MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

V. N. Karazin Kharkiv National University

Department of Physical Chemistry

"APPROVED"

Vice-President for Research and Education

Anton PANTELEIMONOV

_____

"_____"_____ 2021

Working program of the discipline

MEDICAL CHEMISTRY

High-education level: Master

Field of knowledge: 22 Health Protection

Speciality: 222 "Medicine"

Educational program: "Medicine"

Kind of the discipline: Required

Faculty: School of Medicine

2021/2022 academic year

The program is recommended for approval at the meeting of Academic Council of the School of Chemistry of V. N. Karazin Kharkiv National University. Protocol No. 8, June 25, 2021.

The program has prepared by: Dr.Sci., Professor of Department of Physical Chemistry of V. N. Karazin Kharkiv National University Natalya VODOLAZKAYA; Ph.D., Assistant Professor of Department of Physical Chemistry of V. N. Karazin Kharkiv National University Sergey ELTSOV; Scientific Associate, Senior Lecturer of Department of Inorganic Chemistry of V. N. Karazin Kharkiv National University Oleksandr KORSUN.

The program is accepted at the meeting of Department of Physical Chemistry of V. N. Karazin Kharkiv National University. Protocol No. 14, June 22, 2021.

Head of Department of Physical Chemistry Mykola MCHEDLOV-PETROSSYAN

The program is agreed with the guarantor of the educational program “Medicine”.

Guarantor of the educational program “Medicine” Yevhenii NIKOLENKO

The program is agreed at the meeting of Scientifically-Methodical Commission of the School of Medicine of V. N. Karazin Kharkiv National University Protocol No. 10, June 09, 2021.

Head of Scientifically-Methodical Commission Olha GOVALENKOVA

Introduction

Working program of course "Medical Chemistry" has prepared for the first-year students of the School of Medicine according to field of knowledge 22 Health Protection and for master degree in speciality 222 "Medicine".

1. Description of academic discipline

1.1. The aim of the discipline

Give fundamentals of general chemistry, physical and colloid chemistry.

1.2. The main tasks of the discipline

Give basic knowledge of general chemistry, physical and colloid chemistry for future speciality; to be able for abstract thinking, for analysis and synthesis; to have the modern knowledge in chemistry (**GC01**); to be able to use the knowledge of chemistry for practical purpose (**GC02**); the understanding connection between chemistry and medicine and how to use chemistry knowledge in medicine (**GC03**); to have the knowledge of chemistry.

1.3. Total ECTS credits: 3.

1.4. Total hours: 90.

1.5. The discipline characteristic

Required Discipline	
Daytime education	Other form of education
Year of Learning	
First	–
Semesters	
1, 2	–
Lectures	
12 hours	–
Practical Lessons	
40 hours	–
Laboratory Lessons	
–	–
Self-Work of Student	
38 hours	–
Individual Work	
–	–

1.6. Planned learning results

To have basic knowledge of general chemistry, physical and colloid chemistry (**PLR 1**); to know how to solve problems of chemistry (**PLR 3**) and to have experience of work in laboratory (to know how to prepare a solutions, how to measure some values by special devices) (**PLR 5**, **PLR 20**).

2. Subject plan of academic discipline

Module No. 1. "Acid-base equilibria and complex formation in biological liquids"

Theme 1. Biogenic *s*- & *p*-block elements: biological role, application in medicine.

Introduction to the structure of matter. Electronic structure of chemical elements. Periodic table. Valence electrons and oxidation numbers. Oxidation state of chemical element. Balancing redox equations. Biological role of redox reactions. *s*- and *p*-block chemical elements and their properties. Metals and nonmetals. Molecules and ions. Classification of biogenic elements. Macrominerals.

Theme 2. Biogenic *d*-block elements: biological role, application in medicine.

Electronic structure of *d*-elements. Typical chemical properties of transition metals. Biological activity and medical application of *d*-elements. Biocomplexes of Fe, Co, Cu, and Zn. Toxic properties of transition metals.

Theme 3. Chemical bonding.

Chemical bonding. Chemical bonds: covalent, ionic, metallic. Electronegativity. Types of coordination compounds. Chemical bonds in coordination compounds. Central ion and coordination sphere. Stability constants. Complex formation in biological systems.

Theme 4. Solutions. Electrolytic dissociation.

The dissolving process and solubility. Solvation and hydration. Expression of the solution concentration: mass and volume percents, molar fraction, molarity, molality. Electrolytic dissociation, electrolytes. Strong and weak electrolytes. The degree of dissociation and dissociation constant. Ostwald's dilution law.

Theme 5. Acid-base equilibrium in biological liquids.

General properties of acids and bases. Hydronium and hydroxide ions. Acid dissociation constant and base dissociation constant. The neutralization reactions. The law of equivalents. Acid-base indicators. The methods of the volumetric analysis. Acid-base titration, equivalence point. Titration curve and the equivalence point.

Theme 6. Dissociation of water, pH scale. Buffer solutions.

Ion product of water. pH scale and methods of pH determination. pH of biological liquids. Hydrolysis of salts. Buffer solutions. Mechanism of buffer action. Henderson–Hasselbalch equation.

Theme 7. Colligative properties of solutions.

Colligative properties of solutions: vapor pressure lowering (Raoult's law), elevation of boiling point and depression of freezing point of the solution, osmosis. Osmotic pressure, vant Hoff's equation. Biological role of osmosis. Cryoscopy, ebullioscopy, osmometry and their using in biomedical investigations.

Module No. 2. "Equilibrium in biological systems at the phase interface"

Theme 8. Chemical thermodynamics. Thermochemistry.

First law of thermodynamics. Exothermic and endothermic processes. Functions of state. Enthalpy and Hess's law. Thermodynamic equilibrium. Second law of thermodynamics. Entropy, Gibbs energy and Helmholtz energy. Endergonic and exergonic processes in the organism. Thermodynamics conjugation.

Theme 9. Kinetics of biochemical processes.

Main concepts of chemical kinetics: the rate of chemical reaction, reaction rate constant, homogeneous and heterogeneous systems. Mass action law. Molecularity and the reaction order. Kinetic equations for zero-, first-, and second- order reactions. Temperature dependence of the reaction rate. Mechanism of catalysis. Peculiarities of enzyme catalysis. Michaelis–Menten theory of enzyme catalysis.

Theme 10. Electrochemical phenomena in biological processes.

Electrochemistry. Voltage of electrochemical cell. Electrode potential. Nernst's equation. Diffuse membrane potential. Biopotentials. Diffusion and membrane potentials. The varieties of the electrodes: gas electrodes, 1-st type electrodes, 2-nd type electrodes, glass electrodes, ion-selective electrodes. Potentiometry. Potentiometric determination of the pH values of solutions. Potentiometric titration.

Theme 11. Colloidal solutions and colloid stability.

Physicochemical fundamentals of colloidal systems. Classifications of colloidal systems. Lyophobic systems. Preparation of lyophobic solutions and the structure of colloidal particles. Purification of colloidal systems. Hemodialysis. The colloid stability. Coagulation

of lyophobic colloidal systems and coagulation threshold. Schultze–Hardy rule. Kinetic and aggregate stabilities. Phenomenon of protective action. Flocculation. Introduction to blood coagulation.

Theme 12. Electric double layer and electrokinetic phenomena. Adsorption. Chromatography.

Electric double layer and electrokinetic phenomena. The structure of the electric double layer. Electrokinetic potential. Surface phenomena. Adsorption. Gibbs's equation. The Langmuir adsorption theory. Medical applications of activated carbon. Chromatography. Macromolecules. Properties of polymers. Synthetic organic polymers. Proteins are polymers of amino acids. Protein structure. Nucleic acids.

3. Structure of academic discipline

Topics	Hours											
	Daytime education						Other form of education					
	In total	lect.	pract.	lab. ex.	self-work	ind. work	In total	lect.	pract.	lab. ex.	self-work	ind. work
1	2	3	4	5	6	7	8	9	10	11	12	13
Part 1. Lectures												
Module No. 1 Lecture No. 1		2			6							
Lecture No. 2		2			6							
Lecture No. 3		2			7							
Module No. 2 Lecture No. 4		2			6							
Lecture No. 5		2			6							
Lecture No. 6		2			7							
In total for Part I:		12			38							
Part 2. Practical Lessons												
Module No. 1 Praxis No. 1 Test No. 1			2									
Seminar No. 1			2									
Praxis No. 2 Test No. 2			2									
Seminar No. 2			2									
Praxis No. 3 Test No. 3			2									
Seminar No. 3			2									
Praxis No. 4 Test No. 4			2									
Seminar No. 4			2									
Final Test			2									
Grading			2									
Module No. 2 Seminar No. 1			2									
Praxis No. 1 Test No. 1			2									
Seminar No. 2			2									
Praxis No. 2 Test No. 2			2									

Seminar No. 3			2									
Praxis No. 3 Test No. 3			2									
Seminar No. 4			2									
Praxis No. 4 Test No. 4			2									
Final Test			2									
Grading			2									
In total for Part II:			40									
In total:		**12**	**40**			**38**						

3.1. Lectures

No.	Topic	Hours
1	**Module No. 1** Lecture No. 1. Atoms, molecules and ions. Periodic law and periodic table. Valence electrons and chemical properties of the atoms. Classification of biogenic elements. Chemical bond. Coordination compounds.	2
2	Lecture No. 2. Solutions. Solubility. Effect of temperature and pressure on solubility. Acids and bases. Acidity of solutions, pH scale. Buffer solutions. Acid-base indicators.	2
3	Lecture No. 3. Determination of the pH using indicators. Buffer solutions in an organism. Hydrolysis of salts. Colligative properties of solutions.	2
4	**Module No. 2** Lecture No. 4. Chemical thermodynamics. Chemical kinetics: fundamentals.	2
5	Lecture No. 5. Electrochemistry: basic concepts. Concentration cells. Physicochemical fundamentals of colloidal systems.	2
6	Lecture No. 6. The colloid stability. Coagulation. Electric double layer and electrokinetic phenomena. Adsorption. Chromatography. Macromolecules. Properties of polymers.	2
In total:		**12**

4. Practical Lessons

No.	Topic	Hours
1	**Module No. 1** Safety rules in chemical laboratory. Seminar No. 1. Atoms, molecules and ions. Periodic law and periodic table. Valence electrons and oxidation numbers of the atoms.	2
2	Praxis No. 1. Qualitative reactions on some important ions in medicine. Test No. 1.	2
3	Seminar No. 2. Chemical bonding and complex formation in biological systems.	2
4	Praxis No. 2. Preparation of coordination compounds. Test No. 2.	2
5	Seminar No. 3. Solutions. Electrolytic dissociation. Acid-base indicators.	2
6	Praxis No. 3. Preparation of solution and acid-base titration. Test No. 3.	2
7	Seminar No. 4. Dissociation of water, pH scale. Buffer solutions. Hydrolysis of salts. Colligative properties of solutions.	2
8	Praxis No. 4. Determination of the pH value of solutions by indicator method.	2

	Test No. 4.	
9	Final Test.	2
10	Summing up of the Module. Grading.	2
11	**Module No. 2** Safety rules in chemical laboratory. Seminar No. 1. Chemical thermodynamics.	2
12	Praxis No. 1. Determination of the integral heat of solution of a salt. Test No. 1.	2
13	Seminar No. 2. Chemical kinetics.	2
14	Praxis No. 2. Determination of the rate constant of the chemical reaction. Test No. 2.	2
15	Seminar No. 3. Electrochemistry: galvanic cells.	2
16	Praxis No. 3. Potentiometric titration. Test No. 3.	2
17	Seminar No. 4. Colloidal systems. Colloid stability.	2
18	Praxis No. 4. Preparation of hydrophobic colloidal systems and determination of a coagulation threshold. Test No. 4.	2
19	Final Test.	2
20	Summing up the Module. Grading.	2
In total:		**40**

5. Topics for the Self-Work

No.	Topic	Hours
1	Atomic orbitals. Electronic configurations of atoms. Three important atomic properties: the atomic and ionic radii, the ionization energy, and the electron affinity. Valence electrons and chemical properties of the atoms. Natural abundance of the elements. Classification of biogenic elements. The functions of biogenic elements.	6
2	Convertation of the solution content. Effect of temperature and pressure on solubility. Buffer solutions. Acid-base indicators.	6
3	pH of solutions in the organism and nature. Buffer solutions in an organism. Colligative properties of electrolyte solutions.	7
4	Calorimetry. The Hess's law. Energy content of foods and fuels. Calculation of the entropy changes. Catalysis. Enzyme catalysis. Enzyme kinetics: Michaelis–Menten equation, Lineweaver–Burk equation.	6
5	The types of electrodes. The hydrogen electrode. Standard reduction potential. The glass electrode. Applications of electrode potentials: potentiometric titration and determination of the pH values. Biological concentration cells. Purification of colloidal systems. Hemodialysis.	6
6	Introduction to blood coagulation. Ion exchange adsorption. Paneth-Fajans-Hahn adsorption rule. Medical applications of activated carbon. Practical application of adsorption. Chromatography. Macromolecules. Properties of polymers. Synthetic organic polymers. Proteins are polymers of amino acids. Protein structure. Nucleic acids.	7
In total:		**38**

6. Individual work

Absent in the working plan.

7. Teaching methods

Lectures (explanation with presentations, questions-answers); praxis (demonstration of laboratory experiments, calculation of results, problems solving, self-solving of problems, discussion of theoretical materials).

8. Control methods

Checking up of the tests, praxis and Final Tests.

9. Grading of the Modules

Type of the work	Points
Test	15 4 tests × 15 = 60
Praxis	15 4 praxis × 15 = 60
Final Test	80 1 Final Test × 80 = 80
In total:	**200**

Grading for the Module No. 1 is according to the "Two-level Grade".

Final Graded Credit according to the "Four-level Grade" is calculated as average points of two Modules (No. 1 and No. 2) and placed to the student's Diploma Appendix.

9.1. Grading level system

Points	**Module No. 1** (Two-level Grade)	**Final Graded Credit** (Four-level Grade)
200 – 180	credit	excellent
179 – 150	credit	good
149 – 120	credit	satisfactorily
119 – 0	not credited	unsatisfactorily

10. References

1. Chang, Raymond; Overby, Jason. Chemistry. – 13-th ed. New York: McGraw-Hill, 2019.

2. Burdge, Julia R. Chemistry. – 5-th ed. New York: McGraw-Hill, 2019.

3. Atkins, Peter; de Paola, Julio; Keeler, James. Atkins' Physical Chemistry. – 11-th ed. Oxford University Press, 2018.

4. Eltsov, Sergey V.; Vodolazkaya, Natalya A. Practical Medical Chemistry: Manual. – 2-nd ed. Kharkiv: V. N. Karazin Kharkiv National University, 2018.

5. Brown, Theodore L. *et al*. Chemistry: the Central Science. – 14-th ed. Glenview: Pearson, 2018.

6. Silberberg, Martin S. Chemistry: the Molecular Nature of Matter and Change. – 6-th ed. New York: McGraw-Hill, 2012.

7. Laird, Brian B. University Chemistry. New York: McGraw-Hill, 2009.