

## CHEMISTRY EXAM PROGRAM

### Fundamentals of Theoretical Chemistry

**Atom.** Atom structure: nucleus (protons and neutrons) and electrons. Isotopes. Orbital distribution of electrons. Electronic configurations of atoms and ions. Valence electrons. The ground and excited states of atoms. Electronic classification of chemical elements (s-, p-, d-elements).

The modern wording of the Periodic Law and the modern The state of the Periodic system of chemical elements Mendeleev. Periodic properties of elements (atomic radii, ionization energy, electronegativity) and the compounds formed by them.

**Molecules and chemical bonding.** Covalent bond: mechanisms education, polarity division;  $\sigma$  and  $\pi$  bonds. Oxidation state and valence. Hybridization of atomic orbitals. Spatial structure molecules. Ion bond. Metal bond. Hydrogen bond.

**Substances** of molecular and non-molecular structure. Crystalline and amorphous substances. Types of crystal lattices (atomic, molecular, ionic, metal). The dependence of the properties of substances on the type of crystalline gratings. The reasons for the diversity of substances: isomerism, homology, allotropy, isotopy. Classification and nomenclature of inorganic and organic substances. Pure substances and mixtures. Dissolution as a physicochemical process. Thermal phenomenon upon dissolution. The concentration of solutions - mass fraction solute (percentage concentration).

### Chemical reactions

Classification of chemical reactions in inorganic and organic chemistry. Thermal effects of reactions. Thermochemical equations.

The reaction rate, its dependence on various factors. Concept of catalysts. Reversibility of reactions. Chemical equilibrium. Bias equilibrium under the influence of various factors. Le Chatelier principle.

Electrolytic dissociation. Strong and weak electrolytes. Reactions ion exchange, the conditions of irreversible reactions in solutions. Amphotericity.

Hydrolysis of inorganic and organic compounds. Hydrolysis value in biological metabolic processes. The use of hydrolysis in industry (saponification of fats, glucose, hydrolysis alcohol).

Redox reactions. Electronic balance method. A number of standard electrode potentials (a series of metal activity). Corrosion of metals. Corrosion protection methods.

Electrolysis of solutions and melts. Electrolytic production alkali, alkaline earth metals and aluminum. Practical the use of electrolysis.

### **Inorganic chemistry**

The characteristic chemical properties of metals, non-metals and basic classes of inorganic compounds.

Hydrogen. The position of hydrogen in the Periodic system. Connections hydrogen with metals and non-metals. Water, chemical properties of water.

Halogens. General characteristics of the halogen subgroup. Chemistry features fluoride. Hydrogen halides. Production of hydrogen halides, hydrogen halides acids and their salts. Qualitative reactions to halide ions. Oxygen-containing chlorine compounds. The use of halogens and their critical compounds.

Oxygen, its physical and chemical properties, preparation and use, being in nature. Ozone, its properties, production and use. Oxides and peroxides. Hydrogen peroxide, its properties and applications.

Sulfur. Physical and chemical properties of sulfur. Hydrogen sulfide, its physical and chemical properties, production, use, finding in nature. Sulfides. Sulfur oxide (IV), its physical and chemical properties, receiving application. Sulfuric acid and sulfites. Sulphuric acid, properties of dilute and concentrated sulfuric acid. Sulphuric acid as an oxidizing agent, sulfates. Qualitative reactions to sulfide, sulfite and sulfate ions.

Nitrogen, the structure of the molecule, its physical and chemical properties, application, being in nature. Nitrides. Ammonia getting it in industry and laboratory, physical and chemical properties, application. Ammonia water. The formation of ammonium ion. Ammonium salts. Qualitative reaction to ammonium ion. Nitrogen oxides (II, IV, V), their production, physical and chemical properties, application. Nitric acid, its receipt. Properties of nitric acid, application. Nitrates, their thermal decomposition.

Phosphorus. Phosphorus allotropy. Phosphine. Oxides of phosphorus (III and V), Phosphoric acid and its salts.

Carbon. Carbon allotropy (diamond, graphite, carbene, fullerenes). Activated carbon adsorption. Carbides of calcium and aluminum. Carbon monoxide and carbon dioxide, their physical and chemical properties,

production and application. Carbonic acid and its salts (carbonates and bicarbonates). Qualitative reaction to carbonate ion.

Silicon, obtaining, physical and chemical properties, being in nature. Silan Silica (IV). Silicic acids, silicates.

Alkali metals. General characteristics of the subgroup. Physical and chemical properties of lithium, sodium, potassium. Their receipt and application.

Oxides and peroxides of sodium and potassium. Caustic alkalis, their properties, production and application. Salts of alkali metals. Recognition of sodium cations and potassium.

Alkaline earth metals. General characteristics of the subgroup. Physical and chemical properties of magnesium and calcium, their preparation, application and finding in nature. Salts of calcium and magnesium, their importance in human life. Water hardness and ways to eliminate it.

Aluminum, its physical and chemical properties, preparation and application.

Amphotericity of aluminum oxide and hydroxide.

Transition elements (iron, manganese, chromium, copper, zinc), features atomic structures, physical and chemical properties, preparation and use. Oxides and hydroxides of these metals, the dependence of their properties on the degree oxidation of the element. Oxidizing properties of manganese and chromium salts in highly oxidized. The balance of chromates and dichromates. Integrated compounds on the example of zinc and aluminum compounds.

General methods for producing metals. The concept of metallurgy.

## **Organic chemistry**

The main provisions of the theory of the structure of organic compounds. Chemical structure as an order of atomic bonding and mutual influence atoms in the molecules. The property of carbon atoms to form linear, branched, closed, single and multiple bonds. Education single, double and triple bonds in the light of the theory of atomic hybridization orbitals. Homology, isomerism, functional groups in organic connections. Classification of organic compounds, general formulas different classes of compounds.

*Alkanes* (saturated hydrocarbons). Homological series of methane. Total formula for the composition of alkanes.  $sp^3$ -hybridization of the carbon atom orbitals. Isomerism of the carbon skeleton. Systematic nomenclature. Chemical properties: substitution reaction, thermal decomposition, dehydrogenation, isomerization, catalytic oxidation, combustion. Reaction mechanism

substitution. Hydrocarbon synthesis: aluminum carbide hydrolysis, electrolysis sodium acetate solution, Wurz reaction. Getting hydrogen and unsaturated hydrocarbons from the limit. The practical significance of the limit hydrocarbons. Cycloalkanes, production, carbon chain structure. Types reactions for small and large cycles.

**Alkenes.** Unsaturated hydrocarbons of a number of ethylene. Sp<sup>2</sup>-hybridization electron clouds of carbon atoms,  $\sigma$  and  $\pi$  bonds. Types of Isomerism. Alkenes, geometric isomerism. Nomenclature of ethylene hydrocarbons. Chemical properties - addition reactions: hydrogen, hydrogen halides, halogens, water; oxidation reactions, polymerizations. Reaction mechanism joining. Markovnikov rule. The concept of diene hydrocarbons: production, addition reactions, polymerizations. Rubbers, reaction vulcanization.

**Alkines** Acetylene: molecular structure, hybridization type sp. Getting acetylene. Chemical properties of acetylene. Use of acetylene in organic synthesis.

**Aromatic hydrocarbons (arenas).** The electronic structure of molecules. Chemical properties of benzene: substitution reactions (bromination, nitration), addition (hydrogen, chlorine). Homologs of benzene, their production, isomerism among benzene homologues. The mutual influence of atoms in toluene molecule.

Comparison of the structure and properties of the limiting, unsaturated and aromatic hydrocarbons. The relationship of homological series.

**Alcohols and phenols.** The atomicity of alcohols. Homological series of limit monohydric alcohols. Types of isomerism. Primary, secondary alcohols, tertiary. Nomenclature of alcohols. Hydrogen bond and its effect on physical properties of alcohols. Alcohol poisoning, fatal effects on the human body. Chemical properties of alcohols: combustion, oxidation to aldehydes, interaction with alkali metals, hydrogen halides, carboxylic acids. Obtaining alcohols: from haloalkanes, alkenes. Industrial methanol synthesis.

Ethylene glycol and glycerin as representatives of polyhydric alcohols. Features of their chemical properties, practical use, high-quality response.

Phenols. The structure of phenols, the physical properties of phenols. Chemical properties: interaction with sodium, alkali, bromine; quality response on phenol. The mutual influence of atoms in the phenol molecule.

**Aldehydes.** The structure of aldehydes, a functional group, its electronic structure. Homological series of aldehydes. Nomenclature. Chemical Properties: Aldehyde oxidation and reduction reactions. Getting acetic aldehyde by

acetylene hydration and catalytic oxidation ethylene. The use of formic and acetic aldehydes.

The structure of *ketones*. Nomenclature. Preparation of Ketones by Oxidation secondary alcohols. Acetone is the most important representative of ketones, its hydration reaction preparation, practical application.

***Carboxylic acids***. The electronic structure of the carboxyl group, mobility of a hydrogen atom. The basicity of acids. Homologous series saturated monobasic acids. Nomenclature. Hydrogen bond her effect on the physical properties of acids. Chemical Properties: Interaction with metals, alkalis, salts; esterification reaction. Strength change acids under the influence of substituents in the hydrocarbon radical. Features formic acid. The most important representatives of carboxylic acids. Acid production by oxidation of aldehydes, alcohols, unsaturated hydrocarbons. Higher carboxylic acids.

The genetic link of hydrocarbons, alcohols, aldehydes and ketones, carboxylic acids.

***Esters and fats***. The structure of esters. Reaction reversibility esterification. Hydrolysis of esters. Fats as esters glycerol and higher carboxylic acids. Fats in nature, their physical properties. The conversion of fats in the body. Hydrolysis and saponification of fats. Soaps like salts of higher carboxylic acids. Hydrogenation of fats in technology.

***Carbohydrates***. Classification of carbohydrates. Glucose - the most important representative monosaccharides. Physical properties, being in nature. Structure glucose. Chemical properties: oxidation, reduction, fermentation reactions. The use of glucose. Fructose as a glucose isomer. Summary of the structure of ribose and deoxyribose. Sucrose. Physical properties being in nature. Hydrolysis of sucrose. Starch is a natural polymer. The structure of macromolecules from glucose units. Chemical properties: hydrolysis, high-quality reaction to starch. The conversion of starch in the body. Cellulose is a natural polymer: the structure of macromolecules from glucose units. Chemical properties: hydrolysis, ester formation. Application cellulose and its derivatives.

***Amines***. The structure and classification of amines. Amines as Organic bases: interaction with water and acids. Amines Production alkylation of ammonia and reduction of nitro compounds. Aniline - aromatic amine: its structure, the reason for the weakening of the basic properties in comparison with amines of the limiting series. Obtaining aniline from nitrobenzene (Zinin reaction).

**Amino acids.** The structure of amino acids, their physical properties. Isomerism amino acids. Amino acids as amphoteric organic compounds. The synthesis of peptides, their structure. The biological significance of  $\alpha$ -amino acids.

**Proteins** as biopolymers. Protein structures. Properties of proteins: hydrolysis, denaturation, color reactions. The conversion of food proteins in the body.

General concepts of the chemistry of macromolecular compounds: monomer, polymer, structural unit, degree of polymerization. The main synthesis methods are polymerization and polycondensation reactions. Polyethylene, polypropylene, polystyrene, phenol-formaldehyde resins: their structure, properties, application.

### Settlement Tasks

Calculation of the mass fraction of a chemical element in a compound.

Establishment of the simplest formula for a substance by mass fractions chemical elements.

Calculation of volumetric ratios of gases in chemical reactions.

Calculation of the mass of substances or the volume of gases by a known amount substances of the original (reacted) or reaction products (resulting substances).

Calculation of the thermal effect according to the thermochemical equation and data on the amount of one of the substances involved in the reaction.

Calculations by equations when one of the substances is taken in the form of a solution with a certain mass fraction of solute

Equation calculations when one of the substances is taken in excess.

Equation calculations when the starting material contains impurities.

Determination of the yield of the reaction product from theoretically possible.

Calculation of mass or volume of solute and solvent, necessary to prepare a solution with a certain mass fraction of solute.

Determination of the molecular formula of a substance by its relative density and (or) on products of combustion.

### ***Recommended Reading***

1. Chemistry. Manual tutor for applicants to universities. Ed. A.S. Egorova. (Rostov n / a, 2010, 768 p.)
2. A short course in chemistry. Manual for applicants to universities. Kuzmenko N.E., Eremin V.V., Popkov V.A. (M: VS. 2008, 416 pp.)
3. Chemistry. Thematic tests to prepare for the exam. Assignments high difficulty level (C1-C5). Doronkin V.N., Berezhnaya A.G., Sazhneva T.V., Fevaleva V.A. (Rostov n / A, 2012, 233 pp.)
4. Chemistry. The most complete publication of typical job options. Kaverina A.A., Dobrotin D.Yu., Snastina M.G. (FIPI, 2013)