University of Gdańsk

Subject card

Subject name and code	Physical Chemistry, PG_00199407						
Field of study	Nuclear safety and radiological protection						
Date of commencement of studies	October 2026		Academic year of realisation of subject	2026/2027			
Education level	Bachelor's studies		Subject group	Obligatory subject group in the field of study Subject group related to scientific research in the field of study			
Mode of study	full-time studies		Mode of delivery	at the university			
Year of study	1		Language of instruction	Polish			
Semester of study	2		ECTS credits	5.0			
Learning profile	academic		Assessment form	exam			
Conducting unit	Faculty of Chemistry -> Rector						
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. Piotr Storoniak				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	15.0	30.0	0.0	0.0	75
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours	Self-study	SUM	
	Number of study hours	75		0.0	50.0	125	
Subject objectives	Acquainting students with the description of irreversible processes and the functioning of nature based on thermodynamics, with the phenomenological description of chemical changes over time based on chemical kinetics, with the description and applications of catalytic phenomena, and with the description and utilization of electrochemical processes. Acquiring the skills to understand and quantitatively describe physical transformations, chemical reactions, and to use physicochemical data in preparation for studying other subjects.						

Learning outcomes

Course outcome	Subject outcome	Method of verification
[BJORL3_U03] Is able to use the formalism of physics and chemistry to describe phenomena in the microworld.	is able to analyze problems and find their solutions based on laws and methods of physical chemistry	[SU2] presentation/project/paper/ report [SU3] text preparation/written work [SU4] test/exam - oral or written
[BJORL3_W02] Understands the role of physical and chemical experimentation, mathematical theoretical models approximating reality, and computer simulations in scientific research methodology; is aware of technological, apparatus, and methodological limitations in scientific research.	has knowledge of research techniques used in physicochemical research	[SW4] test/exam - oral or written [SW2] presentation/project/paper/ report [SW3] text preparation/written work
[BJORL3_W03] Knows how to plan and perform a simple physical or chemical experiment and analyze the results obtained; knows the elements of the theory of measurement uncertainty as applied to experiments; knows the basic units of the SI system and its most important derived units; knows other systems of measurement units.	identifies scientific and research equipment and explains the principles of its operation	[SW4] test/exam - oral or written [SW2] presentation/project/paper/ report [SW3] text preparation/written work
[BJORL3_U01] Can formulate the laws of physics and chemistry using mathematical formalism.	solves tasks using theories and formulas from the curriculum content of physical chemistry	[SU2] presentation/project/paper/ report [SU3] text preparation/written work [SU4] test/exam - oral or written
[BJORL3_U02] Has the ability to perform measurements of basic quantities used in physics and chemistry; can develop, describe and present the results of simple experiments and computer simulations; can perform quantitative analyses and formulate qualitative conclusions on this basis; can estimate measurement uncertainties.	is able to plan and perform simple experimental tests or observations and analyze the results, draws conclusions from the conducted research and proves their correctness based on available literature data	[SU2] presentation/project/paper/ report [SU3] text preparation/written work [SU8] observation of student's independent or team work
[BJORL3_W05] Has advanced knowledge of the elementary components of matter and the types of fundamental interactions between them, the manifestations of these interactions in phenomena occurring at scales ranging from subatomic to subatomic, knows the time and energy scales associated with these phenomena.	has general knowledge of the concepts and theories of physical chemistry, understands the molecular basis of physicochemical phenomena and processes occurring in nature	[SW4] test/exam - oral or written [SW2] presentation/project/paper/ report [SW3] text preparation/written work
[BJORL3_W01] Has a detailed knowledge of the basic concepts and principles of nuclear physics and chemistry, understands their historical development and their importance not only for nuclear safety and radiation protection, but also for understanding the modern world.	understands and is able to explain regularities, phenomena and processes using the language of mathematics, in particular is able to independently reproduce basic laws and theorems	[SW4] test/exam - oral or written [SW2] presentation/project/paper/ report [SW3] text preparation/written work

Subject contents	Issues of the lecture: Basics of chemical thermodynamics of reversible processes, basic thermodynamic quantities, principles of thermodynamics. Phenomenological and molecular interpretation of energy and entropy. Thermodynamic criteria of equilibrium, equilibrium constant. Thermodynamics of the formation of ideal and real solutions. Physicochemical properties of gases, liquids and solids. Phase equilibria, phase diagrams, physicochemical description of distillation, rectification, crystallization and extraction processes. Chemical kinetics: elementary and complex processes, theory of absolute reaction rate. Homo- and heterogeneous catalysis: mechanisms, technological significance and in nature. Conductivity of electrolyte solutions. Dependence of conductivity on temperature, pressure and type of solvent. Theory of strong electrolytes. Relaxation and electrophoretic effect - Debye-Hückel-Onsager theory. Conductivity of electrolytes in solvents with low electric constant. Basics of electrochemistry. Spontaneous and forced electrochemical processes: cells, electrolysis. Corrosion phenomenon. Issues of auditorium exercises: Calculations of changes in internal energy, heat and work for physical processes and chemical reactions. Calculations of changes in entropy, free energy and free enthalpy of physical transformations and chemical reactions. Determination of the chemical equilibrium constant, calculation of free enthalpy based on the chemical equilibrium constant, van't Hoff isotherm. Phase equilibria, Gibbs phase rule. Identifying the order of reactions, deriving kinetic equations based on reaction mechanisms, determining the kinetics of complex reactions, deriving and using integrated forms of kinetic equations, calculations using the Arrhenius equation, active collision theory, transition state theory. Calculation of specific and equivalent conductivity, mobility and speed of movement of ions in solution, determination of ion transfer numbers using the Hittorf method and the moving boundary method, determining the hydrodynamic radius of ions. Using normal potentials to determine chemical equilibrium constants, calculations using the Nernst equation, determining the emf of a working cell and ion activity coefficients, calculating thermodynamic functions of reactions taking place in cells, calculating cell temperature coefficients. Laboratory exercises: Determination of the dissociation constant based on spectroscopic measurements; calculations based on the Lambert-Beer law; applications of spectroscopic measurements; principle of operation of a UV-VIS spectrophotometer; behavior of a molecule in an electric field; determination of the refractive index; principle of operation of a dielectrometer. Principle of calorimetric measurements (heat capacity, bomb calorimeter, limitations of the method); liquid-vapor equilibrium diagrams for infinitely miscible two-component systems (isotherms and isobars); leverage rule; fractional distillation of zeotropic and azeotropic systems; refractive index and its measurement. Basic types of physical adsorption isotherms (Langmuir, Freundlich, BET); specific surface area and its calculation; application of the adsorption phenomenon. Methods of measuring SEM and determining the activity coefficient; pH coefficient and its potentiometric measurement, pH meters, glass, calomel, quinhydrone, antimony electrodes, electrode characteristics. Determination of activation energy, influence of the catalyst on the reaction, precise control of the reaction temperature.
Prerequisites and co-requisites	The necessity to complete courses in: general chemistry, basics of advanced mathematics, and fundamentals of physics. Knowledge of general chemistry at the undergraduate level, familiarity with basic concepts and principles of mathematics and physics.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
written exam, closed and open questions	51.0%	50.0%
reports from laboratory exercises	51.0%	25.0%
colloquium, closed and open questions	51.0%	25.0%

Recommended reading

Basic literature	P. Atkins, J. De Paula, J. Keeler, Atkin's Physical Chemistry, Oxford University Press, 2022. P. Atkins, Julio De Paula, Elements of Physical Chemistry, Oxford University Press, 2016. P. Atkins, Physical Chemistry: A Very Short Introduction, Oxford University Press, 2014.
Supplementary literature	P. Atkins, The Laws of Thermodynamics: A Very Short Introduction, Oxford University Press, USA, 2010. A. M. Steane,Thermodynamics: A Complete Undergraduate Course, Oxford University Press, 2016. R. M. Rosenberg, I. M. Klotz,Chemical Thermodynamics: Basic Concepts and Methods, Wiley-Intrerscience, 2008. C. H. Hamann, A. Hamnett, W. Vielstich, Electrochemistry, Wiley-VCH GmbH, 2007.
eResources addresses	

Example issues/ example questions/ tasks being completed	1. Work, heat and changes in internal energy and enthalpy in the isothermal, isochoric, isobaric and adiabatic transformations of ideal gases. 2. Derive the Claussius-Clapeyron law and show how the pressure of saturated vapor in equilibrium with the liquid should depend on temperature. 3. Using the theory of active collisions, explain the origin of steric, pre-exponential and exponential factors. 4. How does Lindemann's theory explain the second order of unimolecular reactions observed at low substrate pressures? 5. Compare Hittorf's method with the moving boundary method. Describe the advantages and disadvantages of each method. 6. Derive relationships between the electromotive force and its temperature coefficient and the thermodynamic functions of the reaction taking place in the cell.
Work placement	Not applicable

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