National Pirogov Memorial Medical University, Vinnytsia
(full name of the higher educational institution)
Department of **Biological and General Chemistry**

"APROVE"
Vice - Rector for on scientific and pedagogical (educational) work

_____Prof. Y.I. Guminskiy
" 31 " August 2020 year

"AGREED"
Head of the Department of the Biological and General Chemistry Department

_____ prof. Zaichko N.V.
" 28 " August 2020 year

SYLLABUS OF ACADEMIC DISCIPLINE

"MEDICAL CHEMISTRY"

training of specialists of the second (master's) level of higher education

qualification of educational "Master of Medicine"
qualification of professional "Doctor"

Field of study 22 "Health care"

specialty 221 - "Dentistry"

2020-2021 academic year

1. Course abstract:
Semester – 1.
Volume: total number of hours – 90, of which:

- lectures – 10,
- practical and laboratory classes – 36,
- independent work – 44,
- credits – 3.

The course of Medical Chemistry should serve as a basis for further study by students of physiology, biological chemistry, pharmacology, sanitation, hygiene, as well as be used as a source of useful theoretical information for clinical disciplines.

From the 2010-2011 academic year, the teaching of medical chemistry under the conditions of joining the Bologna process began at the Faculty of Dentistry. Medical chemistry studies the chemical basis of the processes of life of a living organism, subject to the basic chemical laws. Most of the processes occurring in a living organism are explained by the theoretical principles of inorganic, physical and colloidal chemistry.

The main task of the course of medical chemistry is to increase the level of theoretical training of students, students 'understanding of the meaning of chemical phenomena occurring in living organisms, to form students' skills in organizing occupational safety and health in the chemical laboratory when working with devices and reagents; study of the mechanisms of formation of the main inorganic substance, bone tissue and tooth enamel; study of the most important laws of electrochemistry, which allow to predict corrosion resistance and optimize the search for new structural dental materials.

According to the curriculum, the study of Medical Chemistry is carried out in the first year of study and includes lectures and practical classes. The organization of the educational process is carried out in accordance with the requirements of the Bologna process. The amount of student workload is described in ECTS credits - credit credits, which are credited by students upon successful mastering of the credit credit.

Types of classes according to the curriculum are lectures, practical classes, independent work of students. The topics of the lecture course reveal the problematic issues of the relevant sections of medical chemistry.

Practical classes are independent performance of chemical experiments, ability to draw conclusions, ability to independently perform individual operations, writing schemes of chemical reactions and transformations, solving computational and situational problems.

When assessing students' knowledge, preference is given to standardized methods of control: testing (oral and written), structured control of practical skills.

Independent work — written performance of tasks for independent work.

Final control is carried out by means of test tasks, oral questioning (tasks and exercises), the performance of which requires obligatory motivation. Assessment of student performance in the discipline is a rating and is set on a multi-point scale and is determined by the ECTS system and the scale adopted in Ukraine.

2. Prerequisites and postrequisites of the discipline

Prerequisite — before mastering the discipline of Medical Chemistry was preceded by disciplines that contain the knowledge, skills and abilities necessary for its development. These are primarily general chemistry, which provides knowledge of valence, the degree of oxidation of elements, the skills of writing formulas, reaction equations, the structure of atoms, chemical bonds and the structure of molecules; the first theoretical foundations of bioenergy, physicochemical foundations of the kinetics of biochemical reactions; solutions and their role in the course of biochemical processes, general information about nutrients.

Postrequisite — medical chemistry as an academic discipline lays the foundations for students to study biological chemistry, physiology, pathophysiology, general and molecular pharmacology and toxicology, hygienic disciplines and ecology:

1. The ability to identify knowledge in practical situations, use them, analyze and evaluate chemical processes; ability to demonstrate the current level of knowledge of relevant issues in medical chemistry in relation to solving medical problems.
2. The ability to compare the fundamental phenomena of chemistry to the principles of medicine and to develop components and processes of clinical trials based on these principles.

3. The purpose of the course: the formation of a dentist's systematic knowledge of the basic physical and chemical patterns of biochemical processes at the molecular and cellular levels; about the structure and mechanisms of functioning of biologically active compounds; formation of natural-scientific thinking of dental specialists.

4. Learning outcomes of the discipline:

Students need to know:

- The relationship between the biological role of biogenic s-, p-, d- elements and the form of their presence in the body
- Principles of structure of complex compounds
- Features of the structure of complex compounds as a basis for their use in chelation therapy
- Characteristics of the quantitative composition of solutions
- Mechanisms of action of buffer systems and their role in maintaining acid-base balance in biosystems
- Relationship between colligative properties and solution concentration
- Thermal effects of chemical and biochemical processes
- Thermodynamic functions to assess the direction of processes
- The concept of process kinetics, conditions of formation and dissolution of sediments
- The mechanism of formation of electronic potentials
- Physico-chemical bases of methods of adsorption therapy
- Physico-chemical properties of proteins that are structural components of all body tissues

Students should be able to:

- Characterize the quantitative composition of solutions, prepare solutions with a given quantitative composition
- Analyze the quantitative content in the solution of acids and bases using acid-base titration methods
- To draw conclusions about the acidity of biological fluids on the basis of hydrogen
- Explain the mechanism of action of buffer systems and their role in maintaining equilibrium in biosystems
- Analyze the relationship between the colligative properties and the concentration of solutions
- Interpret chemical processes from the standpoint of their thermal effects, be able to use thermodynamic functions to assess the direction of processes, interpret the dependence of the reaction rate on the activation energy, explain the mechanisms of enzymes and chemical equilibrium
- Explain the mechanisms of formation of electrode potentials and draw conclusions about their use in medical and biological research
- To draw conclusions about the surface activity of substances on the basis of their structure
- Explain the physico-chemical basis of methods of adsorption therapy
- Explain the physicochemical basis of hemodialysis

- Interpret the physicochemical properties of proteins that are structural components of all cells of the body

5. The content of the discipline

Subjects of practical and laboratory employment for the students of 1 courses

№	The name of a theme of practical or laboratory lesson	Hours
1	Introduction. Safety in chemical laboratory. Periodical system by D.I. Mendeleev. Electronic structure of elements and ions. Control test of initial knowledge. Biogenic s - elements: chemical properties, biological role, uses in medicine.	2
2	Biogenic p - elements: chemical properties, biological role, uses in medicine.	2
3	Biogenic d - elements: chemical properties, biological role, uses in medicine.	2
4	Formation of complexes in biological systems.	2
5	Methods of expressing of solution.	2
6	Volumetric analysis. Method of acid-base titrations. Alkalimetry. Acidimetry.	2
7	Acid-base equilibrium in the organism. pH scale of biological liquids.	2
8	Buffer systems: classification, mechanism of the action. Buffer capacity. The Role of Buffers in Biological Systems	2
9	Colligative properties of solutions. Osmosis.	2
10	Thermal effects of the chemical reactions. Direction of the processes.	2
11	Kinetics of biochemical reactions. Solubility product.	2
12	Potenciometric method of analysis.	2
13	Determination of oxidation-reduction (redox) potential.	2
14	Adsorption and ion exchange processes in biological systems. Chromatography.	2
15	Preparation, purification and properties of colloidal solutions.	2
16	Coagulation of colloidal solutions.	2
17	Physicochemical properties of biopolymers solutions. Practical skills examination.	2
18	Differential Credit of Medical Chemistry.	2
	Practical and laboratory employment	**36**
	Lectures	**10**
	Independent work	**44**
	At all	**90**

Topic of lectures

№ p/p	Topic of lectures	Duration	Lector
1	Formation of complexes in biological systems.	2	Senior Lecturer Shunkov V.S.
2	Colligative properties of biological liquids.	2	Senior Lecturer Shunkov V.S.
3	Theoretical principles of bioenergetics.	2	Senior Lecturer Shunkov V.S.

4	Electrode processes, biological role and medicine use.	2	Senior Lecturer Shunkov V.S.
5	Physical-chemistry of surface tension.	2	Senior Lecturer Shunkov V.S.
	• At all.	**10**	

List of topics for independent work of students:

№ p/p	Theme	Hours
1	Studies of V.I. Vernadskiy about biospheres. Biogeochemical provinces. Problems of contamination of biosphere	4
2	Biological meaning of elements and their compounds	6
3	Methods of expression of concentration of solutions: molal, titre	4
4	Theory of indicators	2
5	Acid-base equilibrium in human body and its support	4
6	Cryometry, application in medicine	4
7	Potentiometric titration	4
8	Catalysis and catalysts	4
9	Reactions of precipitation and dissolutions. Solubility product.	2
10	Chromatography, application in medicine	4
11	Donnan membrane equilibrium	2
12	Bioenergetics essentials	4
• At all:		**44**

Questions to the Differential Credit from discipline
"Medical Chemistry"

Content module №1. Acid-base equilibria and complex formation in biological fluids

1. Biogenic s-elements: definition, position in the periodic table. Sodium: electronic structure of atom and ion, chemical properties of compounds (oxide and hydroxide), biological significance and drugs.
2. Biogenic s-elements: definition, position in the periodic table. Calcium: electronic structure of atom and ion, chemical properties of compounds (oxide and hydroxide), biological significance and drugs.
3. Biogenic p-elements: definition, position in the periodic table. Nitrogen: electronic structure of atom and ion (3−), possible oxidation states (formulas of compounds), chemical properties of compounds (ammonia), biological significance and drugs.
4. Biogenic p-elements: definition, position in the periodic table. Sulfur: electronic structure of atom and ion (6+), possible oxidation states, chemical properties of compounds (sulfuric acid), biological significance and drugs.
5. Biogenic d-elements: definition, position in the periodic table. Iron: electronic structure of atom and ion (3+), possible oxidation states, amphoteric properties of compounds (oxide and hydroxide), biological significance and drugs.
6. Biogenic d-elements: definition, position in the periodic table. Manganese: electronic structure of atom and ion (7+), possible oxidation states, oxidizing properties of compounds (permanganate), biological significance and drugs.
7. Complex compounds: definition. The main provisions of the theory of the structure of Werner complex compounds (central atom, coordination number, ligands, dentation,

complex ion, internal and external coordination spheres) on the example of cationic and anionic complex compounds. Intracomplex compounds.
8. Nomenclature and classification of complex compounds. Stability and instability constant of complex compounds. Biological significance of complex compounds and their use in medicine.
9. The concept of equivalence factor and its calculation for acids, bases, salts, oxidants and reducing agents (examples). Molar concentration of equivalent. The law of equivalents.
10. Ionic product of water. The concept of total, active and potential acidity and alkalinity, their calculation for solutions of strong and weak electrolytes.
11. pH: definition, calculation formulas for solutions of weak and strong electrolytes. Methods for determining pH.
12. pH: definition, biological significance. PH values of blood, urine and gastric juice, oral cavity. Acidosis and alkalosis.
13. Titrimetric method of analysis and its varieties. The concept of working solutions and their preparation. Starting materials and requirements for them.
14. Titration: definition, equivalence point, jump and titration curves. Indicators and their color transition interval. The principle of selection of indicators for titration.
15. Acidimetry: definitions, working solutions and their preparation, starting materials, indicators. Use in clinical, sanitary and hygienic analysis, pharmacy.
16. Alkalimetry: definitions, working solutions and their preparation, starting materials, indicators. Use in clinical analysis, pharmacy.
17. Buffer systems: definition, classification and biological significance. Composition and mechanism of action of acid buffer systems.
18. Buffer systems: definition, classification and biological significance. Composition and mechanism of action of basic buffer systems.
19. Hydrogen carbonate and phosphate buffer systems: composition, ratio of components, mechanism of action and biological significance.
20. Hemoglobin-oxyhemoglobin and protein buffer systems: composition, mechanism of action and biological significance.
21. Buffer capacity: definitions, calculation formulas for acid and alkali. Factors on which the buffer capacity depends. Acid-base balance, its maintenance in the human body.
22. Buffer capacity: definition, biological significance. The value of the buffer capacity of blood for acid and alkali. Alkaline blood reserve. Acidosis and alkalosis.
23. Colligative properties of solutions: definition. Raoul’s first and second laws. Cryometry and ebuliometry, their application in medicine.
24. Osmosis: definitions, semipermeable membranes. Vant-Hoff's osmotic law: formulation, mathematical expression for electrolytes and non-electrolytes. The isotonic Van Goff coefficient and its relationship to the degree of dissociation.
25. The biological significance of osmosis. Osmotic and oncotic blood pressures. Hypotonic, isotonic and hypertonic solutions. Hemolysis, plasmolysis, turgor.

Content module №2. Equilibrium in biological systems at the interface between phases

1. The first law of thermodynamics: formulation, mathematical expression. The concept of internal system energy and enthalpy. Application of the first law of thermodynamics to biological systems.
2. The second law of thermodynamics: formulation. The concept of entropy. Thermodynamic potentials. Criteria for spontaneous processes. Application of the second law of thermodynamics to biological systems
3. Thermochemical equations. Standard heat of formation and combustion. Thermal effect of the reaction. Hess’s law and its consequences. Calorimetry method. Application in medicine.

4. Rate of chemical reactions: definitions, calculation formulas for homogeneous and heterogeneous systems. Dependence of reaction rate on concentration of reactants. The law of acting masses. Kinetic equations. Speed constant.
5. Dependence of reaction rate on temperature. Vant-Goff's rule. Arrhenius equation. Activation energy, activation energy of biological systems.
6. Molecularity and order of reactions. Classification of reactions by molecularity and order, examples in living organisms. Complex reactions and their biological significance. The concept of free radicals. Antioxidants.
7. Chemical equilibrium: definition, equilibrium constant and its physical content. The principle of Le Chetelier. Thermodynamic equilibrium conditions. The role of heterogeneous equilibrium with the participation of salts in the general homeostasis of the organism.
8. Electrode potential: definition, mechanism of occurrence, factors on which it depends. Nernst's equation.
9. Galvanic cell. Jacobi-Daniel element: structure, electromotive force. Concentration element.
10. The concept of electrodes. Determination and comparison electrodes. Galvanic circuits for pH determination.
11. Diffusion and membrane potentials. Rest potential and action potential, mechanism of occurrence and biological significance.
12. Redox potential: definition, mechanism of origin, Peters equation, factors on which it depends, biological significance.
13. Surface tension: definition, mathematical expression, factors on which it depends, methods of determination. Classification of substances by the effect on surface tension. Surface tension in the human body.
14. Sorption of substances at the liquid-gas interface. Gibbs equation and isotherm. Positive and negative adsorption. Surface activity and its significance in biology and medicine. Duclos-Traube rule.
15. Sorption of substances at the liquid-solid interface. The concept of adsorption, absorption, desorption, physical and chemical adsorption. Adsorbents and their types. Adsorbents. Adsorption surfaces in a living organism.
16. The magnitude of adsorption on the surface of a solid body: determination of the factors on which it depends. Equations and isotherms of Langmuir, Freundlich, BET. Physico-chemical bases of adsorption therapy (hemosorption, enterosorption, application therapy).
17. Adsorption of electrolytes (selective and ion exchange). Fajans–Paneth rule's. The concept of ion exchangers and their types. Biological role of selective and ion exchange adsorption.
18. Chromatography: definition, classification of methods and their principle. Application of chromatography in biology and medicine.
19. Colloidal solutions: definitions, methods of preparation and purification, examples in living organisms.
20. Properties of colloidal solutions: molecular kinetic, optical and electrokinetic.
21. The structure of the micelle of colloidal solutions. Fajans–Paneth rule's. Double electric layer. Electrokinetic potential (zeta potential) of a colloidal particle and its value.
22. Stability of colloidal solutions: definitions, types, factors. Coagulation of colloidal solutions: external signs, factors, mechanism. Schulze-Hardy rule. Biomedical significance of coagulation.
23. Stability of HMC solutions and factors that determine it. Isoelectric point and isoelectric state of proteins. Violation of the stability of HMC solutions: coacervation, salinization, denaturation of proteins and their biomedical significance.
24. Swelling of HMC, definition, mechanism, factors, swelling pressure, biological significance. Bound water, its properties.

1. Lyogel (gelation) of HMC solutions: definition, mechanism, factors. Lyogel in the human body. Properties of the lyogel: thixotropy, syneresis, peculiarities of diffusion and reactions in lyogel, biological significance.

List of tasks for the Differential Credit for Medical Chemistry

1. What volume of 20 % solution of H_3PO_4 (ρ = 1,18 g / ml) is necessary for the preparation of 4 L of solution with C_N = 2 mol / l, if phosphoric acid reacts completely?
2. For the injected patient in anesthetizing use sodium oxybutyrate, which is produced in 20% - 10 ml. Body weight of the patient is 70 kg. The drug is introduced from the calculation at a rate of 70 mg / kg. How many ml of solution should be administered to the patient (ρ = 1 g / ml)?
3. How is the pH of water changed, if 30 ml solution of NaOH is added with C_N = 0,1 mol / l (α = 1) to 90 ml of it?
4. Calculate the pH of 5% KOH solution (ρ = 1 g / ml, α = 1).
5. Calculate the pH of the solution of NH_4OH with C_N = 0.4 mol / l (Kd=1,8·10–5)
6. Determine the pH of the solution obtained after mixing the same volumes of H_2SO_4 solutions with C_N = 0,2 mol / l and NaOH with C_N = 0,7 mol / l.
7. Calculate the pH of the ammonia buffer, consisting of 80 ml of 0.1 N NH_4Cl solution and 40 ml of 0,2 N NH_4OH solution (Cd (NH_4OH) = $1,8 \cdot 10^{-5}$).
8. Calculate the ratio of components of phosphate buffer with pH = 6,3 if component concentration equal to 0,1 mol / l (Cd (KH_2PO_4)=$1,6 \cdot 10^{-7}$)
9. Calculate the buffer capacity of the phosphate buffer, which consists of 110 ml of 0,1 N Na_2HPO_4 solution and 90 ml of 0,1 N Na_2HPO_4 solution (Cd = $1,6 \cdot 10^{-7}$), if the titration of 10 ml of this buffer was 8,2 ml 0,1N HCl solution.
10. Calculate the buffer capacity of the blood serum by acid, if the titration of 5 ml of it was followed by 7,5 ml of 0,1N HCl solution.
11. Calculate osmotic pressure of 10% solution of sodium chloride (ρ = 1,12 g/ml).
12. Calculate the molar concentration of glucose solution, which is isotonic with blood.
13. Calculate depression of 4,5% glucose solution (ρ = 1,014 g / ml).
14. At what temperature does the freezing of a 4% solution of ethanol occurs(ρ = 1 g / ml) in water?
15. Osmotic pressure of urine at 0 °C is 2,23 atm. Compute depression of urine.
16. Calculate the osmotic pressure of urine, if its depression is 1,65.
17. Is the reaction possible: $Al_2O_3 + 3SO_3 = Al_2(SO_4)_3$ if the change in the Gibbs energy Al_2O_3 = –1576,4 kJ / mol, SO_3 = –370,37 kJ / mol, $Al_2(SO_4)_3$ = –3091,9 kJ / mol? Answer confirm with calculations.
18. How will the reaction rate of $2NO (g) + Cl_2 (g) \rightarrow 2NOCl (g)$ change, if the pressure in the system is reduced by 2 times?
19. As a result of an increase in temperature of 20 °C, the reaction rate increased 16 times. Calculate the temperature coefficient of the reaction.
20. The constant of the equilibrium of the reaction $N_2O_4 \leftrightarrow 2NO_2$ is 0,26. The equilibrium concentration of NO_2 is 0,3 mol / l. Calculate the equilibrium and initial concentration of N_2O_4.
21. Calculate the product of solubility of Lead phosphate $Pb_3(PO_4)_2$, if the solubility of this salt is $1,5 \cdot 10^{-9}$ mol / l.
22. The element consists of a hydrogen electrode immersed in the test solution, and a calomel electrode. The Weston element is compensated for the segment of the reochord AC = 360 mm, and the studied element – on a segment of 190 mm. Draw the circuit of this diagram and calculate the pH of the test solution at 25 °C.
23. The element consists of two hydrogen electrodes. One electrode is immersed in a solution with pH = 5, and the second – in a solution with pH = 2. Write the scheme of this element and calculate the EMF for 18 °C.

24. Calculate the EMF and write the scheme of the copper-zinc element at 25 °C, if the concentration of electrolytes in the elemental elements is 1M $CuSO_4$ and 0,01M $ZnSO_4$ (e^0 Zn = 0,76 V; e^0Cu = + 0,34 V).
25. For oxidation-reduction system, pyruvate / lactate ered = 0,22 V, e^0 red = 0,180 V. Two electrons are involved in the reaction. Calculate the ratio of concentrations of oxidized and reduced forms of substance at 18 °C.

6. Types of training sessions: lectures, practical classes, laboratory classes**.**

7. Form of study: full-time.

8. Teaching methods: verbal, explanatory-demonstration.

9. Control methods: oral, written, test.

10. Forms of final control: differential test.

11. Tools for diagnosing learning success: questions for current control, tasks, tests.

12. Language of instruction: English.

13. Student performance appraisal system from Medical Chemistry

Differential Credit - 2 theoretical questions (25 scores each) and 1 task (30 scores)

Criteria of estimation for discipline (subject)

«5» A – 180-200 scores
«4» B – 170-179,99 scores
«4» C – 160-169,99 scores
«3» D – 141-159,99 scores
«3» E – 122-140,99 scores
«2» FX and F – less 122 scores

Compliance with the scales for assessing the quality of learning material

The grade in the discipline “Medical Chemistry” is set on a 200-point scale and is defined as the sum of assessments of current educational activities in points (maximum number of points - 120) and assessments of final control (maximum number of points - 80).

Assessment of knowledge in the discipline is carried out taking into account the relevant scales:

Score in points	Score on a national scale	Score on a scale ECTS	
		Rating	Explanation
180 – 200	Excellent	A	Excellent (excellent performance with only a small number of inaccuracies)
170 – 179,99	Good	B	Very good (above average with a few minor errors)
160 – 169,99		C	Good (generally correct execution with a small number

			of significant errors)
141 – 159,99	Satisfactory	D	Satisfactory (not bad, but with a significant number of shortcomings)
122 – 140,99		E	Enough (performance meets minimum criteria)
	Unsatisfactory	FX	Unsatisfactory (reusable)
		F	Unsatisfactory (with mandatory re-study of the discipline)

Upon receipt of an unsatisfactory grade in the discipline (FX), the student has the right to re-pass it: once to the departmental commission with the participation of the head of the department, the last time - the commission with the participation of the head of the department and the dean's office.

Upon receiving an unsatisfactory grade in discipline (F), the student is obliged to re-study it. The decision is made by the management of the NMU in accordance with the regulations approved in the prescribed manner.

14. Course policy

The policy of the course is carried out according to the Law “On Higher Education" from 01.07.2014 № 1556-VII, the Charter of National Pirogov Memorial Medical University, Vinnytsya, Rules of Procedure of National Pirogov Memorial Medical University, Vinnytsya, Regulations on the organization of the educational process in National Pirogov Memorial Medical University, Vinnytsya, the Code of Academic Integrity, Security Regulations on the procedure for training and testing of knowledge.

15. List of educational and methodical literature

Basic:

1. Zaichko N.V., Smirnova O.V., Chervyak M.M., Shunkov V.S. Medical chemistry. – Vinnytsia, Nilan-LTD, 2017.- 299.

Auxiliary:

1. Kalibabchuk V.A., Halinska V.I., Hryshchenko V.I., Hozhdzynskyi S.M., Ovsiannikova T.A., Samarskyi V.A. Medical Chemistry. - K. : Medicine. - 2010.

16. Information resources:

website address of the department: **http: // biochem.vsmu.edu.ua/**
library: **http: //library.vnmu.edu.ua/**

Discussed and recommended at a meeting of the Department of Biological and General Chemistry of National Pirogov Memorial Medical University, Vinnytsya, Protocol № from 2020 year.

Head of Department _____ Zaichko N.V.
signature surname and initials

Lecturer _____ Shunkov V.S.
signature surname and initials