

AL-FARABI KAZAKH NATIONAL UNIVERSITY
Faculty of chemistry and chemical technology
Department of physical chemistry, catalysis and petrochemistry

APPROVED

Dean of the Faculty



Duysebaeva M.A.

"01" September 2025

EDUCATIONAL AND METHODOICAL COMPLEX OF THE DISCIPLINE

SPFH7301 «Modern Problems of Physical Chemistry»

8D05301 - Chemistry

Course – 1

Semester – 1

Number of credits – 5

Almaty, 2025

The educational and methodical complex of the discipline was compiled by PhD
Supiyeva Zhazira

Based on the curriculum for the educational program
8D05301 – Chemistry

Reviewed and recommended at the meeting of the Chair of physical chemistry,
catalysis and petrochemistry
«01» **September** 2025, Protocol № 1

Head of the department  Aubakirov Ye.A.
(signature)

SYLLABUS
Full semester 2025-2026 academic year
Educational program "8D05301 - Chemistry"

ID and name of course	Independent work of the student (IWS)	Number of credits			General number of credits	Independent work of the student under the guidance of a teacher (IWST)
		Lectures (L)	Practical classes (PC)	Lab. classes (LC)		
SPFH7301 Modern Problems of Physical Chemistry	3	1.7	3.3	0	5	7

ACADEMIC INFORMATION ABOUT THE COURSE

Learning Format	Cycle, component	Lecture types	Types of practical classes	Form and platform final control
Offline	PD/UC	Informative, lecture-presentation, lecture-consultation	Solving problems and tests	Standard written, offline
Lecturer	Supiyeva Zhazira Asilbekovna, PhD., acting associate professor			
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ACADEMIC COURSE PRESENTATION

Purpose of the course	Expected Learning Outcomes (LO) *	Indicators of LO achievement (ID)
The purpose of this course is to deepen doctoral students' understanding of contemporary theoretical and experimental approaches in physical chemistry, with a focus on frontier research areas such as reaction dynamics, quantum chemistry, spectroscopy, surface phenomena, and molecular modeling.	1. Demonstrate understanding of the fundamental principles and laws of classical thermodynamics, including the ability to apply them to describe and calculate energy, work, and heat in physical and chemical systems;	1.1. Formulates the First and Second Laws of Thermodynamics;
		1.2. Performs calculations of internal energy, work, and heat for various thermodynamic processes;
		1.3. Solves problems related to isobaric, isochoric, and adiabatic processes;
	2. Apply quantum mechanical models (such as the particle in a box and the hydrogen atom) to describe the structure and behavior of atoms and molecules;	2.1. Explains the fundamental postulates of quantum mechanics applicable to physical chemistry;
		2.2. Analyzes energy levels of the particle-in-a-box model and the hydrogen atom model;
		2.3. Solves basic quantum chemical problems using these models;
	3. Analyze and calculate thermodynamic functions and equilibrium constants, and explain how they relate to the energetics and direction of chemical reactions;	3.1. Calculates ΔG , ΔH , and ΔS for chemical reactions under given conditions;
		3.2. Uses the Van't Hoff equation and the Gibbs isotherm to determine equilibrium constants;
		3.3. Interprets thermodynamic parameters to predict the direction and spontaneity of reactions;
	4. Interpret IR and UV-visible spectra of organic and inorganic compounds to identify functional groups and understand molecular structure;	4.1. Identifies characteristic absorption bands in IR spectra;
		4.2. Determines chromophores and conjugation effects in UV-visible spectra;
		4.3. Applies spectroscopic data to deduce the structure of simple compounds;
	5. Evaluate the physical and chemical properties of solutions and surface phenomena, including solubility, vapor pressure, and surface tension, and explain their relevance in real systems.	5.1. Explains the dependence of solubility and vapor pressure on temperature;
		5.2. Calculates surface tension and other solution-related parameters;

		5.3. Provides examples of practical applications of surface phenomena (e.g., in colloidal systems or emulsions);
Prerequisites	Physical Chemistry, Quantum Chemistry, Thermodynamics and Kinetics, Theory and Problems of physical chemistry	
Postrequisites	Mathematical Methods in Chemistry, Scientific Research Methodology	
Learning Resources	Main literature: 1. Atkins, P., de Paula, J. Atkins' Physical Chemistry, 11th Edition, Oxford University Press, 2018. 2. Levine, I.N. Physical Chemistry, 6th or 7th Edition, McGraw-Hill, 2009/2013. 3. House, J.E. Fundamentals of Quantum Chemistry, 2nd Edition, Academic Press, 2004. 4. Hammes-Schiffer, S., et al. Physical Chemistry for the Biological Sciences, University Science Books, 2009. 5. Zhdanov, V.P. Elementary Physicochemical Processes on Solid Surfaces, Springer, 1991. Additional literature: 1. Journals: Journal of Physical Chemistry A/B/C, Physical Chemistry Chemical Physics (PCCP), Chemical Physics Letters, Accounts of Chemical Research. 2. McQuarrie, D.A., Simon, J.D. Physical Chemistry: A Molecular Approach, University Science Books, 1997. Research infrastructure 1. Lecture classes – 412 lab. 2. Practical classes – 412 lab. Professional scientific databases 1. https://en.wikipedia.org/wiki/ 2. «WEB OF SCIENCE» [site]. – URL: http://www.webofscience.com/ Internet resources 1. http://elibrary.kaznu.kz/en 2. open.kaznu.kz	

Academic course policy	The academic policy of the course is determined by the Academic Policy and the Policy of Academic Integrity of Al-Farabi Kazakh National University. Documents are available on the main page of IS Univer. Integration of science and education. The research work of students, undergraduates and doctoral students is a deepening of the educational process. It is organized directly at the departments, laboratories, scientific and design departments of the university, in student scientific and technical associations. Independent work of students at all levels of education is aimed at developing research skills and competencies based on obtaining new knowledge using modern research and information technologies. A research university teacher integrates the results of scientific activities into the topics of lectures and seminars (practical) classes, laboratory classes and into the tasks of the IWS, which are reflected in the syllabus and are responsible for the relevance of the topics of training sessions and assignments. Attendance. The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the course. Failure to meet deadlines results in loss of points. Academic honesty. Practical/laboratory classes, IWS develop the student's independence, critical thinking, and creativity. Plagiarism, forgery, the use of cheat sheets, cheating at all stages of completing tasks are unacceptable. Compliance with academic honesty during the period of theoretical training and at exams, in addition to the main policies, is regulated by the "Rules for the final control", "Instructions for the final control of the autumn / spring semester of the current academic year", "Regulations on checking students' text documents for borrowings". Documents are available on the main page of IS Univer. Basic principles of inclusive education. The educational environment of the university is conceived as a safe place where there is always support and equal attitude from the teacher to all students and students to each other, regardless of gender, race / ethnicity, religious beliefs, socio-economic status, physical health of the student, etc. All people need the support and friendship of peers and fellow students. For all students, progress is more about what they can do than what they can't. Diversity enhances all aspects of life. All students, especially those with disabilities, can receive counseling assistance by phone / e-mail +7-701-391-91-56/ Zhazira.Supiyeva@kaznu.edu.kz or via video link in Zoom https://us04web.zoom.us/j/73603766209?pwd=tAtGLMXa2k61nURHGnrvBmPaouoQYg.I. Integration MOOC (massive open online course). In the case of integrating MOOC into the course, all students need to register for MOOC. The deadlines for passing MOOC modules must be strictly observed in accordance with the course study schedule. ATTENTION! The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the course, as well as in the MOOC. Failure to meet deadlines results in loss of points.
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INFORMATION ABOUT TEACHING, LEARNING AND ASSESSMENT

Score-rating letter system of assessment of accounting for educational achievements				Assessment Methods	
Grade	Digital equivalent points	points, % content	Assessment according to the traditional system	Criteria-based assessment is the process of correlating actual learning outcomes with expected learning outcomes based on clearly defined criteria. Based on formative and summative assessment. Formative assessment is a type of assessment that is carried out in the course of daily learning activities. It is the current measure of progress. Provides an operational relationship between the student and the teacher. It allows you to determine the capabilities of the student, identify difficulties, help achieve the best results, timely correct the educational process for the teacher. The performance of tasks, the activity of work in the classroom during lectures, seminars, practical exercises (discussions, quizzes, debates, round tables, laboratory work, etc.) are evaluated. Acquired knowledge and competencies are assessed. Summative assessment - type of assessment, which is carried out upon completion of the study of the section in accordance with the program of the course. Conducted 3-4 times per semester when performing IWS. This is the assessment of mastering the expected learning outcomes in relation to the descriptors. Allows you to determine and fix the level of mastering the course for a certain period. Learning outcomes are evaluated.	
A	4.0	95-100	Great		
A-	3.67	90-94			
B+	3.33	85-89	Fine		
B	3.0	80-84			
B-	2.67	75-79			
C+	2.33	70-74			
C	2.0	65-69	Satisfactorily	Formative and summative assessment	Points % content
C-	1.67	60-64		Activity in classes	5
D+	1.33	55-59		Work in practical classes	20
D	1.0	50-54		Independent work	20
				Colloquium	15
FX	0.5	25-49	Unsatisfactory	Final control (exam)	40
F	0	0-24		TOTAL	100

Calendar (schedule) for the implementation of the content of the course. Methods of teaching and learning.

A week	Topic name	Number of hours	Max. ball
Module 1. Fundamentals of Thermodynamics and Molecular Chemistry			
1	L 1. Basic principles and formulations of thermodynamics	1	
	PC 1. Quantitative calculations of energy, work and heat in thermodynamic processes	2	
2	L 2. Model representations of atoms and molecules in physical chemistry	1	
	PC 2. Basic quantum mechanical models: particle in a potential well and the hydrogen atom model	2	
	IWST 1. Consultation on the Implementation of IWS №1: "Mini-review of a recent article in physical chemistry"		
3	L 3. Laws of chemical equilibrium and energetics of equilibrium processes	1	
	PC 3. Calculation of thermodynamic functions and equilibrium constants	2	
4	L 4. Introduction to Molecular Spectroscopy Methods	1	
	PC4. Interpretation of IR and UV spectra of organic and inorganic compounds	2	10
	Colloquium: Based on Lectures 1-3 (written and oral)		
	IWST 2. Submission of IWS №1		5
5	L 5. Surface phenomena, solutions and properties of phase boundaries	1	
	PC 5. Properties of solutions: solubility, vapor pressure, surface tension	2	10
	IWST 3. Consultation on the Implementation of IWS №2: "Selection and translation of scientific terms"		
Module 2. Chemistry in Life and Energy			
6	L 6. Fundamentals of homogeneous and heterogeneous catalysis: principles and applications	1	
	PC 6. The role of catalysts in chemical reactions: mechanisms and examples	2	10
	IWST 4. Submission of IWS №2		15
7	L 7. Chemical energy sources: galvanic cells and fuel cells	1	
	PC 7. Examples and Calculations: Daniell Cell and Fuel Cells	2	10
8	L 8. Biochemical catalysis and enzyme functions in living systems	1	
	PC 8. Mechanisms of enzymatic catalysis: energy profiles and specificity	2	40
	Colloquium: Based on Lectures 4-7 (written and oral)		
Midterm control 1			100
Module 3. Reactions, photo effects and sensors			
9	L 9. Fundamentals of Statistical Thermodynamics: Microstates and Distributions	1	
	PC 9. Boltzmann distribution and ideal gas: quantitative analysis	2	5
10	L 10. The rate of chemical reactions and the mechanisms of their occurrence	1	
	PC 10. Plotting graphs and calculating kinetic parameters	2	5
	IWST 5. Consultation on the Implementation of IWS №3: "Modern methods of spectroscopy in physical chemistry"		
11	L 11. Properties and behavior of colloidal systems and nanoparticles	1	

	PC11. Stability, surface charge and examples of colloidal systems Colloquium: Based on Lectures 9-10 (written and oral).	2	
12	L 12. Fundamentals of Photochemistry: The Interaction of Light and Matter	1	
	PC 12. Fluorescence, quantum yield and photochemical efficiency	2	5
13	L 13. Nanomaterial-based sensors and analytical systems	1	
	PC 13. Biosensors and sensor platforms: examples and operating principles	2	5
	IWST 6. Submission of IWS №3		30
14	L 14. Chemical reactions under changing external conditions: the influence of temperature and pressure	1	
	PC 14. Dependence of equilibrium and reaction rate on temperature and pressure	2	5
15	L 15. Modern trends and tasks of physical chemistry	1	
	PC 15. Discussion of current applications of physicochemical approaches Colloquium Based on Lectures 11-15 (written and oral)	2	40
	IWST 7. Consultation on Final Exam Questions		
Midterm control 2			100
Final control (exam)			100
TOTAL for course			100

Policy of assessment of master student's independent work. The number of IWS is 3. The assignment is uploaded to the Univer system one week before the due date. The assignments are practical tasks, the solution of which consists of several stages, each of which is evaluated. Each task is accompanied by methodical recommendations.

RUBRICATOR OF THE SUMMATIVE ASSESSMENT OF IWS №1-3

Independent work of the student №1-3 (20% of 100% MC)

Criterion	"Excellent" 15-20%	"Good" 10-15%	"Satisfactory" 5-10%	"Unsatisfactory" 0-5%
Application of the information provided in the methodological recommendations	A thorough understanding theory, equations and formulas from lecture material and recommended textbooks. The presented course of problem solving is correct.	Understanding of theory, equations and formulas from lecture material and recommended textbooks. The solution algorithm is correct, but there are inaccuracies.	Limited understanding of theory, equations and formulas from lecture material and recommended textbooks. The progress of problem solving is not presented.	Superficial understanding/lack of understanding of theory, equations and formulas from lecture material and recommended textbooks. The progress of problem solving is not presented.
Quantitative results of the task	Good at linking key concepts of lecture material. Excellent grounding of arguments with evidence from empirical research in finding references and calculating intermediate values.	Relates key concepts of the lecture material. Supports arguments with evidence from empirical research.	Limited connection of key concepts of lecture material. Limited use of empirical research evidence.	Little or no connection of key concepts of the lecture material. Little or no use of empirical research.
Completeness and literacy of the assignment	Offers competent practical recommendations, suggestions on the possible algorithm of calculation problems tasks.	Offers some competent practical recommendations, suggestions on the on the possible algorithm of calculation problems tasks.	The proposed recommendations are insubstantial, not based on careful analysis, and shallow.	Little or no practical guidance or very poor quality guidance.

Dean _____ M.A. Duysebaeva

Chair of the Academic Committee
on the Quality of Teaching and Learning _____ A.U. Bektemisova

Head of Chair _____ E.A. Aubakirov

Lecturer _____ Zh.A. Supiyeva

