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MEDICAL UNIVERSITY

GENERAL, PHYSICAL AND COLLOID CHEMISTRY CHEAR

STUDY GUIDE

On self-preparation for lesson and performance of laboratory operations

ON GENERAL CHEMISTRY

For the students of treatment-prophylactic department

(Part 1)



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К 91 Учебно-методические разработки по самоподготовке к занятиям и выполнению лабораторных работ по общей химии для студентов лечебного факультета. – Витебск, ВГМУ, 2004. – с.68

Учебно-методические разработки по самоподготовке к занятиям и выполнению лабораторных работ по общей химии составлены в соответствии с типовой учебной программой по общей химии для студентов лечебного факультета высших медицинских учебных заведений.

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ABOUT THIS STUDY GUIDE

The present study guide are made in view of the educational program on general chemistry for the students of treatment-prophylactic department of Vitebsk state medical university and are intended for rendering assistance to the students in self-preparation for lesson and performance of laboratory operations.

In study guide are included: the methodical paper to each lesson, are given general purposes and problems of a sectional course of chemistry, ground rules of operation and laboratory safety guidelines in chemical laboratory, literature, methodical paper for laboratory work, reference on self-preparation of the students in lesson. In the extremity the list of knowledge, skills and skills is resulted which should the students get during study of a course of general chemistry, and also reference on self-preparation for examination.

On each lesson are resulted: the methodical indicatings and references, which acquaint the students with a theme and purpose of lesson, brief substantiation of the medicobiological importance of a theme for the student, program questions and question for self-preparation with the indicating of the literature. The methodical paper on performance of laboratory work are given.

We consider, that the submitted study guide will appear to rather useful students and will facilitate by him preparation for lesson, and the performance of the references will serve as a pledge of successful study.

THE PURPOSE AND PROBLEMS OF A COURSE

Formation and development at the students of systemic knowledge about a role of relative connection between the physical and chemical shapes of a motion of a substance in biological processes in norm and pathological states; development of skills and skills of application of theoretical positions and experimental methods of chemistry at study of medicobiological disciplines and in medical practice.

Before to initiate with operation in a laboratory practical work, the students should study rules of operation in chemical laboratory and laboratory safety guidelines.

The literature:

1. N.S.Akhmetov "General and inorganik chemistry". M. 1983.
2. Uno Kask, J.David Rawn "General chemistry" WCB 1993.
3. J.P.Sevenair, A.R.Burkett "Introductory Chemistry". WCB 1997.
4. N.Akhmetov, M.Azizova, and L.Badygina. "Problems and laboratory experiments in inorganic chemistry". M. 1982.
5. "Chemistry in context". WCB. 1994.
6. C.G.Gebelein "Chemistry and our world". WCB.

How to Succeed in General Chemistry

General chemistry has been described by many students as one of the hardest courses that they took in university. There are many reasons for this generalization: among them are the large amount of vocabulary that is learned, the quantitative nature of the material and the many concepts that are learned in the short period of time. However, many students take and do quite well in general chemistry, so what is the secret to success? The key to success in general chemistry is the proper balance of study habits and time invested in the course. Some suggestions towards achieving this balanced are offered. First, you must actively participate in the course to succeed. Many instructors believe that a student in general chemistry should spend about three to five hours working on the course for every hour of lecture. Second, you should not fall behind, because the pace of a university general chemistry class is fast, and it is very difficult to catch up once you get behind.

Before lectures, read the sections of the text and study guide that pertain to the lecture topics: in this reading, you are not striving for understanding, but general notions of what topics are to be covered. Pay attention to figures and equations and what they pertain to.

During the lecture, take notes. It is important that you not only write down selected portions of the lecture, but also jot down questions about what may not be clear. You should develop a compact way of taking notes.

After the lecture, review your notes and work homework problems. Some students find it helpful to copy over their lecture notes. In reviewing your lecture notes, check for accuracy by comparing the definitions and equations with those in your text and study guide. Go through sample problems solved in the lecture to make sure that the method is clear to you. Reread the text and study guides, much more thoroughly than you did before the lecture, paying special attention to the sample problems. You should also work many of the problems in your text, even those which are not assigned as homework. A significant portion of your grade will be determined on how accurately you can solve problems and the only way to get better is by practice.

Before an exam, you should re-read your text and your notes. Review your homework sets, and perhaps a few extra problems which gave you trouble during the homework. Your instructor may also post a sample examination, which may help you determine something of the test's style.

RULES OF OPERATION AND BEHAVIOUR IN CHEMICAL LABORATORY

1. Each student is obliged to come in laboratory for 4-5 minutes before class and take your constant workplace.

2. The student should test cleanliness of a workplace and presence of all necessary equipment and reagents for carrying out of laboratory work.

3. Before each laboratory work to study a theoretical material, concerning this theme. The practical operation can be begun after careful study of a procedure of its performance.

4. Each student should know, where are found the running water tap, medicine chest agent of a quenching of fire.

5. During practical operation to contain a workplace in cleanliness.

6. To not spend reagents it is more than the specified quantity.

7. To not carry away devices and reagents of general usage on the your workplace. Each subject or reagent to put on its place immediately after its use.

8. Don't exchange the stoppers at different vessels, pipets, and measuring cylinders for different reagents.

9. It is categorically forbidden to put vessels, flask with reagents on the books, copybooks methodical materials.

10. After finishing the work to wash up ware to put reagents on its places, to clean the workplace, to close running water tap.

11. To time of class is nominated on duty, which tracks the order and cleanliness in laboratory, behind keeping by the students of rules of safety.

12. In an operating time in laboratory each student is obliged:

- a) to keep silence and order;
- b) carefully to fall into to material values: to the books and manuals, to laboratory property (benches, chairs, devices and ware etc.);
- c) to keep safety measures.

LABORATORY SAFETY GUIDELINES

By operation in laboratory it is necessary to be especially attentive and to keep exclusive care. Poor acquaintance to devices and properties of substances or the negligence in operation can cause accidents (damage of an eye, skin of hand and person, mucosas of a nose, throat and bodies of respiration, cuts etc.). You should have read and understood the safety section in that manual. Safety in the laboratory cannot be overemphasized. Therefore we present here an abbreviated list of safety rules.

1. Safety glasses or safety goggles must be worn at all times when you are in the laboratory. Even if you are performing an experiment that is using no potentially dangerous chemicals, you are still in a laboratory where numerous potential hazards exist.

2. Unless your instructor indicates otherwise, contact lenses are not to be worn in the laboratory.

3. You should know where to find and how to use first aid equipment.

4. Your instructor will show you where the eye wash is located. If a corrosive chemical gets in your eyes, immediately wash the affected area with large quantities of water from the eye wash. Notify the instructor of the accident.

5. Your instructor will show you where the safety shower is located. If a corrosive chemical gets on your skin or clothes, immediately wash the affected area with large quantities of water. If your clothing catches fire or if a large quantity of chemicals is spilled on your clothing, then use the safety shower. Notify the instructor of the accident.

6. Never taste anything in the laboratory. Smoking, chewing, eating, or drinking in the laboratory under any circumstances is strictly prohibited.

7. Never directly smell the source of vapor, but rather bring a small quantity of the vapor to your nose with your cupped hand.

8. Reactions involving malodorous, noxious, or dangerous chemicals should be performed in the hood.

9. You should know the location of and know how to use a fire extinguisher. A small fire, such as a liquid burning in a beaker, can be extinguished by covering the beaker to remove the source of oxygen.

10. No unauthorized experiments are to be performed.

11. Clean up broken glassware immediately.

12. When pouring one liquid into another, do so slowly and cautiously. To dilute an acid, pour the acid into the water: never pour water into acid.

13. When heating a test tube, make certain that the open end is pointed away from you and your fellow students. Then, if overheating causes the contents to bump out, they will not splash anyone.

14. Do not rub your eyes while in the laboratory, as your hands might have chemicals on them.

15. In case of any accident, immediately notify the instructor. In the event that your instructor is not available, notify the stockroom personnel.

CONDUCTING A LABORATORY MAGAZINE

The laboratory journal is a report of the student on the executed research work (RW). The conducting it is obligatory.

Each student conducts a laboratory journal, where the course of performance and results of experimental operation is featured.

For a laboratory journal most approaches copybook in a cell. The record in a journal is conducted only by ink., how the records in a laboratory journal are conducted, it is possible to judge the attitude of the student to operation and to quality of its performance.

Each operation should be begun with new pages. On pages of copybook it is necessary to leave fields for calculations, of the padding notes etc. Student should learn to apply for the records the natural and precise formulations, to explain results of experiment and to make conclusion.

THE PROVISIONAL PLAN OF VENEERING LABORATORY OPERATION (RW)

1. The number and name of research work (RW). Date of performance.
2. The purpose of research work.
3. A course of operation (brief transfer of consecutive operations 1, 2, 3..., operation, necessary for performance,).
4. Results of experiment: quantitative sectional are reduced in the table; the quality observations are numbered 1, 2 ..., or also are reduced in the table. Is resulted chemical reactions (molecular and ionic equations of reactions).
5. Calculations: 1) complete calculation of result; 2) calculation of an error.
6. A deduction: the achievement of the purpose of experiment, performance of the put problem RW is reflected.

The note: (attention!)

- 1) the protocol of laboratory work on items 1-3 is made at home on the eve of lesson and is a part of the home work.
- 2) on item 4 of a house the shape of the table for the experimental data is made.
- 3) on lesson the students carry out experiment, fill in items 4-6. Amend in other items of the protocol.

Each operation executed by the student, is protected at the teacher. The protection consists in the answers to questions, bound with a principle of the executed operation, substance of the apparent phenomena and received results.

The operation is considered executed, if it proofs by the student and is signed by the teacher. Without presentation of the protocols or, if the protocols will not answer the showed demands, the operation of the student on sectional partition will not be marks.

The students successfully executed all laboratory operations, gain offset and it are supposed to a passing examinations on chemistry.

LESSON 1

THEME: introduction in a practical work. Rules and laboratory safety guidelines in chemical laboratory. Introduction in chemistry of biogenic elements and qualitative analysis.

Medicobiological value: the qualitative analysis will be used in the solution of series of problems of practical medicine: in diagnostics and at overseeing by development of diseases; quality surveillance of medicinal preparations; at the sanitary-hygienic analysis of water, air, nutrition etc.

Study of theoretical bases of qualitative analysis and the performance of a control-analytical problem pawns a basis for study of special disciplines, bound with performance of the analysis (biological chemistry, clinical biochemistry etc.); develops thinking, as it is necessary to lead series of prestress observations and trials, to analyse likeness and difference in properties of various ions to make a final deduction about presence at a decomposed solution of a concrete ion. Similarly doctor will spend series of ideational activities to differentiate sectional disease from others, with identical signs.

The purpose of lesson: acquaintance with the content and basic problems of laboratory class at the rate of general chemistry; by rules and laboratory safety guidelines in chemical laboratory; with theoretical bases of qualitative analysis of ions of biogenic elements.

To lesson it is necessary:

1. TO FAMILIARIZE with rules and laboratory safety guidelines in chemical laboratory; by the purposes and problems of a course.
2. TO REMEMBER some characteristic reactions of ions described in the school textbooks, and TO STUDY original positions of qualitative analysis:
 - 1) Fractional and systematic methods of the analysis. Characteristic, selective and group reactions of ions;
 - 2) Analytical effects of reactions and technique of their carrying out.

Theoretical material to lesson:

Introduction in qualitative analysis

Qualitative analysis is a branch of chemistry in which we identify unknown substances. Inorganic qualitative analysis in aqueous solution is concerned with the identification of ions present in solution.

An unknown substance can be identified by systematically studying its chemical reactions with various reagents that are chosen to produce a characteristic color change, a precipitate, or a gas having a specific color or odor. The solubility of an unknown substance in various solvents also provides clues about its identity.

An unknown ionic substance is identified by separate tests of its anion and cation components. Analysis of cations in aqueous solution is usually carried out by separating groups of cation followed by further separation and identification of individual cations within each group. Anion analysis, on the other hand, does not require the separation of all of the ions because individual tests for the presence or absence of certain anions can be done in the presence of other anions which do not interfere with the tests.

The basic problem of qualitative analysis is the detection of various substances in the explored object. In a sectional course the qualitative analysis of ions is surveyed.

The chemical method of qualitative analysis is based on application of reactions, which are accompanied by analytical effect:

- Gassing;
- Occurrence of new colouring;
- Formation of an insoluble solid form.

Distinguish specific (characteristic), selective and group reactions of ions.

The specific reactions is an analytical reaction, appropriate only to sectional ion. For example, dark blue staining of amyllum at activity of iodine. reaction of detection NH_4^+ activity of alkali on salt of ammonium at warming etc.

Due to specific reactions it is possible to unclose a particular ion in separate assay of an explored solution, at the presence of other ions. The opening of ions is termed as specific reactions by the fractional analysis.

The fractional analysis will use for detection of ions in more simply admixtures. The absence of specific reactions for the majority of ions does to impossible carrying out of qualitative analysis of composite admixtures by a fractional method. A systematic course of the analysis in this case will be used.

A mixture of ions separated on groups with the help of group reagents. From these groups each ion evolve in a rigorous sequence, and then already unclose it by

analytical reaction characteristic for it. Reagents, which allow to divide ions into analytical groups, are called as group reagents. For example, alkali and ammonia are group reagents at the analysis of a mixture containing Al^{3+} , Fe^{3+} , Ni^{2+} , Zn^{2+} , Cu^{2+} , Co^{2+} .

The selective reactions proceed with several ions. For example, Cl^- the ions form deposits with cations Ag^+ , Hg_2^{2+} , Pb^{2+} , i.e. this reaction is selective for the specified ions, and HCl can be used as a group reagent of analytical group containing these cations. The group reagents will be used for the analysis of composite mixtures.

In analytical practice frequently apply a fractional-systematic method. Minimum number of group reagents in this case will be used, that allows to plan tactics of the analysis in general, which then will carry out by a fractional method.

Technique of carrying out of analytical reactions

Distinguish:

- precipitate reactions;
- microcrystalloscopic reactions;
- reactions accompanying with excretion of light-end products;
- reactions given on a paper;
- extraction reactions;
- colour reactions;
- a staining of flame reactions.

At carrying out of precipitate reactions necessarily note colour and character of a precipitate (crystalline, amorphous). Check a precipitate on a solubility in strong and weak acids, alkalis and ammonia, excess of reagent. It is possible to study the shape of a crystal under a microscope.

At carrying out of reaction accompanying with gassing, note its colour and odor.

In analytical chemistry the reactions will widely be used, during which there is a new colouring. It is reactions of a complexing or oxidation-reduction reactions more often. On occasion such reactions are convenient for carrying out on a filter paper (drop reactions).

To intensifying colouring sometimes apply extraction in an organic solvent.

For trial tests will used reactions of a staining of a flame.

Group reactions of cations and anions

One of many possible scheme of separating cations into groups in aqueous solution is exist. The general strategy of this (or any) scheme of qualitative analysis is to assume that an unknown substance contains all possible cations and anions.

The qualitative analysis scheme is based on the solubilities of metal chlorides, sulfides, hydroxides, and carbonates in aqueous solution. Metal ions in this scheme are divided into five groups.

Group I the metal ions of group I are Ag^+ , Pb^{2+} , and Hg_2^{2+} . *Group I cations are precipitated as chlorides: AgCl , PbCl_2 , and Hg_2Cl_2*

Group II the metal ions of group II are Hg^{2+} , Cu^{2+} , Pb^{2+} , and Sn^{2+} . *Group II cations are precipitated as sulfides from an acid solution saturated with H_2S .*

Group III the cations of group III are Al^{3+} , Cr^{3+} , Fe^{3+} , Mn^{2+} , Ni^{2+} and Zn^{2+} . *Group III cation precipitate as sulfides and hydroxides from a solution made alkaline with ammonia and saturated with H_2S*

Group IV the metal ions of group IV are Mg^{2+} and Ca^{2+} . *The cations of group IV precipitate as carbonates in alkaline solution. Metal carbonates are soluble in acid solution.*

Group V the metal ions of group V are Na^+ , K^+ , and NH_4^+ is also included. Most alkali metal salts and ammonium salts are soluble in water. Therefore, *the cations of group V are identified by special tests.*

Schemes of anion analysis are usually less systematic than schemes of cation analysis. However, in all schemes the anions are divided into groups based on their behavior in major types of reactions such as acid-base reactions, redox reactions, and precipitation reactions.

We consider 10 common anions: SO_4^{2-} , SO_3^{2-} , CO_3^{2-} , NO_3^- , PO_4^{3-} , S^{2-} , Cl^- , Br^- , I^- , and CH_3COO^- . These anions can be divided into five groups. Each anion of group can be identified by a specific test.

The first group contains anions of volatile acids. These anions are relatively strong conjugate bases of weak acids, and they are therefore easily protonated to acid whose vapors can be identified by their characteristic odors.

The second group of anions is the sulfate group. These anions precipitate as barium salts from alkaline solution.

The third group of anions is the chloride group. These anions can be precipitated as silver salts from acid solution.

The fourth group contains only nitrate, which is an oxidizing anion.

The fifth group contains reducing anions.

Problems for discussion

1. Chemical analysis and its value for practical medicine and medicobiological examinations.
2. What odds between a fractional and systematic method of the analysis exists.
3. Give the examples of group and characteristic reactions of anions and cations.
4. In what the substance of a fractional-systematic method of the analysis consists?
5. Give examples of salts, for which the following combination of analytical effects will be characteristic at activity of group reagents:
 - a) HCl - deposit; H_2SO_4 - deposit;
 - b) BaCl_2 - deposit; AgNO_3 , H^+ - there is no deposit;
 - c) I^- , H^+ - brown staining; BaCl_2 - there is no deposit.
6. Sodium bromide will be used in medicine as a calmative. Describe analytical effects, which will be observed at addition to this substance:
 - a) silver nitrate;
 - b) potassium permanganate in the acidic medium.
7. Write the formulas of the compounds that precipitate in each group. What is the color of each of these compounds?
8. What is the color of the flame in the flame test for:
 - (a) Na^+ ions;
 - (b) K^+ ions?

LEGITIMACIES OF COURSE CHEMICAL REACTIONS

LESSON 2

THEME: **chemical thermodynamics and bioenergetics.**

Medicobiological value: the thermodynamics is the theoretical basis of a modern bioenergetics - science which study legitimacy of accumulation, keeping and using of energy by alive systems.

Since the change of energy does not depend on way of process, but only from an initial and final state of the system. therefore there is no necessity to know

true mechanism of reactions occurring in alive organisms (cells). It is possible to simulate them outside of an organism. So, it was possible to establish on model experience, with the help of thermodynamic calculations, that at multiphase process of an oxidizing of nutritious substances in an organism the same quantity of energy precipitates out, as well as at their immediate burning outside of an organism. It allows to establish connection between a calorific of nutrition and serviceability of an organism. These connection is a base of scientific dietology. The model operation of various biochemical processes can be carried out at various temperatures distinguished from that, at which they proceed in an organism, and using the relevant equations of thermodynamics it is possible to count change of energy in substantial requirements.

The thermochemical investigation of processes of an oxidizing of various products in alive organisms are necessary not only for study of mechanisms of transformation of various substances in energy. The comparison of energetics healthy and patients of cells allows to develop early diagnostics of various diseases and check behind their current. The diseases of the man are always accompanied by change of values of thermodynamic parameters describing a sectional organism in norm. So, occurrence and the course of diseases is accompanied by increasing of entropy system. The increasing of entropy is marked also at development of processes of neogenesis and embryogenesis.

The application of the basic laws of thermodynamics allows to establish specific features of an alive nature, to prognosticate a direction of spontaneous course of processes in an organism and their depth depending on requirements, to predict an possibility of participation of this or that medicinal substance in the necessary reaction proceeding in biological medium, and relevant bioenergy changes.

Knowledge of thermodynamic legitimacies and skill to apply them for decision of concrete practical questions it is necessary for study of the following chapters of these course (chemical kinetics and equilibrium, theory of solutions, electrochemistry, physico-chemistry of surface phenomena), and also for study of biochemistry, physiology both other medicobiological and clinical disciplines.

To lesson it is necessary:

1. TO STUDY the following program questions: a subject and problems of chemical thermodynamics. Interrelation between processes of a metabolism and energy in an organism. Chemical thermodynamics is a theoretical basis of a bioenergetics.

The basic concepts of thermodynamics. Internal energy. Work and heat – two forms of energy transmission. Types of thermodynamic systems and processes.

The first low of thermodynamics. Enthalpy. Standard enthalpy changes of formation, standard enthalpy changes of combustion. The Hess's law of heat sum-

mation. Thermochemical processes. Application of the first law of thermodynamics to biosystems.

The second law of thermodynamics. Reversible and nonreversible in thermodynamic sense processes. Entropy. Standard entropy. Gibbs's free energy. The standard Gibbs free energy change of formation. The standard Gibbs free energy change of a biological oxidizing. The chemical potential.

Measure of a direction of spontaneous processes.

The literature:

7. N.S.Akhmetov "General and inorganik chemistry". M. 1983. p. 166-184.
8. Uno Kask, J.David Rawn "General chemistry" WCB 1993. p.166-200, p.748-772.
9. J.P.Sevenair, A.R.Burkett "Introductory Chemistry". WCB 1997. p.112-123.

Research work:

"Definition the heat of neutralization reaction"

Starting sectional

Mass of an interior glassful of a calorimeter m_1 , g

Volumes of the reactants solutions of V, ml

Concentration of solutions C, mol/l

Density of solutions ρ , g/ml

Specific heat of water $C_m(\text{H}_2\text{O}) - 4.184 \text{ J}/(\text{g} \cdot \text{K})$

Specific heat of glass $C_m(\text{gl}) - 0,753 \text{ J}/(\text{g} \cdot \text{K})$

1. By measuring cylinder measure till 20 ml of solutions of a strong acid and strong base.
2. Measure temperature of one of solutions, for example base, is immediate in the cylinder by the thermometer. After that wash the thermometer by distilled water and again insert into a calorimeter.
3. Add a solution of an acid through a funnel to an interior glassful of a calorimeter and also write down its temperature.
4. Add the solution of base prompt in a calorimeter to a solution of an acid and intermix.
5. Within several seconds observe for level of mercury in the thermometer and write down the highest indication.
6. The obtained experimental data write down in the table under the shape:

The measured and calculated quantities	reactants
	... + ...
Temperature of a solution of an acid T_a	
Temperature of a solution of the basis T_b	
Reference temperature of experience $T_1 = 0,5 (T_a + T_b)$	
Best temperature after mixture T_2	
$\Delta T = T_2 - T_1$	
Q, kJ	
ΔH_c , kJ/mol	

Processing of results of experiment:

- 1) Calculate the heat capacity of a calorimeter C_m , taking into account a heat capacity of a solution and heat capacity of an interior glassful:

$$C_m = C_m(\text{gl}) \cdot m(\text{gl}) + C_m(\text{H}_2\text{O}) \cdot m(\text{sol}),$$

Where $m(\text{sol})$ - mass of a solution in a calorimeter calculated on volume of a solution and density (density can be accepted per 1 g/ml).

- 2) Calculate the heat, allocated in a calorimeter:

$$Q = C_m \Delta T$$

This heat gradually in accordance with alignment of temperature is transmitted in a surrounding medium and can be accepted per on absolute value to change of enthalpy of system (calorimeter) - ΔH_c :

$$\Delta H_c = -Q$$

- 3) For calculation of reaction heat ΔH_r the found value of heat count on 1 of a mol reacting acid or basis, that corresponds 1 of mol generated water:

$$\Delta H_r = \frac{\Delta H_c}{n} = \frac{\Delta H_c}{cV}$$

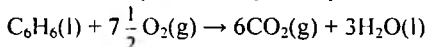
Where n - chemical quantity of one of substances participating in reaction.

Problems for discussion:

1. What is: a) an exothermic reaction, b) an endothermic reaction?
Give two examples of each.
2. Discuss some different forms of energy and give examples of their conversions.
3. What is meant by a "system" in thermodynamics?
4. Define "enthalpy change for a system".
5. What is the difference, if any, between "enthalpy of formation" and "enthalpy of reaction"?
6. What is the difference, if any, between ΔH_r and ΔH_f° .

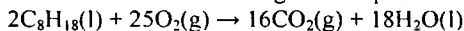
- Write an equation relating the heat of a reaction and the heats of formation of the reactants and the products of the reaction.
- For the metabolism of sugar, $C_{12}H_{22}O_{11}$, in the body, $\Delta H = -5645 \text{ kJ mol}^{-1}$. How many kilocalories (Ccal) of energy would your body gain from the sugar in a candy bar that has the mass of 150.0 g and contains 60.0 percent sugar and no other nutrients?

- The combustion of benzene is represented by the equation



Using the data from Table to four significant figures, calculate the standard enthalpy of combustion of benzene.

- The combustion of octane occurs according to the equation



The standard enthalpy for this reaction as written is $-1,094 \cdot 10^4 \text{ kJ}$. Using the data from Table, calculate the standard enthalpy of formation of octane.

- What is a "spontaneous process"? Give examples of some spontaneous and of some nonspontaneous processes.
- What is entropy? Give examples of some systems of low entropy and others of higher entropy.
- State the second law of thermodynamics.
- In thermodynamics, what is a "reversible" process?
- What is the Gibb's free energy? Write an equation for the Gibb's free energy of a system in terms of the change, the entropy change, and the temperature of the system.
- What is the relationship between the free energy change of a reaction and the spontaneity of the reaction?
- Write an equation for calculating the standard free energy change for a reaction from the values of the standard free energies of formation for the reactants and products.
- Show how you would calculate the standard free energy change for a reaction from given values of standard enthalpies of formation and standard absolute entropies for the reactants and the products.
- Predict the sign of ΔS for each of the following reactions and give a reason for each prediction:
 - $AgCl(s) \rightarrow Ag^+(aq) + Cl^-(aq)$;
 - $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$;
 - $H_2(g) + I_2(g) \rightarrow 2HI(g)$;
 - $H_2(g) + I_2(s) \rightarrow 2HI(g)$;
 - $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$.

- Using S^0 values, calculate ΔS^0 for each of the following reactions:

- (a) $\text{N}_2(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$;
 (b) $\text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$.

21. Calculate ΔG^0 for each of the following reactions using the values for ΔH_f^0 and S^0 :

- (a) $\text{N}_2(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$;
 (b) $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$.

22. Calculate ΔG^0 for each of the following reactions using the values of ΔG_f^0 :

- (a) $2\text{H}_2\text{O}_2(\text{l}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$;
 (b) $\text{NH}_4\text{Cl}(\text{s}) \rightarrow \text{NH}_3(\text{g}) + \text{HCl}(\text{g})$.

LESSON 3

THEME: a chemical equilibrium.

Medicobiological value: many biochemical processes in a human organism are reversible. Among them such vital processes, as interaction of haemoglobin with oxygen, transport of carbon dioxide and transport role of protein, the hydrolysis of ATP etc. Knowing an equilibrium constant is possible to give a quality estimation of a direction of many biochemical transmissions in an human organism for medical diagnostics. According to a Le Chatelier's principle it is possible to prognosticate many infringements in an organism caused by change of temperature, pressure and concentration of metabolites; to adjust many biochemical and physiological processes. In particular, to understand influence of changes of partial pressure of oxygen on process of transport it in a human organism; shift of equilibriums of buffer systems on a constancy pH of biological fluids and tissues; allocation of ions till both parties of biological membranes. Action of a radioactive ion strontium, bound with equilibrium process of replacement of calcium - basic builder of an osteal tissue - on strontium. The sharp shift of chemical equilibriums in a human organism can cause death.

The study of these theme is necessary for the future doctor for successful mastering of many questions of biochemistry, pharmacology, physiology. therapy.

To classis is necessary:

1. TO STUDY the following program questions: a chemical equilibrium. Reversible and nonreversible reaction. A constant of a chemical equilibrium and ways of its expression: K_p , K_c , K_a . The isotherm of chemical reaction equation. To predict a shift of a chemical equilibrium, according to a Le Chatelier principle. Concept about a homeostasis and stationary state of an alive organism.

The literature:

1. N. Akhmetov General and inorganic chemistry. 1983. M. - P.184-196.
2. Uno Kask, J.David Rawn General chemistry – P.490-520.

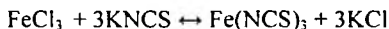
Research work:**"Quality experience on a chemical equilibrium"**

Purpose of operation: To study experimentally direction of shift of a chemical equilibrium at change of concentration of reagents and temperature.

Performance of experiment

Experiense 1. Study of shift of a chemical equilibrium at change of concentration of reagents.

For experience we shall take advantage a reaction of formation iron (III) thiocyanide:



Iron (III) thiocyanide is intensively painted in red colour, solution FeCl_3 - in yellowish, and the solutions KNCS and KCl are colourless. At change of concentration $\text{Fe}(\text{NCS})_3$ colourings of a solution change, that allows visually to establish a direction of shift of equilibrium.

In a laboratory magazine for record and analysis of observations prepare the table under the following shape:

The test tube	is added in a test tube	observation - change of intensity of colouring	a direction of shift of equilibrium (finger to the right or to the left)
1	FeCl_3 (l)		
2	KNCS (l)		
3	KCl (s)		
4	-		

1. To four test tubes bring till 5-7 drops 0.0025 mol/l of solutions FeCl_3 and KNCS . Solutions stir by a glass rod and put in a support.
2. The fourth test tube with a received solution leave for comparison of results of experience. In other test tubes add the following reagents: in first - 1 drop of a saturated solution FeCl_3 , in second - 1 drop of a saturated solution KNCS , in a third - a little crystals KCl .
3. Compare intensity of colouring of received solutions to intensity of colouring of a solution in 4-th test tube and bring sectional in the table.

Experiens 2. Study of shift of a chemical equilibrium at change of temperature.

- To two test tubes bring till 4-5 mls of a solution of amyllum and add there till 3-4 mls of a solution I_2 . Write down observations (colour of the formed solution).
- Heat up one of test tubes in a glassful with hot water. The second test tube leave for comparison. Observe change of colouring. How the colouring of a solution in a heated test tube changes in comparison with cold?
- Write down observations in a laboratory magazine.
- Cool a heated test tube under a jet of cold water. What occurs? Write down the equation of the investigated equilibrium:

$$I_2 + \text{Amyllum} \leftrightarrow [I_2 \cdot \text{Amyllum}]$$

yellow colourless dark blue
- Being grounded on results of observations, make a conclusions about a direction of shift of equilibrium in system at warming and cooling. Using a Le Chateliers principle , answer a question – exo- or endothermic the reaction of formation $[I_2 \cdot \text{Amyllum}]$ and reaction of its dissociation is.

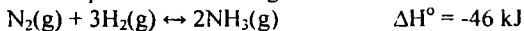
In the report on laboratory operation write down also expressions of the mass action law for the investigated equilibriums.

Problems for discussion:

- What is meant by the “position” of an equilibrium?
- What is meant by a “shift” of an equilibrium?
- What is a “reaction quotient”?
- Write an expression for K_c for each of the following gaseous equilibria:
 - $3O_2(g) \leftrightarrow 2O_3(g)$,
 - $H_2(g) + I_2(g) \leftrightarrow 2HI(g)$,
 - $2HI(g) \leftrightarrow H_2(g) + I_2(g)$,
 - $4NH_3(g) + 3O_2(g) \leftrightarrow 6H_2O(g) + 2N_2(g)$,
 - $2H_2S(g) + 3O_2(g) \leftrightarrow 2H_2O(g) + 2SO_2(g)$
- Write an expression for the equilibrium constant, K_c , for each of the following reactions:
 - $Fe(s) + 5CO(g) \leftrightarrow Fe(CO)_5(g)$,
 - $C(s) + H_2O(g) \leftrightarrow CO(g) + H_2(g)$,
 - $2HgO(s) \leftrightarrow 2Hg(l) + O_2(g)$,
 - $HC_2H_3O_2(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + C_2H_3O_2^-(aq)$,
 - $NH_3(aq) + H_2O(l) \leftrightarrow NH_4^+(aq) + OH^-(aq)$,

- (f) $2\text{H}_2\text{O}(l) \leftrightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq})$.
6. For the reaction $\text{SO}_2(\text{g}) + \text{NO}_2(\text{g}) \leftrightarrow \text{SO}_3(\text{g}) + \text{NO}(\text{g})$ at 973 K the equilibrium constant, K_c , is 9.00. Calculate the equilibrium concentrations of all the species present when:
- 1.00 mol of SO_2 and 1.00 mol of NO_2 are injected into a 1.00-L container at 973 K;
 - 1.00 mol of SO_2 and 1.00 mol of NO_2 are injected into a 2.00-L container at 973 K;
 - 1.00 mol of SO_3 and 1.00 mol of NO are injected into a 1.00-L container at 973 K.
7. For the reaction $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \leftrightarrow 2\text{NO}(\text{g})$, the value of K_p is 0.050 at 2473 K. If the equilibrium partial pressures of N_2 and NO in this system are 0.20 and 0.045 atm, respectively, what is the partial pressure of O_2 ?
8. At 1000 K, K_p for the reaction $2\text{NO}_2(\text{g}) \leftrightarrow 2\text{NO}(\text{g}) + \text{O}_2(\text{g})$ is 158. When a certain mixture of these reactants and products is at equilibrium at 1000 K, the partial pressure of NO is 0.50 atm and the partial pressure of O_2 is 0.30 atm. Calculate the partial pressure of NO_2 in this equilibrium mixture.
9. Formulate the Law of chemical equilibrium (Guldberg and Waage).
10. Formulate the Le Chatelier's principle.
11. Write an equation relating K_p to K_c . Show how this equation can be rearranged to solve for either of these equilibrium constants from the known value of the other.
12. In the following system at equilibrium $4\text{NH}_3(\text{g}) + 3\text{O}_2(\text{g}) \leftrightarrow 6\text{H}_2\text{O}(\text{g}) + 2\text{N}_2(\text{g})$
how is the amount of nitrogen present affected by each of the following changes?
- The volume of the container is doubled;
 - the volume of the container is decreased;
 - more water vapor is introduced;
 - more ammonia is introduced;
 - some oxygen is removed from the system;
 - temperature is increased (the forward reaction in this system is exothermic);
 - the pressure of the system is increased by introducing helium gas;
 - a catalyst is added.
13. For the gaseous equilibrium mixture $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \leftrightarrow 2\text{NO}(\text{g})$ $\Delta H^\circ = +180$ kJ
- State the effect on the equilibrium of each of the following changes:
- more oxygen gas is introduced:

- (b) some nitrogen is removed;
 (c) the temperature is increased;
 (d) the volume of the container is decreased without allowing any of the gas to escape;
 (e) the pressure is increased on the system by introducing helium gas;
 (f) a catalyst is added. Explain your reasoning in each case.
14. Consider the Haber process for making ammonia:



Complete the following table to state the effects (increased, decreased, unchanged) the indicated changes will have on the concentrations of the components at equilibrium:

Change	Concentration of N_2	Concentration of H_2	Concentration of NH_3
Increasing pressure by decreasing the volume of the reaction vessel			
Increasing temperature			
Increasing the amount of N_2			
Adding neon gas			
Adding a catalyst			

LESSON 4

THEME: The chemical kinetics.

Medicobiological value: The study of the rates and mechanisms of chemical reaction is known as chemical kinetics. Chemical kinetics has major practical value (for studying of chemical reactions proceeds in alive organisms). On the basis of legitimacies of chemical kinetics and thermodynamics it is possible to prognosticate course in time of biochemical transmutations. All biochemical reactions are composite. Practically all processes of a metabolism are consecutive reactions (for example, metabolism of a glucose etc.). Photochemical reactions are the processes underlying activities of the visual evaluator and at formation of sunburn of a skin. It is important to know an influence of various exterior actions on rate of metabolic transmutations. For example, is similar to reactions proceeding in a lifeless nature, at rising temperature of a human body as a result of any of disease the rate of biochemical transmutations in a human body strongly increases.

To lesson it is necessary:

1. TO STUDY the following program questions: a subject and basic concepts of chemical kinetics. Chemical kinetics as a basis for study of rates and mechanisms of biochemical processes. Reactions simple and composite, homogeneous and heterogeneous.

The mass action law for reaction rate. A specific reaction rate. Molecularity of reaction. The order of reaction. The equations of kinetics of reactions 1-st, 2 and zero orders. A half-life of the reaction. The effect of temperature on a reaction rate. A temperature coefficient of reaction rate and its peculiarities for biochemical processes. The Arrhenius equation. An activation energy. Concept about the collision theory and transition state theory. Concept about kinetics of composite reactions: competing, consecutive, conjugate, reversible, chain. Photochemical reactions and their role in vital activity of organisms and surrounding medium.

Problems for discussion:

- List three factors that can affect reaction rates.
- What is a rate law? Write the general form of the rate law for the reaction $A \rightarrow B$ and for the reaction $A + B \rightarrow C + D$.
- What is meant by the order of a reaction? Considering the general form of the rate expression you wrote in question 2 for the reaction $A + B \rightarrow C + D$, what is the order of this reaction in:
 - reactant A;
 - reactant B?
 - what is the overall order of the reaction?
- Write an equation for a first-order reaction that relates the initial concentration of a reactant A with its concentration at time t , the rate constant, k , and time t .
- What is the meaning of "half-life"?
- Write a modified form of the equation in question 7 so that the equation contains $t_{1/2}$ instead of t . What is the numerical value of the product $kt_{1/2}$ in this equation? Show that you can obtain this number on your calculator.

LESSON 5

THEME: A catalysis. Peculiarities of catalytic activity of the enzymes.

Medicobiological value: The special interest for medicine represents study of kinetics of enzymatic reactions, as practically all reactions in a human organism proceed with participation of biological catalytic agents - enzymes; besides the ferment drugs will be used in therapy of many diseases.

The rate of reactions transiting in an organism, substantially causes activity of various medicinal substances. At a keeping of medicinal preparations the chemical reactions proceed, which rate defines a period of validity of medicines. The medical discipline "pharmakokinetics" studies legitimacies of an adsorption of medicinal substances in a blood, allocation them on bodies and tissues, metabolism and removing from an organism. With this purpose through particular time slices determine the content of medicinal preparations and their metabolites in various biological fluids and organs of an organism. On the basis of these data a dose and regimen of assignment, and also toxic activity of medicinal substances and others biologically active substances are determined.

To lesson it is necessary:

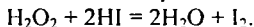
1. TO STUDY the following program questions: catalysis. Homogeneous and heterogeneous catalysis. Potential energy change during catalyzed and uncatalyzed reaction. Acid-base catalysis and its role in biological systems. Peculiarities of catalytic activity the enzymes. The Michaelis-Menten equation its analysis.

Research work:

**"Definition of oxidation reaction rate constante
in the reaction whith hidriodic acid and hydrogen peroxide"**

The purpose: To learn experimentally to determine a rate constant of chemical reaction proceeding as the I-order reaction.

The content of operation: the reaction proceeds on the equation:



The amount of reacted H_2O_2 is determined by equivalent amount of liberated iodine, which is defined by a solution $\text{Na}_2\text{S}_2\text{O}_3$ titration. HI is formed due to action H_2SO_4 (in excess) on a sodium iodide. The following reactions take place in this case:

- a) $2\text{NaI} + \text{H}_2\text{SO}_4 = 2\text{HI} + \text{Na}_2\text{SO}_4$;
- b) $\text{H}_2\text{O}_2 + 2\text{HI} = 2\text{H}_2\text{O} + \text{I}_2$;
- c) $\text{I}_2 + 2\text{Na}_2\text{S}_2\text{O}_3 = \text{Na}_2\text{S}_4\text{O}_6 + 2\text{NaI}$.

The reactions (a) and (b) proceed practically instantaneously, therefore rate of cooperative process is determined by rate of more sluggish reaction (b).

Performance of experiment:

1. In a flask measure 50 ml of a solution NaI , 2.5 ml 1M of a solution H_2SO_4 and give admixtures to stand 5 min.

- In 5 min. in a flask from a burette add 1ml of a solution $\text{Na}_2\text{S}_2\text{O}_3$, 5 drops of a solution of amylum and 5ml of a solution H_2O_2 .
- Carefully intermix contents of a flask and note time (τ_0) of a blue colour occurrences.
- Promptly add in a flask from a burette still 1 ml of a solution of sodium thiosulfate, intermix before disappearance of a blue colour and note, in what time (τ_1) the same colour again will appear. So iterate 4 times, scoring time (τ_2, τ_3 , etc.) in seconds (from the moment of τ_0).
- After that to a flask bring in 3 drops of a solution of ammonium molybdate and add from a burette in contents of a flask (titrate) a solution $\text{Na}_2\text{S}_2\text{O}_3$ before disappearance of yellow - brown colouring.
- Note on a burette (beginning from the cut-in) total number a ml (A) of a sodium thiosulfate solution.
- For each time term ($\tau_1 - \tau_4$) to within the third significant digit calculate a rate constant (K) by the equation:

$$K = \frac{2,303}{\tau} \lg \frac{A-1}{(A-1)-X}$$

- Where A-1 - initial concentration H_2O_2 ;
 X - amount reacted H_2O_2 (For τ_1 X = 1, for τ_2 X = 2 etc.);
 τ - time in seconds (beginning from τ_0);

- Observed datas bring in the table under the shape:

Time (τ) from a beginning of experience before occurrence of each blue colour, sec	Time of occurrence of a blue colour (astronomical time)	volume of a solution $\text{Na}_2\text{S}_2\text{O}_3$, ml of the time, which has reacted to the sectional moment, (X)	a constant of rate, K, s^{-1}

- Calculate medial value of a rate constant.

Problems for discussion:

- Write the general and the logarithmic form of the Arrhenius equation. Identify all the symbols used in the equation, and explain how, according to this equation, the value of the rate constant, and consequently the reaction rate, is affected by varying T .

2. Explain the term "activation energy".
3. What is: (a) collision theory:
(b) transition state theory?
4. What is the molecularity of a reaction? Illustrate this.
5. The decomposition of hydrogen peroxide to water and oxygen is a first-order reaction with a rate constant of $5.0 \cdot 10^{-6} \text{ s}^{-1}$ at a certain temperature. How long will it take at that temperature for a 0.820 M solution of H_2O_2 to decrease to 0,500M?
6. The reaction $\text{SO}_2\text{Cl}_2(\text{l}) \rightarrow \text{SO}_2(\text{g}) + \text{Cl}_2(\text{g})$ is a first-order reaction with a rate constant of $2,2 \cdot 10^{-5} \text{ s}^{-1}$ at 320°C . What percent of SO_2Cl_2 is decomposed after heating the substance at 320°C for 1.0 h?

LESSON 6

**THEME: bases of chemical thermodynamics and kinetics.
(Control work 1).**

Medicobiological importance: (see appropriate item to lesson) 2 – 5).

The purpose of lesson: summarizing of independent work and finding - out of a level of knowledge of general thermodynamic and kinetic laws (opportunity, direction, depth and rate) course of chemical reactions; the control of skills and skills of application of theoretical knowledge for the decision of tasks and exercises.

To lesson it is necessary:

1. TO BE PREPARED for performance of control work.

The literature: (see appropriate item to lesson) 2 – 5).

The control work includes:

1. Questions from the list of program questions on the investigated themes.
2. Two settlement tasks.

The note: To control work the students who are not having of debts on lesson are supposed.

LESSON 7

THEME: solubility of substances. Expedients of expression concentration of a solution.

Medicobiological value of dissolution: the formation of solutions is connect to dissolution of various substances in the relevant dissolvents. Such dissoivent is the wate in alive organisms. The water is the basic constituent of all cells and tissues of organisms. It provides processes of an adsorption, movement of nutritious substances and products of metabolism in an organism. Besides the formation of water as final product of an oxidizing of substances is accompanied by excretion of a great quantity of energy (29 kJ/mol). Total volume of liquid (aqueous) mediums of an organism makes 60% from mass. From them volume invascular liquid - 5%, endocellular - 40%, and intercellular - 15%. The important biological and biochemical role of water is connect with peculiaritys of its structure and properties.

Knowledge of legitimacies of dissolution of gases it is necessary for study of such vital processes as transport of oxygen and product of an oxidizing nutritious substances - CO_2 by a blood. A quantitative basis of a solubility of gases - the Henry's and Dalton's, Sechenov's laws have major value not only in chemistry, but also in medicine, as the infringement of a solubility of gases in a blood can be caused pathological changes. The Henry's law, in particular, allows to open a pathology of diseases at the divers, pilots, which operation is connect to prompt transferring on medium with sharply distinguished atmospheric pressure. On the basis of the Henry's law the treatment in pressure chamber (hyperbaric oxygenation) - inhale of oxygen at abnormally higt pressure (at treatment gangren, anemia, at poisonings etc. diseases). will be carried out. According to the Sechenov's law, not only electrolytes, but also protein and the lipids, which content in a blood can change, render influence on a solubility in it O_2 and CO_2 .

In physiological, biochemical, sanitary - hygienic, pharmacological and other laboratories solutions of precise concentration is used for studing of product metabolism. of metabolism drags, difinition chemical composition biological liquids and etc. Samples of substances, the various assays for carrying out of the analysis. including clinical. usually transfer in a solution.

To lesson it is necessary:

1. TO STUDY program questions: a role of water and solutions in vital activity. Physico - chemical properties of water as biodissolvent. Thermodynamics of dissolution. Enthalpy and entropy changes for dissolution. Concept about ideal solution.

Ways of expressing of composition of a solution: percent by mass, molarity, molality, molar concentration of an equivalent, mole fraction.

Dissolution processes: dissolving solids in liquids; dissolving liquids in liquids; solubility of gases in liquids and its dependence on the various factors. Henry's and Dalton's laws Influence of electrolytes on a solubility of gases. The Sechenov's law A solubility of gases in a blood.

The literature:

- N. Akhmetov. "General and inorganic chemistry." M. 1983. – P.132-137.
- U.Kask, J.D.Rawn. "General chemistry." WCN. 1999. – P.112-116. 452-459.
- N. Akhmetov, M.Azizova, and L.Badygina. "Problems and laboratory experiments in inorganic chemistry". M. 1982. – 254-255.

Research work:

"Preparation of solutions of given concentration"

The task 1. Preparation of a solution of a given percent by mass (w. %).

Having received from the teacher the individual task.

- 1) calculate what quantity of solid substance and the waters are necessary for preparation of the solution.
- 2) give on weights the designed shot of solid substance.
- 3) transfer a shot to a chemical glass.
- 4) add necessary quantity of water, having measured its cylinder.
- 5) intermix contents before complete dissolution by circular motions.
- 6) transfer in a measuring cylinder the prepared solution. Spot density of a solution areometer (under the check of the teacher).
- 7) on quantity of found density, using the relevant table (see is lower). establish a true percent by mass (, %) in a solution.

The note: If the measured value of density will appear between two values in the table, a mass share (, %) find by a method of interpolation.

For example, density of your solution is peer 1247 kg/m^3 . The densities 1241 and 1263 kg/m^3 are specified in the table to which there correspond(meet) (%) 22% and 24%. Hence, to change on 2% there corresponds(meets) change of density on $1263-1241=22$. Your solution differs on density from 1241 on quantity 6.

Let's make a proportion:

22 - 2%

6 - x%

$$x = \frac{6 \cdot 2}{22} = 0,54\%$$

The percent by mass (%) of your solution will be peer: 22 % + 0,54 % = 22,54 %.

The task 2. Preparation of a solution of a given percent by mass by a dilution of a starting solution.

- 1) calculate necessary quantity of a solution and water;
- 2) measure necessary volumes by the cylinder (or pipet) in a chemical glass;
- 3) spot density of a solution by an areometer and under the table establish a true percent by mass of a solution (see task 1, item 6 and further);
- 4) calculate absolute errors and relative errors.

Table

Densities (kg/m^3) of aqueous solutions of salts (20°C)

Na_2CO_3		NaCl		KCl	
w. (%)	ρ	w. (%)	ρ	w. (%)	ρ
1.62	1015	2,0	1012	2,0	1011
2.10	1020	4,0	1029	4,0	1024
3.05	1030	6,0	1041	6,0	1037
4.03	1040	8,0	1056	8,0	1050
6.00	1060				

$\text{K}_2\text{Cr}_2\text{O}_7$		CuSO_4	
w. (%)	ρ	w. (%)	ρ
2.0	1012	2.0	1019
3.0	1019	3.0	1030
4.0	1026	4.0	1040
5.0	1033	5.0	1051
6.0	1040	6.0	1062
7.0	1048		
8.0	1055		

Problems for discussion:

1. What is meant "solution"?
2. What is: (a) a saturated solution: (b) supersaturated solution?
3. What is meant by the general statement "like dissolves like"?

- Why are low – molecular- weight alcohols soluble in water, but high – molecular – weight alcohols insoluble or only sparingly soluble?
- How does an increase in temperature generally affect the solubility of:
 - solids in liquids;
 - liquids in liquids;
 - gases in liquids?
- What effect, if any, does an increase in pressure have on the solubility of:
 - solids in liquids;
 - liquids in liquids;
 - gases in liquids?
- What is Henry’s law? Write a mathematical expression for Henry’s law and define the symbols used.
- What is “molality”?
- What is the molarity of a sodium chloride solution that contains 6,82 g of NaCl in 450 ml of solution?
- Which of the following compounds would you expect to be water soluble?
 - $(\text{NH}_4)_3\text{PO}_4$;
 - H_2S ;
 - CCl_4 ;
 - C_6H_6 ;
 - HCOOH ;
 - CH_3OH ;
 - NH_3 ;
 - HCl ;
 - $\text{Ca}(\text{NO}_3)_2$.
- Explain why Na_2SO_4 is soluble in water but BaSO_4 is not.
- Predict how an increase in temperature might affect the solubility of each of the following substances in water (a) KNO_3 ; (b) $\text{Cl}_2\text{H}_{22}\text{O}_{11}$; (c) SO_2 ; (d) O_2 .
- How does the concentration of dissolved oxygen in water in a river at sea level compare with that in a mountain brook? Explain.
- What is the molality of a solution that contains 1,2 mol of a solute per 4,0 L of water? Assume that the density of water is 1.0 g mL^{-1} .
- How many grams of potassium hydrogen phthalate, $\text{KHC}_8\text{H}_4\text{O}_4$, must be used to make 250,0 mL of 0,400 M solution?

LESSON 8

THEME: colligative properties of solutions.

Medicobiological value: Colligative properties of solutions are: the decrease in the vapor pressure of a solvent above a solution, boiling point elevation, freezing point depression, osmosis. The osmotic phenomena are most important for biology and medicine. It is caused by that the travel of nutritious substances and yields of an exchange occurs first of all by means of a diffusion and osmosis. In too time a diffusion and osmosis in alive organisms are adjusted by a function state of tissues of an organism and depend on their structure. The change of physico-chemical properties of phases till both parties of biological membranes results in change of rate of an osmosis, and intensity of metabolic processes.

Due to an osmosis entering water in cells and intercellular frames is adjusted. The osmotic pressure, incipient at it, provides elasticity of cells (turgor), elastance of tissues and shape of bodies, the water-salt exchange etc. All this is necessary for normal current of manifold physical and chemical processes in an organism: reactions of a hydrolysis, oxidizing, hydration, dissociation etc. It explains a constancy of osmotic pressure (osmotic homeostasis) blood and other biological fluids. The basic body of an osmoregulation at the human, are the kidneys. The osmotic pressure of a blood at the man is supported at a level 740-780 kPa. The drugs for injection should be isotonic to biomediums (except for hypertonic salt solutions - for example, 25 % a solution of magnesium sulfas at hypertonic crises). The introduction of hypotonic salt solutions can give in fracture of erythrocytes shells and yield of a haemoglobin in plasma (hemolysis). Eye drops should be isotonic necessarily. All solutions used as blood substitutes, are also isotonic with the blood.

With the help of drugs it is possible to change locally osmotic pressure. It is used for intensifying a uropoiesis at acute poisonings, at acute renal failure, at various edemas. The activity of saline purgative drugs also depends on osmotic pressure.

The knowledge of the numbered phenomena and properties has direct application in therapeutic and surgical practice, scientific - medical examinations. This knowledge is necessary for study of separate questions of biochemistry, physiology, pharmacology.

To lesson it is necessary:

1. TO STUDY the following program questions: Colligative properties of dilute solutions. An osmosis and osmotic pressure. A Van't - Hoff law. Osmolarity

and osmolality of biological fluids and perfused solutions. Hyper-, hypo- and isoosmotic solutions. Concept about osmotic homeostasis. A role of an osmosis and osmotic pressure in biological systems. A plasmolysis and cytolysis.

Vapor pressure of a solution. A Raoult's law and consequences from it: freezing point depression, boiling point elevation of a solution. A cryometry and ebulliometry.

Colligative properties of dilute solutions of electrolytes. An Van't Hoff's isotonic coefficient.

The literature:

- N.A.Akhmetov. General and inorganic chemistry. M. 1983. – P.135-138.
- U.Kask, J.D.Rawn. General chemistry. WCB – P.459-477.

Research work:

"Definition of osmotic concentration and isotonic coefficient of a solution"

Performance of experiment

1. Receive from the laboratory assistant the device for cryometric definitions. The device (fig. 1) consists of a wide glass test tube 1, stoppered, into which are inserted the thermometer 2 and metal stirrer 3. The test tube is placed in a thick-walled glassful 4, in which there is a cooling mixture.
2. Prepare a cooling mixture from 3 parts of snow or ice and 1 parts NaCl and place it in a vessel 4.
3. Measure by the thermometer temperature of a cooling mixture. It should be about -5°C . The cooling mixture should fill in a glassful approximately on $3/4$ of its volume.
4. In a test tube 1 add such volume of distilled water completely to cover the tank of the thermometer, close a test tube by a fuse with the thermometer and stirrer and place a test tube in a glassful with a cooling mixture.
5. Stirring the water by a stirrer 3 (try to not concern by an stirrer of the thermometer), track change of temperature. Track, that the thermometer did not concern bottom and walls of a test tube 1. Usually temperature falls little bit below than freezing point of water. then the crystallization begins. the energy and level of mercury rises upwards sharply and then stiffens on value of temperature of a crystallization of water (about 0°C). Note freezing temperature of water, write down it in a magazine with accuracy, which allows to fix the thermometer, used by you. Take out a test tube from a cooling mixture and, warm-

ing up it by an hand, completely dissolve the formed crystals of ice. Again sink a test tube in a cooling mixture and iterate definition of freezing temperature of water.

6. Receive from the teacher a flask with a decomposed solution and write down in a magazine dates about a solution. Wash a test tube 1. fill it by a solution the same as at measuring freezing temperature of water. Close a test tube by a fuse, insert into it the thermometer and stirrer (previously and that and another should be washed by a decomposed solution).
7. Spot temperature began of freezing of a solution, as determined freezing temperature of water. All measurments write down in a laboratory magazine.

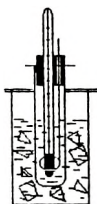


Fig. 1. A simple apparatus for cryometry mesurments

Processing of experiment results

- a) Calculate molality of a decomposed solution.
- 6) On the experimentally found freezing point depression of a solution in comparison with freezing temperature of water calculate an isotinic coefficient of a solution and real osmotic ion concentration in a solution.

Problems for discussion:

1. What is Raolt's law? Write a mathematical expression for Raolt's law and define the symbols used.
2. Explain why the vapor pressure of a solution of a solid in a liquid is lower than the vapor pressure of the pure solvent.
3. Show how Raolt's law can be used to calculate the vapor pressure of a solution of two liquid components, assuming ideal behavior.
4. Explain why the boiling point of a solution of a solid in a liquid is higher than that of the pure solvent.

5. What different types of data are needed to determine the molar mass of a non-volatile nonelectrolyte in a given solvent? Show how you would calculate the molar mass from these data.
6. Explain why the boiling point elevation of a 0.01 m solution of sodium chlorite is nearly twice that for a 0.01 m solution of sucrose, and the boiling point elevation for a 0.01 m solution of sodium sulfate is nearly three times that for a 0.01 m solution of sucrose.
7. What is interionic attraction theory? How does that theory explain the fact that the boiling point elevation for a dilute sodium chlorite solution is nearly twice the boiling point elevation for an equally dilute sucrose solution?
8. How does the freezing point depression of a 0.01 m solution of acetic acid compare with:
 - (a) the freezing point depression of a 0.01 m solution of sucrose;
 - (b) the freezing point depression of a 0.01 m solution of sodium chloride?Explain the difference.
9. What is osmosis, and what is the meaning of osmotic pressure? Give some examples of the importance of osmosis in nature.
10. Explain which of the following 0.100 m aqueous solutions has the highest and which has the lowest vapor pressure at 25°C: (a) sucrose; (b) sodium chloride; (c) magnesium chloride.
11. What is the vapor pressure of water over the solution prepared by dissolving 100 g of glucose, $C_6H_{12}O_6$, in 1.00 L of water (the density of water is 1.00 g mL⁻¹) at 25°C is 23.8 torr.
12. Calculate the boiling point and the freezing point of a solution containing 12.5 g of benzoic acid ($C_7H_6O_2$) in 110 g of benzene (C_6H_6). The freezing point of benzene is 5.48°C and its K_f is 4.90°C m⁻¹. Benzoic acid is a very weak acid in water but does not ionize in benzene.
13. A 0.0100 m acetic acid solution freezes at -0.0194°C. Calculate the percent dissociation of acetic acid in this solution.
14. Calculate the osmotic pressure of a 0.100 m glucose solution at 22.0°C.
15. Human blood serum freezes at -0.56°C. Calculate the osmotic pressure of blood at 0°C and at 37°C, assuming that 1.0 ml of the blood serum contains 1.0 g of water.

LESSON 9

THEME: acid-base equilibriums. Buffer solutions.

Colorimetric definition pH.

Medicobiological value: the normal vital activity of an organism is impossible without supported of constant characteristics (temperature, osmotic pressure, concentration of substances) in endocellular and tissues fluids of an organism. One of the constant characteristics an organism is the value pH of all liquid mediums of an organism (isohydrya). The conservation of a constancy pH of liquid mediums has for an organism the vital value, as all biochemical and physiological processes with participation of hormones and enzymes proceed only in a particular interval of values pH. Besides the hydronium ion are catalytic agents of many biochemical processes, and even the small changes of an concentration H^+ ion in a blood and intertissues fluids strongly influence on value of osmotic pressure in these biofluids. The diversion pH of a blood from norm (7,36) is results in infringement of processes of vital activity of an organism. The restricted constancy pH in various mediums of our organism is supported first of all by physicochemical way - buffer systems.

In chemical, toxicological, sanitary - hygienic and clinical laboratories the buffer solutions are applied to support of a constancy pH of medium, for example, at study of properties of protein, enzymes, hormones and others biologically active substances; at excretion of toxins from a biological material and their analysis; for preparation injectionly of solutions, blood substitutes and stabilization of series of medicinal substances. The definition pH of series of biological fluids (urine, gastric juice) is the important diagnostic test, as the various diseases are accompanied by infringement of acid - alkaline equilibrium in an organism. It is a subject of study of clinical disciplines.

To lesson it is necessary:

1. TO STUDY the following program questions: autoionization of water and K_w , pH and pOH

Chemical mechanisms of support of an acid-base equilibrium in an organism. Buffer systems, their classification and buffer action. Calculating pH of buffer solutions. Buffer capacity and factors determining it. Buffer systems of a blood. Concept about acid-alkaline equilibrium of a blood. An acidosis and alkalosis.

Acid base indicators. The mechanism of activity of indicators. A point of transferring (pK) of indicators and zone of change colouring. Definition of active reaction of medium by a colorimetric method.

The literature: U.Kask J.D. Rawn " General Chemistry " WCN 1999 p554 – 580.

Research work:
“ Properties of buffer solutions “

Experience 1. An establishment of dependence pH of buffer solutions from a relation of concentrations of constituents and from delution

Course of operation:

1. Prepare 3 buffer solutions with the following relations of concentrations CH_3COOH and CH_3COONa : 9/1; 5/5; 1/9. Each prepared solution intermix.
2. Prepare 3 buffer solutions with the same relation of concentrations but more dilute. For this purpose take on 1ml prepared before buffer solutions and add to everyone on 8ml of water. Each weak solution intermix.
3. In all prepared solutions add till 3 drops of an alcohol solution of lackmoid. Solutions intermix.
4. Compare on a white background colouring of solutions and write down. Calculate pH of the prepared solutions. An ionization constant of an acetic acid (K_a) = $1.85 \cdot 10^{-5}$.
5. Results of observations and calculations present to the table:

№ of a test tube	1	2	3
Relation concentration $\text{CH}_3\text{COOH}/\text{CH}_3\text{COONa}$	9/1	5/5	1/9
Colour of a solution after addition of lackmoid			
№ of a test tube with a dilute buffered solution	1''	2''	3''
Relation of concentrations $\text{CH}_3\text{COOH}/\text{CH}_3\text{COONa}$ in a weak solution			
Colour of a solution after addition of lackmoid			
pH			
Calculations			
	pH ₁ =	pH ₂ =	pH ₃ =

6. Make conclusions on the basis of comparison of colouring in 1. 2. 3 test tubes. and also 1 and 1''; 2 and 2''; 3 and 3'' also explain obtained conclusions.

Experience 2. Finding - out of the relation of buffer solutions to addition of small quantities of strong acids and bases.

1. Prepare 2 identical buffered solutions, merging on 4ml 0.1M of a solution CH_3COOH and 6ml 0.1 M of solution CH_3COONa .
2. In both test tubes add till 3 drops of an alcohol solution of lackmoid. Solutions intermix.
3. In one test tube add 5 drops 0.1 M of solution HCl; in the second 5 drops 0.1 M of solution NaOH. Solutions in both test tubes intermix and write down their colouring.
4. Results present as the table and explain them.

Buffered solution	1	2
Colouring after addition 0.1 M HCl		
Colouring after addition of lackmoid		
Colouring after addition 0.1 M NaOH		

Problems for discussion:

1. Write a chemical equation for the autoionization of water and a mathematical equation for K_w .
2. What is: (a) pH; (b) pOH?
3. What is a buffer solution? Give an example of an acid buffer solution and an alkaline buffer solution.
4. What is meant by "buffer capacity"?
5. Briefly explain how an acid buffer solution resists a change in pH when a small amount of hydrochloric acid is added.
6. Explain how you would choose a buffer system that is effective at a given pH.
7. Use the Henderson – Hasselbalch equation to explain how the [base]/[acid] ratio of a buffer solution affects the pH of the solution.
8. What are the hydronium ion concentration and hydroxide ion concentration of a 0.15M solution of nitric acid?
9. What are the hydronium ion concentration and hydroxide ion concentration of:
 - (a) a 0.080M solution of potassium hydroxide;
 - (b) a 0.0035M solution of barium hydroxide?
10. What are the pH and pOH of:
 - (a) a 0.010M solution of nitric acid;
 - (b) a 0.25M solution of hydrochloric acid?
11. What are the pH and pOH of:
 - (a) a 0.010M solution of sodium hydroxide;
 - (b) a 0.25M solution of potassium hydroxide;
 - (c) a 0.0056M solution of barium hydroxide?

12. The pH of a solution is 5.70. What are the pOH, the hydronium ion concentration, and the hydroxide ion concentration of the solution?
13. If you dissolve 1.58 g of solid potassium hydroxide in water to make 850 ml of solution, what is the pH of the solution?
14. Calculate the pH of 100 ml of 2.00M solution of nitric acid. What is the pH of this solution after it is diluted with water to 450 ml?
15. Calculate the hydronium ion concentration, hydroxide ion concentration, pH, and pOH of a 0.400M solution of HCN.
16. Calculate the hydronium ion concentration of (a) 0.0400M HCN; (b) 0.0040M HCN.
17. What volume of 0.50M sodium benzoate must be added to 500 ml of 2.0M benzoic acid solution to prepare a solution of pH 4.00?
18. Calculate the $[\text{HCO}_3^-]/[\text{H}_2\text{CO}_3]$ ratio of blood that has pH 7.40.

LESSON 10

THEME: equilibria in solutions of coordination complexes.

Medicobiological value: the coordination complexes carry out various biological functions. So, for vital activity of a human organism the unique value has a coordination complex of iron ions with protein - haemoglobin exercising transport of oxygen from lung to tissues. In life of plants the important role is played chlorophyll - complex of magnesium, due to which the plants transmute carbon dioxide and water into composite organic matters (amylum, saccharum, etc.). The ion Cu^{2+} is the component of several important enzymes - participants of a biological oxidizing. The coordination complexes of a cobalt considerably raise intensity of protein metabolism, regulate composition of a blood. Metalenzymes is the coordination complexes with high specificity of ions of metals, among them, except for mentioned above, is more often than others there are ions of zinc, molybden, manganese. In the whole cations almost of all metals are in alive organisms as coordination complexes.

Pollution by transition metals and their compounds: mercury, lead, cadmium, chromium, nickel - can result into a poisoning. The toxicity of such compounds in many cases is explained to that these ions supersede ions of biogenic metals (Fe, Zn, Cu, W) from coordination complexes with a bioorganic ligand (for example, porphyrin). The stability of coordination complexes, formed at it, usually is higher, they collect in an organism, therefore the normal vital activity of an organism is broken and the toxicosis begins.

The coordination complexes will be used in medical practice. Various metals (macroelements) introduce to the organism as coordination complexes. The complex drugs of platinum will be used as anticancerogenic drugs. However the efficiency of many medicinal preparations in an organism changes, as they form stable coordination complexes with protein of a blood.

Property of ions of metals to form stable bonds with sulfurcontaining ligands will be used at selection of medicines used at poisonings. Such medicines are called - antidotes. For example, unithiolum will be used at a poisoning with an arsenic, mercury, cadmium, lead, chromium, cobalt and some radioelements. As antidotes will be used in medical practice also a coordination complex in which the metal ion is coordinated to one or more chelating ligands – chelate. (for example disodium salt of ethylenediaminetetraacetic acid $\text{Na}_2\text{H}_2\text{EDTA}$). The activity of this compound is grounded that acting in roles of ligands they form more stable coordination complexes with ions of metals, than complexes of the same ions with sulfurcontaining groups of protein, enzymes, amino acids. The generated complexes in an organism are not blasted and are easily output through kidneys. Chelate will be used also as stabilizers at preservation of a blood, for dissolution of stones in kidneys, liver and cholic bubble.

Chelate will be used for quantitative definition of cations of many metals, including biological objects".

The knowledge, obtained on lesson will be used at the further study of chemistry, pharmacology, therapy, toxicology etc.

To lesson it is necessary:

1. TO STUDY the following program questions: coordination complexes. The basic concepts of the Werner's coordination theory. Classification and naming coordination complexes. Chelate. Formation and dissociations coordination complexes in solutions. Constants of formation and instability of complexes. Complexing ability s-, p-, d - elements. Representation about a structure metalenzymes and other complexes (haemoglobin, cytochromes, cyanocobalamin). Mechanism of toxic activity serious metals and arsenic.

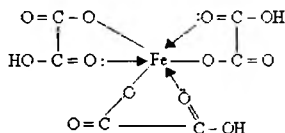
The literature: U. Kask, J. D. Rawn. "General Chemistry" WCN 1999 p. 810 – 840.

Research work:
"Reception of complexes"

Experience 1. Reception of chelate iron oxalate (III).

To 2 test tubes bring till 3 drops of a iron (III) chloride solution. One of test tubes leave as control. In the second test tube add 3 drops of sodium hydroxide. To the formed deposit add 12 - 15 drops of a solution of an oxalic acid $H_2C_2O_4$. What is observed? In both test tubes add 1 - 2 drops of a solution of potassium thiocyanate $KCNS$. What is observed? Write down the equations of reactions:

a) Formation of iron hydroxide (III);



b) Formations of chelate iron (III) oxalate), which has the following structure:

c) Formations of iron (III) thiocyanate (has blood-red colour).

Answer the questions:

1. In what test tube the iron (III) thiocyanate was not formed? Why?
2. What complex $Fe(CNS)_3$ or $Fe(HC_2O_4)_3$ - stronger?
3. The constant of what instability from these complexes is less?

Experience 2. Reception hexaamminenickel (II) sulfate.

To 3 drops of a solution of nickel (II) sulfate add some drops a solution of ammonia before dissolution of precipitating basic salt.

Write down the equations of reactions:

- a) Formation hexaamminenickel (II) sulfate.
- b) Dissociation of complex.

Write expression of a constant of instability of a sectional complex.

Problems for discussion:

1. What is: (a) a ligand; (b) a coordination sphere?
1. Write a formula to illustrate a complex compound that is composed of: (a) monatomic cations and negatively charged coordination spheres;

- (b) positively charged coordination spheres and monatomic anions;
 (c) neutral molecules that are coordination spheres;
 (d) positive coordination spheres and negative coordination spheres.
- What is meant by "coordination number" in a coordination complex?
 - Give the formula of: (a) a monodentate ligand; (b) a bidentate ligand.
 - Explain how you can determine the oxidation states of the central metal ion in a coordination sphere from the formula of the complex.
 - A coordination compound of chromium contains 1 mol of chromium, 3 mol of chlorine, and 5 mol of ammonia per mole of the compound. Treatment of 0.5 mol of this compound with silver nitrate gives an immediate precipitate of 1 mol of silver chloride. Write the formula of the compound and indicate the coordination sphere in brackets. What are the oxidation states of chromium in this compound?
 - What are the oxidation states of the central metal in each of the following coordination complexes? (a) $\text{Ag}(\text{NH}_3)_2^+$; (b) FeCl_4^- ; (c) $\text{Fe}(\text{CN})_6^{3-}$; (d) $\text{K}_4[\text{Fe}(\text{CN})_6]$; (e) $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$; (f) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$; (g) $[\text{Co}(\text{NH}_3)_6]\text{Br}_3$.
 - Which of the following species can act as ligands and which cannot? (a) H_2 ; (b) CH_4 ; (c) Be^{2+} ; (d) F^- ; (e) AlH_3 ; (f) PH_3 ; (g) NH_4^+ .
 - Classify each of the following ligands as monodentate, bidentate, terdentate, and so on: (a) H_2O ; (b) CN^- ; (c) $\text{H}_2\text{NCH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2\text{NH}_2$; (d) Cl^- .
 - Which of the following ligands can act as chelating agents? (a) OH^- ; (b) EDTA^{4-} ; (c) Br^- ;
 - Name each of the following: (a) $\text{Ag}(\text{NH}_3)_2^+$; (b) $\text{Cu}(\text{H}_2\text{O})_4^{2+}$; (c) $\text{Fe}(\text{CN})_6^{3-}$; (d) $\text{Fe}(\text{CN})_6^{4-}$; (e) $\text{Co}(\text{NH}_3)_6\text{Br}_3$; (f) $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{NO}_3$; (g) $\text{K}_2[\text{PtCl}_6]$; (h) $\text{Na}_2[\text{Zn}(\text{OH})_4]$; (i) $\text{Al}(\text{OH})_4^-$; (j) $[\text{Cu}(\text{NH}_3)_4]^{2+}$.
 - Write a formula for each of the following:
 - tetraamminecopper (II) ion;
 - tetraaquadichlorochromium (III) ion;
 - tetrahydroxozincate ion;
 - sodium tetrahydroxozincate;
 - tetraamminedichlorocobalt (III) chloride;
 - trisethylenediaminenickel (II) bromide;
 - diamminesilver (I) hexacyanoferrate (II);
 - aquapentaammineruthenium (III) ion.

LESSON 11

**THEME: the basic types of chemical equilibriums in solutions.
Heterogeneous equilibriums and processes.**

Medicobiological value: the formation of an bone tissue, which inorganic basis is calcium hydroxidephosphate - a typical example of heterogeneous process in an organism. The study of legitimacies of a heterogeneous equilibrium is important for medicine, as at collateral presence of ions at biological fluids the formation of slightly soluble compounds is possible (at infringement of their concentration or some functions of an organism).

For example the formation of gall - stones, deposition of a cholesterin and calcium in walls of vessels (atherosclerosis and calcification) and salts in joints.

On the basis of solubility product constant K_{sp} it is possible to prognosticate, at what ion concentrations in a solution the slightly soluble salt begins presipitate at absence or presence of other electrolytes. Knowing, for example, ion concentration of calcium - ions and oxalate - ions in a blood and, using tabulared values of solubility product constant of calcium oxalate, it is possible to solve whether there are requirements for formation of slightly soluble deposit of calcium oxalate (at a gout). It is similarly possible to test an efficiency of various medicinal preparations at treatment of diseases, bound with formation slightly soluble salts in various biological fluids and tissues of an organism. Fixed also, that there is a close interrelation between a solubility of compounds in water and toxic activity of series elements ions. For example, the excess of aluminium ions in an organism results in a rachitis, owing to formation of slightly soluble aluminium phosphat.

The reactions of precipitation underlie a method of precipitation, which is used in a quantitative analysis of medicinal preparations. The method of precipitation is applied also in the clinical analysis of chlorides in urine, gastric juice, blood, in sanitary - hygienic practice - at the analysis of drinking water.

To lesson it is necessary:

1. TO STUDY the following program questions: a solubility product constant K_{sp} of slightly soluble electrolyte. Requirements of formation and dissolution of deposits. Isolated and combined heterogeneous equilibriums in solutions of electrolytes. Reactions underlying formations of nonorganic substance of an bone tissue (calcium hydroxidphosphate). The phenomenon of isomorphism: replacement of hydroxide - ions in calcium hydroxidphosphate on ions of fluorine, ions of calcium on ions strontium. Heterogeneous processes proceeding in an organism at a pathology (formation of concrements: urates, oxalates, carbonates).

The literature: U.Kask J.D.Rawn "General Chemistry". WCN. 1999. – p. 598 – 626.

**Research work:
"Study of heterogeneous equilibriums and processes"**

Experience 1. Select in a test tube 5 drops of a solution $\text{Pb}(\text{NO}_3)_2$ with concentration 0,5 mol/l and 15 drops of a solution NaCl ($c = 1$ mol/l). The dropped out heavy deposit of lead chloride promptly settles at the test tubes bottom. Test completeness of precipitation of a deposit: add 1-2 drops a solution HCl with concentration 2 mol/l to a fluid above a of deposit. In case of complete precipitation of lead as PbCl_2 the solution above a deposit is not turbid. Precipitation of PbCl_2 should be complete. Remove a solution from a deposit. A light solution divide into 2 parts. To one add 1-2 drops of a solution Na_2SO_4 ($c = 1$ mol/l). Whether the formation of a deposit of lead sulfate is observed? Having compared $K_{sp}(\text{PbCl}_2)$ with $K_{sp}(\text{PbSO}_4)$, explain the apparent phenomenon. To other part of a saturated solution PbCl_2 add a solution KI ($c = 1$ mol/l). What is observed? Explain observations, using solubility product constant of PbCl_2 and PbI_2 . Write the chemical equation.

Experience 2. Measure in a test tube 10 drops of a solution CaCl_2 ($c=0,5\text{mol/l}$), add to it 10 drops of a solution $\text{Na}_2\text{C}_2\text{O}_4$ of the same concentration. The deposit of calcium oxalate is formed. Divide contents of a test tube together with a deposit into two parts. To one add 5 drops of a solution HCl ($c = 1$ mol/l), and to another - 5 drops of a solution of an acetic acid of the same concentration. Whether in both test tubes the deposit of calcium oxalate was dissolved? Explain result of experience, using solubility product constant of calcium oxalate, and also K_a of acetic and oxalic acids. Write the chemical equation.

Experience 3. Select in a test tube 5 drops of iron (II) sulfate ($c = 0,1\text{mol/l}$), and in second - same volume of a solution of copper (II) sulfate of the same concentration. Add in both test tubes till 5 drops of solutions of a sodium sulfide ($c=0.01$ mol/l). What is observed? Write the chemical equation.

Remove solutions from deposits and add some 2mol/l of a solution of a hydrochloric acid to deposits FeS and CuS . Whether both deposits were dissolved? Write down the equation of reaction. Explain difference in a solubility of deposits, using solubility product constant.

Problems for discussion:

- Define "molar solubility" and the "solubility product constant" for a sparingly soluble salt.
- Assuming that the molar solubility of a sparingly soluble salt is x , show how can be calculated from the K_{sp} for each of the following types of salt: (a) AB ; (b) AB_2 ; (c) A_2B ; (d) AB_3 ; (e) A_3B_3 .
- Given the following sulfides and their respective K_{sp} values: CuS , $6.3 \cdot 10^{-36}$; PbS , $8.2 \cdot 10^{-28}$; MnS , $1.4 \cdot 10^{-15}$; HgS , $1 \cdot 10^{-50}$; and ZnS , $1.1 \cdot 10^{-21}$
 - Which of these sulfides is most soluble in water?
 - Which has the smallest $[S^{2-}]$ in its saturated solution?
- Calculate the molar solubility of silver bromide. What are $[Ag^+]$ and $[Br^-]$ in a saturated solution of silver bromide.
- Calculate the solubility of barium chromate in moles per liter and in grams per liter of water.
- How many grams of lead (II) sulfate can be dissolved in 3.0 l of water to make a saturated solution of lead (II) sulfate?
- The solubility of silver chloride is $1.25 \cdot 10^{-5}$ mol per liter. Calculate K_{sp} for silver chloride.
- The solubility of manganese (II) hydroxide is $3.2 \cdot 10^{-3}$ g per liter of water. Calculate: (a) the pH of a saturated solution of manganese (II) hydroxide; (b) K_{sp} for of manganese (II) hydroxide.
- Write a net ionic equation for the reaction that occurs when solution of each of the following pairs of substances are mixed:
 - sodium chloride and silver nitrate;
 - barium nitrate and sodium sulfate;
 - lead (II) nitrate and hydrochloric acid;
 - potassium chromate and lead (II) nitrate;
 - magnesium chloride and sodium hydroxide;
 - calcium chloride and sodium phosphate;
 - iron (II) nitrate and sodium sulfide;
 - silver nitrate and sodium chromate.
- Will a precipitate of mercury (I) chloride form when a 0.20 M solution of mercury (I) nitrate, $Hg_2(NO_3)_2$, is made 0.010 M in sodium chloride? If a precipitate forms, what are the molar concentrations of Hg_2^{2+} and Cl^- ions remaining in the solution?
- The solubility of calcium fluoride is $1.6 \cdot 10^{-2}$ g L^{-1} . Calculate the solubility product constant for calcium fluoride. Ignore the hydrolysis of fluoride ions.

12. The solubility product constant for lead sulfate is $1.6 \cdot 10^{-8}$. Calculate the molar solubility of lead sulfate in water. How many grams of lead sulfate dissolves in 1.0 L of water?
13. Calculate the molar solubility of silver chloride in 0.20 M solution of sodium chloride. What is the Ag^+ ion concentration in a saturated solution of AgCl that is also 0.20 M in NaCl ?

LESSON 12

THEME: properties of solutions (control work).

Medicobiological meaning: see appropriate items to lessons 7 - 11.

The purpose of lesson: generalization, fastening and ordering of knowledge a program material on chapter " The doctrine about solutions "; development of skills of application of theoretical knowledge for the decision of tasks and exercises.

To lesson it is necessary: TO REPEAT program questions and decision of sample tasks to lessons 7 – 11.

LESSON 13

THEME: physico-chemistry of surface phenomenas.

Medicobiological value: the surface phenomenas observe on a phase boundary (in heterogeneous systems) and are caused by difference of physico-chemical properties of different phases. The alive organisms is the systems with the very much advanced interfaces (dermal integuments, wall of blood vessels and nervous terminations, of cell's membrane etc.). So, for example, the surface area of erythrocytes of all blood of the man makes approximately 3800 m^2 , surface of a skeleton - about 200 km^2 .

All vital processes in an organism occur on a surface of biological membranes, therefore for comprehension of their mechanism and pathological changes, bound to a permeability of cell's membranes, it is important to know legitimacies, to which the surface phenomenas submit. The surface tension, on a phase boundary in biological fluids, is one of diagnostic tests at some diseases (anaphylactic shock, cancer etc.). The surface tension plays a considerable role in such phenomena as

division of cells, englobement, change of a permeability of a cell's membranes. From process of an adsorption - spontaneous change of concentration of substances in surface layer, the process of an adsorption of nutritious and medicinal substances, infiltration of toxins into cells and tissues of an organism begins. On the phenomenon of an adsorption the application of adsorbents for interlinking poisons, toxins in a gastrointestinal path and adsorption of gases in an intestine.

The study of features of surface layer and orientation to a nem of surface-active substances plays a major role in development of the doctrine about structure of biological membranes, that is one of questions investigated on a lesson. Important acquaintance with legitimacies of an adsorption of ions is also. The selectivity of an adsorption of ions allows to make a conclusion, that the selectivity takes place and in an alive nature. So, the toxins of microbes selectively amaze bodies and tissues of an organism. The immune proteins and enzymes have very major selectivity. The knowledge of theoretical bases of an ionic adsorption is necessary for study of the following chapter of a course - for physico-chemistry of disperse systems.

The major value has and ionexchanges adsorption, investigated on a lesson. The ionexchanges adsorption is used for preparation of injections solutions; at clearing both excretion of antibiotics and amino acids. The ionites apply to erasion of ions Ca^{2+} from a blood before its preservation, for correction of infringements of gastric acidity etc.

The various sorption processes underlie such important method of physico-chemical investigations, as a chromatography.

To lesson it is necessary:

I. TO STUDY the following program questions: surface phenomenas and their value in biology and medicine. A surface Gibbs energy and surfase tension. Adsorptive equilibriums and processes on relative phase boundarys. An adsorption. The Gibbs equation. Surface active and surface inactive substances. Change of a surface activity in homologous series (Thraube's rule). The isotherm of an adsorption. Orientation of molecules in surface layer and structure. of biological membranes.

Adsorptive equilibriums on fixed phase boundarys. Physical adsorption and chemosorption. An adsorption of gases on solids. An adsorption from solutions. The Lengmyur's and Freindlikh's equation. Dependence of quantity of an adsorption on the various factors. Selective and an ion-exchanges adsorption. Value of adsorptive processes for vital activity (adsorptive therapy, hemosorption), application in medicine of ionites.

The literature:

- ❖ "Chemistry in context". WCB. 1994. – P.143-144.
- ❖ C.G.Gebelein "Chemistry and our world". WCB. 1997. – P.38-40. 336-342.

Research work:**"Measuring of an adsorption of CH_3COOH on a charcoal"**

Purpose. To study quantitatively to measure an adsorption from solutions on solid adsorbents.

Equipment. A burette by containment 25 mls, pencil-point flasks by containment 500 mls, funnels, cylinders measuring, flask for titration, filter paper.

Reagents. Charcoal, solutions of an acetic acid by four different concentration about 0.1 mol/l, solution of phenolphthalein in ethanol (indicator).

Performance of the experiment: In a laboratory magazine write down precise value of concentration of alkali and table under the shape:

flask	initial concentration of an acetic acid, c, mmol/l	volume, ml		equilibrium concentration of an acetic acid, c, mmol/l	an adsorption a, mmol/g
		of an acetic acid taken for titration	of a solution NaOH, spent on titration		
1	50	5			
2	100	5			
3	200	5			
4	400	5			

In four dry numbered flasks (see table) add 20 ml of a solution of an acetic acid of the concentration, specified in the table. To each flask bring simultaneously on 1.0 g previously of crushed charcoal. Contents of flasks intermix by circular motions during 20 min., then filter through dry fold filters. The first portion of a filtrate of volume 5 mls reject. From each filtrate with the help pipets select sample for titration (volume of sample for each of solutions is specified in the table). Titrate select assay by a solution of a sodium hydroxide at the presence of phenolphthaleinum (2-3 drops). Results of titrations write down in the table.

Processing results of experiment. Calculate equilibrium concentration of an acetic acid, $c(\text{CH}_3\text{COOH})$ and adsorption, \bar{a} :

$$a = \frac{(c_0 - c) \cdot 0.020}{m}$$

Where c_0 - starting concentration of an acetic acid, mmol/l;
 c - equilibrium concentration of an acetic acid, mmol/l;
 0.020 - volume of an acetic acid taken for an adsorption, l;
 m - mass of an adsorbent..

Obtained datas bring in the table.

Draw the isotherm of an adsorption: $a = f(c)$.

For a finding of constants in the Freindlich's equation isotherm converse it to the linear equation by logarithmic form:

$$\lg a = \lg K + n \lg c.$$

Calculate $\lg a$ and $\lg c$, write down a sectional of calculation in the table under the shape:

a, mmol/g	c, mmol/l	$\lg a$	$\lg c$	1/a	1/c

On sectional the tables draw the graph of dependence $\lg a = f(\lg c)$. Values of constants K and n find pictorially: $\lg K$, as a piece cut on an axis $\lg a$; n , as a tangent of angle of lean direct to an axis $\lg c$.

For definition of constants in the Lengmyur's equation converse it to the equation of a direct line by division 1 on both parts of the equation.

Thus gain $\frac{1}{a} = \frac{1}{a_{\max}} + \frac{\alpha}{a_{\max}} \cdot \frac{1}{c}$. On sectional tab. 2 draw the graph of dependence

$\frac{1}{a} = f\left[\frac{1}{c}\right]$.

Under the graph $1/a = f(1/c)$ find values of constants a_{\max} and α .

Problems for discussion:

1. What is meant "adsorption"?
2. Give a definition of "surface tension".
3. Give examples of most frequently used adsorbents. in a practice.
4. What is meant surface active and surface inactive substances.
5. Write down the Gibb's equation for definition of adsorption? Identify each of symbols.

6. Dependence of quantity of an adsorption on the various factors.
7. Write down the Langmuir's equation. Identify each of symbols.
8. Formulate the Traube's rule.
9. Describe the structure of the surface active substances.
10. Write down the Freundlich's equation. Identify each of symbols.

LESSON 14

THEME: reception, clearing and properties of colloidal solutions.

Medicobiological value: the colloidal systems play an important role in human life. In biological fluids of an organism series of substances are in a colloidal state, which features are studied in a sectional theme. In medical practice series of drugs in a colloidal degree of dispersion will be used. Such drugs have prolonged activity, as are more slowly output from an organism. On this lesson are studied series of properties of colloids, which take place and in biological systems: disability of colloid particles to transit through a membrane (dialysis), and research methods (ultracentrifugation and ultramicroscopy; electrophoresis and electroosmosis). In particular, in a basis of clearing of a blood from products of metabolism the principle of a dialysis lays. By a principle of a dialyzer works kettle "a synthetic kidney", which can temporarily replace function of the patients of kidneys at such disease, as acute renal failure as a result of poisonings, at serious combustions and others. For investigation of biological fluids will widely be used vivodialysis, with which help in a blood it is possible to find out, for example, not bound with protein medicinal substances.

The ultracentrifuges are an irreplaceable agent for separation and excretion of fractions of protein, nucleic acids, viruses. A ultramicroscopy apply at a blood analysis. lymph. vaccines, to the check of cleanliness ijectional of solutions, water and air medium. With the help of a ultramicroscope it is possible to spot the shape and size of colloid particles.

The electrophoretic analysis of serum proteins will widely be used in medicobiological investigations with the purpose of the diagnosis of diseases. At the healthy people electrophoregrams have the approximately same pattern. At various diseases electrophoregrams change. For example, at inflammatory processes a fraction of γ -globulins grows sharply; at nephritises - the bands α - and β - globulins are increased and almost fractions of a γ -globulin and albumin disappear. With the help of electrophoresis into an organism inlet various medicinal substances and determine cleanliness of medicinal preparations. The method of an immunoelectrophoresis will be used for detection of antigenes specific to sectional antibodies.

The method of electroosmosis is applied to elimination of water from medical cotton and draining of medicinal preparations.

To lesson it is necessary:

1. TO STUDY the following program questions: classification of disperse systems by a degree of dispersion; on a nature of phases; on force of an intermolecular interaction between a dispersed phase and dispersion medium.

Colloidal solutions. A nature of a colloidal state. Methods of reception and clearing of colloidal solutions. A dialysis, electro dialysis, ultrafiltration, principle of functioning of a synthetic kidney. Molecular-kinetic properties of colloidal-dispersion systems: a Brownian's motion, diffusion, osmotic pressure. A ultracentrifugation. Optical properties: a dispelling of light (Rayleigh's law). Electrokinetic properties: electrophoresis and electroosmosis; potential of proceeding and potential of a sedimentation. Electric charge and structure of electrical - double layer of a colloid particle. A micelle. Aggregate and core, colloid particle (granula). An electrokinetic potential and its dependence on the various factors.

The literature: U.Kask, J.D.Rawn "General chemistry". WCB. 1999. – P.478-480.

Research work:

"Reception, clearing and properties of colloidal solutions"

The experience 1. Reception of sol of a colophonium

In a test tube measure 5 ml of distilled water and add 2 drops of 1% an alcohol solution of a colophonium. and intermix. Note colour of a obtained solution and specify a method of reception of sol.

The experience 2. Reception of sol of iron (III) hexacyanoferrate (II).

In a test tube measure 3 ml 0,005 M of solution $K_4[Fe(CN)_6]$ and add 1ml 0.005M of a solution $FeCl_3$. Gain sol painted in dark blue colour. Specify, by what method sol was received, what electrolyte is the stabilizer. Write the chemical reaction and formula of a micelle.

The experience 3. Reception of sol of iron (III) hydroxide.

Measure in a flask by the cylinder 25 ml of distilled water and heat up to boil, add promptly 5 ml 2% of a solution $FeCl_3$. The received sol has red - brown colour. Specify a method of reception of sol and stabilizer. Write the chemical reaction and formula of a micelle. Obtained sol use for a dialysis (experience 4).

The experience 4. Clearing of sol by a dialysis

In a test tube measure 1 ml of sol $\text{Fe}(\text{OH})_3$, obtained in experience 3. A hole of a test tube (close) by cellophane, fix by rubber ring. A test tube with cellophane bottom insert into a hole of a cardboard circle and sink in a glassful with distilled water (10 ml). In 15 minutes from a glassful in a test tube select sample of water (1ml), carry out a qualitative test on ions of chlorine (reaction with AgNO_3). Explain absence in a glassful with water of a red - brown staining and presence there of ions of chlorine.

The experience 5. Observation of a Faraday - Tyndall's cone.

In installation for observation of a Faraday - Tyndall's cone put a glassful with a colloidal solution. The same experience do with distilled water. Explain result. Draw the Faraday - Tyndall's cone.

Problems for discussion:

1. How classify disperse systems on the size of particles of a dispersed phase?
2. What systems are called colloidal?
3. What is meant "dispersed phase" and "dispersion medium"?
4. What methods of clearing of colloidal solutions from impurities do you know?
5. Give an example of using of dialysis.
6. What is Tyndall effect?
7. 12 ml 0,02 M of solution of copper (II) sulfas and 10 ml 0,05 M of solution of potassium hexacyanoferrate (II) are immixed. To write the formula of a micelle of the formed sol and to designate its constituents.
8. What volume 0,05 M of solution of silver nitrate needs to be added to 25 ml 0,01 M of solution KCl to receive negative sol of silver chloride? To write the formula of its micelle.
9. At intermixturing 12 ml 0,02 M of solutions of iron (III) chloride with 100 ml 0,005 M of solutions of potassium hexacyanoferrate (II) sol was formed. Write the formula of a micelle of sectional sol. To what electrode at electrophoresis the particles of dispersed phase are transferred?

LESSON 15

THEME: a coagulation and peptization of sols.

Medicobiological value: the study of processes of a coagulation and peptization has an important value, since the colloids of cells and biological fluids of an organism are subject to a coagulation. The formation of thrombuses in blood vessels, sticking of erythrocytes is the processes similar coagulations. One of the reasons of above named pathological changes can be electrolytes. As the colloids of all cells of an organism are in constant contact to electrolytes and slightest change of a constancy of an ion concentration or quality composition them can give in infringing of aggregate stability of colloids - coagulation. In an organism: the phenomenon of accustoming (to alcohol, narcotics and some medicinal preparations); activity of an admixture of electrolytes or multicomponent medicinal preparations take place. In hygiene and the sanitations apply intercoagulation - to clearing drinking and waste water. The substance of these phenomena and legitimacies of the coagulation by electrolytes you will study on sectional lesson.

The peptization plays an essential role in boosted dissolving power of serum of a blood in relation to series slightly soluble in water of substances; in dissolution of fresh deposit of thrombuses under activity of medicines - anticoagulants.

At preparing series of medicinal substances representing colloidal solutions, it is necessary to protect them from a possible coagulation, for example, colloidal drugs a silver - collargol and protargolum.

To lesson it is necessary:

1. TO STUDY the following program questions: kinetic and aggregate stability. The factors influencing stability of lyosols. A coagulation. A critical coagulation concentration and its definition. A Shults-Hardy's - rule. Concept about the modern theories of a coagulation. The phenomenon of abjuce. Intercoagulation. Colloidal protective action, peptization. Biological value of processes of a coagulation, colloidal protective action and peptization.

The literature: Lecture material.

Research work:

"Definition of a critical coagulation concentration. A peptization"

The experience I. Definition of critical coagulation concentration.

Carry out consistently two experience with solutions of electrolytes Na_2SO_4 and $\text{K}_3[\text{Fe}(\text{CN})_6]$ with concentration $C_N(X) = 0.0025 \text{ N}$. Prepare starting electrolyte solutions of various concentrations, admixing in five test tubes measured with the help of burettes starting electrolyte solution and distilled water in relations specified in the table.

Test tube	Volume, ml		Effects of observations	Coagulable electrolyte	
	Electrolyte solution	Distilled water		Na_2SO_4	$\text{K}_3[\text{Fe}(\text{CN})_6]$
1	2,5	0,5			
2	2,0	1,0			
3	1,5	1,5			
4	1,0	2,0			
5	0,5	2,5			

In 5 well washed up test tubes measure from a burette till 5.0 ml of iron (III) hydroxyde sol. In all test tubes with sol add prepared electrolyte solutions and immediately intermix. Observe of changes in test tubes. Through 10 mines note, in what test tubes the opacification or sedimentation is observed. Effects of observations write down in the table: is familiar "+" note presence of a coagulation, is familiar "-" absence.

Processing effects of experiment. Calculate critical coagulation concentration of sol and coagulable ability (C.A.). For each electrolyte, using such equations:

$$c.c.c.(X) = \frac{c(1/zX) \cdot V_{\min} \cdot 1000}{V_{sol}}$$

$$C.A. = \frac{1}{c.c.c.(X)}$$

Where $C(1/z X)$ - molarity of an equivalent of electrolyte solution. mol/l;

V_{\min} - least volume of starting electrolyte solution causing a coagulation of sectional volume of sol, ml;

$1/z$ - factor of equivalence;

V_{sol} - cooperative volume of sol, starting electrolyte solution and water, ml.

Least volume of starting electrolyte solution causing a coagulation of sol, find as medial value on the equation

$$V_{min} = \frac{V_i + V_{i+1}}{2}$$

Where V_i - volume of starting electrolyte solution in a test tube, in which there was a coagulation, ml;

V_{i+1} - volume of starting electrolyte solution in the next test tube, in which the coagulation has not taken place (see table).

Formulate a deduction, scoring, whether there are experimental data according to Shults-Gardi's - rule.

Experience 2. A peptization of a iron (III) hexacyanoferrate (II) deposit.

1. Receive a deposit of iron (III) hexacyanoferrate (II): in a test tube to 1 ml of a saturated solution $FeCl_3$ add 0,1 ml of a saturated solution of $K_4[Fe(CN)_6]$.
2. Transfer a little deposit by a glass rod on the impregnated-paper filter.
3. On the filter add 3 ml 0,1 M of solution of an oxalic acid (peptizator).
4. Note, that thus is observed. Explain a method of a peptization. Write the formula of a micelle of received sol by peptization method.

Problems for discussion:

1. Give definition of concepts "kinetic" and "aggregate" stability of sols.
2. What phenomenon is termed as a coagulation? What the visual attributes of the coagulation do you know?
3. What factors are cause a coagulation of lyophobic sols?
4. What is meant "critical coagulation concentration". Write down the mathematical expression of C.C.C
5. What is meant "coagulable ability" of electrolyte? On what factors the C.A. depends on?
6. The coagulation 10 ml of $Fe(OH)_3$ sol has come at addition to it 2 ml of a solution Na_2SO_4 with molarity of an equivalent $0,0025 \text{ mol} \cdot \text{l}^{-1}$. Calculate a critical coagulation concentration and coagulable ability of that electrolyte.
7. What volume of a solution $K_2Cr_2O_7$ with concentration $0,01 \text{ mol} \cdot \text{l}^{-1}$ can be added to 1 l of sol to cause its coagulation, if it is known, what the critical coagulation concentration is per $0,6 \text{ mol} \cdot \text{l}^{-1}$?
8. What volume of aluminium sulfate solution of concentration $0,01 \text{ mol/l}$ is required for a coagulation 10^{-3} M^3 of silver chloride sol? The critical coagulation concentration is per $96 \cdot 10^{-6} \text{ mmol/l}$;

9. In 2 flasks is added on 100 cm^3 of iron (III) hydroxide sol. To cause an obvious coagulation of this sol it was required to add 62.5 cm^3 of a 0.01 M sodium sulfate solution in one flask. and in second - 67 cm^3 0.001 M of sodium phosphate solution. To calculate critical coagulation concentration and to define a sign of a charge of particles of this sol. To write the formula of a micelle of this sol in an isoelectric state.

LESSON 16

THEME: suspensions, emulsions, aerosols and colloidal surfers active substances (SAS).

Medicobiological value:, The milk, egg yolk, natural latex of plants, a lymph, blood, fatty tissue etc. are examples of emulsions meeting in a nature. In a blood and lymph fats are as emulsions. During mastering of fats there is their emulsification in an intestine by salts of cholic acids. In the shape of an emulsion there is an adsorption of fats in a blood through a wall of an intestine and their enzymatic hydrolysis.

The suspensions and emulsions are used as medicinal preparations for example, emulsion of a synthomycin, albicholic, naphtalanic, aloe etc. And the emulsions such as oil/water (O/W) usually apply to interior consumption, and such as water/oil (W/O) - for outside consumption. The suspensions of camphora, mentholum, sulfur, novocillinum, insulin etc. are widely used.

The aerosols founded wide application in medicine. The sterile aerosols apply to sterilization of a surgery field, wounds and combustions. Ingalational aerosols containing antibiotics and other medicinal substances, apply to treatment of respiratory diseases. The aerosols as glue apply in surgical practice to conglutinating wounds, skins, bronchuses, vessels etc.

The clouds of bacteria and viruses - microbiological and bacterial aerosols are one of trajectories of transmission (transfer) of infectious illnesses: a pulmonary tuberculosis, influenza, acute respiratory diseases etc. Aerosols containing particles of charcoal, cause a mild diseases - anthracosis, oxide of silicon (IV) - silicosis, asbestos - asbestosis.

The value of micellar SAS solutions for biological systems is defined first of all by ability of their micelles to dissolve nonsoluble in aqueous solutions compounds. For example, with the help micellar SAS gain water-soluble medicinal preparations from nonsoluble in water vitamins A and E. The presence micellar SAS changes rate of an adsorption of medicinal preparations. The hygienic (washing) role of colloidal SAS is also great. Many cationic and anionic SAS have

strong antimicrobial activity and are used in surgery as antiseptics. Colloidal SAS are used as stabilizers at reception of suspensions and emulsions. The micelles of colloidal SAS are surveyed as model of biological membranes. The micelles of cholic acids salts play the important role in transport of lipids. They solubilise a cholesterol in an organism.

To lesson it is necessary:

1. TO STUDY the following program questions: suspensions and emulsions, reception and properties. Suspensions and emulsions as the medicinal forms.

Colloidal SAS. Biologically important colloidal SAS (soap, detergents, cholic acids). Formation the micells in solutions of SAS. Definition of critical concentration of micelle formatting. Aerosols, feature of aerosols as disperse systems. Using of aerosols in medicine. Negative action of aerosols on an organism of the man: an industrial dust (silicosis, anthracosis, etc.); a dust containing organic matters, allergens, radionuclides.

The literature: The lectures materials.

Research work:

"Definition of critical concentration of micell formation (CCM) of a sodium oleate"

The purpose of operation: To get skills of experimental definition CCM colloidal SAS by measuring of interfacial tension.

Performance of experiment:

1. Prepare to operation the Rebinder's device.
2. Note a zero position of a fluid in a pressure gauge at the unclosed fuse.
3. At first spot pressure previous to separation of air bubble for distilled water, which interfacial tension is known. In a test tube of the device add of distilled water it is so much, that at the densely closed fuse the capillary only concerned a surface of a fluid.
4. Unclose cock of an aspirator and adjust effluxion of water from it so that air bubbles generation rate air in capillary test tube did not exceed 1-2 bubbles in 1 sec.
5. Note and write down pressure (P_0), relevant to a separation of air bubble (maximal uprise of a fluid in a pressure-gauge).
6. Do experience not less than two times.

7. Then carry out similar measurements (P) for 4 solutions of a sodium oleate (in ascending order concentrations). Accurately rinse each time before filling a test tube by an explored solution.
8. Calculate interfacial tension (σ_i) solutions of an oleate of a sodium for all 4 concentrations on the equation $\sigma_i = \sigma_0 \cdot P/P_0$.
9. Received values bring in the table under the shape:

Experi- ence	Concentration C, mol/l	pressure of air bubble P, mm of a pole of a fluid in a pressure-gauge	interfacial tension, N/m $\cdot 10^{-3}$	the logarithm of concentration of a sodium oleate solution, lg C
1	0,025			
2	0,050			
3	0,100			
4	0,150			

10. Construct the graph of dependence of interfacial tension from the logarithm of concentration.
13. On a sharp fracture of the curve spot CCM.

Problems for discussion:

1. Briefly characterize properties of emulsions and suspensions. Note the similar and different properties of these systems and colloids. Give examples of medicobiological value of emulsions and suspensions.
2. Number the basic properties of aerosols.
3. What value for vital activity of the man the aerosols have? In what cases the formation of aerosols is undesirable? How they can be blasted?
4. What different between colloidal SAS and truly soluble SAS?
5. Number the basic applications of colloidal SAS.
6. What property of colloidal SAS characterizes the quantity CCM. how it can be determined?
7. What is an emulsion, suspension?
8. Term the basic types of emulsions. Give examples.
9. How it is possible to distinguish a colloidal solution from coarse-dispersion system?
10. By what methods it is possible to receive emulsions? What are emulgents? What substances can be emulgents?

LESSON 17

THEME: solutions of high-molecular compounds (HMS).

Medicobiological value: HMS, to which the fissile substances concern biologically: the protein, nucleic acids and glycogen, are the basic building material of a protoplasm and kernes of cells. These compounds play the important role during vital activity of organisms. For example, the protein protect hydrophobic colloids in a blood and other biological fluids from a coagulation, provide a buffer effect, oncotic pressure, allocation of water both mineral substances between a blood and tissues. At change of the content of protein in a blood and infringement of their protective functions the various pathological changes in an organism are observed which will be surveyed at study patophysiology, therapy, surgery and other disciplines.

The knowledge of the basic legitimacies of a bloating and deaquation of protein is necessary for comprehension of physiological and biochemical processes at an anegensis, combustions, formation of edemas, centers of an inflammation and aging of an organism. In the diagnostic purposes everyone are more widely implanted immunological examinations, which will be carried out in jellies, which properties and substance of an immunodiffusion are studied on sectional lesson.

Important the study of process of salting-out and isoelectric state of protein is, as these questions underlie excretion of protein with the purpose of their study and preparation of medical serums. The method of a staining of cells of a tissue is based also on knowledge I.E.P. at histochemical examinations.

In medicine the tretment-diagnostic devices from polymers are widely used: catheters, sondes, squirt guns, system for a capture, transfusion and preservation of a blood, kettles for replacement of functions of bodies (heart, liver, kidney) etc.

Some polymers have properties to prolong activity of medicinal substances in an organism, to represent itself as blood substitutes (vinyl alcohol, dextran, gelatine etc.). On any other business modified cellulose apply to manufacturing bandage and cotton with antimicrobial properties.

For successful application of polymers in medical practice, activities of biological medium to know exceptions of their side effect, it is important of the best acclimatization them to as physicochemical properties of used polymers, and biopolmers of our organism.

The purpose of lesson: formation of systemic knowledge about legitimacies of process of dissolution HMS, properties of their solutions and role in vital activity of an organism; purchase of skills of experimental definition of quantity of a bloating and isoelectric point of protein.

To lesson it is necessary:

1. TO STUDY the following program questions: features of dissolution HMS as a consequence of their frame. The shape of macromolecules. The mechanism of a swelling and dissolution of HMS. Dependence degree of swelling on the various factors. Abnormal viscosity of HMS solutions. The Staudinger equation. Viscosity of a blood and other biological fluids. Osmotic pressure of solutions of biopolymers. The Haller equation. Polyelectrolytes. An isoelectric point (IP) and methods of its definition. Membranes Donnan equilibrium.

Fastness of solutions of biopolymers and factors its determining. Salting-out of biopolymers from a solution. Jellification of HMS solutions. Properties of jellies: a syneresis and thixotropy.

2. TO BE PREPARED for performance of research work.

The literature: Colloid chemistry

Research work:**"Influence pH and electrolytes on degree of swelling of gelatine"**

Experiment 1. Study of influence pH on degree of swelling and definition of the isoelectric point of gelatine.

Performance of experiment:

1. To 3 test tubes bring on 0,5 g of a powder of gelatine. With the help of a strip millimetrovoy of a paper measure height of bed of dry gelatine (h_0).
2. In test tubes add accordingly: in the first 6 ml 0,1M HCl; in the second 6 ml 0,1M NaOH; in a third - 3 ml 0,1M CH_3COOH ($K=1,8 \cdot 10^{-5}$) and 3 ml 0,1M CH_3COONa .
3. Contents of test tubes intermix and leave on 20 minutes.
4. Through 20 minutes measure height of swelling gelatine (h), calculate a degree of swelling and pH of solutions.
5. Observed data bring in the table.
6. Explain apparent dependence of the degree of swelling gelatine from pH.
7. For definition isoelectric point (IP) of gelatine construct the graph of dependence $h = f(\text{pH})$. IP find, having sinked from valleys on the curve a perpendicular on an abscissa axis.

Experiment 2. Study of influence of electrolytes on the degree of swelling.

Performance of experiment:

1. To 3 test tubes bring on 0,5 g of a powder of gelatine. Measure height of gelatine layer.
 2. In test tubes accordingly add till 6 ml 0,5M of solutions K_2SO_4 , KCl, KCNS. Contents of test tubes intermix.
 3. Through 20 minutes measure height of swelling gelatine and calculate a degree of swelling.
 4. Results of gauging bring in the table.
 5. In a conclusion explain various influence of anions on process of a swelling.
- The table

№ of a test tube	The added fluid	height of dry gelatine layer (ho)	height of swelling gelatine (h)	a degree of swelling
1				
2				
3				

Problems for discussion:

1. What mechanism of dissolution HMS? What the features of dissolution HMS in comparison with dissolution LMS are bound?
2. Give and analyse the graph of dependence the degree of swelling HMS on pH.
3. How it is possible to increase a degree of swelling? Pose halogenids - ions in lyotropic series on their ability to strengthen process of a swelling.
4. For what in medicine is defined IP of protein? Term methods of its definition. Explain substance of each method.
5. At pH = 4,64 albuminums of serum of a blood are in an isoelectric state. To what electrode albuminum will move, if it to place in a buffered solution prepared from 5ml 0,1M of solutions of ammonia and 5 ml 0,1M of ammonia chloride solutions. The ionization constant of ammonia is peer $1,8 \cdot 10^{-5}$.
6. Pose cations of alkali metals on ability them to accelerate jellification. Explain, why the various ions render unequal influence on rate of jellification.
7. Give the graph and write the formulas used at viscosimetric a method of definition M of polymers.

8. Calculate molecular weight of protein, if the characteristic viscosity of its solution is peer 0.105. Constants of the Staudinger equation: $K = 1.7 \cdot 10^{-5}$, $\alpha = 0.69$.
9. Write and analyse the equation for evaluation of osmotic pressure of biopolymers. Compare to the similar equation for LMS.
10. Than the abnormal viscosity of solutions HMS is explained?
11. In what the biological role of the phenomenon of colloidal protection consists?

LESSON 18

Final lesson

1. To final lesson the students who are not having of debts on laboratory work are supposed.
2. The student should have notebook for laboratory work with the made out protocols of works.

THE LIST OF PRACTICAL SKILLS ON GENERAL CHEMISTRY FOR EXAMINATION

1. Preparation of a solution of the given concentration (see Lesson №7).
2. Preparation of a buffer solution with the given pH (see Lesson №9).
3. Reception of complexes (see Lesson №10).
4. Reception of lyophobic colloids (see Lesson №14).
5. Influence of the various factors on an adsorption (see Lesson №13).

EXAMINATION QUESTIONS ON GENERAL CHEMISTRY

ELEMENTS OF CHEMICAL THERMODYNAMICS AND BIOENERGETICS

1. Relationship between processes of a metabolism and energy in an organism. Chemical thermodynamics as a theoretical basis of bioenergetics. Systems: isolated, closed, open, homogeneous, heterogeneous. Examples.
2. The first law of thermodynamics. Internal energy. Isobaric and isochoric heat effects. Enthalpy.
3. Hess's law of heat summation. The thermochemical equations. Standard enthalpy of formation and standard enthalpy of combustions. Thermochemical accounts and their use for the energetic characteristic of biochemical processes.
4. The second law of thermodynamics. Entropy. Standard entropies of substances. Gibbs's free energy.
5. Conditions of thermodynamic equilibrium. Criterion of a direction of spontaneously proceeding processes. Enthalpy and entropy effects. Exo - and endorganic processes in organisms. A hydrolysis ATP as a universal energy source in an organism.
6. Reversible and nonreversible chemical reactions. A chemical equilibrium. An equilibrium constant and ways of its expression: K_c , K_p , K_a . Examples.
7. Mass action law for a chemical equilibrium. An equilibrium constant. The equation of the isotherm of chemical reaction.
8. Predicting the direction of a reaction. Le - Chatelier's principle. Examples.

PYSICO-CHEMICAL BASES OF KINETICS BIOCHEMICAL REACTIONS

1. Subject of chemical kinetics. Chemical kinetics as a basis for study of rates and mechanisms of biochemical processes. Reactions single-stage (simple). multi-phase (complex). homogeneous. heterogeneous. Examples. Photochemical reactions and their role in vital activity of an organism and environment.
2. Rate of homogeneous chemical reactions and methods of its definition. The mass action law for rate of reaction. A rate constant of a reaction, its definition.
3. Molecularity and order of reaction. Examples.
4. Equations of 1-st, 2 and zero order reactions. The half – life of the chemical reaction.
5. Dependence of reaction rate on temperature. A temperature coefficient of reaction rate and its peculiarity for biochemical processes. The Arrhenius equation.
6. Activation energy. The collision theory. The theory of a transition state.
7. Homogeneous and heterogeneous catalysis. Acid-base catalysis and its role in biological systems. Enzymes as biological catalysts. The Michaelis - Menten equation.

THE DOCTRINE ABOUT SOLUTIONS

1. Solutions. A role of solutions in vital activity of organisms. Water as an universal solvent. Concentration of solutions and ways of its expression. Examples.
2. Thermodynamics of dissolving. Enthalpy and entropy effects of dissolving and their communication with the mechanism of dissolving. Influence on solubility of a nature of components and external conditions. Importance of the phenomenon of dissolving in a metabolism processes.
3. Solubility of gases in liquids and its dependence on the various factors. The Henry's and Dalton's law. Influence of electrolytes on solubility of gases: the Sechenov's law. Solubility of gases in a blood. The "bends" condition.
4. Vapor pressure and Raoult's law. Boiling point elevation and freezing point depression. A cryometry and ebulliometry.
5. Osmosis and osmotic pressure in solutions. The Vant-Hoff's law. Hypotonic, hypertonic, and isotonic solutions.
6. Colligative properties of weak electrolytes solutions. An isotonic coefficient. A role of an osmosis and osmotic pressure in biological systems. A plasmolysis and hemolysis.
7. Osmotic pressure of biopolymers solutions. Polyelectrolytes. An isoelectric point and its definition. Oncotic pressure of plasma and serum of a blood.

8. Base positions of the strong electrolytes solutions theory. Activity and coefficient of activity. Ionic force of solutions. Electrolytes in an organism.
9. Theory of acids and bases. The protolytic theory of acids and bases. Force of acids and bases. An acid and base ionization constant. The Ostwald's law.
10. Autoionization of water. Autoionization constant (K_w) of water. pH and pOH.
11. Types of protolytic reactions: neutralization, hydrolysis, ionization. A hydrolysis constant. A role of a hydrolysis in biochemical processes.
12. Buffer systems. Capacity of buffer solutions and factors determining its. Comparative size of capacity of buffer systems of a blood.
13. Buffer systems, their classification and mechanism of their action.
14. The hydrocarbonate buffer solution. The Henderson-Hasselbalch equation.
15. Stability of biopolymers solutions. Salting-out of biopolymers from solutions. Jellification of solutions HMS. Properties of jellies.
16. Feature of dissolution HMS. Structure and shape of macromolecules. The mechanism of swelling. Influence of the various factors on degree of swelling.
17. Anomalous viscosity of solutions HMS. The Staudinger's equation. Viscosity of a blood and other biological liquids.
18. Polyphase equilibrium. A solubility product constant of slightly soluble electrolyte. Conditions of formation and dissolving of deposits. Influence of a like ion on solubility of a deposit. Compounds of calcium in an osteal tissue. Heterogeneous processes proceeding in an organism at a pathology.

COMPLEXES

1. Complexes. The Werner's coordination theory. Classification and naming of complexes. Complexing ability s-, p-, d-elements.
2. Chelates. Formation and dissociation of complexes. Constants of instability and stability of complexes. Examples.
3. Metalloenzymes. Reactions of complex formation of iron, cobalt, nickel ions, their biological role. A complex nature of a haemoglobin, catalase, cyanocobalamin.
4. Mechanism of hard metals (mercury, lead) toxic action. Application of complexes formation reactions in therapy of diseases. Chelation therapy.

PHYSICO-CHEMISTRY OF THE SUPERFICIAL PHENOMENA

1. Superficial phenomena and their importance in biology and medicine. Surface active and surface inactive substances. Examples.
2. The free superficial energy and interfacial tension. The isotherm of interfacial tension. Superficial activity. A Thraube's rule.
3. The adsorption on relative phase boundaries: a liquid - gas and liquid - liquid. The Gibbs equation. Orientation of SAS molecules in surface layer and structure of biological membranes.
4. The adsorption on fixed phase boundaries: a solid - gas and solid - liquid (solution). Monomolecular and polymolecular adsorption. The Lengmyur's and Frenclikh's equation.
5. Adsorption of strong electrolytes: selective, ion-exchange. Ionites and their application in medicine.
6. Chromatography. Classification of chromatographic methods. Application of a chromatography for separation of substances (on an example of laboratory work) and in medical - biological researches.

PHYSICO - CHEMISTRY OF DISPERSE SYSTEMS

1. Disperse systems, their classification. A nature of a colloidal state. Preparation of colloidal solutions. Examples.
2. Purification of colloidal solutions. A filtration, dialysis, electro dialysis, ultrafiltration.
3. Kinetic properties of colloidal systems: Brounian movement, diffusion, osmotic pressure. A ultracentrifugation.
4. Optical properties of colloidal systems: scattering of light (Rayleigh's equation), ultramicroscopy, Tyndall effect.
5. Mechanism of occurrence of electric charge of colloid particles. A structure of double electrical layer. A micelle, colloidal particle.
6. Electrokinetic potential of a colloid particle. Influence of electrolytes on value of an electrokinetic potential. The phenomenon of recharge of a colloid particle.
7. Electrokinetic properties. Electrophoresis and electroosmosis. The Helmholtz - Smoluchowski equation. Potential of course and potential of a sedimentation. Importance of the specified phenomena for biology and medicine.
8. Kinetic and aggregate stability of lyosols. The factors of stability.
9. Coagulation. A sluggish and fast coagulation. A critical coagulation concentration, its definition. The Schulze - Hardy rule.

10. Interoagulation of colloids. Processes of a coagulation at clearing water. Colloidal protection. A peptization. Importance of these phenomena in medicine.
11. Aerosol, preparing and properties. Aerosols as the medicinal form. Aerosols as the reason of occurrence of some diseases (silicosis, anthracosis etc.).
12. Suspension, preparing and properties. Application.
13. Emulsion, preparing and properties. Application.
14. Colloidal SAS: soaps, detergents, cholic acids. their application. Micellformation in a solution of colloidal SAS (spherical and plate micelles).

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