NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

Department of General, Organic and Physical Chemistry

"APPROVED"
Dean of the Faculty
Plant protection, biotechnology and ecology
Kolomiets Yu.V.
_____

"_____"_____2023 p.

"REWIED and APPROVED"
at a meeting of the Department of General,
organic and physical chemistry
Protocol 9 of 25.04 2023
Head of Department
_____ (Kovshun L.O.)

" REWIED "
Garant OP
_____ (Klyachenko O.L.)

WORK PROGRAM OF ACADEMIC DISCIPLINE
_____« Physical and colloid chemistry»_____

specialty _____162 Biotechnology and Bioengineering _____
educational program _ Biotechnology and Bioengineering _____
Faculty __ Plant Protection, Biotechnology and Ecology _____
Author: ____ Associate Professor of General, Organic and Physical Chemistry,
Ph.D., Associate Professor O.I. Khyzhan
Head of Department, Professor L.O. Kovshun

Kyiv – 2023

1. Academic discipline description

« Physical and colloid chemistry»

Branch of knowledge, specialty, educational program, Educational qualification		
Educational qualification	«Bachelor»	
Specialty	162 «Biotechnology and bioengineering »	
Educational program	«Biotechnology and bioengineering »	
Characteristics of training programme		
Type	Ordinary (standard)	
The total number of academic hours	210	
Number of ECTS credits allocated	7	
Number of modules	3	
Forms of control	Exam	
Indicators of academic discipline for full-time and part-time forms of training course		
	Full-time	Part-time
Year of study (course)	3	
Semester	5	
Number of lecture, hours	*15*	
Number of seminars, practical classes	-	
Laboratory sessions (activities)	*30*	
Independent study	*165*	
Individual lessons	-	
Number of weekly in-class academic hours for full-time forms of training	*3*	

1.Goal and objectives of academic discipline

The development of the agro-industrial complex requires the training of specialists who have knowledge of basic sciences and know all the possibilities of modern science to pose current problems, introduce advanced technologies to protect plants from pests and the negative impact of the environment. The course of physical and colloid chemistry aims to give a clear idea of the theoretical and experimental foundations of science, defining its special role as an interdisciplinary science synthesizing knowledge of related fields of chemistry, physics, biology and other natural sciences. Physical chemistry study is the relationship of physical phenomena that accompany chemical transformations and, widely used in theoretical and experimental methods of physics and chemistry, deals with general factual material of various sections of chemistry, reveals the general regularity of chemical reactions. Colloid chemistry studies the physicochemical properties and behavior of highly dispersed and macromolecular systems that are widespread in the environment

Task:

- to reveal the physical meaning of the basic laws of physical and colloidal chemistry;

- to teach the student to determine the areas of application of the laws and principles of physical and colloid chemistry to solve specific practical problems;

- highlight methodologically important issues of physical and colloid chemistry and show the relationship of physical and colloid chemistry with biology, physics and other disciplines of the natural cycle with specific examples.

Acquisition of competences

Integral competence :

The ability to solve complex specialized tasks and practical problems characterized by complexity and uncertainty in biotechnology and bioengineering, or in a learning process that involves the application of theories and methods of biotechnology and bioengineering.

General competences

5. Ability to learn and master modern knowledge

9. The ability to preserve and multiply moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and technologies, to use various types and forms of motor activity for active recreation and leading a healthy lifestyle.

Special (professional) competences:

2. Ability to use a thorough knowledge of chemistry and biology to the extent necessary to achieve other outcomes of the educational program.

5. The ability to carry out experimental research on the improvement of biological agents, including causing changes in the structure of the hereditary apparatus and the functional activity of biological agents

Program learning outcomes :

3. Be able to calculate the composition of nutrient media, determine the peculiarities of their preparation and sterilization, control the quality of raw materials and finished products based on knowledge of the physical and chemical properties of organic and inorganic substances.

22. Be able to take into account social, ecological, ethical, economic aspects, requirements of labor protection, industrial sanitation and fire safety during the formation of technical solutions. To be able to use different types and forms of motor activity for active recreation and leading a healthy lifestyle.

Module 1.Fundamentals of chemical thermodynamics and kinetics

Basic concepts of physical chemistry. Chemical thermodynamics. Thermochemistry

Introduction, Subject, Methods, Features and Importance Of Thermodynamics. Basic concepts – a system, parameters, state functions, a composition, a process. Thermodynamic state. Application of the first law of thermodynamics. Hess's law-formulation, consequences. Thermal and physicochemical processes - heats of formation, heat of combustion. Kirchhoff's law—dependence of the reaction enthalpy on temperature, integral and differential form. The second law of thermodynamics. Reversible thermodynamic processes. Maximum work. Heat capacity. Formulation of the second thermodynamic law. Entropy. Analytical expression of the second thermodynamic law. Statistical interpretation of entropy. Thermodynamic potentials

Kinetics and mechanisms of chemical reactions. Chemical equilibrium

Formal kinetics. Basic concepts - rate, order, molecularity. The main postulate of kinetics. Kinetic equations of irreversible reactions under static conditions - zero-order, first-order and second-order reactions. Method, for chemical reactions rate determination. Kinetics of complex reactions - reversible, parallel and consecutive reactions. Steady- state method. Dependence of of the chemical reaction rate constant k on the temperature. Arrhenius equation. Activation energy - definition, calculations. Collision theory. Transition-state theory. Theories application to the calculation of the rate constant of chemical processes.

Chemical equilibrium

Module 2.Solutions. Electrode processes

Properties of aqueous solutions of non-electrolytes and electrolytes

Properties of aqueous solutions of non-electrolytes and electrolytes

Solubility. Solubility curves. Factors affecting solubility. Solubility of solids, liquids and gases in liquids. Henry's Law. Dependence of gas solubility on temperature and gas partial pressure. Solutions in a living organism.

The phenomenon of osmosis. Osmotic pressure. Osmometer. Factors affecting osmotic pressure. Van't Hoff equation. Blood osmotic pressure. Osmosis and metabolism in the body. Isotonic solutions.

Saturated vapor pressure. Diagram of the state of water and aqueous solutions. Mathematical expression of Raoult's law. Isotonic coefficient. Boiling and freezing point of pure solvents. State diagrams. Change in boiling point and freezing point of solutions. Raoult's second law. Ebulioscopic and cryoscopic constants.

Electrolytes. Deviations from Van't-Hoff and Raoult's laws in electrolyte solutions. Van't Hoff coefficient, its physical content. Basic provisions of the theory of strong electrolytes. Activity of electrolytes, ionic strength of solutions. Electrolytes in nature, the body.

Acid-base properties of solutions

Concept of water as a weak electrolyte, electrolytic dissociation of water. Water constant, ion product of water and its logarithmic expression. Causes of acid, neutral and alkaline environments in aqueous solutions of various substances. Ways of expressing the "acidity" of the environment, ideas about pH and pH. Theoretical and experimental methods of determining the pH of aqueous solutions. Indicator and instrumental methods of pH measurement: advantages and disadvantages.

Soil acidity and factors influencing it. Determination of soil acidity by instrumental methods. pH-metry as an analytical method in agronomy

Electrical conductivity of solutions. Electrode processes

Specific and equivalent electrical conductivity of the solution. Conductometry. Electrochemistry.

Specific and equivalent electrical conductivity of a solution as characteristic indicators of its state and properties. Conductometry.

Electrode potential, physical and chemical essence of the electric double layer. The Nernst equation. Concept of diffusion potential. A galvanic cell and its emf. Concentration galvanic elements. Basic ideas about indicator electrodes and equalization electrodes. Redox potential, electrodes and circuits. Biological significance of diffusion and membrane potentials. Potentiometric methods of pH determination and potentiometric titration.

Module 3.

Surface phenomena and dispersed systems

Surface phenomena. Adsorption

Surface energy. Surface tension. Adsorption at the liquid-gas interface. Surfactants. Wetting, flotation, Rebinder effect.

Sorption of gases and vapors by solid bodies. Types of sorption: physical adsorption, capillary condensation, chemisorption. Theories of adsorption. Adsorption at the solid–liquid interface. Adsorption of electrolytes. Molecular adsorption from solutions.

Ion exchange adsorption processes. Ion exchange in soils. Chromatography. Significance of sorption phenomena in agronomy.

Disperse systems and their properties

Classification of dispersed systems. Microheterogeneous systems. Classification of microheterogeneous systems: suspensions, emulsions, foams, aerosols. Colloid systems, their classification and properties. Production and purification of colloidal systems. General conditions for obtaining colloidal systems. Condensation methods of obtaining colloidal systems. Dispersion methods. Cleaning of colloidal systems.

Electrical properties of dispersed systems. Electric double layer, electrokinetic phenomena. Micelle structure. Molecular-kinetic properties of colloidal systems. Brownian motion. Diffusion. Optical properties of dispersed systems. Ultramicroscopy. Nephelometry.

Stability and coagulation of dispersed systems. Types of stability of dispersed systems. Coagulation. Theory of coagulation of sols by electrolytes. Coagulation kinetics. Coagulation and peptization. Protection of colloidal systems. The role of coagulation processes in the formation of soils and stability of colloidal fertilizers.

High molecular compounds and their properties. Synthetic and natural IUDs. Building of the Navy. Solutions of high molecular compounds. Swelling

3. Structure of discipline _____« Physical and colloid chemistry»_____

Modules and themes	hours											
	full-time learning						Part-time					
	Total	including					Total	including				
		Lec	Pr	Lab	Ind	Ind		Lec	Pr	Lab	Ind	Ind
1	2	3	4	5	6	7	8	9	10	11	12	13
Module 1. Fundamentals of chemical thermodynamics and kinetics												
1**.** Basic concepts of physical chemistry. Chemical thermodynamics. Thermochemistry	36	3		5		28						
2. Kinetics and mechanisms of chemical reactions. Chemical equilibrium	34	2		5		27						
Total for module	70	5		10		55						
Module 2. Solutions. Electrode processes.												
3. Properties of aqueous solutions of non-electrolytes and electrolytes.	22	2		2		18						
4. Acid-base properties of solutions	24	1		4		19						
5. Electrical conductivity of solutions. Electrode processes	24	2		4		18						
Total for module	70	5		10		55						
Module 3. Surface phenomena and disperse systems												
6**.** Surface phenomena and dispersed systems Surface phenomena. Adsorption	35	3		4		28						
7**.** Disperse systems and their properties	35	2		6		27						
Total for module	70	5		10		55						
Total	210	15		30		165						

4. Topics of seminars
5. Topics of practical training
6. Title themes laboratory studies, hours

№	Title theme	Hours
Module 1. Chemical thermodynamics. Chemical kinetics.		
1	Determination of the heat of reaction of the formation of salt crystal hydrate:$CuSO_4 \cdot 5H_2O$	2
2	Determination of the heat of reaction of the formation of salt crystal hydrate: $Na_2CO_3 \cdot 10H_2O$	2
3	Determination of the heat of reaction of neutralization of a strong acid with a strong base	2
4	Determination of the dependence of the rate of a chemical reaction on the concentration of reactants	2
5	Determination of the dependence of the rate of a chemical reaction on temperature	2
6	Control work	
Module 2. Solutions. Electrode processes.		
1	Determination of the molecular weight of the solute, the osmotic pressure of the solution and the degree of dissociation of the weak electrolyte by cryoscopy.	2
2	Conductometric determination of the degree and constants of dissociation of weak electrolytes.	2
3	Determination of pH of solutions	2
4	Conductometric and potentiometric titration. Determination of buffer capacity of solutions	2
5	Measurement of EMF of galvanic cells.	2
6	Control work	
Module 3. Surface phenomena and disperse systems		
1	Investigation of acetic acid adsorption on coal	2
2	Determination of σ of liquids by stalagmometric method	2
3	Obtaining and cleaning colloidal systems	2
4	Study of coagulation of Fe (OH) 3 sol with electrolyte solutions	2
5	Investigation of IUD solutions	2
6	Control work	

7. Questions, test to determine the level of students learning

1. Subject, sections and methods of Physical Chemistry.
2. Basic concepts – a system, parameters and functions of a state, a composition, a process. Thermodynamic state.
3. Ideal gas. Basic gas laws. An ideal gas state equation.
4. Real gases. A real gas state equation. Liquefaction.
5. Chemical thermodynamics - subject, characteristics and importance. The zeroth and the first law of thermodynamics. Energy, heat and work. Heat content of reaction at P, V = const. Relation between Qp and Qv.
6. Application of the first law of thermodynamics. Hess's law. Corollaries of the Hess's law. Heat of formation and combustion. The Kirchhoff's law.
7. The second law of thermodynamics. Formulation. The Carnot's cycle. Analytical expression of the second law of thermodynamics.
8. Entropy. Determination of the process direction in an adiabatically isolated system. Entropy change calculations.
9. Statistical explanation of the entropy. The second law of thermodynamics - limits of application. Critical approach to the theory of the heat death of the universe. The third law of thermodynamics. The Nernst's theorem. The Planck's hypothesis.
10. Thermodynamic functions - U, H, F, G. Characteristic functions. Thermodynamic potentials. Helmholtz energy /isochoric-isothermal potential /. Gibbs energy / isobaricisothermal potential/. Dependence of the isochoric-isothertmal and the isobaricisothermal potentials on the system's parameters – the pressure, the volume and the temperature. Criteria referring to the determination of the direction of isochoricisothermal and isobaric-isothermal processes as well as the conditions required to reach thermodynamic equilibrium. Gibbs-Helmholtz Equation.
11. Partial molar quantities. Chemical potential - definition, physical meaning. Conditions for equilibrium in multi-component and multiphase systems.
12. Chemical equilibrium - characteristics. The chemical variable. The law of mass action. Chemical equilibrium dependence on the temperature and the pressure. The Le Chatelier - Brown principle. Relation between Kp and Kc. The Van't Hoff's equation. Equilibrium in biochemical and biological systems. Importance.
13. The reaction isotherm equation – application. Standard isobaric potential (standard maximum work). Reaction isobar and isochore equations. Temperature dependence of the equilibrium constant.
14. Phase equilibria - basic concepts. The phase rule. One-component systems. State diagrams. The Clausius-Clapeyron's Equation
15. Binary systems. State diagrams. Liquids of limited miscibility. A solid-liquid equilibrium state.
16. Solutions. General characteristics of solutions. Ideal solutions. Raoult's law. Thermodynamic properties of ideal solutions.
17. Real solutions. Positive and negative deviations from the Raoult's law. Ideally dilute solutions. Colligative properties. Boiling-point elevation and freezing-point depression of ideally dilute solutions of involatile solutes. Ebullioscopy and Cryoscopy.
18. Osmotic pressure - thermodynamics and importance. Activity. Activity coefficient Solubility of gases in liquids. Positive and negative deviations from the Raoult's law. Liquid-vapor Equilibrium. Distillation and rectification of liquid mixtures. Steam distillation.
19. Ternary systems. Gibbs-Rooseboom diagrams. Distribution of the third component between the system's two phases - extraction.
20. Solutions of electrolytes. Strong and weak electrolytes. Electrolyte conductivity. Specific and equivalent conductivity. Mobility and transport numbers of ions.
21. Adsorption and adsorption forces. Types of adsorption. Criteria to distinguish physical from chemical adsorption.
22. Main adsorption dependencies - isotherms, isosteres, isobars. Adsorption heat. Determination of isosteric adsorption heats. Capillary condensation.

23. Adsorption on solid and liquid surfaces. Isotherms of Freundlich ,Langmuir, BET and Gibbs - derivation and application of the isotherms. Surfactants. Thin liquid layers.

24. Surface tension of individual liquids and solutions. Surface tension of solutions. Isotherm of surfactants – the Shishkovsky's equation. The Traube's rule.

25. Chemical kinetics. Basic postulate. Basic concepts - rate, order, molecularity of a chemical reaction. Kinetics of irreversible reactions under static conditions. Reactions of zeroth-, first- and second-order - kinetic equations. Methods for reactions rate determination.

26. Kinetics of complex reactions. First-order parallel, consecutive and reversible reactions. Kinetic equations.

27. Theoretical foundations of chemical kinetics. Dependence of the reaction rate on the temperature. The Arrhenius equation. Activation energy - definition, calculations.

28. Collision theory. Transition-state theory. Application of the rate theories for the calculation of the chemical processes rate constants.

29. Catalysis and catalysts. Characteristics of the phenomenon. Homogeneous catalysis. Basics. Mechanism and kinetics of homogeneous catalysis.

30. Heterogeneous catalysis. Mechanism (elementary steps). Scheme of the activation energy decrease. Apparent and effective activation energy.

31. Theories of heterogeneous catalysis. The Balandin's multiplet theory. Role of the energy and the geometric factor . Micro-heterogeneous catalysis- enzyme catalysis.

32. Electrochemistry. Scope of electrochemistry. Basic concepts Electric dissociation. The Faraday's laws. Theory of Arrhenius.

33. Conductivity of electrolytes solutions. Specific and equivalent conductivity. Factors affecting conductivity. Strong electrolytes. The Debye–Hückel theory. The Kohlrausch's Laws. Transport numbers.

34. Electrochemical thermodynamics. Electrochemical elements – classification. Electromotive force (EMF) - generation, dimension, sign, measurement. Relationship between EMF and other terms.

35. Causes for occurrence of a potential jump on the system's interface. Types of electrode potentials - mechanism of generation and measurement. Thermodynamic derivation of the Nernst's equation .The standard electrode potential. Determination of the direction of oxidation-reduction processes. Types of electrodes.

36. Kinetics of electrochemical processes. Electrode polarization - concentration and electrochemical polarization. The hydrogen overpotential.

37. Colloidal chemistry as a science. Concept of colloidal systems. Classification, preparation and purification of colloids: dispersion and condensation methods, dialysis and ultrafiltration. Colloids formation.

38. Optical properties of colloidal systems. Light scattering. Theory of Rayleigh. Ultra-microscopy, nephelometry, turbidimetry. Coloring colloidal dispersion systems.

39. Molecular-kinetic properties of colloidal systems- osmosis, sedimentation. Brownian motion. The Einstein's and Smoluhovsky's conclusions.

40. Electric properties. Electrical double layer. Coagulation of colloidal solutions by electrolytes. Recharging of sols. Irregular rows. Electro - kinetic phenomena - electrophoresis, electro-osmosis.

41. Stability of colloidal solutions - sedimentation factors and kinetics, sedimentation analysis. Coagulation and peptization.

42. Aerosols - classification, formation, destruction. Thermal precipitation. Thermal phoresis. Photophoresis.

43. Emulsions – classification, properties of dilute and concentrated emulsions. Stabilization of emulsions. Coalescence,

44. Foams - formation, structure and stabilization. Role of surfactants.

45. Solutions of high-molecular compounds. The Schulze-Hardy's rule. Molecularkinetic properties. Solutions of polyelectrolytes. Gels and gel state.

1.Match the words from column A with ones from column B to make a word combination and write sentences with each combination.

Column A	Column B
1 osmotic	a) pressure
2 chemical	b) protection
3 colloid	c) equilibrium
4 isotonic	d)temperature
5 eutectic	e) coefficient
6 constant	f) composition
7 boiling	g) pressure

2.Fill in the gaps using the words from the box and translate the sentences.

coagulation adsorbent the boiling temperature swelling entropy shelf life surfactant

1. The term _____ is a blend of surface active agent.
2. _____ of a solution depends upon the atmospheric pressure.
3. _____ becomes unlimiting under increased temperature.
4. _____ is the direction criterion of the spontaneous process.

3. Physical chemistry, in contrast to chemical physics is a macroscopic or supra-molecular science as _____

a) the majority of the principles on which it was founded relate to the molecular/atomic structure alone.
b) the majority of the principles on which it was founded relate to the bulk.
c) the majority of the principles on which it was founded relate to the molecular weight.

4. Some of the relationships that physical chemistry strives to resolve include _____

a) electrochemistry.
b) surface science.
c) surface science and electrochemistry of cell membranes.

5. The term colloid suspension refers to _____

a) the overall mixture.
b) the word suspension.
c) larger particle size.

6. *To qualify as a colloid, the mixture must be* _____

a) one that settled or would take a very long time to settle appreciably.
b) one that does not settle and wouldn't take not a very long time to settle appreciably. c) one that does not settle or would take a very long time to settle appreciably.

7. Put the words in the correct order to make up a sentence:

1. the study/ Physical / is / atomic/ subatomic / and / in chemical / systems / of / in terms of / the principles / chemistry / and/ concepts of / physics/ macroscopic/ particulate phenomena/ practices.

2. in contrast to/ chemical /physics/ predominantly/ a macroscopic /or/ /science/ Physical chemistry/ is/ but not always/ supra-molecular. _____
_____

3. Some of / that /physical /chemistry / to resolve/ include / reaction /kinetics/ on the rate of / the relationships/ strives/ the effects of / a reaction. _____
_____

4. a colloid / in which / of microscopically/ dispersed / particles/ is / another/ substance/ in chemistry/ is /a mixture/ one substance/ insoluble/ suspended/ throughout.

_____
_____
5. mixtures /with / / in / range / may be / colloidal aerosols / colloidal foams / colloidal dispersions / hydrosols / Homogeneous / a dispersed phase/ this size/ called/ colloidal emulsions / or .
_____

8.TEACHING METHODS

Before teaching a course, the instructor must identify what she or he intends for the students to learn. For most Physical and colloid chemistry chemistry instructors, this usually involves an assessment of what methods and techniques to include and at what depth to cover them. There are many other skills, though, that will be important to students for their future success. Most university classes in Physical and colloid chemistry chemistry are taught in a lecture format. An alternative to lecturing is the use of cooperative learning. Cooperative learning offers the potential to develop skills such as teamwork, communication, and problem-solving that are more difficult to impart in a lecture format. The laboratory component of Physical and colloid chemistry chemistry courses is often an underutilized learning resource. More often than not, the lab is used to demonstrate fundamental wet and instrumental analysis techniques and develop rudimentary laboratory skills. The analytical lab should also be used to develop meaningful problem-solving skills and to demonstrate and have students participate in the entire analytical process.

A teaching method comprises the principles and methods used for students teaching. Commonly used teaching methods for styding subject “Physical and colloid chemistry chemistry” include on-time participation, demonstration, recitation, memorization, or combination of these. The choice of teaching method or methods to be used depends largely on the information or skill that is being taught, and it may also be influenced by the aptitude and enthusiasm of the students.

Explaining, or lecturing, is the process of teaching by giving spoken explanations of the subject that is to be learned. Lecturing is often accompanied by visual aids to help students visualize an object or problem.

Demonstrating is the process of teaching through examples or experiments. For example, a chemistry teacher must teach an idea by performing an experiment for students. A demonstration may be used to prove a fact through a combination of visual evidence and associated reasoning.

Demonstrations in Physical and colloid chemistry chemistry and own experiment are permit to obtain experimental skills needed for environmental monitoring etc. Memorization of a list of facts is a detached and impersonal experience, whereas the same information, conveyed though demonstration, becomes personally relatable. Demonstrations help to raise student interest and reinforce memory retention because they provide connections between bacts and real-world applications of those facts. Lectures, on the other hand, are often geared more towards factual presentation than connective leaning.

Collaboration allows students to actively participate in the leaning process by talking with each other and listening to other points of view. Collaboration establishes a personal connection between students and the topic of study and it helps students think in a less personally biased way. Group projects and discussions are examples of this teaching method. Teachers may employ collaboration to assess students’ abilities to work as a team, leadership skills, or presentation abilities.

Collaborative discussions can take a variety of forms, such as fishbowl discussions. After some preparation and with clearly defined roles, a discussion may constitute most a lesson, with the teacher only giving short feedback at the end or in the following lesson.

Learning by teahing in the method, when students assume the role of teacher and teach their peers. Students who each others as a group or as individuals must study and understand a topic well enough to teach it to their peers. By having students participate in the teaching process, they gain self-confidence and strengthen their speaking and communication skills.

10. FORMS OF CONTROL

The main forms of knowledge control are control at the lectures at labs and workshops, outside the classrooms, and the consultations, tests and exams.

I. Control of the lectures can be conducted as a selective oral questioning of students or tests using the previously laid material, particularly in sections of the course that are necessary for the understanding of the lecture topics, read, or to establish a degree of mastery of the material lectures (held by the manner of the late first or early second hour lectures). Testing during lectures designed to teach students to systematic elaboration covered material and prepare for the upcoming lectures, establish the degree of assimilation theory to identify the most difficult students to read chapters from the following explanation of them. Control of ther lectures has to subtract time. By spending time to conrol oral examination yields control, programmable for cards.

II. Current control on laboratory studies conducted to elucidate ready students for employment in the following forms:

1. Writing (30 min.). Control work.
2. Colloquium on separate sections of theoretical courses (modules or themes).

III. Credits. Some subjects (theoretical courses, practical training) is applied differential test of performance appraisal on a five point scale. In a lecture course or its individual parts, which are not accompanied by laboratory or practical classes, the teacher may conduct interviews or colloquium, offer oral or written questions.

IV. Examinations. Exam is a final step in the study of the whole or part of the discipline and are designed to test students' knowledge on the theory and identify the skills apply the acquired knowledge in solving practical problems, as well as independent work skills with educational and scientific literature.

Student's rating of knowledge of an academic discipline consists of training work rating – 70 points and final attestation – 30 points. Thus, rating of content modules, that are consistuents of an academic discipline, makes 70 points. Rating of content modules as well as attestation rating are also measured by 100-point-scale.

10. Distribution of points received by students.

Assessment of student knowledge is on a 100-point scale and is translated into national assessments according to table. 1 "Regulations on examinations and tests in NULES of Ukraine" (order of entry into force of 27.12.2019 № 1371)

Percentage score	National grade	
90-100	Excellent	Passed
74-89	Good	
60-73	Satisfactory	
0-59	Unsatisfactory	Non-passed

11. Methodological support

Scientific and methodological support of the educational process includes: state educational standards, curricula, curricula in all normative and elective disciplines; programs of training, production and other types of practices; textbooks and manuals; instructional and methodical materials for seminars, practical and laboratory classes; individual educational and research tasks; control works; text and electronic versions of tests for current and final control, methodical materials for the organization of independent work of students.

11. Educational and methodological support

1. Хижан О.І., Ковшун Л.О. Фізична і колоїдна хімія: навчальний посібник. К.: НУБіП України, 2022. 436 с.
2. Хижан О.І., Ковшун Л.О. Навчальний посібник. Фізична і колоїдна хімія. К.: НУБіП України, 2019. 444 с.
3. Khyzhan O.I., Boyko R.S., Kovshun L.O., Krotenko V.V. Methodical recommendations for laboratopy works in physical and colloid chemistry for students of the bachelor level of qualification. K.: DDP Expo-Druk, 2022, 157 p.

12. Recommended sources of information

1. Ковшун Л.О., Хижан О.І. Навчальний посібник. Фізична і колоїдна хімія. К.: НУБіП України, 2018. 501 с.
2. Khyzhan O.I., Boyko R.S., Krotenko V.V. , Kovshun L.O.Notebook for laboratory works in phisycal and colloid chemistry. K.: DDP Expo-Druk, 2021,155 p.
3. Khyzhan O.I., Kovshun L.O. Notebook for laboratory works in phisycal and colloid chemistry. K.: DDP Expo-Druk, 2020, 160 p.
4. Хижан О.І., Ковшун Л.О. Науково-методологічні основи лабораторного контролю безпечності сільськогосподарської продукції. Монографія. К.: НУБіП України, 2022. 448 с.
5. Tereshchenko N.Yu., Kovshun L.O., Khyzhan O.I., Nesterova K.A.. Methodology of laboratory control for the production of safe plant products. Monograph. Kyiv: NULES of Ukraine, 2021. 480 p.
6. Kovshun L.O., Boyko R.S., Khyzhan O.I., Krotenko V.V. Notebook for Laboratory Works in ORGANIC, BIOORGANIC, PHISYCAL AND COLLOID CHEMISTRY. Kyiv: NULES of Ukraine, 2019. 240 p.

13. Information resources

1. Electronic database of the NULES library of Ukraine
2. Distance learning course in the shell of Moodle "Physical and Colloid Chemistry" https://elearn.nubip.edu.ua/course/view.php?id=4567