Kirov State Medical University

CHEMISTRY ENTRANCE EXAMINATION REQUIREMENTS

Chemistry entrance exam is mainly to test basic theoretical principles of Chemistry as an important natural science, the basis for scientific understanding of natural phenomena.

The applicant should know/understand:

- the most important notions in Chemistry and use them to explain certain factors and phenomena;
- the basic laws and theories in Chemistry and limits of their application;
- the most important chemical substances and materials based on them;
- properties of the most important chemical compounds used in medicine, industry, agriculture and household;
- principles of chemical production (without delving into the details of chemical apparatus arrangement).

The applicant should be able:

- to apply the studied theoretical principles when considering substance classes and specific compounds, showing the dependence of substance properties on their structure and application of substances depending on their properties;
- to give substances their common and international names;
- to carry out calculations by chemical formulas and equations.

The following tables are available at the exam: "Mendeleyev Periodic System", "Water Solubility of Bases, Acids and Salts", "Electrochemical Series of Metals".

When solving typical calculation tasks, it is allowed to use microcalculators.

CHEMISTRY ENTRANCE EXAMINATION PROGRAMME CONTENT

Foundations of Chemistry

1.1. Elementary chemical notions. Basic laws of chemistry.

Subject and aims of Chemistry. Place of Chemistry among other natural sciences. Atomic theory. Molecules. Atoms. A chemical element, a simple substance, a complex substance. Chemical symbols (signs) and chemical formulas. Calculation of chemical element mass fraction by its formula.

Relative atomic and relative molecular mass. Mole as the base unit used in representing an amount of substance. Mole weight. Avogadro's number. Law of definite proportions of substance. Law of conservation of substance mass, its importance in Chemistry. Avogadro's law and its consequences. Law of volumes.

1.2. Modern ideas of atomic structure.

Structure of electron shells of atoms of elements in the first four periods: s-, p- and d-elements. Electron configuration of an atom. Ground and excited states of atoms. Mendeleyev's periodic law and periodic system.

Regularities in changing properties of elements and their compounds in periods and groups.

General characteristics of group IA, IIA and IIIA metals in connection with their position in Mendeleyev's periodic system and peculiarities of their atomic structure.

Characteristic of transition elements (copper, zinc, chromium, iron) in connection with their position in Mendeleyev's periodic system and peculiarities of their atomic structure.

General characteristics of nonmetals in groups IVA-VIIA in connection with their position in Mendeleyev's periodic system and peculiarities of their atomic structure.

1.3. Chemical bond and substance structure.

Covalent bond, its types and formation mechanisms. Characteristics of covalent bond (bond polarity and bond energy). Electrostatic bonding. Metallic bonding. Hydrogen bonding.

Electronegativity. Valence and oxidation state of elements. Molecular and non-molecular substances. Type of crystal lattice. Dependence of substance properties on its composition and structure.

1.4. Chemical reaction.

Classification of chemical reactions in inorganic and organic chemistry. Solutions. Solubility of substances. Dependence of substance solubility on their nature, temperature, pressure.

Enthalpy change of a reaction. Thermochemical equations. Speed of a reaction, its dependence on various factors. Reversible and irreversible chemical processes. Chemical equilibrium. Displacement of chemical equilibrium under the influence of various factors.

Electrolytic dissociation of electrolytes in water. Strong and weak electrolytes. Ionic replacement reactions. Salt hydrolysis. Acidic, neutral, alkaline aqueous solutions.

Oxidation-reduction reactions. Metal corrosion and ways to protect against it. Electrolysis of melts and solutions (salts, alkalis, acids). Ion (Markovnikov's rule) and radical mechanisms of organic reactions.

Inorganic Chemistry

Acidic, basic, amphoteric oxides. Methods of preparation and properties.

Bases, methods of preparation and properties. Alkalies, their preparation, properties and application.

Acids, their properties and methods of preparation. Neutralization reaction.

Salts. Their composition and properties. Salt hydrolysis.

Hydrogen. Its chemical and physical properties. Interaction with oxygen, metal oxides, organic substances. Use of hydrogen as environmentally friendly fuel and raw material for the chemical industry.

Oxygen. Its chemical and physical properties. Allotropes of oxygen. Application of oxygen. Oxygen cycle.

Water. Its physical and chemical properties. Crystalline hydrates. Importance of water in industry, agriculture, houshold, nature. Protection of water against pollution.

Chlorine. Its physical and chemical properties. Reactions with inorganic and organic substances. Production of chlorine in industry. Chlorine compounds. Application of chlorine and its compounds.

Halogens. General characteristics of halogens. Halogen compounds in nature, their application.

Carbon subgroup. General characteristics of IV group elements of the principal subgroup. Their physical and chemical properties. Carbon, its allotropic forms. Carbon compounds: oxides (II, IV), carbonic acid and its salts.

Silicon. Silicon compounds in nature, their application in engineering.

Oxygen subgroup. General characteristics of VI group elements of the principal subgroup. Sulfur, its physical and chemical properties. Sulfur compounds: hydrogen sulphide, sulfur oxides. Sulfuric acid, its properties, chemistry of production.

General characteristics of V group elements of the principal subgroup. Nitrogen. Its physical and chemical properties.

Nitrogen compounds: ammonia, ammonium salts, nitrogen oxides, nitric acid, nitric acid salts (their physical and chemical properties).

Ammonia production. Application of ammonia, nitric acid and its salts.

Phosphorus, its allotropic forms, physical and chemical properties. Phosphorus oxides (V), phosphoric acid and its salts. Phosphate fertilizers.

Metals. Their position in the periodic table. Features of their atomic structure. Metal bonding. Typical physical and chemical properties. Metal corrosion.

Alkali metals. General characteristics in the context of their position in Mendeleyev's periodic system. Sodium and potassium compounds in nature, their application. Potassic fertilizers.

General characteristics of II and III groups elements of the main subgroups of Mendeleyev's periodic table. Calcium, its compounds in nature. Water hardness and ways to eliminate it.

Aluminum. Characteristics of aluminum and its compounds. Aluminum oxide amphoteric character. Application of aluminum and its alloys.

Iron. Characteristics of iron, oxides, hydroxides, iron salts (II) and (III). Natural compounds of iron. Iron alloys: cast iron and steel. Application of iron alloys and compounds.

Metal industry. Metals in modern equipment. Main methods of metal production. Blast-furnace cast iron production. Methods of steel production. Problem of low-waste metal industry and environment protection. Development of national metal industry and its importance for the development of other industries.

Organic Chemistry

Main theses of Butlerov's theory of chemical structure. Dependence of substance properties on their chemical structure. Isomerism.

Electronic nature of chemical bonds in organic molecules, ways of breaking chemical bonds, free radicals.

Saturated hydrocarbon series (alkanes), their electronic and spatial structure (sp3 hybridization). Methane. Nomenclature for alkanes, their physical and chemical properties. Cycloalcanes (or naphthenes).

Saturated hydrocarbons in nature.

Ethylene hydrocarbons (alkenes). Alkene series. Double bond in alkenes. σ- and π-bonds, sp2, sp hybridization. Physical properties. Carbon skeleton chain isomerism and position of the double bond. Nomenclature. Chemical properties.

Dehydrogenation of hydrocarbons. Application of ethylene hydrocarbons. Natural rubber, its structure and properties.

Acetylene. Triple bond, sp hybridization. Acetylene series. Physical and chemical properties, application of acetylene. Its production from methane by a calcium carbide process.

Benzene, its electronic structure and chemical properties. Manufacture and application of benzene. Pesticides and their use for environment-friendly purposes.

Interrelation of saturated, unsaturated and aromatic hydrocarbons.

Natural sources of hydrocarbons: oil, natural and associated gases, coal. Oil fractional distillation. Cracking distillation. Aromatization of oil products. Environmental protection in oil refining.

Alcohols, their structure and chemical properties. Isomerism. Nomenclature for alcohols. Chemical properties of alcohols. Application of methyl and ethyl alcohol. Alcohol toxicity and harmful effect on the human body.

Genetic relationship between hydrocarbons and alcohols.

Phenol, its structure and physical properties. Phenol chemical properties. Phenol application. Protection of environment from phenol-containing industrial wastes.

Aldehydes, their structure and chemical properties. Production and application of formaldegide and acetylaldehyde.

Carboxylic acids. Alcanoic acid series, their structure. Carboxy group, mutual influence of carboxy group and hydrocarbyl. Physical and chemical properties of carboxylic acids.

Acetic, palmitic, stearinic, oleinic acids. Production and application of carboxylic acids.

Esters, their structure. Esterification reactions. Chemical properties.

Fats in nature, their structure and properties.

Synthetic detergents and their importance. Environmental contamination with synthetic detergents.

Sucrose, its structure, chemical properties, role in nature. Sucrose hydrolysis.

Starch and cellulose, their structure, chemical properties, role in nature. Application of cellulose and its derivatives. Synthetic fibers.

Amines as organic bases. Their structure, amine group. Interaction of amines with water and acids.

Aniline. Aniline production from nitrobenzene, practical application of aniline and its importance.

Aminoacids. Their structure, chemical properties, isomerisation. Aminoacids, their importance in nature and application. Peptide synthesis, their structure.

Nitrogen-containing heterocyclic compounds, such as pyridine and pyrrole.

Proteins. Protein structure and properties. Success in the study and synthesis of proteins. Importance of industrial microbiology.

Nucleic acids, nucleotide structure. Complementarity in DNA duplex formation. Role of nucleic acids in a cell life cycle.

General concepts of high molecular weight compound chemistry: a monomer, a polymer, a structural unit, degree of polymerization, average molecular weight.

Polymerization, polycondensation. Linear arm-like structure of polymers.

Dependence of polymer properties on their structure.

CALCULATIONS BY CHEMICAL FORMULAS AND EQUATIONS

1. Calculation of mass of a solute in the given mass of a solution with a precisely known mass fraction.
2. Calculation of gas volumes in chemical reactions.
3. Calculation of substance mass or gas volume in accordance with a precisely known amount of a substance, mass or volume of one of the substances involved in the reaction.
4. Calculation of chemical reaction enthalpy.
4. Calculation of mass (volume, amount of a substance) of reaction products, if one of the substances is given in excess (contains impurities).
5. Calculation of mass (volume, amount of a substance) of a reaction product, if one of the substances is a solution with a given mass fraction of a solute.
6. Determination of substance molecular formula.
7. Calculation of mass or volume fraction of actual reaction product yield and theoretical yield.
9. Calculation of mass fraction (mass) of a chemical compound in a mixture.

Chairman of Chemistry Examination Board  Irina A. Tokareva