements and their compounds. Metals.

General information about metal elements and metals.

To know: The position of the metallic elements in the periodic table; features of the electronic structure of atoms of metallic elements; metallic bond; general physical and chemical properties of metals, general methods of their obtaining; activity row of metals; corrosion phenomenon, how to protect metals from corrosion; alloys based on iron (cast iron, steel).

To be able to: Identify the position of the metallic elements in the periodic system, to characterize the metallic bond, metal lattices, physical properties of metals. Distinguish between metallic and non-metallic elements according to the atomic structure. Write electronic formula of the atoms of metallic elements - lithium, sodium, magnesium, aluminum, potassium, calcium, iron; reactions equations which characterize chemical properties of the metals (interaction with oxygen, halogens, sulfur, water, solutions of acids, alkalis and salts) and processes of their preparation (oxides reduction by carbon, carbon monoxide (II), hydrogen, metal (aluminothermy)); reactions equations that occur during the production of cast iron and steel. Explain the relationship between reactivity of metals and their electronic structure of atoms; the essence of metal corrosion; chemical transformations during the production of iron and steel. Predict the products of chemical reactions of metals with water, solutions of acids, salts, bases.

Alkali and alkaline earth elements

To know: Chemical properties of sodium, potassium, magnesium, calcium; formulas and names of essential compounds of alkaline metals; natural compounds of sodium, potassium, magnesium, calcium; chemical formulas and names of the most important potash fertilizers; hardness of water.

To be able to: Characterize the position of the sodium, potassium, magnesium and calcium in the periodic table, the physical properties of sodium and potassium, magnesium and calcium, types of hardness of water - temporary or carbonate; permanent, general; use of magnesium and calcium oxides, hydroxides of sodium, potassium, magnesium and calcium. Write electron configurations of atoms and ions of sodium, potassium, magnesium, calcium; reactions equations that characterize the chemical properties of sodium, potassium, magnesium, calcium (reaction with oxygen, halogen, sulfur, water), oxides and hydroxides of sodium, potassium, magnesium, calcium; reactions equations that are used to reduce or eliminate water hardness (boiling, adding of soda or lime).

Aluminum

To know: Chemical properties, obtaining and use of aluminum; formulas and names of the most important aluminum compounds.

To be able to: Characterize aluminum position in the periodic table, physical properties of aluminum oxide and aluminum hydroxide, the use of aluminum. Write down electronic formula of the atom and the aluminum ion; reactions equations which characterize chemical properties of aluminum (reaction with oxygen, halogens, sulfur, solutions of acids, bases and salts), amphoteric oxide and aluminum hydroxide (interaction with basic and acid oxides, acids and alkalis).

Iron

To know: The chemical properties and methods of iron production; names and formulas of the most important iron compounds; the use of iron and its compounds.

To be able to: Characterize the position of iron in the periodic table, the physical properties of iron, its oxides and hydroxides; the use of iron and its compounds; physiological role of its ions. Compose the electronic formula of the iron atom; write down the reactions that describe the chemical properties of iron (reactions with oxygen, chlorine, sulfur, steam, solutions of acids and salts, corrosion), iron oxides and hydroxides (interaction with acids), iron salts (interaction with solutions of bases, acids, salts), interconversion of compounds of iron (II) and iron (III).

Nonmetallic elements and their compounds. Non-metals.

Halogens.

To know: Chemical formula of fluorine, chlorine, bromine, iodine; chemical formulas, names and physical properties of the most important compounds of halogens (chloride, halides, metal elements); laboratory methods of the preparation and chemical properties of hydrogen chloride and hydrochloric acid; major industry use of chlorine, hydrogen chloride, hydrochloric acid; qualitative reaction for the detection of chloride ions.

To be able to: Write reactions equations typical for chlorine (interaction with metals, non-metals, water), hydrochloric acid and hydrogen chloride (interaction with metals, major oxides, amphoteric compounds, salts); reactions equations of hydrogen chloride production in the laboratory. Compare the chemical activity of halogens. Characterize the most important branches of chlorine application (as an oxidant, in the production of organic and inorganic substances), hydrochloric acid (in production plastics, for chloride), chlorides (sodium chloride - food seasonings - for chlorine, sodium, sodium hydroxide, soda). Know how to choose the method of chloride ions determination in the solution.

Oxygen and sulfur.

To know: Chemical formula of oxygen, ozone, sulfur and essential oxygen and sulfur compounds; the physical and chemical properties of oxygen, ozone, sulfur, sulfur dioxide, sulfuric acid, sulphates; methods of oxygen obtaining in a laboratory; major industry use of oxygen, ozone, sulfur, sulfuric acid and sulphates; qualitative reaction of sulfate ions determination.

To be able to: Write reactions equations typical for oxygen (interaction with metals, non-metals, hydrogen), sulfur (interaction with metals, some nonmetals), sulfur oxides (interaction with water, basic oxides, bases), sulfuric acid (reactions with metals, basic oxides, amphoteric compounds, salts); obtaining of oxygen and ozone in the laboratory. Compare the composition, chemical activity of oxygen and ozone. Characterize the most important branches of oxygen applications (as oxidizing agent), ozone (water disinfection), sulfur (sulfuric acid production, rubber, matches, anti-inflammatory drugs, cosmetics), sulfuric acid (production of mineral fertilizers, fibers) and sulfates (gypsum - in construction, medicine; bluestone - for controlling plant pests, wood etching). Select correct method for determination of oxygen and sulfate ions (in solution).

Nitrogen and phosphorus.

To know: Chemical formulas of nitrogen, white and red phosphorus, essential compounds of nitrogen and phosphorus; the physical and chemical properties of nitrogen, the white and red phosphorus, nitrogen (II) oxide, nitrogen (IV) oxide, phosphorus (V) oxide, ammonia, ammonium salts, nitric acid, nitrates, orthophosphoric acid, orthophosphates; methods for the preparation of ammonia, nitric, orthophosphoric acids in the laboratory; the most important branches of application of nitrogen, ammonia, nitric acid, nitrates, orthophosphoric acid, orthophosphates; qualitative determination reactions for ammonia and orthophosphate ions.

To be able to: Write reactions equations typical for nitrogen and phosphorus (interaction with metals, some nonmetals), ammonia (interaction with oxygen, water, acids), ammonium salts (reacting with alkalis, salts), nitric acid (reactions with metals, basic oxides, amphoteric compounds, salts), nitrogen (IV) oxide and phosphorus (V) oxide (reaction with water, basic oxides, bases), phosphoric acid (reactions with metals, basic oxides, bases, salts); the reactions equations which characterize interconversion of normal and acid orthophosphates, thermal decomposition of ammonium salts (chloride, nitrate, carbonate and bicarbonate) and nitrates; the reactions equations of ammonia, nitric acid and phosphoric acid obtaining in a laboratory.

To characterize the composition and structure of allotropic modifications of phosphorus (red and white phosphorus), the most important sector of application of nitrogen (creation a low temperature), ammonia (production of nitric acid, fertilizers, ammonia alcohol), nitric acid (production of fertilizers, explosives, nitrogen-containing organic compounds), nitrates (fertilizers, explosives), orthophosphoric acid and orthophosphates (fertilizers). Compare the chemical activity of nitrogen, red and white phosphorus. Select correct method for determination of ammonia ions and phosphate ions (in solution).

Carbon and silicon.

To know: Allotropy of carbon; adsorption, the adsorption properties of the activated carbon; chemical formulas of major carbon and silicon compounds; physical and chemical properties of carbon, silicon, carbon oxides, carbonates, silicon (IV) oxide, silicic acid, silicates; ways of getting

this substances in the lab; major industry application of diamond, graphite, activated carbon, carbon oxides, carbonates, hydrocarbons, silicon (IV) oxide, silicates; qualitative reactions of identification of carbonate ion, hydrogen carbonate ion and silicate ion.

To be able to: Write reactions equations typical for carbon and silicon (interaction with the active metals and non-metals, oxides of metal elements), carbon (II) oxide (reactions with oxygen, oxides of metal elements), carbon (IV) oxide (reactions with water, basic oxides, alkali, carbon), silicon (IV) oxide (interaction with the basic oxides, alkalis); interconversion between hydrocarbonates and carbonates, thermal decomposition of the carbonates, hydrocarbonates, carbon oxides obtaining in the laboratory. Characterize the composition, structure and physical properties of the simple carbon materials (graphite, diamond, carbyne), key industry application of the diamond (in cutting and grinding tools), graphite (in production of pencils, electrodes), activated carbon (in medicine, in gas masks, for water purification), carbon oxides (CO as a reducing agent, CO₂ - in the production of soda, sugar carbonated beverage filler extinguishers), sodium hydrogen carbonate, calcium and sodium hydroxide, silicon (IV) hydroxide (glass manufacture, construction materials), silicates (components of cement, ceramics, porcelain, liquid glass). Select correct method for determination of carbon monoxide, silicate and carbonate ions (in solution).

3. ORGANIC CHEMISTRY

Theoretical Foundations of Organic Chemistry.

To know: Essential-organogenic elements, organic compounds; natural and synthetic organic compounds.

To be able to: Identify the major organogenic elements (C, H, O, N, S, P). Distinguish between characteristic features of inorganic and organic compounds.

The molecular structure of organic compounds.

To know: Chemical bonding in organic molecules: energy, length, spatial orientation, polarity. Covalent bond (σ and π). Single, multiple (double, triple).

To be able to: Characterize the covalent bond multiplicity, polarity or non-polarity in molecules of organic compounds. σ and π -bonding. Compare single, double, triple bonds with energy, length and spatial orientation. Analyze the reactivity of organic compounds with different types of bonds.

Hybridization of electron orbitals of carbon atoms: sp^3 -, sp^2 -, sp -hybridization.

To be able to: Define the types of hybridization and the spatial orientation of the hybrid electron orbitals of carbon atoms in organic molecules.

Classification of organic compounds according to the carbon chain structure and the presence of characteristic (functional) groups.

To be able to: Classify organic compounds according to the structure of the carbon chain in the aliphatic hydrocarbons: saturated (alkanes), unsaturated (alkenes, alkynes) and cyclic hydrocarbons (homo- and hetero-): cycloalkanes and arenes; according to the nature of characteristic (functional) group.

Homology: homologues, homologous series, homologous difference.

To know: The classes of organic compounds. General formulas of classes of organic compounds.

To be able to: Identify the homologues of hydrocarbons and their derivatives. Distinguish between homologous series and classes of organic compounds. Determine the correspondence between the representatives of the homologous series and their general formulas, classes of organic compounds and their characteristic (functional) groups.

The concept of primary, secondary, tertiary and quaternary carbon atoms.

To be able to: Identify the primary, secondary, tertiary and quaternary carbon atoms in the molecules of different structure organic compounds.

Nomenclature of organic compounds.

To be able to: Name the organic compounds according to the IUPAC nomenclature. Draw the structural formulas of organic compounds according to the name (IUPAC nomenclature).

Isomerism: isomers, structural and spatial (geometric, or cis-trans) isomerism.

To be able to: Identify the isomers structural formulas. Distinguish between structural and stereoisomers (geometric, or cis- and trans-) isomers. Determine the difference between isomers and homologues by the qualitative and quantitative composition and molecular structure.

Mutual influence of atoms or groups of atoms in organic molecules.

To be able to: Determine the connection between the structure and properties of organic compounds based on the electron density redistribution on the examples of: propene (addition of hydrogen halides and water according to Markovnikov's rule); alcohols (acidic properties); phenol (acidic properties, substitution reactions in the benzene ring); saturated monocarboxylic acids (acidic properties), amines (basic properties, substitution reactions of aniline in the benzene ring). Analyze the chemical structure of organic compounds under the fundamentals of the of Butlerov's theory. Predict the reactivity of organic compounds using the concept of the mutual influence of atoms or groups of atoms in molecules.

Classification of the chemical reactions in organic chemistry (addition reactions, substitution reactions, isomerization).

To be able to: Classify the chemical reactions: substitution, addition, elimination, isomerization). Determine the connection between the structure of organic molecules and their ability to react according to the certain type.

Hydrocarbons.

Alkanes.

To know: The general formula of alkanes, their nomenclature, isomerism, molecular structure, physical and chemical properties, methods of preparation and application.

To be able to: Name the first 10 members of the homologous series of alkanes according to IUPAC nomenclature. Write the molecular and structural formula of alkanes; reaction equations that characterize the chemical properties of alkanes (substitution reaction of methane chlorination, complete oxidation of alkane, partial oxidation of methane, methane thermal decomposition, cracking, isomerization of alkanes), preparation of methane (laboratory method). Explain the phenomenon of sp^3 -hybridization of the electron orbitals of carbon atoms in the molecules of alkanes. Compare the physical properties of alkanes on the base of their boiling points and melting points. Substantiate the relationship between: 1) the aggregate state under normal conditions, the melting and boiling temperature of alkanes and their relative molecular weight; 2) the ability of alkanes for substitution reaction and the electronic structure of molecules; 3) the use of alkanes (oil, fuel, solvents, production of carbon-black, hydrogen, halogenated alkanes) and their properties. Determine the connection between molecular structure and properties of alkanes.

Alkenes.

To know: General formula of alkenes, their nomenclature, isomerism, molecular structure, chemical properties, methods of preparation, applications; qualitative reactions to the double bond.

To be able to: Identify the structural isomers of alkenes according to the structure of the carbon chain, the position of a double bond; functional group isomerism (alkenes and cycloalkanes) and spatial (geometric, or cis-trans) isomers. Name alkenes according to the IUPAC nomenclature. Write the molecular and structural formula of alkenes; reaction equations that characterize the

chemical properties of ethene and propene (addition reaction with hydrogen, halogens, hydrogen halides, water; polymerization; the partial oxidation of ethene and complete oxidation of alkenes), industrial and laboratory processes for preparing alkenes (thermal cracking of alkanes, dehydrogenation of alkanes, dehydration of saturated monoalcohols, the reaction of haloalkanes with an alcoholic alkali solution, the reaction of alkynes and hydrogen), the preparation of ethene in the laboratory. Explain the phenomenon of sp^2 -hybridization of the electron orbitals of carbon atoms in the molecules of alkenes. Apply the knowledge to select the method for determining the ethene (reaction with bromine water, aqueous solution of potassium permanganate), alkenes (reaction with bromine water). Substantiate the relationship between: the use of alkenes (production of polyethylene, polypropylene, ethanol, 1,2-dichloroethane) and their properties; the structure and the ability to addition reactions of alkenes. Analyze addition reaction of hydrogen halides and water to propene according to the Markovnikov's rule.

Alkynes.

To know: General formula for alkynes, their nomenclature, isomerism, molecular structure, chemical properties, methods of preparation, applications; qualitative reactions to the triple bond.

To be able to: Identify the structural isomers of alkynes according to the structure of the carbon chain, the position of a double bond. Name alkynes according to the IUPAC nomenclature. Write the molecular and structural formula of alkynes; reaction equations that characterize the chemical properties of acetylene (addition reaction with of hydrogen, halogens, hydrogen halides, water; substitution reactions with sodium, silver (I) hydroxide in ammonia solution; trimerization of acetylene, complete oxidation of alkynes and partial oxidation of acetylene), industrial and laboratory processes for acetylene preparing (thermal decomposition of methane, calcium acetylide reaction with water, the reaction of 1,2-dichloroethene with alkali). Substantiate the relationship between the use of acetylene (gas cutting and welding of metals, preparation of vinyl chloride, polyvinyl chloride, acetaldehyde) and their properties. Explain the phenomenon of sp -hybridization of the electron orbitals of carbon atoms in the molecules of alkynes. Apply the knowledge to select the method for determining the acetylene (reaction with bromine water, an aqueous solution of potassium permanganate, ammonia hydroxide solution of silver (I)). Compare the reactivity of ethene and ethyne in addition reactions. Substantiate the relationship between the structure and the ability of acetylene to addition reactions, substitution reactions.

Aromatic hydrocarbons. Benzene.

To know: The general formula of the homologous series of benzene. Structure, properties, methods of benzene preparation; the concept of aromaticity.

To be able to: Write the molecular and structural formula of benzene; reaction equations that characterize the chemical properties of benzene (substitution reaction with halogen, addition reactions (hydrogenation, chlorination and oxidation)), industrial processes for benzene preparing (catalytic dehydrogenation of hexane, cyclohexane, trimerization of ethyne). Distinguish between unsaturated and aromatic hydrocarbons. Explain the phenomenon of aromaticity, oxidants resistance of benzene and its ability to substitution reactions. Compare the nature of bonds between carbon atoms in molecules of benzene, alkanes and alkynes, reactivity of benzene, alkanes and alkynes in the oxidation and substitution reactions.

Natural sources of hydrocarbons and their processing.

To know: Petroleum, natural gas and assist petroleum gas, coal and their composition; cracking and aromatization of petroleum and petroleum products, knock characteristic of gasoline, octane number; processing of coal; problems of liquid fuel production of from coal and alternative sources. **To be able to:** Name petroleum and coal refining products. Make examples of the use of natural raw hydrocarbons as a source of organic compounds. Write the reaction equations that occur during combustion of natural gas. Distinguish reactions that occur during the cracking of hydrocarbons and aromatization. Compare the knock characteristics of gasoline in view of their gasoline octane numbers.

Carbon-oxygen bond.

Alcohols.

To know: The characteristic (functional) group of alcohols. Alcohols classification. The general formula of monohydric saturated alcohols, their structure, nomenclature, isomerism, properties and methods of preparation and use. The concept of a hydrogen bond.

To be able to: Identify the structural isomers of monohydric saturated alcohols according to the structure of the carbon chain, position of the hydroxyl groups and interclass isomers (esters). Name monohydric saturated alcohols, ethylene glycol and glycerol according to the IUPAC nomenclature. Classify alcohols according to the structure of the carbon chain (saturated, unsaturated), the number of hydroxyl groups (mono- and polyhydric), the nature of carbon atoms, which is bonded with a hydroxyl group (primary, secondary and tertiary alcohols). Write the molecular and structural formula of alcohols; describe the chemical properties of saturated monohydric alcohols and glycerol (substitution reactions (with active metals, hydrogen halides, esterification, intermolecular dehydration, intramolecular dehydration, partial and complete oxidation), industrial preparing processes for methanol (from gas), ethanol (by hydration of ethene, enzymatic glucose fermentation, reduction of ethanal) and laboratory preparing methods for alcohol (hydrolysis of haloalkanes). Characterize the composition and molecular structure of monohydric saturated alcohols. Substantiate the relationship between the use of ethanol (production of acetic acid, diethyl ether) and methanol (receiving formaldehyde) with their properties. Compare the physical properties (boiling temperature, water solubility) of monohydric saturated alcohols and the corresponding alkane; activity of saturated monohydric alcohols, water and inorganic acids in reactions with alkali metals. Substantiate the relationship between the electronic structure of monohydric saturated alcohols molecules and their physical and chemical properties.

To know: Ethylene glycol and glycerol, as representatives of the polyols; qualitative reaction on polyols.

To be able to: Write the reaction equations that indicate chemical properties of ethylene glycol and glycerol (with sodium hydroxide, complete oxidation); glycerol (reacting with nitric acid and higher saturated and unsaturated carboxylic acids); glycerol preparing processes (saponification of fats). Substantiate the relationship between the structure of the polyol molecules and their properties. Apply the knowledge to select the method for determining the polyols (reaction with copper (II) hydroxide).

Phenol.

To know: The phenol general formula. The characteristic (functional) group of phenol. Properties, methods of phenol preparation, application; phenol qualitative reaction.

To be able to: Write the molecular and structural formula of phenol; reaction equations that characterize the chemical properties of phenol (reaction with the hydroxyl groups (with sodium, sodium hydroxide), reactions involving benzene ring (with bromine water, nitric acid)), its preparation in industry (hydrolysis of chlorobenzene). Substantiate the interactions between the hydroxyl group and the benzene ring in the phenol molecule. Compare the acidic properties of alcohols, phenol and carbonic acid; ability of benzene and phenol to substitution reactions. Substantiate the relationship between the structure of the phenol molecules and its properties. Apply the knowledge to select the method for determining the phenol (reaction with iron chloride (III), bromine water).

Aldehydes.

To know: The general formula of aldehydes. The characteristic (functional) group of aldehyde molecules, nomenclature, isomerism, preparation, properties, application; qualitative reaction to an aldehyde group.

To be able to: Identify the structural isomers of aldehydes according to the structure of the carbon chain. Name aldehydes according to the IUPAC nomenclature. Make examples of application of ethanal (production of acetic acid, ethyl alcohol) and methanal (formalin receiving, urotropine), based on their properties. Write structural formulas of aldehyde and their structural

isomers; reaction equations that characterize the chemical properties of aldehydes (reduction reaction, incomplete oxidation), receiving of ethanal in industry (hydration by reaction of acetylene) and in laboratory (ethanol oxidation). Apply the knowledge to select the method for detection of aldehydes (qualitative reactions): reaction with ammonia hydroxide solution of silver (I), copper (II) hydroxide.

Carboxylic acids.

To know: The characteristic (functional) group of a carboxylic acid. Classification of carboxylic acids. The general formula of saturated monocarboxylic acids. Structure, nomenclature, isomerism, preparation, properties, application of monocarboxylic acids.

To be able to: Identify the structural isomers of saturated monobasic carboxylic acids according to the structure of the carbon chain, interclass isomers (esters). Name saturated monobasic carboxylic acids according to the IUPAC nomenclature. Give common names of first three monocarboxylic acids. Classify the carboxylic acid according to the structure of the carbon chain (saturated, unsaturated), the number of carboxyl groups (mono-, dibasic). Write structural formulas of saturated monocarboxylic acids; reaction equations that characterize the chemical properties of carboxylic acids (reaction with the active metals, basic oxides, bases, salts of carbonic acid, alcohols); receiving of formic (methanoic) acid (oxidation of methane, reaction of carbon (II) oxide with sodium hydroxide, followed by the action of hydrochloric acid) and acetic (ethanoic) acid (oxidation of butane, ethanol, ethanal). Substantiate the ability of carboxylic acids to the electrolytic dissociation and the ability of their solutions to change the coloring of indicators; special chemical properties of formic acid (reaction with the ammonia solution of silver oxide (I), copper (II) hydroxide). Compare the physical properties (boiling temperature, solubility in water) of saturated monocarboxylic acids and saturated monohydric alcohols. Compare the acidic properties of carboxylic acids with alcohols, phenol and inorganic acids. Substantiate the relationship between the structure of carboxylic acid molecules and their physical and chemical properties.

Esters. Fats.

To know: The general formula of the carboxylic acid esters. Structure, nomenclature, isomerism, preparation, properties, application. Fats (glycerol esters of higher carboxylic acids). Classification of fats, preparation, properties and application. Soaps and detergents.

To be able to: Identify the structural isomers of esters according to the structure of the carbon chain, interclass isomers (carboxylic acids); structural formula of fats (triolein, tristearin); structural formulas of salts of palmitic and stearic acids. Name esters according to the IUPAC nomenclature. Classify fats as animal and vegetable; solid and liquid. Write the reaction equations of formation of esters (esterification) and hydrolysis; reaction equations that characterize the properties of fat (saponification, hydrogenation). Substantiate the relationship between the composition, molecular structure, properties and application of fats. Apply the knowledge to select the method of detecting liquid unsaturated fats (interaction with bromine water).

Carbohydrates.

To know: Classification of carbohydrates; composition, molecular formula of glucose, fructose, sucrose, starch and cellulose; structural formula of the open form of glucose molecule; properties of glucose, sucrose, starch and cellulose; receiving of glucose, sucrose and starch; qualitative reactions for the detecting glucose and starch; application of glucose, starch, cellulose.

To be able to: Differentiate between mono-, di- and polysaccharides. Give examples of application of glucose, starch and cellulose based on their properties. Write the reaction equations that characterize the chemical properties of glucose (complete or partial oxidation, reduction, alcoholic and lactic acid fermentation, esterification and heating), sucrose (complete oxidation, hydrolysis), starch (acid hydrolysis and fermentation), and cellulose (complete oxidation, hydrolysis, esterification), photosynthesis. Substantiate the similarity and difference between starch and cellulose in composition, structure and properties. Apply the knowledge to select the method of detection of glucose (reaction with ammonia hydroxide solution of silver (I), the reaction with

copper (II) hydroxide) and starch (reaction with iodine).

Nitrogen-containing organic compounds.

Amines.

To know: The characteristic (functional) group of amines. Amines classification, nomenclature, isomerism, structure, preparation, properties and application.

To be able to: Identify the structural formulas of isomeric amines according to the structure of the carbon chain, the position of the amino group and as primary, secondary, tertiary amines. Name amines according to the IUPAC nomenclature. Classify amines as ammonia derivatives (primary, secondary and tertiary), and according to the structure of the carbon chain (saturated, aromatic). Write the reaction equations that characterize the chemical properties of saturated organic bases like amines (reaction with water, inorganic acids, burning); aniline (reaction with an inorganic acid, bromine water); receiving of aniline. Substantiate the basic properties of saturated amines and aniline; decreasing of basic properties and increasing of reaction ability of aniline in substitution reactions. Compare the basic properties of ammonia, primary, secondary, tertiary saturated amines, and aniline.

Amino acids.

To know: The composition and the structure of amino acids molecules, nomenclature, properties, methods of preparation and application. The concepts of amphoteric amino acids, bipolar ion; di-, tri-, polypeptides, peptide bond.

To be able to: Name amino acid according to the IUPAC nomenclature. Write structural formulas of amino acids (glycine and alanine; reaction equations that characterize the chemical properties of amino acids (reaction inorganic acids, bases; formation of di-, tri- and polypeptides). Substantiate the amphoteric properties of amino acids, formation of bipolar ion. Compare the structure and chemical properties of amino acids with carboxylic acids and amines.

Proteins.

To know: The structure of proteins, their properties, application, color reactions for proteins.

To be able to: Characterize the processes of proteins hydrolysis and denaturation. Apply the knowledge to select the method of protein detection (xanthoproteic test and biuret test).

Synthetic macromolecular substances and polymeric materials based on them.

To know: The concept of polymer, monomer, elementary unit, degree of polymerization. Classification of high-molecular substances; methods of the synthesis of high-molecular substances; structure and properties of polymers; thermoplastic polymers and plastics based on them; the concept of natural and synthetic rubbers, synthetic fibers; importance of polymers in industry and daily life.

To be able to: Classify polymers according to the way of preparation (natural, artificial, synthetic); heat effect (thermoplastic); structure (linear, branched, reticulated). Write polymerization reactions to form key polymers (polyethylene, polypropylene, polystyrene, polyvinyl chloride, Teflon, phenol-formaldehyde resins, nylon, lavsan). Distinguish methods of synthesis of high-molecular compounds (polymerization and condensation). Compare the properties of natural (cotton, linen, silk, wool), synthetic (artificial silk viscose and acetate) and synthetic fibers (nylon, polyester). Substantiate the relationship between the properties and the application of polymers.

Generalization of knowledge about organic compounds.

To know: Substantiation the genetic relationship between the different classes of organic compounds, between the organic and inorganic compounds.

To be able to: Compare chemical properties of organic compounds of different classes. Substantiate the relationship between the composition and chemical properties of organic

compounds of different classes, between organic and inorganic compounds. Write interconversion reactions of organic compounds of different classes.

Calculations in chemistry.

Determination of the chemical formulas of compounds and calculations dealt with them.

To know: How to find number of moles, number of particles in a certain amount of a substance, mass fraction of the element in a compound, relative gas density, mass / volume fraction of the component in a mixture, the derivation of the compounds formula according to the mass percentage of elements.

To be able to: Calculate the relative molecular and molar masses of a substance; the number of particles, the volume of a gas; the relative density of the gas compared to other gases; mass and volume (for gases) percentage of the substances in the mixture; average molar mass of the mixture of gases; mass percentage of the element in the compound. Determine the chemical formula of compound according to mass percentage of its elements.

The expression of the quantitative composition of the solution (mixture).

To know: Mass percentage of the solute.

To be able to: Calculate the percent by mass of solute in solution, mass (volume) of solution and solvent, mass of solute. Perform calculations for the preparation of solutions of crystalline hydrates.

Problems dealt with reaction equation.

To know: Methods of solution tasks based on chemical reactions equations.

To be able to: Find mass, volume, number of moles of a reactant or a product if mass or volume (for gases) percentage is known. Determine the chemical formula of a compound if quantitative data about reagents or products of reaction is given. Perform calculations, if the substances contain impurities or are given in excess. Solve combined tasks (a combination of two algorithms).

Examples of tests for entrance exam

1. Single answer questions (5 points each)

What is the oxidation state of nitrogen in copper nitrate?

- +1
- +5
- +3
- +6

2. Exercises with single numeric or text answer (10 points each).

Calculate the molar concentration (mol/L) of hydrochloric acid if 200 ml of its solution contains 3,7 g of solute. Round the answer to one decimal places.

Molar concentration (mol/L):

3. Exercises with double numeric or text answers (10 points each, 20 points total).

After burning 8 g of a metal (M), 11.2 grams of its oxide (MO) was formed. Identify the metal (M) in the form of chemical symbol and determine the volume of oxygen in liters (round to two decimal place; STP: 273 K, 101,3 kPa) required for the reaction.

Symbol of the metal:

Volume of oxygen, L:

4. Organic chemistry exercises with double numeric or text answers (10 points each, 20 points total).

The substance Z was obtained from propane according to the following chemical transformation scheme.



Name the compound X (according to the IUPAC system) and determine the molecular weight of compound Z (round to the nearest integer).

Name of compound X	2-bromopropane	10 points
Molecular weight of compound Z		10 points

Entry test evaluation criteria

The entrance test is conducted in test form on the digital platform of "Crimean Federal University named after V. I. Vernadsky": <https://en-exams.edcampus.ru>.

Applicants are invited to perform test tasks of 4 types:

- 1) Single choice tasks (5 tasks on general and inorganic chemistry and 5 tasks on organic chemistry. A total of 10 assignments, each correct answer is worth **5 points**);
- 2) The first level calculation problem with one answer entered as a number or a text. (1 task, the correct answer is worth **10 points**, the wrong answer - 0 points);
- 3) Organic chemistry assignment with two answers entered by number or text (1 task, one correct answer is worth **10 points**, two correct answers are worth 20 points).
- 4) A second level calculation problem with two correct answers entered by number or text (1 task, one correct answer is worth 10 points, two correct answers are worth **20 points**).

Time for test tasks - 60 minutes.

The entry test score is evaluated on the basis of the **100 point** system as the sum of the points scored on all tasks.

Head of chemistry exam commission

Konstantin V. Robotyagov

First Vice-Rector



Vladimir O. Kurianov