Ministry of Science and Higher Education of Russian Federation
Federal State Budgetary Educational Institution of Higher Education
«Pitirim Sorokin Syktyvkar State University»
(FSBEI HE «SyktSU»)

The Program of the Entrance Tests in Chemistry for the Students entering Bachelor and Specialist Programmes

Syktyvkar – 2020

THE LIST OF BASIC TERMS AND BASIC QUESTIONS

GENERAL CHEMISTRY

Subject of chemistry. Physical and chemical phenomena.

Basic concepts of chemistry. Substance. Atom. Chemical element. Molecule. Ion. Pure substances and mixtures. Simple and complex substances. Allotropy. Chemical formula. Substances of molecular and non-molecular structure. Relative atomic, formula and molecular masses. The number of chemicals. Molar mass. Law of definite proportions and the law of conservation of mass. Avogadro's Law. The molar volume of gas. The relative density of gas.

The structure of the atom. The composition of atomic nucleus. Isotopes. The electronic structure of the atom. The concept of the electron cloud. Atomic orbital. Energy level and sublevel, S- and p-orbitals in an atom. Formulas of electronic configurations of atoms. The structure of electron shells (electron distribution over orbitals) of atoms of elements of the first three periods. Atomic and ionic radii.

The periodic law and the periodic system of elements of D. I. Mendeleev. The physical meaning of the atomic element number, period number, and group number. The structure of the periodic system. The frequency of changes in the properties of atoms of chemical elements of the first three periods (atomic radius, electronegativity) and their compounds (acid-base properties of oxides and hydroxides). Characterization of a chemical element by its position in the periodic system and atomic structure.

The nature and types of chemical bonds. Polar and nonpolar covalent bonds. Exchange and donor-acceptor mechanisms of covalent bond formation. Valence, oxidation state of element atoms. Single and multiple bonds. Ion bond. Metal bond. Intermolecular interaction. Hydrogen bond. Crystal lattices of substances with various types of chemical bonds (atomic, ionic, molecular, metal).

Classification of chemical reactions in inorganic chemistry. The thermal effect of a chemical reaction. Thermochemical equations.

The rate of chemical reactions. Factors affecting the speed of chemical reactions: the nature of the reacting substances, temperature, concentration, contact surface area, catalyst.

Reversible and irreversible chemical reactions. Chemical equilibrium and conditions for its displacement.

Oxidation-reduction (redox) reaction. Arrangement of coefficients in the equations of redox reaction. Oxidizing agent. Reducing agent.

Solutions. Concentrated and diluted, saturated and unsaturated solutions. Dissolution as a physicochemical process. The solubility of substances and its dependence on the nature of the reacting substances, temperature and pressure. Mass fraction of solute.

Electrolytic dissociation. Cations and anions. Electrolytes and non-electrolytes. Strong and weak electrolytes. Electrolytic dissociation of acids, alkalis, salts. Ion exchange reactions and the conditions of their irreversibility. Ionic reaction equations. The concept of a hydrogen indicator (pH). Characterization of solutions using pH. Coloring of acid-base indicators (litmus, phenolphthalein, methyl orange) in aqueous solutions.

Oxides: composition, nomenclature, classification, production. General chemical properties of basic, amphoteric (for example, zinc and aluminum oxides) and acid oxides.

Base: composition, nomenclature, classification, receipt. General chemical properties of alkalis, amphoteric hydroxides (for example, zinc and aluminum hydroxides), insoluble bases.

Acids: composition, nomenclature, classification, receipt. General chemical properties of acids.

Salts: composition, nomenclature. Medium and acid salts. Getting medium salts. General chemical properties of medium salts.

The relationship between the main classes of inorganic compounds.

The position of metals in the periodic system of chemical elements D. I. Mendeleev. Metals, general physical and chemical properties. Reactivity series. General methods for producing metals.

Chemical properties of metals of the IA group, IIA group, aluminum. Acid-base behavior of period 3 oxides and groups (for example, IIA group). Qualitative detection of calcium and barium cations.

The position of non-metals in the periodic system of chemical elements D. I. Mendeleev. Allotropy on the example of oxygen, sulfur, carbon. Chemical properties of non-metals: interaction with oxygen, hydrogen and metals.

INORGANIC CHEMISTRY

Hydrogen: physical and chemical properties. Hydrogen production and use of hydrogen.

Water: physical and chemical (interaction with metals, acid and basic oxides) properties.

General characteristics of the elements of the VIIA group: comparative characteristics based on the position in the periodic system, structure of atoms. Chemical properties: interaction with hydrogen and metals. Hydrochloric acid and its salts. Qualitative reaction to chloride ions.

General characteristics of the elements of the VIA-group: comparative characteristics based on the position in the periodic system, structure of atoms. Oxygen, its physical and chemical properties. Ozone as an allotropic modification of oxygen. Obtaining oxygen in the laboratory.

Sulfur: physical and chemical properties. Sulphuric acid. Chemical properties of dilute sulfuric acid: interaction with metals, basic oxides, bases, salts. Features of the interaction of concentrated sulfuric acid with metals on the example of a reaction with copper. Sulfuric acid salts. Qualitative reaction to sulfation. Sulfuric acid and sulfates in industry and agriculture.

Nitrogen: physical and chemical properties. Ammonia: physical and chemical properties: interaction with oxygen, water, acids. Receiving. Ammonium salts. Nitric acid. Oxidative properties of nitric acid on the example of interaction with copper. Salts of nitric acid. The use of nitric acid and nitrates.

Phosphorus. Phosphorus Oxide (V). Phosphoric acid and its salts.

The most important mineral fertilizers: nitrogen, phosphorus, potash. General characteristics of the elements of the IVA group of the periodic system; comparative characteristics based on the position in the periodic system, structure of atoms.

Carbon, its allotropic forms. Carbon oxides (II) and (IV), their physical and chemical properties. Carbonic acid. Carbonates and bicarbonates, their interconversion. Qualitative reaction to carbonate ion.

Silica (IV) and silicic acid. Salts of silicic acid. The use of silicic acid and silicates.

ORGANIC CHEMISTRY

The theory of the chemical structure of organic compounds. Classification of organic compounds and their reactions. The nomenclature of organic compounds. The dependence of the properties of organic compounds on the chemical structure. Homology. Isomerism.

Alkanes (saturated hydrocarbons): homological series, structural isomerism, nomenclature, electronic and spatial structure of alkane molecules. Physical properties Chemical properties of alkanes: substitution reaction (halogenation), oxidation on the example of methane and ethane.

Alkenes (unsaturated hydrocarbons of the ethylene series): homologous series, structural and spatial isomerism (cis-, transisomer), nomenclature, electronic and spatial structure of alkenes. Physical properties. Chemical properties of alkenes: reactions of addition of hydrogen, halogens, oxidation. Addition reactions of hydrogen halides and water on the example of ethene (ethylene).

Ethene production (ethane pyrolysis, ethanol dehydration, removal of hydrogen halide from halogen alkanes).

Diene hydrocarbons with conjugated double bonds. Nomenclature and isomerism. Physical and chemical properties of butadiene-1,3 and 2-methylbutadiene-1,3 (isoprene): reactions of addition of hydrogen and halogens. Obtaining butadiene-1,3 from butane (dehydrogenation), from ethanol (dehydrogenation and dehydration); isoprene from 2-methylbutane (dehydrogenation).

General concepts of high molecular weight compounds (monomer, polymer, structural unit, degree of polymerization). The polymerization reaction of ethylene and diene hydrocarbons (butadiene-1,3 and 2-methylbutadiene-1,3). Polyethylene, natural and synthetic rubbers (butadiene and isoprene).

Alkines (unsaturated hydrocarbons with one triple bond): homologous series, structural isomerism, nomenclature. Electronic and spatial structure of an ethine (acetylene) molecule. Physical properties of ethine. Chemical properties of alkynes on the example of ethine (the reaction of addition of hydrogen, halogens, hydrogen halides, water). Obtaining ethine from methane and calcium carbide.

Arenas (aromatic hydrocarbons). The structure of aromatic hydrocarbons on the example of benzene. Chemical properties of benzene: substitution reactions (halogenation and nitration), addition (hydrogen).

Hydrocarbons in nature. Industrial refining: distillation and cracking. The use of hydrocarbons.

Saturated monohydric alcohols: homologous series, structural isomerism (isomerism of the carbon chain and position of the functional group), nomenclature. Functional group of alcohols, its electronic structure. Physical properties. Hydrogen bonding and its effect on the physical properties of alcohols. Chemical properties of monohydric alcohols: interaction with alkali metals, hydrogen halides, organic acids, intramolecular dehydration reaction, oxidation (full and partial). Obtaining ethanol by hydration of ethene (ethylene), hydrolysis of chloroethane. The use of ethanol.

Polyhydric alcohols. Composition, structural formulas, physical properties of ethylene glycol and glycerol. Chemical properties: interaction with alkali metals, copper (II) hydroxide and nitric acid. The use of ethylene glycol and glycerol.

Phenols. The composition and structure of the phenol molecule. Molecular and structural formulas of phenol. The concept of the mutual influence of groups of atoms in a phenol molecule. Physical properties. Chemical properties: interaction with alkali metals, alkali solutions, bromine water and nitric acid. Obtaining phenol from chlorobenzene. The use of phenol.

Aldehydes. Electronic and spatial structure of the functional group of aldehydes. Homological series, structural isomerism, nomenclature. Chemical properties: reduction (addition of hydrogen) and oxidation reactions. Obtaining aldehydes by the oxidation of alcohols. Obtaining acetic aldehyde by hydration of ethine (acetylene) and oxidation of ethylene. The use of acetic aldehyde.

Carboxylic acids. The electronic structure of the carboxyl group. Homological series, structural isomerism, nomenclature of saturated monobasic carboxylic acids. Physical properties Chemical properties of saturated monobasic carboxylic acids: interaction with metals, bases, salts and alcohols. Obtaining acetic acid by oxidation of acetic aldehyde and catalytic oxidation of butane. The use of acetic acid. Oleic acid as a representative of unsaturated monobasic carboxylic acids: composition and structure. Chemical properties of oleic acid: addition of halogens and hydrogen.

Esters. Nomenclature, the structure of molecules. Structural isomerism. Physical and chemical properties: esterification reaction, hydrolysis. The concept of polyester fibers as an example of lavsan.

Fats as representatives of esters. Physical properties Chemical properties: hydrolysis, hydrogenation, oxidation. Fats in nature. Soaps.

Carbohydrates. Classification of carbohydrates. Monosaccharides: glucose and fructose as representatives of hexoses. The structure of the glucose molecule: linear and cyclic (α- and β -) forms. Physical and chemical properties of glucose:

oxidation, reduction, alcohol fermentation reactions. Being in nature, obtaining and using glucose.

Disaccharides. Sucrose as a representative of disaccharides. Physical and chemical properties (hydrolysis). Sucrose in nature.

Polysaccharides. Starch and cellulose as representatives of polysaccharides. The composition and structure of macromolecules. Chemical properties of starch: hydrolysis, reaction with iodine. Chemical properties of cellulose: hydrolysis, formation of esters (esters of acetic and nitric acids). The use of starch, cellulose. Cellulose-based artificial fibers.

Amines. The electronic structure of the amino group. Primary amines. Structural isomerism, nomenclature. Amines as organic bases. Chemical properties: interaction with acids, reaction with water. Aniline as a representative of aromatic amines. The structure of the aniline molecule. Chemical properties: reactions with inorganic acids and bromine water. Obtaining aniline from nitrobenzene. The use of aniline.

Amino acids. Structure, functional groups, structural isomerism, nomenclature. Representatives of α-amino acids: glycine, alanine and glutamic acid. Chemical properties of amino acids: interaction with bases, inorganic acids, amino acids with the formation of peptides. Peptide bond. Synthetic nylon fiber nylon.

Proteins. The composition and structure of protein macromolecules. Chemical properties of proteins: hydrolysis, denaturation, color reactions of proteins.

Interrelationship between the most important classes of organic compounds.

LIST OF TYPICAL CHEMISTRY CALCULATIONS

1. The calculation of the relative molecular and relative formula mass of substances by chemical formulas.
2. Calculation of the mass fraction of a chemical element by the formula of a substance.

3. The calculation of the chemical amount of a substance by its mass and mass by its chemical amount.
4. Calculation of the chemical amount of gas by its volume (at norm. cond.) and the volume (at norm. cond.) of gas by its chemical amount.
5. Calculation according to chemical equations of mass, chemical quantity or volume (for gases, with norm. cond.) based on the known mass, chemical quantity or volume (for gases, with norm. cond.) of one of the reacted or obtained substances.
6. The calculation of the mass fraction and mass of solute (solvent).
7. Finding an empirical and molecular (true) formulas by mass fractions of chemical elements that are part of the substance.
8. Calculation of the relative density and molar mass of gases.
9. Calculations by thermochemical equations.
10. The calculation of the mass (volume) of the substance necessary for the preparation of the solution with a given mass fraction of solute.
11. Determination of the practical yield of product of reaction.
12. Determination of the molecular formulas of organic compounds according to general formula with the composition of its compounds.
13. Determination of the molecular formula of an organic composition on the base of its quantitative and qualitative composition.
14. Calculation according to chemical equitation: one of the reacting substances is taken in excess.

EVALUATION CRITERIA

The entrance test is carried out in writing.
The entrance test lasts 60 minutes.

The maximum number of examination points is 100, the minimum is 39.