Federal State Autonomous Educational Institution of Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA
RUDN University

Agrarian and Technological Institute

educational division (faculty/institute/academy) as higher education programme developer

COURSE SYLLABUS

Physical and Colloidal Chemistry

course title

Recommended by the Didactic Council for the Education Field of:

36.05.01 Veterinary

field of studies / speciality code and title

The course instruction is implemented within the professional education programme of higher education:

36.05.01 Veterinary

higher education programme profile/specialisation title

1. GOALS AND OBJECTIVES OF THE COURSE

The aim of mastering the course "**Physical and Colloidal Chemistry**" is to reveal the relationship between physical and chemical phenomena and understanding of the essence of physical and colloid-chemical processes occurring in nature and in biological systems.

2. REQUIREMENTS FOR LEARNING OUTCOMES

The implementation of the course "**Physical and Colloidal Chemistry**" is aimed at creating the following competencies (parts of competencies) for students:

Table 2.1. List of competencies formed by students during the development of the course (results of the development of the course)

Competence code	**Competence descriptor**	**Indicators of competence accomplishment** (within the course**)**
GPC-4	Is able to use in professional activity methods to solve problems using modern equipment in the development of new technologies and use modern professional methodology to conduct experimental research and interpretation of the results	GPC-4.1 Has the conceptual and methodological apparatus of the basic natural sciences at a level sufficient for full professional activity at the modern level
		GPC-4.3 Willing to use modern methodology in designing and conducting experimental research
		GPC-4.4 Uses modern professional methodology in interpreting research results

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The course "**Physical and Colloidal Chemistry**" refers to the mandatory part of block B1 of the Educational Program of Higher Education.

As part of the Educational Program of Higher Education, students also master other courses and /or practices that contribute to achieving the planned results of mastering the course "**Physical and Colloidal Chemistry**".

Table 3.1. List of Higher Education Program components courses that contribute to expected learning outcomes

Competence code	**Competence descriptor**	**Previous courses/modules, internships***	**Subsequent courses/modules, internships***

GPC-4	Is able to use in professional activity methods to solve problems using modern equipment in the development of new technologies and use modern professional methodology to conduct experimental research and interpretation of the results	Inorganic and analytical chemistry Organic chemistry Biological physics	Biological chemistry Immunology Laboratory diagnostics of infectious and invasive diseases Study practice Clinical internship Industrial practice Academic research practice with the preparation of a scientific qualification project Preparation for and passing the state exam

4. COURSE WORKLOAD AND TRAINING ACTIVITIES

Course workload of the course "**Physical and Colloidal Chemistry**" is 2 credits.

*Table 4.1. Types of academic activities during the period of the HE program mastering for **full-time** study*

Types of academic activities		**HOURS**	**Semesters**			
			2	**-**	**-**	**-**
Contact academic hours		36	36	-	-	-
including						
Lectures		18	18	-	-	-
Lab work		18	18			-
Seminars (workshops/tutorials)		-	-	-	-	-
Self-study		30	30	-	-	-
Evaluation and assessment (exam/pass/fail grading)		6	6	-	-	-
Course workload	Academic hour	**72**	**72**	**-**	**-**	-
	Credit unit	**2**	**2**	**-**	**-**	-

5. COURSE CONTENTS

Table 5.1 Content of the course (module) by type of academic work

Modules	**Content of the modules (topics)**	**Types of academic activities**

Module 1. Phase equilibria. Properties of solutions	Topic 1.1 Types of solutions: liquid, gas, solid. Thermodynamics of solutions. Chemical potential of a solution component. Types of solutions. Heterogeneous multicomponent systems. Gibbs phase rule. Single-component heterogeneous systems. Clapeyron-Clausius equation. State diagrams of water.	Lectures, Lab work.
	Topic 1.2 Characteristics of binary systems. Number of parameters and number of phases. Equilibrium between liquid solution and vapor. Raoul's law. Deviations from Raoul's law for non-ideal liquid solutions. Liquid-vapor state diagrams for binary systems. Lever rule. Azeotropic solutions. Fractional distillation. Limited solubility of liquids. Extraction. Solubility of gases in liquids. Sechenov's law. Cryoscopy and ebulioscopy. Osmosis. Colligative properties of electrolyte solutions.	Lectures, Lab work.
	Topic 1.3 Vant-Goff isotonic coefficient.	Lectures, Lab work.
	Topic 1.4 Equilibria between solid phases and melts. Types of melting diagrams. Physical and chemical analysis.	Lectures, Lab work.
	Topic 1.5 Three-component systems. The Gibbs-Rosebohm triangle. The solubility diagram of three liquids.	Lectures, Lab work.
Module 2. Electrochemistry.	Topic 2.1 Differences between the properties of electrolyte solutions and the properties of non-electrolyte solutions. Arrhenius theory of electrolytic dissociation. Ionic equilibria in solutions. Dissociation constants. Ionic derivation of water. Hydrogen index. Buffer solutions. Reasons for the stability of ionic systems. The ionic strength of solutions.	Lectures, Lab work.

	Theme 2.2 Electrical conductivity of electrolyte solutions. Specific, equivalent and molar conductivity of electrolyte solutions and their dependence on concentration. Kohlrausch's rule. Mobility of ions. Application of conductometry in analytical chemistry.	Lectures, Lab work.
	Topic 2.3 Mechanism of appearance of the potential jump at the interface. Diffusion potential.	Lectures, Lab work.
	Topic 2.4 Electrode potentials. The Nernst equation. Standard electrode potentials. Hydrogen electrode. Measurement of pH.	Lectures, Lab work.
	Topic 2.5 Galvanic elements and electromotive force. Electrochemical and concentration elements. The Nernst equation. Calculation of the standard Gibbs energy.	Lectures, Lab work.
Module 3. Chemical kinetics. Catalysis.	Topic 3.1 Basic definitions. Simple and complex reactions. Reaction rate. Kinetic law of acting masses. Kinetic equation, molecularity and order of reaction. Kinetics of simple zero, first and second order reactions. The half-turn period. Methods for determining the order of a reaction.	Lectures, Lab work.
	Topic 3.2 Complex reactions: reversible, parallel, serial and conjugate.	Lectures, Lab work.
	Topic 3.3 Influence of temperature on the reaction rate. Van Goff rule and Arrhenius equation. Determination of the shelf life of drugs and storage conditions.	Lectures, Lab work.
	Topic 3.4 The theory of active collisions. Reaction activation energy, methods of determination. The theory of activated complex. Peculiarities of reactions in liquid solutions. Photochemical reactions.	Lectures, Lab work.
	Topic 3.5 Catalysis. Kinetics of homogeneous catalytic reactions. Enzymatic catalysis. Michaelis-Menten equation. Inhibitors. Heterogeneous catalysis.	Lectures, Lab work.

Module 4. Surface phenomena. Adsorption. Chromatography.	Topic 4.1 Surface tension and phenomena at the interface: adsorption, adhesion, wetting. Flotation as a method of separation of dispersed phases. Lyophobic and lyophilic surfaces. Adhesion. Dupré's equation. Wetting. The Gibbs adsorption theory. Adsorption on liquid surfaces. Surface active substances (surfactants). The Duclos-Traube rule. The Szyszkowski equation.	Lectures, Lab work.
	Topic 4.2 Physical adsorption, chemisorption. Model theories of reversible adsorption on homogeneous surfaces. Henry and Langmuir adsorption isotherms. Ultimate adsorption, determination of specific surface area of sorbents. Heat of adsorption. Peculiarities of adsorption of molecules and ions from solutions on solid surfaces. Adsorption isotherm with exchange constant. The lyotropic series. Ionites.	Lectures, Lab work.
	Topic 4.3 Porous materials. Enterosorbents.	Lectures, Lab work.
	Topic 4.4 Chromatography. Types of chromatography. Qualitative and quantitative chromatographic analysis.	Lectures, Lab work.
Module 5. Colloid chemistry. Classifications, methods of production and properties of dispersed systems.	Topic 5.1 History, major tasks and directions of development of colloidal chemistry. Classification of dispersed (colloidal) systems, their importance. The role of stabilizer.	Lectures, Lab work.
	Topic 5.2 Conditions and methods of obtaining dispersions. Peptization.	Lectures, Lab work.
	Topic 5.3 Micelle structure of hydrophobic sol.	Lectures, Lab work.
	Topic 5.4 Commonality of molecular and kinetic properties of solutions and disperse systems. Diffusion and Brownian motion. Fick's, Einstein's and Einstein-Smoluchowski's equations. Osmosis and membrane processes of purification of colloidal systems (dialysis, ultrafiltration).	Lectures, Lab work.

	Topic 5.5 Kinetic stability of free-dispersed systems. Sedimentation. Analysis of dispersity of colloidal systems according to sedimentation and centrifugation. Suspensions. Hypsometric law.	Lectures, Lab work.
	Topic 5.6 Optical properties. Scattering and absorption of light in colloidal systems. Rayleigh's law. Application of Lambert-Beyer law to turbid media. Optical methods of research of dispersions (nephelometry, turbidimetry, ultramicroscopy, electron microscopy).	Lectures, Lab work.
Module 6. Electrical phenomena in dispersions. Aggregative stability. Coagulation.	Topic 6.1 Appearance of the double electric layer (DES) at the phase boundary. Lippmann equation. The structure of DES and its potentials DES (thermodynamic, adsorption and electrokinetic) and the influence of various factors on them. The isoelectric state.	Lectures, Lab work.
	Topic 6.2 Electrokinetic phenomena (electrophoresis, electro-osmosis, sedimentation and flow potentials) and their practical significance. Electrophoresis. Helmholtz-S Moluchowski equations.	Lectures, Lab work.
	Topic 6.3 Factors of kinetic and aggregative stability of disperse systems. Coagulation, electrolyte coagulation threshold (rule of significance). Deryagin-Landau-Ferwey-Overbeck /DLFO/ theory of stability of hydrophobic colloids. Potential curves. Thixotropy.	Lectures, Lab work.
	Topic 6.4 Gels of hydrophobic sols. Coagulation kinetics. Special cases of coagulation of sols with electrolytes. Structural and mechanical factor of stabilization of dispersions. Colloidal protection. Protective substances, protective numbers.	Lectures, Lab work.
Module 7. Lyophilic colloids. Solutions of high molecular weight compounds (HMS) and their properties.	Topic 7.1 General characteristics of high molecular weight compounds (HMS). Classification of high-molecular-molecular compounds. Natural and synthetic high-molecular-molecular-	Lectures, Lab work.

	molecule compounds. Conformation of macromolecules.	
	Topic 7.2 Swelling of OMC. Thermodynamics and kinetics of swelling. Resolutions of hydrophobic polymeric materials as thermodynamically equilibrium colloidal systems. Comparison of properties of solutions of HMS and hydrophobic sols. Osmotic pressure, viscosity and optical properties of the Navy solutions. Solutions of polyelectrolytes. Polyampholytes. Protein isoelectric point and methods of its determination. Gibbs-Donnan membrane equilibrium. Disturbance of stability of polymer solutions (gelation, coacervation, desalinization, denaturation).	Lectures, Lab work.
	Topic 7.3 Gels of the Navy solutions. Properties of the gels of the Navy and gels of hydrophobic sols. Syneresis of gels. Gels.	Lectures, Lab work.

6. COURSE EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Material and technical support of the course

Classroom for Academic Activity Type	***Equipping the classroom***	**Specialized educational/laboratory equipment, software and materials for the development of the course** (if necessary)
Lecture	An auditorium for conducting lecture-type classes, equipped with a set of specialized furniture; a board (screen) and technical means of multimedia presentations.	*-reagents,* *-instruments,* *-sets of reference materials,* *-materials for current knowledge control (tests, control tasks).*
Laboratory	An auditorium for laboratory work, individual consultations, routine monitoring and interim certification, equipped with a set of specialized furniture and equipment.	*-distiller,* *-analytical scales,* *-magnetic stirrers,* *-ionomers,* *-pH-meters,* *-Liquid thermostat,* *-polarimeter (saccharimeter),* *-meters*

		-Conductivity meters (conductivity meters), EMF-measurers, -photometers, -gasometers, -chromatographs, -nephelometers, -Viscosimeters
Self-studies	An auditorium for independent work of students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to an electronic information and educational environment.	

7. RESOURCES RECOMMENDED FOR COURSE STUDIES

Main readings:

1. Belyaev A.P. Physical and colloidal chemistry : textbook / A.P. Belyaev, V.I. Kuchuk ; edited by A.P. Belyaev. - 3-th edition, revised. and supplement. - Moscow : GEOTAR-Media, 2021. - 816 c. - ISBN 978-5-9704-5690-3.
2. Mikhalenko Irina Ivanovna. Practical work in physical chemistry : a textbook for full-time students of Pharmacy, studying in the course of physical and colloid chemistry. Kinetics of chemical reactions. Catalysis. Module / I.I. Mikhalenko. - Moscow : PFUR, 2020. - 78 c. : ill. - ISBN 978-5-209-09653-5

Additional Readings:

1. A.G. Stromberg, D.P. Semchenko Physical Chemistry. M: Vysshaya shkola. 2001.
2. Emanuel N.M., Knorre D.G. Course of Chemical Kinetics. Textbook. M: High School. 1984. 463 c.
3. Filippov Yu.I., Popovich M.P. Physical Chemistry. Moscow State University. 1980. 399 c.
4. Glazov V.M., Fundamentals of Physical Chemistry. Textbook. M. Vysshaya shkola.1981. 465c.
5. Atkins P. Physical Chemistry: In 2 vols. Moscow: Mir, 1980. T.1, 2.
6. Laboratory work and tasks in colloid chemistry. Edited by Yu.G. Frolov. M.1986.215s.

Internet sources

1. Electronic libraries (EL) of RUDN University and other institutions, to which university students have access on the basis of concluded agreements:

- RUDN Electronic Library System (RUDN ELS) http://lib.rudn.ru/MegaPro/Web
- EL "University Library Online" http://www.biblioclub.ru
- EL "Yurayt" http://www.biblio-online.ru
- EL "Student Consultant" www.studentlibrary.ru
- EL "Lan" http://e.lanbook.com/
- EL "Trinity Bridge"

2.*Databases and search engines:*

- electronic foundation of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https:// www .yandex.ru/
- Google search engine https://www.google.ru/
- Scopus abstract database http://www.elsevierscience.ru/products/scopus/

Educational and methodological materials for independent work of students during the development of the course/ module*:

1. A course of lectures on the course "**Physical and Colloidal Chemistry**".
2. Laboratory workshop on the course "**Physical and Colloidal Chemistry**".

* - The training toolkit and guidelines for the internship are placed on the internship page in the university telecommunication training and information system under the set procedure.

8. ASSESSMENT TOOLKIT AND GRADING SYSTEM* FOR EVALUATION OF STUDENTS' COMPETENCES LEVEL AS COURSE RESULTS

The assessment toolkit and the grading system* to evaluate the level of competences (competences in part) formation as the course results are specified in the Appendix to the course syllabus.

* The assessment toolkit and the grading system are formed on the basis of the requirements of the relevant local normative act of RUDN University (regulations / order).

DEVELOPERS:

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