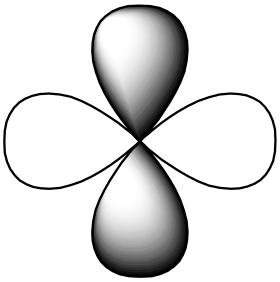
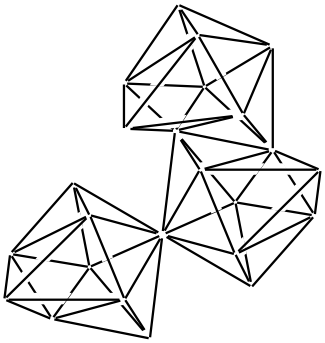
Vinnytsia National Pirogov Memorial Medical University
Biological and General Chemistry Department
Medical chemistry course





SYSTEMATIC COURSE

practical lessons of medical chemistry for foreign students

Module 1. Acid-base equilibrium and chemistry of complexes in biological liquids

Vinnytsia 2017

A work sheet and methodical developments (Methodical of recommendation for practical classes from Medical chemistry for 1-st year foreign students) are made by the employees of department of biological and general chemistry of VNMMU Pirogov in accordance with a curriculum, worked out on principles of the European credit-transfer system (ECTS) for higher medical establishments of Ukraine III - IV levels of accreditation for specialities of "Medical Affairs" direction of the preparation "Medicine" is in accordance with education qualification descriptions (EQD) and scientific profesional programs (SPP) of the preparation of specialists, approved by an order MES Ukraine from 16.04.03 № 239.

It is considered and accepted on a meeting of the methodical soviet of medical-theoretical disciplines, protocol № 1 from 30.08.2017y.

It is discussed and approved on a meeting of the department of biological and general chemistry, protocol № 1 from 28.08.2017y.

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CONTENT

SAFETY IN THE CHEMICAL LABORATORY AND FIRST AID RULES.

1. The chemical laboratory must be always extremely clean and kept 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 helpfull 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*	*Residence*
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: Periodic system of D.I. Mendeleev. Electron-atomic structure of elements and ions.

1. Actuality of the topic: The laboratory safety information allows to avoid undesirable incidents during practical chemical experiments. The students are offered a refresher course on the structure of chemical compounds to study inorganic chemistry deeply.

2. General aim:
- mastering the rules of the laboratory safety;
- to be capable of explaining the dependence of location and properties of chemical elements in Periodic Table.

3. Actual aims and abilities:
- to know electronic structure of atoms;
- to master the Periodic Law and to be orientated in Periodic Table of D.I.Mendeleev;
- to be capable of writing the various types of chemical reactions.

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. and S.D. Gammon. 2002. General Chemistry. Seventh Edition.Houghton Mifflin Co., Boston, MA.

5. The main questions of the seminar:
5.1. The introduction to the laboratory safety.
5.2. Mendeleev Periodic Law as a background of inorganic chemistry.
5.3. Electronic structure of atoms and ions.
5.4. The groups of inorganic compounds.

TOPIC 2: Biogenic s-elements, chemical properties, biological role and application in medicine.

***1. Actuality of the topic*:** humans and the environment consist of chemical compounds which have properties that influence the mechanism of biological activities. The medicines and drugs are synthesized from them, overcoming the complex chemical ways.

2. General aim: To study the properties of s-elements and their influence on the human organism.

3. Actual aims and abilities:
- to understand the characteristics of energetic states of the given elements;
- to know the compounds of elements and their properties;
- to be able to write the electronic configuration of atoms and ions;
- to carry out the quantitative analysis.

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. and S.D. Gammon. 2002. General Chemistry. Seventh Edition. Houghton Mifflin Co., Boston, MA.

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

5.1. s-elements:
- electronic structure,
- oxides, hydroxides,
- peroxides, superperoxides,
- biological meaning of sodium, potassium, calcium, magnesium, strontium.

6.The questions for individual learning:

6.1. The role of biogenic elements in human organism.
6.2. The scientific study of V. I. Vernadskiy about biosphere.
6.3. The medicines containing of sodium, potassium, calcium, magnesium.

7. The examples of the task:

7.1. The chemical conversion of calcium is given. Write the chemical reaction of the scheme:
$Ca \rightarrow CaO \rightarrow Ca(OH)_2 \rightarrow CaCO_3$

The answer:

$2Ca + O_2 \rightarrow 2CaO$

$CaO + H_2O \rightarrow Ca(OH)_2$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

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

8.1. Hydrogen (H_2) acts as the oxidizing agent as well as the reducing agent. How do you explain the redox properties of it?
8.2. The chemical conversion of sodium is given. Write the reaction of the given scheme:
$Na_2CO_3 \rightarrow NaHCO_3 \rightarrow Na_2CO_3 \rightarrow BaCO_3$

9. The control test **contains 3 tasks:**

9.1. Write the electronic configuration of the sodium atom and ion.
The electronic formula of Na atom is $1s^2 2s^2 2p^6 3s^1$ and Na^+ is $1s^2 2s^2 2p^6 3s^0$
9.2. Write the electronic configuration of the beryllium atom and ion.
The electronic formula of Be atom is $1s^2 2s^2$ and Be^{+2} is $1s^2 2s^0$
9.3. Write the chemical equations of the given chain:
a) $BeCl_2 \rightarrow Be(OH)_2 \rightarrow BeSO_4$

The answer:

$BeCl_2 + 2NaOH \rightarrow Be(OH)_2 + NaCl$

$Be(OH)_2 + H_2SO_4 \rightarrow BeSO_4 + 2H_2O$

10. The algorithm of the experiments:

10.1. The quantitative reaction on the potassium ions.
10.2. The quantitative reaction on the calcium ions.
10.3. The quantitative reaction on the magnesium ions.

11. The detailed explanation of the following experiments:

11.1. The qualitative reaction on the potassium ions.

Put 5 drops of tartric in a test-tube then add 5 drops of KOH and the resulting solution must be mixed by a glass rod to form a precipitate.
Note the effect of the reaction, write the chemical equation, and make a conclusion.

11.2. The qualitative reaction on the calcium ions.
In a test-tube put 2 drops of $Na_2C_2O_4$ solution and add 1 drop of $CaCl_2$ solution. Note the effect of the reaction, write the chemical equation, and make a conclusion.

11.3. The qualitative reaction on the magnesium ions.
In a test-tube put 2 drops of magnum chloride solution and add the ammonia solution until precipitation occurs. Then add certain amounts of ammonium chloride solution for complete disappearance of the precipitation. Write the chemical equation, and make a conclusion.

TOPIC 3: Biogenic p-elements, chemical properties, biological role, application in medicine.

1. ***Actuality of the topic*:** the chemical compounds of p-elements play an important role in human activity. Some of them are used as medicals but others pollute the nature and are toxic for humans.

2. ***General aim*:** is to study the properties of p-elements and biomedical influence on the human organism.

3. Actual aims and abilities:
- to understand the character of energetic states of given elements;
- to know the compounds of elements and their properties;
- to be able to write the electronic configuration of atoms and ions;
- to carry out the quantitative analysis.

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. and S.D. Gammon. 2002. General Chemistry. Seventh Edition. Houghton Mifflin Co., Boston, MA.

5*. The main questions of the seminar:*
5.1. p-elements:
- electronic structure, valancy, the oxidation stage;
- acid-base properties,
- redox properties,
- biological meaning of nitrogen oxide (II), nitrites, phosphorus, arsenic, oxygen, sulphur, halogens.

6.The questions for individual learning:
6.1. The biological role and medicals of phosphorus, arsenic, oxygen, sulfur, halogens.

7. The examples of the task:
7.1. Write the chemical reaction of the presented chemical conversion:
$P_2O_5 \rightarrow H_3PO_4 \rightarrow Ca_3(PO_4)_2 \rightarrow CaHPO_4$
The answer:
$P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$
$2H_3PO_4 + 3Ca(OH)_2 \rightarrow Ca_3(PO_4)_2 + 6H_2O$
$Ca_3(PO_4)_2 + H_3PO_4 \rightarrow 3CaHPO_4$

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

8.1. White the electronic configuration of S in the oxidation stage +4.

8.2. Write the chemical reaction of the scheme: $S \rightarrow SO_2 \rightarrow SO_3 \rightarrow Na_2SO_4$.

8.3. What are the products of the reaction: $NaI + KMnO_4 + H_2SO_4 \rightarrow$

***9. The control test* contains 3 tasks:**

for instance:

9.1. Write the electronic configuration of nitrogen atom and ion in the oxidative stage +4.
The electronic formula of N atom is $1s^2 2s^2 2p^3$ and N^{+4} is $1s^2 2s^1$

9.2. Write the chemical equations of given chain:

$SO_2 \rightarrow SO_3 \rightarrow H_2SO_4$

The answer:

$SO_2 + O_2 \rightarrow SO_3$

$SO_3 + H_2O \rightarrow H_2SO_4$

9.3. Complete the redox reaction and fix the coefficients using the method of electronic balance:

$H_2S + KMnO_4 + HNO_3 \rightarrow$

The answer:

$5H_2S + 2KMnO_4 + 6HNO_3 \rightarrow 2Mn(NO_3)_2 + 5S + 2KNO_3 + 8H_2O$

$S^0 + 2e^- \rightarrow S^{2-} \quad | \ 5$

$Mn^{7+} + 5e^- \rightarrow Mn^{2+} \quad | \ 2$

10. The algorithm of the experiments:

10.1. The quantitative reaction on the carbonate ions.

10.2. The quantitative reaction on the sulphate ions.

10.3. The quantitative reaction on the nitrite ions.

10.4. The quantitative reaction on the tiosulphate ions.

11. The detailed explanation of the following experiments:

<u>11.1. The qualitative reaction on the carbonate ions</u>

In a test-tube put 2 drops of Na_2CO_3 solution and add 2 drops of $BaCl_2$ solution. After the appearance of the precipitation acetic acid must be added. Note the effect of the reaction and write the equations. Make a conclusion.

<u>11.2. The qualitative reaction on the sulfate ions</u>

In a test-tube put 2 drops of H_2SO_4 solution and add 2 drops of $BaCl_2$ solution. Then add 5 drops of hydrochloric acid must be added to the formed precipitation. Note the effect of the reaction and write the equations. Make a conclusion.

<u>11.3. The qualitative reaction on the nitrite ions</u>

In a test-tube put 2 drops of $NaNO_2$ solution and add 2 drops of acetic acid and 2 drops of KI. Note the effect of the reaction. Write the equations. Make a conclusion.

<u>11.4. The qualitative reaction on the tiosulfate ions.</u>

In a test-tube put 3 drops of $Na_2S_2O_3$ solution and add 2 drops of hydrochloric acid. Note the effect of the reaction. Write the equations. Make a conclusion.

TOPIC 4: Biogenic d- elements, chemical properties, biological role, application in medicine.

1. ***Actuality of the topic*:** tiny amount of d-elements are contained in human organism. However the role of these micro elements is significant in physiologic and patalogic processes. The nature of micro elements influences the structure and properties of enzymes. The disfunction of metabolism causes a various type of diseases.

2.General aim: is to study the properties of d-elements and its biological meaning.

3. Actual aims and abilities:
- to understand the character of energetic states of given elements;
- to be capable explaining the acid-base properties of d-elements;
- to understand the main concept of the complexes;
- to know the medicals and drugs containing d-elements.

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. and S.D. Gammon. 2002. General Chemistry. Seventh Edition. Houghton Mifflin Co., Boston, MA.

5. The main questions of the seminar:
Chromium as an example of d-elements: electronic structure, oxidation stage, acid-base properties, redox properties.

6. The questions for individual learning:
6.1. The biological role and medicals of iron, zinc, manganese, molybdenum compounds.

7. The examples of the task:
7.1.Write the equations of the given chemical conversion:
$Fe \rightarrow FeO \rightarrow FeSO_4 \rightarrow Fe(OH)_2$
Answer:
$2Fe + O_2 \rightarrow 2\ FeO$
$FeO + H_2SO_4 \rightarrow FeSO_4 + H_2O$
$FeSO_4 + 2NaOH \rightarrow Fe(OH)_2 + Na_2SO_4$

8. Homework (must be performed in the laboratory notebook):
8.1. Write the chemical reaction of the scheme:
$Fe_2O_3 \rightarrow Fe_2(SO_4)_3 \rightarrow NaFeO_2 \rightarrow FeCl_3$
8.2. Finish the redox reaction: $K_2Cr_2O_7 + NaCl + H_2SO_4 \rightarrow$

***9. The control test* contains 3 tests:**
for instance:
9.1. The electronic configuration of iron (II)
9.2. Write the equations of the chemical conversion:
$Cr_2O_3 \rightarrow Cr_2(SO_4)_3 \rightarrow Cr(OH)_3$
The answer: $Cr_2O_3 + H_2SO_4 \rightarrow Cr_2(SO_4)_3 + H_2O$
$Cr_2(SO_4)_3 + 6NaOH \rightarrow 2Cr(OH)_3 + 3Na_2SO_4$
9.3. Write the reaction products and the equation coefficients using the electronic balance of the reaction:

$$10FeSO_4 + 2KMnO_4 + 8H_2SO_4 \rightarrow 5Fe_2(SO_4)_3 + 2MnSO_4 + K_2SO_4 + 8H_2O$$

$$Fe^{3+} + 1e^- \rightarrow Fe^{2+} \quad | \ 5$$

$$Mn^{7+} + 5e^- \rightarrow Mn^{2+} \quad | \ 1$$

10. The algorithm of the experiments:

10.1. The quantitative reaction on the manganate- ions.
10.2. The quantitative reaction on the iron (II) ions.
10.3. The quantitative reaction on the iron (III) ions.
10.4. The quantitative reaction on the copper (II) ions.

11. The detailed explanation of the following experiments:

11.1. The qualitative reaction on the manganate ions

In a test-tube put 2 drops of $KMnO_4$ solution, then add 2 drops of H_2SO_4 solution with the following dropwise adding of H_2O_2. Note the effect of the reaction and write the equations. Make a conclusion.

11.2. The qualitative reaction on the iron (II) ions

In a test-tube put 2 drops of $FeSO_4$ solution and 2 drops of $K_3[Fe(CN)_6]$. Note the effect of the reaction and write the equations. Make a conclusion.

11.3. The qualitative reaction on the iron (III) ions

a) In a test-tube put 2 drops of $FeCl_3$ solution and 2 drops of $K_4[Fe(CN)_6]$. Note the effect of the reaction and write the equations. Make a conclusion.
b) In the test-tube put 2 drops of $FeCl_3$ solution and 2 drops of KSCN. Note the effect of the reaction and write the equations. Make a conclusion.

11.4. The qualitative reaction on the copper (II) ions

a) In a test-tube put 2 drops of $CuSO_4$ solution and 2 drops of ammonia. Note the effect of the reaction and write the equations.

TOPIC 5 : The formation of complexes in biological systems.

***1. Actuality of the topic*:** many chemical substances are identified in quantitive and qualitative analysis conversting to the complexes. The complexes have physiological significance in the processes of breathing, photosynthesis, biological oxidation, and enzymatic catalysis.

2. General aim: to explain the physiological action of the complexes and their application as medicals.

3. Actual aims and abilities:

- to know the structure and nomenclature of complexes;
- to be able to write the instability constant of complexes.

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. and S.D. Gammon. 2002. General Chemistry. Seventh Edition. Houghton Mifflin Co., Boston, MA.

5. The main questions of the practical lesson:

5.1. What are the complexes?

5.2. The basic rules of Werner theory (central atom, ligands, coordination number exterior sphere).

5.3. Classification of the complexes:

- by charge of complex ion;
- by nature of ligands;
- by chelates;

5.4. Dissociation of complexes,the constant instability of complexes.

5.5. Biological meaning of complex irons-, cobalt-, zinc- containing biocomplexes; complexions.

6. The questions for individual learning:

6.1. Isomerization of complexes (geometric, hydrated).

7. The examples of the task:

7.1. How can the compound $[Ag(NH_3)_2]OH$ be named?

The answer: diamminesilver (I) hydroxide

7.2. What is the charge of the central ion in the molecule $Na[Al(OH)_4]$?

The answer:

The charge of sodium is +1, the charge of hydroxide groups is -1, the charge of aluminum ion is X (unknown).

$(+1) + 4(-1) + X = 0$

$X = +3$

7.3. What is the charge of complex ion in the molecule $[Co(NH_3)_5CI]CI_2$:

The answer:

The charge of chloride ion in the exterior sphere is -1, the charge of complex ion is +2.

7.4. Write the dissociation of complex compound $[Co(NH_3)_5CI]CI_2$:

The answer:

$[Co(NH_3)_5CI]CI_2 \leftrightarrow [Co(NH_3)_5CI]^{2+} + 2CI^-$

7.5. Write the instability constant of $[Co(NH_3)_5Br]SO_4$:

The answer:

$[Co(NH_3)_5Br]SO_4 \leftrightarrow [Co(NH_3)_5Br]^{2+} + SO_4^{2-}$

$$K_{instab} = \frac{[Co(NH_3)_5Br] \cdot [SO_4]}{[Co(NH_3)_5Br]SO_4}$$

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

8.1. How do you call the substances?

$[AI(H_2O)_6]CI_3$;

$Na_3[Co(NO_2)_6]$;

$K_2[HgI_4]$.

8.2 What is the charge of complex ion and central ion in given compounds?

$Na_3[Cr(OH)_4SO_4]$;

$[Pt(NH_3)_4CI_2]CI_2$.

8.3. Write the equation of K_{instab} of complex ion $[Fe(CN)_6]^{4-}$

***9. The control test* contains 5 tests:**
for instance:
9.1. If given the complex of copper $[Cu(NH_3)_4]SO_4$:
How is it named?
What is the charge of complex ion?
What is the oxidation stage of metal ion?
What is the coordination number?
How does the dissociation equation look like? (write it)

9.2. If given the complex of $Fe_4[Fe(CN)_6]_3$:
How is it named?
What is the charge of complex ion?
What is the charge of central ion?
What is coordination number?
How does the dissociation equation look like? (write it)

10. The algorithm of the experiments:
10.1. Formation of sodiumaluminate.
10.2. Instability of complex ions.
10.3. Formation of potassiumtriiodide.

11. The detailed explanation of the following experiments:
11.1. Formation of sodiumaluminate.
Put 1 drop of $AlCl_3$ solution in a test-tube, then add 1 drop of NaOH solution until precipitation occurs. Then the excess of NaOH must be added to dissolve the precipitation. Note the effect of the reaction and write the equations. Make a conclusion.

11.2. Instability of complex ions.
Put 2 drops of $CoCl_2$ solution in the test-tube and 3 drops of concentrated NH_4SCN solution until the blue color appears. Then add water and the color is changed. Note the effect of the reaction and write the equations. Make a conclusion.

11.3. Formation of potassiumtriiodide
In a test-tube put 1-2 crystals of I_2 and add 3 ml of H_2O. Then add the concentrated solution of KI until dissolving of the crystals(by drops). Note the effect of the reaction and write the equations. Make a conclusion.

TOPIC 6: Preparation of the solutions and calculation of their concentrations.

1. Actuality of the topic: Preparation of the solution with certain concentration is necessary for following studying of biochemistry, pharmacy, hygiene and for interpretation of laboratory analysis data as well as for calculation of the medical dose.

2. General aim: *is* to learn the different ways of concentration expression and relationship between them.

3. Actual aims and abilities:
- to be capable of calculating the mass of the solid substance for preparing the solution;
- to have information about using chemical apparatus for soluted preparation.

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. and S.D. Gammon. 2002. General Chemistry. Seventh Edition. Houghton Mifflin Co., Boston, MA.

5. The main questions of the seminar:

5.1. What is the mass fraction?

5.2. What is the molar concentration?

5.3. Factor of equivalency (acids, bases, salts, oxidizing agents, reducing agents)

5.4. Molar mass of equivalent;

5.5. Relationship of various concentration expressions;

5.6. The law of equivalent.

6. The questions for individual learning:

6.1. Molality;

6.2. Laboratory apparatus for the solution preparation (the volumetric flasks, the calibration pipets, burets and others)

7. The examples of the task:

7.1. How many grammes of boric acid and water do you need for preparation of 250 g of solution with the mass fraction of boric acid equal 3%?

The answer: mass percentage is calculated using the equation 5.1

$$\omega = \frac{m_x}{m_p} \cdot 100\% \omega \qquad 5.1$$

thus, $m_x = \frac{\omega \cdot m_p}{100}$ 5.2

$$m_{H_3BO_3} = \frac{3 \cdot 250}{100} = 7.5\,\text{g}$$

weight of water is 242,5 g: 250-7,5 = 242,5 g

7.2. How many grammes of sodium chloride must be taken for preparation of 1 l of solution withC_X =2 mol/l?

The answer: molar concentration is calculated using the equation 5.3

$$C_x = \frac{m_x}{M_x \cdot V_p} \qquad 5.3$$

thus, $m_x = C_x M_x V_p = 2 \cdot 58.5 \cdot 1 = 117$ g

7.3. What weigh of $KMnO_4$ have to be taken for preparation of 2 l of the solution with C_N=0.5 mol/l analyzing in the acid medium?

The answer: molar concentration is calculated using the equation 5.4

$$C_m = \frac{m_x}{M_x \cdot feqv \cdot V_p} \qquad 5.4$$

thus, $m_x = C_m M_x feqv V_p = 0.5 \cdot 158 \cdot 1/5 \cdot 2 = 31.6$

7.4. What is the molar concentration of equivalent of sulfuric acid if the weight fraction is 10

% (density is 1.22, f_{eqv} = 1/2).
The answer: molar concentration of equivalent is

$$C_n = \frac{\omega \cdot \rho \cdot 10}{M_x \cdot feqvx} = \frac{10 \cdot 1.22 \cdot 10}{98 \cdot 0.5} = 2.38 \text{ mol/l}$$

7.5. A patient must be injected by 100 g bemegrid. How many milliliters of the solution with the weight fraction of 0.5 % must be injected?
The answer: m_x = 100 mg = 0,1 g

$$\omega = \frac{m_x}{m_p} \cdot 100\%; \quad p = 1; \quad m_p = V_p \cdot \rho; \quad \omega = \frac{m_x}{V_p \cdot \rho} \cdot 100\%$$

$$V_p = \frac{m_x}{\omega \cdot \rho} \cdot 100\% = \frac{0.1}{0.5 \cdot 1} \cdot 100\% = 20\text{ml}$$

8. Homework (must be performed in the laboratory notebook):
8.1. What weight of NaCl and H_2O must be taken for preparation of 2 L isotonic solution (the weight fraction is 0.9 %, density is 1.02)
8.2. Calculate the molar equivalent concentration of sulfuric acid if density is 1.04 and weight fraction is 3.2 %.
8.3. A patient (the weight is 76 kg) must be injected the solution of $NaHCO_3$ in the concentration of 0.66 mol/kg. How many milliliters of this solution with the weight fraction of 4.2 % must be taken?

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

9.1. Mass fraction of a substance in solution is
a) the mass of a substance multiples to the mass of solutions;
b) the ratio of them as of substance to the mass of the solvent;
c) the ratio of them as of substance to the mass of the solution.
The answer: c
9.2. What is the weight of KOH must be taken for preparation of 2 kg of the solution with the mass percentage equal 2 %?
a) 40 g
b) 20 g
c) 60 g
The answer: a

TOPIC 7: Acid-base equilibrium in human body. pH scale of biological liquids.

1. ***Actuality of the topic:*** the role of biological catalysts and the unique behaviour of the biochemical processes is absolutely connected to the presence of hydrogen ions. To predict the processes in living things, to have a better understanding of the physiological processes and biochemical reactions, the establishing of the hydrogen ion concentrations is important.

2. General aim: is to estimate and predict the phisiological processes that are depended on pH values.

3. Actual aims and abilities:
- to be able to estimate the solution properties and the direction of chemical reaction

depending
on pH;
- to calculate the pH values of the solutions of strong and weak electrolytes;
- to determine pH using indicators.

4. Literature:

4.1. Lecture materials;

5. The main questions of the seminar:

5.1. Brensted and Loury theory of acids and bases.
5.2 Dissociation constant and ion product of water
5.3. Total, active and potential acidity and basecity and their calculations.
5.4. Oswald's law of dilution.
5.5. Calculation of the strong and weak electrolyte of pH.
5.6. Biological meaning of pH (the value of blood, stomach liquid, urine, intestinal liquid, acidosis and alkalosis, the influence of pH values on the activity of enzymes).
5.7. Indicators: the points of inflection; methyl orange and phenolphthalein, the standard indicator.

6. The question for individual learning:

6.1. What is an indicator?
6.2. Determination of pH using indicators.

7. The examples of the task:

7.1. What is pH of solution knowing that the concentration of H^+-ions is $4.2\ 10^{-5}$•mol/l)
The answer:
$[H^+] = 4{,}2 \cdot 10^{-5}$ mol/l.
$pH = -\log [H^+] = \lg 4.2 \cdot 10^{-5} = -\lg 462 - \lg 10^{-5} = 5 - 0.62 = 4.8$

7.2. What is the pH value of HCl solution knowing that HCl concentration is 0.15 mol/l and NaOH is 0.2 mol/l?
The answer:
HCl solution $pH = -\lg[H^+]$; $[H^+] = \alpha \cdot [acid] = 1 \cdot 0.15 = 0{,}15$ mol/l
$pH = -\lg 0.15 = -\lg 1.5 \cdot 10^{-1} = -\lg 1.5 - \lg 10^{-1} = 1 - 0.18 = 0.82$
NaOH solution $pH + pOH = 14$; $pH = 14 - pOH$; $pOH = -\lg [OH^-]$
$[OH^-] = \alpha \cdot [base] = 1 \cdot 0{,}2 = 0{,}2$ mol/l
$pOH = -\lg 0.2 = -\lg 2 \cdot 10^{-1} = -\lg 2 - \lg 10^{-1} = 1 - 0.3 = 0{,}7$
$pH = 14 - 0{,}7 = 13{,}3$.

7.3. Calculate the pH values of HCOOH solution with $C_N = 0.1$ mol/l ($K_d = 1.8 \cdot 10^{-5}$) and NH_4OH solution with Cn=0.2 mol/l ($K_d = 1.85 \cdot 10^{-5}$).
The answer:
HCOOH solution of $pH = -\lg[H^+]$

$$[H^+] = \sqrt{K_D \cdot [acid]} = \sqrt{1.8 \cdot 10^{-1} \cdot 0.1} = 4.24 \cdot 10^{-3}$$

$pH = -\lg 4.24 \cdot 10^{-3} = -\lg 4.24 - \lg 10^{-3} = 3 - 0.63 = 2.37$.

NH_4OH solution of $pH = 14 - pOH$
$pOH = -\lg[OH^-]$

$$[OH^-] = \sqrt{K_D \cdot [base]} = \sqrt{1.8 \cdot 10^{-5} \cdot 0.2} = 1.92 \cdot 10^{-3}$$

$pOH = -\lg 1.92 \cdot 10^{-3} = -\lg 1.92 - \lg 10^{-3} = 3 - 0.28 = 2.72$

pH = 14 – 2.72 = 11.28.

7.4. What is the pH of the solution knowing that 80 ml of water and 20 ml of 0.1 M (α = 1) sodium hydroxide were mixed?
The answer: since after mixing the base solution was obtained, equivalent law is used to find The pH $V_1 \cdot C_1 = V_2 \cdot C_2$;
V_2 = 80 ml + 20 ml = 100 ml
$C_2 = \frac{V_1 \cdot C_1}{V_2} = \frac{20 \cdot 0{,}1}{100} = 0{,}02 = 2 \cdot 10^{-2}$ (the concentration of resulting solution)
$[OH^-] = \alpha \cdot C_{base} = 1 \cdot 2 \cdot 10^{-2}$.
$pOH = -\lg[OH^-] = -\lg 2 \cdot 10^{-2} = -\lg 2 - \lg 10^{-2} = 2 - 0.3 = 1.7$
pH = 14 – 1.7 = 12.3
ΔpH = 12.3 – 7 = 5.3.

7.5. What is the pH of the solution after mixing the equal volumes of 0.2 M (α =1) HCl and of 0.1 M(α = 1) NaOH?
The answer: HC1 + NaOH = NaC1 + H_2O
Acid interacts with base in ratio 1:1. Thus, 0.1 mol of HCl is in excess in solution (0.2 – 0.1 = = 0.1M). The volume of the mixture was doubled twice resulting the final concentration of HCl is equal of 0.05 M.
$[H^+] = \alpha \cdot [acid] = 1 \cdot 0.05 = 5 \cdot 10^{-2}$.
$pH = -\lg [H^+] = -\lg 5 \cdot 10^{-2} = 2 - 0{,}7 = 1.3$.

7.6. What are the concentration of hydrogen ions in blood at pH = 7.36?

TOPIC 8: BASIC CONCEPTS OF VOLUMETRIC ANALYSIS. NEUTRALIZATION METHOD. ACIDIMETRY.

1. Actuality of the topic: neutralization method is part of volumetric analysis acids, bases and salts. This method is widely used for quantitative analysis of medical composites in clinical and biological investigations.

2. General aim: *is* to interpret the results of analysis in medical practice.

3. Actual aims and abilities:
to prepare the working solutions;
to be able to establish the molar equivalent concentration of the working solutions.

4. Literature: the lecture,

5. The main questions of the seminar:
5.1. What is the basic concepts of neutralization method, the main equation.
5.2. Base standardization:
preparation of working titrated solutions;
initial compounds;
titration curves; the point of inflection, the equivalence point;
indicators: the points of inflection; methyl orange and phenolphthalein, the colors in the acid and base mediums; the correct selection of the indicators.
5.3. Application of base standardization in the clinical analysis.

6. The questions for individual learning:

6.1. *The theory of indicators:*

What are the indicators?

Why does an indicator change the color?

The standard indicators.

7. The examples of the task:

7.1. What is the concentration (C_N) of base taking into account that 5.3 ml of base were titrated by 5 ml of oxalate with C_N=0.10 mol/L.

Answer:

$C_N(NaOH) * V(NaOH) = C_N(H_2C_2O_4) * V(H_2C_2O_4)$

$C_N(NaOH) = C_N(H_2C_2O_4) * V(H_2C_2O_4)/ V(NaOH) = 0.1 * 0.005/0.0053 = 0.094$ mol/L

7.2. How many grams of H_3PO_4 must be taken for preparation of 2 L solution with $C_н$ 0.1 mol/L?

Answer

$$C_н = \frac{m_x}{M_x f_{екв} V}; \qquad m_x = C_н \cdot M_x \cdot f_{екв} \cdot V = 0{,}1 \cdot 0{,}8 \cdot \frac{1}{3} \cdot 2 = 6{,}53$$

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

8.1. What weight of NaOH must be taken for preparation of 1.5 L solution with $C_н$=0.2 mol/L.

8.2. Calculate the molar equivalent concentration of KOH knowing that 5 ml of it was consumed for titration of 2 ml 0.1 N acetic acid solution.

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

for instance:

9.1. The working solution is called:

a) the solution with known concentration;

b) the solution with unknown concentration;

c) the prepared solution from known weight.

Answer: a

9.2. Calculate the molar equivalent concentration of KOH if 3 ml of the last was consumed for titration of 3.2 ml 0.1N oxalate acid solution.

10. The algorithm of the experiments:

10.1. Determination of NaOH concentration.

11. The detailed explanation of the following experiment:

<u>11.1. Determination of NaOH concentration.</u>

In the flask for titration 5 ml of oxalate acid solution is put adding 2-3 drops of phenolphthalein. The mixture is heated to 50-60 C^o and the hot solution is titrated by NaOH solution. Fill the below given table by received data.

Note the effect of the reaction, write the chemical equation, and make a conclusion.

<u>11.2. The qualitative reaction on the calcium ions.</u>

In the test-tube put 2 drops of $Na_2C_2O_4$ solution and add 1 drop of $CaCl_2$ solution. Note the effect of the reaction, write the chemical equation, and make a conclusion.

11.3. The qualitative reaction on the magnesium ions.
In the test-tube put 2 drops of magnum chloride solution and add the ammonia solution until a precipitation occurs. Then add certain amount of ammonium chloride solution to complete disappearance of the precipitation. Write the chemical equation, and make a conclusion.

Topic 9: NEUTRALIZATION METHOD. ALKALIMETRY.

1. Actuality of the topic: neutralization method is part of volumetric analysis acids, bases and salts. This method is widely used for quantitative analysis of medical composites in clinical and biological investigations.

2. General aim: *is* to interpret the results of analysis in medical practice.

3. Actual aims and abilities:
- to prepare the working solutions;
- to be able to establish the molar equivalent concentration of working solutions.
- to be capable detecting percent contain of hydrochloric acid in pharm drugs.

4. Literature: the lecture,

5. 5. The main questions of the seminar:
5.1. What are the basic concepts of neutralization method? Main equation.
5.2 Acid standardization:
- the working solutions, their preparations;
- the initial substances;
- the titration curves, the equivalence point
- indicators: the points of inflection; methyl orange and phenolphthalein, the colors in the
- acid and base medium; the correct selection of the indicators.

5.3. Application of base standardization in the clinical analysis.

6. The question for individual learning:
6.1. Describe the determination method of ammonia in baking soda.

7. The examples of the task:
7.1. Calculate the weight Na_2CO_3 to prepare 400 ml of aqueous solution with C_H = 0.05 mol/L.
The answer:

$$C_H = \frac{m_x}{M_x f_{екв} V}$$

$$m_x = C_H \cdot M_x \cdot f_{екв} \cdot V = 0,05 \cdot 106 \cdot \frac{1}{2} \cdot 0,4 = 1,06 г$$

7.2. How many grams of phosphoric acid do you need to prepare 2 L of aqueous solution with C_H = 0.1 mol/L.
Answer:

$$C_H = \frac{m_x}{M_x f_{екв} V};$$

$$m_x = C_H \cdot M_x \cdot f_{екв} \cdot V = 0,1 \cdot 98 \cdot \frac{1}{3} \cdot 2 = 6,53 \text{ g}$$

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

8.1. What is the weight of H_2SO_4 must be taken for preparation of 1.5 L aqueous solution with C_H=0.2 mol/L.

8.2. Calculate the molar equivalent concentration of HCl knowing that 5 ml of the last was consumed for titration of 5 ml of 0.1 M sodium carbonate.

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

for instance:

9.1. How is indicator as namely methyl orange colored?

a) pink color;
b) yellow color;
c) violet color
Answer: a

9.2. Calculate the molar concentration of Na_2CO_3 if 3 ml of 2.6 g was dissolved in 100 ml calibrated flask.

10. The algorithm of the experiments:

10.1. Determination of hydrochloric acid weight fraction in pharmsolution (Acidum hydrochloridum dilutum).

11. The detailed explanation of the following experiment:

11.1. Determination of hydrochloric acid weight fraction in pharmsolution (Acidum hydrochloridum dilutum)..

5 ml of HCl pharmsolution (ρ=1,04 g/ml) is put in the 100 ml flask and H_2O is added to the total volume.

5 ml of the obtained solution are put in the flask for titration with the following adding 1-2 drops of methyl orange. The mixture is titrated by 0.1 N NaOH solution

№	V (HC1)/L	V (NaOH)/L	The average volume of NaOH/L	ω% HCl
1				
2				
3				

TOPIC 10: Buffer systems, classification and mechanism.

1. ***Actuality of the topic****:* Biochemical processes take place in organism at a specific pH that is supported by buffer systems. The latter is also used for creating of biological mediums. For biochemical investigations in *vitro*, the solutions are prepared using the buffer systems to establish pH of the corresponding biological liquids. Knowledge of the topic is useful for studying biochemistry, microbiology, physiology, pharmacy.

2. ***General aim****:* is to understand the action of buffer systems in maintaining of pH values and to calculate pH of buffer systems.

3. Actual aims and abilities:

- to be able to prepare the buffer systems with given pH.

4. Literature:

4.1. Lecture materials;

5. The main questions of the seminar:

5.1.What is the buffer system?
5.2. The main phisiological buffer systems: their composition, the examples.
5.3. Mechanism of the buffer system.
5.4. Henderson-Hasselbach equation.
5.5. Buffer system in organism: an action, ratio of compounds in hydrocarbonate and phosphate buffer systems.
5.6. Significance of buffer systems.

6. The question for individual learning:

6.1. Give the example of two buffer systems, explain their mechanism;
6.2. What is the role of hemoglobin and oxyhemoglobin in maintaining of blood pH?

7. The examples of the task

7.1. What is pH of buffer systems containing 100 ml of 0.1 M acetic acid solution and 200 ml of 0.2 M sodium acetate with $K_D = 1.75\ 10^{-5}$?

The answer:

$$\mathrm{pH} = \mathrm{pK} + \lg\frac{[\mathrm{salt}]}{[\mathrm{acid}]} = -\lg 1.75 \cdot 10^{-5} - \lg\frac{100 \cdot 0.1}{200 \cdot 0.2} = 5 - 0.24 - 0.25 = 4.51$$

$$\mathrm{pH} = -\mathrm{lgK} - \lg\frac{[\mathrm{acid}]}{[\mathrm{salt}]} = -\lg 1.75 \cdot 10^{-5} - \lg\frac{100 \cdot 0.1}{200 \cdot 0.2} = 5 - 0.24 - 0.25 = 4.51$$

7.2. What are the volumes of sodium acetate and acetic acid must be taken for preparation of 3 l acetate buffer in volume and with pH = 5.24 ($K_D = 1.758 \cdot 10^{-5}$) knowing that the concentration both of them is equal 0.1 M.

The answer:

$$\mathrm{pH} = \mathrm{pK} - \lg\frac{[\mathrm{salt}]}{[\mathrm{acid}]}$$

$$\lg\frac{C_S V_S}{C_a V_a} = \lg\frac{0.1 \cdot V_S}{0.1 \cdot V_a} = \lg\frac{V_S}{V_a} = 5.24 - 4.76 = 0.48$$

$$\frac{V_S}{V_a} = \mathrm{antlg}\ 0.48 = 3$$

$$\frac{V_S}{V_a} = \frac{3}{1}$$

Thus, 3 parts of the salt solution and 1 part of the acid solution must be taken for preparation of buffer systems with pH = 5.24. The volume of salt is calculated as:

$$\frac{3000}{4} \cdot 3 = 2250\mathrm{ml}$$

and acid as:

$$\frac{3000}{4} \cdot 1 = 750\mathrm{ml}$$

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

8.1. What is pH of the buffer solution contain 3.6 ml of 0.2 M NH_4Cl and 2.6 ml of 0.1 M

NH_4OH (K_D=1,8·10 $^{-5}$)?

8.2. What are the volumes of sodium acetate and acetic acid must be taken for preparation of the acetate buffer in volume of 150 ml and with pH = 4.94 (K_D (CH_3COOH)= $1.8 \cdot 10^{-5}$) knowing that the concentration both of them is equal 0.1 M.

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

9.1. The acid buffer system contains
a) the weak acid and the conjugative salt formed by strong base;
b) the strong acid and the conjugative salt formed by strong base;
c) the weak acid and the conjugative salt formed by weak base.
The answer: a

9.2. What is the ratio of acetic acid and sodium acetate must be taken for preparation of the buffer system with pH = 4.05 ($K_D = 1.75 \cdot 10^{-5}$)?

10. The algorithm of the experiments:

10.1. Preparation of the buffer system and calculation of pH.
10.2. Influence of acid and base on pH of buffer system.
10.3. Influence of dilution on pH of buffer system.

11. The detailed explanation of the following experiment:

11.1. Preparation of buffer system and calculation of pH.

Prepare the buffer systems as reported in the next table.

№ the test-tube	***Buffer system (ml)***		***Color***	***Approximated pH***	***Calculated pH***
	CH_3COOH (0.1 M)	CH_3COONa (0.1 M)			
1	9.0	1.0			
2	1.0	9.0			

Add 2 drops of the standard indicator to solution №1 and №2. Determine the approximated pH, to corresponding using the colored scale and calculate pH using equations. How does ratio of components influence on pH of buffer system.

11.2. Influence of acid and base on pH of buffer system.

Fill a test-tube with 5 ml of 0.1 M CH_3COOH solution and 5 ml of 0.1 M CH_3COONa solutions. The resulting mixture must be divided in 3 parts. Add 3 drops of 0.1 M HCl solution to the first part, 3 drops of 0.1 M NaOH solution to the second part, (drop abit).

TOPIC 11: Buffer capacity. The role of buffer solutions in biological systems.

1. Actuality of the topic: the ability of buffer system to maintain pH after addition of acid or alcalic is limited. Buffer capacity is a qualitative limit of buffer system. In the case of distraction of buffer capacity in organism, denaturising of proteins take place. Therefore the determination of buffer capacity has a greater diagnostic meaning. Knowledge of the topic is useful for studying biochemistry, physiology and other subjects.

2.General aim: *is* to determine the limits of buffer system.

3. Actual aims and abilities:

- to determine the buffer capacity acetate buffer and blood plasma.

4. Literature:
4.1. Lecture materials;

5. The main questions of the seminar:
5.1.What is buffer capacity?
5.2. Factors that influence buffer capacity.
5.3. Determination of the buffer capacity in acid and base.
5.4. What are the buffer capacity values of blood plasma in acid and base.
5.5. What is the base supply of blood. Acid-base equilibrium.

6. The question for individual learning:
6.1. Organs and systems that are responsible for the acid-base equilibrium in human organism?

7. Examples of the task
7.1. How does pH of the buffer system change after adding for 30 ml of 0.2 M NaOH solution taking into account that before the buffer system contained 100 ml of 0.1 M acetic acid and 200 ml of 0.2 M of sodium hydroxide?
The answer: Firstly, calculate pH of the buffer system before adding of base:

$$\mathrm{pH_1} = \mathrm{pK} - \lg\frac{[\mathrm{acid}]}{[\mathrm{salt}]} = -\lg 1.75\cdot 10^{-1} - \lg\frac{100\cdot 0.1}{200\cdot 0.2} = 5.3$$

After adding NaOH the formation of sodium acetate takes place according to:

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

Thus, the acid amount decreases and the salt amount increases by equivalent base amount correspondently:

$$\mathrm{pH_2} = -\lg 1.75\cdot 10^{-1} - \lg\frac{100\cdot 0.1 - 30\cdot 0.2}{200\cdot 0.2 + 30\cdot 0.2} = 5.82$$

$$\Delta\mathrm{pH} = \mathrm{pH_2} - \mathrm{pH_1} = 5.82 - 5.3 = 0.49$$

7.2. Calculate the buffer capacity of solution containing of 7 ml of 0.1 M acetic acid and 3 ml of 0.1 M sodium hydroxide (K_D=1,8·10^{-5}) knowing that it was titrated by 4 ml of 0.1 M NaOH.
The answer: the buffer capacity is calculated as:

$$\mathrm{B_{base}} = \frac{\mathrm{C}}{\mathrm{pH_1} - \mathrm{pH_0}}$$

$$\mathrm{pH_0} = \mathrm{pK} - \lg\frac{[\mathrm{acid}]}{[\mathrm{salt}]} = -\lg 1.8\cdot 10^{-1} - \lg\frac{7\cdot 0.1}{3\cdot 0.1} = 4.38$$

$$\mathrm{pH_1} = 8.2$$

Calculation of C:
4 ml of NaOH is used for titration of 10 ml of buffer solution
400 ml of NaOH is used for titration of 1000 ml of buffer solution
1000 ml of NaOH solution contain 0.1 mol-equivalent of NaOH
400 ml of NaOH solution contain 0.04 mol- equivalent of NaOH
Finally,

$$\mathrm{B} = \frac{0.04}{8.2 - 4.38} = 0.01\mathrm{mol}\cdot\mathrm{eqiv/value\ \ pH}$$

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

8.1. How does the pH of phosphate buffer change which contains from 100 ml to 0,1 M potassium dihydrophosphate and 100 ml of 0.3 M potassium hydrophosphate after adding of 10 ml of 0.2 M NaOH ($K_D(NH_4OH) = 1{,}6 \cdot 10^{-7}$) ?

8.2. Calculate the buffer capacity of ammonium buffer containing 60 ml of 0.1 N NH_4OH and 40ml of 0.2 N NH_4Cl knowing that for titration of 10 ml solution, 5.5 ml of 0.1 N HCl was used ($K_D(NH_4OH) = 1{,}8 \cdot 10^{-5}$).

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

for instance:

9.1. The buffer capacity is dependent on:

a) the total amount of the components;

b) the ratio of components;

c) the product of components.

The answer: b

9.2. What is the buffer capacity of blood plasma taking into account that 36 ml of 0.05 N HCl solution was used for titration.

10. The algorithm of the experiments:

10.1. Determination of the buffer capacity in blood plasma by acid and base.

11. The detailed explanation of the following experiment:

11.1. Determination of the buffer capacity in blood plasma by acid and base.

Fill the first flask for titration by 5 ml of blood plasma (pH = 7.36) and add 2 drops of methyl orange and titrate by 0.1 M HCl solution.

Fill the second flask for titration by 5 ml of blood plasma (pH = 7.36) and add 2 drops of phenolphthalein and titrate by 0.1 M NaOH solution.

Calculate the buffer capacity of blood plasma by acid and base. Make a conclusion.

TOPIC 12: Colligative properties. Osmosis.

1. Actuality of the topic: osmosis and osmotic pressure play a significant role in the processes of biological equilibrium. Calculation of osmotic pressure is used for preparation of the medical liquids for intraveined injection and for eye drops. Knowledge of the topic is important for understanding of many biological processes.

2.General aim: is to apply the theoretical information about osmosis for understanding the processes in humans.

3. Actual aims and abilities:

- to calculate osmotic pressure, osmotic concentration and isotonic coefficient.

4. Literature:

4.1. Lecture materials;

5. The main questions of the seminar:

5.1.What is the coligative properties of solution?

5.2. What is osmosis?

5.3. Semipermeable membranes (the determination and the samples).

5.4. Osmotic pressure.

5.5. Van't Hoff's law. Osmotic concentration.
5.6. Isotonic coefficient of Van't Hoff and its relationship with the dissociation degree.
5.7. Hypotonic, isotonic, hypertonic solutions and their meaning in medicine.
5.8. Biological meaning of osmosis.
5.9. Donnan membrane equilibrium.

6. The question for individual learning:
6.1. The freezing point of solution.
6.2. Raul law.
6.3. Cryometry and ebuliometry, application in medicine.

7. The examples of the task
7.1. Calculate the osmotic pressure of 0.2 M diamide carbonic acid ($CO(NH_2)_2$ at t = 0 °C.
The answer: The osmotic pressure for non-electrolytes is calculated as:
$P_{OSM.} = CRT = 0.2 \bullet 0.082 \bullet 273 = 4.48$ atm

7.2. Calculate the osmotic pressure of glucose solution with the weight fraction of 5 %, ρ= 1 g/ml, t = 27 ^oC.
The answer: firstly, the molar concentration is calculated as:

$$C_x = \frac{\omega\% \cdot \rho \cdot 10}{M} = \frac{5 \cdot 1 \cdot 10}{180} = 0.28 \text{ mol/l}$$

The osmotic pressure for non-electrolytes is found to be:
$P_{OCM.} = CRT = 0.28 \bullet 0{,}082 \bullet (273+27) = 6.8$ atm
7.3. Calculate P_{OSM} of NaCl with of 5.85 %, ρ= 1.04 g/ml, t = 0 ^oC.
The answer:
a) the molar concentration is calculated as:

$$C_x = \frac{\omega\% \cdot \rho \cdot 10}{M} = \frac{5.85 \cdot 1.04 \cdot 10}{58.5} = 1 \text{ mol/l}$$

b) isotonic coefficient (*i*) is determined as:

$$i = 1 + \alpha (n - 1) = 1 + 0.96 (2 - 1) = 1.96$$

c) the osmotic pressure for electrolytes is found to be:

$$P_{OSM.} = iCRT = 1.96 \bullet 1 \bullet 0{,}082 \bullet 273 = 4.36 \text{ atm}$$

8. Homework (must be performed in the laboratory notebook):
8.1. Calculate the osmotic pressure for diamide of carbonic acid ($CO(NH_2)_2$ and acetic acid knowing thatboth of them have 0.6 % of weight fraction and dissociation degree of acetic acid equals 0.01, ρ= 1 g/ml. Are the solutions isotonic?
8.2. Determine molar concentration of sucrose solution that is isotonic to blood.

***9. The control test*:**
for instance:
9.1. Colligative properties of the solutions are depended on:
a) solution concentration;
b) the amount of the soluble particles;
c) the molar concentration.
The answer is b.
9.2. Calculate P_{OSM} of NaCl with of 5.85 %, ρ= 1.04 g/ml, t = 0 ^oC.

10. The algorithm of the experiments:
10.1. Osmosis observation.
10.2. Preparation of the inorganic semipermeable membrane.

10.3. The formation of tree likewise compounds.
10.4. Hemolysis and plasmolysis of red blood cell (erythrocyte).

11. The detailed explanation of the following experiment:

11.1. Osmosis observation.

Osmosis meter is filled by sucrose solution and immersed in a glass with water. Fix the initial level of the solution in the osmosis meter and the level of the solution 30 min later. Make a conclusion.

11.2. Preparation of the inorganic semipermeable membrane.

A test-tube is filled with 2 ml of $CuSO_4$ solution and potassium hexacyanoferrate (II). Do not mix. Observe the change 20 min later. Write the equations and explain which substance is the semipermiable membrane. Why does a cell grow?

11.3. Three like wise formation

A test-tube is filled with 5 ml of sodium silicate and the crystals of $MnCl_2$, $CoSO_4$, $NiCl_2$ are immersed. Do not mix the solutions. Write the equations and indicate the semipermiable membrane.

11.4. Hemolysis and plasmolysis red blood cell (erythrocyte).

Prepare three compositions as stated in the following table:

1 test-tube	***2 test-tube***	***3 test-tube***
3 ml of 0.2 % NaCl	3 ml of 0.9 % NaCl	3 ml of 4 % NaCl
3 drops of blood	3 drops of blood	3 drops of blood

Leave the test-tube for 15 min (do not mix). Make a conclusion.