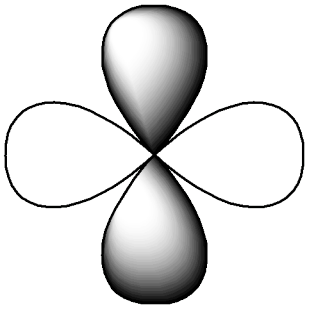
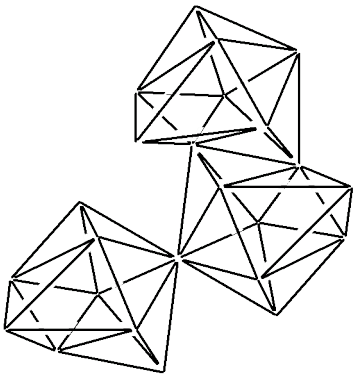
Pirogov National Medical University of Vinnitsa
Biological and General Chemistry Department
Medical chemistry course





SYSTEMATIC COURSE

practical seminars of medical chemistry for foreign students

Module 2. Equilibrium in biological systems at the interfaces

Vinnitsa 2006

CONTAINS

SAFETY IN THE CHEMICAL LABORATORY AND FIRST AID RULES.

1. The chemical laboratory must be always extremely clean and kept in the order and silence. It should not be present unnecessary staff and the roles of safety must be performed.
2. The student has to wear the laboratory coat and special medical hat in the laboratory.
3. Every student have to know where the fire-preventing means and the first-aid kit are placed in the laboratory.
4. It is forbidden to smoke, eat and drink in the laboratory.
5. It is not allowed to start the laboratory work without knowing the technique of the experiments.
6. Experiments must be carried out only in the clean laboratory dishes. After laboratory work finishing the dishes have to be washed.
7. The students must carefully perform the experiments and avoid getting the chemicals in eyes, on face and hands skin.
8. Do not taste the chemicals. To smell the substances is necessary to move the hand in the direction of face carefully.
9. Do not use the chemicals without the identified label on the flask or vessel.
10. Do not direct the test-tube towards the front of your face or near standing person during heating of solid or liquid substance. Do not have a look in the test-tube during such procedure.
11. Switch off gas, water, and electricity before leaving the laboratory.
12. It is forbidden to pour out the concentrated acid or base. The students have to use the special glasses, the gas mask working with the poisoning compounds, concentrated acid and base, phenol and others.
13. The experiments with the inflammable compounds (ether, acetone, benzene, alcohol) must be carried out far from fire and switched off instruments.
14. If fire starts, gas must be closed immediately. All inflammable compounds must be shifted far a way from fire and used the antifire stuffs (a fire-extinguisher, sand, antifire coating). Wrap person in fire blanket. DO NOT USE WATER TO PUT OUT FIRE.
15. The below given table is helpful in an accident situation. Read and remember them.

Situation	Safe Response
Burns	Flush with ethanol solution or diluted solution of $KMnO_4$.
Cuts and Bruises	Treat as directed by instructions included with first aid kit
Fainting or collapse	Provide person with fresh air, have him recline in a position so that his head is lower than their body
Foreign Matter in Eyes	Flush about 15 min with plenty of water, then go to the doctor

Severe bleeding	Apply pressure or a compress directly to the wound and get medical attention immediately
1. Spills, general 2. Acid burns 3. Base burns	1. Wash area with plenty of water, use safety shower if needed 2.Use sodium hydrogen carbonate (baking soda) 3. Use 3 % of boric acid or acetic acid

Short methodical directions for practical lesson:
Practical lesson is started from the general questions (5 min).
Explanation of unclear questions (25 min)
Writing of control test (15 min)
Carrying out a laboratory work, filling a laboratory notebook, signing the laboratory notebook by a teacher, announcing of student marks (45 min).

Technological map of practical lesson:

N	*Steps*	*Time (min)*	*Educational handout*	*Resi-dence*
1	General questions	5		Faculty
2	Correction of theoretical student knowledge	20	Tables, task	
3	Control test	15	Test, questions	
4	Performing of laboratory work	40	Chemicals, chemical dishes, equipments.	
5	Analysis and conclusion of a practical lesson	10		

Topic 1. THERMODYNAMICS. DIRECTION OF THE PROCESSES.

1. ***Actuality of the topic***: knowledge of chemical thermodynamics is necessary to understand the energetics of biochemical processes. Calculation of thermal effect is used in dietology for determination of food energy.

2. ***General aim:*** is to interpret the base thermodynamics laws for biological process characterization.

3. ***Actual aims and abilities:***

   ✓ to know thermodynamics laws;
   ✓ to be able to calculate thermodynamic equations and to use them for determination of food energy.

4. ***Literature:***

5. ***The main questions of the seminar:***

   5.1. Chemical thermodynamics as a branch of the physical chemistry. Thermodynamic system, types and the examples of the thermodynamic systems, intensive and extensive parameters of the system.
   5.2. The first law of thermodynamics. Internal energy of system. Enthalpy.
   5.3. Thermochemical equations. The standard enthalpy of formation and combustion.
   5.4. Hess's law. Calorimetry.
   5.5. The energetic characteristics of biochemical processes. Thermochemical calculations for the estimation of the calorie content in foodstuff and the dietotherapy.

6. ***The questions for individual learning:***

   6.1. The second law of thermodynamics. Entropy. Gibbs free energy.
   6.2. Thermodynamic processes (reversible and irreversible). Thermodynamic equilibrium. Irreversibility of the processes in vital activity.
   6.3. ATP as the source of the biochemical processes. Exergonic and endergonic processes in the human organism.

7. ***The examples of the task:***

   7.1. <u>Calculation of ΔH.</u>

Calculate ΔH° of the reaction CO_{gas}+ H_{2gas} = $CH_{4\ gas}$ + H_2O_{gas} knowing that the standard enthalpy of formation for CO=-110 кJ/mol, CH_4=-74.9 кJ/mol, H_2O= -241.8 кJ/mol.

<u>Answer:</u>

$\Delta H°_f = \sum \Delta H°_{PRODUCTS.} - \sum \Delta H°_{REACTANTS}$

$\Delta H°_f = (\Delta H^0_f (CH_4) + \Delta H^0_f (H_2O)) - \Delta H^0_f (CO) =$

$= - 74,9 + (-241,8) - (-110,5) = -206,2$ кJ/mol.

7.2. Calculations for the estimation of the calorie content in foodstuff

100 g of cod (fish) contain 11.6 g of proteins. The calorie content of 1 g of proteins is 4.1 кcal. Calculate the calorie proteins content of cod.

Answer.

1 g of protein contains 4.1кcal

11.6 г of protein contain X кcal

$X = 11.6 \cdot 4.1 = 47.56$ кcal.

7.3. Detect the spontaneity of the process.

Can the following reaction

$SiO_{2\ (solid)} + 2NaOH_{\ (solution)} = Na_2SiO_{3(solid)} + H_2O_{\ (solution)}$

follow spontaneously if Gibbs energy of $SiO_{2(solid)} = -803,75$ кJ/mol,

$NaOH_{(sol)} = -419,5$ кJ/mol,

$Na_2SiO_{3(solid.)} = -1427,8$ кJ/mol,

$H_2O_{(sol)} = -237,5$ кJ/mol ?

The answer:

$\Delta G = \sum \Delta G^o_{\ PRODUCTS} - \sum \Delta G^o_{\ REACTANTS.} = (-1427,8 - 237,5) - (-803,75 - 2 \cdot 419,5) = - 22,5$ кJ/mol.

Since $\Delta G < 0$, it is spontaneous.

8. Homework (must be performed in the laboratory notebook):

8.1. Calculate ΔH of the reaction:

$$H_2C_2O_4 + 2CH_3OH \rightarrow H_3COOC - COOCH_3 + 2H_2O.$$

$\Delta H^0_f (H_2C_2O_4) = -60.10$ кJ/mol;

$\Delta H^0_f (CH_3OH) = -173.65$ кJ/mol;

$\Delta H^0_f (H_3COOC - COOCH_3) = -401,0$ кJ/mol;

$\Delta H^0_f H_2O = -241.8$ кJ/mol.

8.2. Energy of the fat formation in human organism contains 9.3 kcal/g. Daily necessity of the male organism is 106 g of fat. Calculate the daily energy of fat for the male organism.

8.3. Can the reaction of glucose oxidation follow spontaneously at room temperature if the standard Gibbs energies of glucose, water, carbon oxide (IV) equal - 910 кJ/mol; -237 кJ/mol; - 394 кJ/mol.

9. The control test:

for instance:

1.Choose the correct answer. The extensive parameters of the system are

a) the volume, mass; b) pressure, temperature; c)the concentration, potential.

2. Choose the correct answer. Exergonic systems in the human organism is

a)glucose; b)ATP; c) glycogen.

3. Energy of the carbohydrates formation in human organism contains 4.1 kcal/g. Daily necessity of the female-student organism is 135 g of carbohydrates. Calculate the daily energy of carbohydrates for the female-student organism

10. The algorithm of the experiments:

10.1. Determination of thermal effect of neutralization reaction.

11. The detailed explanation of the following experiment:

11.1. Determination of thermal effect of neutralization reaction.

Thermal effect of a chemical reaction is determined in calorimeter. The calorimeter with known mass is filled by 150 mls of NaOH solution with Cn=1 mol/L. The temperature of the solution must be measured. Tn the glass put 150 mls of 1 M HCl solution and the temperature of the second solution must be measured too. The solution of HCl is added to the solution of the NaOH *constantly mixing*. The temperature of the final solution is measured.

The experimental date are filled in the table.

Mass of the calorimeter (m_1)/g	
Concentration of the acid and base (C)	1 M
Volume of the solutions (V)	150 ml
Temperature of NaOH solution (t_{NaOH})/°C	
Temperature of HCl solution (t_{HCl})/°C	
The initial temperature of the resulting solution t_1=1/2 (t_{NaOH}+t_{HCl})/°C	
The temperature of the resulting solution after neutralization t_2/°C	
The total mass of the solutions m_2=2 V ρ	

Calculate the heat of the neutralization reaction using :

$$Q = \frac{\Delta t \cdot C}{V \cdot C_H} = \_\_\_\_\_,$$

where $\Delta t = t_2 - t_1$; $C = m_1c_1 + m_2c_2$;

c_1 (specific heat of the glass) =0,753 J/g °C,

c_2 (specific heat of the solution) = 4,184 J/g °C.

$$NaOH + HC1 = NaCl + H_2O; \quad \Delta H = - \_\_\_\_\_.$$

Topic 1. KINETICS OF BIOCHEMICAL PROCESSES.

1. ***Actuality of the topic***: knowledge of the kinetics laws is necessary to study the mechanism of the organic reactions, the enzymatic processes, the formation of metabolite, the suction and transmutation of the drugs.

2. ***General aim:*** is to interpret the base kinetics laws for biological process characterization.

3. Actual aims and abilities:

- ✓ to have an idea about the main meanings of the chemical kinetics;
- ✓ to know the laws and rules of kinetics;
- ✓ to be able to reveal and explain the influence of the various factors on the rate of the chemical reactions, to determine the order and molecularity of the chemical reaction as well as the biological one.

4. Literature:

5. The main questions of the seminar:

5.1. The rate of the homogeneous and heterogeneous reactions and its dependence on the concentration. The law of mass action states. The rate constants.
5.2. The rate of the reaction. The kinetic equations of zero-, first- and second-orders.
5.3. Conception of the reaction mechanism. Molecularity of the reaction.
5.4. The dependence of the reaction rate on the temperature. Van't Hoff rule. The characteristic properties of the temperature coefficient for the biological processes.
5.5. Collision theory. Activation energy. Arrhenius equation. Transition states.
5.6. Enzyme kinetics.

6. The questions for individual learning:

6.1. Half-life.
6.2. The parallel, consecutive, conjugate, reversible and chain reactions. Photochemical reactions.
6.3. Free radical reactions in the living organism. Antioxidants.
6.4. Catalysis and the catalysts. Homogeneous and heterogeneous catalysis. Acid-base catalysis. The mechanism action of the catalysts. Autocatalysis. The promoters and inhibitors.

7. The examples of the task:

7.1. The influence of the concentration on the reaction rate.

How does the reaction rate of the oxidation nitrogen (II) to nitrogen (IV) change if the system pressure is raised in 3 times?

The answer.

$2NO + O_2 \rightarrow 2NO_2$;

$V_1 = \kappa [NO]^2 \cdot [O_2]$;

When the pressure is increased in 3 times, the volume of the system is decreased in 3 times. Consequently the concentration of the components is increased in 3 times.

Then, $V_2 = \kappa [3NO]^2 \cdot [3\ O_2] = 27\ \kappa\ [NO]^2 \cdot [O_2]$;

$$\frac{V_2}{V_1} = \frac{27\kappa[NO]^2 \cdot [O_2]}{\kappa[NO] \cdot [O_2]} = 27$$

thus, the reaction rate is increased in 27 times.

7.2. The influence of the temperature on the reaction rate.

The reaction time is 2 min 15 sec at 50 °C. Calculate the reaction time at 70 °C knowing the temperature coefficient (γ) is 3.

The answer.

$$\frac{r_2}{r_1} = \gamma^{\frac{t2-t1}{10}} = 3^{\frac{70-50}{10}} = 3^2 = 9$$

$$r_1 = \frac{\Delta C}{\Delta t_1}$$

$$r_2 = \frac{\Delta C}{\Delta t_2}$$

$$\frac{r_2}{r_1} = \frac{\Delta C\, \Delta t_1}{\Delta t_2\, \Delta C}$$

Since ΔC is canceled it follows $\frac{r_2}{r_1} = \frac{\Delta t_1}{\Delta t_2} = \gamma^{\frac{t2-t1}{10}}$

$$\Delta t_2 = \frac{\Delta t_1}{\gamma^{\frac{t2-t1}{10}}} = \frac{135}{9} = 15 \text{ sec}$$

Where,

7.3. Determination of the reaction order.

Determine the reaction order of the interaction of hydrogen with iodine.

The answer.

$H_2 + I_2 = 2HI$;

$V = \kappa [H_2] \cdot [I_2]$;

The reaction rate depends on the concentration of two components and the sum of the exponents is 2. The reaction is the second order.

8. Homework (must be performed in the laboratory notebook):

8.1. How does the reaction rate of ammonia synthesis change if the volumes of molecular hydrogen and nitrogen are enlarged in 3 times?

8.2. The reaction time are 25 min at 30 °C and 4 min at 50 °C. Calculate the temperature coefficient (γ) of the reaction rate for the given temperature range.

8.3. Determine the reaction order of the hydrolysis.

***9. The control test*:**

for instance:

9.1. The reaction rate is affected by:

a) the volume;

б) the concentration:

в) density.

9.2. How does the reaction rate change if the temperature is increased by in 3 times30 ^{0}?

10. The algorithm of the experiments:

10.1. Dependence of the reaction rate on the concentration of the reactants.
10.2. Dependence of the reaction rate on the temperature.

11. The detailed explanation of the following experiment:

11.1. Dependence of the reaction rate on the concentration of the reactants.

Prepare the sodium thiosulphate solution of different concentrations.

	1 test-tube	*2 test-tube*	*3 test-tube*
$Na_2S_2O_3$	5 drops	10 drops	15 drops
H_2O	10 drops	5 drops	-

Add 1 drop of H_2SO_4 solution in the first test-tube and fix the end of the reaction (time when the dimness of the solution occurs). Analogous perform the same procedure for the last two test-tubes. Fill the table.

№ of the test-tube	Number of $Na_2S_2O_3$ drops	Number of H_2O drops	Reaction time / sec.	Relative rate, 1/sec
1				
2				
3				

Depict the graph of the reaction rate *vs.* the concentration of the reactants where the abscissa is the concentration data and the ordinate axis is the reaction rate. Write the reaction question and make a conclusion.

11.2. Dependence of the reaction rate on the temperature.

In the first test-tube add 10 drops of $Na_2S_2O_3$ solution and measure the room temperature, then add 1 drop H_2SO_4 solution and fix time (sec) when the solution becomes to be muddy.

The second test-tube must be filled by 10 drops of $Na_2S_2O_3$ solution and heat the test-tube to the higher room temperature by 10 °C, add 1 drop of sulphuric acid and fix time (sec) when the solution becomes to be muddy.

The third test-tube must be filled by 10 drops of $Na_2S_2O_3$ solution and heat the test-tube to the higher room temperature by 20 °C, add 1 drop of sulphuric acid and fix time (sec) when the solution becomes to be muddy.

Fill the table. Is van't Hoff rule valid for the given experiments?

№ of the test-tube	$Na_2S_2O_3$	t	H_2SO_4	Time/sec
1 test-tube	10 drops	room	1 drop	
2 test-tube	10 drops	room + 10 ^{0}C	1 drop	
3 test-tube	10 drops	room + 20 ^{0}C	1 drop	

Topic . CHEMICAL EQUILIBRIUM. SOLUBILITY.

1. ***Actuality of the topic***: knowledge of the chemical equilibrium principles is necessary to study the direction of the chemical and enzymatic processes as a result of the action of the various factors.

2. ***General aim:*** is to interpret the base chemical equilibrium for biological process characterization.

3. Actual aims and abilities:

- ✓ to have an idea about the main meanings of the chemical equilibrium;
- ✓ to know the Le Chatelier's principle;
- ✓ to be able to reveal and explain the influence of the various factors on the chemical equilibrium.

4. Literature:

5. The main questions of the seminar:

5.1. Reversible and irreversible chemical reactions.
5.2. Chemical equilibrium.
5.3. Thermodynamic conditions of equilibrium.
5.4. The constant of the chemical equilibrium and its expression.
5.5. The shift of chemical equilibrium changing temperature, pressure and concentration. Le Chatelier's principle.

6. The questions for individual learning:

6.1. Solubility and precipitation reactions.
6.2. The conditions of solubility and precipitation.
6.3. Solubility product.
6.4. The role of the heterogeneous equilibrium (in the presence of the salts) in the general homeostasis of human organism.

7. The examples of the task:

7.1. The shift of chemical equilibrium changing the concentration.

What is the direction of the chemical reaction $HCl + O_2 = H_2O + Cl_2$ if the concentration of all substances is accelerated in 2 times?

The answer.

I way

$$4HC1 + O_2 = 2H_2O + 2C1_2$$

1) Accordingly the mass action law:

$V_{FORVARD.} = K_1 \cdot [HC1]^4 \cdot [O_2]$

$V_{REVERSE} = K_2 \cdot [H_2O]^2 \cdot [C1_2]^2;$

2) After the increase the concentrations in 2 times :

$V_{FORVARD} = K_1 \cdot [2HC1]^4 \cdot [2\ O_2] = 32 \cdot K_1 \cdot [HC1]^4 \cdot [O_2].$

$V_{REVERSE} = K_2 \cdot [2H_2O]^2 \cdot [2\ C1_2]^2 = 16 \cdot K_2 \cdot [H_2O]^2 \cdot [C1_2]^2;$

3)

$$\frac{V_{FORVARD}}{V_{REVERSE}} = \frac{32}{16} = 2$$

The chemical equilibrium is shifted in the side of the direct reaction.

II way

1. The equilibrium constant before the increase of the concentrations.

$$K_{P1} = \frac{[H_2O]^2 [Cl_2]^2}{[HCl]^4 [O_2]}$$

2. The equilibrium constant after the increase of the concentrations.

$$K_1 = \frac{[2\ H_2O]^2 [2\ Cl_2]^2}{[2\ HCl]^4 [2\ O_2]}$$

3.

$$\frac{K_1}{K_2} = 2$$

The chemical equilibrium is shifted in the side of the direct reaction.

7.2. The shift of chemical equilibrium changing the pressure.

The equilibrium of the reaction $NO + O_2 = NO_2$ is stated at [NO] = 0.5 mol/L, [NO_2] = 2.1. mol/L, [O_2] = 0.7mol/L. What is the direction of the reaction if the pressure in the system is lowered in 2 times?

The answer.

$2\ NO + O_2 = 2NO_2$

1 way.

1)

$$K_{equil.} = \frac{[NO_2]^2}{[NO]^2 \cdot [O_2]}$$

2) $V_{FORVARD} = K_1 * [NO]^2 * [O_2] = K_1 (0.5)^2 * (0.7) = K_1 * 0.175$

$V_{REVERSE} = K_1 \cdot [NO_2]^2 = K_2 \cdot (2.1)^2 = K_2 \cdot 4,41$

3) After decreasing of the pressure in 2 times:

$$V_{FORVARD}' = K_1 \cdot \left(\frac{0,5}{2}\right)^2 \cdot \frac{0,7}{2} = K_1 \cdot 0,0219$$

$$V_{REVERSE}' = K_1 \cdot \left(\frac{2,1}{2}\right)^2 = K_2 \cdot 1,101$$

4)

$$\frac{V_{FORVARD}}{V_{FORVARD}'} = \frac{K_1 \cdot 0,175}{K_1 \cdot 0,0219} = 8 \text{ times}$$

(it is decreased);

$$\frac{V_{REVERSE}}{V_{REVERSE}'} = \frac{K_2 \cdot 4,41}{K_2 \cdot 1,101} = 4 \text{ times}$$

(it is decreased).

The chemical equilibrium is shifted in the indirect side.

II way.

1) The equilibrium constant before the pressure change:

$$K_{equil\,1} = \frac{[2,1NO_2]^2}{[0,5NO]^2 \cdot [0,7O_2]} = \frac{4,41}{0,175} = 25,2;$$

2) The equilibrium constant after the pressure change:

$$K_{equil\,2} = \frac{[2,1/2]^2}{[0,5/2]^2 \cdot [0,7/2]} = \frac{1,1025}{0,022} = 50,4$$

3) $$\frac{K_2}{K_1} = \frac{50,4}{25,2} = 2.$$

The chemical equilibrium is shifted in the indirect side.

7.3. Calculation of solubility product (SP) of the low soluble compounds.

Calculate SP of silver chromate if the solubility is $6,5 \cdot 10^{-5}$.

The answer.

1. Silver chromate is dissociated as
   $Ag_2CrO_4 \leftrightarrow 2Ag^+ + CrO_4^{2-}$
2. The concentration is calculated as
   $[Ag^+] = 2 \cdot 6{,}5 \cdot 10^{-5} = 1{,}3 \cdot 10^{-4}$ mol/L
   $[CrO_4^{2-}] = 6{,}5 \cdot 10^{-5}$ mol/L
3. $SP_{Ag_2CrO_4} = [Ag^+]^2 \cdot [CrO_4^{2-}] = (1{,}3 \cdot 10^{-4})^2 \cdot 6{,}5 \cdot 10^{-5} = 1{,}1 \cdot 10^{-12}$

8. Homework (must be performed in the laboratory notebook):

8.1. The equilibrium constant of the thermal reaction $N_2O_4 = 2NO_2$ is 0.26. The equilibrium concentration of NO_2 is 0,28 mol/L. Calculate the equilibrium concentration of N_2O_4.
8.2. What is the equilibrium direction of the reaction $CH_4 + H_2O = CO + H_2$ if the volumes are lowered in 3 times?
8.3. Calculate SP of barium sulfate if its solubility is $1.05 \cdot 10^{-5}$.

***9. The control test*:**
for instance:

9.1. The chemical equilibrium of the reaction $SO_3 \leftrightarrow SO_2 + O_2$ as the result of pressure decrease shifts in:
a) left side; b) right side; c) does not shift.
9.2. Calculate SP of calcium oxalate if its solubility is $5.07 * 10^{-5}$ mol/L.

10. The algorithm of the experiments:
10.1. Influence of the reactant concentration on the equilibrium shift.
10.2. Influence of temperature on the equilibrium shift.

11. The detailed explanation of the following experiment:
11.1. Influence of the reactant concentration on the equilibrium shift.
Add 1 drop of saturated $FeCl_3$ solution and 1 drop of NH_4SCN solution to 50 mls of water. The solution is mixed and divided in 4 test-tubes. 1) add 2 drops of saturated $FeCl_3$ solution; 2) add 2 drops of saturated NH_4SCN solution; 3) add some crystals of NH_4Cl; 4) the blank test-tube. Give data in table. Write the chemical equations, the equilibrium constants, make the conclusions.

№ test-tube	Added component	Color change	Conclusion (equilibrium shift)
1	$FeCl_3$		
2	NH_4SCN		
3	NH_4Cl		

11.2. Influence of temperature on the equilibrium shift.

In two test-tubes add 5 ml of starch solution and 1 drop of iodine solution. Heat one of them and then cool it. The second one is the blank test-tube. Make a conclusion.

Topic . POTENTIOMETRY.

1. ***Actuality of the topic***: electrochemical phenomena are observed in human organism. The muscles movements, heartbeat, spreading of nerve impulses are accompanied by electrochemical phenomena. Electrochemical analysis is widely used in medicine for determination of pH, biological liquids, for determination of the concentration of acids and bases that can not be detected by visual titration.

2. ***General aim:*** is to detect the active and potential acidity of biological liquid and organs by potentiometry.

3. Actual aims and abilities:

- ✓ Use the knowledge about the mechanism of creation of electrode potential to estimate the character of biochemical processes in wide pH range.
- ✓ To be able to measure the pH, the total acidity of biological liquids and organs for the diagnostic, prediction and medical treatment.

4. Literature:

4.1. Lecture materials;
4.2. "Chemistry" 3th ed. 2001. J. Mc Murry and R. Fay; Prentice Hall, Upper Saddle River, New Jersey 07458, ISBN 0-13-087205-9;
4.3. Ebbing, D.D. 2002. General Chemistry. Fifth Edition. Houghton Mifflin Co., Boston, MA, chapter 19, pp.786-810.

5. The main questions of the seminar:

5.1. Galvanic cell. Determination, its structure, the schema.
5.2. Electrode potential. The half-cells.
5.3. Nernst equation, Standard electrode potential.
5.4. Reference electrodes: hydrogen electrode, saturated calomel electrode. Structure and their standard electrode potentials.
5.5. Electrodes for pH measurements: hydrogen, glass electrodes, their structure, schema of the electrodes.
5.6. Electro motive force.
5.7. Concentrated galvanic cell, the principle, the schema, the equation.
5.8. Determination of pH using hydrogen-hydrogen, saturated calomel-hydrogen, saturated calomel-glass galvanic cells, the schema, equation of pH calculation.
5.9. Measurement of pH using pH meter.

6. The questions for individual learning:

6.1. Potentiometric titration.
6.2. Ion-selective electrodes.

7. The examples of the task:

7.1. pH calculation using emf.

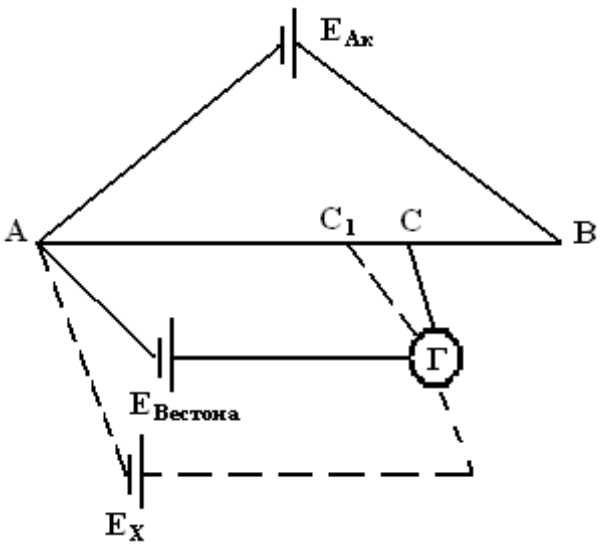
The cell contains hydrogen electrode immersed in the solution with unknown concentration of H^+ and saturated calomel electrode. Emf equals 0.51 V. Write the schema of given cell and calculate pH at 18 °C.

Answer: (-) Pt (H_2) | H^+ || Hg_2Cl_2, KCl | Hg(+)

$$pH = \frac{\text{emf} - e_{SCE}}{0,058} = \frac{0,51 - 0,25}{0,058} = 4$$

7.2. Вычисление pH по данным компенсационного метода.

Задача 2. Элемент состоит из водородного электрода, погруженного в раствор с неизвестной концентрацией H^+ и каломельного электрода. Элемент Вестона компенсируется на отрезке реохорды AC=500 мм, а гальванический элемент – на отрезке реохорды AC_1=250 мм. Вычислить pH и концентрацию ионов гидрогена.



Решение:

1) найдем цену деления:

$$Ц.Д. = \frac{E_{ВЕСТОНА}}{AC} \cdot AC_1 = \frac{1018}{500} \cdot 250 = 2,04 мв / мм.$$

2) найдем E_X составленного гальванического элемента:

E_X= Ц.Д.· AC_1 = 2,04 · 250 =510 мВ = 0,51 Вольт;

3) вычисляем pH раствора:

$$pH = \frac{E_X - 0,25}{0,058} = \frac{0,51 - 0,25}{0,058} = 4,47.$$

8. Homework (must be performed in the laboratory notebook):

8.1. The cell contains the hydrogen electrode immersed in gastric juices and the saturated calomel electrode. Write the schema of the cell; calculate pH and Cn of gastric juices knowing that emf equals 0.33 at 18 °C.
8.2. The cell contains two hydrogen electrodes. One of them is immersed in the solution with pH = 4 and other in solution with pH = 1. Calculate emf at 25 °C.

***9. The control test*:**
for instance:

9.1. Choose the correct answer. Nernst equation is

a) $e = e_0 + \frac{0,058}{n\mathrm{F}} \ln a_{Me^{n+}}$ b) $e = e_0 + \frac{0,058}{n} \ln a_{Me^{n+}}$ c) $e = e_0 + \frac{RT}{nF} \ln a_{Me^{n+}}$

9.2. Immersing an electrode in the solution of its salt:
a) the electrode is positively charged;
b) the electrode is negatively charged;
c) the electrode does not charge.
9.3. The cell contains two electrodes. One of them is immersed in the solution with pH = 4 and other in solution with pH = 2. Calculate emf at 18 °C.

10. The algorithm of the experiments:
10.1. Measurement of pH using pH meter.

11. The detailed explanation of the following experiment:
11.1. Measurement of pH using pH meter.
Detect pH of the solutions №1, №2, №3 using pH meter. Write the schema of the saturated calomel-glass cell, make a conclusion.

Topic . DETECTION OF THE REDOX POTENTIAL.

1. Actuality of the topic: biological oxidation is a net of the redox reactions. The certain redox system possessing the corresponding potential is responsible for every unit of biological net oxidation. Knowledge of the topic is necessary for studying biochemistry, physiology and other subjects.

2. General aim: is to have an idea about the redox potentials for explanation of the biological oxidation in living organisms.

3. Actual aims and abilities:

✓ to use the physical-chemical characteristics of the redox systems to estimate and predict biological oxidation in tissue;

- ✓ to interpret the biological oxidation as a main source of energy in the organism;
- ✓ to use the redox elements for studding redox processes in living organisms with the aim of diagnostics, predictions and treatment.

4. Literature:

4.1. Lecture materials;

4.2. "Chemistry" 3th ed. 2001. J. Mc Murry and R. Fay; Prentice Hall, Upper Saddle River, New Jersey 07458, ISBN 0-13-087205-9;

4.3. Ebbing, D.D. 2002. General Chemistry. Fifth Edition. Houghton Mifflin Co., Boston, MA, chapter 19, pp.786-810.

5. The main questions of the seminar:

5.1. Redox systems (determination, the examples).

5.2. Mechanism of redox potential appearing.

5.3. Nernst equation, the depending factors of redox potential, the standard redox potential.

5.4. Biological meaning of the redox system.

5.5. Diffusion and membrane potentials.

6. The questions for individual learning:

6.1. Explain the appearance of the redox potential during lactate acid oxidation to pyruvic acid. Write formula of electrode potential.

7. The examples of the task:

7.1. Calculation of the component ratio in the redox system.

The redox potential of $FeCl_3$/ $FeCl_2$ system is +0.888 V. The standard redox potential of the given system is +0.77 V. Calculate the ratio of oxidized and reduced forms at 25 °C.

Answer:

$$e_{red} = e^0_{red} + \frac{0,059}{n} \cdot \lg \frac{[\text{oxidizing agent}]}{[\text{reducing agent}]}; \qquad n=1;$$

$$0,888 = 0,77 + 0,059 \cdot \lg \frac{[Fe^{+3}]}{[Fe^{+2}]};$$

$$\lg \frac{[Fe^{+3}]}{[Fe^{+2}]} = \frac{0,888 - 0,77}{0,059} = 2; \quad \frac{[Fe^{+3}]}{[Fe^{+2}]} = 100.$$

8. Homework (must be performed in the laboratory notebook):

8.1. The redox potential and the standard redox potential of Cr^{3+}/ Cr^{2+} system are +0.468 V and +0.41 V correspondently. Calculate the ratio of oxidized and reduced form at 18 °C.

8.2. Calculate the standard redox potential of a system if redox potential is -0.15 V, the mass fractions of oxidized form is 20 % and reduced form is 80 % (n=1).

***9. The control test*:**

for instance:

9.1. Immersing the electrode in the redox system solution where the concentration of oxidized form is predominant, the electrode is charged:

a) negatively; b) positively; c) no change.

9.2. The transformation of $FeSO_4 \rightarrow Fe_2(SO_4)_3$ is:

a)oxidation; ` b)reduction; c) no change.

9.3. How many electrons take place in the redox reaction if E_{red}=0.169 V, $E°_{red}$=0.110 V and the concentration of the oxidizing agent is lower in 10 times than the reducing agent?

10. The algorithm of the experiments:

10.1. Determination of the redox potential ant its dependence on the ratio of oxidized and reduced forms.

11. The detailed explanation of the following experiment:

<u>11.1. Determination of the redox potential ant its dependence on the ratio of oxidized and reduced forms.</u>

11.1. Составить гальванический элемент.

I полуэлемент – платиновый электрод, погруженный в раствор, который содержит 1 мл 0,01М раствора $K_3[Fe(CN)_6]$ и 10 мл 0,01М раствора $K_4[Fe(CN)_6]$;

II полуэлемент – хингидронний электрод сравнения, потенциал которого +0,669 В.

Элемент Вестона компенсируется на отрезке 43 см, а составленный гальванический элемент – на отрезке 12,7 см.

Вычислить величину редокс-потенциала – $e_{red\ 1}$.

<u>Решение:</u>

$$EPC = = e_{x\text{-}г} - e_{red}; \quad e_{red} = EPC - e_{x\text{-}г};$$

$$EPC = \frac{EPC_{ВЕСТОНА}}{43} \cdot 12,7 = \frac{1,018}{43} \cdot 12,7 = 0,283 B;$$

$$e_{red\ 1} = 0,669 - 0\ ,283 = 0,386\ B.$$

11.1.2. Составить гальванический элемент.

I полуэлемент - платиновый электрод, погруженный в раствор, который содержит 10 мл 0,01М раствора $K_3[Fe(CN)_6]$ и 1 мл 0,01Мраствора $K_4[Fe(CN)_6]$;

II полуэлемент – хингидронний электрод сравнения, потенциал которого +0,669 В.

Элемент Вестона компенсируется на отрезке 43 см, а составленный гальванический элемент – на отрезке 9 см.

Вычислить величину редокс-потенциала – $e_{red\ 2}$ (аналогично опыту 11.1.1.).

11.1.3. Составить гальванический элемент.

1 полуэлемент - платиновый электрод, погруженный в раствор, который содержит 5 мл 0,01М раствора $K_3[Fe(CN)_6]$ и 5 мл 0,01М раствора $K_4[Fe(CN)_6]$;

II полуэлемент – хингидронний электрод сравнения, потенциал которого +0,669 В.

Элемент Вестона компенсируется на отрезке 43 см, а составленный гальванический элемент – на отрезке 11 см.

Вычислить величину нормального редокс-потенциала – e_{red}^0 (аналогично опыт

у 11.1.1.).

11.1.4. Вычисление редокс-потенциалов по уравнению Петерса.

Используя величину e_{red}^0 вычислить $e_{red\ 1}$ и $e_{red\ 2}$ по уравнениею Петерса (температура 18 °С) и сравнить с величинами редокс-потенциалов, которые получены в опытах 11.1.1. и 11.1.2.

Topic SURFACE TENSION

1. Actuality of the topic: studying of surface tension at the interface in the biological systems of normal and pathological metabolism under the action of the medicines, toxic compounds is widely used in medical and biological investigations. The surface tension value can be used to measure the activity of the surfactant of the lungs and to identify the liquids.

2. General aim: is to understand the sorption processes at the interface liquid-gas.

3. Actual aims and abilities:

- ✓ to measure the surface tension of the biological liquids;
- ✓ to be able to use the main principles of the surface tension theory explaining the biological processes in human organism;
- ✓ to have an idea about the structure of biological membrane.

4. Literature:

4.1. Lecture materials;

5. The main questions of the seminar:

5.1. Surface tension and surface energy.
5.2. Surface phenomena at the interface liquid-gas: the structure of the surface layer, surface tension.
5.3. Gibbs equation, surface activity.
5.4. Surface active and inactive agents.
5.5. Duclo-Traube rule.
5.6. Methods of surface tension determination.
5.7. Surface tension of biological systems

6. The questions for individual learning:

6.1. The structure of the biological membrane.

7. The examples of the task:

7.1. How does the surface tension of water change after adding of butyric acid CH_3-$(CH_2)_2$-COOH.

Answer:

Butyric acid is diphilic acid possessing the low solubility in water. It is characterized by the concentration at the surface of water lowering the surface tension of it.

7.2. How does the emulsification of fat take place in human organism?

Answer:

Bile acids are the surface active agents adsorbing at the surface of the fat layer causing to the lowering of the surface tension of fat destroying the big fat drops to lower ones.

8. Homework (must be performed in the laboratory notebook):

8.1. Why does the surface tension of water have the higher value than benzene?
8.2. Why does a drop of a liquid have the sphere form?

***9. The control test*:**

for instance:

9.1. Increasing the polarity, the surface tension at the interface liquid-gas is:
a) lowered; b) accelerated; c) the surface tension does not depend on the polarity.

9.2. The Gibbs equation for the adsorption is:

а) $\Gamma = \frac{C}{RT} \cdot \frac{dC}{d\sigma}$ б) $\Gamma = -\frac{C}{RT} \cdot \frac{d\sigma}{dC}$ в) $\Gamma = -\frac{C}{RT} \cdot \frac{d\sigma}{dC}$

9.3. What is the surface tension?

10. The algorithm of the experiments:

10.1. Detection of liquid surface tension.

10.2. The surfactant influence on the surface tension of water.

11. The detailed explanation of the following experiment:

11.1. Detection of liquid surface tension.

Stalagmometer is filled by the certain volume of water and calculate the number of drops. Analogous perform with propanol. Knowing the number of water and propanol drops detect the surface tension of the liquid. Surface tension of water is $\delta = 72.75 \cdot 10^{-3}$ *Н / м.*

$$\delta = \delta_0 \cdot \frac{n_0}{n_x} \rho$$

11.2. The surfactant influence on the surface tension of water.

Detect the surface tension of bile by stalagmometric method. Make a conclusion.

Topic SORPTION OF BIOLOGICAL ACTIVE COMPOUNDS AT THE INTERFACE SOLID-LIQUID

1. ***Actuality of the topic***: the surface phenomena at the interface of solid-liquid and solid-gas are widely occurred in nature. The absorption process in human organism and the interaction of a substrate with an enzyme take place as a result of the adsorption processes. Adsorption therapy is used in the treatment process.

2. ***General aim:*** is to understand the sorption processes at the interface solid-liquid and solid-gas.

3. ***Actual aims and abilities:***

- ✓ to have an idea about of the processes occurring at the interface solid-liquid;
- ✓ to characterize the adsorption processes using the isotherms of Langmur, BET, Freundlich;
- ✓ to explain the living processes on the basis of the adsorption phenomena.

4. ***Literature:***

4.1. Lecture materials;

5. ***The main questions of the seminar:***

5.1. Basic aspects of adsorption. Determinations: sorption, physical and chemical adsorption, absorption, the adsorbents and adsorbates.

5.2. Adsorption at the surface of the solid. Isotherms and equation of Langmur, BET, Freundlich. The value of sorption.

5.3. Hemosorption. Enterosorption.
5.4. Adsorption significance for the living organisms.

6. The questions for individual learning:

6.1. Immunosorbents. Plasmosorption. Application therapy.

7. The examples of the task:

7.1. What is the difference between adsorption and absorption..

Answer:

Adsorption is the process of adsorbate accumulation into the surface of the adsorbent and absorption is the distribution the adsorbate in the bulk of the adsorbent.

8. Homework (must be performed in the laboratory notebook):

8.1. Write the example of the selective absorption.
8.2. Write the examples of the adsorption therapy application.

***9. The control test*:**
for instance:

9.1. How does the adsorption of gases change under temperature changing?
9.2. Adsorption theory of narcosis.
9.3. The basis of the ionic adsorption.

10. The algorithm of the experiments:

10.1. Adsorption of acetic acid by activated carbon.
10.2. Adsorption of the colored substances by activated carbon.
10.3. Dependence of the adsorption on the nature of the adsorbents.

11. The detailed explanation of the following experiment:

11.1. . Adsorption of acetic acid by activated carbon.

Prepare the solutions according to the table data.

№	C_0 CH_3COOH	ml of 0.1 N NaOH for 10 ml of acid	ml of 0.1 N NaOH for 25 ml of acid V_0	ml of 0.1 N NaOH for 10 ml of filtrate	ml of 0.1 N NaOH for 25 ml of acid V_1	Relateve adsorption value $\Delta V=V_0-V_1$
1	0.03 N					
2	0.07 N					
3	0.12 N					

Three test-tubes are put 1gram of activated carbon and filled by 25 ml of acetic acid solution with C_N= 0.03, 0.07 and 0.12 mol/L. The test-tubes are closed and periodically stirred for 20 min.

During 20 min 10 ml of 0.03, 0.07 and 0.12 mol/L acetic acid are titrated –V_0.

The mixtures must be filtrated from the activated carbon 20 min later. 10 ml of the filtrate are titrated by 0.1 N NaOH in the presence of phenolphthalein -V_1.
Calculate the relative adsorption value:$\mathbf{\Delta V=V_0-V_1}$. The table is filled. Depict the graphical dependence of ΔV on C_0. Make a conclusion**.**

11.2. Adsorption of the colored substances by activated carbon.

In the test tube add 1 ml of mixture of fuchsin and fluorescein, nest add 0.2 g of activated carbon and stir it for 3 min. Filtrate the mixture. Write the observations and make the conclusions.

11.3. Dependence of the adsorption on the nature of the adsorbents.

Prepare three test-tubes:

1 test-tube	2 test-tube	3 test-tube
5 ml $Pb(NO_3)_2$	5 ml $Pb(NO_3)_2$	5 ml $Pb(NO_3)_2$
0.2 g Al_2O_3	0.2 g activated carbon	—

The test-tubes must be shake 2 min and filtrated in the clean test-tubes. In every filtrate add 2 drops of KI solution. Write the observations and make the conclusions.

Topic ION EXCHANGE. CHROMATOGRAPHY

1. ***Actuality of the topic***: the selective adsorption is widely extended in human organisms. Chromatographic analysis, adsorption therapy, the lowering of water hardness are grounded on the adsorption phenomenon. Ionic exchange plays the crucial role in the transportation of the ions through the biological membrane.

2. ***General aim:*** is to formulate the theoretical knowledge of adsorption and ionic exchange for the following application in the medical practice.

3. Actual aims and abilities:

- ✓ to have an idea about of ionic exchange and its application in medical practice;
- ✓ to study the adsorption of the electrolytes (selective and ion exchange);
- ✓ to praxis in the separation and identification of the mixture using chromatography analysis

4. Literature:

4.1. Lecture materials;

5. The main questions of the seminar:

5.1. The adsorption of the electrolytes (selective and ion exchange).
5.2. Panet- Phayance rule.
5.3. The natural and synthetic ion-exchanger.
5.4. The role of ionic exchange in the processes of vital functions. Adsorption therapy.

6. The questions for individual learning:

6.1. Chromatography. The principles of the method.
6.2. Classification of the chromatographic analysis:
a) by the phase stage;
b) by techniques;
c) by distribution mechanism.
6.3. Adsorption chromatography, ion-exchange chromatography and partition chromatography.
6.4. Application of chromatography in biology and medicine.

7. The examples of the task:
7.1. *Adsorption of electrolytes*.
How are the ionites called on the surface of which the exchange of cations takes place?
Answer:
Ionites are called the cationic exchanger.
7.2. *Calculation of R_f of the components in the mixture.*
Calculate R_f of monosaccharides if the distance moved by solvent is 21 cm, the distance moved by glucose (1) is 13 cm and the distance moved by fructose (2) is 17 cm.
Answer:

$$R_{f\,1} = \frac{13}{21} = 0,62; \qquad R_{f\,2} = \frac{17}{21} = 0,81.$$

8. Homework (must be performed in the laboratory notebook):

8.1. Write the example of the adsorption phenomena in human organism.
8.2. The distance moved by solvent is 17 cm, the distance moved by amino acid is 13 cm. What is the amino acid if R_f of the following amino acids corresponds 0.84 for leucine; 0.76 for alanine; 0.91 for glycine.

***9. The control test*:**
for instance:
9.1. What is the stationary phase?
9.2. The distance moved by solvent is 43 cm, the distance moved by a substance is 28 cm. What is the carbohydrate under analysing if R_f of the following carbohydrates corresponds 0.88 for sucrose; 0.05 for fructose; 0.41 for ribose and 0.65 for glucose.
10. The algorithm of the experiments:
10.1. Paper chromatography of amino acids.
10.2. Circular paper chromatography.

11. The detailed explanation of the following experiment:
11.1. . Paper chromatography of amino acids.
Put a drop of the mixture of amino acids at the strip of the chromatographic paper about 1 cm from the base. Beside put a drop of the solution of the known

amino acids at the chromatographic paper about 1 cm from the base. The strip must be dried and dipped in the solvent (ethanol:water=7:3) and leave for 4-5 hours. Then the chromatogram is dried and revealed by and again must be dried. Calculate R_f of amino acids and make a conclusion.

11.2. Circular paper chromatography.

At the middle of the circular chromatographic paper drop of the mixture ($CuSO_4$, $FeCl_3$, $Co(NO_3)_2$). The cut and immerse in the water and seal the container. 10-15 min later paper draw out and filled by $K_4[Fe(CN)_6]$. Write the chemical equations. Classify the cations in the line of adsorption increasing.

Topic COLLOIDAL SOLUTIONS. SYNTHESIS, PURIFICATION AND PROPERTIES.

1. ***Actuality of the topic***: the theory of biological systems, the creation and development of life on the Earth are based on the knowledge of the dispersive systems. Therefore the study of the properties, synthesis and purification of colloids have a great meaning for understanding of many technological and vital processes, for studying of many subjects as namely biochemistry, pharmacy and other and for practice of physician.

2. General aim: is to interpret the formation of colloids in medical practice.

3. Actual aims and abilities:

- ✓ to use the phisico-chemical properties of colloids to estimate the properties of biological liquids, drugs;
- ✓ to interpret the properties of biological colloidal liquids;
- ✓ to be able to write the structure of the micelles.

4. Literature:

4.1. Lecture materials;

5. The main questions of the seminar:

5.1. Colloids (determination)
5.2. Synthesis of the colloidal systems.
5.3. Purification of colloids. Artificial kidney.
5.4. Micelle structure. Panet-Phayance rule.
5.5. Colloidal solutions in medicine.

6. The questions for individual learning:

6.1.Classification of the colloids: by particle size, dispersed and dispersing phases, interfacing interaction.
6.2. Molecular-kinetic properties of colloids (Brownian movements, diffusion in sols, osmotic pressure)
6.3. Optical property of colloids. Tyndall effect.

6.4. Electrophoresis and its application in medical practice.

7. The examples of the task:

7.1. *Micelle structure*.

Write the micelle formula of sol obtained in the below given reaction.

$AgNO_{3(excess)} + Na_2SO_4 \rightarrow$

Answer:

$2AgNO_{3(excess)} + Na_2SO_4 \rightarrow Ag_2SO_4 + 2NaNO_3$

Sol of silver (I) is obtained. As the solution of $AgNO_3$ is taken in excess due to the Panet-Payance rule the potential-determining ions are Ag^+. The particle has positive charge.

7.2. *Electro-kinetic property of sol particles.*

Sol of AgI is obtained adding 20 ml 0.01 mol/L of KI solution to 10 ml of 0.2 % $AgNO_3$ (ρ = 1) solution. What is the charge of the particles? Write the structure of the micelle. How do the particles move in electric field?

Answer:

To find the potential-determining ions, it needs to detect what the reactant is in excess.

$AgNO_3 + KI \rightarrow AgI + KNO_3$

$$m(AgNO_3)=\frac{10\cdot 0,2}{100}=0,02\ g$$

$$n(AgNO_3)=\frac{0,02г}{170г/моль}=0,00013\ mol$$

$$m(KI)=\frac{20\cdot 0,01}{1000}\cdot 166=0,033\ g$$

$$n(KI)=\frac{0,033}{166}=0,0002\ mol$$

Calculations show that KI ions are in excess. Therefore potential-determining ions are iodide ions.

$$\{m[AgI]\cdot nI^-(n\text{-}x)K^+\}^{X-}\ x\ K^+$$

The charge of the particles is negative and the movement of the last is directed to the anode.

8. Homework (must be performed in the laboratory notebook):

8.1. Write the structure of PbI_2 micelle obtained after mixing of KI и Pb $(NO_3)_2$ solutions if

a) KI solution is in excess;

b) Pb $(NO_3)_2$ solution is in excess.

How do the particles move in electric field?

***9. The control test*:**

for instance:

9.1. Write the micelle structure after reaction of silver nitrate and calcium bromide solutions at the condition:

a) when silver nitrate is in excess;
b) when calcium bromide is in excess.

9.2. Write the classification of the dispersive systems by particle size. Write the examples.

10. The algorithm of the experiments:

10.1. Synthesis of $Fe(OH)_3$ sol by hydrolysis.
10.2. Synthesis of $Fe(OH)_3$ sol by peptization.
10.3. Synthesis of sulfur sol by the solvent exchange method.
10.4. Synthesis of sulfur sol by chemical reaction.

11. The detailed explanation of the following experiment:

11.1. Synthesis of $Fe(OH)_3$ sol by hydrolysis.

Fill the chemical glass by 20 ml of water and heat to 100 °C. Add 1 ml of diluted $FeCl_3$ solution. Note the colour, write the micelle structure.

11.2. Synthesis of $Fe(OH)_3$ sol by peptization.

In the test-tube add 1 drop of the saturated $FeCl_3$ solution, 1 drop of NH_4OH solution and 2 ml of water. The resulting solution divide in 3 test-tubes. In the first test-tube add HCl solution until dissolving occurs, in second one add saturated $FeCl_3$ solution until dissolving occurs, the last one is the blank experiment. Write observations and chemical reactions. Make conclusions.

11.3. Synthesis of sulfur sol by the solvent exchange method.

In test tube add 5 ml of water and ethanolic solution of sulphur dropwisely under permanent mixing. Write observations and explain the formation of colloidal solution.

11.4. Synthesis of sulfur sol by chemical reaction.

In test tube add 5 ml of $Na_2S_2O_3$ solution and 1 ml of phosphoric acid under permanent mixing. Write observations. Make conclusions.

Topic COAGULATION OF COLLOIDS. COLLOIDAL STABILITY.

1. ***Actuality of the topic***: the biological liquids as namely blood, serum, lymph present the colloidal systems where proteins, cholesterol and glycogen are in colloidal state. Destruction the colloidal state leads to the illnesses and pathology. A great number of drugs are manufactured in the state of high dispersive suspension.

2. ***General aim:*** is to study the theoretical bases of coagulation and protection of colloidal systems.

3. Actual aims and abilities:

- ✓ to know the stability factors of dispersive systems;

✓ to know the factors influenced on stability and coagulation of dispersive systems;
✓ to learn the synthesis and properties of aerosols, emulsions, the low dispersive systems;
✓ to be capable determining of coagulation concentration.

4. Literature:

4.1. Lecture materials;

5. The main questions of the seminar:

5.1. Kinetic and aggregative stability of sols, the stability factors.
5.2. Coagulation and the factors influenced on the coagulation.
5.3. Coagulation mechanism. Schulz-Hardy rule.
5.4. Coagulation ability of electrolytes. Reciprocal coagulation.
5.5. Coagulation concentration.
5.6. Colloidal stability.
5.7. Coagulation in the water purification process.

6. The questions for individual learning:

6.1. Aerosols: the preparation methods, properties, application in medicine. Poisonous action.
6.2. Suspensions: the preparation methods and properties.
6.3. Emulsion: the preparation methods and properties. Types. Emulsifying agent. Application in clinical practices. Biological role of emulsification.

7. The examples of the task:

7.1. Sol coagulation by electrolytes.

Sol can be form after adsorbing of oxalic acid by kidneys from gastrointestinal tract

$CaCl_{2excess} + H_2C_2O_4 \rightarrow$

a) What is the charge of the particle?
b) Which kind of the following ions K^+, Mg^{2+}, NO_3^-, PO_4^{3-}, Al^{3+}exhibits the coagulation action for the particles of the given sol?

Answer:

$$CaCI_{2excess} + H_2C_2O_4 \rightarrow CaC_2O_4 + 2HCI$$

Sol of calcium oxalate is formed. The micelle structure is

$\{mCaC_2O_4 \cdot nCa^{2+} \cdot 2(n-x)Cl^-\}^{2X+} \cdot 2xCl^-$

When the particle has a positive charge the coagulating ions are NO_3^-, PO_4^{3-} according to Schulze-Hardy law.

7.2. Determination of coagulation concentration.

The coagulation concentration of $Fe(OH)_3$ sol for KI and $K_2Cr_2O_7$ electrolytes are 10.0 and 0.095 mmol/L respectively. In how many times the coagulation ability of $K_2Cr_2O_7$ is higher than KI?

Answer.

The coagulation ability of the electrolyte is the reverse value to the coagulation concentration.

$$P = \frac{1}{C}$$

$$P_{KI} = \frac{1}{10} = 0,1$$

$$P_{K_2Cr_2O_7} = \frac{1}{0,195} = 5,1$$

$P_{KI} : P_{K2Cr2O7} = 0.1 : 5.1 = 1 : 51$

For $Fe(OH)_3$ sol the coagulation ability of $K_2Cr_2O_7$ is higher in 51 times than of KI.

8 Homework (must be performed in the laboratory notebook):

8.1. The coagulation concentrations of a sol by electrolytes are C ($NaNO_3$) = 250.0; C ($Mg(NO_3)_2$) = 20; C (Fe ($NO_3)_3$) = 0.5 (mg-eq/L). What are the coagulating ions? What is the charge of the sol particles?

***9. The control test*:**
for instance:

9.1. Write the structure of AgI micelle if the excess of KI was added to $AgNO_3$ solution.

9.2. Select the ions (Na^+, Li^+, Cl^-, SO_4^{2-}, Cr^{3+}, Pb^{2+}, CH_3COO^-, PO_4^{3-}, OH^-, Cs^+, Sr^{2+}, Br^-, Mg^{2+}) that are able to cause the coagulation of the colloidal particles described in question 1.

10. The algorithm of the experiments:

10.1. Conformation of Schulze-Hardy rule.
10.2. Dependence of the coagulation concentration on the charge of coagulating ion.
10.3. Synthesis of emulsion.

11. The detailed explanation of the following experiment:

11.1. Conformation of Schulze-Hardy rule.

Three test-tubes are filled:

1 test-tube	2 test-tube	3 test-tube
5ml $Fe(OH)_3$ sol	5ml $Fe(OH)_3$ sol	5ml $Fe(OH)_3$ sol
1 ml of KCl solution	1 ml of K_2SO_4 solution	1 ml of $K_3[Fe(CN)_6]$ solution

The solution are mixed and the coagulation consecution is observed. Write the micelle structure of $Fe(OH)_3$ sol and arrange the coagulating ions in liotropic row.

11.2. Dependence of the coagulation concentration on the charge of coagulating ion.

Prepare the ammonium sulfate solutions of different concentrations:

In the first test-tube add 10 ml of ammonium sulfate (C_N=1 mol/L).

In the second test-tube add 9 ml of water and 1ml of ammonium sulfate from the first test tube.

In the third test-tube add 9 ml of water and 1ml of ammonium sulfate from the second test tube.

Analogous prepare the forth, fifth and sixth test-tube.

Then add 2 ml of iron (III) hydroxide sol to every test-tube. Fill the below given table marking by "+" and "-".

Analogous perform the experiments with ammonium chloride. Make the conclusions.

Electrolytes	***Coagulating ion***	***Concentration of the electrolyte in the test-tube, mol/L***							***Coagulation concentration***
		1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	
$(NH_4)_2SO_4$	SO_4^{2-}								
NH_4C1	Cl^-								

11.3. Synthesis of emulsion.

The test-tube is filled by 5 ml of water and 5 drops of vegetable oil. Mix intensively. For emulsion stabilization add 5 drops of NaOH. Again shake the test-tube. Note the observation and make a conclusions.

Topic . PROPERTIES OF BIOPOLYMERS. ISOELECTRIC POINT.

1. Actuality of the topic: Biopolymers (proteins, polysaccharides, nucleic acids) are included in the structure of the cells performing the function of the accumulation of nutrients and energy. Nucleic acids together with proteins are the source of hereditary information, glycol proteins occasion the blood group.

2. General aim: is to estimate the polymer's property based on the chemical nature and characteristics of macromolecules.

3. Actual aims and abilities:

- ✓ to classify the polymers by type of monomers and spatial structure;
- ✓ to forecast the swelling process and the polymer's solubility on the base of thermodynamic laws.

4. Literature:

4.1. Lecture materials;

5. The main questions of the seminar:

5.1. What are the polymers?
5.2. Isoelectric state and isoelectric point of the proteins.
5.3. Protection action of proteins, protection number, biological meaning.
5.4. Swelling of polymers (the determination, mechanism, the factors). The fixed water, the properties and biological meaning.
5.5. The stability of polymers. Factors of stability.
5.6. Gelatinization of polymer solution, mechanism, factors, biological meaning.

5.7. Galantines, reaction in galantines, biological meaning.

6. The questions for individual learning:

6.1. Classification of polymers.
6.2. Salting out of the polymers, mechanism, factors, biological meaning.
6.3. Thixotropy, syneresis, coacervation, their biological meaning.

7. The examples of the task:
7.1. What is the influence of pH on gelatinization of proteins.
Answer:
The highest stage of gelatinization takes place at isoelectic point due to the neutrality of the proteins and the loss of stability is observed.

8. Homework (must be performed in the laboratory notebook):

8.1. Biological meaning of fixed water.
8.2. What are the substances extracted from blood by using salting out.

10. The algorithm of the experiments:
10.1. Determination of isoelectric point.
10.2. Determination of coagulation concentration of protected sol.
10.3. Swelling.
10.4. Influence of pH on swelling.
10.5. Influence of electrolytes on swelling.

11. The detailed explanation of the following experiment:
11.1. . Determination of isoelectric point.

Concurrently 2 ml of acetate buffer with pH according to the table are added in 4 test-tubes. Then add 1 ml of 0.5% gelatine solution and mix them. Carefully add 3 ml of ethanol. Five min late estimate the dimness of every solutions and determine the isolectric point of gelatine.

№	*pH of the system*	*0,5% gelatine solution, ml*	*Ethanol, ml*	*Dimness stage*
1	3,8	1	3	
2	4,4	1	3	
3	4,7	1	3	
4	5,1	1	3	

11.2. Determination of coagulation concentration of protected sol.

Prepare the ammonium sulfate solutions of different concentrations:

In the first test-tube add 10 ml of ammonium sulfate (C_N=1 mol/L).

In the second test-tube add 9 ml of water and 1ml of ammonium sulfate from the first test tube.

In the third test-tube add 9 ml of water and 1ml of ammonium sulfate from the second test tube.

Analogous prepare the forth, fifth and sixth test-tube.

Then add 2 ml of iron (III) hydroxide sol. Determine the coagulation concentration. Prepare again the ammonium sulfate solutions of different concentrations and add 1 ml gelatine then 2 ml of iron (III) hydroxide sol. Determine the coagulation concentration for both cases and compare the data. Make a conclusion.

11.3. Swelling..

A piece of rubber immerse in the benzene, the second piece of rubber in water. Explain the observations.

11.4. Influence of pH on swelling.

1 test-tube	II test-tube	III test-tube
dry gelatine	dry gelatine	dry gelatine
5 ml of HC1	5 ml of acetate buffer with pH = 4,7	5 ml of NaOH

15 min later note the results. Make a conclusion.

11.5. Influence of electrolytes on swelling.

1 test-tube	II test-tube	III test-tube
dry gelatine	dry gelatine	dry gelatine
5 ml of K_2SO_4	5 ml of KC1	5 ml of KSCN

15 min later note the results. Make a conclusion.

Questions for module 2.

1. The first thermodynamic law. Internal energy. Enthalpy.
2. Thermochemistry. Thermochemical equations. Standard enthalpy of formation and combustion.
3. The second thermodynamic law. Entropy. Gibbs energy. Direction of spontaneous reactions. Exergonic and endergonic processes in organism.
4. Rate of the chemical reactions. Mass action law for the reaction rate. Rate constant.

5. The complicated and simple reactions: consecutive, parallel, reversible and chain reactions. Photochemical reactions and their role in vital activity.
6. Order of the reaction. Reactions of zerouth, first and second orders. Life-time.
7. Dependence of reaction rate on temperature. Temperature coefficient. Van't Hoff rule. Peculiarity of temperature coefficient for biochemical processes.
8. Arrhenius equation. Activation energy. Collision theory and transition state theory.
9. Chemical equilibrium. Thermodynamic condition of equilibrium.
10. Chemical equilibrium constant. Le Chatelier's principle. Shift of chemical equilibrium.
11. Homogeneous and heterogeneous catalysis. Action of the catalysts. Mechanism of catalysis and its role in metabolism processes.
12. Enzymes as the catalysts of biochemical reactions. Dependence of enzymatic action on the concentration of substrate, temperature and pH.
13. Macroergonic compounds. ATP as a source of energy for biochemical reactions.
14. Precipitation and dissolution reactions. Solubility product.
15. Electrode potentials and mechanism of its creation. Nernst equation. Standard electrode potential. Reference and secondary electrodes. Ion selective electrodes.
16. Redox potentials and mechanism of its creation. Nernst equation
17.. Redox reactions in human organism. Directions of the reaction using the data of standard Gibbs energy and standard redox potentials.
18. Potentiometric titration. Its application in medical and biological investigations.
19. Diffusion and membrane potentials and their biological role.
20. Polymers. Isoelectrical point of proteins and its determination.
21. Mechanism of swelling and solubility of polymers. Role of the swelling in physiology of organism.
22. Gelation of polymers. The properties of galantines.
23. Viscosity of polymers. Viscosity of blood and other biological liquids.
24. Surface tension. Duclo-Traube rule. Gibbs equation. Orientation of molecules at the interface and structure of biological membrane.
25. Adsorption into the solid surface. Langmur and Freundlich isoterms. Adsorption therapy.
26. Selective and ion exchange adsorption of electrolytes. Panet-Phayance rule. Ionites and their application in medicine.
27. Chromatography. Classifications by mechanism, phase stage, techniques. Application of chromatography in medical and biological investigations.
28. Dispersive systems and their classification. Synthesis and purification of colloids. Dialysis, electrodialysis, ultrafiltration.
29. Structure of colloidal micelle.
30. Electrokinetical potential. Electrophoresis and its application in medicine.
31. Stability of colloids. Coagulation by electrolytes. Schultze-Hardy rule. Coagulation ability and concentration.

Types of the tasks.

1. Calculation of Gibbs energy.
2. Thermochemical calculations.
3. Calculation of the reaction rates.
4. Calculation of equilibrium constant.
5. Solubility product calculation.
6. Calculation of redox potential.
7. Calculation using R_f.
8. Micelle structure.