Ministry of Health of Russian Federation
Federal State Autonomous Educational Institution of Higher Education «N.I. Pirogov Russian National Research Medical University»

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The program of entry test in chemistry

Moscow 2021

The program of entry test

1. Theoretical chemistry

1.1. Basic concepts and laws. Chemistry science. Basic concepts of the atomic-molecular theory

Relative atomic and relative molecular masses. Amount of substance. Mole. Avogadro's Law and its consequences. The molar gas volume. STP (Standard conditions for temperature and pressure, Avogadro's hypothesis). Absolute and relative gas density. Reacting gas volume ratio.

1.2. Atomic structure. Mendeleev's periodic law. Chemical bonding

Atom. Atomic structures. Nucleus and nucleons. Nuclides and isotopes. Electron. The structure of atomic shell. Electron shells and sub-shells (energy levels and sublevels), orbitals. Electronic configuration of atoms. Valence electrons. Basic and excited states of atom.

Basic concepts of filling the orbitals, *s*-, *p*-, *d*- elements.

The periodic law. The periodic grouping. Periods, groups and subgroups in the periodic table. Classification of elements and their compounds according to their position in the periodic table.

Molecules and chemical bonding. Covalent bonds, their classsification and formation. Covalent bonds' characteristics. Electronegativity. Oxidation number and valency. Ionic bonding. Metalic bonding. Hydrogen bonding. Molecular and nonmolecular substances.

1.3. Physical and chemical patterns of chemical reactions

Classification of chemical reactions in inorganic and organic chemistry by different features: changes in the oxidation state; the number and composition of reagents and products; the type of bond breakage; the thermal effects; the reversibility.

Energy changes in chemical reactions. The thermal effect. Thermochemical equations of chemical reactions.

The reaction rate. Homogeneous and heterogeneous reactions. The dependence of the reaction rate on different factors. The reversibility. Chemical eqilibrium. The equilibrium constant. Equilibrium shifts. Le Chatelier's principle.

1.4. Solutions

Classification and formation of solutions. Pure substances and mixtures. Methods of expressing the composition of a solution: the mass fraction of the dissolved substance. Solutions of electrolytes.The theory of electrolytic dissociation. Mechanism of electrolytic dissociation of substances with ionic and polar covaent bonds. Dissociation of acids, bases and salts. Weak and strong elecrolytes.

Chemical properties of acids, bases and salts according to the theory of electrolytic dissociation.

Ion-exchange reactions in water solution of electrolyte, conditions of their reversibility. Acid-base reactions in solutions. Amphoterism.

1.5. Redox reactions

Oxidation state (number). Commom oxidizing and reducing agents. Balancing oxidation-reduction equations.

Redox reactions in solutions. Electrolysis of solutions and melts.

2. Elemental chemistry

2.1. Classification of inorganic compounds

Oxides, classification of oxides. Methods of the preparation of oxides. Physical and chemical properties of oxides. Nomenclature of oxides.

Bases, classification of bases. Methods of the preparation of bases. Chemical properies. Amphoteric hydroxides. Nomenclature of bases.

Acids, classification of acids. Methods of the preparation of acids. Physical and chemical properties. Nomenclature of acids.

Salts, classification of salts. Methods of the preparation of salts. Chemical properties. Nomenclature of salts. Hydrolysis of salts.

2.2. Metals. General characteristics

The position of metals in th periodic table. Features of the electronic structure of metals. General characteristics of metals of main and secondary groups of the periodic table of elements, their oxides and hydroxides: their acid-base and oxidation-reduction properties. General methods of production of metals.

2.2.1. Metals of 1 and 2 groups. (The *s*-metals)

Atomic structure. Physical properties. Chemical properties: reactions with nonmetals (halogens, oxygen, sulfur, nitrogen, phosphorus, carbon and hydrogen), water, solutions of acids. Compounds of alkali and alkaline earth metals: oxides, peroxides, hydroxides, hydrites, nitrides, phosphides and carbides and their chemical properties.

2.2.2. Aluminium (Alumnum)

Atomic structure. Physical properties. Chemical properties: reaction with nonmetals(halogens, oxygen, sulfur, nitrogen and carbon), oxides, dilute and concentrated acids (hydrochloric, sulfuric and nitric acids), solutions of alkalis and carbonates of alkali metals, water. Aluminium oxide and hydroxide, their amphoteric properties.

2.2.3. Transition metals (*d*-block elements)

Features of their atomic structures. General characteristics of d-block elements.

2.2.4. Iron

Atomic structure. Characteristic ions and oxidation numbers of iron. Physical properties. Chemial properties: reactions with nonmetals (halogens, oxygen, sulfur), dilute and concentrated acids (hydrochloric, sulfuric and nitric acids). Iron oxide and hydroxide(II), their reducing properties. Iron oxide and hydroxide(III), their amphoteric properties.

2.2.5. Manganese

Atomic structure. Characteristic ions, oxidation numbers and relative oxides, hydroxides and salts. Reactions with acids. Changes in acid-base and oxidation-reduction properties of manganese according to its oxidation number. Manganese oxide(IV), its oxidizing properties in acidic media. Manganates and permanganates, their oxidizing properties.

2.2.6. Chromium

Atomic structure. Characteristic ions, oxidation numbers and relative oxides, hydroxides and

salt. Reactions with acids. Changes in acid-base and oxidation-reduction properties of chromium compounds according to their oxidation number. Chromium oxide and hydroxide (III), their amphoteric preperties. Chromates and dichromates, their interconversion depending on the media. Oxidizing properties of chromium compounds(VI).

2.2.7. Zinc

Atomic structure. Chemical properties: reactions with nonmetals (halogens, oxygen, sulfur), water, dilute and concentrated acids (hydrochloric, sulfuric, nitric), alkalis. Zinc oxide and hydroxide, their amphoteric properties.

2.2.8. Copper and silver

Atomic structure. Characteric oxidation numbers. Chemical properties: reactions with nonmetals (halogens, oxygen, sulfur), acids.

2.3. Nonmetals

The position of nonmetals in the periodic table of elements.

2.3.1. Hydrogen

Hydrogen isotopes. Hydrogen compound with metals and nonmetals. Production of hydrogen.

2.3.2. Group 7 (17). The halogens

Atomic structures. Molecular structures. Physical properties of halogens. Chemical properties: reactions with hydrogen, metls, nonmetals (S, C, Si, P), compounds (acids, salts, alkalis, organic compounds).

Hydrogen halides. Molecular structures. Hydrogen bond in hydrogen flouride. Physical properties. Comparison of strength of hydrohalic acids. Chemical properties: general properties of hydrohalic acids, reducing properties, the reaction between hydrofluoric acid and silicon(IV) oxide. Oxygen compounds of chlorine.

2.3.3. Group 6 (16). The chalcogens

Atomic structure. Physical properties, allotropy.

2.3.4. Oxygen

Chemical properties: reactions with metals, nonmetals, reducing compounds (oxides, hydroxides, acids, salts, organic compounds). Laboratory and industrial production of oxygen.

Water. Molecular structure. Hydrogen bonding and its influence on properties of water. Acid-base and oxidation-reduction properties of water. Hydrogen peroxide. Redox properties of hydrogen peroxide (oxidation of sodium nitrite and hydrigen iodide; reduction of potassium permanganate in acidic media and silver oxide).

2.3.5. Sulfur

Chemical properties: reactions with metals, oxygen, chlorine and hydrogen.

Hydrogen sulfide. Molecular structure. Physical properties. Production of hydrogen sulfide. Acidic properties of water solution of hydrogen sulfide – hydrosulfuric acid. Redox properties of hydrogen sulfide and hydrosulfuric acid (reactions with metals, oxygen, bromine, chlorine, hydrogen piroxide, sulfur (IV) oxide and sulfurous acid). Sulfides, hydrolysis of sulfides.

Sulfur(IV) oxide. Molecular structure. Physical properties. Production of sulfur(IV) oxide.

Acidic properties of sulfur oxide(IV) water solution. Redox properties of sulfur(IV) oxide and sulfurous acid (reactions with metals, oxygen, bromine, chlorine, hydrogen peroxide, hydrogen sulfide).

Sulfur (VI) oxide. Molecular structure. Physical properties. Production of sulfur (VI) oxide. Chemical properties: reactions with water, reducing agents (sulfur, hydrogen, potassium iodide), thermal decomposition.

Sulfuric acid. Molecular structure. Production of sulfuric acid. Chemical properties of diluted and concentrated sulfuric acid.

2.3.6. Group 5 (15). The nitrogen family. (The pnictogens.)

Atomic structures. General characteristics of elements.

2.3.7. Nitrogen

Molecular structure. Chemical properties: oxidation of metals and hydrogen; reduction with oxygen. Polarity of the molecule. Physical properties.

Production of ammonia. Chemical properties: basic properties in reactions with water and acids; reducing properties in reactions with oxygen, halogens, hydrogen peroxide and heavy metal oxides. Acidic properties of ammonium salts: reactions with bases, basic oxides, water (hydrolysis). Reducing properties of salts of ammonia.

Nitrogen oxides. Production. Physical properties. Chemical properties of nitrogen(II) oxide: reactions with reducing agents – hydrogen, ammonia; reaction with oxygen). Chemical properties of nitrogen(IV) oxide: reactions with reducing agents – hydrogen, magnesium, phosphorus; reaction with oxygen; reactions with water and alkalis (disproportionation)).

Nitrous acid . Acidic properties. Instability of nitrous acid. Salts of nitrous acid – nitrites. Thermal decomposition of ammonium nitrite

Nitric acid. Molecular structure. Production of nitric cid. Chemical properties. Acidic properties. Reactions with reducing metals, nonmetals and compounds. Influence of the concentration of nitric acid on reducing ability of metals. Salts of nitric acid – nitrates. Thermal decomposition of nitrates.

2.3.8. Phosphorus

Physical properties. Allotropy. Chemical properties: reaction with reducing agents – metals, hydrogen; reactions with oxidizers – oxygen, chlorine, nitrogen oxides(II) and(IV), ntric and concentrated sulfuric acids.

Phosphorus oxides(III) and (V), phosphoric and orthophosphoric acids. Acidic properties. Phosphine (phosphane).

2.3.9. Group 4 (14). Carbon group

Atomic structure. Allotropy.

2.3.10. Carbon

Chemical properties. Reactions with metals and hydrogen; reactions with oxygen , carbon dioxide, heavy metals oxides and concentrated sulfuric acid. Carbon(II) oxide, its reducing properties. Carbon dioxide. Physical properties. Production of carbon dioxide. Chemical properties: reactions with reducing agents – hydrogen an magnesium. Carbonic acid. Acidic properties. Salts of carbonic acid – carbonates an hydrocarbonates, their interconversion.

2.3.11. Silicon

Production. Cheical properties: reactions with oxidizers – fluorine, oxygen. Halogens; reactions with water solutions of alkalis.
Silicon(IV) oxide. Silicic acid, silicates.

3. Organic chemistry

3.1. Introduction

The theory of the chemical structure of organic compounds. The skeletal formula. Radical. Function group. Homologues and homologous series. Structural isomerism and stereoisomerism. The structure of carbon electron shell. Orbital hybridization (sp, sp^2, sp^3). Types of bonding in organic compounds and methods of their breakage. Types of organic reactions. Ionic and radical mechanisms of reactions. Chemical bonds in carbon compounds. Ionic, covalent and carbon bonds. Electronegativity. Oxidation number and valency.

3.2. Alkanes

Methane, its structural formula, tetrahedral structure of methane molecules, sp^3-hybridization, charateristics of chemical bonds. Homologous series of methane, homologous residue. Spatial structures of saturated hydrocarbons. Nomenclature and isomerism. Physical properties of alkanes.
Chemical properties of alkanes: substitution reaction (halogenation, nitration); thermal decomposition (cracking, pyrolysis); isomerization; reactions of oxidation (combustion, oxidation – production of alcohols, aldehydes, ketones and carboxylic acids).
Radical substitution mechanism. Selectivity of halogens in reaction with alkanes. Usage of saturated hydrocarbons. Synthesis gas and hydrogen from methane.

3.3. Haloalkanes (halogenoalkanes or alkyl halides)

Chemical properties of haloalkenes: reactions with metals (Wurtz reaction).

3.4. Alkenes

Ethene (ethylene), its structure formula, double bond, σ - and π-bonds, sp^2- hybridization. Homologous series of ethylene. Physical properties. Isomerism: chain isomerism, double bond isomerism, cis-trans isomerism. Nomenclature of alkenes.
Chemical properties. Most common reactions – electrophilic addition reactions: halogenation, addtion of halocarbons, addition of sulfuric acid, hydration. Mechanisms of reactions. Markovnikov's rule. Polymerization reaction. Oxidation (oxidizers: oxygen, potassium permanganate in alkali and acidic medii, nitric acid). Production of alkenes: dehydrogenation of alkanes, dehydration of alcohols, dehalogenation of alkyl halides, dehalogenation of dialkyl halides, hydration of alkines.

3.5. Alkadienes

Chemical and electronic structures of alkadienes with conjugated bonds. Nomenclature and isomerism of alkadienes. Chemical properties: addition of halogens, alkyl halides and hydrogen). Polymerization. Features of electrophilic addition to systems with conjugated double bonds. Production of 1,3-butadiene: from ethanol (Lebedev's method), from butane and butene. Production of isopropene. Natural rubber, its structure and properties. Synthetic rubber.

3.6. Cycloalkanes

Structure, homologous series, nomenclature, isomerism. Natural resources.
Chemical properties: most common addition reactions: halogenation, addition of alkyl halides, hyration, hydratation, nitration.

3.7. Alkines

Ethyne (acetylene), its structure formula, triple bonds, sp - hybridization.
Homologous series of ethine. Physical properties. Isomerism: chain isomerism, triple bond isomerism. Nomenclature of alkines. Chemical properties of alkines. Reactions of electrophilic addition: halogenation, addition of hydrogen, alkyl halides, hydration. Polymerization (production of benzene, vinyl acetate). Substitution reactions, acidic characteristics of hydrogen atom at sp-hybridizated carbon atom. Oxidation reactions (oxidizers – oxygen, potassium permanganate). Production of alkines: cracking of carbohydrates, calcuin carbide decomposition with water or acids, dehyrdohalogenation of relative halogenated compounds, dehalogenation of polyhalogenated compounds.

3.8. Aromatic hydrocarbons. Arenes

Chemical and electronic structures of benzene. Benzene- cyclic conjugated system. Conjugation energy. Homologous series of benene, nomenclature, isomerism. Chemical properties of benzene: reactions of electrophilic substitution (nitration, sulfonation, halogenation, alkylation – with with halogenated alkanes, reactions with alkenes; acylation). Addition reactions (addition of hydrogen, halogens). Electrophilic substitution mechanism. Chemical properties of benzene homologues. Mutual influence of atoms in cyclic hydrocarbons. Orientation in benzene rings. Oxidation reaction. Styrene (styrol) – one of the most important derivatives of benzene.

Production of cyclic hydrocarbons: from petroleum and its products, from coal tar, dehydrocyclization of alkanes, alcylation of halogenated alkanes, alkenes and alcohols. Usage of cyclic hydrocarbons. Interrelation of saturated, unsaturated and aromatic hydrocarbons.

3.9. Natural sources of hydrocarbons and their processing.

Natural sources of hydrocarbons: petroleum, natural and associated petroleum gases, cox. Petroleum, its composition and properties. Petroleum processing: fractionation, thermal and catalytic cracking.

3.10. Alcohols

Saturated monohydric alcoohols. Structure of saturated monohydric alcohols. Functional group, its electronic structure. Primary, secondary and tertiary alcohols. Nomenclature of alcohols and their isomerism.
Hydrogen bond and its influence on properties of alcohols. Chemical properties of alcohols. Reactions with O-H bond breakage: formation of metals alcoholates, formation of ethers, formation of acetals and hemiacetals.
Reactions with C-OH bond breakage: substitution of OH group to halogen, dehydration (intramolecular and intermolecular). Redox reactions. Nucleophilic substitution mechanism.

Production of alcohols: hydration of alkenes, fermentation of carbohydrates, reduction of aldehydes and ketones, hydrolysis of halogenated hydrocarbons, hydrolysis of ethers, production of alcohols from carbon oxide (II) and hydrogen.

Polyatomic alcohols. Structure of polyatomic alcohols. Nomenclature and isomerism/

Chemical properties and production of ethylene glycol ang glycerin (glycerol). Comparative characteristics of chemical properties of monohydric and polyatomic alcohols (acidic properties). Usage of alcohols.

3.11. Phenols

Structure of phenols. Nomenclature and isomerism. Chemical properties: acidic properties, reactions of electrophilic substitution in benzene rings (nitration, sulfonation, reaction with bromine water), reduction reactions. Mutual influence of atoms in phenol molecules. Production and usage of phenol.

3.12. Aldehydes and ketones

Structures of aldehydes and ketones. Carbonyl group, its structure. Nomenclature and isomerism of aldehydes and ketones. Physical properties.

Chemical properties: redox reactions, addition of alcohols (production of acetals), halogenation. Production of aldehydes and ketones: oxidation of alcohols, hydration of alkines, decomposition of salts of organic acids, oxidation of alknes, oxidation of ethylene (production of acetaldehyde). Usage of formaldehyde (methanal) and acetaldehyde (ethanal). Connection between aldehydes and ketones and other classes of organic compounds.

3.13. Carboxylic acids

Classification of carboxylic acids. Saturated monobasic and arimatic carboxylic acids. Nomenclature. Homologous series saturated monobasic carboxylic acids. Common carboxylic acids – formic, acetic, palmitic, stearic and benzoic acids. Oxalic acid – as a representative of dibasic carboxylic acids. Isomerism.

Unsaturated monobasic carboxylic acids Nomenclature and isomerism. Common representatives – acrylic, oleic, linoleic and linolenic acids. Physical properties of carboxylic acids.

Carboxyl group, its structure. Mutual influence of carboxyl group and hydrocabon radical. Chemical properties of carboxylic acids.

Properties, due to containing carboxyl group: electrolytic dissociation, reactions with metals, basic and amphoteric oxides, bases, salts, formation of anhydrides, reactions with alcohols, ammonia, redox reactions. Properties, due to containing hydrocarbon radical: substitution reactions, addition reactions, redox reactions.

Production of carboxylic acids: oxidation of alkanes, alkenes, aromatic hydrocarbons, alcohols, aldehydes and ketones; hydrolysis of trihalogenated hydrocarbons; hydrolysis of ethers; decarboxylation of dibasic acids.

Connection between carboxylic acids and other classes of organic compounds. Usage of carboxylic acids.

3.14. Ethers. Fats

Ethers of organic and inorganic acids. Structure of ethers. Nomenclature. Physical properties. Etherification. Reversibility of etherification. Chemical properties of ethers: hydrolysis in acidic and alkali medii.

Fats. Natural fats, their structure and physical properties. Chemical properties of fats: hydrolysis of fats in acidic and alkali medii. Usage of fats. Concept of synthetic washing liquids.

3.15. Carbohydrates

Classification of carbohydrates. Monosaccharides. Structure of monosaccharides. Linear and cyclic forms of monosaccharides. Physical properties and natural sources. Common representatives of monosaccharides – glucose, fructose, ribose and deoxyribose. Chemical properies of monosaccharides. Properties due to containing hydroxy (hydroxyl) group. Properties due to containing carbonyl group.

Disaccharides. Sucrose. Molecular structure. Physical properties and natural sources. Chemical properties: hydrolysis, properties due to containing hydroxy group.

Polysaccharides. Starch. Structure of starch. Chemical properties: Hydrolysis, reaction with iodide, properties due to containing hydroxy groups. Cellulose. Structure of cellulose. Chemical properties of cellulose: hydrolysis, properties due to containing hydroxy groups. Usage of polysaccharides and their derivatives.

3.16. Nitrogen-containing organic compounds

Amines. Structure of amines. Amino group. Nomenclature and isomerism. Physical properties. Chemical properties of amines: reactions with water and acids, reaction with nitrous acid, combustion. Aniline – common representative of aromatic amines. Production of aniline from nitrobenzene. Chemical properties of aniline: properties due to containing amino group, reactions in benzene ring.

3.17. Amino acids

Structure of α-amino acids. Nomenclature and isomerism. Physical properties. Chemical properties of α-amino acids: properties due to containing amino group; properties due to containing carboxyl group. Special features of amino acids due to containing both amino and carboxyl groups. Formaion of dipeptides.

3.18. Proteins as biopolymers

Common α-amino acids forming proteins: glycine, alanine, valine, phenylalanine, tyrosine, serine, cysteine, glutamic acid, lysine, tryptophan. Primary, secondary, tertiary and quaternary protein structures. Chemical properties of proteins: hydrolysis, denaturation, protein color reactions.

3.19. High molecular weight compounds

General concepts of monomers, polymers, structural link, degree of polymerization. Reactions of polymerization and polycondensation. Polymers produced by polymerization: polyethylene, polypropylene, polyvinyl chloride, polymethyl methacrylate. Rubbers. Natural and synthetic rubbers, vulcanization of rubber. Polymers produced by polycondensation. Phenol formaldehyde resins.

Sample entry test

1. Choose two elements, which being in basic state, have one unpaired electron in the valence shell (outer level): Al, S, Cr, P, Si.

2. Of the following, choose three non-metal elements and put them in the order of decrease of their reducing properties: Al, S, Cr, P, Si.

3. Of the following, choose two elements that have the oxidation number of +6 in their higher oxides: Al, S, Cr, P, Si.

4. Of the following, choose two compounds whose molecules have a nonpolar covalent bond.
1) H_2S 2) P_4 3) CH_4 4) C_2H_4 5) HNO_3

5. Match the following compounds with its class/group. Choose the appropriate group for every given compound.

Compounds	**Class/group**
A) sulfur hydroxide(VI)	1) bases
B) nitrogen oxide(V)	2) acids
C) calcium oxide	3) amphoteric oxides
	4) basic oxides
	5) acidic oxides
	6) non-salt-forming oxides

6. Of the following, choose two compounds that are formed when chromium oxide(VI) is dissolved in excess of potasiium hydroxide solution.
1) potassium dichromate
2) potassium chromate
3) chromium hydroxide(II)
4) chromium hydroxide(III)
5) water

7. Solid barium carbonate was placed in two test tubes. A solution of a strong acid was added to the first tube which led to the dissolution of a precipitate. Water was added to the second tube and passing a gas Y through the liquid also led to the dissolution of a precipitate. Of the following substances, decide which substances are X an Y.
1) sulfuric acid
2) ammonia
3) carbon oxide(IV)
4) nitric acid
5) hydrobromic acid

8. Match the following formulas with the series where there are only reagents the given substance can react with.

Formulas	**Reagents**
A) KOH	1) $Ba(NO_3)_2$, $SrBr_2$, H_2SO_4
B) $Ba(OH)_2$	2) $AlCl_3$, NH_4Cl, HNO_3
C) K_2SO_4	3) NaOH, I_2, Na
D) $KHSO_4$	4) CH_3COOH, N_2, Na_2SO_4
	5) KOH, $Ca(OH)_2$, Mg

9. Match the following reagents with the products of their reactions.

Reagents	**Products of their reactions**
A) $Ca(OH)_2$ and N_2O_5	1) $CaSO_4$ and H_2O
B) $Ca(OH)_2$ and SO_2	2) $Ca(NO_2)_2$, H_2O and $Ca(NO_3)_2$
C) $Ca(OH)_2$ and SO_3	3) $Ca(NO_3)_2$ and H_2
D) $Ca(OH)_2$ and NO_2	4) $CaSO_4$ and H_2
	5) $CaSO_3$ and H_2O
	6) $Ca(NO_3)_2$ and H_2O

10. Match the following net ionic equations with the reagents of the reactions.

Net ionic equations	**Reagents**
A) $3Li^+ + PO_4^{3-} = Li_3PO_4$	1) $LiBr_3$ and K_3PO_4
B) $Pb^{2+} + 2F^- = PbF_2$	2) $CoCO_3$ and H_2S
C) $3Ag^+ + PO_4^{3-} = Ag_3PO_4$	3) $Pb(NO_3)_2$ and NaF
D) $Co^{2+} + S^{2-} = CoS$	4) AgBr and K_3PO_4
	5) $AgNO_3$ and K_3PO_4

11. Match the following salts with the type of the hydrolysis of these salts in water

Salts	**Type of the hydrolysis**
A) aluminium sulfide	1) cationic
B) sodium sulfide	2) anionic
C) magnesium nitrate	3) both cationic and anionic
D) potassium sulfite	4) does not hydrolyze

12. Match the following salts with the correct type of the medium of their water solutions.

Salts	**Type of the medium**
A) ammonium nitrate	1) neutral
B) potassium nitrite	2) acidic
C) lithium chloride	3) alkaline
D) sodium sulfide	

13. Of the following, choose two compounds that are the products of dehydrocyclization of hexane.

1) toluene 2) benzene 3) hydrogen 4) 1,2-dimethylbenzene 5) ethylbenzene

14. Of the following, choose two compounds that decolorize a solution of potassium permanganate in sulfuric acid.

1) cyclohexane 2) styrol 3) methylbenzene 4) benzene 5) 2-methylpropane

15. Of the following, choose two compounds that can be produced by alkaline hydrolysis of proteins.

1) NH_2CH_2COONa 2) $C_6H_5NH_2$ 3) CH_3CH_2OH
4) $CH_3CH(NH_2)COONa$ 5) C_6H_5ONa

16. Match the following elements with the oxidation number it can have.

Elements	**Oxidation number**
A) oxygen	1) –4, 0, +4

B) bromine	2) 0, +2, +3, +6
C) silicon	3) –2, –1, 0, +2
	4) 0, +2, +4, +6, +7
	5) –1, 0, +1, +5, +7

17. Match the following reagents with the organic products of their reactions.

Reagents	**Organic products**
A) ethanol and sodium	1) sodium ethyl
B) ethanol and hydrogen bromide	2) sodium ethoxide
C) ethane and bromine	3) bromoethane
D) ethanol and methanol	4) bromoethene
	5) methyl ethanol
	6) methyl ethyl ether

18. Match the following pairs of compounds with the substances they can be distinguished by.

Compounds	**Substances**
A) propine and 1,3-butadiene	1) bromine water
B) propene and propane	2) $AlCl_3$
C) phenol and ethanediol	3) phenolphthalein
D) acetic acid and 2-propanol	4) $[Ag(NH_3)_2]OH$
	5) litmus

19. Of the following, choose two reactions that are irreversible.
1) reaction between ethyl alcohol and acetic acid
2) hydrolysis of sodium carbonate
3) hydrolysis of calcium carbide
4) reaction between carbon oxide(IV) and water
5) reaction between sodium carbonate and hydrochloric acid

20. Of the following, choose two external influences that decrease the reaction rate of the oxidation of sulfur dioxide.
1) addition of a catalyst
2) decrease of pressure
3) increase of oxygen concentration
4) decrease of temperature
5) increase of sulfur dioxide concentration

21. Of the following, choose two substances that can react with both sodium and chlorine.
1) oxygen 2) carbon oxide(IV) 3) phosphorus 4) calcium oxide 5) water

22. Math the changes in the oxidation number of elements with the reaction equations where these changes occur.

Changes in the oxidation number	**Reaction equations**
A) $P^{-3} \rightarrow P^{+5}$	1) $SiO_2 + 3C = SiC + 2CO$
B) $Si^{+4} \rightarrow Si^{0}$	2) $SiO_2 + 4HF = SiF_4 + 2H_2O$
C) $P^{0} \rightarrow P^{+5}$	3) $PH_3 + 2O_2 = H_3PO_4$
	4) $SiO_2 + 2C = Si + 2CO$
	5) $5HNO_3 + P = H_3PO_4 + 5NO_2 + H_2O$

23. Of the following. choose two compounds that have cis-trans isomers.
1) propylene 2) 1-butene 3) 2-butene 4) 2-pentene 5) 1,3-butadiene

24. Match the following influences on the equilibrated system

$$CaCO_3 \text{ (solid.)} \rightleftarrows CaO \text{ (solid)} + CO_2\text{(gas)} - Q$$

with the equilibrium shifts they result in.

Influences on the equilibrated system	**Equilibrium shifts**
A) increase of carbon dioxide concentrtion	1) towards the forward reaction
B) decrease of temperature	2) towards the backward reaction
C) addition of a catalyst	3) practically does not shift
D) decrease of pressure	

25. Match the following pairs of compounds with the reagent they can be distinguished by.

Compounds	**Reagent**
A) $Ca(OH)_2$ and KOH	1) Na_3PO_4
b) K_2SO_4 and $ZnSO_4$	2) $CuCl_2$
C) $ZnCl_2$ and $ZnSO_4$	3) HNO_3
D) Na_2SO_4 and H_2SO_4	4) CuO
	5) $Ba(NO_3)_2$

26. Match the following formulas with the products of electrolysis of their water solutions that are formed at the inert electrodes.

Formulas	**Products of electrolysis**
A) $CuBr_2$	1) H_2, O_2
B) $CuSO_4$	2) Cu, O_2
C) $NaNO_3$	3) Cu, Br_2
D) $Ba(NO_3)_2$	4) H_2, Br_2
	5) H_2, NO_2

27. 80 g of water was added to 200 g of a 8% solution of sodium chloride. Calculate the mass fraction of the salt (in percent) in the finite solution. (Write the number accurate to the tenth.)

28. For the total combustion of carbon is needed 78 L of oxygen (STP). Calculate the volume (in litres) of caron dioxide that is theoretically produced. (Write the number accurate to the whole.)

29. 14.5 g of zinc was dissolved in an excess of sodium hydroxide water solution. Calculate the volume of gas (in litres) released from the reaction (STP). (Write the number accurate to the whole.)

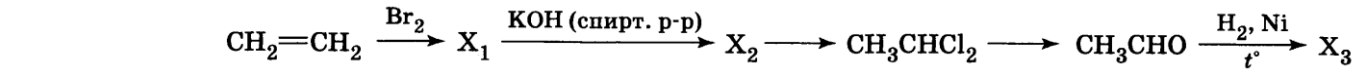
30. Calculate the sum of the coefficients in the equation of the oxidation-reduction reaction occured by the addition of potassium iodide to a solution of potassium dichromate acidified by sulfuric acid.

31. An ion-exchange reaction occured by mixing of solutions of sodium hydrosulfide and an excess of copper nitrate. Calculate the sums of the coefficients in the molecular, complete and net ionic equations of the reaction. (Write the numbers in the given order.)

32. A gas (A) was released from the reaction between magnesium silicide and hydrochloric acid solution, then this gas (A) was combusted. A solid product of the reaction of combustion (B) was mixed with sodium carbonate, heated to the melting point and observed for some time. After the cooling a solid product of the reaction (C) was dissolved in water and treated with sulfuric acid solution, as the result of that the dissolution of a precipitate (D) was observed. Of the following substances, decide which substances are A, B, C and D

1) SiO_2 2) SiH_4 3) Na_2SiO_3 4) $MgCl_2$ 5) H_2SiO_3 6) Na_2SO_4

33. Of the following compounds, decide what X1, X2 and X3 stand for in the transformation chain. Put the compounds in the correct order.



Put the compounds in the correct order.

1) 1,1-dibromoethane 2) ethanol 3) ethine
4) bromoethane 5) 1,2 –dibromoethane 6) ethanal

34. A 10% solution of zinc sulphate was made by dissolution of 114.8 g of zinc vitriol (copperas) in water. \((ZnSO_4 \cdot 7H_2 O)\) Then 12 g of magnesium was added to the solution. When the reaction was over, 365 g of a 20% solution of hydrochloric acid was added to the formed mixture. Calculate the mass fraction of the acid in the finite solution. (Omit the hydrolysis.) (Write the number accurate to the tenth.)

35. 8.96 L of carbon dioxide (STP), 12.6 g of water and 2.24 L of nitrogen (STP) were produced from the combustion of 9 g of a gaseous organic compound. The relative density of the compound to air is 1.5552. Make necessary calculations to recognise the molecular formula of the compound. As the answer, put down only the sum of the atoms in the molecule.

Entry test evaluation criteria

№	Question topics	Score	Maximum score
1	Electronic configuration of an atom	2(2)	2
2	Patterns of change in chemical properties. Characteristics of elements.	2(1)	2
3	Electronegativity, oxidation state and valence of chemical elements.	2(2)	2
4	Charasteristics of chemical bonds. Dependence of the chemical properties on the composition and structure.	2(2)	2
5	Classification and nomenclature of inorganic substances.	3(3)	3
6	Properties of simple substances and oxides.	2(2)	2
7	Properties of amphoteric hydroxides, acids and salts.	2(2)	2
8	Properties of inorganic substances	4(4)	4
9	Interrelation of various classes of inorganic substances	4(4)	4
10	Ion exchange and dissociation	4(4)	4
11	Classification and nomenclature of organic compounds	4(4)	4
12	The theory of the chemical structure of organic compounds	2(2)	2
13	Properties of hydrocarbons.	2(2)	2
14	Properties of oxygen containing compounds.	2(2)	2
15	Properties of nitrogen containing compounds.	2(2)	2
16	Classification of chemical reactions in organic and inorganic	2(2)	2

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17	The reaction rate and its dependence on different factors	2(2)	2
18	Oxidation-reduction reactions.	3(3)	3
19	Characteristic properties of different classes of organic compounds.	4(4)	4
20	Properties of hydrocarbons and oxygen containing compounds.	4(4)	4
21	Qualitative reactions of organic compounds.	4(4)	4
22	Electrolysis of melts and solutions.	4(4)	4
23	Hydrolysis of salts.	4(4)	4
24	Chemical equilibrium.	4(4)	4
25	Qualitative reactions of inorganic compounds.	4(4)	4
26	Media of water solutions of salts.	4(4)	4
27	Interrelation of different classes of inorganic substances and reactions description.	4(4)	4
28	Interrelation of organic compounds.	3(3)	3
29	Mass fraction calculation.	3(1)	3
30	Gas volume calculation.	2(1)	2
31	Calculation of the mass or volume by the parametres of one of the reactants.	2(1)	2
32	Calculations for redox reactions	2(1)	2
33	Ion-exchange reactions.	2(1)	2
34	Calculation of the mass fraction in a mixture.	2(1)	2
35	Finding of molecular formulas of substances.	2(1)	2
	Total score:		100

For questions 1, 3-28, one gets maximum points, if the answer is completely correct; if answer is partly correct, one gets only part of points. For questions 2, 29-35, one gets maximum score, if the answer is correct; if the answer is incorrect one gets 0 points.

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