MINISTRY OF SCIENCE, HIGHER EDUCATION AND INNOVATION
OF THE KYRGYZ REPUBLIC
JALAL-ABAD INTERNATIONAL UNIVERSITY
FACULTY OF MEDICINE
Department of Humanities and Natural Sciences

Orozbaeva Zh.M., Abdullaeva M.D., Adysheva A., Kalykova G.S.

CHEMISTRY

EDUCATIONAL AND METHODOLOGICAL COMPLEX

Jalal-Abad - 2025

The educational and methodological complex on physical and colloidal chemistry was compiled by PhD in Biology, Associate Professor Orozbaeva Zh.M., Doctor of Technical Sciences, Professor Abdullaeva M.D., PhD in Chemical Sciences, Associate Professor A. Adysheva, Senior Lecturer Kalykova G.S. based on the state standard for students of medical universities in the specialty "Pharmacy" 560005, approved by the Ministry of Health of the Kyrgyz Republic, 2015.

Compiled by: candidate of biological sciences, associate professor Orozbaeva Zh.M., doctor of technical sciences, professor Abdullaeva M.D., candidate of chemical sciences, associate professor Adysheva A., senior teacher. Kalykova G.S.

Reviewers: Candidate of Chemical Sciences, Associate Professor Suyunbekova A.
Candidate of Chemical Sciences, Associate Professor Tulenbaeva M.

Chemistry: Educational and methodological complex / Comp. Orozbaeva Zh.M., Abdullaeva M.D., Adysheva A., Kalykova G.S. – Jalal-Abad.2025

This manual contains methodological instructions for implementation laboratory work and brief theoretical material necessary for preparation for laboratory work, as well as a list of recommended literature. Tables and figures are provided.
The manual is intended for students studying in the specialty 33.05.01 Pharmacy.

This teaching aid is designed for classes in physical and colloid chemistry. It was compiled in accordance with the requirements of the state educational standard and curricula. In addition to descriptions of experiments, each topic includes assignments and exercises to help develop students' chemical thinking. This teaching aid is intended for medical students majoring in Pharmacy.

Jalal-Abad. 2025

INTRODUCTION

The subject of physical chemistry is the explanation of chemical phenomena based on the general laws of physics. Colloid chemistry studies the properties of highly dispersed heterogeneous systems.

Physical and colloidal chemistry are of great importance for solving the most important problems in pharmacy. The thermodynamic method is one of the most powerful methods in physical chemistry, allowing one to predict the outcome of processes, and therefore it is difficult

To re-evaluate the importance of thermodynamics for pharmaceuticals, which involve chemical synthesis and biological reactions. The theory of phase equilibria allows for informed selection of drug synthesis and purification conditions and resolution of compatibility issues.

When preparing dosage forms, predict the potential for interactions between individual components. The theory of solutions forms the basis for the preparation of most liquid medicinal products.

Electrochemistry is the foundation of such analytical methods as conductometry, potentiometry, polarography, volt- and amperometry, which are widely used today in the control of drug production and in the analysis of finished pharmacopoeial

drugs.

Adsorption is used to remove poisons and overdosed drugs from the gastrointestinal tract, and to remove toxic metabolic products from the blood.

Methods for obtaining and purifying colloidal solutions are used in technologies for producing medicinal products based on condensation and dispersion. The stability and coagulation of colloidal systems is the basis for obtaining stable medicinal products that represent

Thus, the importance of physical and colloidal chemistry in the training of pharmacists is difficult to overestimate. Furthermore, this discipline is closely interrelated with analytical and pharmaceutical chemistry, pharmacology, pharmaceutical technology, and other disciplines studied by future students.

pharmacists.

This teaching aid is intended for students majoring in Pharmacy 33.05.01. It contains guidelines for completing laboratory work and brief theoretical material necessary for preparation for

The manual provides instructions for completing laboratory work, as well as a list of recommended literature. The manual includes numerous tables and figures. The laboratory methodology has been repeatedly tested in physical and colloid chemistry classes. The purpose of this manual is to facilitate students' preparation for laboratory work and familiarize with the methodology for their implementation.

1. General information:

Name of the university: Central Asian International Medical University

Department: " Pharmacy and General Medical Disciplines "

Discipline : " Analytical Chemistry "

Specialty : 560005 "Pharmacy"

Volume of **academic hours (credits) –** 120 hours , 4 credits

Course and semester of study – 3rd year, V - VI semester

Information about the teacher:

No. \p	Full name	Job title	Degree	Contact numbers
1	Orozbaev Zh.M.	Associate Professor	Candidate of Biological Sciences	0778464628
2	Kalykova G.S.	senior lecturer		0552001522

Contact information: location of the department

Address: 174 T. Bayzakova St., 2nd floor, office 211, Department of Pharmacy

The discipline policy is based on the consistent and purposeful implementation of the educational process. Faculty requirements for students are based on the general principles of education at a medical school.

1. Mandatory, regular attendance of lectures and practical classes.
2. Mandatory completion of 2 types of independent work in different forms.
3. Active participation in the educational process (notes of practical work, preparation of theoretical material, solving situational problems and tests, independent completion of practical work) - if the student is insufficiently prepared, no points are awarded for practical work.
4. Submission of laboratory work protocols, tests, situational problems, defense of the independent work topic within the established time according to the subject plan no later than the week corresponding to the given section.

5. Completion of midterm assessments for loans no later than 8 and 15 weeks
6. A student should not be late for classes.
7. Having a clean, ironed, white coat.
8. Respectful attitude towards faculty and students
9. Open discussion of conflict situations in groups with the participation of the curator or head of the department

1. Objectives and tasks of the discipline:

The objective of this course is to prepare students to master the fundamentals of disciplines studied in the training of professional personnel in the field of pharmacy (and other specialties involving the use of various physical and chemical processes), taking into account their future professional activities. This course also aims to develop a natural science worldview and an understanding of the fundamental principles of various physical, chemical, biological, and other natural phenomena and technological processes. Students will also master the physical and chemical principles of forecasting, developing, monitoring, and optimizing various technological processes, particularly in the production, quality control, storage, and use of pharmaceuticals and medicinal products.

Tasks:

- formation of systemic knowledge of the basic laws of chemical processes, chemical structure and properties of inorganic compounds, aimed at developing the competencies necessary for the activities of a pharmacist;
- developing students' understanding of the purpose, objectives and methods of physical and colloidal chemistry, their importance taking into account their future professional activities;
- to develop students' skills independent work with educational and reference literature on physical and colloidal chemistry.

2. The place of the discipline in the structure of the educational program:

Physical and colloidal chemistry is part of the core professional curriculum for specialty 560005 – "Pharmacy," with the index B.1.B3.7. According to the current curriculum, physical and colloidal chemistry is studied in the first and second semesters. It is integrated with the following disciplines: mathematics, physics, computer science, general chemistry, organic chemistry, analytical chemistry, and pharmaceutical chemistry.

3. Requirements for the results of mastering the discipline:

The process of studying the discipline is aimed at developing the following competencies:

PC-33 is capable and ready to conduct drug analysis using chemical, biological and physicochemical methods in accordance with the requirements of regulatory documents.
PC-35 - able and ready to interpret and evaluate drug analysis results
As a result of studying the discipline "Physical and Colloid Chemistry", a student of the specialty 560005 "Pharmacy" must:
Know:

The student should know:

Know:
1. Safety rules for working in a chemical laboratory and with physical instruments.
2. Fundamental principles of thermodynamics, thermochemistry. Consequences of Hess's law.
3. Chemical equilibrium, methods for calculating equilibrium constants.
4. Solutions and processes occurring in aqueous solutions.
5. Processes occurring in solutions and at phase boundaries involving charged particles.
6. The influence of factors on the rate of chemical reactions, including destruction processes medicinal substances; methods for calculating expiration dates and half-life periods medicinal substances.
7. Basic concepts, mechanism, types of catalysis; the role of promoters and inhibitors.
8. Physicochemical properties and quantitative characteristics of true solutions and dispersed systems:
9. Colligative properties of solutions.
10. Quantitative characteristics of molecular and solutions of electrolytes.
11. Behavior of substances at phase interfaces. Properties and characteristics of surfactants, as well as the possibilities of their use in the preparation of dosage forms.
12. Types, methods of production, physical and chemical properties and stability of dispersed systems, possibilities of their use as dosage forms.
13. Chemical nature of high-molecular compounds; properties of high-molecular compounds solutions; possibilities of their use in as auxiliary and medicinal substances.
14. Methods of physicochemical analysis of true and dispersed systems, including those described in the State Pharmacopoeia.

15. Methods of obtaining and separating (physical, chemical, chromatographic, extraction) true solutions and dispersed systems.

The student should be able to:

1. Calculate thermodynamic functions of the state of the system, thermal effects of chemical processes .
2. Calculate quantitative characteristics of solutions and electrode systems.
3. Perform the necessary calculations and prepare true, buffer and colloidal solutions.
4. Calculate the kinetic characteristics of reactions.
5. Assess the physical and chemical properties of substances at the phase interface.
6. Assess the physical and chemical properties of dispersed systems.
7. Assemble simple setups for conducting laboratory research; use physical and chemical equipment.
8. Tabulate experimental data, present them graphically, interpolate, extrapolate to find the desired values.
9. Measure the physical and chemical parameters of solutions.
10. Interpret and evaluate research results, calculate physicochemical characteristics based on experimental data.
11. Conduct elementary statistical processing of experimental data in chemical experiments.
12. Analyze, systematize and generalize the information received from the educational literature and additional sources, concisely express your thoughts when preparing reports and statements.
13. Use educational literature and additional sources of information (the Internet, bibliographic and electronic resources).

Own:

1. Physicochemical terminology and conceptual apparatus.
2. Skills in interpreting calculated values of thermodynamic functions and on their basis predict the possibility of implementation and the direction of chemical processes.
3. Skills in calculating the quantitative characteristics of solutions (for the preparation of various systems, for analysis or based on experimental data), kinetic characteristics reactions.
4. Technique of chemical experiments; skills in working with chemical glassware and simple devices.
5. Skills in preparing true solutions, buffer systems and colloidal solutions.
6. Techniques for working with physical devices used for high-quality and quantitative analysis (photocolorimeter, pH meter, ion meter, calorimeter, cryoscope, hydrometer, Beckmann thermometer, stalagmometer).
7. Methods of processing text and graphic information.
8. Basic technologies for information transformation: text reactors; Internet technology.

4. **Course prerequisites:** General and inorganic chemistry, organic chemistry
5. **Course prerequisites:** Biological chemistry, Normal physiology, Analytical chemistry, pharmacology , pharmaceutical chemistry; toxicological chemistry, biotechnology;

6. Scope of the discipline and types of academic work

Type of academic work		Total hours	Semesters
			1
Classroom activities (total)		30	1
Including:			
Lectures		15	
Practical classes (PZ)		8	
Laboratory exercises (LL)		7	
Seminars (C)			
Independent work (total)		30	
Including:			
Coursework			
Test			
Type of midterm assessment (test, exam)		differential offset	
Total labor intensity:	watch	60	1
	credit units		

7. Lecture and independent work topics

No.	Name of sections/topics of the discipline	Number of hours	Compet.	Expected results
1	**Lecture No. 1** Subject, objectives and methods of physical chemistry .	2	PC-1 PC-33	Knows the basic principles of thermodynamics, thermochemistry; the meaning of thermodynamic potentials (Gibbs and Helmholtz energies); consequences of Hess's law, rules for calculating the temperature coefficient; chemical equilibrium, methods for calculating equilibrium constants;
2	**Lecture No. 2** The second law of thermodynamics. Characteristic functions. Thermodynamics of chemical equilibrium.	2	PC-1- PC-33	Know the essence of the laws of chemical thermodynamics , and Hess's law, to predict, based on the second law of thermodynamics, the direction of spontaneous flow and the characteristics of chemical processes in the human body
3	**Lecture No. 3** Thermodynamics of phase equilibria. Rule Gibbs phase diagrams. State diagrams and binary systems.	2	PC-1 PC-33	Knows the thermodynamics of phase equilibria, the rule Gibbs phases, state diagrams and binary systems.
4	**Lecture No. 4** . Solutions. Colligative properties of solutions.	2	PC-1 PC-33	Knows the basic concepts of solutions and their components, concentration, osmosis, isotonic solution and their relationship, roles in the body's vital functions Understands ways of expressing the concentration of solutions
5.	**Lecture No. 5** Osmosis. Osmotic pressure. Raoult's law and its implications. Cryometry and ebulliometry.	2	PC-1 PC-33	Knows the essence of osmosis, osmotic pressure of isotonic solution and their relationship, roles in the body's vital functions, Raoult's Law, cryometry and ebulliometry.
6	**Lecture No. 6** **Topic:** Buffer solutions and their mechanism of action. Buffer capacity and factors affecting its value. Practical and biological significance of buffer systems.	2	PC-1 PC-33	Knows the basic concepts - acid-base indicators, hydrogen index, buffer systems; Understands the mechanisms of action of the body's buffer systems, their role in maintaining the body's acid-base homeostasis;

	Methods for determining pH.			
7	**Lecture No. 7 Topic:** Kinetics of chemical reactions. Law of mass action for reaction rate. Influence of various factors on reaction rate. Catalysis. Activation energy	2	PC-1 PC-33	Knows the basic concepts of kinetics and can explain the relationships between them; Understands the characteristics of various types of reactions in the body.
8	**Lecture #8:** Photochemical reactions, heterogeneous reactions, in pharmacy. Homogeneous catalysis. Mechanism of catalyst action.	2	PC-1 PC-33	Knows the basic concepts, mechanisms, types of catalysis, the role of promoters, inhibitors, methods for calculating shelf life, half-life of drugs;
9	**Lecture No. 9 Topic:** Thermodynamics of surface phenomena and surface layer. Adsorption. Types of adsorption therapy.	2	PC-1 PC-33	Knows the properties and characteristics of surfactants; the possibilities of using surface phenomena for the preparation of dosage forms;
10	**Lecture #10:** Ion exchange adsorption. Ion exchangers. Classification of ion exchangers. Application of ion exchangers in pharmacy. Chromatographic methods.	2	PC-1 PC-33	Able to measure and determine adsorption values at various phase boundaries, use various types of chromatography to separate and analyze complex mixtures, including medicinal substances
11	**Lecture #11:** Dispersed Systems, Methods of Preparation and Purification. Classification of Dispersed Systems. Methods of Preparation and Purification of Colloidal Solutions.	**2**	PC-1 PC-33	Knows the general properties and classification of dispersed systems, the nature and methods of obtaining colloidal systems; Knows the classification and methods of obtaining dispersed systems and their application in pharmacy differences in the properties of lyophilic and lyophobic colloidal systems; methods for obtaining colloidal systems and methods for purifying such systems from impurities;
12	**Lecture No. 12** Suspensions and their properties.	2	PC-1 PC-33	Able to prepare stable colloidal systems and emulsions and determine the degree of their

	Flotation. Pastes. Foams. Application in pharmacy. Emulsions and methods of preparation. Emulsifiers and their mechanism of action. Application of suspensions and emulsions in pharmacy.			stability, the type of emulsion, the molecular weight of a given polymer,
13	**Lecture #13.** Aerosols and their properties. Classification and production of aerosols. Use of aerosols in pharmacy. Powders and their properties. Flowability	2	PC-1 PC-33	Knows the concept of aerosols and their properties, classification and production of aerosols , use of aerosols in pharmacy.
	Lecture No. 14 The concept of the IUD, classification of IUDs. Swelling and dissolution of the IUD.	2	PC-1 PC-33	Knows how to classify IUDs by structure and their compatibility in the body, the basic properties of high-molecular substances,
15	**Lecture No. 15** Viscosity and osmotic properties of solutions IUDs. Properties of jellies and gels	2	PC-1 PC-33	Knows the fundamentals of phase and physical states of polymers, the possibilities of their changes for use in medicine and pharmacy; factors influencing gelling, swelling, thixotropy, syneresis, coacervation, plastic viscosity, periodic reactions in jellies and gels
	Total:	**30 hours**		

8. Contents of laboratory classes

No.	**Name of sections/topics of the discipline**	**Number of hours**	**Form of control**	**Competence index**	**Expected results**

1	**Lab Session #1:** Safety Rules for Working in a Physical and Colloid Chemistry Laboratory. Determining the Heat of Reaction of Hydrate Formation.	**2**	Oral survey, testing and demonstration of work, submission of reports	PC-1 PC-33	**Able** to handle and work with chemical glassware, laboratory equipment, determine the division value of measuring glassware and work with it, orient and set the sample and weights according to the weighing rule, determine the heat of dissolution of salt and the heat of hydrate formation using calorimetric methods ;
2.	**Laboratory lesson #2.** Observation of the phenomenon of osmosis **.** Osmosis. Osmotic pressure.	**2**	Oral survey, testing and demonstration of work, submission of reports	PC-1 PC-33	**Can** prepare solutions of different concentrations from a sample of a solid substance, by dilution and from a fixed solution **Acquires** skills to characterize the phenomenon of osmosis and its role in the vital activity of organisms.
3.	**Laboratory lesson #3** . Preparation and properties of buffer systems .	**2**	Oral survey, testing and demonstration of work, submission of reports	PC-1 PC-33	**Can determine pH using** colorimetric and electrometric methods **;** Can prepare buffer solutions with given pH values, measure the pH of liquids using colorimetric and potentiometric methods, and carry out measurements
4.	**Lab 4.** The influence of various factors on the rate of a chemical reaction		Oral survey, testing and demonstration of work, submission of reports	PC-1 PC-33	Can describe the course of chemical and biochemical reactions over time using kinetic equations, determine the dependence of reaction rates on the concentration of reagents, temperature, catalysts, pH ; acquires skills of experimental methods for determining the influence of various factors (concentration and temperature) on the rate of chemical reactions
5.	**Laboratory lesson #5.** Production and properties of colloidal solutions Emulsions, their production and properties. Suspensions, their production and properties, foams, aerosols.	**2**	Oral survey, testing and demonstration of work, submission of reports	PC-1 PC-33	Can prepare stable colloidal systems and emulsions and determine the degree of their stability, the type of emulsion, the molecular weight of a given polymer, conductometrically determine the degree and constant of ionization of an electrolyte, the critical concentration of micelle formation, and conduct conductometric titration

6.	**Lab #6:** Surface Phenomena. Adsorption at Mobile and Stationary Phase Boundaries	**2**	Oral survey, testing and demonstration of work, submission of reports	PC-1 PC-33	Knows theoretical principles and evaluates the course of surface phenomena in living organisms.
7.	**Lab #7** IUD swelling. Factors affecting swelling.	**2**	Oral survey, testing and demonstration of work, submission of reports	PC-1 PC-33	Knows safety precautions when working in a chemical laboratory . IUD swelling. Factors affecting swelling.
8.	**Laboratory lesson #8.** Jellies and gels. Coacervation and microencapsulation	**1**	Oral survey, testing and demonstration of work, submission of reports	PC-1 PC-33	Knows safety precautions for working in a chemistry lab. Can prepare jellies and gels. Can prepare reports for lab assignments. Coacervation and microencapsulation
	Total:	**15: 00**			

11. Topics of practical classes

No.	Name of sections, modules, topics and study questions	Number hour.	Form of control	Comp.	Expected results
1.	**Lesson #1 .** Thermochemistry Hess's Law and its Corollaries. Solving Problems Using Hess's Laws	**2**	Oral survey, testing and situational tasks	PC-1 PC-33	**Knowledge of** the fundamental principles of thermodynamics and thermochemistry, chemical equilibrium, and methods for calculating equilibrium constants; ability to use the corollary of Hess's law when solving problems. Can calculate thermochemical problems.
2.	**Lesson #2.** Solutions. Methods for expressing	**2**	Oral survey, testing and	PC-1 PC-33	They can calculate

	solution concentration. Colligative properties of solutions. Raoult's Law. Its Consequences. Calculation Problems		situational tasks		molar, molal concentration , molar concentration of equivalent, mass fraction of dissolved substance, titer of solution and heat effects of chemical reactions; use reference literature on chemistry;
3.	**Lesson No. 3.** Buffer systems. Mechanism of buffer action. pH calculation.	2	Oral survey, testing and situational tasks	PC-1 PC-33	Knows the basic concepts - acid-base indicators, hydrogen index, buffer systems; Understands the mechanisms of action of the body's buffer systems, their role in maintaining the body's acid-base homeostasis; Can calculate pH of solutions.
4.	**Lesson #4.** Basic concepts and laws. The dependence of chemical reaction rate on various factors.	2	Oral survey, testing and situational tasks	PC-1 PC-33	Knows the basic concepts of kinetics and explains the relationships between them; Understands the characteristics of various types of reactions in the body.
5.	**Lesson #5:** Thermodynamics of Surface Phenomena and	2	Oral survey, testing and situational	PC-1 PC-33	Knows the basic concepts of

	Surface Layers. Gibbs Surface Energy and Surface Tension		tasks		surface thermodynamics , Gibbs surface energy, and surface tension. Can solve typical practical problems.
6.	**Lesson #6.** Dispersed systems and their classification. Molecular and optical properties depending on the nature of the reactants.	2	Oral survey, testing and situational tasks	PC-1 PC-33	Knows the general properties and classification of dispersed systems, the nature and methods of obtaining colloidal systems. Can solve typical practical problems.
7.	**Lesson #7** : Structure of a Colloidal Particle. Stability of Colloidal Systems. Coagulation	1			Knows the structure of a colloidal particle, the stability of colloidal systems, and the concept of coagulation .
8.	**Lesson #8.** Swelling of HMCs, their classification, solubility, and properties of their solutions. Stability of HMC solutions. Viscosity and osmotic properties of HMC solutions.	2	Oral questioning, testing and situational tasks, work in small groups	PC-1 PC-33	Knows how to classify IUDs by structure and their compatibility in the body, and is able to solve typical practical problems; - use reference literature on chemistry; **Able to** use chemical terminology, reference materials, electronic databases , the Internet
	Total:	**15:00**			

1 2 . CRITERIA AND RULES FOR KNOWLEDGE ASSESSMENT

Methods of knowledge assessment:

Current control: testing, written/oral survey, programmed control, problem solving, checking the results of assignments, etc., self-assessment and group assessment when working in small groups.

Midterm assessment : testing, written/oral survey, programmed assessment, problem solving.

Final assessment: 4 modules, exam in the second semester (in test and oral form), including questions from the independent work study topics.

The exam assesses competencies such as practical and communication skills, as well as self-improvement. Practical skills are assessed through problem-solving exercises.

Criteria for obtaining the maximum score for completing various types of work:

1. **Practical lesson:**
   - attending a class;
   - preparedness for the lesson;
   - active participation (work in a small group, answering the teacher's questions);
   - calculation of the results of demonstration laboratory work, plotting graphs, and formatting the work according to requirements;
   - analysis of literary sources on the issue under consideration, including regulatory documents;
   - completing a tested task or mapped control (solving problems and answering questions), composing and solving crosswords, puzzles, etc.
2. **Border control**
   - attending a class;
   - execution of tested control;
   - written (oral) answers to questions;
   - problem solving.
3. **SRS**
   - submitting the assignment according to the independent work schedule;
   - making notes;
   - writing an abstract or report, formatting it in accordance with established requirements, and defending it;
   - solving and composing crosswords, puzzles, and problems - correct solutions and appropriate formatting, the ability to explain the solution process and answer the teacher's questions, the ability to complete a similar task;
   - completion of tested control (mapped control), ability to answer teacher's questions on the studied topic of independent work.
4. **Final control**
   - all tasks were completed correctly;
   - the answer entry is complete, correct, and presented in the required logical sequence;
   - the student explains each action, indicates units of measurement of physical and chemical quantities;
   - the student knows the basic concepts and formulas of the topic and can apply them to solve non-standard problems;
   - the student skillfully uses the knowledge gained during the study of all topics of the course, as well as other disciplines;
   - thoroughly reveals the state of the issue, its theoretical and practical aspects;
   - the student has his own evaluative position on the issue being addressed and is able to present it in a reasoned and convincing manner;
   - complete and well-founded solution of problems, freely navigates the chemical properties of substances, confidently formulates chemical reactions.

Module control scores

Percentage content %	Assessment according to the traditional system
87-100	GREAT
74-86	FINE
61-73	SATISFACTORILY
0-60	UNSATISFACTORY

I. Chemical Laboratory Safety Rules and Procedures. Introduction with chemical glassware

Working in a chemical laboratory inevitably involves a number of hazardous and harmful factors. Certain rules must be followed to ensure safety. Inappropriate or careless handling of chemical reagents and equipment can lead to accidents.

The chemistry lab is equipped with special workbenches, cabinets, and shelves for reagents, glassware, and solutions. Fume hoods are available for working with toxic volatile substances. The lab is supplied with running water and sewerage.

Furniture and equipment are arranged so that passages between tables and the exit from the laboratory are always clear to ensure the rapid evacuation of people in emergency situations.

A chemical laboratory must have fire safety equipment and a first aid kit.

1. General rules of conduct in the laboratory

2. Students complete laboratory work during the time specified in the class schedule. Working in the laboratory outside of the designated time is strictly prohibited without the instructor's permission.
3. You should never work alone in the laboratory.
4. Visits by outsiders to students working in the laboratory, as well as distraction of students with extraneous work and conversations, are prohibited.
5. Order and silence must be maintained in the laboratory. Noise and extraneous conversations are distracting and can lead to errors.
6. Outside clothing is not permitted in the laboratory. A lab coat that fastens in the front must be worn, and a towel must be carried. **Students without a lab coat will not be allowed to work** .
7. It is strictly forbidden to eat or drink water in the laboratory.
8. It is prohibited to conduct any experiments that are not provided for in the practical program, to bring your own reagents, or to take reagents out of the laboratory.
9. You can begin performing laboratory work after carefully studying the methodology and rules for working with the devices.
10. The work desk should be stocked with the necessary reagents, equipment, glassware, and a work log. The desk surface should be clean and dry. Avoid cluttering the desk with items such as briefcases, bags, and other objects.
11. While working, avoid rushing or fussing. Haste, disorder, and sloppiness lead to failures and sometimes even accidents. If you encounter any difficulties while working, seek advice from a lab assistant or instructor.
12. When performing laboratory work, all operations must be performed above the table.
13. After finishing work, wash dishes, unplug electrical appliances, turn off the water, tidy up your workspace, and hand it over to the lab technician. Paper, used filters, trash, and broken glassware should be disposed of in the trash can, never in the sink. Any violations of the rules (broken glassware, spoiled reagents, etc.) should be reported to the instructor or lab technician.
14. It is prohibited to work in the laboratory in the absence of a teacher or laboratory assistant, as well as to perform experimental work in the laboratory that is not related to the implementation of the educational practical course.
15. When working with alcohol and other flammable substances, unexpected ignition of vapors is possible. The quantities of these substances in the workshop are limited.
16. Do not connect unknown devices to laboratory sockets.
17. It is prohibited to carry switched-on devices.

1. Rules for working with chemical reagents

In the laboratory, jars and vials containing reagents are stored in a special cabinet. Toxic, volatile, and flammable substances in quantities required for a working day are placed in a fume hood. Vials containing solutions of substances that do not decompose under the influence of light can be placed on open shelves.

When working with chemical reagents, it is necessary to follow a number of rules. Failure to do so may result in poisoning, burns, eye or respiratory damage, and other adverse effects (damage to equipment, clothing, and personal belongings).

1. Under no circumstances should you taste the reagents.
2. You should sniff reagents only if necessary and very carefully.
3. Handling solid reagents is unacceptable. Use a clean, dry spatula. Any reagent accidentally spilled on the table will inevitably become contaminated and should not be poured back into the jar.
4. Liquid reagents, such as various solutions, are poured using a funnel.
5. Reagents should be used sparingly.
6. Do not confuse stoppers and lids from bottles and jars, as this will lead to contamination of the reagents.
7. Experiments with caustic, poisonous, and strong-smelling substances are carried out in a fume hood.

Particular care is required when working with concentrated acid and alkali solutions, which can cause severe, poorly healing chemical burns. Certain solutions, such as chromium mixture, which contains concentrated sulfuric acid, also pose a similar hazard.

1. If concentrated acid spills on the floor, it should be immediately covered with sand, collected and removed from the room, and the spilled area should be treated with a soda solution.
2. Concentrated acid solutions should not be poured down the drain. Used acids should be diluted, neutralized with baking soda, and the neutral solutions can then be flushed down the drain.
3. To avoid splashing, pour acid and alkali solutions by placing the flask directly over the vessel. Use a funnel when pouring solutions. If solutions accidentally spill on the table, they must be cleaned up immediately.
4. When sampling acid and alkali solutions, they should be collected into a pipette using a bulb syringe.
5. After finishing work, dishes must be thoroughly washed and rinsed with distilled water. **Wash dishes after finishing work, not before starting!**

2. Working with mercury thermometers

Mercury and alcohol thermometers are used in chemistry laboratories. Particular care should be taken when handling mercury thermometers, particularly the Beckmann thermometer, which contains a large amount of mercury. All handling of the Beckmann thermometer should be performed over a special tray so that the mercury can be easily collected if the thermometer breaks.

Mercury is an extremely volatile liquid. If a thermometer breaks, tiny beads of mercury scatter throughout the room, getting into the smallest cracks and hard-to-reach places. Spilled mercury is very difficult to clean up completely. Even small amounts, trapped in cracks as tiny droplets, often invisible to the naked eye, evaporate rapidly, quickly creating dangerous vapor concentrations in a confined space.

Metallic mercury vapor, like most of its chemical compounds, is extremely toxic. Even at concentrations hundreds or thousands of times higher than the maximum permissible limit, mercury vapor is odorless, colorless, and does not immediately irritate. Even breaking a single mercury thermometer in a small room without thorough demercurization is enough to cause mercury poisoning to those working in the area over time.

If mercury is spilled on furniture, appliances or the floor, you should immediately stop work and begin cleaning it up, which includes the following steps.

1. Collect visible drops of mercury in a special bottle using a rubber bulb or a cotton swab lubricated with a hydrophobic lubricant (oil).
2. Do not pour collected mercury down the drain!
3. Treat the spill site with a 20% solution of iron (III) chloride and leave until completely dry.
4. After 1-2 days, wash the surface thoroughly with a detergent solution and then with clean water.

3. Providing first aid in case of accidents

Students are required to know first aid measures in case of accidents:

1. For minor thermal burns, cool the affected area under running tap water. For larger thermal burns, cover with sterile gauze. Do not break any blisters.
2. For chemical burns caused by acids, wash the affected area with plenty of running water and then with a 1–2% solution of $NaHCO_3$ (baking soda).
3. If drops of acid get into your eyes, rinse them with running water for 15–20 minutes, then with a 1% $NaHCO_3$ solution.
4. For alkali burns, wash the affected area with plenty of running water, and then with a 1% solution of acetic or citric acid.
5. If your eyes are damaged by alkalis, rinse them with running water for 15–20 minutes and then rinse with a 2% boric acid solution.

If your eyes are affected by chemicals, consult a doctor immediately after rinsing thoroughly.

6. For burns to the mouth or stomach, drink plenty of water. For acid burns, drink a chalk suspension; for alkali burns, drink a diluted solution of vinegar or citric acid.
7. To stop bleeding, treat minor injuries and cuts with hydrogen peroxide solution and apply a thin layer of BF-6 glue or antibiotic collodion with a glass rod. After 1–2 minutes, a strong, elastic film will form, protecting the wound from infection.
8. In case of gas poisoning, remove the victim to fresh air. Perform artificial respiration only if necessary.

Practical lesson #1

Topic: Elements of chemical thermodynamics and bioenergetics

Objective of the lesson: Acquire knowledge about the basic concepts of chemical thermodynamics, the principles of thermodynamics and the thermodynamic laws of processes occurring in the body.

Teaching methods: Combined:

- conversation – joint discussion of discipline policy and safety regulations for the purpose of general scientific competence;
- oral and/or written survey;
- work in small groups (when completing and processing the results of solving situational problems).

Methodological support: Presentation (slides), cards, diagrams, periodic table of chemical elements, tables, didactic material, calculator, projector, table of standard thermal effects of some substances.

Theoretical part

The primary source of energy on Earth is the Sun. During photosynthesis in green plants, solar energy is converted into the energy of the chemical bonds of organic matter. Plants can lose some of the absorbed solar energy as heat.

Life processes on Earth are largely determined by **the accumulation of solar energy** in biogenic substances—proteins, fats, carbohydrates—and the subsequent transformation of these substances in living organisms, **releasing energy.** Chemical transformations and energy processes in the body are interconnected. The energy released during life processes is determined by the oxidation of food products by atmospheric oxygen inhaled by humans.

The science of thermodynamics studies the interconversion of heat and energy .

Open systems , which include living cells, exchange both matter and energy with their environment. **Closed systems** do not exchange matter with their environment, but they can exchange energy. An example of a closed system is a closed glass vessel filled with a gas. Energy is transferred through the vessel walls.

An isolated system exchanges neither matter nor energy with its environment. A Dewar flask, used in a thermos and in this lab, is an approximation of an isolated system.

The section of thermodynamics that studies energy conversion during chemical reactions is called chemical thermodynamics.

The section of chemical thermodynamics that studies the thermal effects of chemical reactions is called thermochemistry .

Chemical reactions during which the enthalpy of the system decreases (**ΔH<0**) and heat **Q is released into the external environment** are called **exothermic** .

Reactions as a result of which the enthalpy increases (**ΔH>0**) and the system absorbs heat **Q** are called **endothermic.**

Enthalpy is a function of state whose increment is equal to the heat received by the system in an isobaric process:

$$\Delta H = Q_p$$

Reaction equations that specify the enthalpy or heat of the process are called thermochemical equations. In such equations, an increase in enthalpy and the heat absorbed are denoted by the "+" sign; a decrease in enthalpy and, in fact, the heat released are denoted by the "-" sign. For example, the oxidation of glucose by oxygen in the human body occurs with the release of a large amount of heat (ΔH = –2800 kJ/mol), i.e., it is an exothermic process. The corresponding thermochemical equation is written as:

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O + 2800\ kJ\ or$$
$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O, \Delta H = -2800\ kJ/mol$$

, the Russian chemist **Herman Ivanovich Hess** formulated a fundamental law that bears his name. G.I. Hess measured the heat of various chemical reactions using calorimeters; a diagram of one is shown below, in the description of the laboratory work. Currently, **Hess's law** is formulated as follows:

The increase in enthalpy during the formation of products from given reagents at constant pressure does not depend on the number and type of reactions that result in the formation of these products, but depends only on the state of the final and initial substances.

An example that explains Hess's law is the combustion of carbon, which can be carried out in different ways:

1 path – in one stage: $C + O_2 \rightarrow CO_2, \Delta H_1$

2nd path – in two stages: *a)* $C + {}^1/_2 O_2 \rightarrow CO, \Delta H_2$

b) $CO + {}^1/_2 O_2 \rightarrow CO_2, \Delta H_3$

According to Hess's law: $\Delta H_1 = \Delta H_2 + \Delta H_3$.

Hess's law and its corollaries find practical application in medicine. They are used to estimate the caloric content of foods.

The calorific value is the enthalpy of combustion of 1 g of a substance, taken with the opposite sign. It is expressed in kJ/g or kcal/g (1 cal = 4.18 J).

The main components of food are proteins, fats and carbohydrates.

Calorie coefficients:

- proteins 16.5 – 17.2 kJ/g;
- carbohydrates 16.5 – 17.2 kJ/g;
- fats 37.7 – 39.8 kJ/g.

To calculate the caloric content of a portion of food containing proteins (m_b), carbohydrates (m_y) and fats (m_f), use the formula:

$$K_{min} = (m_b \cdot 16.5 + m_y \cdot 16.5 + m_f \cdot 37.7)\ \text{kJ}$$
$$To_{max} = (m_b \cdot 17.2 + m_y \cdot 17.2 + m_f \cdot 39.8)\ \text{kJ}$$

Based on food calorie data, scientifically based nutrient intake standards are developed for various population groups based on gender, age, and occupational type. Using these values as averages, the physician calculates nutrient intake standards for each individual patient.

Questions for independent preparation

1. Thermodynamics. Basic concepts and terms. System. Phase. Classification of systems. Thermodynamic parameters. Standard thermodynamic parameters.
2. Thermodynamic functions of the system's state. Internal energy. The first law of thermodynamics, formulation, mathematical expression, philosophical significance, and application to biological systems.
3. Thermodynamic functions of the system's state. Enthalpy. Entropy. Gibbs energy. Chemical potential.
4. Thermochemistry. Thermochemical equations and their properties. Hess's law. Enthalpies of formation and combustion. Standard enthalpies of formation and combustion. Consequences of Hess's law, formulations, mathematical expressions, and examples.
5. The concept of the caloric value of food. Caloric values of the main food components: proteins, fats, and carbohydrates.

Examples of solutions to typical problems

1. Calculate $\Delta H^0_{x.p}$ the chemical reaction

$$Na_2O(т) + H_2O(ж) \rightarrow 2NaOH(т)$$

based on the values of standard enthalpies of formation of substances ΔH° (Appendix 2). Indicate the type of reaction (exothermic or endothermic).

Solution : According to the data **(Appendix 1),** the standard enthalpies of formation

$Na_2O(т)$, $H_2O(ж)$ And $NaOH(т)$ at 298 K are equal to –416, –286, and –427.8 kJ/mol, respectively. Using the corollary of Hess's law, we calculate $\Delta H^0_{x.p}$ the chemical reactions:

$$\Delta H^0_{x.p} = 2\Delta H^0_f(NaOH) - [\Delta H^0_f(Na_2O) + H^0_f(H_2O)]$$
$$2(–427.8) – [–416 + (–286)] = –153.6\ \text{kJ}.$$

The reaction is exothermic since $\Delta H^0_{x.p.} < 0$.

Answer: –153.6 kJ .

2. Determine how entropy changes during a chemical process $Na_2O(т) + H_2O(ж) \rightarrow 2NaOH(т)$.

Solution : In this process, when 1 mole of a crystalline substance and 1 mole of a liquid substance interact, 2 moles of a crystalline substance are formed, therefore, the system goes into a state with less disorder and the entropy decreases ($\Delta S < 0$).

Answer: decreases .

3. Calculate the value $\Delta S^0_{x.p}$ for the process

$$Na_2O(т) + H_2O(ж) \rightarrow 2NaOH(т),$$

using the values of standard entropies of substances.

Solution: Using reference data $S^0(NaOH) = 64{,}16\ Дж/(моль \cdot K)$,

$$S^0(Na_2O) = 75{,}5\ Дж/(моль \cdot K),\ S^0(H_2O) = 70\ Дж/(моль \cdot K),$$

we calculate ΔS^0_{298}:

$$\Delta S^0_{298} = 2 \cdot S^0(\text{NaOH}) - [S^0(\text{Na}_2\text{O}) + S^0(\text{H}_2\text{O})] =$$
$$2 \cdot 64.16 - (75.5 + 70) = -17.18 \text{ J/K}.$$

Answer: entropy decreases. $\Delta S^0_{\text{x.p}} = -17.18$ J/K.

4. Calculate the change in Gibbs energy (ΔG^0_{298}) for the process $\text{Na}_2\text{O}(\text{т}) + \text{H}_2\text{O}(\text{ж}) \rightarrow 2\text{NaOH}(\text{т})$ using the standard Gibbs energies of formation of the substances. Is spontaneous reaction possible under standard conditions and 298 K?

Solution : Under standard conditions ($T = 298$ K) ΔG^0_{298} can be calculated as the difference between the total Gibbs energy of formation of the reaction products and the total Gibbs energy of formation of the starting materials, taking into account the stoichiometric coefficients.

Required reference data: $\Delta G^0_f(\text{NaOH}) = -381{,}1$ кДж/моль.

$$\Delta G^0_f(\text{Na}_2\text{O}) = -378 \text{ kJ/mol}, \Delta G^0_f(\text{H}_2\text{O}) = -237 \text{ kJ/mol}$$
$$\Delta G^0_{298} = 2 \cdot \Delta G^0_f(\text{NaOH}) - [\Delta G^0_f(\text{Na}_2\text{O}) + \Delta G^0_f(\text{H}_2\text{O})] =$$
$$= 2 \cdot (-381.1) - [-378 + (-237)] = -147.2 \text{ kJ}.$$

The value ΔG^0_{298} is negative, so spontaneous reaction is possible in the forward direction.

Answer: possible; –147.2 kJ.

5. Determine whether spontaneous reaction is possible at 95 $\text{Na}_2\text{O}(\text{т}) + \text{H}_2\text{O}(\text{ж}) \rightarrow 2\text{NaOH}(\text{т})$ °C. Justify your answer by calculating the change in Gibbs free energy at this temperature.

Solution: Convert the temperature to the Kelvin scale:

$T = 273 + 95 = 368$ K.

To calculate ΔG^0_{368} we will use the equation $\Delta G^0_{368} = \Delta H^0 - T\Delta S^0$.

We use the enthalpy and entropy changes calculated for this process in the previous problems. However, the entropy change must be converted from J/K to kJ/K, since the values of ΔH and ΔG are usually measured in kJ, i.e. $-17{,}18$ Дж/К $= -0{,}017\,18$ кДж/К

$$\Delta G^0_{368} = -153{,}6 - 368(-0{,}017\,18) = -147{,}3 \text{ кДж}.$$

Thus, $\Delta G^0_{368} < 0$, therefore spontaneous occurrence of this process at 95 °C is possible.

Answer: possible; –147.3 kJ.

Tasks for independent solution

1. Calculate ΔH^0_{298} the chemical reaction

$$2\text{Al}_2\text{SO}_4(\text{т}) \rightarrow 2\text{Al}_2\text{O}_3(\text{т}) + 6\text{SO}_2(\text{г}) + 3\text{O}_2(\text{г})$$

based on the values of the standard heats of formation of substances. Indicate the type of reaction (exothermic or endothermic).

2. Calculate ΔH^0_{298} the chemical reaction

$$\text{NH}_4\text{Cl}(\text{т}) \rightarrow \text{NH}_3(\text{г}) + \text{HCl}(\text{г})$$

Based on the values of standard heats of formation of substances, indicate the type of reaction (exothermic or endothermic).

3. Calculate ΔH^0_{298} the chemical reaction

$$2\text{CC}_4(\text{г}) \rightarrow \text{C}_2\text{H}_4(\text{г}) + 2\text{H}_2(\text{г})$$

based on the values of standard heats of formation of substances. Indicate the type of reaction (exothermic or endothermic).

4. Using the values of standard heats of formation of substances, calculate ΔH^0_{298} the chemical reaction

$$4\text{Fe}(\text{т}) + 3\text{O}_2(\text{г}) \rightarrow 2\text{Fe}_2\text{O}_3(\text{т})$$

Specify the type of reaction (exothermic or endothermic).

5. Determine how entropy changes during a chemical process $\text{BaCO}_3(\text{т}) \rightarrow \text{BaO}(\text{т}) + \text{CO}_2(\text{г})$.

6. Determine how entropy changes during a chemical process $4\text{Fe}(\text{т}) + 3\text{O}_2(\text{г}) \rightarrow 2\text{Fe}_2\text{O}_3(\text{т})$.

7. Determine how entropy changes during a chemical process $2CC_4(г) \rightarrow C_2H_4(г) + 2H_2(г)$.

8. Using the values of standard entropies of substances, calculate the value ΔS^0_{298} for the process

$$2Al_2(SO_4)_3(т) \rightarrow 2Al_2O_3(т) + 6SO_2(г) + 3O_2(г),$$

9. Using the values of standard entropies of substances, calculate the value ΔS^0_{298} for the process

$$NH_4NO_3(т) \rightarrow N_2O(г) + 2H_2O(ж),$$

10. Using the values of standard entropies of substances, calculate the value ΔS^0_{298} for the process

$$2SO_2(г) + O_2(г) \rightarrow 2SO_3(г),$$

11. Using the values of the standard Gibbs energies of formation of substances, calculate the change in Gibbs energy ΔG^0_{298} for the process

$$2Al_2(SO_4)_3(т) \rightarrow 2Al_2O_3(т) + 6SO_2(г) + 3O_2(г)$$

Is it possible for the reaction to proceed spontaneously under standard conditions and 298 K?

12. Calculate the change in Gibbs energy ΔG^0_{298} for the process $BaCO_3(т) \rightarrow BaO(т) + CO_2(г)$ using the standard Gibbs energies of formation of the substances. Is spontaneous reaction possible under standard conditions and 298 K?

Laboratory lesson #1
Topic: Determination of the heat of neutralization reaction

Purpose of the work. Determine the heat of reaction of neutralization of an acid (base) with a base (acid) solution. Learn how to prepare solutions of given molar and normal concentrations from a solid and by dilution.

Theoretical part

Neutralization reactions, like most combustion and oxidation reactions, are accompanied by the release of heat.

The heat of neutralization is the amount of heat released during the interaction of a mole equivalent of an acid with a mole equivalent of a base.

The law of constant heat of neutralization, which follows from Hess's law, is well known. When neutralizing aqueous solutions of strong acids with strong bases at temperatures close to 20°C, the same amount of heat is always released, equal to 57.3 kJ per 1 mole equivalent of acid or base .

The constancy of the heat (enthalpy) of neutralization is explained by the fact that the neutralization reaction involves the interaction of hydrogen ions with hydroxide ions to form water molecules. Thus, the neutralization reaction of sodium hydroxide with hydrochloric acid is described by the equations:

$$NaOH + HCl = NaCl + H_2O + 57.3\ kJ$$

$$Na^+ + OH^- + H^+ + Cl^- = Na^+ + Cl^- + H_2O + 57.3\ kJ$$

$$H^+ + OH^- = H_2O + 57.3\ kJ$$

$$(\Delta H = -57.3\ kJ / mol)$$

Strong acids and bases dissociate almost completely. Regardless of the specific strong acids and bases used, neutralization always results in the formation of water from H^+ and OH^- ions . Experiments have shown that the formation of 1 mole of water from these ions at room temperature releases 57.3 kJ.

When neutralizing a weak acid with a strong base or, conversely, a strong acid with a weak base, the thermal effect deviates from 57.3 kJ/mol in either direction. For example, the thermal effect of neutralizing hydrofluoric acid with potassium hydroxide is –66.9 kJ/mol, while that of hydrocyanic acid (HCN) with sodium hydroxide is –53.9 kJ/mol. The deviation from 57.3 kJ/mol depends on the magnitude and sign of the thermal effect of dissociation of the weak electrolyte involved in the neutralization reaction.

The heat of electrolytic dissociation is the amount of heat absorbed or released during dissociation of 1 mole of electrolyte into ions.

Neutralization of, for example, a weak acid with sodium hydroxide

$$HA + NaOH = NaA + H_2O\ (\Delta H_{neutralization})$$

can be written in two stages as follows:

$$HA = A^- + H^+\ (\Delta H_{dissociation})$$

$$H^+ + OH^- = H_2O\ (\Delta H = -57.3\ kJ/mol)$$

According to Hess's law

$$\Delta H_{neutralization} = \Delta H_{dissociation} + \Delta H,$$

or

$$\Delta H_{neutralization} = \Delta H_{dissociation} - 57.3\ kJ/mol.$$

Thus, having experimentally determined the thermal effect of the neutralization reaction of a weak acid with a strong base, one can calculate the heat (enthalpy) of dissociation of the weak acid. Similarly, one can determine the heat (enthalpy) of dissociation of a weak base.

A neutralization reaction occurs, for example, in the human body when medications with an alkaline reaction (such as a dilute $NaHCO_{3\ solution}$) are taken with increased gastric acidity. The hydrolysis of an aqueous solution of sodium bicarbonate creates an alkaline reaction:

$$NaHCO_3 + H_2O \leftrightarrow H2CO3 + NaOH$$

$$Na^+ + HCO_3^- + HOH \leftrightarrow Na^+ + OH^- + H_2CO_3$$

$$HCO_3^- + HOH \leftrightarrow OH^- + CO_2 + H_2O.$$

The resulting hydroxide ions neutralize the hydrogen ions of the gastric juice: $OH^- + H^+ \rightarrow H_2O.$

Carrying out calorimetric measurements

The experimental determination of the thermal effect is carried out in a special device - a calorimeter, which is a Dewar flask with a Beckmann thermometer fixed in it (see the instructions for using the Beckmann thermometer).

To perform a neutralization reaction, solutions of an acid and a base with a fivefold difference in concentration are used at the same temperature (room temperature). The volumes of the solutions used for the reaction must comply with the law of equivalents. A 500-mL Dewar flask allows for the use of 250 mL of a less concentrated electrolyte solution and 50 mL of a more concentrated one. In this case, the substances are used in equivalent quantities. The amount of each electrolyte in the solution is calculated using the formula:

$$n = C_н \cdot V$$

where C_n – concentration, mol-eq/l, V – volume of solution, l.

The neutralization reaction carried out in a Dewar flask is accompanied by the release of heat, which leads to heating or cooling of the entire system. The temperature change Δt resulting from the chemical reaction is recorded using a Beckmann differential thermometer.

A Beckmann thermometer set to the required temperature is placed in the calorimeter. Temperature changes due to heat exchange with the surrounding environment are recorded at regular intervals (usually 30 seconds). Once the temperature changes become uniform, recordings are continued for another 2-5 minutes. This is the preliminary period. Then, without ceasing to monitor the temperature, the process being studied is carried out in the calorimeter. Over time, the temperature changes quite sharply. This is the main period. The end of the main period and the beginning of the final period are considered to be the establishment of a uniform temperature change. In the final period, the temperature is recorded in the same way as in the preliminary period, for 2-5 minutes. To calculate the exact temperature change during the process being studied, a graph is drawn on graph paper, with time plotted on the x-axis and the corresponding temperature values on the y-axis. Omitting recorded times and corresponding temperature values is not permitted .

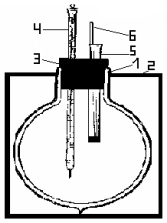


Fig. 1. Calorimeter diagram
1 - Dewar vessel
2 – tripod
3 – plug with holes
4 – Beckmann thermometer or mercury thermometer with a division value of 0.1 °C
5 – glass tube closed with a stopper
6 – glass rod

Beckmann thermometer and how to use it

The Beckmann thermometer (metastatic) is designed to measure small temperature differences in various absolute temperature ranges (Fig. 3a). The thermometer's scale is 25°C long 30 смand graduated in increments of only 5°C (sometimes 2 or 6°C). Consequently, temperature differences can be measured with sufficient accuracy—up to $2 \cdot 10^{\circ}$ C.

The thermometer has two mercury reservoirs: a lower (main) and an upper (spare) reservoir. The device's unique feature is that the amount of mercury in the lower reservoir can be adjusted to suit the measurement range. For measurements at high temperatures, some mercury can be transferred from the main reservoir to the spare (upper) reservoir. For measurements at low temperatures, the opposite is true: mercury is transferred to the main (lower) reservoir. By transferring some mercury from the upper reservoir to the lower one or adding more from the upper to the lower one, the thermometer can be adjusted so that the mercury column is at the desired point on the scale.

The neutralization reaction is accompanied by an increase in temperature, so the thermometer is adjusted so that the mercury level is at the bottom of the scale.

The Beckman thermometer is set to the required temperature as follows.

1. Water is heated in a glass to a temperature 5 °C above room temperature, the temperature is measured using a regular mercury or alcohol thermometer.

2. The mercury in both chambers of the Beckmann thermometer is brought into contact. To do this, warm the lower chamber with your hand. The mercury expands and rises through the capillary, filling it completely. If warming with your hand is insufficient, you can immerse the lower chamber in warm water.

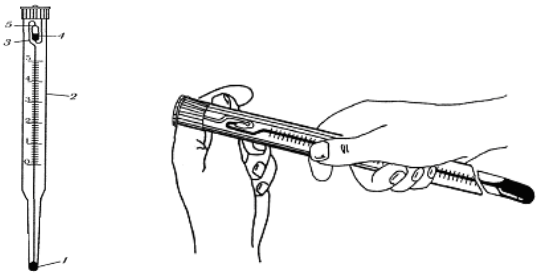
3. Turn the thermometer upside down and, holding it in an inclined position, achieve the merging of the mercury in the reserve reservoir with the column in the capillary (Fig. 3.b).

4. Carefully, so as not to break the mercury, return the thermometer to the vertical position.

5. The lower reservoir is immediately immersed in a pre-prepared glass of water at the required temperature. The thermometer is held in this position for 5 minutes.

6. Remove the thermometer from the water. Holding it firmly in the middle with one hand, vigorously strike the hand holding the thermometer against the other, causing the mercury column to rupture.

7. The thermometer is again immersed in water at the required temperature to ensure that the amount of mercury in the capillary is sufficient to carry out the experiment.



a) b)

Fig. 2. Beckmann thermometer: a) general appearance; b) thermometer settings.

When working with the Beckman thermometer, the following safety precautions must be observed:

1. All handling of the thermometer should be done only over a table (preferably over a tray). Do not carry the thermometer around the laboratory, and do not wash the lower reservoir over the sink.

2. Avoid applying significant force to the thermometer. Attach it to the stand and insert it into the calorimeter cap carefully.

3. The adjusted thermometer cannot be placed on the table; it can only be kept in a vertical position, installed in a tripod.

4. After using the thermometer, rinse its lower part with distilled water over a glass and gently wipe it with filter paper. Return the thermometer to its case. It is also recommended to store the thermometer upright to prevent excess mercury from flowing into the upper reservoir.

Experimental part

Reagents . A solution of a strong acid (H_2SO_4 , HCl , or HNO_3 – as directed by the teacher), a solution of acetic acid (CH_3COOH), and a solution of an alkali (NaOH or KOH) . The concentrations of the acid and alkali solutions should differ by a factor of five.

Equipment and glassware: Device for determining thermal effects (calorimeter), mercury thermometer for 50-100 °C, measuring flasks of 250 ml and 50 ml, 2 glass funnels (for acid and alkali), heat-resistant beaker or heat-resistant flask of 200-250 ml (for heating the water necessary for setting the Beckmann thermometer), electric stove.

Completing the work.

1. Assemble the calorimeter as shown in Fig. 1.

2. **A 0.1 N solution of a strong acid (or alkali)** is poured into a 250 ml measuring flask . A 50 ml solution of a **0.5 N** solution of an alkali (or acid, respectively) is poured into a 50 ml measuring flask .

3. 250 ml of a 0.1 N solution is added to the calorimeter. The Dewar flask is sealed with a stopper with two holes. One hole is for the thermometer, the other for the subsequent addition of a solution with a higher concentration.

4. Insert the thermometer into the calorimeter plug.

5. The temperature is read every 30 seconds until it becomes uniform or until a constant temperature is reached (at least 5 identical readings). The temperature readings are recorded in Table 1 (see below).

6. Quickly pour 50 ml of 0.5 N solution through the glass tube in the calorimeter stopper, seal the tube, and stir the solution. Continue timing and recording the temperature every 30 seconds. The temperature rises during the neutralization reaction. If, for any reason, the temperature reading is not taken, a dash is added to the record. The temperature rise accompanying the neutralization reaction is the key period in the experiment. It continues until a uniform temperature trend is established.

7. When a uniform temperature trend is observed (or a constant value is established) for two minutes, the experiment is stopped.

8. The experiment is repeated in exactly the same way using a weak acid solution. The obtained values are recorded in Table 1.

Temperature change during the experiment

Table 1.

Time, min	Temperature values		
	preliminary period	main period	final period

Report design:

Security questions

1. What safety precautions must be followed during laboratory work?
2. How to use chemical reagents?
3. First aid in case of accidents in a chemical laboratory.
4. What kind of chemical glassware is used to conduct experiments?
5. How to use mercury thermometers?
6. What is the primary source of energy for all living organisms? What is this energy converted into?
7. Which reactions are called exothermic and endothermic? Give examples of such reactions in the human body.
8. Formulate Hess's law and explain it using a specific example.
9. What is called heat of neutralization?
10. Formulate the law of constant heat of neutralization. To which electrolytes is it applicable, and for which electrolytes is it not observed, and why?

Practical lesson #2

Subject: Theory of Solutions. Colligative Properties of Solutions

Objective of the lesson: To summarize knowledge about electrolyte and non-electrolyte solutions, their colligative properties, and to understand their role in the body's vital functions. To learn how to perform

quantitative calculations for the preparation of solutions of various concentrations necessary for the analysis of biological samples .

Teaching methods: Combined:

- conversation – joint discussion of the theory on the topic;
- oral and/or written survey;
- work in small groups;
- solving tests and problems;

Methodological support: Presentation (slides), cards, diagrams, tables, PSHE, solubility table, test questions, multimedia.

Theoretical part

A solution is a homogeneous system consisting of two or more components whose relative amounts can vary widely . In a true solution, the dissolved substances are uniformly distributed as molecules or ions in the solvent. The solvent is usually defined as the component that exists in its pure form in the same state of aggregation as the resulting solution. For example, in the case of a solution of salt in water, the solvent is water.

A solution that is in equilibrium with the solute under given conditions is called **a saturated solution** . It contains the maximum possible amount of solute at a given temperature.

A solution in which the solubility limit is not reached under given conditions is called **unsaturated.** The concentration of the dissolved substance in it is less than in a saturated solution.

A solution that contains a greater amount of dissolved substance at a given temperature than a saturated solution is called **supersaturated** . Such systems are metastable, i.e., in the absence of external influences, they can remain unchanged for a fairly long time, but when, for example, a small crystal of a dissolved substance is introduced, all of its excess in the solution quickly precipitates, the solution enters a stable state and becomes saturated.

Methods of expressing the concentration of solutions

The concentration of a solution is the ratio of the mass or amount of a dissolved substance to a specific mass or volume of a solution or solvent.

1. **The mass fraction of a solute in a solution** ω is the ratio of the mass of the solute to the mass of the solution. It can be expressed as a fraction of a unit (formula 1.1) or as a percentage (formula 1.2).

$$\omega = \frac{m_{р.в-ва}}{m_{р-ра}} \quad (1.1)$$

The mass fraction of a dissolved substance, expressed as a percentage, is called the percent concentration. Percent concentration indicates how many grams of a substance are contained in 100 г а solution. For example, a 15% solution is one that 100 г contains a 15 15 г% substance.

$$\omega = \frac{m_{р.в-во}}{m_{р-ра}} * 100\% \quad (1.1a)$$

2. Molal concentration (molality ***)*** C_m is the amount of dissolved substance (*mol*) contained in a unit mass of solvent (*kg*).

$$C_m = \frac{n_{р.в-ва}}{m_{р-ля}} \quad (1.2) \quad [C_m] = моль/кг.$$

3. Molar concentration (molarity) C_M is the amount of dissolved substance (*mol*) contained in a unit volume of solution (*l*).

$$C_M = \frac{n_{в-ва}}{V_{р-ра}} \quad (1.3) \quad [C_M] = моль/л = M.$$

Taking into account $n_{в-ва} = \frac{m_{в-ва}}{M_{в-ва}}$, formula (1.3) takes the form

$$C_M = \frac{m_{в-ва}}{M \cdot V_{р-ра}} \quad (1.4),$$

where *m* is the mass of the dissolved substance, *g* ,

M is the molar mass of the dissolved substance, *g/mol,*

V – volume of solution, *l* .

An abbreviated form of indicating molar concentration is used, for example, 0.5M – a solution with a concentration of 0.5 *mol/l* .

A solution containing 1 mole of a substance in 1 liter of solution is called **monomolar** (1 M). **A decimolar solution** (0.1 M) contains 0.1 moles in 1 liter, and **a centimolear solution** (0.01M) – 0.01 mol in 1 liter, **millimolar** – 0.001 mol in 1 liter of solution.

4. ***Molar*** **concentration of equivalent *CH*** – the number of mole equivalents of a dissolved substance in a unit volume of a solution.

$$C_H = \frac{n_{э\ р.в.}}{V_{р-ра}} \quad (1.5) \quad [C_H] = моль/л = н.$$

The abbreviation for units of molar equivalent concentration is ***n*** (normality). A solution containing 1 mol-eq of a substance in 1 liter is called **a mononormal solution** (1 N). **A decinormal solution** (0.1 N) contains 0.1 mol-eq in 1 liter, and **a centinormal solution** (0.01N) – 0.01 mol-eq. in 1 liter of solution.

The term "equivalent" implies something of equal value or equivalent. ***A chemical equivalent is defined as the amount of a substance equal to the amount of another substance in a chemical reaction. The standard chemical equivalent is 1 mole of hydrogen atoms or*** $_{1/2}^{mole}$ ***of oxygen atoms*** .

Then, **the equivalent of an element or complex** *The* specific energy **of a substance** is the amount of it that can interact (add to or be replaced by) one mole of hydrogen atoms or $_{1/2}^{mole}$ of oxygen atoms. For example , E(HCl) = 1 mol, E(H2SO4) = $^{1/2}_{mol}$, E(NaOH) = 1 mol, E(Al (OH) $_3$) = $^{1/3}_{mol}$, etc.

molar **mass of the equivalent of** *ME is* expressed in $г/моль$. For example, the molar mass of the equivalent of $_{ME}$ (HCl) = 36.5 g/mol, *ME* (H_2SO_4) = $^1/_2 \cdot 98 = 49$ g/mol, $_{ME}$ (Al (OH) 3) = $^1/_3 \cdot 78 =$ 26 g/mol.

The molar masses of equivalents of complex substances are calculated as indicated in Table 2.

Table 2

Compound	Formula for calculation	Explanations
Acid	$M_{Экислоты} = \frac{M_{кислоты}}{основность\ кислот}$	The basicity of an acid is the number of hydrogen atoms in the acid molecule that are replaced in the reaction
Base	$M_{Эоснования} = \frac{M_{основания}}{кислотность\ основани}$	The acidity of a base is the number of hydroxyl

		groups in the base molecule.
Salt	$M_{Эсоли}=\frac{M_{соли}}{n*в}$	*n* is the number of metal atoms in the salt formula, *b* – valence of the metal

The molar mass of an equivalent is not a constant value, unlike the molar mass, and may vary depending on the reaction.

Comparison of formulas for determining molar and normal concentrations

$$C_M=\frac{m}{M\cdot V} \text{ And } C_H=\frac{m}{M\cdot Э\cdot V},$$

shows that in the case when the equivalent of the dissolved substance E = 1 mol, the molar and normal concentrations of the solutions coincide. This applies to solutions of monobasic acids (HCl , HNO_3 , etc.), monoacidic bases (NaOH , KOH , etc.), salts with singly charged cations and anions (KCl , $NaNO_3$, etc.). For example, $CM_{(HNO_3)} = CN_{(HNO_3)}$; $CM_{(KCl)} = CN_{(KCl)}$, etc. If the equivalent of the dissolved substance is not equal to 1 mol, then the molar concentration of its solution is as many times less than the normal concentration as the equivalent of this substance is less than 1 mol.

5. The titer of a solution is the mass of the dissolved substance contained in 1 ml of the solution.

$$T=\frac{m_{р.в-ва}}{V_{р-ра}} \quad (1.6) \quad [T]=г/мл$$

Questions for independent preparation

1. Give a general concept of solutions, solvent, and dissolved substance.
2. Demonstrate the application of Henry, Dalton, and Sechenov's laws in medicine. Demonstrate the solubility of gases in blood. Describe the causes of decompression sickness and altitude sickness.
3. Characterize the methods of expressing the concentration of a substance in a solution: mass fraction and molar concentration of a substance in a solution.
4. What is the concentration of a solution?
5. Describe the concept of an equivalent, equivalence factor, and molar mass of an equivalent. Molar concentration of an equivalent.

Examples of problem solutions

Example 1. Calculate: *a*) the percentage *C%* ; *b*) the molar *CM* ; *c*) the normal *CH* ; and *d*) the molal *Cm of* *the* concentration of a solution of H_3PO_4 obtained by dissolving 18 g of acid in 282 cm3 of water, if its density is 1.031 g/cm3. What is the titer T of *this* solution?

Solution: *a*) **Percentage concentration** shows the number of grams of dissolved substance contained in 100 g of solution. Since the mass of 282 cm^3 of water can be taken as 282 g, then the mass of the resulting solution is 18 + 282 = 300 g and, therefore,

$$\begin{array}{l} 300\ г - 18\ г. \\ 100\ г - C_{\%}. \end{array}$$

$$C_{\%}=\frac{100\cdot 18}{300}=6\ \%.$$

b) The mass of 1 dm3 of solution is 1031 g. The mass of acid in dm3

we find the solution from the ratio

$$\begin{array}{l} 300\ \text{г} - 18\ \text{г.} \\ 1031\ \text{г} - x\ \text{г.} \end{array}$$

$$x = \frac{1031 \cdot 18}{300} = 61{,}86\ \text{г.}$$

The molar concentration of the solution is obtained by dividing the number of grams of H3PO4 in $_1$ dm3 $^{\text{of the solution by}}$ the molar mass of $_{H3PO4}$, equal to 97.99 g/mol :

$$C_M = \frac{61{,}86}{97{,}99} = 0{,}63\ \text{моль/дм}^3.$$

c) The molar mass of the equivalent of H_3PO_4 is equal to

$$m_{э(H_3PO_4)} = \frac{M}{3} = \frac{97{,}99}{3} = 32{,}66\ \text{г.}$$

The molar concentration of the equivalent or normal concentration will be:

$$C_н = \frac{61{,}86}{32{,}66} = 1{,}89\ \text{н.}$$

d) The mass of H_3PO_4 in 1000 g of solvent is found from the ratio

$$\begin{array}{l} 282\ \text{г} - 18\ \text{г.} \\ 1000\ \text{г} - x\ \text{г.} \end{array}$$

$$x = \frac{1000 \cdot 18}{282} = 63{,}83\ \text{г.}$$

The molal concentration is determined by the ratio of the mass of the dissolved substance contained in 1 kg of water to the molar mass of the acid:

$$C_m = \frac{63{,}83}{97{,}99} = 0{,}65\ \text{моль/кг.}$$

Since 1 dm ^{3} of solution contains 61.86 g of acid, we determine the titer of the solution as

$$T = \frac{61{,}86}{1000} = 0{,}06186\ \text{г/см}^3.$$

Example 2. Calculate the percentage concentration of a solution obtained by dissolving 80 g of sugar in 160 g of water.

Solution: $m_{p-pa} = m_{H_2O} + m_{сахара} = 80 + 160 = 240\ \text{г.}$

$$C\,\% = \frac{80}{240} \cdot 100 = 33{,}3\ \%.$$

Example 3. Calculate the masses of table salt and water required to prepare 250 g of a 2.5% solution.

Solution: $m_{\text{р.в-ва}} = \frac{m_{\text{р-ра}} \cdot C\%}{100\ \%};$

$$m_{NaCl} = \frac{250 \cdot 2}{100} = 6{,}25\ \text{г.}$$

$$m_{H_2O} = m_{\text{р-ра}} - m_{NaCl} = 250 - 6{,}25 = 243{,}75\ \text{г.}$$

Example 4. Calculate the concentration of a solution obtained by mixing 300 g of a 10% hydrogen chloride solution and 400 g of a 20% hydrogen chloride solution.

Solution: Determine the mass of dissolved HCl in each solution:

$$m''_{HCl} = \frac{m'_{p-pa} \cdot C'\,\%}{100\,\%} = \frac{300 \cdot 10}{100} = 30\ г;$$

$$m''_{HCl} = \frac{m''_{p-pa} \cdot C''\,\%}{100\,\%} = \frac{400 \cdot 20}{100} = 80\ г.$$

After mixing

$$m_{HCl} = m'_{HCl} + m''_{HCl} = 30 + 80 = 110\ г;$$

$$m_{p\text{-}pa} = m'_{p\text{-}pa} + m''_{p\text{-}pa} = 300 + 400 = 700\ г.$$

We determine the concentration of the resulting solution:

$$C\,\% = \frac{m_{HCl} \cdot 100\,\%}{m_{p-pa}} = \frac{110 \cdot 100}{700} = 15{,}7\,\%.$$

Example 5. What is the concentration of sulfuric acid in a solution obtained by mixing 200 g of a 10% sulfuric acid solution and 100 g of a 5% sodium sulfate solution?

Solution: The mass of the resulting solution is determined as the sum of the masses of the mixed solutions:

$$m_{p\text{-}pa} = m'_{p\text{-}pa} + m''_{p\text{-}pa} = 200 + 100 = 300\ г;$$

$$m_{H_2SO_4} = \frac{m'_{p-pa} \cdot C\%}{100\,\%} = \frac{200 \cdot 10}{100} = 20\ г.$$

Next, we determine the concentration of sulfuric acid in the resulting solution:

$$C\,\% = \frac{m_{H_2SO_4}}{m_{p-pa}} \cdot 100\,\% = \frac{20 \cdot 100}{300} = 6{,}67\,\%.$$

Example 6. What mass of sulfuric acid is needed to prepare 2 liters of a 2-molar solution?

Solution: $M_{H_2SO_4} = 98$ г/моль;

$$m_{р.в\text{-}ва} = C\, M_{р.в\text{-}ва}\, V;$$

$$m_{H_2SO_4} = 2 \cdot 98 \cdot 2 = 392\ г.$$

Example 7. 250 ml of a solution contains 7 g of KOH. What is the molarity of this solution?

Solution: $M_{KOH} = 56$ г/моль;

$$C = \frac{m_{KOH} \cdot 1000}{M_{KOH}\, V} = \frac{7 \cdot 1000}{56 \cdot 250} = 0{,}5\ моль/л.$$

Example 8. What mass of phosphoric acid is needed to prepare 2 liters of 0.1 N solution?

Solution:

$$Э_{H_3PO_4} = \frac{M_{H_3PO_4}}{3} = \frac{98}{3} = 32{,}7\ г/моль;$$

$$m_{р.в\text{-}ва} = C_н\, Э_{р.в\text{-}ва}\, V;$$

$$m_{H_3PO_4} = 0{,}1 \cdot 32{,}7 \cdot 2 = 6{,}54\ г.$$ **answer 6.54 g H_3PO_4**

Tasks for independent solution

1. What is the mass fraction of the solution obtained by dissolving 25 g of sodium sulfate Na_2SO_4 in 200 g of water? Answer: 11.1%.
2. Calculate how many g and how many moles of the dissolved substance are in a given mass of solution with the specified mass fraction of the substance: a) 200 g of an 8.4% solution.
3. A 200 ml barium chloride solution contains 52 g of salt. Determine the molar concentration of the salt in the solution. (Answer: 1.25 M)
4. What mass of sodium chloride is needed to prepare 1.5 L of a solution with a molar concentration of sodium chloride (NaCl) of 0.25 mol/L? (Answer: 21.94 g)
5. 300 g of water were evaporated from 600 g of a 10% solution. What is the concentration of the resulting solution? Answer: 20%.
6. In medicine, copper sulfate is used as an antiseptic and astringent. How many grams of copper sulfate ($CuSO4 \cdot 5H2O$) are needed to prepare 100 g of a 5% CuSO4 solution ? The answer is 7.81 g of copper sulfate.
7. A 500 ml solution contains 2 g of sodium hydroxide. Calculate the molar concentration of the solution. Answer: 0.1 mol/L = 0.1 M
8. $_{\text{crystalline Na2CO3}} \cdot {}_{10H2O}$ salt are needed to prepare 100 ml of 0.1 M sodium carbonate solution? Answer : 2.86 $_{\text{g Na2CO3}} \cdot {}_{10H2O}$
9. 6 g of urea were dissolved in 500 g of water. Calculate the molal concentration of the resulting solution. Answer: the molality of the solution is 0.2 mol/kg.
10. 2 g of glucose were dissolved in 250 g of water. Calculate the molal concentration of the solution. (Solve it yourself). Answer: 0.044 mol/kg
11. 50 grams of potassium chloride are dissolved in 200 ml of water. Calculate the mass fraction of the substance in the solution. Answer: ω = 20%.
12. Calculate the molarity of a solution containing 25.4 g FeCl2 in 500 ml of solution. Answer: CM = 0.4 M.
13. Calculate the normality of a 50% sulfuric acid solution with a density of 1.5 g/ml. Answer: C_H = 15.3 N.
14. Sodium thiosulfate solution with a molar concentration of 0.33 mol/L is used as an antidote for gastric lavage in many types of poisoning. How many grams of $Na_2S_2O_3$ are needed to prepare one liter of solution? Answer **:** 52.14
15. How many grams of salt must be dissolved in 250 ml of water to obtain a solution with a mass fraction of salt of 6%? (*Answer* :)16 г
16. How many grams of water must be added to 200 гa solution with a mass fraction of salt of 15% to obtain a solution with ω(salt) = 4%? (Answer: 550 г)
17. Water was evaporated ωfrom 600 гa solution with ω10% salt . Determine 100 гthe amount of salt in the remaining solution. (*Answer* : 12%)
18. To prepare the solution, 800 гcopper sulfate $C\ 2SO_4 \cdot 5H_2O$ was used 50 г. Determine the mass fraction of anhydrous salt in the solution. (*Answer* : 4%)
19. was added 50 гto a 500 г10% NaCl solution . What is the mass fraction of salt in the resulting solution? (*Answer* : 18.2%)
20. How much water should be added to a 200 г50 % solution to obtain a 43% solution? (*Answer* :)32,6 г

Laboratory lesson #2
Topic: The Study of Solutions. Colligative Properties of Solutions

Objective of the lesson *:* To summarize knowledge about electrolyte and non-electrolyte solutions, their colligative properties, and to understand their role in the body's vital functions. To learn how to perform quantitative calculations for the preparation of solutions of various concentrations necessary for the analysis of biological samples.

Equipment and reagents: Volumetric flasks with calibrations (100 ml, 150 ml, 200 ml, 250 ml), 250 ml graduated cylinder, beakers, pipettes, a set of hydrometers, an osmometer, a set of test tubes, glass

rods. Reagents: $H_2SO_{4\ solution}$, 0.2%, 0.85%, 4% NaCl solutions, distilled H_2O, blood, colored sucrose solution.

Experimental part .

1. Preparation of solutions of normal acid concentration

Procedure: To prepare 100 ml of 0.1 N sulfuric acid solution, pour the concentrated sulfuric acid solution into a cylinder and measure its density with a hydrometer. Using the measured density, find the mass fraction of the solute in the solution (refer to the reference book). Calculate the volume of concentrated acid solution required to prepare a solution of a given concentration. Review the calculation with your instructor.

Calculation example: 1. Calculate the equivalent of sulfuric acid

$$Э(H_2SO_4) = (98г\text{-}экв.)/2 = 49г\text{-}экв.$$

49 г-экв. - 1н

X г-экв. - 0,1н $\qquad X = 4,9$ г-экв. H_2SO_4

4,9 г-экв. - 1000 мл.

X - 100 мл. $\qquad X = 0,49$

2. When determining the density of H_2SO_4, it is equal to ρ = 1.19 g/ml, according to the reference book, this density corresponds to 26% concentration

26г. - 100г.

0,49 - X

$X = 0,49 * 100/26 = 1,88$ г. H_2SO_4

It is necessary to convert mass into volume using the formula:

$V = m/\rho = 1.88/1.19 = 1.56$ ml. H_2SO_4

This means that 1.56 ml of concentrated H2SO4 is measured using a measuring tube and poured into a 100 ml measuring flask, and the volume is brought up to the mark with distilled water, closed with a stopper, and mixed, i.e. we have prepared approximately a 0.1 N solution of H2SO4 from a more concentrated one .

2. Observation of the phenomenon of osmosis.

Procedure: Fill the osmometer to the mark with a colored sucrose solution. Lower the osmometer into a beaker of distilled water up to the mark. After a while, observe the liquid level in the osmometer rise. Explain this phenomenon. Why can't the solution level in the osmometer rise indefinitely?

3. Changes in the state of red blood cells in solutions different concentrations of NaCl.

Procedure: Pour 5 ml of each of 0.2%, 0.85%, and 4% NaCl solution into three test tubes. Add 2-3 drops of blood to each solution, stir, and let sit. Observe the blood after 1 hour. Record the results and explain where hemolysis and plasmolysis occur, where the blood remains unchanged, and why.

Report preparation

_____

_____

_____

_____

Test questions:

1. Describe the purpose and rules for working with measuring chemical glassware (cylinders, flasks, pipettes).
2. Colligative properties of electrolyte solutions (definition, examples).
3. Explain the phenomena of diffusion and osmosis in the human body. Describe the concept of semipermeable membranes. Describe osmotic pressure, van't Hoff's law, and its mathematical expression. The biological role of osmosis. Osmotic pressure, osmolarity, and plasma osmolality.

4. Specify the distinctive properties of isotonic, hypertonic, and hypotonic solutions and their use in medicine. Plasmolysis and hemolysis.

Practical lesson #3
Topic: Water Dissociation. The Concept of Hydrogen Permeability

Objective of the lesson: To acquire knowledge about the ionic composition and active reaction of aqueous solutions and their importance in life ; to learn how to calculate the hydrogen index (pH) of various solutions and determine it experimentally using the colorimetric method;

Teaching methods:
Combined:
- conversation – joint discussion of the theory on the topic;
- oral and/or written survey;
- work in small groups;
- solving tests and problems;

Methodological support : Presentation (slides), cards, diagrams, tables, PSHE, solubility table, test questions, multimedia, teaching materials.

Theoretical part

The hydrogen index – pH – is a measure of the activity (in the case of dilute solutions, it reflects the concentration) of hydrogen ions in a solution, quantitatively expressing its acidity, calculated as the negative (taken with the opposite sign) decimal logarithm of the activity of hydrogen ions, expressed in moles per liter.

$$\mathbf{p\,H = – lg\,[\,H^{+}\,]}$$

This concept was introduced in 1909 by the Danish chemist Sørensen. The indicator is called pH, from the first letters of the Latin words potentia hydrogeni – the power of hydrogen, or pondus hydrogenii – the weight of hydrogen.

The inverse pH value, pOH, is somewhat less widely used – it is an indicator of the basicity of a solution and is equal to the negative decimal logarithm of the concentration of OH ions in the solution:

$$\mathbf{pOH = – lg\,[\,OH^{-}\,]}$$

In pure water at 25°C, the concentrations of hydrogen ions ($[H^{+}]$) and hydroxide ions ($[OH^{-}]$) are the same and amount to 10^{-7} mol/l, this follows directly from the constant of autoprotolysis of water K_w, which is otherwise called the ionic product of water:

$$\mathbf{K_w = [H^{+}] \cdot [OH^{-}] = 10^{-14}\,[mol^2/l^2]\ (at\ 25°C)}$$

$$\mathbf{pH + pOH = 14}$$

When the concentrations of both types of ions in a solution are equal, the solution is said to have a neutral reaction. When an acid is added to water, the concentration of hydrogen ions increases, and the concentration of hydroxide ions decreases. Conversely, when a base is added, the hydroxide ion content increases, and the hydrogen ion concentration decreases. When $[H^{+}] > [OH–]$ the solution is said to be acidic, and when $[OH–] > [H^{+}]$ it is said to be alkaline.

The body's biological fluids—blood, lymph, gastric juice, urine, saliva, etc.—have different normal pH values. Changes in the composition of biological fluids, including pH, indicate organ dysfunction.

The pH of biological fluids affects the activity of enzymes and hormones that regulate biochemical reactions in the blood and related organs. Changes in blood pH disrupt the structure and function of enzymes and hormones, which disrupts metabolic regulation, causes the accumulation of underoxidized toxic products, poisoning, and can lead to death.

Normally, the pH of saliva is 5.6–7.9. A shift in the pH of saliva towards the acidic side leads to the development of caries, and a shift in the pH of saliva towards the alkaline side leads to the formation of stones.

With a stomach ulcer, the pH of gastric juice shifts toward the acidic side. Measuring pH allows for the detection of various types of pathology, accurate diagnosis, and informed preventive and therapeutic measures.

In biology, medicine, and pharmacy, the potentiomeric method of pH determination is widely used. It has several advantages over the indicator method: it is more accurate (allowing pH measurements to an accuracy of 0.02–0.05); and it also allows for the measurement of the pH of multicomponent systems and colored solutions.

pH values for some biological systems and other solutions
Table 1.

System (solution)	pH
Duodenum	7.0 – 7.8
Gastric juice	1.6 – 1.8
Human blood	7.35 – 7.45
Liquor	7.5
Urine	4.8 – 7.5
Muscle tissue	6.7 – 6.8
Pancreatic juice	8.3
Sweat	4.0 – 8.0
Kidneys	6.6 – 6.9
Cell protoplasm	6.4 – 7.0
Ligaments	7.2
Tears	7.4
Saliva	6.35 – 6.85
Small intestine	6.2 – 7.3
Milk	6.6 – 6.9
Sea water	8.0
Chicken egg white	8.0
Orange juice	2.6 – 4.4
Tomato juice	4.3
Coffee	5.0
Tea	5.5

Test questions:

1. Ionic product of water. Hydrogen index of the environment.
2. Show the dissociation of water and calculate the ionic product of water.
3. Explain the definition of hydrogen and hydroxyl values. pH scale.
4. What is a buffer system? Define acidic and basic buffer systems, give an example, and indicate their composition. Calculate the pH of buffer solutions (Henderson-Hasselbalch equation).
5. List the blood's buffer systems. What is their importance to the body? Provide a comparative analysis of the blood's buffering capacity.
6. Mechanism of action of buffer solutions. Explain the mechanism of buffer action using acetate and ammonia buffer solutions as examples.
7. Calculation of the concentration of hydrogen ions, pH and pOH of the environment in buffer solutions.
8. Calculation of the buffer capacity of buffer solutions for acid and base.

Examples of problem solving

Example 1. Calculate pH, pOH and [OH–] if [H+] = 10^{-5} mol/l .

Solution:

Using formula 2 we find: pH = -lg 10^{-5} = 5.

According to equation 4: pOH = 14 – pH = 14 – 5 = 9.

Using expression 3 we calculate: [OH^-] = 10 -pOH = 10^{-9} mol/l.

Answer : pH = 5, pOH = 9, [OH–] = 10^{-9} mol/l .

Example 2. In an aqueous solution, the concentration of hydrogen ions H^+ is 10^{-3} mol/l at 25 °C. Determine the concentration of OH^- ions in this solution.

Solution:

Based on the ionic product of water $K(H_2O) = [H^+][OH^-]$, we find

$$[OH^-] = \frac{K(H_2O)}{[H^+]} = \frac{10^{-14}}{10^{-3}} = 10^{-11} \text{ mol/l.}$$

Example 3. Calculate the pH of an aqueous solution in 0.01 M KOH solution ($\alpha \approx 1$). How will the color of phenolphthalein change in this solution?

Solution: We find the concentration of OH^- ions in a 0.01 M KOH solution:

$[OH^-] = [KOH] = 0.01$ mol/l, since αKOH in an aqueous solution is equal to 1.

H^+ ions : $[H^+] = \frac{10^{-14}}{10^{-2}} 10^{-12}$ mol/l.

We determine the hydrogen index: $pH = -\lg [H^+] = -\lg 10^{-12} = 12$.

The solution environment is alkaline, since the pH >is 7.

Phenolphthalein turns crimson in an alkaline medium.

Example 4. What is the concentration of hydroxide ions in a solution in which the concentration of hydrogen ions is 3.15 10-4 mol/l?

$K(H_2O) = C(H^+) \cdot C(OH^-) = 10^{-14}$ моль^2/л^2, следовательно

$$C(OH) = \frac{K(H_2O)}{C(H^+)};$$

$$C(OH) = \frac{1 \cdot 10^{-14} моль^2 / л^2}{3{,}15 \cdot 10^{-4} моль/л} = 3{,}17 \cdot 10^{-11} моль/л$$

Ответ: $C(OH^-) = 3{,}17 \cdot 10^{-11}$ моль/л

Tasks for independent solution.

1. Determine the concentration of hydroxide ions if the concentration of hydrogen ions is 10^{-3} mol/l.
2. Determine the concentration of hydrogen ions if the concentration of hydroxide ions is 10^{-5} mol/l.
3. The concentration of hydrogen ions in the solution is $4 \cdot 10^{-3}$ mol/l.

Determine the pH of the solution.

4. Determine the concentration of hydrogen ions if the pH of the solution is 1.6
5. What is the concentration of hydroxide ions in a solution with pH 10.8?
6. What is the concentration of hydroxide ions in solutions in which the pH is: a) 4; b) 6.8?

Answer: a) $C(OH^-) = 10^{-10}$ mol/l. b) C(OH-) = 6.31 · 10^{-8} mol/l.

7. The concentration of hydrogen ions in a solution of a strong acid was 0.001 mol/l. Determine the pH of the solution.

3. Fill in the color table of indicators in different environments with the appropriate colors:

Indicator	Wednesday		
	H^+	H_2O	HE^-
Litmus			
Methyl orange			
Phenolphthalein			

Laboratory lesson #3

Topic: Acid-base balance (ABB) of the body and the role of buffer systems in maintaining the constancy of blood pH

Objective of the lesson: To study the methods for calculating and determining the pH of solutions. To learn how to formulate buffer mixtures with a given pH value. To become familiar with the properties of buffer solutions.

Theoretical part

A number of biological processes and analyses require studies to be conducted at a constant pH. Buffer solutions are used for this purpose. A characteristic feature of buffer systems is their ability to maintain a constant pH when diluted and when certain amounts of strong acids and bases are added. Buffer solutions soften the action of acids or bases, hence their name.

Buffer systems *are* systems that are capable of maintaining a constant pH value when diluted and when certain amounts of strong acids and bases are added.

Buffer systems can be formed:

1) weak acid and its salt:

acetate buffer ($CH_3COOH + CH_3COONa$), $pH \approx 4.76$;

formate buffer (HCOOH + HCOONa), $pH \approx 3.75$;

2) a weak base and its salt

ammonium buffer or ammonia buffer ($NH_4OH + NH_4C1$),

$pH \approx 9.24$;

3) acidic and neutral salt of a weak acid

carbonate buffer ($NaHCO_3 + Na_2CO_3$), $pH \approx 9.93$;

4) mono- and disubstituted salt of a weak acid

phosphate buffer ($Na_2HPO_4 + NaH_2PO_4$), $pH \approx 6.60$.

Solutions containing buffer mixtures that are therefore able to resist changes in pH are called buffers. solutions .

Experimental part

Reagents and equipment: Solutions: 0.1 M CH3COOH and 0.1 M CH3COONa, 0.1 N NaOH, 0.1 N HCl , $NH4OH_{with}$ a concentration of 0.1 mol/l, distilled water, blood serum, indicators: methyl orange, phenolphthalein, universal indicator paper, a rack with test tubes, a pH scale table, pipettes, a pH meter, a potentiometer, 25 ml burettes.

Experiment 1. Determining the pH of solutions using indicators . Pour 2 ml of the reagent into five test tubes: the first contains a 0.1 M solution of hydrochloric acid HCl, the second contains a 0.1 M solution of acetic acid CH_3COOH, the third contains a 0.1 M solution of ammonia NH_4OH, the fourth contains a 0.1 M solution of alkali NaOH, and the fifth contains distilled water. Determine the pH of the solution in each test tube using a strip of universal indicator paper. Compare the theoretically calculated pH of the solution with the experimental data. Fill in Table 1 based on the results.

Table 1.

Величина pH исследуемых растворов

Исследуемый раствор	Окраска индикатора	Величина pH	
		теоретическая	опытная
0,1 M HCl			
0,1 M CH_3COOH			
0,1 M NH_4OH			
0,1 M NaOH			
дистиллированная H_2O			

Experiment 2. Preparation of acetate buffer mixtures and colorimetric determination of buffer pH.

Operating principle: Each buffer mixture is characterized by a specific ion concentration, which the buffer system strives to maintain. The pH value is a measure of the reaction activity of the medium. It is the inverse logarithm of the activity (or concentration) of hydrogen ions, expressed in grams of hydrogen ions per liter (or mol/L). pH = - l g(H+)

Procedure: Prepare an acetate mixture in seven identical test tubes with a total volume of 10 ml. To do this, take seven test tubes and add 0.1 M CH3COOH and 0.1 M CH3COONa solutions from burettes in the ratios shown in Table 5:

Table 2.

№ пробирок	Состав буферный смеси, мл 0,1 М раствор CH_3COOH	0,1 М CH_3COONa	pH смеси по таблице	pH смеси вычисленный
1	9	1		
2	7	3		
3	5	5		
4	3	7		
5	1	9		
6	0,5	9,5		
7	0,2	9,8		

Add 3 drops of methyl orange indicator to each test tube. Find the pH values for each mixture using the color chart for the universal indicator and record them in the table. Plot the curve as a function of the volume of salt. Explain the choice of indicator.

The pH values of buffer solutions are calculated using the Henderson-Hasselbalch equation:

$$pH = pK + (\lg V_{cjkb} - \lg V_{кислоты})$$

where is the inverse logarithm of the dissociation constant of acetic acid = 4.74. pK

Experiment 3. Determination **of the buffer capacity of blood serum**

Procedure: Pour 5 ml of blood serum with a pH of 7.4 into two test tubes. Add two drops of phenolphthalein to one test tube and titrate with 0.1 N NaOH until the color is the same as the standard with a pH of 9.4. Add methyl orange to the other test tube and titrate with 0.1 N HCl until the color is the same as the corresponding standard with a pH of 3.4.

The buffer capacity of serum in relation to alkali and acid is calculated using the formulas:

$$B_к = \frac{Э}{pH_0 - pH_1} \text{ г – экв/л;} \qquad B_{осн} = \frac{Э}{pH_1 - pH_0} \text{ г- экв/л.}$$

Write a detailed report on this work. Compare the buffering capacity of blood serum for acids and bases. Based on the ratio of salts and acids in the carbonate and phosphate buffer systems of blood, explain why the buffering capacity of blood serum for acids is greater than its buffering capacity for bases.

Report design:

_____

_____

_____

Control surveys:

1. Characterize acid-base indicators. Understand their mechanism of action. Understand the concept of a universal indicator.
2. Explain the essence of the colorimetric method for determining the pH of solutions.
3. Using an example, explain the role of electrolytes in the human body.
4. Define buffer systems. Describe the types of buffer systems.
5. The mechanism of action of buffer systems in relation to acids and alkalis.
6. Illustrate the mechanism of action of blood and tissue buffer systems using an example. The specific features of the hemoglobin buffer system.
7. Give the concept of acid-base balance, acidosis, alkalosis.

Practical lesson #4
Chemical reaction rate and chemical equilibrium

Objective of the lesson: Generalization of knowledge about the rate of chemical reactions, study of the influence of various factors on the rate of chemical reactions and the state of equilibrium .

Teaching methods:

Combined:

- conversation – joint discussion of the theory on the topic;
- oral and/or written survey;
- work in small groups;
- solving tests and problems;

Methodological support : Presentation (slides), cards, diagrams, tables, PSHE, solubility table, test questions, multimedia, teaching materials.

Theoretical part

Chemical kinetics is a branch of chemistry that studies the rate and mechanism chemical reactions. **The rate of a chemical reaction is the change in the amount of a substance per unit time per unit volume (for homogeneous reactions) or per unit phase boundary surface (for heterogeneous reactions).**

$$\overline{\upsilon} = \pm\frac{\Delta C(x)}{\Delta \tau} \quad (1)$$

$$\upsilon_{гом} = \pm\frac{\Delta n}{\Delta t \cdot S}. \quad (2)$$

The reaction rate depends on the nature of the reactants, their concentration, temperature, and the presence of catalysts.

The dependence of the reaction rate on concentration is expressed **by the law of mass action** : **at a constant temperature, the rate of a chemical reaction is directly proportional to the product of the concentrations of the reactants .**

Для реакции: $aA + bB = D$

скорость реакции: $\upsilon = kC_A^a \cdot C_B^b = k\,[A]^a \cdot [B]^b$.

The influence of temperature on the rate of a chemical reaction is described by Van't Hoff's rule: **For every ^{100} degrees increase in temperature, the reaction rate increases by 2–4 times.**

$$\upsilon_{t_2} = \upsilon_{t_1} \cdot \gamma^{\frac{t_2 - t_1}{10}},$$

Here γ is **the temperature coefficient** , which shows how many times the rate of a chemical reaction changes when the temperature changes by 10 degrees.

Questions for independent preparation .

1. What is meant by the rate of chemical reactions? Mathematical expression of rate for homogeneous and heterogeneous reactions, units of measurement.
2. What factors determine the rate of chemical reactions?
3. Explain the dependence of the rate of a chemical reaction on the nature of the reacting substances.
4. How does the rate of a chemical reaction depend on the concentration of the reactants? Write a mathematical expression for the law of mass action.
5. How does reaction rate depend on temperature? Write a mathematical expression for van't Hoff's law. What is meant by activation energy?
6. What substances are called catalysts, how do they affect the reaction rate?
7. Types of catalysis, examples. The concept of enzymatic catalysis.

Examples of problem solutions

Example 1. *Write* a mathematical expression for the law of mass action for reactions:

a) $2NO(g) + CI_2(g) = 2NOCI(g)$;

b) $CaO(k) + CO_2(g) = CaCO_3(k)$

Solution. a) $v = kC_{NO}^2 C_{CI2}$;

b) Since CaO is a solid,

whose concentration does not change during the reaction, the law of action will have the form:.

$$v = kC_{CO2}.$$

Example 2. Calculate the average reaction rate if the initial concentration of the starting substances is 6 mol/l, and after 2 minutes it is 2 mol/l.

Solution:

$\upsilon_{avg.} = \pm\frac{c_{кон} - c_{нач}}{\Delta\tau}$ or $\upsilon_{avg.} = \left|\frac{\Delta c}{\Delta\tau}\right|$; $\upsilon_{avg.} = \left|\frac{2-6}{2}\right| = 2$ mol/(l ·min).

Answer : the average reaction rate is 2 mol/(l ·min).

Example 3. Write the kinetic equation for the reaction: $N_2(g) + 2\ O_2(g) \rightarrow 2\ NO_2(g)$, assuming that the reaction equation reflects its mechanism.

Solution : The kinetic equation of a chemical reaction shows how the rate of the reaction depends on the concentration of the components in the reaction mixture. A kinetic equation can be complex, but if the reaction equation reflects its mechanism, the rate is a power-law function of the concentration of the reactants:

$\upsilon = k \cdot c(N_2) \cdot c^2(O_2)$

Example 4 How many times will the reaction rate of 2CO + O2 increase $? \rightarrow 2CO_2$, if the concentration of carbon monoxide (II) is increased by 5 times?

Solution: According to the law of mass action, the rate of a chemical reaction is directly proportional to the product of the molar concentrations of the reacting substances, taken in powers equal to the coefficients in elementary reactions:

$\upsilon = k \cdot c^2(CO) \cdot c(O_2)$. If c (CO) = a mol/l, and c (O_2) = b mol/l, then $\upsilon_1 = k \cdot a^2 c \cdot b$.

When the CO concentration increases by a factor of 5, the reaction rate becomes equal to $\upsilon_2 = k \cdot (5a)^2 \cdot b$. The value of the rate constant (k) is the same in both cases. Comparing υ_1 and υ_2, we see that the rate has increased by a factor of 25: $\frac{\upsilon_2}{\upsilon_1} = \frac{k \cdot (5a)^2 \cdot в}{k \cdot a^2 \cdot в} = 5^2 = 25.$

Answer : the reaction rate will increase 25 times.

Example 5. The reaction of formation of nitrogen oxide (IV) is expressed by the equation:

$2NO + O_2 \rightleftarrows 2NO_2$. How will the rate of the forward reaction change if the pressure is doubled?

Solution: Before the reaction, the reaction rate is described by the following kinetic equation: $\upsilon_1 = k \cdot c^2(NO) \cdot c(O_2)$. If c (NO) = a mol/L and c (O_2) = v mol/L, then $\upsilon_1 = k \cdot a^2 \cdot v$. When the pressure is doubled, the concentrations of all substances will increase by the same amount. In this case: $\upsilon_2 = k \cdot (2a)^2 \cdot 2v$. Comparing V_1 and V_2, we see that the rate of the forward reaction increases by 8 times: $\frac{\upsilon_2}{\upsilon_1} = \frac{k \cdot (2a)^2 \cdot 2в}{k \cdot a^2 \cdot в} = \frac{k \cdot 8 \cdot a^2 \cdot в}{k \cdot a^2 \cdot в} = 8.$

Answer: the reaction speed will increase 8 times.

Tasks for independent solution.

1. Write the expression for the law of mass action (kinetic equations) for the following reactions, having previously placed the coefficients, assuming that they are simple:
   1. $NO + O_2 \rightarrow NO_2$;
   2. $NO + Cl_2 \rightarrow NOCl_2$;
   3. $Fe + Cl_2 \rightarrow FeCl_3$;
   4. $Fe_2O_3 + H_2 \rightarrow Fe + H_2O$;
   5. $CO2 + CCO \rightarrow$;
   6. $CaO + CO_2 \rightarrow CaCO_3$;
   7. $CaCO_3 \rightarrow CaO + CO_2$.
2. Determine the average rate of the chemical reaction $CO2 + H2 = CO + H2O$, if after 80 seconds from the start of the reaction the molar concentration of water vapor was equal to 0.24 mol/l, and after 2 min. 07 sec. it became equal to 0.28 mol/l. (*Answer* : $8.5 \cdot 10^{-4}$ mol/l ·s)
3. How will the rate of a forward one-step reaction change? $2HI_{(g)} \rightleftarrows H2_{(g)} + I2_{(g)}$, if the concentration of hydrogen iodide is increased by 3 times? (*Answer* : it will increase by 9 times)
4. How many times will the reaction rate $HBr + HBrO \rightarrow Br_2 + H_2O$ change when the reacting mixture is diluted 6 times? (*Answer* : decrease by 36 times)
5. By how many degrees must the temperature of the gaseous reactants be increased for the reaction rate to increase by 125 times if the temperature coefficient is 5? (*Answer* : by 30 degrees)
6. How many times should the oxygen concentration be increased so that with a simultaneous decrease in temperature by 30 °C (γ=2) the reaction rate: $2CO + O_2 = 2CO_2$ remains unchanged? (*Answer* : 8 times)

Laboratory lesson #4.
Topic: Chemical Reaction Rate. Studying the Influence of Factors on Reaction Rate

Objective of the lesson: Generalization of knowledge about the rate of chemical reactions, study of the influence of various factors on the rate of chemical reactions and the state of equilibrium.

Equipment and reagents: Test tubes with a stand, 10 and 5 ml pipettes, beakers, 100 ml - 2 pcs, 200 ml - 1 pc, electric stove, thermometer. 0.1 M solution of $Na_2S_2O_3$, 0.2 M solution of H_2SO_4, distilled H_2O

Experimental part

Experiment 1. Study of the dependence of the relative reaction rate on the concentration of reacting substances .

The reaction of sodium thiosulfate with sulfuric acid is studied, which can be expressed by the following equation:

$$\mathbf{a)\ Na_2S_2O_3 + H_2SO_4 \rightarrow H_2S_2O_3 + Na_2SO_4}$$
$$\mathbf{b)\ H_2S_2O_3 \rightarrow S\downarrow + SO_2\uparrow + H_2O}$$

Reaction (a) occurs instantaneously. The rate of reaction (b) is measurable and depends on the concentration of thiosulfuric acid at a constant temperature. The reaction results in the formation of a colloidal sulfur precipitate, which is easily observed visually. The time from the onset of the reaction to the solution becoming cloudy determines the overall reaction rate.

Procedure: Using a burette, pour 0.1 M sodium thiosulfate solution and distilled water into five test tubes. The quantities of 0.1 M Na2S2O3 solution and distilled water are listed in Table 1. Quickly pour the acid into the first test tube and shake. Record the time elapsed from the start of the reaction until faint opalescence appears. Repeat the experiment sequentially with test tubes 2, 3, 4, and 5. The solution temperature should be constant in all cases. Calculate the relative reaction rate. What should the graph look like if the law of mass action is ideally observed? Write the kinetic equation for this reaction. Complete Table 1.

Table 1

п/п	$Na_2S_2O_3$ (мл)	H_2O (мл)	Концентрация раствора H_2SO_4 (моль/л)	Время τ (сек).	Относительная скорость реакции 1/τ
1	1	4	0,01		
2	2	3	0,02		
3	3	2	0,03		
4	4	1	0,04		
5	5	0	0,05		

Experiment 2. Study of the dependence of the relative reaction rate on temperature.

Procedure: Pour 5 ml of sodium thiosulfate solution into 4 test tubes, and 5 ml of sulfuric acid into the others. The experiment is conducted in 4 different test tubes at different temperatures:

1. Place the first pair of test tubes containing sodium thiosulfate and sulfuric acid solutions in a beaker of water with a thermometer at room temperature. After 3-5 minutes, when the temperatures in the test tubes and the beaker have equalized, record the thermometer reading. Pour the contents of the test tubes into one test tube and shake it. Record the time from the start of the reaction until faint opalescence appears.
2. Place the second pair of test tubes in a glass of water with a thermometer and heat it by 10 ^{o}C and then repeat the experiment.

3. Conduct experiments similarly with the third and fourth pairs of test tubes, increasing the solution temperature by 10 ° C each time. How and why does the reaction time change? Calculate the relative reaction rate at all four temperatures and record the results in Table 2.

Table 2

Using the data obtained, plot a curve showing the reaction rate versus temperature, plotting

№	Температуры опыта °C	Время τ (сек)	Относительная скорость реакции 1/τ
1	22°C		
2	22°C + 10°C		
3	22°C + 20°C		
4	22°C + 30°C		

temperature on the x-axis and the relative reaction rate on the y-axis.

Experiment 3. The effect of a catalyst on the reaction rate

In this work, the rate of catalytic and non-catalytic decomposition of hydrogen peroxide:

$$2H_2O_2 \rightarrow 2H_2O + O_2\uparrow$$

Progress of work *:* *Ten drops of* a 3% H2O2 solution are added to a test tube . At room temperature, in the absence of a catalyst, the hydrogen peroxide decomposition reaction proceeds extremely slowly, as evidenced by the lack of external signs of reaction. Several crystals of manganese dioxide (MnO2) are added to the hydrogen peroxide solution (on the tip of a scalpel). Vigorous decomposition of the H2O2 immediately begins, releasing molecular oxygen. This can be detected by holding a smoldering splint to the opening of the test tube—it will burst into a bright flame. This indicates that manganese dioxide acts as a catalyst in this reaction.

Report preparation

Test questions:

1. Give the definition of the rate of a chemical reaction and its application.
2. Explain the factors influencing the rate of a chemical reaction: the nature of the substance and its state of aggregation, concentration, pressure, temperature, and catalyst.
3. Show the meaning and essence of the law of mass action, rate and constant of a chemical reaction.
4. Provide a definition of the rate of homogeneous chemical reactions and provide methods for determining its changes.
5. Using an example, explain the influence of temperature on the rate of chemical reactions and the essence of Van't Hoff's rule.
6. Give an idea of the kinetics of complex reactions.

Explain the process of catalysis. Describe the types of catalysis. Explain enzymatic catalysis using an example.

7. Describe the types of catalysis (homogeneous, heterogeneous, enzymatic).

Lab session #9
Topic: Physicochemistry of dispersed systems

Objective of the lesson: Study of the structure of dispersed systems, properties of colloidal particles of lyophobic sols, basic properties of lyophobic colloidal solutions, their biological role in medicine.

Theoretical part

Dispersed systems are heterogeneous systems that consist of two or more phases .

The fragmented (discontinuous) part of a dispersed system is usually called **the dispersed phase** . and the uncrushed (continuous) *one is* **a dispersion medium** . A necessary condition for the formation of dispersed systems is insolubility or limited mutual solubility.

dispersed phase and dispersion medium. Fragmentation imparts new properties to dispersed systems, which are associated with a sharp increase in the phase separation surface:

Dispersed systems in nature are characterized by a huge diversity, so there is no single classification for them. The existing ones are based on classifications are based on the properties of dispersed systems: particle size DF, the aggregate state of DF and DS, the nature of the interaction of the dispersed phase with

environment and others.

Solutions of high-molecular-weight compounds (HMCs) and colloidal surfactants (surfactants) occupy a special place among dispersed systems. These solutions contain particles whose sizes correspond to those of colloidal solutions. Of the two characteristics of dispersed systems (heterogeneity and dispersion), they possess only one: dispersion.

All living systems are dispersed. A number of substances, such as phosphates, fats, and lipids, exist in a colloidal state in blood, lymph, and cerebrospinal fluid.

Currently, of particular interest is the development of models of cells, living membranes, and nerve fibers that operate according to the laws of colloidal chemistry.

The processes of dialysis and ultrafiltration are combined in the artificial kidney machine. The study of coagulation and peptization processes is of great interest to physicians. The coagulation of colloidal solutions of calcium phosphate and cholesterol in the blood leads to the formation and deposition of deposits on the inner surface of blood vessels. Blood clotting and the aggregation of red blood cells into so-called "rouleaux" are processes similar to coagulation. Peptization underlies the process of clot dissolution.

In hygiene and sanitation, coagulation is used to purify drinking wastewater.

Experimental part

Equipment and reagents: 250 ml flask, 100 and 250 ml beakers, glass rod, colloidal bag, projection lamp. Reagents: H_2O distilled, 2% $FeCl_{3\ solution}$, colloidal iron hydroxide solution, $AgNO_{3\ solution.}$

Experiment 1. Obtaining a colloidal solution of iron hydroxide

Procedure: Add 10 ml of a $_2$ % FeCl3 solution quickly but gradually to 50 ml of boiling water . The sol turns reddish-brown. Describe the structure of the micelle.

Experiment 2. Purification of sol by dialysis.

Procedure: Pour hot Fe(OH)3 sol into a colloidal bag. Suspend the bag and immerse it in a beaker of distilled water. After 10-15 minutes, determine the presence of Cl- ions. Chlorine ions can be detected using AgNO3 . To remove excess electrolyte from the colloidal solution, change the water in the beaker until a qualitative reaction for the corresponding ion is observed. will be negative.

CI-+ Ag += AgCI

Experiment 3. Observation of light scattering.

Procedure: Pour the sol into a flask. Pass a beam of light from a projection lamp through it. Observe the light scattering from the side (Tyndall cone). Conduct the same experiment with water. Note the difference in light scattering between the two solutions.

Report design:

_____
_____
_____
_____
_____
_____

Test questions:

1. Using examples, describe the concept of dispersed systems, dispersed phase and dispersed medium.
2. Show the principles of classification of disperse systems
3. What systems are called colloidal? Name the two main groups of methods for obtaining colloidal solutions, and describe their essence.
4. Give examples of methods for obtaining colloidal solutions (dispersion and condensation).
5. Using an example, explain the methods of purification of dispersed systems (dialysis, electrolysis, compensatory dialysis, vividiasis, ultrafiltration, gel filtration). The principle of the AIP (artificial kidney apparatus).
6. What phenomenon is called coagulation? What are the visible signs of coagulation?

List of test questions for control forms

MODULE #1

1. The negative decimal logarithm of the concentration of hydrogen ions in a solution is:
(One answer)
   - A) ionic product of water
   - B) water constant pH
   - C) hydroxyl index
   - D) buffer capacity

2. Hess's law is a consequence of:
(One answer)
   - A) 2nd law of thermodynamics;
   - B) 3rd law of thermodynamics;
   - C) from the 1st law of thermodynamics;
   - D) 0th law of thermodynamics.

3. If the transition processes of a system occur at a constant system pressure, then they are called:
(One answer)
   - A) isochoric;
   - B) isobaric;
   - C) isothermal;
   - D) isobaric-isothermal

4. According to the international SI system, joules (J) are used to measure:
(One answer)
   - A) weight;
   - B) temperature;
   - C) entropy;
   - D) work, enthalpy, Gibbs energy.

5. Who was the founder of the chemical theory of solutions?
(One answer)
   - A) D. Mendeleev
   - B) .W. Ostwald
   - C) S. Arrhenius
   - D) A. Verne

6. Systems that exchange matter and energy with the environment are called (One answer)

A) open
B) closed
C) isolated
D) thermodynamic

7. If the neutralization method uses an alkali as a titrant, then this definition refers to: (One answer)

A) acidimetry
B) alkalimetry
C) redox titration
D) complexometry

8. Choose the correct safety rule in the chemistry lab: (One answer)

A) It is prohibited to remove necessary items from the table
B) It is forbidden to wash your hands after the experiment.
C) It is forbidden to drink, eat, or taste substances
D) It is forbidden to sniff familiar substances

9. Caustic (hazardous) substances include: (One answer)

A) acid and alkali
B) alkali and carbon dioxide
C) salt and acid
D) water and oxygen

10. Solubility of gases in water with increasing temperature: (One answer)

A) does not change.
B) first decreases and then increases
C) decreases.
D) first increases and then decreases.
E) increases.

11. The scientist who created the thermodynamic absolute temperature scale: (One answer)

A) Celsius;
B) W. Kelvin;
C) G. Fahrenheit;
D) R. Reaumur

12.What is a true solution? (One answer)

A) A homogeneous system of variable composition, consisting of several components.
B) A heterogeneous system of variable composition consisting of several components.
C) A homogeneous system of constant composition consisting of several components.
D) all answers are correct

13. The characteristic function $H = U + pV$ is called (One answer)

A) Gibbs free energy
B) enthalpy
C) isobaric-isothermal potential
D) entropy

14. A substance for which the standard enthalpy of formation is zero is (One answer)

A) ethanol
B) oxygen
C) hydrogen chloride

D) hydrogen sulfide
E) sulfuric acid

15. The human body is a system:
(One answer)
A) closed
B) isolated
C) open
D) all answers are correct

16. Closed systems exchange with the environment
(One answer)
A) neither matter nor energy
B) energy
C) matter and energy
D) substance

17. What device is used to measure the thermal effects of chemical reactions?
(One answer)
A) calorimeter
B) conductometer
B) potentiometer

18. An insulated thermodynamic system is a system that
(One answer)
A) exchanges energy but does not exchange mass
B) exchanges both mass and energy
C) exchanges mass but does not exchange energy
D) does not exchange either matter or energy with the environment

19. The process of dissolution is this process:
(One answer)
A) chemical
B) physical
C) physicochemical
D) isothermal;

20. Select the true solution:
(One answer)
A) water and sugar
B) sand and chalk
C) water and sand
D) all answers are incorrect

21. Solutions are:
(One answer)
A) thermodynamically unstable heterogeneous systems consisting of two or more components
B) thermodynamically stable heterogeneous systems consisting of one component;
C) thermodynamically unstable homogeneous systems consisting of one component;
D) thermodynamically stable homogeneous systems consisting of two or more components;

22. Earth's atmosphere:
(One answer)
A) example of liquid solutions;
B) example of gaseous solutions;
C) example of solid solutions;
D) is not a solution.

23. The colligative properties of solutions are:
(Multiple answers)
A) osmotic pressure;
B) lowering the freezing temperature of solutions;

C) increase in the freezing temperature of solutions;
D) increasing the boiling point of solutions.

24. The author of the theory of electrolytic dissociation is:
(One answer)
A) Lewis.
B) Arrhenius;
C) Lowry;
D) Brønsted

25. The theory of acids and bases put forward by Lewis in 1923 was called:
(One answer)
A) theory of electrolytic dissociation;
B) protolytic theory of acids and bases
C) hydrogen theory of acids and bases;
D) Electronic theory of acids and bases.

26. At pH < 7 the solution environment is called:
(One answer)
A) sour
B) neutral
C) alkaline
D) salty

27. The sum of the hydroxyl and hydrogen indices in aqueous solutions is:
(One answer)
A) 7
B) 10^{-7}
C) 10-14
D) 14;
E) 1

28. According to Van't Hoff's rule, when the temperature increases by 10°, the rate of many reactions:
(One answer)
A) decreases by 2-4 times;
B) decreases by 5-10 times;
C) increases by 2-4 times;
D) increases by 5-10 times

29. A thermodynamic system consisting of two or more phases with different properties, between which there is a boundary surface, is called
(One answer)
A) open
B) homogeneous
C) closed
D) heterogeneous

30. A thermodynamic system in which there is no surface division and the properties are the same at every point in the system is called
(One answer)
A) homogeneous
B) heterogeneous
C) open
D) closed

31. Catalysts are substances that:
(One answer)
A) shift the chemical equilibrium
B) increase the reaction speed by participating in it, but not being spent
C) increase the reaction rate, participate in it and are consumed
D) reduce reaction speed

E) do not affect the reaction rate

32. Unit of measurement of the rate of a chemical reaction
(One answer)
A) mol/s
B) mol/l
C) mol/l*s
D) g/mol
E) kJ/mol

33. The system state parameters are:
(Multiple answers)
A) pressure
B) entropy
C) temperature
D) enthalpy
E) volume.

34. Chemical equations that indicate the state of aggregation of substances and the heat effect of the reaction are called:
(One answer)
A) isochoric
B) isobaric
C) isothermal
D) thermochemical
E) isobaric-isothermal

35. A change in any of the thermodynamic parameters describing the state of a thermodynamic system is called:
(One answer)
A) internal energy
B) thermodynamic process
C) thermodynamics
D) thermodynamic system

36. The concentration of hydroxide ions is lowest in a solution whose pH is:
(One answer)
A) 5
B) 2
C) 7
D) 13

37. Wet litmus paper will turn blue in test tubes containing:
(One answer)
A) ammonia
B) sulfur(IV) oxide
C) methylamine
D) nitrogen

38. Chemical kinetics is a section of physical chemistry that studies:
(Multiple answers)
A) the fundamental possibility of a chemical process proceeding spontaneously in one direction or another;
B) thermal effects of chemical reactions;
C) the rate of chemical reactions over time, factors influencing its magnitude;
D) a possible mechanism of chemical reactions taking into account the structure of the molecules of the substances involved.

39. The rate of a homogeneous chemical reaction occurring in an aqueous solution depends on:
(Multiple answers)
A) concentrations of the starting substances

B) solution temperature;
C) pressure above the solution;
D) presence of a catalyst.

40. The equivalent mass of sulfuric acid ($M(H_2SO_4)$=98 g/mol) is equal to:
(One answer)
A) 32.6
B) 98.0
C) 49.0
D) 56.5
E) 40.0

41. Electrolytes that form hydronium ions when dissociated in aqueous solutions are called:
(One answer)
A) oxides
B) grounds
C) salts
D) acids

42. A buffer solution is a solution containing a mixture of:
(One answer)
A) weak acid and soluble salt
B) strong acid and soluble salt
C) weak acid and insoluble salt
D) strong acid and insoluble salt

43. What factors influence the increase in reaction speed?
(One answer)
A) the nature of the reactants;
B) temperature, concentration, catalyst;
C) catalyst only;
D) only concentration
E) only temperature.

44. What is the maximum capacitance of the p-sublevel?
(One answer)
A) 2
B) 4
C) 6
D) 8

45. Which of the following acids is both unstable and weak?
(One answer)
A) H_2SO_4;
B) H_3PO_4
C) H_2CO_3
D) HCl

46. Which of the following acids is strong, since its degree of dissociation does not depend on concentration?
(One answer)
A) HNO_2
B) H_2S
C) HCN
D) H_2SO_3
E) HNO_3

47. Calculations of the results of determinations in titrimetry are based on the law ……
… (One answer)
A) multiple ratios
B) acting masses

C) Avogadro
D) equivalents

48. Acid-base indicators are …..
(One answer)
A) weak inorganic acids or bases whose color changes with changes in the pH of the environment
B) weak organic acids or bases whose color changes with changes in the pH of the environment
C) strong organic acids or bases whose color changes with changes in the pH of the environment
D) strong inorganic acids or bases whose color changes with changes in the pH of the environment

49. If a student receives a thermal burn, he should
(Multiple answers)
A) inform the teacher immediately
B) inform the teacher after the end of the lesson
C) pour cold water over the burn
D) cover the burn site with your palm

50. First action if corrosive liquid comes into contact with skin
(One answer)
A) do nothing
B) rinse the skin with water
C) scream
D) wipe this place

51. When working with chemicals, do not
(One answer)
A) change the caps from the reagent bottles
B) use dirty test tubes
C) leave bottles with reagents open
D) everything is correct

52. The measure of the disorder of the state of a system is the thermodynamic function:
(One answer)
A) heat;
B) enthalpy
C) internal energy
D) entropy

53. A spirit lamp cannot be lit from another spirit lamp, because
(One answer)
A) you can break the alcohol lamp
B) the alcohol lamp may go out
C) alcohol may spill and cause a fire
D) it's inconvenient

54. The main use of salt in the diet is
(One answer)
A) make food taste better
B) produce small amounts of hydrochloric acid, which is necessary for digesting food
C) make cooking easier
D) increase the solubility of food particles in water

55. A separatory funnel is used to separate substances:
(One answer)
A) with the same density
B) with different solubility
C) with the same particle sizes

D) not mixing with each other.

56. Which of the following compounds is not an electrolyte?
(One answer)
A) NaOH
B) H_2SO_4
C) H_3PO_4
D) $(C_6H_{12}O_5)_n$
E) $Ca(OH)_2$

57. Which salt will undergo complex (stepwise) hydrolysis?
(One answer)
A) NaCl
B) CH_3COONa;
C) Na_3PO_4
D) NH4Cl ;
E) NH_4NO_3

58. The rate of a heterogeneous chemical reaction occurring between a solid and a liquid solution depends on:
(Multiple answers)
A) surface area of a solid
B) solution concentration
C) temperatures
D) pressure above the solution

59. The dependence of the rate constant of a chemical reaction on temperature (when it changes over the widest range) is described using:
(One answer)
A) law of mass action
B) van't Hoff's law
C) Arrhenius equations
D) second law of thermodynamics

60. Molecularity of a simple reaction:
(Multiple answers)
A) always expressed as an integer;
B) can be either an integer or a fractional number;
C) there are no more than three;
D) can take any integer value.

61. Inhibitors are:
(Multiple answers)
A) substances that reduce the rate of a chemical reaction;
B) catalytic poisons;
C) substances that do not affect the rate of a chemical reaction;
D) substances that increase the time it takes for a chemical reaction to reach equilibrium.

62. Natural catalysts of protein nature that accelerate biochemical reactions in animal and plant cells are called:
(One answer)
A) enzymes;
B) antioxidants;
C) vitamins
D) antiglobulins

63. The reaction rate in heterogeneous catalysis depends on:
(Multiple answers)
A) surface area of the solid catalyst;
B) the number of active centers on the catalyst surface
C) colors and shapes of the catalyst

D) concentration of solid catalyst

64. Plasmolysis is:
(One answer)
A) destruction of leukocytes;
B) cell shrinkage;
C) cell swelling
D) destruction of red blood cells

65. When storing an open flask containing a salt solution, crystals formed at the bottom of the flask. What will the solution above the crystals be like?
(One answer)
A) saturated
B) diluted
C) supersaturated
D) unsaturated.
E) Concentrated

66. To prepare 500 g of hypertonic sodium chloride solution with a mass fraction of 10% you need:
(One answer)
A) 50 g NaCl
B) 150 g NaCl
C) 75 g NaCl
D) 25 g NaCl

67. Molal concentration is…
(One answer)
A) the number of moles of dissolved substance in 1 kg of solvent
B) the number of moles of dissolved substance in 1 dm3 of solution
C) the number of moles of dissolved substance in 100 cm3 of solution
D) the number of moles of dissolved substance in 1 cm3 of solution
E) the number of moles of dissolved substance in 1 kg of solution

68. With increasing atmospheric pressure, the solubility of oxygen in the blood:
(One answer)
A) increases
B) changes arbitrarily
C) will not change
D) decreases

69. What is the mass fraction of glucose (in %) in the solution obtained by dissolving 20 g of glucose in 180 g of water?
(One answer)
A) 20
B) 15
C) 30
D) 10
E) 5

70. Hypotonic solutions of drugs cannot be administered intravenously because:
(One answer)
A) red blood cell aggregation
B) erythrocyte plasmolysis
C) increase in osmotic pressure in the blood
D) hemolysis of erythrocytes
E) erythrocyte sedimentation

71. Colligative properties of solutions are properties that depend on:
(One answer)
A) sizes of solvent particles
B) nature of the dissolved substance

C) temperatures
D) particle sizes of the dissolved substance
E) number of particles of dissolved substance

72. Colligative properties include:
(One answer)
A) coagulation
B) diffusion and osmosis
C) sedimentation stability
D) solubility
E) extraction

73. Which of the electrolytes HCl, AgCl, HNO_3, NH_4Cl, NH_4OH, CH_3COOH, CH_3COONa are considered weak?
(One answer)
A) AgCl, NH_4Cl
B) HCl, AgCl
C) NH_4OH, CH_3COOH
D) NH_4Cl, NH_4OH
E) CH_3COOH, CH_3COONa

74. In which of the following solutions is the hydrogen index equal to zero?
(One answer)
A) 0.1 M HCl
B) 0.1 M KOH
C) 1 M HCl
D) 1.5 M $Ba(OH)_2$
E) 0.8M H_2SO_4

75. Which interactions of substances does the abbreviated ionic equation correspond to?
$H^+ + OH^- = H_2O$?
(One answer)
A) potassium hydroxide and nitric acid
B) aqueous solution of ammonia and carbonic acid
C) sodium hydroxide and sulfidic acid
D) aqueous solution of ammonia and hydrochloric acid
E) .aqueous solution of ammonia and acetic acid

76. Among the reasons given, the strongest is:
(One answer)
A) $Zn(OH)_2$
A) $Al(OH)_3$
B) $Fe(OH)_2$
C) $Ca(OH)_2$
D) $Sn(OH)_3$

77. In an alkaline solution, pH and pOH are respectively equal to:
(One answer)
A) pH = 7, pOH = 7
B) pH > 7, pOH > 7
C) pH < 7, pOH<7
D) H<7,pOH>7
E) pH > 7, pOH<7

78. The normal pH of blood plasma can fluctuate within the following range:
(One answer)
A) 8.01 – 8.25
B) 7.35 – 7.45
C) 4.50 – 5.35
D) 6.80 – 7.00

E) 7.65 – 7.85

79. In acidosis, the blood pH value is within the range:
(One answer)
A) 7.35 – 7.45
B) 6.50 – 7.00
C) 7.65 – 7.85
D) .4.50 – 5.35
E) 7:00 – 7:35

80. To correct the acid-base balance in acidosis, the following solution is recommended:
(One answer)
A) glucose
B) NaCl
C) HCl
D) $NaHCO_3$
E) Na_2SO_4

81. To determine which of the following substances can a KOH solution be used as a titrant?
(One answer)
A) Na_2CO_3
B) H_2SO_4
C) NaCl
D) NaOH
E) K_2SO_4

82. What is the name of the moment in the titration process when the analyzed substance and the titrant have reacted completely?
(One answer)
A) color transition point
B) end point of titration
C) equivalence point
D) point of neutrality

83. A solution with a precisely known molar concentration of the equivalent of a substance is called:
(One answer)
A) titrated
B) normal
C) molal
D) worker
E) molar

84. What is the name of the pH range in which the indicator gradually changes color?
(One answer)
A) pH range
B) basicity interval
C) indicator value
D) acidity range
E) color transition interval

85. The blood buffer systems do not include:
(One answer)
A) acetate
B) phosphate
C) protein
D) hydrocarbonate
E) hemoglobin

86. Buffer systems are used for the following purposes:
(One answer)
A) changes in the instability constant of a substance

B) changes in the dissociation constant of a substance
C) changes in the solubility product of a substance
D) changes in the ionic strength of a solution
E) maintaining a certain pH value of the environment

87. The normal pH of urine can fluctuate within the following range:
(One answer)
A) 2.0 – 3.5
B) .2.5 – 3.5
C) 7.5 – 9.5
D) 8.5 – 10.5
E) 5.0 – 6.5

88. The main buffer system includes a mixture of:
(One answer)
A) ammonium hydroxide and ammonium ion
B) potassium sulfate and ammonium hydroxide
C) ammonium chlorides and sulfates
D) sodium and potassium hydroxides
E) potassium hydroxide and potassium sulfate

89. The following buffer solution is not included in the composition of blood buffer systems: A.
(One answer)
A) hydrocarbonate
B) protein
C) oxyhemoglobin
D) ammonia
E) phosphate

90. What is the acid buffering capacity of a solution?
(One answer)
A) the number of moles of acid in 1 liter of buffer solution
B) the number of mole equivalents of acid that must be added to 1 liter of buffer solution to change the pH by one unit
C) the number of grams of acid required to change the pH of a buffer solution
D) the number of moles of a substance required to change the pH of 1 liter of a buffer solution
E) the volume of acid required to change the pH of 1 liter of buffer solution

91. The electrolytic theory of acids and bases was proposed by:
(One answer)
A) Lewis
B) Brønsted
C) Lowry
D) Arenius

92. The protolytic theory of acids and bases was proposed by:
(One answer)
A) Archimedes
B) Arenius
C) Bronsted and Lowry
D) Lewis

93. According to the proton theory (Brenneted-Lowry), a substance (particle) capable of donating protons is called:
(One answer)
A) acid
B) basis
C) with salt
D) oxides

94. The ionic product of water Kw is equal to:

(One answer)

A) the product of the acidity constant and the basicity constant of the conjugate base of this acid

B) the ratio of the acidity constant to the basicity constant of the base conjugate to this acid

C) the sum of the acidity constant and the basicity constant of the base conjugate to this acid

D) the difference between the acidity constant and the basicity constant of the substance conjugate to this

95. Maintaining the acid-base balance in the body occurs due to:

(One answer)

A) all of the listed systems
B) buffer system
C) respiratory system
D) renal activity
E) liver functions

96. The number of elementary acts of interaction per unit of time determines:

(One answer)

A) order of reaction
B) reaction speed;
C) molecularity of the reaction;
D) half-life.

97. Indicate which substance is used as a titrant in acidimetric titration:

(One answer)

A) potassium permanganate;
B) potassium hydroxide
C) hydrochloric acid
D) methyl orange

98. A 400 ml solution contains 5.6 g of sodium hydroxide. Determine the molar concentration (in mol/L) of the alkali in this solution.

(One answer)

A) 0.10
B) 0.25
C) .0.75
D) 1.00
E) 0.50

99. What reaction of the solution will be observed during hydrolysis of the salt NH4Cl?

(One answer)

A) highly alkaline;
B) neutral
C) sour
D) slightly alkaline

100. 0.9% aqueous sodium chloride solution is:

(One answer)

A) hypertensive
B) hypotonic
C) isotonic
D) atonic

101. A reaction is necessarily simple if:

(One answer)

A) the reaction takes place between simple substances
B) the order of the kinetic equation of the reaction is zero
C) the half-life does not depend on the initial concentration of the reactants
D) the reaction is carried out through a large number of similar elementary acts
E) the order of the kinetic equation of the reaction is equal to one

102. The main mineral substance of bone tissue is
(One answer)
A) calcium phosphate
B) fluorapatite
C) calcium fluoride
D) calcium hydrogen phosphate
E) calcium hydroxide phosphate

103. The rate of a chemical reaction is
(One answer)
A) change in the concentration of reactants per unit of time
B) the number of molecules participating in an elementary act of a chemical reaction
C) the number of substrate molecules converted by one enzyme molecule
D) change in catalyst concentration per unit of time

104. The dependence of the rate of a chemical reaction on temperature is expressed by the rule
(One answer)
A) Hunda
B) Markovnikova
C) Van't Hoff
D) Zaitseva

105. The hydrogen index (pH) is determined by the formula:
(One answer)
A) pH = lg[H+]
B) pH = -lg[H+]
C) pH = -lg[OHx]
D) pH = pOH

106. The ionic product of water is:
(One answer)
A) variable
B) constant for any aqueous solution at constant temperature
C) dependent on the pH value of the solution
D) dependent on the concentration of acid in the solution

107. In protolytic reactions the transferred particle is:
(One answer)
A) proton
B) ion
C) electron
D) electron pair

108. Strong electrolytes include all substances in the series:
(One answer)
A) H2O , HCl, $_{NaCl}$
B) CH_3COOH, NH_4OH, H_2CO_3
C) KCl, CH_3COOH, NH_4OH
D) H_2CO_3 HNO_3 H_2SO_4
E) KCl, NaOH, HNO_3

109. The ratio of the number of molecules that disintegrate into ions to the total number of dissolved molecules is called
(One answer)
A) degree of electrolytic dissociation
B) buffer capacity
C) dissociation constant
D) degree of swelling

110. The alkalimetric method is used to analyze:
(One answer)

A) metal oxides;
B) salts of strong bases and weak acids;
C) strong and weak acids;
D) strong and weak bases

111. When aqueous solutions of calcium chloride and sodium carbonate interact, the following precipitate:
(One answer)
A) calcium oxide
B) calcium hydroxide
C) calcium carbonate
D) calcium bicarbonate

112. Substances that, when dissociated in an aqueous solution, form only hydroxide ions as anions are:
(One answer)
A) medium salts
B) basic salts
C) alkalis
D) acids

113. Between which substances is an ion exchange reaction possible?
(One answer)
A) H_2SO_4 and $NaNO_3$
B) $Al_2(SO_4)_3$ and $BaCl_2$
C) Na_2SO_4 and HCl
D) KNO_3 and Na_2SO_4

114. Between which substances is an ion exchange reaction possible with the release of gas?
(One answer)
A) H_2SO_4 and $Ca_3(PO_4)_2$
B) $Al_2(SO_4)_3$ and $BaCl_2$
C) Na_2CO_3 and HCl
D) HNO_3 and KOH

115. The ion exchange reaction proceeds to completion if the following conditions are met
(One answer)
A) gas, sediment, strong electrolyte
B) gas, sediment, weak electrolyte
C) gas, sediment, water
D) gas and sediment

116. Provide the most correct definition of the term "electrolytes." These are substances:
(One answer)
A) conducting electric current;
B) decomposable under the influence of electric current;
C) solutions and melts of which conduct electric current
D) all answers are correct

117. The process of destruction of salt under the influence of water with the formation of a weak electrolyte is called:
(One answer)
A) hemolysis;
B) electrolysis.
C) hydrolysis
D) dissociation
E) plasmolysis

118. Salts formed by: are not hydrolyzed.
(One answer)
A) strong base and weak acid;
B) weak base and weak acid;

C) strong base and weak acid;
D) strong base and strong acid

119. When preparing a burette for titration, it is necessary:
(One answer)
A) rinse it with distilled water
B) wash it with titrant.
C) rinse with the test solution;
D) no need to rinse

120. Select one answer. Only non-electrolytes are listed in the row.
(One answer)
A) sodium chloride, hydrochloric acid, sodium bicarbonate;
B) benzene, glucose, sulfur
C) glucose, sodium chloride, acetic acid;
D) hydrogen sulfide, carbonic acid, sodium carbonate

121. Strong electrolytes include bases.
(One answer)
A) formed by p-metals;
B) formed by d-metals;
C) formed by alkali and alkaline earth metals
D) all answers are correct

122. Select multiple answer options. Reaction equations reflecting electrolytic dissociation:
(Multiple answers)

A) $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$;

B) $Cu^{2+} + H_2O \rightleftharpoons CuOH^+ + H^+$

C) $CaCO_3 \rightarrow CaO + CO_2$;

D) $H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$.

123. Select one answer. Cation hydrolysis is characteristic of salts:
(One answer)
A) formed by the cation of a weak base and the anion of a strong acid;
B) formed by the cation of a strong base and the anion of a weak acid
C) formed by the cation of a weak base and the anion of a weak acid
D) all answers are incorrect

124.The reaction between:
(One answer)
A) K_2SO4 and HCl
B) NaCl and $CuSO4$
C) Na_2SO_4 and KOH
D) $BaCl_2$ and $CuSO_4$

125.When sodium hydroxide solution was added to a solution of an unknown salt, a brown precipitate formed.
Formula of unknown salt:
(One answer)
A) $BaCl_2$
B) $FeCl_3$
C) CuSO4
D) KNO_3

126.The rate of a chemical reaction at a constant temperature at any given moment in time is proportional
(One answer)
A) the sum of the exponents at concentrations
B) product of exponents at concentrations

C) the sum of the concentrations of the reacting substances in powers equal to their stoichiometric coefficients

D) the product of the concentrations of the reacting substances in powers equal to their stoichiometric coefficients

127.The rate of enzymatic reactions with increasing temperature:
(One answer)

A) does not change
B) first rises and then falls
C) is decreasing
D) first decreases and then increases

128.The function of enzymes in a living organism is to:
(One answer)

A) oxygen transport
B) catalysis of biochemical reactions
C) ensuring immunity
D) energy supply
E) slowing down of biochemical reactions

129.The direction of the shift in chemical equilibrium when external conditions change is determined
(One answer)

A) Zaitsev's rule
B) Pauli exclusion principle
C) Le Chatelier's principle
D) Hund's rule

130.There is an equilibrium in blood plasma: $CO_2 + H_2O = H_2CO_3$. How will the concentration of carbonic acid change when the blood in the tissue capillaries is saturated with carbon dioxide?
(One answer)

A) decreases
B) does not change
C) increases
D) increases then decreases

131.For complete precipitation of CO_3^{2-} ions from a saturated $CaCO_{3\ solution}$, it is necessary to add:
(One answer)

A) Na_2CO_3
B) $Ca(NO_3)_2$
C) K_2SO_3
D) K_2SO_4

132.Bronsted acid is:
(One answer)

A) electron pair donor
B) H+ donor
C) electron pair acceptor
D) H+ acceptor

133.The foundation of Bronsted is:
(One answer)

A) H+ donor
B) H+ acceptor
C) electron pair acceptor
D) all answers are correct

134.Calculate the mass of sodium chloride to prepare 100 g of isotonic (0.9%) solution, which is used for intravenous administration.
(One answer)

A) 1.8 g
B) 0.9 g

C) 18 g
D) 0.36 g
E) 0.18 g

135.The normal concentration (molar equivalent concentration) is.....
(One answer)
A) the number of mole equivalents of a dissolved substance in 1 dm3 of solution
B) the number of mole equivalents of a dissolved substance in 1 kg of solution
C) the number of mole equivalents of a dissolved substance in 1 kg of solvent
D) the number of mole equivalents of a dissolved substance in 1 cm3 of solution

136.What mass (in g) of argentum nitrate should be taken to prepare 10 g of a 2% solution (eye drops)
(One answer)
A) 0.1
B) 0.2
C) 10
D) 2
E) 20

137.The movement of solvent from the environment into the osmotic cell is called:
(One answer)
A) exosmosis
B) endosmosis
C) turgor
D) diffusion.

138.Buffer solutions can be prepared from:
(One answer)
A) HNO_3 and KOH,
B) CH_3COOH and NaOH,
C) HCl and KNO_3
D) NH_4OH and H_2S

139.Buffer capacity is quantified by:
(One answer)
A) mol/eq of a strong acid or base that must be added to 1 L of a buffer solution to change its pH by one unit;
B) mol/L of a strong acid or base that must be added to 1 L of a buffer solution to change its pH by one unit;
C) the number of ml of weak acid or base that must be added to 1 l of buffer solution to change its pH by one unit;
D) the number of ml of a strong acid or base that must be added to 1 liter of a buffer solution to change its pH.

140.The pH of the buffer system depends on:
(One answer)
A) concentrations of components,
B) buffer volume,
C) breeding,
D) ratio of component concentrations.

141.With compensated alkalosis:
(One answer)
A) pH = 7.4, alkaline reserve 55% by volume,
B) pH = 7.2, alkaline reserve 70% by volume,
C) pH = 7.4, alkaline reserve 70% by volume,
D) pH = 7.4, alkaline reserve 40% by volume.

142.With compensated acidosis:
(One answer)
A) pH = 7.4, alkaline reserve 55% by volume,

B) pH = 7.2, alkaline reserve 70% by volume,
C) pH = 7.4, alkaline reserve 70% by volume,
D) pH = 7.4, alkaline reserve 40% by volume.

143.In case of acidosis, the following solution is not used as an emergency measure:
(One answer)
A) sodium bicarbonate;
B) ascorbic acid
C) sodium lactate
D) trisamine

144.Among the proposed salts CH_3COONH_4, $CuBr_2$, $Al_2(SO_4)_3$ – hydrolysis is (are) subjected to
(One answer)
A) CH_3COONH_4
B) $CuBr_2$
C) $Al_2(SO_4)_3$
D) all substances

145.Which reaction corresponds to the abbreviated equation $H^+ + OH^- = H_2O$?
(One answer)
A) $ZnCl_2 + 2\ NaOH = Zn(OH)_2 + 2\ NaCl$
B) $NaOH + HNO_3 = NaNO_3 + H_2O$
C) $H_2SO_4 + Cu(OH)_2 = CuSO_4 + 2\ H_2O$
D) $H_2SO_3 + Ba(OH)_2 = BaSO_3 + 2\ H_2O$

146.Ions of the group cannot be in solution at the same time:
(One answer)
A) $K^+, H^+, NO^{3-}, SO_4^{2-}$
B) Ba^{2+}, Ag^+, OH^-, F^-
C) $H^+, Ca^{2+}, Cl^-, NO_3^-$
D) Mg^{2+}, H^+
E) $Br^- Cl^-$

147.The reaction equation $Zn(OH)_2 + H_2SO_4 = ZnSO_4 + 2H_2O$ corresponds to the abbreviated ionic equation:
(One answer)
A) $H^+ + OH^- = H\ 2\ O$
B) $Zn^{2+} + SO_4^{2-} = ZnSO_4$
C) $H_2SO_4 + Zn^{2+} = ZnSO_4 + H_2O$
D) $Zn(OH)_2 + 2H^+ = Zn^{2+} + 2H_2O$

148.An 800 ml solution contains 40 g of sodium hydroxide. Determine the molar concentration (in mol/L) of the alkali in this solution.
A) (One answer)
B) 1.00
C) 2.50
D) 0.50
E) 1.50
F) 1.25

149.Hypotonic solutions of drugs cannot be administered intravenously because:
(One answer)
A) red blood cell aggregation
B) erythrocyte plasmolysis
C) increase in osmotic pressure in the blood
D) hemolysis of erythrocytes
E) erythrocyte sedimentation

150.In medicine, what parameter is used to classify solutions as hypo-, hyper-, and isotonic? What does a 3% glucose solution qualify for according to this classification?
(One answer)

A) osmotic pressure, isotonic
B) blood pressure, isotonic
C) osmotic pressure, hypertonic
D) osmolar concentration, hypertonic
E) osmotic pressure, hypotonic

151.What happens to red blood cells when placed in a 10% NaCl solution?
(One answer)
A) plasmolysis
B) changes arbitrarily
C) hemolysis and plasmolysis
D) hemolysis
E) does not change

152.Which law expresses the dependence of saturated vapor pressure on the concentration of the solution?
(One answer)
A) Raoult's law
B) Henry's Law
C) Van't Hoff's law
D) Mendeleev-Clapeyron law

153.In the process of osmosis.
(One answer)
A) Solvents from a solution with a lower concentration move into a solution with a higher concentration.
B) Solvents in solutions move simultaneously from one solution to another
C) Solvents in solutions move with greater intensity into solutions of lower concentration.
all answers are incorrect

154.Which of the electrolytes are HCl , AgCl , HNO3 , NH4Cl , NH4OH , CH3COOH , CH3COONa ? are considered weak:
(One answer)
A) AgCl, NH4Cl
B) HCl, AgCl
C) NH_4OH, CH_3COOH
D) NH_4Cl, NH_4OH
E) CH_3COOH, CH_3COONa

155.What is the concentration of hydroxide ions (in mol/L) in a solution with a pOH of 9?
(One answer)
A) 10^{-5}
B) 10–11
C) 10–9
D) 10^{-3}
E) 10^{-7}

156.Indicate the reaction that is impossible:
(One answer)
A) $KI + Br_2 = KBr + I_2$
B) $KCl + I_2 = KI + Cl_2$
C) $NaBr + Cl_2 = NaCl + Br_2$
D) $KCl + Br_2 = KBr + Cl_2$
E) $NaI + Cl_2 = NaCl + I_2$

157.To correct the acid-base balance in acidosis, the following solution is recommended:
(One answer)
A) glucose
B) NaCl
C) HCl

D) $NaHCO_3$
E) Na_2SO_4

158.What is the name of the moment in the titration process when the analyzed substance and the titrant have reacted completely?
(One answer)
A) color transition point
B) end point of titration
C) equivalence point
D) point of neutrality

159.The acid buffer system includes a mixture of:
(One answer)
A) sodium acetate and sodium chloride
B) dihydrogen phosphate and hydrogen phosphate anions
C) hydrochloric acid and sodium chloride
D) ammonium chloride and ammonium hydroxide
E) phosphoric acid and sodium sulfate

160.The main buffer system includes a mixture of:
(One answer)
A) sodium hydroxide and sodium sulfate
B) ammonium chlorides and sulfates
C) potassium sulfate and ammonium hydroxide
D) ammonium sulfate and ammonium hydroxide
E) sodium and potassium hydroxides

161.The greatest contribution to the maintenance of red blood cells is made by:
(One answer)
A) hemoglobin buffer system
B) Hydrocarbonate buffer system
C) protein buffer system
D) hydrophosphate buffer system

162.Maintaining the acid-base balance in the body occurs due to:
(One answer)
A) all of the listed systems
B) buffer system
C) respiratory system
D) renal activity
E) liver functions

163.When calculating heat balances for chemical processes in drug production, it's often impossible to experimentally determine the thermal effect of the process. In such cases, the following law is used for calculations:
(One answer)
A) Faraday
B) Van't Hoff
C) Raul
D) Hess

164.The mathematical expression of the first law of thermodynamics according to IUPAC is the equation:
(One answer)
A) $Q=\Delta U–A$
B) $\Delta U=Q–A$
C) $Q=–\Delta H$
D) $Q=\Delta U+A$
E) $\Delta U=Q+A$

165.Chemical thermodynamics is a branch of science that studies:
(One answer)

A) Transformations of various types of energy in the form of heat and work.
B) Methods of transferring heat from one body to another
C) Mutual transformations of different types of energy;
D) Mutual transformations of heat and work;

166.Select the correct equation of the second law of thermodynamics:
(One answer)
A) ΔS=ΔQ/T
B) ΔG=ΔHTΔS;
C) A=-ΔG;
D) S=K ln W

167.What is the name of the fundamental law of chemical kinetics?
(One answer)
A) law of constancy of composition
B) law of conservation of mass of matter
C) law of mass action
D) law of equivalents
E) Ostwald's law of dilution

168.The empirical rule according to which the rate of a chemical reaction increases 2-4 times with an increase in temperature by 10 ^{o}C was formulated by:
(One answer)
A) Van't Hoff.
B) Ostwald.
C) Kirchhoff.
D) Hess.
E) Henry

169.The formula for calculating the mass fraction of a solution is
(One answer)
A) $W\% = \frac{m_{р\text{-}ля}}{m_{р\text{-}ра}} \cdot 100\%$

B) $W = \frac{n_{в\text{-}ва}}{m_{р\text{-}ра}}$;

C) $W\% = \frac{m_{в\text{-}ва}}{V_{р\text{-}ра} \cdot \rho_{р\text{-}ра}} \cdot 100\%$.

170.Methods of expressing the composition of solutions -
(Multiple answers)
A) molar concentration;
B) molality;
C) equivalence factor
D) mass fraction
E) solubility.

171.Molarity or molar concentration is (Multiple Answers)
A) method of expressing the concentration of a solution;
B) the number of moles of dissolved substance in 1 kg of solvent
C) the number of moles of dissolved substance in 1 liter of solvent;
D) the number of moles of dissolved substance in 1 liter of solution.

172.Select one answer. Anion hydrolysis is characteristic of salts.
A) formed by the cation of a weak base and the anion of a strong acid;
B) formed by the cation of a strong base and the anion of a weak acid
C) formed by the cation of a weak base and the anion of a weak acid
D) all answers are correct

173.Select one answer. Hydrolysis by cation and anion is characteristic of salt (One answer)

A) NH_4CH_3COO;
B) NH4Cl
C) CH_3COONa
D) KNO_3

174. Reaction of the medium in a solution of Na_2SiO_3
(One answer)
A) sour
B) alkaline
C) neutral
D) heterogeneous

175. If during the transition of a system from one state to another, the pressure is maintained, the process is called:
(One answer)
A) adiabatic
B) isobaric
C) isothermal
D) isochoric

176. According to the state of aggregation, solutions can be:
(One answer)
A) liquid and gaseous
B) liquid and solid
C) gaseous and solid
D) gaseous, liquid and solid

177. Method for determining the concentration of hydrogen or hydroxyl ions, based on the change in color of the indicators:
(One answer)
A) ebullioscopy
B) cryoscopy
C) colorimetry
D) all answers are correct

178. An insoluble salt is formed by the interaction
(One answer)
A) A) KOH (solution) and H_3PO_4 (solution)
B) HNO_3 (solution) and CuO
C) HCl (solution) and $Mg(NO_3)_2$ (solution)
D) $Ca(OH)_2$ (solution) and CO_2

179. A precipitate will form when the solutions interact:
(One answer)
A) H_3PO_4 and KOH
B) Na_2SO_3 and H_2SO_4
C) $FeCl_3$ and $Ba(OH)_2$
D) $Cu(NO_3)_2$ and $MgSO_4$

180. Abbreviated ionic equation of the reaction
$Al^{3+} + 3OH^- = Al(OH)_3$
corresponds to the interaction:
(One answer)
A) aluminum chloride with water
B) aluminum chloride with alkali
C) aluminum with alkali
D) aluminum with water

MODULE #2

1. Elements - organogens: choose two correct answers
(Multiple answers)

A) form the basis of biologically important molecules and macromolecules - proteins, fats,
B) carbohydrates, etc.;
C) are part of the composition of biologically active substances - enzymes, hormones, vitamins;
D) provide the basic vital processes in the body - maintenance
E) constancy of pH, osmotic pressure, etc.
F) all of the above

2. Endemic diseases are associated with:
(One answer)

A) residence in a given area;
B) metabolic disorders;
C) lack of microelements in the body;
D) lack of vitamins

3. The following is used as a radiopaque agent in the diagnosis of gastric ulcers:
(One answer)

A) $_4$ suspension
B) 0.9% solution of BaCl $_2$
C) 0.9% NaCl solution.
D) $_4$ OH solution

4. Iodine deficiency in the body causes:
(One answer)

A) fluorosis
B) endemic goiter
C) chronic hepatitis
D) anemia.

5. Which of the nitrogen oxides is used as a component for inhalation anesthesia?
(One answer)

A) N_2O;
B) NO;
C) N_2O_3
D) No. $_2$
E) N_2O_5

6. The main amount of phosphorus in the body is contained in:
select multiple questions
(Multiple answers)

A) in the blood
B) in bone tissue
C) in the liver;
D) in brain tissue

7.In which of the following processes does restoration occur?
(One answer)

A) $C10_2 \rightarrow 2Cl$
B) $S^{2-} \rightarrow S°$;
C) $HNO_2^- \rightarrow HNO_3^-$
D) $CO \rightarrow CO_2$

8. The microelement cobalt is a component of:
(One answer)

A) vitamin B12
B) chlorophyll
C) hemoglobin
D) vitamin B6

E) cytochrome

9.What cations form a precipitate with sulfuric acid that is insoluble in mineral acids?
(One answer)

A) Barium, strontium, calcium
B) Calcium, silver
C) Barium, mercury (I).
D) Strontium, calcium
E) Silver, barium

10. For plaster casts use:
(One answer)

A) calcium sulfate
B) magnesium sulfate;
C) calcium carbonate;
D) calcium chloride.

11. A physiological (isotonic) solution of NaCl with a concentration of:
(One answer)

A) 0.7%;
B) 0.9%
C) 2%
D) 9 %.

1. The following substances exhibit oxidation-reduction duality:
(One answer)

A) HNO_2
B) NO
C) NH_3
D) HNO_3

13. In which case does the oxidation process occur?
choose two correct answers
(Multiple answers)

A) $KMnO_4 \rightarrow MnO_2$;
B) $HClO \rightarrow H\,CI$;
C) $HNO_2 \rightarrow NO_2$
D) $P \rightarrow H_3PO_4$

14. An oxidizing agent is:
(One answer)

A) an atom that gives up electrons and increases its oxidation state
B) an atom that accepts electrons and lowers its oxidation state
C) an atom that gives up electrons and lowers its oxidation state
D) all answers are correct

15. In the compound $Ba(ClO_3)_2$ chlorine exhibits the oxidation state:

A) +5
B) +3
C) +1
D) -1

16. Select a complex biologically active compound:
(One answer)

A) Hem
B) Deoxyribose
C) Fructose
D) Ascorbic acid
E) Vitamin B12

17.Ferrocene $Fe(C_5H_5)_2$ is an effective drug for the treatment of:
(One answer)

A) anemia
B) arthritis
C) malignant tumors
D) tuberculosis
E) skin diseases

18. What coordination number is most characteristic of Fe^{3+}?
(One answer)

A) 4
B) 2
C) 6
D) 8
E) 5

19. Which of the reactions, the schemes of which are given below, is an oxidation reaction? restorative:
(One answer)

A) $Na_2O + 2HCl = 2NaCl + H_2O$
B) $ZnSO_4 + Na_2CO_3 = ZnCO_3 + Na_2SO_4$
C) $2K + 2H_2O = 2KOH + H$

D) all answers are correct

20. Oxidation-reduction reactions are reactions:
(One answer)

A) occurring without changing the oxidation state of the atoms that make up the
B) reactants
C) between complex substances that exchange their constituent parts
D) occurring with a change in the oxidation state of the atoms that make up the
E) reactants
F) neutralization reactions

21. This substance is only a reducing agent:
(One answer)

A) HNO_3
B) N_2O_5
C) NH_3
D) $KMnO_4$

22. The recovery process is a process of:
(One answer)

A) acceptance of electrons
B) electron loss
C) increasing the oxidation state of an atom
D) all of the above

23. When a substance is oxidized, its electrons are released and its:
(One answer)

A) weight
B) oxidation state
C) atomic number
D) valence

24. The oxidation state of chlorine is -1 in the compounds:
Select multiple answers from 4 answer options

A) $MgCl_2$
B) Cl_2
C) HCl
D) Cl_2O

25. The oxidation state of the reducing agent in a redox reaction:
(One answer)

A) is increasing
B) is decreasing
C) remains unchanged
D) first it rises, then it falls

26. The highest oxidation state of an element is determined by:
(One answer)
A) by period number
B) by group number
C) by serial number
D) by subgroup

27. The oxidation state of the oxidizing agent in a redox reaction:
(One answer)
A) is increasing
B) is decreasing
C) remains unchanged
D) first it rises, then it falls

28. The oxidation state of chlorine in the compound $Ca(ClO)_2$:
(One answer)
A) +1
B) +2
C) -2
D) -1

29. An element that increases its oxidation state during a redox reaction is called:
(One answer)
A) Oxidant
B) Reducing agent
C) acid
D) grounds

30. Which of the following elements are s-elements?
(Multiple answers)
A) potassium
B) silver
C) beryllium;
D) zinc

31. Routes of entry of chemical elements into the human body: a) with food; b) with water; c) with air; d) in the form of aerosols; d) through the skin; e) medications and dietary supplements.
(One answer)
A) a, b,
B) a, b, c
C) All
D) a, b, d, e

32. A complex substance containing an element in its highest oxidation state performs the role of:
(One answer)
A) oxidizing agent and reducing agent
B) only oxidizer
C) only a reducing agent
D) there is no correct answer

33. The greatest complexing capacity is possessed by…
(One answer)
A) d-elements
B) p-elements
C) s-elements
D) all answers are correct

34. What electron formulas belong to p-elements?
select multiple options
(Multiple answers)
A) $1s^2 2s^2 2p^3$
B) … $3s^2 3p^4$
C) …$3s^2 3p^3 3d^1$
D) …$3 s^1 3p^1$

35. What electron formulas belong to s-elements:
choose two answers
(Multiple answers)
A) $1s^2 2s^1$
B) $1s^2 2s^2 2p^6 3s^1$
C) $1 s^2 2 s^2 2 p^1$
D) $1 s^2 2 s^2 2 p^5$

36. Biogenic elements are divided into:
select multiple answers
(Multiple answers)
A) macronutrients
B) microelements
C) ultramicroelements
D) carbon, hydrogen, oxygen.
E) metals, non-metals.

37. Fluoride deficiency causes:
(One answer)
A) caries
B) fluorosis
C) anemia
D) endemic goiter.

38. What are biogenic elements?
(One answer)
A) a chemical element, a part of all organic substances in nature
B) permanent constituents of organisms and performing certain functions
A) biological functions
B) avitaminosis, endocrinopathies
C) all answers are correct

39. Which ion increases the strength of tooth enamel?
(One answer)
A) chlorine
B) iodine
C) bromine, potassium
D) fluorine

40. What are macronutrients?
(One answer)
A) a homogeneous part of rocks in composition and structure
B) elements found in the body in very small quantities
C) These are elements that are contained in the human body in relatively large quantities
A) quantities
D) all answers are incorrect

41. Which elements are organogenic:
(One answer)
A) O, H, C, S, P, N;
B) O,H,Fe,S;P;N;
C) C, O, H, S, Mg, Ca

D) P, S, Na, K, Ca,

42. Select a range of ultra-micronutrients.
(One answer)
A) I, Hg, As, Cu
B) Hg, Au, A s, Ra
C) Br, Sr, Co, F
D) Cl, P, S, N,

43. Select a range of micronutrients.
(One answer)
A) Mo , Sr, Co, Cu, Zn
B) F, Br, Sr, Na
C) Mg, I, As, Cu
D) Ca, Na, K, Mg

44. Select a range of macronutrients.
A) Mg, Na, Cl, Co
B) Na, C l, N, O
C) F, Cl, Co, H
D) Fe, Mn, Zn,

45. Name the d-elements - the "metals of life".
(One answer)
A) Fe, Cu , Co, Zn, Mn, Mo;
B) Fe, Mn, Co, Cr, Zn
C) Co, Ni, Fe, Cu, Au, Pt.
D) C, H, N, P, S

46. The coordination theory of complex compounds was developed by:
(One answer)
A) Chugaev
B) A. Werner
C) D. Mendeleev
D) Butlerov

47. In complex compounds there must be a connection:
(One answer)
A) ionic;
B) covalent;
C) covalent, formed by an exchange mechanism;
D) covalent, formed by the donor-acceptor mechanism;

48. In the center of the complex there is:
(One answer)
A) anion;
B) molecule
C) complexing agent
D) cation
E) ligand

49. In the complex compound $K[Co(NH_3)_2Cl_4]$ the complexing agent is:
(One answer)
A) K^+
B) From $^{3+}$
C) NH_3;
D) CI

50. What is the ligand in the following complex compound $K_2[Cu(CN)_4]$?
(One answer)
A) K^+
B) Cu^{2+}

C) CN^-
D) $[Cu(CN)_4]^{2-}$

51. In which of the following complex compounds is the coordination number of the complexing agent equal to 4?
(One answer)
A) $K[Fe(SO_4)_2]$
B) $K_2[SnCl_6]$
C) $[Cu(NH_3)_4]Cl_2$;
D) $K_4[Fe(CN)_6]$.

52. Elements that create an electrolyte environment in the blood, cellular and intercellular fluids are called:
(One answer)
A) s-elements
B) d-elements:
C) p-elements
D) all answers are correct

53. Toxic carbon compound:
(One answer)
A) CO2
B) CO
C) CaC_2
D) $NaHCO_3$

54. How does the water content in the body of an adult change in comparison?
with newborn children?
(One answer)
A) In newborns - 74-76% water, and in adults - 65-67%
B) in newborns - 65-67% water, in adults - 74-76%
C) The water content in the human body does not depend on age
D) there is no correct answer

55. The body of an adult at rest consumes oxygen per minute
(One answer)
A) 264 ml
B) 215 ml,
C) 412 ml
D) 224 ml

56. The elements that form the bulk of biopolymers and the corresponding monomers—proteins, nucleic acids, carbohydrates, lipids—are called
(One answer)
A) organogens.
B) acids
C) alkalis
D) metals

57. In hemoglobin, the complexing agent is
(One answer)
A) With u^+
B) With u^{2+}
C) Fe^{2+}
D) Fe^{3+}
E) Co^{3+}

58. In the complex compound $K_3[Fe(H_2O)(CN)Cl_4]$ the coordination number of the complexing agent is:
(One answer)
A) 1

B) 2
C) 3
D) 4
E) 6

59. Water hardness is caused by the presence of Ca^{2+} and Mg^{2+} ions. Which drinking water is healthier?
(One answer)
A) tough
B) soft;
C) doesn't matter.
D) both

60. Copper plays an important role in many processes occurring in the body.
The biological activity of copper is due to the ability of Cu^{2+} ions:
(One answer)
A) destroy cell membranes
B) bind carbon dioxide
C) form coordination compounds with bioligands
D) maintain a stable osmotic pressure of biological fluids

61. Biometals are characterized by the ability to:
(One answer)
A) regulation of acid-base properties of biosystems
B) regulation of acidic properties of biosystems
C) participation only in complexation reactions
D) participation in oxidation-reduction processes and complex formation

62. For the given complex compound $K_2[HgI_4]$, indicate the complexing agents:
(One answer)
A) $K_2[HgI_4]$
B) HgI_4^{2-}
C) K^+
D) Hg^{2+}

63. The internal coordination sphere in the KS consists of:
(One answer)
A) ligands and adends
B) adenoids and neutral molecules
C) adenoids and acid residues
D) ligands and central atom

64. Complexones (polydentate ligands, in particular, trilon B) are used in medicine as an antidote for poisoning:
(One answer)
A) chlorine
B) ammonia
C) salts of light metals
D) heavy metal salts

65. Which ligands are monodentate?
(One answer)
A) NH_3 and CN^-
B) OH^- and SO_4^{2-}
C) H_2O and CO_3^{2-}
D) Cl^- and P^{2-}

66. Select the formula of the complex compound:
(One answer)
A) $K_4[Fe(CN)_6]$
B) $(CuOH)_2CO_3$
C) CaClOCl

D) $KAl(SO_4)_2$
E) $PtCl_4 \times 2KCl$

67. The formation of $Ca_5(PO_4)_3OH$ in osteoblasts is promoted by:
select multiple answers
(Multiple answers)
A) decrease in pH
B) increase in pH
C) increase in the concentration of phosphate ions
D) decrease in the concentration of phosphate ions

68. Which physiological processes in a living organism can be classified as heterogeneous processes:
(Multiple answers)
A) bone formation
B) tooth formation
C) formation of connective tissue
D) all answers are correct

69. Which calcium salt is part of tooth enamel?
(One answer)
A) $Ca_3(PO_4)_2$
B) $Ca_5OH(PO_4)_3$
C) $Ca_5(PO_4)_3F$
D) $Ca(OH)_2$

70. Is the biological role shared by the trace elements zinc and manganese?
(One answer)
A) inclusion in enzyme systems
B) participation in oxidation-reduction processes
C) participation in lowering blood sugar levels
D) participation in acid-base processes
E) formation of chelate compounds

71. The formula of the compound is $[Co(NO_2)Cl(NH_3)_3]$. Indicate the ions of the outer coordination sphere:
(One answer)
A) None
B) NH_3
C) Cl^-
D) Co^{3+}

72. Select the complexing ion in the compound $[Ni(NH_3)_6]SO_4$:
(One answer)
A) Ni^{2+}
B) $[Ni(NH_3)_6]^{2+}$
C) SO_4^{2+}
D) NH_3

73. Establish a correspondence between the equation of a chemical reaction and its type:
$2H_2+O_2=2H_2O$:
(One answer)
A) Non-OVR compounds
B) Connections, OVR
C) Exchange, not OVR
D) decomposition, OVR

74. This substance is only an oxidizing agent:
(One answer)
A) H_2S
B) H_2SO_4
C) Na_2SO_3

D) SO_2

75. What role does the $H3O^+$ ion play in gastric juice? a) antimicrobial action; b) catalyst in hydrolysis reactions; c) acid denaturation of proteins.
(One answer)
A) a, b, c;
B) a, b;
C) b;
D) in, b.

76. is the bactericidal action of $H2O2$ based on ?
(One answer)
A) on oxidizing capacity;
B) harmlessness of the reduction products – water, $O2$;
C) on the reducing capacity with oxidation to O_2;
D) on the oxidizing capacity and harmlessness of the reduction products – water and $O2$.

77. $^+$ ions are necessary for: a) contraction of the heart muscle; b) conduction of nerve impulses; c) activation of intracellular enzymes; d) the emergence of membrane potential.
(One answer)
A) a, b, c
B) a, b, c, d
C) b, c
D) a, g.

78. The equivalence point in permanganatometry is determined, as a rule:
(One answer)
A) experimentally, using potentiometric measurements;
B) visually, using acid-base indicators;
C) visually, using redox indicators.

79. To determine oxidizing agents in permanganatometry the following can be used:
(Multiple answers)
A) direct titration method;
B) back titration method;
C) substitution method;
D) any of the titration methods

80. Indicate the correct name of the complex compound $K_4[Fe(CN)_6]$:
(One answer)
A) tetrapotassium iron(II) hexacyanide;
B) potassium hexacyanoferrate (II);
C) iron(II) hexacyanide potassium;
D) potassium hexacyanidoferrate(II)

81. What is the state of aggregation of the dispersion medium in suspensions?
(One answer)
A) liquid
B) solid;
C) gaseous
D) anything is possible

82. Which elements of group I-A of the PSE are considered microelements?
(One answer)
A) K, Li, Rb;
B) Rb, Cs, Fr;
C) Li, Rb, Cs;
D) Na, K, Rb

83. At low levels of Ca^{2+} in the blood the following develops:
(One answer)
A) convulsions

B) suppression of neuromuscular excitability;
C) deposition of calcium salts in the kidneys;
D) muscle hypotonia

84. What is the state of aggregation of the dispersion medium in fog?
(One answer)
A) liquid;
B) solid;
C) gaseous
D) anything is possible

85. Which of the elements of group II-A are vital?
(One answer)
A) Ca, Sr;
B) Mg, Ca;
C) Ca, Ba;
D) Sr, Ba.

86. H2O2 exhibits the properties of ... in permanganatometry .
(One answer)
A) oxidizing
B) restorative
C) disproportionates
D) all answers are correct

87. The precipitation method is based on the reaction...
(One answer)
A) complex formation
B) formation of a poorly soluble substance
C) oxidation-reduction
D) neutralization

88. In which organs is Si concentrated in the body?
(One answer)
A) liver, adrenal glands
B) hair, skin, heart
C) kidneys, heart
D) in all organs

89. Specify the number of electrons involved in the process:
alkaline environment
Cr^{3+} ----------> CrO_4^{2-}
(One answer)
A) 5
B) +3
C) 1
D) 8

90. In the complex compound potassium trioxalatomanganate (III), the coordination number is complexing agent is equal
(One answer)
A) six
B) four
C) oxidation state of the complexing agent
D) three
E) number of ligands

91. The oxidation-reduction reaction of the compound corresponds to the scheme
(One answer)
A) $BaO + H_2O = Ba(OH)_2$
B) $P_2O_5 + CaO = Ca_3(PO_4)_2$

C) $NO_2 + H_2O + O_2 = HNO_3$
D) $Cl_2O_7 + Na_2O = NaClO_4$

92. Why are nitrites toxic and prohibited from being added as preservatives to meat products? a) They cause methemoglobinemia; b) They deprive tissues of oxygen; c) They increase free radical oxidation in the body; d) They are converted in the stomach to HNO2 , and then to nitrosamines – carcinogens.
(One answer)
A) a, b, c, d
B) a, b
C) in, d
D) G

93. Potassium permanganate solutions of various concentrations are used for:
select multiple answers
(Multiple answers)
A) gastric lavage
B) douching in urology and gynecology
C) titrimetric analysis
D) disinfection of instruments

94. To create an acidic environment in permanganatometry, the following is used:
(One answer)
A) any strong acid;
B) diluted sulfuric acid;
C) diluted nitric acid.

95. Working solutions in permanganatometry are:
choose two answers
(Multiple answers)
A) $KMnO_4$ solution ;
B) KI solution ;
C) $Na_2S_2O_3$ solution ;
D) solution of $H_2C_2O_4$

96. What is the state of aggregation of the dispersed phase in emulsions?
(One answer)
A) liquid;
B) solid;
C) gaseous;
D) anything is possible

97. As a result of the polymerization reaction, the following are formed from the corresponding monomers: choose two answers
(Multiple answers)
A) nucleic acids;
B) natural rubber;
C) gelatin;
D) polypropylene.

98. Biopolymers include:
select multiple answers
(Multiple answers)
A) polysaccharides;
B) proteins
C) nucleic acids;
D) polyamide fibers.

99. As a result of the polycondensation reaction, the following are formed from the corresponding monomers:
select multiple answers
(Multiple answers)

A) polysaccharides;
B) proteins;
C) nucleic acids;
D) polyethylene.

100. Protein denaturation is:
(One answer)
A) violation of its primary structure
B) hydrolysis of its molecule under the action of enzymes;
C) decomposition of protein molecules with the formation of volatile substances that have specific smell;
D) violation of its tertiary structure

101. Specify the methods for preparing solutions: a) by weight; b) from fixanals; c) by diluting a more concentrated solution.
(One answer)
A) a, b
B) b, c
C) a, b, c
D) a, in

102. Calcium ions in blood plasma are: a) in complex with proteins; b) in complex with lactates and citrates; c) in a free ionized state.
(One answer)
E) a, in
F) a, b, c
G) b, c
H) a. b.

103. Using the table data, answer, in what order should the Na_2SO_4 solution be added ?
(One answer)
A) $CaSO_4$, $BaSO_4$, $SrSO_4$
B) $BaSO_4$, $SrSO_4$, $CaSO_4$
C) $CaSO_4$, $SrSO_4$, $BaSO_4$
D) $SrSO_4$, $BaSO_4$, $CaSO_4$

104. Protein denaturation is always observed:
select multiple answers
(Multiple answers)
A) when dissolved in water;
B) when adding large quantities of strong acids to the protein solution;
C) when heating the protein solution;
D) all answers are incorrect

105. Suspensions are microheterogeneous systems.
(One answer)
A) with a liquid dispersion medium and a liquid dispersed phase
B) with a gaseous dispersed phase
C) with a gaseous dispersion medium
D) with a liquid dispersion medium and a solid dispersed phase
E) with a solid dispersion medium and a liquid dispersed phase

106. As a result of limited swelling of the IUD, a
(One answer)
A) true solution
B) colloidal solution
C) sediment
D) sol
E) gel

107. Red blood salt $K_3[Fe(CN)_6]$ is a reagent for ions:

(One answer)

A) Ca^{2+} ions
B) Fe^{2+} ions
C) Na^{+} ions
D) g^{2+} ions

108. The molecules of insulin and vitamin B_{12} contain trace elements:
(One answer)

A) Cu, Co
B) Fe, Co
C) Zn, Co
D) Fe, Zn
E) Zn, Cu

109. The molecules of hemoglobin and chlorophyll contain the following elements:
(One answer)

A) Co, Cu
B) Ni, Ca
C) Fe, Co
D) Fe, Ni
E) Fe, Mg

110. Cyanocobalamin (vitamin $B12_{)}$ is a cobalt complex compound. What type of complex compound is it?
(One answer)

A) acidocomplexes
B) cationic complexes
C) chelate complexes
D) aquatic complexes

111. Complexones (polydentate ligands, which include
(One answer)

A) antidotes
B) antianemic agents
C) antiseptics
D) antacids
E) antitumor agents

112. What are complexones III (trilon)? One answer

A) ethylenediaminetetraacetate ion
B) nitriloacetic acid
C) disodium salt of ethylenediaminetetraacetic acid
D) aminoacetic acid
E) ethylenediaminetetraacetic acid

113. What disease occurs when there is a lack of iron in the body?
(One answer)

A) caries, osteoporosis, osteoarthritis
B) eczema, anemia, ulcers, infections
C) anemia, immune disorders, cholesterol metabolism
D) all answers are correct

114. Acidic foods formed after eating contribute to:
(One answer)

A) strengthening dental tissue
B) destruction of dental tissue, since the H+ cation neutralizes the formed
A) dissociation of hydroxyapatite anion hydroxyl, and lactic, pyruvic and
B) Succinic acids bind calcium ions into stable complex compounds.
C) do not affect dental tissue
D) all answers are correct

115. Biological role of zinc:
(One answer)
A) is a part of 40 enzymes and is involved in all types of metabolism;
B) biological role not studied;
C) is part of hemoglobin and participates in the transfer of oxygen;
D) is part of vitamin B12 and is involved in the process of hematopoiesis.

116. How to remove the last drop from a pipette?
(One answer)
A) touch the end of the pipette to the wall of the flask;
B) blow out the last drop
C) shake the pipette.
D) all answers are correct

117. What is the main role of potassium and sodium ions in the body?
(One answer)
A) are part of bone tissue
B) electrolytes of cellular and extracellular fluid
C) are part of coenzymes
D) all answers are incorrect

118. The oxidation state of sulfur is -2 in the compounds:
(One answer)
A) MgS, $_{H2S}$
B) $_{SO2}$
C) S_8
D) SO3

119. The sum of the coefficients in the reaction equation
$Ca + H_2SO_4(conc.) = CaSO_4 + H_2S + H_2O$:
(One answer)
A) 8
B) 18
C) 14
D) 10

120.Balance the chemical equation using the electron balance method, find the coefficients for each compound and write them sequentially, separated by commas, without spaces.
$KMnO_4 + KCl + H_2SO_4 = Cl_2 + MnSO_4 + K_2SO_4 + H_2O$:
(One answer)
A) 2,10,8,5,2,6,8
B) 2,10,5,8,2,6,8
C) 2,10,8,5,2,8,6
D) 2,6,2,8,10,8

121.Only reducing properties are exhibited due to the nitrogen atom.
(One answer)
A) NH_3
B) N_2
C) N_2O_3
D) N_2O_5

122.The iron compound acts as an oxidizing agent in the reaction, the scheme of which is:
(One answer)
A) $Fe(OH)_2 + {}_{O2} + {}_{H2O} \rightarrow Fe(OH)_3$
B) $FeCl_2 + Cl_2 \rightarrow FeCl_3$
C) $Fe(OH)_2 + H_2SO_4 \rightarrow FeSO_4 + H_2O$
D) $FeSO_4 + Zn \rightarrow ZnSO_4 + Fe$

123.A process in which chemical interactions occur between molecules
adsorbate and surface-active molecules of the adsorbent are called:

(One answer)

A) desorption
B) adsorption
C) sublimation
D) solvation
E) chemisorption

124.The heat of adsorption is the amount of heat that:

(One answer)

A) absorbed during adsorption of 1 mole of adsorptive
B) released during the adsorption of 1 mole of adsorbate
C) absorbs 1 mole of adsorbent
D) released during adsorption of the entire mass of the adsorbate
E) released during desorption of the entire mass of the adsorbate

125.From the listed substances, select a surfactant:

(One answer)

A) $HNO3$
B) NaCl
C) C_2H_5OH
D) $H2O$
E) $K_4Fe[(CN)_6]$.

126. Surfactant by nature:

(One answer)

A) hydrophobic substance
B) substance of organic origin
C) hydrophilic substance
D) polar substance
E) amphiphilic substance

127.Sorption is called:

(One answer)

A) attraction (adhesion or sticking) of the surfaces of two condensed phases brought into contact;
B) spontaneous change in the shape of the boundary surface;
C) spontaneous accumulation (absorption) of a gaseous or liquid-dissolved substance on the surface or in the volume of a condensed phase (solid or liquid);
D) all answers are correct

128.Adsorption is:

(One answer)

A) accumulation of adsorbent particles on the surface of the adsorbent;
B) accumulation of adsorbate particles on the surface of the adsorbate;
C) accumulation of adsorbate particles inside the adsorbent.
D) accumulation of adsorbent particles on the surface of the adsorbent;

129.Absorption is: choose two answers

(Multiple answers)

A) volumetric absorption of a gaseous substance by the condensed phase;
B) the process of mixing different gases together;
C) volumetric absorption of a substance dissolved in a liquid by a solid phase;

the process of mixing two mutually soluble liquids.

130.Chemisorption is the process of selective accumulation of a sorbent on the surface or in the volume of a sorbent:

(Multiple answers)

A) occurring due to chemical interaction and leading to the formation of new substances;
B) in which the particles of both interacting substances do not lose their individuality;

C) occurring due to the forces of Coulomb interaction between charged particles, which do not lose their individuality;

D) accompanied by the formation of new compounds that do not form an independent phase.

131.Neutral complexes are:
(One answer)

A) $[Fe(H_2O)]Cl_3$
A) $[Fe(CO)_5]$;
B) $[Fe(NH_3)_4Cl_2]Cl$;
C) $Na_2[Zn(OH)_4]$

132.Aquatic complexes are:
(One answer)

A) $[Co(H_2O)_6]SO_4$;
B) $Na_2[Zn(OH)_4]$;
C) $Na[AlH_4]$
D) $NaAlO_2$

133.Hydroxocomplexes are:
(One answer)

A) $Li[BH_4]$;
B) $Na_3[Al(OH)_6]$;
C) $[Cu(H_2O)_4]Cl2$;
D) [Ag (NH 3)2] Cl .

134.Ammonia complexes are:
(One answer)

A) $Na_3[Co(NO_2)_6]$;
B) $K[Ag(CN)_2]$;
C) $[Cu(NH_3)_4]Cl_2$;
D) $Na_2[Cu(OH)_4]$.

135.Specify the correct name of the complex compound
$Na[Cr(H_2O)_3F_2]$:
(One answer)

A) sodium triaquadifluorochromate(III);
B) sodium difluorotriaquachromate (III);
C) sodium difluorotrihydroxochromate (III);
D) trihydroxodifluoronodium chromate (III).

136.Specify the correct name of the complex compound
$[Co(NH_3)_3Cl_3]$:
(One answer)

A) trichlorotriamminecobalt;
B) triamminotrichlorocobaltate;
C) cobalt trichlorotriammine;
D) trichloridotriamminecobalt.

137.Specify the correct name of the complex compound
$[Al(H_2O)_5OH]SO_4$
(One answer)

A) aluminum hydridopentaaquasulfate;
B) pentaaquahydridoaluminate sulfate;
C) hydroxypentaaquaaluminium sulfate;
D) pentaaquahydroxoaluminate sulfate

138.Surfactants include substances whose molecules:
(One answer)

A) consist only of a hydrophobic hydrocarbon chain;
B) are symmetrical and both of their parts are either hydrophilic or hydrophobic;

C) have an asymmetrical structure and consist of a relatively small polar group and a long hydrocarbon radical;
D) can have a wide variety of structures

139.Dispersed systems in which the substance of the dispersed phase is in a gaseous state of aggregation, and the dispersion medium is a liquid, are called:
(One answer)
A) aerosols;
B) foams
C) fog;
D) emulsions

140.Dispersed systems in which the substance of the dispersed phase is in gaseous form
(One answer)
A) emulsions;
B) hard foams
C) jellies;
D) suspensions

141.Coagulation is the process of:
(One answer)
A) uniform distribution of colloidal particles throughout the entire volume of the solution;
B) aggregation of colloidal particles into larger aggregates;
C) movement of colloidal particles in an external electric field;
D) settling of colloidal particles under the action of gravity

142.The primary stage of dissolution of a solid polymer sample is called differently:
(One answer)
A) swelling
B) salting out
C) aging
D) denaturation

143.Salting out is the process of precipitation of proteins from a solution in result:
(One answer)
A) decreasing the temperature of the solution;
B) adding large quantities of a solvent in which the protein does not dissolve
A) or dissolves poorly;
B) adding large amounts of electrolyte
C) increasing external pressure above the solution

144.In what state are Na and K in the body?
(One answer)
A) ionic
B) atomic
C) aqua- and hydroxocomplexes
D) all answers are correct

145.In what state are the p-elements of group VII-A found in the body?
A) hydrated ions
B) in a bound state
C) hydrated ions (Br, Cl) and in a bound state (F, I)
D) electrolytes

146.What explains the laxative effect of magnesium sulfate?
(One answer)
A) osmosis of water into the intestinal lumen
B) diffusion of salt inside the intestine
C) dissolution of intestinal contents
D) all answers are incorrect

147.The formation of bone tissue is promoted by:
(One answer)
A) alkalinity of the environment
B) acidity of the environment
C) neutrality of the environment
D) anything is possible
148.The artificial kidney device (AID) is based on:
(One answer)
A) ultrafiltration
B) electrodialysis
C) hemodialysis
D) cogulation
149.A blood clot is...
(One answer)
A) sol
B) gel
C) jelly
D) suspension
150.Unithiol is:
(One answer)
A) an antidote that forms a complex compound with heavy metals
B) a drug used to improve hematopoiesis
C) antidote for selenium poisoning
D) all answers are correct
151.At low levels of Ca in the blood, ... develops.
(One answer)
A) increased neuromuscular excitability
B) suppression of neuromuscular excitability
C) deposition of calcium salts in the kidneys
D) anything is possible
152.When the amount of sodium in the body increases,
(One answer)
A) increased excretion of potassium by the kidneys
B) potassium retention in the body
C) increased excretion of sodium in urine and sweat
D) all answers are correct
153. In what processes does the microelement Al participate?
a) in phosphorus metabolism
b) replaces calcium and magnesium ions in their complexes with enzymes
c) in the formation of epithelial and connective tissues
d) in transamination reactions - transfer of an amino group
(One answer)
A) in all
B) a, b
C) in, d
D) in, d
154.Impaired hemoglobin synthesis is associated with...
(One answer)
A) deficiency of Fe and Co in the body, excess of Al
B) Fe deficiency in the body
C) deficiency of Mn, Mg, Cu in the body
D) excess of Sr and Ca in the body
155.What role does Zn play as a component of enzymes?

(One answer)

A) is part of the active centers
B) participates in the formation of the tertiary structure
C) participates in the formation of the quaternary structure
D) anything is possible

156.The swelling process is: choose two answers
(Multiple answers)

A) one-sided penetration of small and mobile solvent molecules into a solid polymer sample;
B) slow diffusion of polymer macromolecules from a solid sample into the liquid phase of the solvent
C) simultaneous two-way diffusion of solvent and polymer into each other;
D) solvation of certain regions of the polymer macromolecule.

157.To cleanse the blood of low-molecular metabolic products, the Artificial Kidney apparatus uses:
(Multiple answers)

A) gel filtration;
B) compensatory dialysis;
C) vividiasis;
D) ultrafiltration

158.A colloidal dispersed system in which liquid droplets are uniformly distributed distributed in a solid substance is called:
(One answer)

A) solid sol
B) lyosol;
C) emulsion
D) hydrosol

159.A colloidal dispersed system in which liquid particles of the dispersed phase evenly distributed in gaseous nitrogen, called:
(One answer)

A) lyosol;
B) fog;
C) smoke;
D) aerosol.

160.Capable of passing through all types of filters without hindrance:
(One answer)

A) true solutions
B) highly dispersed systems
C) ultramicroheterogeneous systems
D) microheterogeneous systems.

161.The degree of dispersion is:
(One answer)

A) diameter of dispersed phase particles;
B) the value reciprocal to the transverse size of the particles of the dispersed phase;
C) total surface area of dispersed phase particles;
D) total mass of particles of the dispersed phase.

162.The initial low molecular weight substance from which the polymer is synthesized is called:
(One answer)

A) elementary link
B) structural link;
C) monomer
D) the simplest link

163.The process of precipitation of a polymer from a solution upon addition of an electrolyte is called:
(One answer)

A) coagulation;

B) peptization;
C) salting out;
D) dispersion.

164.What is the state of aggregation of the dispersed phase in suspensions?
(One answer)
A) liquid;
B) solid;
C) gaseous
D) anything is possible

165.Coagulation of sols by electrolytes is subject to:
(One answer)
A) Duclos-Traube rule;
B) Schultz-Hardy rule;
C) Le Chatelier's principle;
D) van't Hoff's rule

166.During the operation, to prevent blood clotting, the following is injected into the blood:
choose two answers
(Multiple answers)
A) heparin solution;
B) caproic acid solution;
C) polyglucin solution;
D) isotonic glucose solution.

167.In relation to H_2O, surfactants are:
(One answer)
A) organic compounds such as alcohols, amines, carboxylic acids;
B) saturated and unsaturated hydrocarbons;
C) aromatic hydrocarbons;
D) inorganic and organic electrolytes.

168.Osmotic pressure of intercellular fluids is determined by ions
(One answer)
A) Ca^{2+}, Na^{+}, CO_3^{2-}, HCO_3^{-}
B) K^{+}, Mg^{2+}, Cl^{-}, CO_3^{2-}, HCO_3^{-}
C) Fe^{2+}, Co^{2+}, Ni^{2+}
.D) Cl^{-}, Cr^{2+}, Cu^{2+}

169.The osmotic pressure of intracellular fluids is determined mainly by ions:
(One answer)
A) Ca^{2+}, Na^{+}, CO_3^{2-}, HCO_3^{-}
B) K^{+}, Mg^{2+}, Cl^{-}, CO_3^{2-}, HCO_3^{-}
C) Cr^{3+}, Cu^{2+}, Mn^{2+}
D) Fe^{2+}, Co^{2+}, Ni^{2+}

170.When forming a coordination bond, the complexing agent acts as:
(One answer)
A) electron pair donor;
B) electron pair acceptor;
C) negative charge carrier
D) source of unpaired electrons.

171.When forming a coordination bond, the ligand acts as:
(One answer)
A) electron pair donor;
B) electron pair acceptor;
C) negative charge carrier;
D) source of unpaired electrons.

172.The outer sphere of a complex compound may contain:

choose two answers
(Multiple answers)

A) neutral molecules;
B) positively charged ions;
C) negatively charged ions;
D) only positively charged ions.

173.Chemical elements in whose atoms the last to be filled is electrons outer p-sublevel ($ns^2 np^6$), are called
(One answer)

A) p-elements
B) s-elements
C) d-elements
D) f - elements

174.Oxidation-reduction processes are: choose two answers
(Multiple answers)

A) rusting of iron
B) pyrite roasting
C) slaking of lime
D) the transition of glucose from a linear to a cyclic form

175.Chemisorption is the process of selective accumulation of a sorbent on the surface or in the volume of a sorbent:

A) occurring due to chemical interaction and leading to the formation of new substances;
B) in which the particles of both interacting substances do not lose their individuality;
C) occurring due to the forces of Coulomb interaction between charged particles, which do not lose their individuality;
D) accompanied by the formation of new compounds that do not form an independent phase.

176.Ligands are:

A) electron pair donor molecules;

electron pair acceptor ions;

B) c) electron pair donor molecules and ions;
C) d) molecules and ions that accept electron pairs

177.Permanganatometry refers to the methods:

A) neutralization
B) oxidation-reduction
C) precipitation
D) oximetry

178.Strong electrolytes are substances with the bond:

A) a) ionic;
B) b) covalent non-polar;
C) c) hydrogen;
D) d) coordination.

179.A solution that contains the maximum possible amount of dissolved substance under given conditions is called:

A) concentrated;
B) supersaturated;
C) saturated;
D) unsaturated.

180.Abbreviated ionic equation of the reaction
$Al^{3+} + 3OH^- = Al(OH)_3$ corresponds to the interaction:
(One answer)

A) aluminum chloride with water

B) aluminum chloride with alkali
C) aluminum with alkali
D) aluminum with water

List of questions and topics on forms of control

MODULE #1

1. The essence of the subject and objectives of chemistry in medical education. Bioinorganic and biophysical chemistry as subjects reflecting the foundations of medical sciences. The relationship between the chemical and biological forms of matter motion.
2. The basics of elementary physical and colloidal chemistry, as well as the chemistry of the immune system. The role of chemistry in implementing a health program.
3. Qualitative and quantitative analysis are the basis of physicochemical methods for studying substances.
4. Methods of qualitative analysis: chemical analysis (qualitative reactions), physicochemical analysis (spectral, chromatographic, etc.).

b) methods of quantitative analysis: chemical, physical, physicochemical.

5. Chemical laboratory, its equipment: operating rules. Safety regulations.
6. Chemical glassware, its purpose.

a) general purpose tableware.
b) special purpose tableware.
c) measuring glassware (pipettes, burettes, glasses, flasks, pycnometers).

7. Devices, equipment.
8. Weighing as a method of gravimetric analysis. Scales and their types.

a) for rough weighing (cup, training, technical, gastronomic).
b) analytical (semi-microchemical, microchemical, ultra-microchemical).
c) for precise weighing: technochemical of different classes.
d) special (torsion, vacuum, instrument).
d) types of weights: conventional, analytical

9. Fundamentals of quantum mechanics: Bohr's theory of the hydrogen atom, the study of the absorption and emission spectra of the hydrogen atom. Planck's equations, Einstein's theory, Louis de Broglie's theory, Heisenberg's uncertainty principle, the electron cloud, and the physical meaning of the Schrödinger equation.
10. Modern quantum mechanical model of the atom.
11. Characterization of the energy state of an electron by a system of quantum numbers: principal, orbital, magnetic and spin quantum numbers.
12. Atomic orbital. Electron filling of atomic orbitals of elements with short and long periods: the Pauli exclusion principle, the minimum energy principle. Hund's rule.
13. The order of filling quantum numbers in atoms of large periods of Klechkovsky's rule.
14. Characteristics of the ground and excited states of an atom.
15. Electron configuration of atoms of the S , P , d , f blocks of elements of the periodic table of D. I. Mendeleev. Quantum cells, electrons, elements, orbitals.
16. The periodic law and the system of elements in light of the quantum theory of atomic structure. S, P, d, f.
17. The essence of the valence bond method.
18. The mechanism of formation of a covalent chemical bond: exchange, donor-acceptor.
19. The main parameters of a covalent bond, their characteristics: energy, directionality, saturation, multiplicity, polarizability.
20. The concept of hybridization of atomic orbitals, □**,** □ bonds. SP^1 , SP^2 SP^3 hybridization, localization of lone electron pairs. Bond multiplicity.
21. Hydrogen bonding. Intermolecular and intramolecular hydrogen bonding. The role of hydrogen bonding in association, dissolution, and biochemical processes.

22. The essence of the molecular orbital method. Basic principles of MO - LCAO. Energy schemes of homonuclear molecules: H_2, H_2^+, N_2, O_2, Energy schemes of heteronuclear molecules: CO, NH_3.

23. Examples of the dependence of biological activity on the type of chemical bond, structure of molecules.

24. Chemical saturated and unsaturated molecules and ions CO_2, CO, NO_2, NO_3^- NH_4^+ dipole moment of the molecule. Examples of polar and nonpolar molecules.

25. First law of thermodynamics. Internal energy. Isobaric and isochoric thermal effects.

26. Enthalpy. Hess's law and its consequences. Thermochemical equations. Standard heats of formation, combustion, dissolution, and neutralization. Problem solving.

27. Thermochemical calculations and their use for energy characterization of biochemical processes. Problem solving.

28. The relationship between metabolic and energy processes in the body.

29. Reversible and irreversible processes in the thermodynamic sense. Life processes as an example of irreversible processes.

30. The second law of thermodynamics. Entropy, mathematical expression, units of entropy measurement.

31. Gibbs free energy, mathematical expressions of the Gibbs equations, units of measurement. Problem solving.

32. Criteria for the direction of spontaneous processes.

33. Thermodynamic conditions of equilibrium. Entropy and enthalpy factors of exothermic and endothermic processes in the body.

34. Steady state of biological systems. The Onsager-Prigogine principle and its implications for the thermodynamic assessment of biological processes.

35. Standard thermodynamic quantities of some foods and metabolic end products.

36. A general overview of solutions. The implications of van't Hoff, Mendeleev, and other solution theories for modern solution theory.

37. Thermodynamics of dissolution. Enthalpy and entropy factors of the dissolution process and their relationship to the dissolution mechanism.

38. Solubility of gases in liquids and their dependence on external factors. Henry's, Dalton's, and Sechenov's laws. Solubility of gases in blood. Decompression sickness.

39. Solubility of liquids and solids. The influence of the nature of the components, temperature, pressure, and the nature of the solvent on solubility. Water as a universal solvent.

40. Methods of expressing the concentration of solutions (percentage, molar, normal, equivalent concentration, titer).

41. Fundamentals of the theory of strong electrolytes. Activity and ionic strength of solutions.

42. Electrical and colligative properties of electrolyte solutions:

43. Colligative properties of dilute non-electrolyte solutions. Raoult's law. Osmosis and osmotic pressure, boiling point change; freezing point, saturated vapor pressure above the solution.

44. The role of osmosis and osmotic pressure in biological systems. Van't Hoff's law. Hypo-, hyper-, and isotonic solutions. Plasmolysis, hemolysis, turgor.

45. Colligative properties of dilute electrolyte solutions. Isotonic coefficient.

46. Cryometry, ebulliometry, osmometry and their application in medical and biological research.

47. Ionic product of water. Hydrogen and hydroxyl indices. pH scale.

48. Definition of buffer systems, mechanism of action of buffers.

49. The Henderson-Hasselbalch equation for calculating the pH of various types of buffer systems.

50. Methods for determining the pH of buffers, colorimetric (bufferless, buffer), electrometric (conductometric, potentiometric).

51. Mechanism of action of buffer systems of blood and tissues.

52. Capacity of buffer systems.

53. Acid-base balance.

54. The concept of the rate of a chemical reaction

55. Factors influencing the rate of a chemical reaction: the nature of the substance and its state of aggregation: concentration, pressure, temperature and catalyst.

56. Law of mass action, rate and constant of chemical reaction.

57. The rate of homogeneous chemical reactions and the method of its changes.

58. Influence of temperature, Van't Hoff's rule.

59. Activation energy, molecular energy distribution curve. Arrhenius equation.

60. Molecularity and reaction order. Reaction kinetic equations for first, second, and zero orders. Half-life.

61. The concept of the kinetics of complex reactions: parallel, sequential, conjugate, reversible and chain.

62. Reversible and irreversible reactions. The rate of forward and reverse reactions.

63. Chemical equilibrium. Equilibrium shift, Le Chatelier's principle. Factors influencing chemical equilibrium.

64. Types of catalysis (homogeneous, heterogeneous, enzymatic).

65. Mechanisms of acid-base catalysis.

66. Enzymes as biological catalysts. The Michaelis-Menten equation

67. The Brønsted-Lowry protolytic theory of acids and bases. Types of protolytic reactions: hydrolysis, neutralization, ionization.

68. Hydrolysis of salts, constant and degree of hydrolysis:

a) salts formed by a weak acid and a strong base (for example, CH_3COONa)

b) salts formed by a weak base and a strong acid (for example, NH_4Cl)

c) salts formed by a weak acid and a weak base (for example, CH_3COONH_4)

d) The role of hydrolysis in biological processes, ATP hydrolysis as a universal source of energy in the body. Acid-base balance.

69. The essence of quantitative analysis.

70. Classification of volumetric analytical methods of analysis.

a) Neutralization method. Alkalimetry and acidometry

b) Initial working solutions with established and prepared titers and the requirements imposed on them.

71. Titration curves in the neutralization method.

A) titration of a strong acid with a strong base and vice versa

B) titration of a strong acid with a weak base and vice versa

B) titration of a weak acid with a strong base and vice versa.

72. Equivalence point. Selecting an indicator for titrating acids and bases of varying strengths.

73. The concept of indicators. Indicator color transition intervals. The mechanism of indicator action.

74. Use of neutralization methods in clinical sanitary and hygienic practice.

MODULE #2

1. Redox reactions and their role in life processes. Oxidation and reduction processes. Oxidizing agent and reducing agent. Types of redox reactions. Main classes of oxidizing agents. Redox duality. Compiling redox reaction equations using the electron balance method.

2. The influence of the environment on the course of the ORR.

3. Oxidizing and reducing agent equivalent, how it is calculated.

4. Fundamentals of the oximetric method of analysis (titrants, indicators, their preparation, research environment, application of the method in medicine).

5. The essence of permanganatometry and iodometry (titrants, indicators, their preparation, the research environment, and the application of the method in medicine).

6. Determining the concentration of a reducing agent and an oxidizing agent in iodometry. Provide specific examples of indirect, direct, and back titration.

7. Determining the concentration of a reducing agent and an oxidizing agent in

permanganatometry. Provide examples.

8. determination of the direction of oxidation-reduction reactions based on standard values of reagent formation and the values of oxidation-reduction potentials.

9. Iodometry and permanganometry and their application in sanitary-hygienic and clinical studies.

10. Features of a living organism as a thermodynamic system.

11. Diffusion, membrane, interphase potentials.

12. What are gradients (concentration, osmotic, electrical)

13. Solubility product.

14. Conditions of formation and dissolution of precipitates.

15. Equilibrium in a saturated solution of a sparingly soluble electrolyte.

16. displacement and constant of heterogeneous equilibrium.

17. Factors affecting solubility: activity, ionic environment, eponymous ion, salt effect, pH environment.

18. The essence of the precipitation method (Mohr and Volhard method) and its application in medical practice.

19. The essence of Werner's coordination theory and its development by Chugaev's school.

20. Components and structure of complex compounds (central atom, ligand, coordination number of the central atom, inner and outer sphere of the complex compound).

21. Types of ligands, donors, electron pairs, ligand dentancy.

22. Nomenclature of complex compounds.

23. Covalent donor-acceptor bond between ligands and complexing agent.

24. Hybridization of atomic orbitals of the complexing agent and the structure of the complexes.

25. Isomers in the series of complex compounds.

26. Stability of complexes in solutions, instability constant.

27. Methods of destruction of complexes in solutions.

28. Metalloenzymes as chelate compounds, OM and transport properties of some metalloenzymes (hemoglobin, hemocyanin, ferridoxin).

29. The importance of complex compounds in biology and medicine.

30. Chelated compounds. Application of complexometry in clinical and sanitary-hygienic analysis.

31. Water hardness and ways to eliminate it.

32. Distribution of chemical elements in the earth's crust.

33. The teachings of V.I. Vernadsky on the biosphere and biogeochemistry.

34. The concept of biogenicity of elements (macro, oligo, microbiogenic elements of the environment in the human body).

35. The relationship between endemic diseases and the characteristics of biogeochemical provinces.

36. The distribution pattern for s- , p- , d- , f -blocks in the periodic table of D.I. Mendeleev.

37. General characteristics of s -elements as alkali and alkaline earth metals. The most important compounds are oxides, peroxides, hydroxides, and salts. Their physicochemical properties.

38. Content in the earth's crust, plant, animal tissues, and human tissues and organs. Biological role of H , Li , Na , K , Mg , Ca , Be , Ba , Sr. Calcium content in bone tissue, blood, and muscle tissue.

39. Hydrogen. Hydrogen isotopes and their medical applications. Hydrogen peroxide. Its role as a metabolic byproduct in vital functions. Bactericidal properties.

40. Medical use of carbonates and chlorides of Group IA elements , oxides, sulfates, carbonates, and chlorides. Use of peroxides for oxygen regeneration in rooms.

41. General characteristics of p-elements (change in the radius of atoms, ions, ionization potential, chemical activity, change in non-metallic properties in accordance with the PSE).

42. Nitrogen, phosphorus in organisms, their biological role.

43. Oxygen and its biological role. The use of $O2_{and}$ $O3_{in}$ medicine and their bactericidal effects.

44. Sulfur: the biological role of sulfur and its compounds. Hydrogen: the sulfite groups of protein and coenzyme A, their properties as hydrogen sulfide derivatives. The medical use of sulfur compounds.

45. halogens . Chlorine compounds. Bleaching powder – bactericidal properties. The biological role $_{of\ F2}$, Cl2 , Br2 , $_{and}$ $I2_{and}$ their compounds. The medical use of Cl2 and $_{I2\ compounds}$ $_{(chlorination}$ of water, hydrochloric acid, bleach, fluorides, $_{and}$ bromides) and their bactericidal action.

46. Qualitative reaction for ions K^{+}, Na^{+}, Mg^{2+}, Ca^{2+}, Ba^{2+}, Al^{3+}, Pb^{2+}, NO_3^{-}, PO_4^{3-}, Br^{-}, I^{-}.

47. General characteristics of d -elements, their location in the periodic table,

48. Change in radii, ionization energy, chemical activity, their complexing ability.

49. d -elements of groups I and II , chemical properties, biological role of bactericidal action of Ag^{+}, $Cu^{+\ ions}$. Amalgam alloys of gold, silver, copper in dentistry In practice, the chemistry of the toxic effects of mercury compounds. Proper handling of reagents containing mercury salts. Qualitative reactions for Ag^{+} and $Cu2^{+\ cations}$.

50. Chemistry of d -elements VI and groups VII . Chromium, molybdenum, manganese in the body and their

51. The role and use of compounds in medicine as drugs. $KMnO_4$. Qualitative reactions for $Mn^{2+\ ions}$.

52. Structural features of Group VII of the Periodic Table. Chemistry of d- elements of the first triad (Fe^{3+} , Co^{2+}) of Group VII d -elements . Use of compounds in medicine. Qualitative reactions for Fe^{3+}, Fe^{2+}, Co^{2+}, Ni^{2+}.

53. Surface phenomena and their significance in biology and medicine.

54. Surface energy and surface tension.

55. Surface tension isotherm.

56. Surface-active and surface-inactive substances.

57. Duclos-Traube rules.

58. Orientation of molecules in the surface layer and the structure of biological membranes: surface film and monomolecular layer.

59. Adsorption at the liquid-gas, liquid-liquid interface.

60. Gibbs equation. Surface activity.

61. Positive and negative adsorption.

62. Dispersed systems, dispersed phase and dispersed medium.

63. Classification of dispersed systems.

64. The nature of the colloidal state (aggregative and sedimentation stability).

65. Methods for obtaining colloidal solutions (dispersion and condensation) provide examples.

66. Methods for purifying dispersed systems and the specifics of purifying colloidal solutions (dialysis, electrolysis, compensatory dialysis, vividiasis, ultrafiltration, gel filtration). Artificial kidney.

67. Molecular-kinetic properties of colloidal systems: Brownian motion, diffusion, sedimentation, osmosis.

68. Optical properties of colloidal particles (light scattering, Rayleigh equation), and the color of sols in reflected and transmitted light. Methods based on measuring scattering intensity: nephelometry.

69. Colligative properties of colloidal systems: osmotic pressure, determination of the relative mass of colloidal particles, shape, size, optical methods of dispersion analysis.

70. Ultracentrifugation. Ultramicroscopy. Medical significance of these methods. Research.

71. Conditions for the formation of colloidal systems.

72. The mechanism of formation of the double electric layer and its structure.

73. Micellar theory of the structure of a colloidal particle (core, adsorption layer, granule, diffusion layer).

74. Electrokinetic and electrodynamic properties of colloidal phenomena in colloidal systems.

75. Electrokinetic phenomena. Electrophoresis, electroosmosis.
76. The influence of electrolytes on the magnitude of electrokinetic potential.
77. Phenomenon of recharging of colloidal particles.
78. Helmholtz-Smoluchowski equation.
79. Electrophoretic research methods in medicine.
80. Write the structures of the following micelles.

a) silver iodide micelles with potassium iodide and silver nitrate stabilizer.

b) micelles of arsenic sulfide with excess hydrogen sulfide.

c) obtaining a micelle of iron hydroxide by hydrolysis of $FeCl_3$ and the structure of this micelle with the stabilizer FeO^+.

d) Prussian blue micelles with ferric chloride and potassium ferricyanide as stabilizers.

81. Kinetic and aggregative stability of colloidal systems.
82. Factors affecting sustainability.
83. Study of coagulation kinetics. Slow and fast coagulation, latent and apparent coagulation thresholds, and units of coagulation threshold measurement.
84. Factors influencing the coagulation process.

a) temperature

b) the action of a mixture of electrolytes (synergism, antagonism, additivity)

c) the action of electrolytes (Schulz-Hardy rule)

85. Mutual coagulation of colloids. Phenomena of habituation. Study of the phenomenon of protection.
86. The concept of modern coagulation theory.
87. Coagulation protection processes.
88. Microheterogeneous systems: aerosols, emulsions, suspensions, foams, their general characteristics.
89. Aerosols: classification, production and application.
90. Properties of aerosols, their destruction.
91. Aerosols as medicinal forms and as a cause of some occupational diseases (silicosis, anthracosis, etc.)
92. Suspensions and emulsions, methods of their production, properties.
93. Colloidal surfactants: soaps, detergents, dyes, etc.

Glossary

AVOGADRO NUMBER (Avogadro constant): $N_A = 6.02 \cdot 10^{23}$ units/mol.

ADSORPTION is the concentration of a substance at a phase boundary. For example, the concentration of gas molecules (adsorbate) on a solid surface (adsorbent). Adsorption can result solely from physical forces between the particles of a substance, but it can also be accompanied by chemical interaction between the adsorbate and the adsorbent (chemisorption).

ACCEPTOR (ELECTRON-ACCEPTOR) PROPERTIES - the ability of an element's atoms to attract (retain) electrons. The quantitative measure of the acceptor properties of atoms forming a chemical bond is their electronegativity.

ALLOTROPY is the phenomenon of the existence of a chemical element in the form of two or more simple substances that differ in structure and properties.

AMPHOTHERICITY is the ability of some chemical compounds to exhibit both acidic and basic properties depending on the nature of the substances that react with them.

AMPHOLYTES are protolytes that can exhibit the properties of both donors and acceptors of H^+ in acid-base reactions.

ANIONS are negatively charged ions.

ANODE - the electrode at which oxidation occurs.

ATOM is the smallest particle of a chemical element that is the carrier of its properties.

BUFFER SYSTEMS - systems consisting of two conjugated components that are capable, up to a certain limit, of counteracting changes in the pH of the medium when small amounts of acid and alkali are added to them, as well as when the solution is diluted or concentrated.

BUFFER CAPACITY is a value that characterizes the ability of a buffer system to counteract the shift in the reaction of the medium when acids or alkalis are added (B).

VALENCE is the number of electron pairs by which an atom of a given element is bonded to other atoms.

REDUCTION (of a substance) is the process of adding electrons to an atom, molecule, or ion.

REDUCING AGENT - a substance capable of donating electrons to another substance (oxidizing agent).

HIGH MOLECULAR WEIGHT SUBSTANCES (polymers) are substances with a molecular weight from ten thousand to several million units.

Gas constant (R) - 8.314 J mol^{-1} K^{-1}

GALVANIC CELL - a system of two electrodes that are located in environments with conductivity by corresponding ions.

HETEROGENEOUS REACTIONS - chemical reactions between substances in different phases (different states of aggregation of the substance).

HOMOGENEOUS REACTIONS - chemical reactions that occur in a homogeneous phase.

DISPERSED SYSTEM - a system in which one substance in a more or less fragmented (dispersed) state is uniformly distributed in the mass of another substance.

DIFFUSION - (from the Latin diffusio - distribution) - spontaneous equalization of the concentration of substances in a mixture, caused by the thermal movement of molecules.

DONOR (ELECTRON-DONOR) PROPERTIES - the ability of atoms of an element to give their electrons to other atoms.

AVOGADRO'S LAW . Equal volumes of any gases (at the same temperature and pressure) contain an equal number of molecules. 1 MOL of any gas under standard conditions occupies a volume of 22.4 liters.

LAW OF CONSERVATION OF MASS . The mass of substances entering into a chemical reaction is equal to the mass of substances formed as a result of the reaction.

LAW OF EQUIVALENTS . At the moment of equivalence of a chemical reaction, the number of equivalents of the titrant and the analyzed substance are equal

NUCLEAR CHARGE is the positive charge of an atomic nucleus, equal to the number of protons in the nucleus of a given element. The atomic number of a chemical element in D.I. Mendeleev's Periodic Table is equal to the charge of the nucleus of that element's atom.

ISOTOPES are atomic varieties of the same element. Isotopes consist of atoms with the same nuclear charge. (that is, with the same number of protons), but with different relative atomic masses (that is, with a different number of neutrons in the nucleus).

INHIBITORS - substances that reduce the rate of a chemical reaction.

INDICATORS (acid-base) – weak organic acids or bases of complex structure, the molecular and ionic form of which has different colors.

INITIATORS are substances whose addition to reactants is sometimes necessary to initiate a chemical reaction, which then proceeds independently. Initiators are consumed during the reaction, so they should not be confused with catalysts .

An ionic bond is a limiting case of a heteropolar bond. A bond between two atoms is considered ionic if the difference in electronegativity between the atoms is greater than or equal to 2.1.

IONS are negatively or positively charged particles formed when atoms of elements (or groups of atoms) gain or lose electrons.

IUPAC (International Union of Pure and Applied Chemistry) is an organization founded in 1919. It is a member of the International Council of Scientific Unions. It coordinates research requiring international harmonization, control, and standardization, and recommends and approves chemical terminology.

CATALYSTS are substances that can accelerate chemical reactions while remaining unchanged.

CATIONS are positively charged ions.

CATHODE - the electrode at which reduction occurs.

ACID is an electrolyte in which only H^+ ions are present as cations in an aqueous solution.

A COVALENT BOND is a bond between atoms that is formed by shared electron pairs. A nonpolar covalent bond is formed between atoms of the same type. A polar covalent bond exists between two atoms when their electronegativities are not equal.

CONCENTRATION - the relative amount of any substance in a solution.

COLLIGATIVE PROPERTIES - properties of a solution that depend only on the number of particles of the dissolved substance.

COLLOID CHEMISTRY – the science that studies the physicochemical properties of heterogeneous, highly dispersed systems in the solid state and in solutions. CRYSTAL **HYDRATES** are crystalline hydrates (compounds of a substance with water) with a constant composition. They are isolated from solutions of many substances, especially salts.

METALLIC BOND - a chemical bond in a crystal between positively charged metal ions through freely moving (throughout the entire volume of the crystal) electrons from the outer shells of the metal atoms.

A MOLECULE is the smallest particle of a substance that determines its chemical properties and is capable of independent existence. Molecules are composed of atoms.

MOLES are quantities of a substance equal to $6.022^{\mathbf{10}}23^{\text{structural}}$ units of the substance: molecules (if the substance consists of molecules), atoms (if it is an atomic substance), and ions (if the substance is an ionic compound). The number $6.022^{\mathbf{10}}23^{\text{is}}$ called the Avogadro constant or Avogadro number.

MOLAR MASS is the mass of a substance taken in an amount of 1 mole (dimension g/mol). MOLARITY (of a solution) is the concentration of a solution, expressed in moles of solute per 1 liter of solution. It is denoted by the letter M. For example, 1 M NaOH is a NaOH solution with a concentration of 1 mol/L.

NEUTRALIZATION – a reaction of interaction between acids and bases, with the formation of an aqueous solution of salt.

NORMAL CONDITIONS (n.u.) are defined as a temperature of $0\ ^{o}C$ (273 K) and a pressure of 1 atm (760 mm Hg or 101,325 Pa).

OXIDATION (of a substance) is the process of giving up electrons by an atom, molecule, or ion. OXIDIZING AGENT is the substance that accepts electrons in a given chemical reaction.

OXIDES are complex substances consisting of atoms of two elements, one of which is oxygen in the oxidation state (-2).

A BASE is a complex substance in which a metal atom (or atoms) are bonded to hydroxy groups (OH groups). In base solutions, only hydroxide anions OH^- are present as anions.

SOLUBILITY is the ability of a substance to dissolve in a given solvent. A measure of a substance's solubility under given conditions is its content in a saturated solution.

A SATURATED SOLUTION is a solution of the maximum concentration in which a given substance no longer dissolves at a given temperature. A saturated solution is in dynamic equilibrium with the undissolved substance.

SOLUTIONS are physicochemical homogeneous mixtures of variable composition, consisting of two or more substances and the products of their interaction.

REAGENTS are the starting materials in a chemical reaction. Reactant formulas are always written on the left side of a chemical reaction equation.

SALTS are complex substances in which metal atoms (or NH_4^+) are bound to acid residues.

SOLVATION is the formation of chemical bonds between a solute and a solvent. For aqueous solutions, the process is called hydration (hydrogen).
OXIDATION DEGREE is the charge that develops on an atom in a compound, taking into account the polarity of the chemical bond.

HEAT OF REACTION - the heat released or absorbed during a chemical reaction. Usually denoted by the symbols Q or ΔH. At constant pressure, the HEAT OF REACTION (Q) is equal to the change *in ENTHALPY* (ΔH).

TITRATION is the process of gradually adding a titrant to the substance being analyzed.

occurs. Chemical phenomena are also called chemical reactions.

ELECTROLYTIC DISSOCIATION - the decomposition of a substance into ions in a melt or as a result of chemical interaction with a solvent in a solution.

List of references

1. General chemistry. Biophysical chemistry. Chemistry of biogenic elements./ Yu.A. Ershov, V.A. Popkov, V.A. Berland et al.; Under. ed. Yu.A. Ershov. – 2nd ed., revised. and additional – M.: Vyssh. school, 2000. – 560 p.
2. A.V. Skalny. Chemical elements in human physiology and ecology. – M.: Publishing house "ONIX 21st century": Mir, 2004. – 216 p.
3. V.I. Slesarev. Chemistry: Fundamentals of Living Chemistry: Textbook for Universities. - 2nd ed., corrected and enlarged. - St. Petersburg: Khimizdat, 2001. - 784 p.
4. Glinka, N.L. Problems and exercises in general chemistry: a tutorial / M.: Integral-press, 2008. – 240 p.
5. S.A. Balezin. Practical training in physical and colloidal chemistry. – Moscow: Prosveshchenie, 1985.
6. Romantseva, L.M. Collection of problems and exercises in general chemistry L.M.Romantseva, Z.L.Leshchinskaya, V.A.Sukhanova – M.: Higher. school, 1991. – 288 p.
7. Medicinal Chemistry. V.A. Kalibabchuk, S.M. Gozhdzinsky, Textbook for medical specialized universities. Kyiv, "Medicine", 2008. pp. 209-215.
8. N.L. Glinka General Chemistry. Moscow, "Higher Education", 2010. 16th edition. Pp. 255-262.
9. M.B. Gokzhaev, E.V. Belova, K.E. German, A.V. Afanasyev General Chemistry Part I. Textbook on General Chemistry for Independent Study of Medical Students Moscow 2016 Granits Publishing House
10. Borsoeva, S. A. Chemistry: textbook. manual / S. A. Borsoeva, V. A. Mironova, etc.; Sib. state aerospace univ. – Krasnoyarsk, 2006.
11. Collection of problems and exercises in general chemistry: Textbook / S.A. Puzakov, V.A. Popkov, A.A. Filippova. - M.: Higher. school, 2004. - 255 p.
12. Brief reference book of physical and chemical quantities. / Ed. A.A. Ravdel – St. Petersburg: Chemistry, 1998.
13. Chemist's Handbook / Ed. B.P. Nikolsky. –L.: Chemistry, 1964.
14. Goldovskaya L.F. Examples of solving problems in physical and colloidal chemistry. – Belgorod: Belgorod State University Publishing House, 2005, 92 p.
15. Korovin, N. V. General Chemistry: textbook / N. V. Korovin. - M.: Higher. school, 2000.
16. Shelinsky, G. I. Fundamentals of the Theory of Chemical Processes: a textbook / G. I. Shelinsky. - M.: Education, 2000
17. Lebedeva, M.I. Collection of problems and exercises in chemistry / M.I. Lebedeva, I.A. Ankudimova. - 2nd ed., corrected. and additional. - Tambov: Publishing house of TSTU, 2007. - 188 p.
18. Korovin, N.V. General Chemistry / N.V.Korovin . – M.: Higher School, 2008. –560 p.
19. Romantseva, L.M. Collection of problems and exercises in general chemistry / L.M.Romantseva, Z.L.Leshchinskaya, V.A.Sukhanova - M.: Higher. school, 1991. - 288 p.
20. N.L. Glinka; edited by V.A. Rabinovich, H.M. Rubina. – M.: Integral Press, 2008. – 240 p.
21. Problems and Exercises in General Chemistry. Edited by N. V. Korovin. – Moscow: Higher School, 2006.
22. Romantseva L.M. et al. Collection of problems and exercises in general chemistry. Moscow: Higher School, 1991.
23. Ugay Ya.A. General and Inorganic Chemistry. Moscow: Higher School, 1997. 3. Frolov V.V. Chemistry. Moscow: Higher School, 1979.
24. Methods of organizing and conducting a chemical experiment, Akmaeva T.A., Kozhina L.F., 2017
25. General Chemistry, Laboratory Workshop, Korovina N.V., Kamyshova V.K., Udris E.Ya., 2015
26. Laboratory practical training in general and inorganic chemistry, Guide to laboratory work, Part 1, Bezrukova S.A., 2011

27. Laboratory practical training in general and inorganic chemistry, Guide to laboratory work, Part 2, Bezrukova S.A., Andreev V.A., 2011
28. General and Inorganic Chemistry for Physicians and Pharmacists, Textbook and Workshop for Secondary Vocational Education, Negrebetsky V.V., Belavin I.V., Sergeeva V.P., 2019
29. Zelenin K.N., Alekseev V.V. Chemistry.- St.-Pb.: ELBI-SPb, 2003.- P. 107-124.
30. Popkov V.A., Puzakov S.A. General chemistry: textbook.- M.: GEOTAR-Media, 2009.- P.150-239, 760-796.