

## EXPLANATORY NOTE

Chemistry –the natural science that studies the world around us , in other words, it studies matter and motion in their unbreakable unity, and a multi-faceted perspectives in all areas of scientific - technological progress.

Major technical advances (space technology, nuclear energy, microelectronics, computers, etc.) would be impossible without the use of new materials with special properties, created in chemistry.

Knowledge of chemistry is required for the productive creative activity of a contemporary expert in many fields: chemistry and chemical engineering, biology, medicine, physics, instrumentation and mechanical engineering, electrical and radio engineering , microelectronics, agriculture, construction and so on.

The course of chemistry for foreign citizens is one of the basic training courses in different fields: chemistry, health, biology, agriculture, physical education, physics as well as technical engineering and economic engineering.

The curriculum guide in chemistry for the students of higher educational establishments was concluded on the basis of the new curriculum guides in chemistry for the Ukrainian secondary schools and higher educational institutions of Ukraine.

The main goal of teaching "Chemistry" is to train foreign students to study at higher educational establishments of Ukraine . It is aimed to:

- 1) Fill the knowledge gaps of foreign students, caused by a mismatch in the national and Ukrainian curriculum guides in chemistry;
- 2) Shape modern ideas of the world from the scientific point of view, deepening the knowledge of phenomena and laws of chemistry that will be used while studying chemistry and other disciplines in higher educational institutions.
- 3) Teach foreign students chemical terminology in Ukrainian or Russian by revising the material, already familiar to them ;
- 4) Master the language of chemistry as a means of obtaining scientific information in an amount which provides:

- Free reading and understanding of text books in chemistry in Ukrainian (Russian) ;

-Listening to and summarizing lectures during the first year of studies of chemical disciplines in Ukrainian or Russian at higher educational institutions;

- Passing oral and written exams in chemistry in Ukrainian (Russian) .

While studying according to the curriculum guide, it is important to pay special attention to the basics of general chemistry: the basic laws of chemistry, the atomic- molecular theory, the structure of the atom, Mendeleev`s periodic table of chemical elements, Mendeleev`s periodic law , chemical bonding , the laws of chemical reactions , solutions and the theory of electrolytic dissociation, major classes of inorganic compounds, the Redox (reduction– oxidation) processes .

On the basis of modern theoretical principles and laws of chemistry we distinguish between inorganic and organic chemistry.

Depending on the level of knowledge of foreign students ( manifested through testing) and the timing of the beginning of studies ( depending on the arrival of foreigners) the succession of studying the questions, within the curriculum sections, may be varied by a teacher.

The curriculum guide envisages simple, manageable lab works that help to extend the theoretical material, to master practical skills and to conduct experiments.

The individual work of foreign students is an integral part of studying chemistry.

The curriculum guide provides the list of topics for the individual work of students under the guidance of a teacher.

It is recommended to combine the traditional means of studying with the usage of computers, textbooks and other facilities.

The final exam in chemistry is the entrance exam to the higher educational institutions of Ukraine .

## **The Content**

### **Section 1. General Chemistry**

#### **Theoretical basics of the course**

##### **1.1. Introduction**

Chemistry –the natural science about the world.

The subject of chemistry. Matter and motion.

Substance, its properties.

Physical and chemical phenomena. Chemical transformations .

The task of chemistry, its significance for the productive activity of people, modern technology , medicine , pharmacy, agriculture and construction.

##### **1.2. The atomic-molecular theory. The basic concepts and laws of chemistry**

The basics of the atomic -molecular theory . Atoms . Molecules . Chemical elements .

Relative atomic mass. Relative molecular mass.

Mole. Molar mass.

The law of conservation of mass. The equation of a chemical reaction.

The Law of equivalents.

The law of definite proportions (Proust's Law).

Gas laws. Avogadro's law . The molar volume of gas. Volumetric fraction.

Relative density of gases. Calculation of the relative molecular mass of a substance.

Chemical formula. Mass fraction of a substance. Calculations based on chemical formulas.

Calculations based on chemical equations .

##### **1.2. The structure of atoms and the periodic table of elements**

The electronic structure of atoms. Quantum- mechanical model of an atom. Quantum numbers .

Atomic orbitals. Types of atomic orbitals.

The Pauli principle . Hund's rules.

The sequence of electrons, filling atomic orbitals. The structure of multi-electron atoms.

The electronic structure of atoms and the periodic table of elements , s-, p-, d-, f- elements.

Mendeleev's periodic law and the periodic table of elements.

The energy of ionization . The electron affinity. Electronegativity .

The dependence of the chemical properties of the elements on the electronic structure of atoms.

The importance of Mendeleev`s periodic law.

#### **1.4. The Chemical bond**

The main types of chemical bonds and their interpretation through the method of valence bonds.

The covalent bond and its characteristics. The orientation of the covalent bond .

Hybridization of atomic orbitals. Types of hybridization and the spatial configuration of molecules

The polarity of the covalent bond. Polar and non-polar bonds. The polarity of molecules.

The Ionic bond.

Valency and the oxidation state .

#### **1.5. Intermolecular bond. The structure of matter**

The main types of interaction between molecules. The forces of intermolecular bonds .

The Hydrogen bond .

Physical states of matter .

Solids . Crystalline and amorphous states.

Lattice (atomic , molecular , ionic, metallic ).

The dependence of the properties of substances on the connection type between the particles in crystals.

#### **1.6. Major classes of inorganic compounds**

Classification of basic inorganic compounds.

Oxides , their chemical properties. The nomenclature of oxides , their composition , graphic representation of chemical formulas. Methods of production and basic chemical properties of oxides.

The properties of compounds  $E(OH)_x$ , depending on the chemical nature of the element E ( basic, acidic, amphoteric hydroxides ).

Bases. Nomenclature of bases, graphic representation of formulas. Acidity of bases. The remains of bases.

Alkali and the insoluble in water bases. Methods of production. Major chemical properties of bases.

Acids and their classification, based on composition ( oxygen-free , oxygen ). Nomenclature , graphic representation of formulas. Basicity of acids. Acidic residues. Methods of production of acids. The main chemical properties of acids.

Amphoteric hydroxides. Nomenclature. Methods of production. The main chemical properties of amphoteric hydroxides.

Salts. Classification, based on chemical properties and composition (neutral, acidic , basic ).

Nomenclature of salts. Graphic representation of formulas. Methods of salt production. The main chemical properties of salts.

The genetic bond between the main classes of inorganic compounds.

#### **1.7. Laws of chemical reactions**

Classification of chemical reactions on the basis of :

- Changes in the number of initial and final substances;
- Discharge or absorption of thermal energy ;
- Changes in the oxidation level.

#### **1.8. Solution**

##### **1.8.1. General characteristics of solutions**

The concept of solutions. The solvent and the soluble substance. The solubility . The dependence of the solubility of substances on different factors.

##### **1.8.2 . The solutions of electrolytes**

The theory of electrolytic dissociation. Strong and weak electrolytes. The degree of electrolytic dissociation.

The electrolytic dissociation constant.

Electrolytic dissociation of acids, bases , amphoteric hydroxides and salts. The step dissociation.

Electrolytic dissociation of water. Ionic product of water. pH("the power of hydrogen"). Indicators. Ionic processes. The ion exchange reactions in electrolyte solutions .

### **1.9. The Redox(reduction-oxidation) processes**

The degree of oxidation.

The processes of reduction and oxidation. The redox agents. The redox reactions. The method of electronic balance. The redox potentials. Direction of redox reactions.

### **1.10. Electrochemical processes**

The concept of electrode potentials. Standard electrode potentials. Electrochemical number of standard electrode potentials . The dependence of electrode potential on the concentration of ions in the solution.

Galvanic cell. The electromotive force of a galvanic cell .

Electrolysis. Anode oxidation and cathodic reduction. The sequence of electrode processes. Faraday's laws.

## **Section 2. Inorganic chemistry**

### **The properties of chemical elements and their compounds**

#### **2.1. General properties of metals**

General characteristics of metals. Their place in Mendeleev`s periodic table of elements. Production of metals. The physical properties of metals. The chemical properties of metals.

#### **2.2. s- elements**

##### **2.2.1. Elements of the I A group**

Position in the periodic table of elements and the structure of their atoms. General characteristics . Sodium, its production. Properties of sodium. The compounds of sodium. The uses of the sodium compounds.

Potassium, its properties and compounds ( oxides, hydroxides, salts). The uses of the potassium compounds. Potash fertilizer.

The biological function of the potassium and sodium compounds.

##### **2.2.2. Elements of the II A group**

Position in the periodic table of elements and the structure of their atoms. General characteristics .

Calcium in nature and its production. Physical and chemical properties. The calcium compounds and their uses ( oxide, hydroxide, carbonate, sulfate).

Temporary and permanent hardness of water . Means of its removal.

#### **2.3. p-elements**

##### **2.3.1. Elements of the III A group**

Position in the periodic table of elements and the structure of their atoms.

Aluminium. The natural compounds of aluminum and its production.

The properties of aluminum. The Aluminum compounds ( oxides, hydroxides, salts).

The uses of aluminum and its compounds.

#### **2.4. d- elements**

##### **2.4.1. Elements of the VI B group**

Position in the periodic table of elements and the structure of their atoms.

Chromium. Physical and chemical properties of chromium. The dependence of the chemical properties of oxides and hydroxides on the oxidation states of chromium .

The redox properties of chromium compounds . The uses of chromium and its compounds.

### **2.4.2. Elements of the VII B group**

Position in the periodic table of elements and the structure of their atoms.

Manganese . The chemical properties of oxides and hydroxides of various oxidation states of manganese. The redox properties of manganese compounds and their dependence on the solution surrounding.

### **2.4.3. Elements of the VIII B group**

Position in the periodic table of elements and the structure of their atoms.

Iron . Natural compounds of iron. Production of iron, steel and cast iron.

Oxides, hydroxides and salts of iron (II) and iron ( III). The uses of iron, its alloys and compounds.

## **2.5. General properties of non-metals. Hydrogen**

General characteristics of non-metals. The place of non-metals in the periodic table of elements. The structure of atoms of non-metals . Chemical activity of non-metals .

Hydrogen . The structure of its atom. Production of Hydrogen in laboratory and industry. Physical and chemical properties of hydrogen. The hydrides of metals .The renewable and oxidative properties of water. The uses of hydrogen.

## **2.6. p- elements**

### **2.6.1. Elements of the IV A group**

Position in the periodic table of elements and the structure of their atoms.

Carbon. Its presence in nature. Allotropy and the chemical properties of carbon (IV). Laboratory and industrial facilities of its production.

Coal (carbon ) acid and its salts. The carbon cycle in nature.

Protection of the environment from the products of combustion.

The natural compounds of silicon . Production of silicon, its properties. The silicon oxide (VI).

### **2.6.2 Elements of the V A group**

Position in the periodic system and the structure of their atoms (p- elements) .

Nitrogen, its presence in nature. Production of nitrogen, its physical and chemical properties. Ammonia.

Laboratory and industrial methods of producing ammonia. Physical and chemical properties of ammonia.

Ammonium salts. The oxides of Nitrogen, their production and properties. The Nitric acid, its physical and chemical properties. Salts of nitric acid. Production of nitric acid and its salts.

The nitrogen cycle in nature. Nitrogen fertilizer.

Phosphorus in nature, its production, allotropy . Chemical properties and the uses of phosphorus. The oxides of phosphorus (V), orthophosphoric acid, its properties and salts.

Phosphorus cycle in nature. Phosphate fertilizers.

### **2.6.3. Elements of the VI A group**

Position in the periodic table of elements and the structure of their atoms.

Oxygen. The presence of oxygen in nature. Production of oxygen in laboratory and industry. Physical and chemical properties of oxygen. Oxygen as oxidizer . Allotropy of oxygen ( ozone ) .

Sulfur. Its presence in nature, allotropy, physical and chemical properties. Hydrogen sulfide, its production and properties. The oxides of sulfur (IV), the oxides of sulfur (VI), orthophosphoric acid, its properties and production.

### **2.6.4. Elements of the VII A group**

The place of halogens in the periodic table of elements and the structure of their atoms. General characteristics of halogens. The presence of halogens in nature. Laboratory and industrial methods of producing halogens.

Chlorine . Hydrogen chloride and hydrochloric acid. The uses of hydrochloric acid.

The oxygen chlorine compounds (oxides , acids , salts ).

The uses of halogens.

## Section 3. Organic chemistry

### 3.1. The basics of Organic Chemistry

The subject of organic chemistry.

Butlerov`s theory of chemical structure of organic compounds .

Electronic structure of hydrocarbons bonds: types of hybridization,  $\sigma$ - and  $\pi$  - ties.

Classification of organic compounds. Functional groups.

Nomenclature of organic compounds.

### 3.2. Hydrocarbons

Classification of hydrocarbons.

Saturated hydrocarbons ( alkanes ). Methane, the tetrahedral structure of methane ,  $sp^3$ -hybridization.

Topological indices of alkanes, nomenclature, electronic structure, isomerism. Physical and chemical properties, production.

Unsaturated hydrocarbons. The structure of molecules ,  $sp^2$ - hybridization ,  $sp$ - hybridization,  $\sigma$ - and  $\pi$  - ties. Alkenes and alkynes , nomenclature, isomerism. Physical and chemical properties, production and uses.

Polymerization . The concept of polymers.

Alkadiene, their electronic structure and conjugated double bonds. The properties of divinyl and isoprene. Natural and synthetic caoutchouces.

Aromatic hydrocarbons. Benzene, electronic structure of benzene, isomerism. Physical and chemical properties, production and uses. The concept of benzene derivatives .

The interrelation between the homologous series of hydrocarbons. Natural sources of hydrocarbons. Oil, natural gas.

### 3.3. The oxygen-containing organic compounds

Alcohols . Homologous series of saturated monohydric alcohols.

Methanol and ethanol. Electronic Structure . Physical and chemical properties, production.

Polyhydric alcohols - ethylene glycol and glycerol.

Aromatic alcohols and phenols. Structure, properties and uses. The genetic interrelation between alcohol and carbohydrates.

Aldehydes and ketones. Homologous series of aldehydes. Formaldehyde and acetaldehyde, their structure, properties and uses. Polycondensation reaction .

Carboxylic acids. Homologous series of saturated aliphatic monocarboxylic acids. The acids: formic and acetic acid , their structure , properties, production and uses.

Unsaturated aliphatic monocarboxylic acids . The genetic interrelation between hydrocarbons.

Alcohols, aldehydes and acids.

Esters . Reactions of esterification . Hydrolysis of esters.

Fats . Carbohydrates . Monosaccharides. Disaccharides . Glucose , sucrose. Structure, properties and uses.

Polysaccharides . Starch, cellulose.

### 3.4. The Nitrogen-containing organic compounds

Nitro compounds . The general formula . Structure . Classification and nomenclature. Production and properties.

Amines , their structure, isomerism , classification. Production and chemical properties.

Amino Acids . Classification and nomenclature. Production and chemical properties.

The Nitrogen-containing heterocyclic compounds.

Proteins , their classification, structure and importance. Nucleic acid.

### **The List of recommended laboratory works**

1. The basic techniques of work in a chemical laboratory. Chemical apparatus and equipment. Safety measures.
2. Classes of inorganic compounds. Production and chemical properties of oxides.
3. The chemical properties of bases, acids, amphoteric hydroxides.
4. Salts. Production and chemical properties.
5. The rate of chemical reactions.
6. Preparation of solutions with a given concentration of solute.
7. Ionic processes in solutions of electrolytes.
8. Hydrolysis of salts.
9. The redox (reduction -oxidation) reactions .
10. Renewing properties of metals.
11. Electrochemical processes. Galvanic cell.
12. Electrolysis of salt solutions.
13. Chemical properties of alkali metals and their compounds.
14. The properties of the compounds of magnesium and calcium; the hardness of water.
15. Production and properties of oxygen.
16. The chemical properties of saturated and unsaturated carbohydrates.
17. The properties of the oxygen-containing organic compounds. Alcohols . Aldehydes . Carboxylic acids.

### **The list of recommended topics for individual work of foreign students under the guidance of the teacher**

1. The structure of matter ( atomic structure, the periodic system of elements , chemical bond ).
2. The laws of chemical processes (energy of chemical reactions) .
3. Solution. Electrolytic dissociation.
4. The redox (reduction -oxidation) reactions.