Questions for a written test

1. Structure and physical properties of elements. Type of bonding of atoms in an element, the change in the chemical bond energy, the boiling point and the melting point of elements in a subgroup.
2. Chemical properties of elements. Change in their oxidative and reducing properties in a subgroup.
3. Ionic, covalent, polymeric and nonstoichiometric hydrides. Types of hydrides.
4. Features of the structure of oxides, ionic, molecular and polymeric structures. Acidic and basic oxides, properties of oxides.
5. Change in the acidic and basic properties of hydroxides of elements by periods and groups depending on the degree of oxidation of element atoms.
6. Salts of oxoacids and oxygen-free acids. Formation of elements of salts in the cation and anion forms depending on the degree of oxidation of an element and its position in the periodic system.
7. Solubility and hydrolysability of salts.
8. The propensity of elements for complex formation and the formation of molecules and ions that have the properties of ligands depending on the position in the periodic system.
9. Classification and basic principles of the nomenclature of organic compounds. Isometric types.
10. Conformation and configuration concepts. Methods of its solution and the fundamentals of a conformational analysis.
11. Classification of organic reactions by type and mechanism.
12. Basic ideas about the mechanisms of radical and nucleophilic substitution in the saturated carbon atom and electrophilic substitution in the aromatic nucleus.
13. Mechanisms of the reactions of elimination, electrophilic and nucleophilic addition by multiple bonds. Combination and elimination reactions.
14. General properties of synthesis and the most important properties of compounds of various classes.
15. Saturated and unsaturated hydrocarbons, alkanes, alkenes and alkynes.
16. Monofunctional alkane derivatives, haloalkanes, monohydric alcohols, polyhydric alcohols, carbonyl compounds, aldehydes and ketones.
17. Carboxylic acids, derivatives of carboxylic acids, esters, amides, nitriles and acid halides.
18. Aromatic hydrocarbons. Heterocycles. Substitution reactions in the aromatic ring of benzene under the action of electrophilic reagents orienting the effect of the substituent in the ring on the place of entry of the electrophilic agent.
19. Phenols, aromatic amines and aromatic diazo compounds.
20. Correctness and reproducibility of analysis results. Methods for evaluating the correctness and reproducibility of analysis results.
21. Method selection depending on the permissible error of the analysis results. Analysis arbitration method requirements. The choice of the method of analysis depending on the relative content of the component being determined.
22. Acid-base titration with visual and instrumental methods of fixing the end point of titration.
23. Titrimetric methods based on precipitation reactions. Methods of analysis based on the use of oxidation-reduction reactions.
24. Methods of analysis based on the use of complex formation reactions.
25. Molecular absorption spectroscopy (spectrophotometry). Laws of light absorption. Absorption spectra.
26. Emission spectral analysis. Electric arc and spark discharge as the sources of excitation of emission spectra. Atomic emission spectroscopy with the inductively coupled plasma.
27. Atomic absorption spectroscopy. Flame and electrothermal methods of sample atomisation. IR spectroscopy and Raman spectroscopy. Nature of vibrational spectra. The structural, functional and quantitative analysis of vibrational spectra.

28. Ionometry. Classification of ion selective electrodes, the principle of their action. A glass electrode for measuring pH solutions.
29. Voltammetry. General description of the classical polarography and modern variants of the method.
30. Coulometry. Direct coulometry and coulometric titration.
31. Extraction as a method of separation and concentration in analytical chemistry. Classification of extractingcompounds. Gas-liquid and gas adsorption chromatography.
32. Qualitative and quantitative gas chromatographic analysis. Ion-exchange chromatography as a method of separation of complex mixtures of electrolytes. Cation and anion exchangers. Distribution chromatography in a thin layer (TLC).
33. Peculiarities of the crystalline state of a substance. Processes of alignment and disalignment of a substance. The concept of symmetry.
34. Spatial lattice. Point groups (classes) of symmetry. Spatial symmetry groups. Shingonia. Bravais lattices. Symbols of nodes, rows and planes. Miller indices.
35. Effective radii of atoms and ions. Dense packages and polyhedral models. Isostructurality, isomorphism and polymorphism.
36. The first law of thermodynamics. Warmth and work. Internal energy and enthalpy. System state functions. Laws of thermochemistry.
37. The second law of thermodynamics and its consequences. Entropy as a function of state. Change in entropy in various processes. The statistical meaning of entropy.
38. Characteristic functions. Functions of Helmholtz and Gibbs, their properties. Maxwell's relations for the connection of the thermodynamic parameters of the system.
39. Conditions of equilibrium and criteria for the spontaneous flow of processes. The Gibbs-Helmholtz equation and its role in chemistry.
40. Chemical potentials, their definition, calculation and properties.
41. Condition of chemical equilibrium. Thermodynamic derivation of isothermal equations and isobar (isochor) chemical reaction.
42. Influence of various factors (temperature, pressure, admixture of inert gas) on the equilibrium position.
43. Condition of the heterogeneous equilibrium without chemical reactions. The Gibbs phase rule. Phase transitions.
44. One-component systems and their state diagrams.
45. Polymorphic phase transformations.
46. Two-component systems and their state diagrams. Methods for constructing diagrams of state.
47. Solutions. Thermodynamic mixing functions for ideal and non-ideal solutions. Partial molar quantities.
48. Solubility of gases and solids. Colligative properties of solutions. Laws of Raoul and Henry. Ebullioscopy and cryoscopy. Osmosis.
49. Solutions of electrolytes. Basic provisions of the Arrhenius theory. Ideality and non-ideality of electrolyte solutions. The concepts of mean activity and mean activity coefficient.
50. Equilibrium electrochemical chains and their EMF. The Nernst formula and the Gibbs-Helmholtz equation.
51. The concept of electrode potential. Classification of electrodes and electrochemical circuits.
52. Determination of activity coefficients and transport numbers based on EMF measurement. Chemical sources of current.
53. Description of irreversible processes in thermodynamics. Streams. Thermodynamic forces. Onsager reciprocity relations.
54. Non-equilibrium phenomena in the solutions of electrolytes. Diffusion and migration flows. The Nernst-Einstein formula. The specific and equivalent conductivity.
55. Transport numbers and methods for their determination.

56. Current density as a measure of the speed of the electrode process; electrode polarisation. Mechanisms of charge and mass transfer, diffusion, migration and convection. Concentration and chemical polarisation. Overvoltage.
57. Basic concepts of chemical kinetics, the rate of chemical reaction, the basic postulate, order and molecularity. Kinetic equations.
58. Methods for determining the rate constants and the order of reactions. Kinetics of irreversible reactions.
59. Kinetics of reversible and parallel reactions.
60. Dependence of the reaction rate on temperature. The Arrhenius equation.
61. The theory of active collisions in chemical kinetics. Advantages and disadvantages of the theory of collisions. Theory of the transition complex.
62. Colloidal systems: classification, formation (acquisition), electrical properties, stability. Disperse systems, sols, emulsions, foams, aerosols; Properties and applications; Colloid chemistry in the environmental protection.
63. Adsorption and adsorption equilibrium. Thermodynamic theory of adsorption equilibria. Practical applications of adsorption.
64. Surface phenomena: surface energy, capillary phenomena and wetting, surface-active substances.
65. Statistical-thermodynamic model of an imperfect crystal. The perfect crystal. Defects of the crystal structure. Equilibrium and non-equilibrium defects.
Point defects, electronic disordering of a crystal.
66. Types of disorder, Schottky's and Frenkel's. the chemical thermodynamics of a crystal with defects.
67. Dependence of the concentration of defects on temperature. Quasi-chemical approach.
The energy of defect formation. Thermal equilibrium of defects.
68. Crystal-gas equilibrium. Impurity disordering of crystals.
69. Models of ordering and interaction of defects. Interdependence of structures. Continuously adapted structures.
70. Stagedness of solid-phase transformations. Sequential and parallel flows of the stages. Induction period. The theory of the rate-determining step. Laws of nucleation. Models of formation and growth of embryos.
71. Diffusion transfer. Volume, surface and grain boundary diffusion.
Reactions in powder mixtures. Particle distribution by size.
72. Model methods for studying reactions such as solid/solid and solid/gas. Model concepts of the mechanism of solid/gas reactions. Oxidation of metals.
73. Classification of solid-phase materials by functional properties. Ionic conductivity and solid electrolytes. Superionic conductors. Cationic conductors. Oxygen-ionic conductors.
74. Dielectrics. The chemical and physical nature of dielectrics. Induced and spontaneous polarisation. Ferroelectrics, pyroelectrics and piezoelectrics.
75. Magnetic materials. Functional parameters. Classification of magnetic materials, basic structures and properties (metals and alloys, transition metal oxides, spinels, garnets, perovskites, hexaferrites). Areas of application, the relationship between structure and properties.
76. Superconducting materials. Traditional (metals and intermetallides) and high-temperature (oxide) superconductors.
77. Polymer state of matter. Classification of polymers by the chemical and spatial structure of the chain.
78. Synthesis of polymers. Ionic and radical polymerisation. Stereospecific polymerisation.
79. Polycondensation. The mechanism of reactions. Examples of polycondensation polymers.
80. Preparation of network polymers in polymerisation, polycondensation, crosslinking of macromolecules.
81. Chemical properties of polymers. Reactions of units and reactions of macromolecules.

82. Features of the ‘molecular mass"’ concept for polymers. Methods for determining molecular masses. Flexibility of macromolecules. Factors determining the flexibility of the chain. Conformations and configurations of macromolecules.
83. Highly elastic state of polymers. Mechanical properties of elastomers. Relaxation phenomena, their role in the development of high-elastic deformation.
84. Glassy state of polymers. The glass transition temperature and the factors affecting it. Mechanical properties of polymer glasses.
85. Crystalline state of polymers and its features. Effect of the chemical structure of the polymer on crystallisability. Morphology of polymer crystals.
86. Solutions of polymers in low-molecular liquids and their features. Swelling. Phase diagrams of polymer solutions.
87. Basic electrochemical phenomena during electrolysis. Faraday’s laws.
88. The nature and mechanism of the appearance of the electrode potential. Thermodynamic formula for the equilibrium electrode potential.
89. Electrochemical circuits. Classification. Diffusion potential, methods of its elimination.
90. Electrocapillary phenomena on the surface of liquid and solid electrodes.
91. The structure of a double electrical layer at the electrode-electrolyte interface.
92. Kinetics of electrochemical processes. Diffusive overstrain.
93. Electrochemical overvoltage. Basic provisions of the slow-discharge theory.
94. Basic regularities of mixed kinetics.
95. Overstrain of crystallisation.
96. Basic regularities of the anodic dissolution of metals.