Chemistry program

1. The structure of matter. The structure of the atom. The composition of atomic nuclei. Isotopes. The distribution of electrons in atoms. Chemical element. Periodic law and the structure of the periodic system. s-, p-, d-elements. Simple substance, complex substance, mixture of substances. The concept of allotropic modifications. Relative atomic mass, relative molecular weight. The law of conservation of mass. Mole is a unit of quantity of a substance. Molar mass. Avogadro's law and its consequences. Types of chemical bonds. Electronegativity of chemical elements. The formation of covalent polar and non-polar bonds. Bond length and energy. The formation of ionic bonds. Metal bond. Substances of molecular and non-molecular structure. Types of crystal lattices. Hydrogen bond. Valence and degree of oxidation.

2. Chemical reactions. Physical and chemical phenomena. Classification of reactions: addition, decomposition, substitution, exchange. Oxidation-reduction reactions, the most important oxidizing and reducing agents. Electrolysis with inert electrodes of molten salts and oxides; salt solutions. The rate of chemical reactions and its dependence on various factors. The rate constant of chemical reactions. Catalysis. Thermal effects of chemical reactions. Exo- and endothermic reactions. Reversibility of reactions. Chemical equilibrium and conditions for its displacement (Le Chatelier principle).

3.Solutions. Solubility of substances. Types of solutions (gaseous, liquid, solid). The expression of the composition of the solution. The idea of colloidal solutions. The value of solutions in medicine and biology, in everyday life. Electrolytic dissociation. The degree of dissociation. Strong and weak electrolytes. Ionic reaction equations.

4. Main classes of inorganic compounds Oxides, acids, bases, salts (classification, nomenclature). Hydrolysis: cation hydrolysis (salts of aluminum, iron, chromium, copper, zinc, ammonium, etc.); anion hydrolysis (sulfites, sulfides, carbonates, phosphates, acetates, silicates, etc.). Full hydrolysis (for example, aluminum sulphide). Amphoteric properties on the example of compounds of beryllium, zinc, germanium, tin, lead, aluminum, gallium, indium, chromium (III), antimony (III), vanadium (IV); titanium (IV). Ideas about the formation of hydroxo complexes.

5. Hydrogen and its compounds. Hydrogen, its physical properties. Chemical properties of hydrogen: interaction with metals and non-metals. Laboratory and industrial methods for producing hydrogen. The use of hydrogen. Water. The structure of the molecule. Physical and chemical properties (interaction with metals under various conditions; electrolysis; formation of crystalline hydrates). The concept of hydrides. Hydride interaction with water. The composition of volatile hydrogen compounds with non-metals (diborane, silane, phosphine, arsine, hydrogen selenium, hydrogen sulfide).

6. Halogens and their compounds. General characteristics of the VIIA group of the periodic system. Chlorine, molecular structure, physical and chemical properties (reactions with metals and non-metals; water; solutions of alkalis; bromides and iodides of metals, with other complex substances with reducing properties). Laboratory and industrial methods for chlorine production. Hydrogen chloride, the structure of the molecule. Physical properties of hydrogen chloride. Chemical properties of hydrogen chloride and its aqueous solution (hydrochloric acid): interaction with metals, basic oxides, bases, salts, substances with oxidizing properties.

Laboratory and industrial methods for producing hydrogen chloride. Comparison of hydrogen chloride with hydrogen fluoride, hydrogen bromide and hydrogen iodide. Qualitative reactions to halide ions. Oxygen-containing chlorine compounds: chlorine oxides, hypochlorous acid and its salts hypochlorites; chloric acid and chlorites; chloric acid and chlorates, perchloric acid and perchlorates.

7. Elements of group VIA. General characteristics of the VIA group of the periodic system. Oxygen, its physical properties. Chemical properties of oxygen: interaction with metals and non-metals. Laboratory and industrial methods for producing oxygen. Comparison of the physical and chemical properties of oxygen and ozone. Chemical properties of hydrogen peroxide. Allotropic modification of sulfur. Physical and chemical properties of sulfur (reactions with metals; with halogens, oxygen, phosphorus and carbon; relation to acids; disproportionation in alkali solution). Hydrogen sulfide, its physical properties. Chemical properties of hydrogen sulfide as a weak acid and reducing agent. High-quality reaction to hydrogen sulfide and sulfide ions. Sulfur oxides. The redox duality of sulfur oxide (IV) and sulfites. Sulfuric acid, its physical properties. Chemical properties of sulfuric acid as a strong acid and oxidizing agent. Features of the interaction of sulfuric acid with metals. Sulfuric acid salts and their properties.

8. Elements VA group. General characteristics of the VA group of the periodic system. Nitrogen, molecular structure, physical properties. Chemical properties of nitrogen: interaction with metals and non-metals. Ammonia and metal nitrides. The structure of the ammonia molecule. The physical properties of ammonia. Chemical properties of ammonia as a weak base and reducing agent. Chemical basis of ammonia production. Properties of ammonium salts (reactions with alkalis, decomposition reactions). Properties of nitric oxide (II): reaction with oxygen. Nitrogen (IV) oxide properties: dissolved in water in the presence of oxygen; disproportionation. Nitric acid, its physical properties. Chemical properties of nitric acid as a strong acid and oxidizing agent, decomposition of nitric acid. Features of the interaction of nitric acid with metals. Chemical bases of nitric acid production. Thermal decomposition of nitrates. Allotropic modification of phosphorus. Physical and chemical properties of phosphorus: interaction with metals and non-metals. Phosphorus production. Phosphorus oxide (V), its physical properties. Chemical properties of phosphorus (V) oxide: interaction with water, bases and basic oxides, water-removing properties. Phosphoric acids (metaphosphoric, orthophosphoric, diphosphoric), their interconversion. Properties of phosphoric acid as a weak acid. Orthophosphates, hydroorthophosphates, dihydrotrophosphates.

9. Elements of IVA group. General characteristics of the IVA group of the periodic system. Carbon, its allotropic modifications: the structure of diamond and graphite. The physical properties of diamond and graphite. Chemical properties of carbon: the interaction of a simple substance with metals and non-metals, the reduction of metals from their oxides. Hydrolysis of calcium carbide and aluminum carbide. Carbon oxides, molecular structure, physical properties. Redox duality of carbon monoxide (II): reduction of metals from their oxides, oxidation by oxygen. The formation of carbon monoxide (II). Properties of carbon monoxide (IV): reactions with magnesium; carbon; calcium hypochlorite. Properties of carbonic acid and its salts. Interconversion of carbonates and bicarbonates. Decomposition of hydrocarbons and insoluble carbonates. Qualitative reaction to carbonate ion. The physical and chemical properties of silicon, silicon oxide (IV); silicic acid and silicates. Natural compounds of carbon and silicon. The use of compounds of carbon and silicon.

10. General characteristics of metals. The position of metals in the periodic system. Physical properties of metals. Alloys. General methods of producing metals. Chemical properties of metals. Electrochemical series of voltages of metals. Corrosion of metals.

11. Properties of metals IA and IIA groups. General characteristics of the IA and IIA groups of the periodic system. Natural compounds of sodium and potassium. Chemical properties of alkali metals: reactions with hydrogen, oxygen, halogens, sulfur, water. Obtaining oxides and hydroxides of sodium and potassium. The reaction of sodium peroxide with carbon dioxide. The use of compounds of sodium and potassium. Medical and biological significance of sodium and potassium compounds. Natural compounds of magnesium and calcium. Chemical properties of beryllium, magnesium and alkaline-earth metals: reactions with oxygen, hydrogen, nitrogen, halogens, sulfur, water. Properties of compounds of metals of group IIA. Medical and biological significance of magnesium and calcium compounds.

12. Aluminum properties. Natural aluminum compounds. The properties of a simple substance: reactions with oxygen, halogens, sulfur, carbon, alkalis and acids. Properties of aluminum oxide and hydroxide: relation to acids and alkalis. The formation of aluminates during fusion and hydroxocomplex formation in the aquatic environment. The use of aluminum and its compounds.

13. Properties of iron and some d-elements. Natural compounds of iron. Properties of a simple substance: reactions with oxygen, halogens, sulfur, water vapor; the ratio of iron to dilute and concentrated acid solutions. Iron rusting. The properties of oxides and hydroxides of iron (II), (III) in comparison. Oxidation of iron (II) compounds with oxygen, hydrogen peroxide, and other oxidizing agents. Qualitative reactions to Fe^{2+} and Fe^{3+} ions (with potassium hexacyanoferrates). Medical and biological value of iron compounds. An idea of the properties of chromium, copper, zinc and their compounds.

14. Introduction to Organic Chemistry. Structural and spatial isomerism (geometric and optical). Electronic nature of chemical bonds in molecules of organic compounds. Types of hybridization of the electron orbitals of the carbon atom: sp^3; sp^2; sp. Principles of nomenclature of organic compounds. Types of reactions: substitution, addition, elimination, isomerization. Understanding of the mechanisms of reactions in organic chemistry. Homolytic and heterolytic rupture of a covalent bond. Free radical and ionic reactions. Nucleophiles and electrophiles. Mutual influence of atoms in molecules of organic substances: inductive and mesomeric effects.

15. Alkanes. Classification of hydrocarbons. Natural sources of hydrocarbons. A homologous series of alkanes. The general formula of alkanes. Electronic structure of methane molecule. Production of alkanes: hydrolysis of aluminum carbide, Würz synthesis, decarboxylation of carboxylic acid salts, hydrogenation of alkenes. Physical properties of alkanes. Chemical properties of alkanes: free radical substitution, dehydrogenation, dehydrocyclization (aromatization), cracking (pyrolysis), isomerization, nitration. The mechanism of radical substitution reactions on the example of methane and propane. Alkane oxidation: the formation of peroxide compounds, catalytic oxidation (formation of methane from methanol and formaldehyde), combustion. The use of alkanes. Methane conversion.

16. Unsaturated hydrocarbons. A homologous series of alkenes. The general formula of alkenes. Electronic structure of ethylene molecule. Methods for producing alkenes: dehydration of alcohols; dehydrohalogenation of halogen alkanes (Zaitsev rule); dehalogenation of dihaloalkanes; alkane dehydrogenation. Physical properties of alkenes. Chemical properties of alkenes: addition of halogens, hydrogen halides, hydration. The mechanism of electrophilic addition reactions. Markovnikov's rule. Addition of hydrogen. Oxidation of alkenes with potassium permanganate in a neutral medium (formation of diols) and in an acidic medium. The formation of ethylene oxide, its interaction with water. Polymerization. Polyethylene and polypropylene. Electronic structure of acetylene molecule: triple bond. Methods for the preparation of alkynes: dehydrohalogenation of dihaloalkanes; dehydrogenation of alkenes, interaction of acetylene with haloalkanes. Chemical properties of alkynes: electrophilic addition reactions. Features of hydration of acetylene and its homologues. Hydrogenation of alkynes, interaction of alkynes with bases (ammonia solution of silver oxide, sodium amide), oxidation of alkynes. Properties of acetylene: oxidation with potassium permanganate in a neutral medium; dimerization and trimerization. Alkadiens. Types of alkadiens (conjugated, isolated and cumulated double bonds). Production of butadiene from ethanol and butane. Preparation of alkadienes by dehydrohalogenation of dihaloalkanes.

17. Cyclic hydrocarbons. The structure of cycloalkanes. Methods for producing cycloalkanes: hydrogenation of benzene, dehalogenation of dihalogen derivatives, pyrolysis of salts of dicarboxylic acids. Chemical properties of small (C3 – C4) cycles: addition of hydrogen, halogens, hydrogen halides; and normal (C5 – C6) cycles: reactions of free radical substitution: halogenation, nitration. Aromatic hydrocarbons. Electronic structure of the benzene molecule. Condensed aromatic systems: naphthalene, anthracene, phenanthrene. Benzene homologues (toluene, xylenes, ethylbenzene, cumene). Methods for producing benzene and its homologues: dehydrogenation of cycloalkanes, dehydrocyclization of alkanes, alkylation of benzene with alkenes and haloalkanes; modification of würz synthesis, acetylene trimerization. Physical properties of aromatic hydrocarbons. Chemical properties of aromatic hydrocarbons: electrophilic substitution reactions (halogenation, nitration), addition reactions (hydrogenation, chlorination). The mechanism of electrophilic substitution reactions. The orienting action of the substituents in the benzene ring is: orientants I type (alkyl, halogen, $–NH_2$, –OH) and II type ($–CF_3$, $–NO_2$, –CH=O, –COOH). Features of the reactions of benzene homologues: substitution reactions with respect to the alkyl substituent, oxidation with potassium permanganate (formation of benzoic and terephthalic acids).

18. Alcohols and ethers. Classification of alcohols by the number of hydroxyl groups: monatomic, diatomic (ethylene glycol, etc.), triatomic (glycerol, etc.), polyatomic (sorbitol, etc.). Primary, secondary, tertiary alcohols. Methods for producing alcohols: hydrolysis of halogen-alkanes, hydration of alkenes, reduction of aldehydes and ketones, oxidation of alkenes (formation of glycols), fermentation of glucose. Hydrogen bonding. Physical properties of alcohols. Chemical properties of alcohols. Nucleophilic substitution: interaction with hydrogen halides (reaction mechanism). Intramolecular and intermolecular dehydration. The formation of esters with organic and inorganic acids. Hydrogenation of alcohols. Comparison of the effects of oxidizing agents on primary, secondary and tertiary alcohols. The reaction of dehydration – dehydrogenation of ethanol (production of butadiene). Features of the chemical properties of polyhydric alcohols (ethylene glycol, glycerin): complexation (with copper (II) hydroxide); the

formation of glycerol trinitrate. The use of alcohols. The structure of ethers. Production of ethers: intermolecular dehydration of alcohols, the interaction of alcoholates with halogen-alkanes.

19. Phenols. The structure of monatomic (phenol, cresol) and polyatomic (pyrocatechin, resorcinol, hydroquinone, pyrogallol) phenols. Electronic structure of the phenol molecule. Phenol production (from chlorobenzene). Physical properties of phenol. Chemical properties of phenol. Acidic properties of phenol: interaction with alkali metals and alkalis; interaction of phenolates with acids, with carbon dioxide in one solution. Electrophilic substitution reactions: bromination and nitration. Hydrogenation of the aromatic ring. Polycondensation of phenol with aldehydes. Qualitative reaction to phenols with iron (III) chloride.

20. Aldehydes and ketones. Electronic structure of the carbonyl group. Benzaldehyde. Methods for producing aldehydes: oxidation (dehydrogenation) of primary alcohols, hydration of acetylene, catalytic oxidation of ethylene. Methods for producing ketones: oxidation (dehydrogenation) of secondary alcohols, hydration of acetylene homologues, pyrolysis of calcium salts of carboxylic acids. Physical properties of aldehydes and ketones. Chemical properties of aldehydes: reduction to alcohols, oxidation to acids or salts of acids: silver mirror reaction, with copper (II) hydroxide when heated. Halogenation of aldehydes and ketones. The mechanism of nucleophilic addition reactions: the addition of water, hydrocyanic acid, sodium hydrosulfite, organomagnesium compounds. The use of aldehydes and ketones.

21. Carboxylic acids and their functional derivatives. Electronic structure of the carboxyl group. The structure of carboxylic acids: homologous series of formic acid (trivial names of acids C1-C7); dibasic acids (oxalic, malonic, succinic), acrylic, methacrylic, crotonic, vinyl acetic, citric, lactic, gluconic, benzoic, terephthalic, salicylic, acetylsalicylic acids. Methods of obtaining carboxylic acids: the oxidation of primary alcohols and aldehydes, the hydrolysis of carboxylic acid derivatives, the interaction of carbon monoxide (IV) with organomagnesium compounds, the oxidation of benzene homologues (for aromatic acids). Obtaining formic acid by the interaction of carbon monoxide (II) with sodium hydroxide and subsequent treatment with sulfuric acid. Getting acetic acid by the interaction of methanol with carbon monoxide (II). Physical properties of the most important acids. Chemical properties of carboxylic acids on the example of acetic acid. The mechanism of the esterification reaction. Reactions of carboxylic acids with phosphorus (III) chloride and thionyl chloride. Hydrocarbon acid reactions: addition for unsaturated acids; substitution for saturated acids (formation of chlorine derivatives of carboxylic acids). The structure of functional derivatives of carboxylic acids: anhydrides, acid chlorides, amides, esters. Nomenclature of esters (names of acid residues: formate, acetate, propionate). Obtaining anhydrides by the interaction of salts of carboxylic acids with acid chlorides, the preparation of esters by the interaction of alcohols with acid chlorides and anhydrides. Preparation of amides and nitriles by the action of ammonia on carboxylic acids, followed by hydration. Hydrolysis of nitriles. The use of carboxylic acids, their salts and esters.

22. Fats. The structure of fats. Acids of fats: palmitic, stearic, oleic, linoleic, linolenic. Physical properties of fats. Alkaline and acid hydrolysis of fats. Hydrogenation of fats containing residues of unsaturated acids. Transformation of fats in the body. The use of fat. synthetic detergents.

23. Carbohydrates. The structure of monosaccharides (glucose, fructose, galactose, ribose, deoxyribose). Linear and cyclic (α- and –β) forms of glucose. Physical and chemical properties

of glucose: oxidation (silver mirror reaction, with copper (II) hydroxide when heated), reduction, formation of a complex compound with copper (II) hydroxide. Fermentation reactions: alcoholic, lactic acid, butyric acid. The structure of disaccharides (sucrose, maltose, lactose). Hydrolysis of disaccharides. The structure of amylose and amylopectin (starch), dextrins, cellulose. Chemical properties of polysaccharides: hydrolysis; the formation of cellulose ethers (acetates, nitrates). High-quality reaction to starch with iodine. Synthesis of glucose and starch in plants. The transformation of carbohydrates in the body. The use of carbohydrates.

24. Amines. The structure of amines. Classification of amines: primary, secondary and tertiary; aliphatic and aromatic. Quaternary ammonium salts. Methods for producing amines: reacting haloalkanes with ammonia (primary amines) or amines (secondary, tertiary amines and tetraalkylammonium cations); restoration of nitro compounds. Physical properties of amines. Chemical properties of amines: basicity of amines (reactions with acids; with salts of metals, forming insoluble hydroxides). The dependence of the basicity of amines on their structure. The interaction of salts of amines with alkalis. Reactions of nucleophilic substitution: the interaction of amines with esters, acid chlorides, anhydrides (formation of amides). Features of the chemical properties of aniline (reaction with bromine water). Amines burning. The use of amines.

25. Amino acids. Proteins. The general formula of amino acids. Nomenclature, isomerism of amino acids (α-, β-, γ-amino acids). The structure of amino acids: glycine, alanine, valine, glutamic acid, lysine, serine, cysteine, phenylalanine, tyrosine. Optical isomerism on the example of alanine. Methods for obtaining amino acids: the interaction of α-chlorocarboxylic acids with ammonia; protein hydrolysis. Amphoteric properties of amino acids: interaction with acids and bases, the formation of an internal salt. The dependence of the amino acid ionization on the nature of the medium. The formation of peptides. Peptide (amide) bond. Proteins as high-molecular substances. Primary, secondary and tertiary structure of proteins. Globular and fibrillar proteins. Hydrolysis and denaturation of proteins (reversible and irreversible). Color protein reactions: xantoprotein, biuret, with lead acetate. The role of proteins in life.

26. Heterocyclic compounds. Nucleic acids. The structure of pyridine and pyrrole (aromaticity). Physical properties of pyridine and pyrrole. Chemical properties of pyridine: basic properties, nitration, hydrogenation (piperidine formation). Comparison of the acid-base properties of pyrrole with the properties of pyridine. The structure of pyrimidine and purine. The structure of nucleic bases (cytosine, uracil, thymine, adenine, guanine). Tautomerism of nucleic bases. The structure of nucleotides. Polynucleotides: the structure of DNA and RNA, the principle of complementarity. The role of polynucleotides in life.