

Program in Chemistry
Pre-university training of foreign
students.

Content of subject

Introduction

Subject and aims of chemistry. Chemical and physical phenomena.

General chemistry

Topic 1. Basic definitions and laws of chemistry.

Atomic-molecular doctrine. Atoms. Chemical elements. Molecules. Simple and composite substances. Allotropy. The relative atomic weight. The relative molecular weight. Mole. Molar mass.

Chemical formulas. The Law of Definite Proportions. The Law of Multiple Proportions. Moles and molar mass. Empirical formulas of compounds. Valency.

Chemical equations. The Law of Conservation of Mass. Calculations of chemical formulas. Percent composition of compounds.

Avogadro's law. Molar volume of a gas.

Topic 2. Mendeleev's Periodic law and periodic table of chemical elements.

Mendeleev's Periodic law and periodic table of chemical elements. Modern periodic law. Periods and groups of elements. Structure of atoms. Protons and neutrons. Periodic properties: atomic radius, electronegativity, ionization energy, electron affinity, metallic and nonmetallic properties. Electronic configuration of an atom.

Topic 3. Chemical bond.

Covalent bond (polar and nonpolar). Nature of covalent bond. Properties of covalent bond. Electronegativity. Valency and oxidation state. Electronegativity. Ionic bond. Hydrogen bond. Metallic bond. Types of a crystal lattice.

Topic 4. Basic classes of inorganic compounds.

Classification of inorganic compounds. Oxides: composition and nomenclature. Basic, acidic and amphoteric oxides. Methods preparation and chemical properties.

Acids. Composition and nomenclature of an acids. Methods preparation and chemical properties of an acid.

Bases, their composition and nomenclature. Methods preparation and chemical properties. Alkalis. Amphoteric hydroxides.

Salts, their composition and nomenclature. Normal, acidic and basic salts. Methods preparation and chemical properties of salts.

Topic 5. Chemical reactions.

Classification of chemical reactions. Oxidation-reduction reactions. Oxidizers and reducers. Heat effects of a chemical reactions. Rate of reaction. Catalysis and catalysts. Reversible and nonreversible chemical reactions. Chemical equilibrium. Le-Chatelier's principle.

Topic 6. Solutions. Dissociations.

Solutions. Principles of solubility. Dependence the solubility of substances upon various factors: nature of solvent and solute, temperature and pressure. Saturated and unsaturated solutions. Concentration of solutions: molarity and percentage by mass.

Electrolytes and nonelectrolytes. Dissociation in solutions. Strong and weak electrolytes. Ion-exchange reactions in solutions. Net ionic equations. Degree of dissociation.

Chemical properties of acids, bases and salt with a point of dissociation theory.

Metals

Position of metals in Periodic Table and peculiarities structure of their atoms.

General physical and chemical properties of metals. General principles of extraction of metals (metallurgy).

Alkali metals and their compounds. General physical and chemical properties of sodium and potassium. Compounds of sodium and potassium. Metals in biology.

Alkali earth metals and their compounds. General properties of calcium and magnesium. Compounds of calcium and magnesium.

Aluminium. Chemical properties of aluminium. Amphoteric properties of aluminium oxide and hydroxide.

Iron. Chemical properties of iron and its compounds.

Nonmetals

Position of nonmetals in Periodic Table and peculiarities structure of their atoms.

Position of hydrogen in Periodic Table. Discovery and occurrence. Preparation. Chemical properties of hydrogen. Isotopes of hydrogen. Applications of hydrogen. Water. General physical and chemical properties of water. Heavy water. Hydrogen peroxide.

Halogens. Position in Periodic Table. Structure of their atoms and molecules. Chlorine. Chemical properties of chlorine. Hydrogen chloride and its properties. Hydrochloric acid and its salts.

Oxygen family. Position in Periodic Table. Allotropy. Occurrence and preparation. Chemical properties of oxygen.

Sulphur. Physical and chemical properties of Sulphur. Hydrogen sulphide. Occurrence and preparation. Sulphides. Sulphur dioxide and Sulphur trioxide and their chemical properties. Sulphuric acid. Physical and chemical properties. Salts of sulphuric acid.

Elements of nitrogen family. Position in Periodic Table. Structure of molecules and simple substances. Nitrogen. Occurrence and chemical properties. Important compounds of nitrogen. Ammonia. Structure of molecule. Physical and

chemical properties. Occurrence and preparation. Nitric acid. Physical and chemical properties. Nitrates.

Phosphorus. Occurrence. Allotropic modifications of phosphorus. Phosphorus pentoxide. Phosphoric acids and its salts. Applications of nitrogen and phosphorus compounds.

Elements of carbon family. Position in Periodic Table. Carbon. Allotropic modification of carbon. Chemical properties of carbon. Carbon monoxide and carbon dioxide and their chemical properties. Carbonic acids, carbonates and bicarbonates.

Silicon. Chemical properties. Silicon dioxide. Silicon acid. Compounds of silicon in nature.

Organic chemistry

Subject of organic chemistry. Peculiarities of organic compounds. The basic principles of the theory of chemical structure of organic compounds (A. M. Butlerov). Dependence of chemical properties of organic compounds on their structure. Isomerism. The nature of covalent bonds in organic compounds. Classification of organic compounds, nomenclature and hybridization.

Alkanes. Nomenclature. Hybridization. General methods of preparations. General properties: halogenation, combustion, nitration, thermal decomposition. Methane, structure of molecule.

Unsaturated hydrocarbons (alkenes, alkynes and alkydienes). Nomenclature and isomerism. Preparation. Chemical properties.

Aromatic compounds. Preparation and nomenclature. Chemical properties. Benzene. Chemical properties.

Alcohols. Saturated alcohols and their structure. Isomerism and nomenclature of saturated alcohols. Chemical properties of alcohols. Methods preparation of ethanol. Applications of ethanol and methanol.

Chemical properties of glycol and glycerol.

Phenol. Structure, properties and applications.

Aldehydes and ketones. Nomenclature. Structure of molecules. Chemical properties. Preparation and applications.

Carboxylic acids. Structure of molecules. Nomenclature. Chemical properties. Preparation and applications. Methanoic and acetic acids.

Esters. Structure of esters. Reaction of esterification. Hydrolysis of esters.

Fats and oils.

Carbohydrates. Glucose and fructose. Occurrence in nature. Preparation. Chemical properties. Sucrose and its hydrolysis.

Starch and cellulose. Chemical properties.

Amines. Chemical properties of amines. Biological importance of amines.

Amino acids. Structure of amino acids. Preparations and properties. Biological importance and applications of amino acids.

Proteins. Structure of proteins.

Problems:

1. Calculating moles of one species from moles of another species.
2. Calculating the molecular mass (weight) of a chemical compounds.
3. Calculating percentage by mass.
4. Converting between moles and grams.
5. Determining the mass of a given number of moles of a compound.
6. Determining the number of moles from the mass of a compound.
7. Solving limiting reactant mole-mole and gram-gram problems.
8. Finding the empirical formula from the percent composition.
9. Calculating gas density.
10. Calculation of concentration of the solution (percent by mass (%), molar concentration – molarity).
11. Calculation mass of solute and solvent in the solution, if the solution concentration is know.