FACULTY OF PHARMACY

STUDY PROGRAM 0916.1 PHARMACY

CHAIR OF GENERAL CHEMISTRY

APPROVED
at the meeting of the Commission for Quality Assurance and Evaluation of the Curriculum faculty of Pharmacy
Minutes No. 2 of 09.11.2021
Chairman, PhD, associate professor
Uncu Livia _____

APPROVED
at the Council meeting of the Faculty of Pharmacy
Minutes No. 3 of 16.12.2021
Dean of Faculty, PhD, associate professor
Ciobanu Nicolae _____

APPROVED
approved at the meeting of the chair of
General chemistry
Minutes No. 3 of 10.09.2021
Head of chair, PhD, associate professor
Cheptanaru Constantin _____

SYLLABUS

DISCIPLINE **PHYSICAL CHEMISTRY**

Integrated studies

Type of course: **Compulsory**

Syllabus was elaborated by:
Cheptanaru Constantin, PhD, associate professor.
Jora Elena, lecturer

Chisinau, 2021

I. INTRODUCTION

General presentation of the discipline: the place and the role of the discipline in the formation of the specific competences of the professional / specialty training program

Physical Chemistry curriculum for Pharmacist Qualification is a normative pedagogical document and a didactic tool for the efficient organization of the educational process, elaborated on the basis of the Framework Plan for Pharmaceutical Higher Education in the Republic of Moldova, based on the Charter of the State University of Medicine and Pharmacy ,,Nicolae Testemitanu", Regulation for the higher education studies based on the National Credit System, no. 1/8 of 06.04.2017, Regulation of evaluation and academic performance in the State University of Medicine and Pharmacy, Nicolae Testemitanu, nr. 5/4 of October 12, 2016, in coordination with the curriculum of the pharmaceutical disciplines (pharmaceutical chemistry, pharmaceutical biochemistry, pharmaceutical technology, pharmacology and clinical pharmacy, toxicological chemistry).

Physical chemistry is the branch of chemistry that sets and develops laws that explain and interpret phenomena discovered in other branches of chemistry. Physical chemistry has a multilateral, theoretical and practical importance. It encompasses the study of a large number of physical and chemical phenomena and the link between them. The vast range of physical chemistry has imposed the knowledge of the notions of this discipline in pharmaceutical education. This particular field has recently seen a very rapid development, and the complexity of preparation, optimization, bioavailability, etc. requires the application of this discipline, which presents a broad spectrum of possibilities to classify many issues commonly encountered in medicine, industry and research.

Mission of the curriculum (aim) in professional training

Physical chemistry is a fundamental discipline for the formation of future pharmacists, the acquired knowledge being necessary for understanding the physicochemical mechanisms present in the process of preparation and analysis of pharmaceutical forms. The physical chemistry course has the purpose of forming the theoretical knowledge in the field of physical chemistry, the accumulation of practical skills and their application to the study of FCMA and pharmaceutical chemistry, pharmaceutical technology, pharmacology and clinical pharmacy. The acquired knowledge allows the future ability to measure and control the physicochemical properties of drugs.

Languages of the course: Romanian, Russian, English;

Beneficiaries: the students of the II year, faculty of Pharmacy, Pharmacy specialty.

II. MANAGEMENT OF THE DISCIPLINE

Code of the course		**F.03.O.027**	
Name of the course		**Physical Chemistry**	
Persons in charge of the course		PhD, associate professor, **Budu Grigore** lecturer **Jora Elena** lecturer **Mirzac Viorica**	
Year	**II**	Semester/Semesters	**III**
Total number of hours, including:			**120**
Lectures	**15**	Practical/laboratory hours	**45**
Seminars	**-**	Self-training	**90**
Clinical internship			
Form of assessment	**E**	Number of credits	**5**

III. TRAINING AIMS WITHIN THE DISCIPLINE

At the end of the course the student will be able to:

- ***at the level of knowledge and understanding:***

• determine the subject of study of the discipline;
• know the theoretical principals of physical and physicochemical processes that take place in various chemical systems.
• interpret and understand the basic energy parameters of chemical and biochemical processes, their role in defining the direction of processes, the calculation of their equilibrium constants.

- ***at the application level:***

• apply physical and physicochemical methods in the study of chemical and biochemical systems;
• define the direction of the chemical reactions on the basis of thermodynamic constants;
• calculate thermodynamic and kinetic parameters in order to study various chemical systems;
• solve situational problems, processing multilaterally and critically acquired information;
• be competent to apply the cause-effect principle.

- ***at the integration level:***

• apply the knowledge acquired in studying the following disciplines: analytical chemistry, physical chemical methods of analysis and pharmaceutical chemistry;
• appreciate the importance of physical chemistry in the context of pharmacy
• define the interrelationship between physical chemistry and other fundamental disciplines;
• understand the principles of the new achievements of pharmaceutical disciplines;
• implement the knowledge gained in the research activity;
• be competent to use critically and with confidence the scientific information gained while using the new information and communication technologies;
• use multimedia technology to receive, evaluate, store, produce, present and exchange information, to communicate and participate in networks via Internet;
• apply the learning and researching abilities to the management of the professional path.

IV. PROVISIONAL TERMS AND CONDITIONS

From Student of the second year is required:
• knowledge of the language of instruction;
• high school knowledge level of sciences (chemistry, physics, mathematics, biology);
• digital abilities (use of Internet, document processing, electronic tables and presentations, use of graphic programs);
• ability to communicate and team work;
• qualities - tolerance, compassion, autonomy.

V. THEMES AND ESTIMATED ALLOCATION OF HOURS

Lectures, practical hours/ laboratory hours/seminars and self-training

No. d/o	THEME	Number of hours		
		Lectures	Practical hours	Self-training
1.	Introduction. The subject of physical chemistry and its significance in pharmacy. The first law of thermodynamics. The connection between the changes of enthalpy and internal energy. The dependence of reaction enthalpy from temperature. Kirchhoff´s law.	1	3	2
2.	The Second Law of thermodynamics. The entropy change in isolated systems for reversible and irreversible processes. The connection between entropy and the thermodynamic probability of the system state. The statistical nature of the Second Law of thermodynamics.	1	3	6
3.	The Helmholtz and Gibbs functions. The Gibbs - Helmholtz equations and their application in pharmacy. Chemical potential.	1	3	6
4.	The law of mass action for homogeneous and heterogeneous chemical equilibrium. Isotherm, isochore and isobar equations of chemical reaction and their analysis and application in pharmaceutical analysis.	1	3	5
5.	The thermodynamics of phase equilibrium. The phase rule. Phase diagrams of one component systems. The Clausius – Clapeyron equation. Phase diagrams of two component systems. Thermal analysis and their application in pharmacy. **Quiz nr.1.**	1	3	8
6.	The vapour pressure – composition and the temperature – composition diagrams. The lever rule. Konovalov's Rules. Mutual solubility of liquids. Nernst-Shilov´s distribution law. The extraction and its application in pharmacy.	1	3	6
7.	The thermodynamics of diluted solutions. The correlation between the colligative properties of solutions: the relative lowering of vapour pressure, the depression of freezing point, the elevation of boiling point, the osmotic pressure of diluted solutions of electrolytes and nonelectrolytes. Cryoscopy, ebullioscopy and osmometric method of measuring of molecular mass, osmotic concentration of a drug solution, the isotonic and osmotic coefficients.	1	3	6
8.	Electrochemistry. Conductors of the second type. The specific and equivalent electric conductivities of electrolyte solutions and their dependence of the dilution. The Kohlrausch´s law. The conductometric determination of the degree and the dissociation constant of a weak electrolyte, the coefficient of electric conductivity of a strong electrolyte, the ionic product of water, the solubility of slightly soluble salts. Conductometric titration and their application in pharmacy.	1	3	5
9.	The electrode potential. The mechanism of electrical double layer formation. Nernst equation for electrode potential calculation. Types of electrodes and their applications in pharmacy. Reversible and	1	3	6

No. d/o	THEME	Number of hours		
		Lectures	Practical hours	Self-training
	irreversible galvanic cells and their applications in pharmacy. The dependence of electromotive force on electrolyte concentration. Potentiometric measurement of pH. Potentiometric titration.			
10.	The measuring of electrode potentials and electromotive forces (emf) of galvanic cells. Potentiometric definition of standard Gibbs energy and the equilibrium constant of the chemical process. Electrolysis and electrode processes. **Quiz nr.2.**	1	3	8
11.	The kinetics of chemical reactions. Rate of homogeneous chemical reactions and the methods of its measurement. The dependence of reaction rate on various factors. Molecularity and order of the reaction. The kinetics of zero, first and second-order reactions. The half-life and its application in pharmacy.	1	3	6
12.	Methods for determination of order of a reaction. The collision theory. The activation energy. Arrhenius equation. Methods of determining drug half-life. Transition state theory.	1	3	6
13.	Complex reactions: reversible, parallel and sequential. Chain reactions. Photochemical reactions. The Stark-Einstein law of photochemical equivalence. The quantum yield.	1	3	6
14.	Heterogeneous reactions. The rate of heterogeneous reactions and the factors determining it. Kinetics and diffusion phenomena of heterogeneous processes. **Quiz nr.3.**	1	3	8
15.	Catalytic reactions. Positive and negative catalysis. The mechanism of action of catalysts. The activation energy of catalytic reactions. Acid-base catalysis. Biocatalysts. Heterogeneous catalysis theories.	1	3	6
Total		**15**	**45**	**90**

VI. REFERENCE OBJECTIVES OF CONTENT UNITS

Objectives	Content units
Chapter 1. Basics of chemical thermodynamics. Thermodynamic conditions of steady state.	
• To define the thermodynamic system, state parameters, energy functions, caloric capacities; • to know the basic principles of thermodynamics, the fundamental laws of chemical and biochemical equilibrium; • to demonstrate the relationship between energy functions and their relationship with predicting the possibility, spontaneity and direction of chemical and physical processes; • to apply the knowledge of the thermodynamic parameters and the thermal effects to correct processing of the conditions for synthesis of the drugs; • to use thermodynamic knowledge to compare the energy of healthy and diseased cells that enables the study of different pathological processes and to develop diagnostic methods.	The statement of the First and Second Laws of thermodynamics and mathematical expressions. Enthalpy. Correlation between the changes of enthalpy and internal energy and dependence of temperature. Entropy and thermodynamic probability of system state. Helmholtz function, Gibbs function, and its relations to the maximum work done in a process. The variation of Helmholtz function and Gibbs function and the criteria for spontaneous change. Thermodynamic conditions of steady state. Law of mass action for homogeneous and heterogeneous chemical equilibrium. The equilibrium constant of the reaction and its modes of representation. The calculation of the equilibrium constant, using standard entropy and enthalpy of formation of the chemical components of the reaction. Equations of isothermal, isobaric and isochoric of the chemical reaction and their analysis.
Chapter 2. Transformations and phase equilibrium. Colligative properties of electrolyte and non-electrolyte solutions. Electrical conductivity of electrolyte solutions.	
• To define the phase, component, degrees of freedom, phase diagrams, ideal solution, extraction, cryoscopy, ebullioscopy, ionization degree, osmosis, absolute ion velocity; • to know the Gibbs' phase law, the Raoult's law, the Conovalov's rules, the Nernst distribution law, the Ostwald dilution law; • to know and analyse the phase diagrams of various drug mixtures; • to apply the theoretical knowledge to the calculation of the extracted and remained masses in the unitary and multiple extractions; • to plot the phase diagram of the binary system and perform its analysis to determine the critical solubility temperatures, the solubility limits and the determination of the concentrations of the mixtures and the conditions for their storage; • to define the relationship between the colligative properties of the solutions;	Transformations and phase equilibrium. Clapeyron-Clausius equation and its application to vaporization, sublimation and melting equilibria. The Gibbs' Phase Law. Phase diagrams of binary mixtures. Thermal analysis. Ideal solutions. Raoult's law. Mutual solubility of liquids. Law of distribution between two solvents. Colligative properties of electrolyte and non-electrolyte solutions. Electrical conductivity of electrolyte solutions. Conductometry and its application in the pharmacy. Ostwald's dilution law.

Objectives	Content units
Chapter 3. Electrode potential and electromotive force of galvanic cells. Kinetics of chemical reactions.	
• To define the electrode, galvanic element, standard potential, potentiometric titration, titration curve, reaction rate, molecularity and reaction order, half-life, activation energy; • to know the types of electrodes and their use, methods of determining reaction order and activation energy; • to make a galvanic element for pH determination and to perform potentiometric titration, determination of concentrations of strong acids and bases, determination of ionization constants of weak acids and weak bases; • to demonstrate the relationship between emf and the activity of ions in the solution; • to apply kinetic data to determine the half-life and shelf-life of drugs; • to understand how the catalyst influences the activation energy; • to integrate information about oxidation and reduction cells in the study of biological oxidation processes;	Potential of electrode and electromotive force of galvanic cells. Electrodes and their classification. Potentiometric titration and its use in determination of activity and activity coefficient of ions, degree and ionization constant of weak electrolytes. The potential of diffusion and membrane. The rate of chemical reactions and its methods of measuring. Molecularity and reaction order. The kinetics of irreversible reactions of the zero order, first and second order. Half-life. Activation energy. Methods for determining the shelf-life of drugs. Complex reactions: parallel, consecutive, conjugate and reversible, chain reactions. Photochemical reactions. The peculiarities of the heterogeneous reactions. Kinetic and diffusion domain of heterogeneous processes.

VII. PROFESSIONAL (SPECIFIC (SC)) AND TRANSVERSAL (TC) COMPETENCES AND STUDY OUTCOMES

- **Professional (specific) (SC) competences**
  - PC1. Knowledge of the theoretical principals and the notions of physical chemistry necessary for the understanding of chemical and biochemical processes and the acquisition of specific knowledge in order to deepen the physical chemical methods used in the analysis of the drugs.
  - PC2. The ability to use appropriately and in the context of specialized terminology in study of chemical and biochemical processes.
  - PC3. The ability to explain and interpret the theoretical and practical contents of the physical chemistry discipline in an interdisciplinary approach to other fundamental and specialized biomedical subjects: organic chemistry, analytical chemistry, physical chemical analysis methods, pharmaceutical chemistry, pharmaceutical technology.
  - PC4. Developing skills to use laboratory methodologies and specific techniques to physical and chemical processes. Acquiring the experience and skills of laboratory equipment and study techniques in the preparation, analysis and standardization of drugs, rigorous application of methods of analysis and interpretation of results, in compliance with occupational safety and health standards.
- **Transversal competences (TC)**
  - TC1. Using notions in new contexts, promoting logical thinking, developing teamwork skills.
  - TC2. Using theoretical notions in problems solving, recognizing a problem when it comes out and providing solutions that are responsible for solving.
  - TC3. Optimal and creative use of own potential in scientific activities, acquiring the necessary notions in professional development
  - TC4. Awareness of the need for individual study as a basis for personal autonomy and professional development. Professional development.
- **Study outcomes**

• the use of thermodynamic research in biochemistry and medicine for the correct processing of the conditions for the synthesis of drug substances.

• the skill of building and analyzing phase diagrams of mixtures, predicting the optimum proportion of components in drug mixtures, preparation and storage conditions, and determining the shelf-life terms of drugs.

• knowing the colligative properties of non-electrolyte and electrolyte solutions and determining the osmotic concentration of drug substances in solutions, the isotonic coefficient, the degree of dissociation of medicinal preparations, which are weak electrolytes.

• the ability to use electrochemical analysis methods to determine properties and to analyze pharmaceutical preparations in solutions.

• knowledge of theoretical bases of chemical kinetics and application of kinetic data to determine the duration of drug use, factors contributing to increased stability.

• be able to implement the knowledge gained in the research activity.

• be competent to use critically and with confidence the scientific information obtained using the new information and communication technologies.

VIII. STUDENT'S SELF-TRAINING

No.	Expected product	Implementation strategies	Assessment criteria	Implementation terms
1.	Working with sources of information.	Read the lecture or course material on the subject carefully. Read the questions on the subject, which require a reflection on the subject. Get acquainted with the list of additional information sources on the topic. Select the source of additional information for that subject. Read the text entirely, carefully and write the essential content. Write generalizations and conclusions regarding the importance of the subject.	Ability to extract the essentials; interpretative skills.	During the semester
2.	Working with the problem book.	Problem solving on the subject of laboratory work.	Volume and accuracy of solved problems.	During the semester
3.	Essay	Analysis of relevant sources on the topic of the paper. Analysis, systematization and synthesis of information on the proposed subject. Compilation of the report in accordance with the requirements in force and presentation to the chair.	The quality of systematization and analysis of the informational material obtained through its own activity. Concordance of the information with the proposed subject.	During the semester

IX. METHODOLOGICAL SUGGESTIONS FOR TEACHING-LEARNING-ASSESSMENT

- ***Teaching and learning methods used***

The discipline of physical chemistry is taught in the classical way: with lectures and practical works. Lectures will be read by course holders. In practical work, students will study the most important experiences, completing the workbook at the end with explanations of general applicability and specific field of research of the medicine.

Methods of teaching-learning: Traditional: didactic exposure, didactic conversation, demonstration, work with manual, exercise; Modern: problem-solving, scheduled training, case study, discovery learning.

The experiment allows intensive student engagement and a particularly active participation in the instructive-educative process and the formation of intuitive practical skills for students. The experiment is the fundamental way of teaching physical chemistry, being considered a "pillar" for supporting active methods. The observation develops the spirit of observation, investigation, the ability to understand the essence of objects and phenomena, the processing and interpretation of experimental data, the interest in knowledge. Diagram analysis - Selection of required information. Recognition based on knowledge and information selected structures indicated in the drawing, drawing. The didactic discovery is done through different teaching methods: directed observation; independent observation; learning by experience - experiences; case study; problem solving; individual study, etc. Diagram design - Element selection. Wording of an appropriate title and legend of the symbols used. Classification - Determination of classification criteria. Distribution of structures / processes by groups according to established criteria. Individual study - study of bibliography, solving exercises and problems.

- ***Applied teaching strategies / technologies*** *(specific to the discipline)*

In order to be successful in learning Physical Chemistry, the student should actively work both in the courses and in the laboratory, as well as in their own right, and the teacher to use the didactic technologies specific to the discipline. The most important methods in teaching physical chemistry are brainstorming, multi-voting, and round table discussions. "Brainstorming" is a technique of stimulating individual creativity by organizing free discussions on a given theme based on free-of-charge ideas for solving a problem. "Multi-voting"; used to select the most important or most popular items in a list to narrow down the list to a few high priority items. "The round table"; "Case Study"; are also used efficiently in physical chemistry classes where it is necessary to confirm many ideas by performing certain experiences.

- ***Methods of assessment*** *(including the method of final mark calculation)*

Current: frontal and / or individual control by applying docimological tests, solving problems / exercises, analyzing laboratory work as well as totalizing works.

Final*:* exam (semester III). The final exam is a computer-based testing. The final exam mark is calculated by the computer testing mark and the average mark for the semester. The average mark for the semester is based on total points earned for quizzes and student self-training. The students with the average semester score below grade 5 are not admitted to exam, as well as students who have not process absences from the practical work. Exam subjects and the list of theoretical questions are approved at the meeting and are brought to the attention of the students at least one month before the session.

Method of mark rounding at different assessment stages

Intermediate marks scale (annual average, marks from the examination stages)	National Assessment System	ECTS Equivalent
1,00-3,00	**2**	**F**
3,01-4,99	**4**	**FX**
5,00	**5**	**E**
5,01-5,50	**5,5**	
5,51-6,0	**6**	
6,01-6,50	**6,5**	**D**
6,51-7,00	**7**	
7,01-7,50	**7,5**	**C**
7,51-8,00	**8**	
8,01-8,50	**8,5**	**B**
8,51-8,00	**9**	
9,01-9,50	**9,5**	**A**
9,51-10,0	**10**	

The average mark and the marks of all stages of final examination (computer assisted, test, oral) - are expressed in numbers according to the mark scale (according to the table), and the final mark obtained is expressed in number with two decimals, which is transferred to student's record-book.

Absence on examination without good reason is recorded as "absent" and is equivalent to 0 (zero). The student has the right to have two re-examinations.

X. RECOMMENDED LITERATURE:

A. Compulsory:

1. Peter ATKINS, Julio de PAULA. Physical Chemistry, Eighth edition, W. H. Freeman and Company, New York, 2006. (Electronic version)
2. V. SARBU, E. JORA, V. MIRZAC: Physical chemistry study guide, manuscript in preparation, accessible in electronic version.

B. Additional

1. Steven S. ZUMDAHL. Chemistry. Lexington, Massachusetts, Toronto.
2. Francis Marion MILLER. Chemistry, Structure and dynamics. McGraw-Hill book company, USA.