Ministry of Education and Science of Ukraine

CHEMISTRY

Curriculum for comprehensive schools

Grades 10-11

Standard level

Grade 10
52 hours, 1.5 hours per week

Expected learning and cognitive outcomes of students	Content of the study material	Practical part
Review of the basic concepts of organic substances		
Student: **The knowledgeable component** ***names*** the ten members of the homologous series of alkanes (CH4 - C10H22); understands the composition of substances as hydrocarbons, oxygens and nitrogens. **The activity component** ***makes up*** molecular, structural and semi-structural formulas for methane and its nine homologues (C2H6 - C10H22), ethane, ethane, methanol, ethanol, glycerol, ethanoic acid and aminoethanoic acid equation of reactions: combustion (total oxidation) of hydrocarbons; substitution for methane (chlorination); addition for ethane and ethane (halogenation, hydrogenation); describing the chemical properties of ethanoic acid (interaction with indicators, metals, alkalis, salts in terms of electrolytic dissociation).	Composition, properties, applications of individual hydrocarbons (methane, ethane, ethane, ethane), oxygens (methanol, ethanol, glycerol, ethanoic acid) and nitrogens (aminoethanoic acid) organic substances.	
Topic 1: Theory of the structure of organic compounds		
Student: **The knowledgeable component** ***explains*** the essence of the phenomenon of isomerism; the dependence of the properties of substances on the composition and structure of their molecules on the basis of the theory of structure of organic compounds; gives examples of organic compounds with simple, double, triple carbon-carbon bonds. **The activity component** ***differentiates*** organic compounds according to their qualitative composition: hydrocarbons, oxy- and nitrogen-containing substances; simple, double, triple	The theory of structure of organic compounds. Dependence of the properties of substances on the composition and chemical structure of molecules. The concept of the phenomenon of isomers and isomers. Covalent carbon-carbon bonds in molecules of organic compounds: simple, double, triple. Classification of organic compounds.	***Task for calculation*** 1. Deriving the molecular formula of a substance by mass fractions of elements. ***Showcases*** 1. Models of molecules of organic compounds (including 3D design). 2. Models of isomer molecules (including 3D design). ***Study projects*** 1. Isomers in nature. 2. History of creation and development of the theory of

carbon-carbon bonds; characterises the essence of the theory of structure of organic compounds;solves molecular formula problems based on the mass fractions of elements, justifying the chosen solution.		structure of organic compounds. 3. 3D models of molecules of organic compounds.
Topic 2: Hydrocarbons		
Student: **The knowledgeable component** ***names*** alkanes, alkenes and alkynes according to systematic nomenclature; general formulas of alkanes, alkenes, alkynes; physical properties of benzenes; ***explains*** the nature of structural isomers of hydrocarbons; ***recognises*** the structural isomers of a given substance; ***gives*** examples of saturated saturated, unsaturated and aromatic hydrocarbons; structural formulas of isomers of alkanes, alkenes and alkynes. **The activity component** ***differentiates*** between hydrocarbons of different homologous series; ***draws up*** molecular formulas of hydrocarbons from a given homologous series; molecular and structural formulae of benzene; Structural formulas of alkanes, alkenes and alkynes; structural formulas of isomers of alkanes, alkenes and alkynes from the molecular formula of the compound equation of reactions describing chemical properties of alkanes (thermal decomposition, isomerisation, halogenation), ethene and ethine (partial oxidation, accession of halogen hydrocarbons, hydration), benzene (combustion, halogenation, hydrogenation), making alkanes (hydrogenation of alkenes, dehydrogenation of ethane), ethane (dehydrogenation of ethane, ethane, hydrolysis of calcium acetylene), benzene (from ethane, dehydrogenation of n-hexane); ***classifies*** hydrocarbons of different homologous series***, compares*** their structure and properties; ***characterises*** the chemical properties of alkanes, ethene and ethine, benzenes and the ways in which they are obtained;	Classification of hydrocarbons. **Alkanes**. Social formula of alkanes, structural isomerism, systematic nomenclature. Chemical properties of alkanes. **Alkenes and alkynes**. General and molecular formulas of alkenes and alkynes, structural isomerism, systematic nomenclature. Chemical properties of ethene and ethine. **Arens**. Benzenes: molecular and structural formula, physical properties. Chemical characteristics of benzenes. Methods for the preparation of alkanes, ethene, ethine, benzenes. Application of hydrocarbons.	***Task for calculation*** 2. Deriving the molecular formula of a substance from the general formula of the homological series and the density or relative density. 3. Deriving the molecular formula of a substance from the mass, volume or amount of substance of the reactants or reaction products. ***Showcases*** 3. Saturated hydrocarbons in relation to alkalis, acids . ***Study projects*** 4. Octane number and quality of gasoline. 5. Cetane number of diesel fuel. 6. Aromatic compounds around us. 7. Smog as a chemical phenomenon. 8. Coking of coal: products and their use. 9. Biogas. 10. Environmental impact of hydrocarbons and their derivatives.

establishes links between the composition, structure, properties, storage, transport and use of hydrocarbons and their effects on the environment; interrelationships between homologous series of hydrocarbons; observes the rules of safe handling of hydrocarbons and their derivatives at home; ***solves problems*** deduce the molecular formula of a substance using the general formula of a homological series and the density or relative density mass, volume or quantity of a substance of reagents or reaction products, justifying the chosen method of solution.		
Topic 3. Oxygen-containing organic compounds		
Student: **The knowledgeable component** ***names*** general formulas and characteristic (functional) groups of alcohols, aldehydes, carboxylic acids, esters; according to the systematic nomenclature of alcohols, aldehydes, saturated mono-basic carboxylic acids, esters; ***explains*** influence of the characteristic (functional) group on physical and chemical properties of oxigen-containing organic compounds; the influence of a hydrogen bond on the physical properties of oxygene-containing organic compounds; ***gives examples of*** alcohols, aldehydes, enriched mono-basic carboxylic acids, esters, fats, carbohydrates and their trivial names; expansion of oxigenic organic spores in nature and foodstuffs. ***The activity component*** ***differentiates*** Non- saturated and saturated fats; Mono-, di-, polysaccharides; natural arithmetic reactions; classifies the oxigenic organic compounds into characteristic groups;	**Alcohols.** Concept of a characteristic (functional) group. Hydroxyl characteristic (functional) group. Saturated monatomic alcohols: general and structural formula, isomerism (propanols and butanols), systematic nomenclature. Hydrogen bonding, its influence on physical properties of alcohols. Chemical properties of saturated monatomic alcohols. Obtaining ethanol. Concept of polyatomic alcohols using glycerol as an example, its chemical properties. **Phenol:** composition and structure of the molecule, physical and chemical properties. **Aldehydes.** Composition, structure of aldehyde molecules. Aldehyde characteristic (functional) group. General and structural formulas,	***Task for calculation*** 4. Calculating from chemical equations the amount of substance, mass or volume from the amount of substance, mass or volume of a reagent containing a certain proportion of impurities. ***Showcases*** 4. Oxidation of ethanol to ethanol. 5. Oxidation of methanol (ethanol) with ammonia oxide (I) solution (virtual). 6. Oxidation of methanol (ethanol) with freshly obtained cuprum (II) hydroxide (virtual). 7. Acquaintance with samples of esters. 8. Relation of fats to water and organic solvents.

compiles molecular and structural forms of alcohols, phenols, aldehydes, esters, fats, carbohydrates (names and general formulas of corresponding homologous series); ration of reactions that describe the chemical properties of enriched monatomic alcohols (total and partial oxidation, dehydration, interaction with base metals, hydrogen halogens), glycerol (total oxidation, interrelationship with base metals), phenol (interrelationship with base metals, compounds, bromine water), ethanol (partial oxidation and reoxidation), mono-basic carboxylic acids (interrelationship with indicators, metals, compounds, salts, The main properties of the synthesis process are hydrolysis, organic (hydrogen bonding), fat (hydrogenation and liquefaction), glucose (partial oxidation, hydration, alcoholic and lactic acid fermentation), saccharose, starch and cellulose (molecular equation of hydrolysis), Production of ethanol (hydration of ethane, fermentation of glucose), ethanol (hydration of ethane, oxidation of ethanol), ethanoic acid (oxidation of ethanol, ethanol), photosynthesis, production of sucrose, starch and cellulose in nature; ***compares*** the structure and properties of compounds with different characteristic groups, monatomic alcohols and phenol, starch and cellulose; chemical properties of saturated single-base carboxylic and inorganic acids; properties of natural and artificial fibres; ***characterises*** chemical properties of single-atom saturated alcohols, ethanol, saturated single-base carboxylic acids, esters, fats, carbohydrates methods of producing ethanol, ethanol, ethanoic acid, glucose, sucrose, starch and cellulose; predicts chemical properties of oxigen-containing organic compounds on the basis of knowledge about the properties of characteristic (functional) groups; ***identifies*** cause-effect relations between the composition, structure, properties, application and environmental impact of oxygene-containing organic compounds genetic relations between oxygene-containing organic compounds;	systematic nomenclature and physical properties of aldehydes. Chemical properties of ethanal, its preparation. **Carboxylic acids,** their distribution in nature and classification. Carboxylic characteristic group. Composition, molecular structure of saturated mono-basic carboxylic acids, their general and structural formulas, isomerism, systematic nomenclature and physical properties. Chemical properties of saturated mono-basic carboxylic acids. The esterification reaction. Preparation of ethanoic acid. **Esters,** general and structural formulas, systematic nomenclature, physical properties. Hydrolysis of esters. Fats as representatives of esters. Classification of fats, their chemical properties. **Carbohydrates.** Classification of carbohydrates, their formation and distribution in nature. Glucose: molecular formula and open form. Chemical properties of glucose. Sucrose, starch and cellulose: molecular formulas, hydrolysis.	9. Proof of the unsaturated nature of liquid fats (virtual). 10. Oxidation of glucose by ammonia solution of argentum(I) oxide (in the absence of reagents - virtually). ***Laboratory experiments*** 1. Identification of organic acids in foodstuffs. 2. Oxidation of glucose with freshly obtained cuprum (II) hydroxide. ***Practical works*** *1*. Solving experimental problems. ***Study projects*** 11. Environmental safety in the use and production of phenol. 12. Detection of phenol in green tea extract or gouache. 13. Carbohydrates in foodstuffs: detection and biological significance. 14. Âèðîáíèöòâî öóêðó. 15. Natural fibres of plant origin: their characteristics, effect on the human body, application. 16. Artificial fibres: their application in the home and industry. 17. Esters and esters in cosmetics. 18. Biodiesel fuels.

identifies the presence of aldehydes, carboxylic acids, glucose; ***observes*** the rules of safe handling of organic substances; ***calculates*** from chemical equations the quantity of a substance, mass or volume by the quantity of a substance, mass or volume of a reagent containing a certain proportion of impurities, justifying the chosen method of solution; ***solves*** experimental problems, justifying the chosen solution.		
Topic 4: Nitrogen-containing organic compounds		
Student: **The knowledgeable component** ***names*** common formulas and characteristic (functional) groups of amines and amino acids; ***explains*** structural formulas of amines and amino acids; amino acid amphoterism; the terms: characteristic (functional) amino group, peptide group, polypeptide ***gives examples*** of amines, amino acids, proteins. **The activity component** ***distinguishes*** between saturated and aromatic amines; ***draws up*** molecular and structural formulas of amines and amino acids according to names and general formulas; equation of reactions describing the chemical properties of methanamine (combustion, interaction with water and chloride acid), aniline (interaction with chloride acid, bromine water), aminoethanoic acid (interaction with sodium hydroxide, chloride acid, formation of dipeptide.) ***classifies*** nitrogen-containing organic compounds according to characteristic (functional) groups; ***predicts*** chemical properties of amino acids caused by peculiarities of their molecular structure; ***characterises*** chemical properties of methanomine, aniline, aminoethanoic acid and proteins (hydrolysis, colour reactions)	**Saturated and aromatic amines:** composition and structure of molecules, names of the simplest compounds. Structure of the amino group. Amines as organic bases. Chemical properties of methanomine, aniline. The preparation of aniline. **Amino acids:** composition and structure of molecules, general and structural formulae, characteristic (functional) groups, systematic nomenclature. Peptide group. Chemical properties of aminoethanoic acid. Peptides. Proteins as high molecular weight compounds. Chemical characteristics of proteins (without recording reaction equations).	***Showcases*** 11. Interaction of aniline with chloride acid (virtual). 12. Interaction of aniline with bromine water (virtual) ***Laboratory experiments*** 3. Biuret reaction. 4. Xanthoprotein reaction. ***Study projects*** 19. Natural fibres of animal origin: their characteristics, effect on the human body, application. 20. Aniline - the basis for the production of dyes. 21. Protein synthesis. 22. Balanced nutrition for a healthy life. 23. Removing stains of organic origin.

biological role of amino acids, proteins; ***establishes*** cause-effect relationships between the composition, structure, properties of nitrogen-containing organic compounds; ***observes*** the rules of safe handling of organic substances.		
Topic 5. Synthetic high molecular weight substances and polymeric materials based on them		
Student: **The knowledgeable component** ***explains*** the essence of the concept of a polymer; polymerisation and polycondensation reactions as ways of extracting polymers; ***gives examples of*** synthetic high-molecular weight substances and polymeric materials based on them; equations of polymerisation and polycondensation reactions; and **The activity component** ***differentiates*** between polymerisation and polycondensation reactions; plastics, rubbers, rubber and synthetic fibres ***describes*** the properties of polymeric materials; ***compares*** natural, man-made and synthetic fibres and plastics ***establishes*** cause-and-effect relationships between the composition, structure, properties and application of polymers ***observes*** the rules of safe handling of synthetic materials.	Synthetic high molecular weight substances. Polymers. Polymerisation and polycondensation reactions Plastics. Rubber, rubber. The most common polymers and their applications. Impact of polymer materials on human health and environment. Challenges of recycling polymers and plastics in the context of sustainable development of society. Synthetic fibres: physical properties and applications.	***Showcases*** 13. Samples of plastics, rubbers, rubber, synthetic fibres . ***Study projects*** 24. Synthetic fibres: their significance, domestic and industrial applications. 25. Recycling as the only civilised way to dispose of municipal solid waste. 26. Recycling of domestic waste in Ukraine and the developed countries of the world. 27. Prospects of production and application of polymers with predetermined properties. 28. Research of labeling of products made of polymeric materials and plastics. 29. Fabrication of products from plastic bottles.
Topic 6: Diversity and relationships between classes of organic substances		
Student: **The knowledgeable component** **explains** the reasons for the diversity of organic substances; **gives examples of** homologues and isomers; compounds with simple and multiple bonds;	Links between classes of organic substances. General concepts of biologically active substances (vitamins, enzymes).	***Study projects*** 30. The most important organic chemistry industries in Ukraine. 31. Feasibility and harmfulness of biologically active additives.

compounds with different characteristic (functional) groups; natural and synthetic biologically active compounds. **The activity component** **differentiates** organic compounds by their homologous series; **makes** equations of reactions characterising the genetic relationships of organic compounds; **investigates** the presence of organic acids in foodstuffs by means of indicators; **establishes** links between classes of organic compounds; **uses knowledge** about organic compounds to explain their diversity; **observes** the rules of safe handling of organic substances.	The role of organic chemistry in solving the problems of raw materials, energy, food, creation of new materials.	

Grade 11

70 hours, 2 hour per week

Expected learning and cognitive outcomes of students	Content of the study material	Practical part
1. The periodic law and the periodic system of chemical elements		
Student: **The knowledgeable component** ***names*** the s-, p-, d-elements according to their place in the periodic system; explains the valence and oxidation states of elements of periods 2 and 3 in the ground and excited states of atoms; ***gives examples*** of s-, p-, d-elements. **The activity component** ***makes up*** electronic and graphical electronic formulas for atoms of s-, p-, d-elements (ferum) of periods 1-4, taking into account the principle of "minimal energy"; atoms of non-metallic elements of periods 2 and 3 in ground and excited states; ***analyses*** differences in electronic configurations of atoms of s-, p-, d-elements (ferum) of periods 1-4; ***compares*** possible degrees of oxidation of non-metallic elements 2 and 3 being in one group of periods on the basis of electronic structure of their atoms.	The phenomenon of periodic change in the properties of elements and their compounds based on ideas about the electronic structure of atoms. Electronic and graphical electronic formulas of atoms of s-, p-, d-elements. The principle of "minimum energy". Excited state of the atom. Valence states of elements. Possible oxidation states of non-metallic elements of periods 2 and 3.	***Showcases*** 1. Different variants of the periodic system of chemical elements (long and short forms, virtual 3D). 2. Shapes of electron orbitals (including 3D projection). 3. Models of atoms of s-, p-, d-elements (including 3D projection). ***Study projects*** 1. Creating 3D models of atoms of the elements. 2. Application of radionuclides in medicine. 3. Use of radioactive isotopes as indicators in animal husbandry, archaeology.
Topic 2: Chemical bond and substance structure		
Student: **The knowledgeable component** ***identifies*** the types of chemical bonds in substances by their formulas; ***gives examples of*** substances with different types of chemical bonding; amorphous and crystalline substances. **The activity component** ***explains the differences*** in the mechanisms of covalent bonding in the ammonia molecule and the ammonium ion; between amorphous and crystalline substances; ***predicts*** the physical properties of substances based on their structure and the construction of substances based on their physical properties.	Ionic, covalent, metallic, hydrogen chemical bonding. Donor-acceptor mechanism of covalent bonding (using ammonium cation as an example). Crystalline and amorphous states of solids. The dependence of physical parameters of substances on their structure.	***Showcases*** 4. Models of different types of crystal lattice (including 3D design). 5. Formation of ammonium chloride from ammonia and hydrogen chloride. 6. Samples of crystalline and amorphous substances. ***Study projects*** 4. The use of liquid crystals. 5. The use of substances with different types of chemical bonds

		in engineering. 6. The significance of hydrogen bonding for organization of biopolymer structures.
Topic 3: Chemical reactions		
Student: **The knowledgeable component** ***explains*** the influence of different factors on the shift in chemical equilibrium, on the hydrolysis of salts; the principle of the galvanic cell; ***gives examples*** of irreversible and reversible chemical reactions. **The activity component** ***makes*** an equation for salt hydrolysis reactions; ***differentiates*** between irreversible and reversible chemical reactions; ***characterises*** the essence of chemical equilibrium, the hydrolysis of salts; predicts the possibility of a hydrolysis reaction of salts; the pH of aqueous salt solutions; ***chooses*** the conditions for shifting the chemical equilibrium of reversible ***processes*** on the basis of Le Chatelier's principle; ***observes*** safety rules when performing chemical experiments; ***experimentally determines*** pH of aqueous salt solutions using indicators; ***calculates*** the relative yield of the reaction product using chemical equations, justifying the chosen method of solution.	Irreversible and reversible chemical processes. Chemical equilibrium. Le Chatelier principle. Hydrolysis of salts. The concept of a galvanic cell as a chemical source of electric current.	***Task for calculation*** 1. Calculate from chemical equations the relative yield of the reaction product. ***Laboratory experiments*** 1 Determination of the pH of aqueous salt solutions using indicators.. ***Study projects*** 7. Galvanic cell from potato, lemon. 8. Types and principles of operation of small electric current sources, their utilisation.
Topic 4: Inorganic substances and properties		
Student: **The knowledgeable component** ***names*** The most common metallic and non-metallic elements in nature; representatives of classes of inorganic compounds according to systematic nomenclature;	Non-metals. General characteristics of non-metals. Physical characteristics. Alotropy. Alotropic modifications of substances of non-metallic elements. The phenomenon of adsorption.	***Task for calculation*** 2. Calculating the amount of substance, mass or volume of a reaction product from a chemical equation if one of the reactants is taken in excess.

explains the essence of the phenomenon of allotropy; differences in the properties of allotropic modifications of Oxigen, Sulphur, Carbon, Phosphorus by their quantitative composition or structure; the essence of the phenomenon of adsorption; anthropogenic and natural preconditions for the occurrence of oxides of non-metallic parts in the atmosphere; ***gives examples of*** allotropic modifications of Oxygen, Sulphur, Carbon, Phosphorus; compounds of non-metallic elements with hydrogen (hydrogen chloride, hydrogen sulphide, ammonia); interrelationships between substances **The activity component** ***makes up*** equations confirming the reducing properties of metals, in particular aluminium and iron (reactions with non-metals, water, acids and salts in solutions) oxidising properties of non-metals (oxygen, sulphur, carbon, chlorine) in reactions with hydrogen and metals; reduction properties of hydrogen and carbon in reactions with oxides of metal elements; reactions characterizing peculiarities of aqueous solutions of hydrogen chloride (with bases), hydrogen sulphide (with alkalis), ammonia (with acids); reactions characterising the chemical properties and production of basic, acidic and amphoteric oxides; acids, bases, amphoteric hydroxides (aluminium and zinc), and intermediate and acidic salts reactions of nitrate and concentrated sulphate acid with magnesium, zinc, copper; ***characterises*** metals and non-metals, their physical properties and applications (including metal alloys); applications of hydrogen chloride, hydrogen sulphide, ammonia; physical and chemical properties (interaction with magnesium, zinc, copper) of nitrate and concentrated sulphate acid;	Oxidising and reducing properties of non-metals. Applications of non-metals. Compounds of non-metallic elements with hydrogen. Features of aqueous solutions of these compounds and their applications. Oxides of non-metallic parts, their content in the atmosphere. Acids. Acid rain. Peculiarities of interaction of metals with nitrate and concentrated sulphate acids. The social trait of metals. Physical properties of metals based on their structure. Aluminium and iron: Physical and chemical properties. Applications of metals and alloys. Basics. Application properties of Sodium and Calcium hydroxides. Salts, their distribution in nature. Medium and acid salts. Concept of water hardness and methods of its elimination. Modern silicate materials. Mineral fertilizers. The concept of acidic and alkaline soils. Qualitative reactions to certain ions. Biological significance of metallic and non-metallic elements. Genetic relationships between the main classes of inorganic compounds.	***Showcases*** 7. Samples of metals and alloys. 8. Samples of non-metals. 9. Crystalline lattice models of allotropic modifications of Carbon and Sulphur (including 3D design). 10. Detection of Ferum(2+) (virtual), Ferum(3+) (virtual), Barium, Ammonium cations in solution. ***Laboratory experiments*** 2. investigating the adsorption capacity of activated carbons and similar drugs. 3-6. Detection of Ferum(2+), Ferum(3+), Barium, Ammonium cations in solution. 7, 8. Detection of silicate and orthophosphate ions in solutions. ***Practical work*** 1. Examining the qualitative composition of the salts. 2. Genetic relationships between inorganic substances. ***Study projects*** 7. Artificial diamonds in engineering. 8. Rational use of fertilisers and the problem of environmental protection. 9. 9. Prevention of adverse effects of nitrates on the human body. 10. Inorganic substances in pharmacy (or home medicine

application of sodium and calcium hydroxides; distribution of salts in nature; *makes a research* plan and experimentally establishes the genetic relationships between inorganic and organic substances ***compares*** the physical and chemical properties of metals (aluminium and iron) and non-metals, and of oxides of metallic and non-metallic elements;; features of aqueous solutions of hydrogen chloride, hydrogen sulphide, ammonia; bases (sodium and calcium hydroxides); ***analyzes*** and interprets the results of investigations; ***predicts*** the pH of acidic and alkaline soils; ***establishes*** genetic relationships between the main classes of inorganic compounds; ***conducts*** qualitative reactions and determines ions in solutions: Ferum(2+), Ferum(3+), precipitating alkali, Barium, ammonium, silicate- and orthophosphate- ions ***investigates*** qualitative composition of the salts; the adsorption capacity of activated carbon and similar preparations; ***analyses*** types of water hardness and suggests safe ways of eliminating water hardness in the home; ***observes*** safety rules when performing chemical experiments; ***calculates*** the quantity of a substance, mass or volume of a product using a chemical reaction equation if one of the reagents is taken in excess, justifying the chosen method of solution.		cabinet) and food industry. 11. Acid rain. 12. Researching the pH of the soils in their area. Fertility mapping. 13. Properties and application of carbonates, nitrates and orthophosphates of alkali and alkaline earth metal elements, ammonium salts. 14. Elimination of temporary and permanent water hardness.
Topic 5: Chemistry and human progress		
Student: **The knowledgeable component** ***gives examples*** of the use of chemical compounds in various industries and in everyday life.	The role of chemistry in creating new materials, developing new areas of technology, solving food, raw material, energy and environmental problems.	***Study projects*** 15. Solution of the problem of disposal of different types of electric lamps.

	"Green chemistry: current challenges for chemical science and chemical technology.	16. Preparation of an essay in foreign language "The role of chemistry in my life".