GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Principles of physical and biophysical chemistry, PG_00047944						
Field of study	Biomedical Engineering, Biomedical Engineering, Biomedical Engineering						
Date of commencement of studies	October 2024		Academic year of realisation of subject		2026/2027		
Education level	first-cycle studies		Subject group		Optional subject group 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	3		Language of instruction		Polish		
Semester of study	6		ECTS credits		4.0		
Learning profile	general academic profile		Assessment form		assessment		
Conducting unit	Department of Physical Chemistry -> Faculty of Chemistry						
Name and surname of lecturer (lecturers)	Subject supervisor						
	Teachers						
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	15.0	0.0	0.0	0.0	45
	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	45		4.0	51.0		100
Subject objectives	Understanding the laws governing (bio)chemical processes and reactions						

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K6_W02] knows and understands, to an advanced extent, selected laws of physics and physical phenomena as well as methods and theories explaining the complex relationships between them, constituting the basic general knowledge in the field of technical sciences related to the field of study	Student learns how to apply the laws of thermodynamics and kinetics to understand and quantitatively describe chemical and biochemical reactions, as well as other biomolecular processes, such protein folding, ligand binding, molecular recognition, DNA-protein binding. Student learns how to apply theoretical knowledge acquired throughout the course to solve basic and practical computational problems. Student learns to develop algorithms for solving problems of varying difficulty.	[SW2] Assessment of knowledge contained in presentation [SW1] Assessment of factual knowledge
[K6_U53] can apply equipment used in biomedical diagnostics	Student learns the physical foundations of most important experimental techniques (including spectroscopic, calorimetric and diffraction methods) used in physical and biophysical chemistry.	[SU5] Assessment of ability to present the results of task [SU2] Assessment of ability to analyse information

Subject contents

Basic concepts of the phenomenological thermodynamics: the first and second law of thermodynamics and their consequences. Basic principles of the statistical theory. The most probable distribution, the probability of the fluctuation. The Boltzmanns principle, molecular interpretation of the entropy. The Maxwell-Boltzmann distribution. Employing of thermodynamics in chemistry, biochemistry and biophysics. The chemical equilibrium and its dependence on the pressure and temperature. Energy conversion in biological systems; bioenergetics. Phase equilibria, the Clausius-Clapeyron equation, phase diagrams in a single and multi-component systems. Ideal and real solutions, the activity coefficients, colligative properties, osmotic phenomena, mixing thermodynamics Principles of electrochemistry: the potential difference on the border of phases. Cells and electrode potentials. The polarization of electrodes. Diffusion and transport phenomena in biological systems. Principles of the chemical kinetics. The reaction rate, the velocity constant, the order of reaction and the activation energy, the influence of the temperature on reaction rate. Enzymatic catalysis. Theoretical bases of molecular spectroscopy, UV/Vis, IR and NMR spectroscopy.

Prerequisites and co-requisites	Mathematics, Physics, General Chemistry, Technical Thermodynamics

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Presentation of the assigned topic	50.0%	15.0%
Written exam	50.0%	60.0%
Presentation of the task solution	50.0%	25.0%

Recommended reading		
	Basic literature	1. Atkins P. W. Podstawy Chemii Fizycznej, PWN 2. Libuś W. Chemia Fizyczna, Część I, Wydawnictwo PG 3. D. Zuckerman. Statistical Physics of Biomolecules. Wykłady z Chemii Fizycznej, WNT 4. Barrow G. M. Chemia Fizyczna, PWN 5. Kęcki Z. Podstawy Spektroskopii Molekularnej, PWN 9.
	Supplementary literature	1. K. Gumiński, Termodynamika, PWN 2. K. Huang Podstawy Fizyki Statystycznej, PWN
	eResources addresses	Adresy na platformie eNauczanie:

Example issues/ example questions/ tasks being completed	(a) sample presentation topics 1. Fluorescence (complementary color, light absorption, HOMO-LUMO gap and its dependence on the number of conjugated double bonds and donor/acceptor groups, UV-Vis spectroscopy, chlorophyll, luminescence, Jablonski diagram (why there's a difference in the frquency of the absorbed and emited radiation), fluorescence vs. phosphorescence, radiationless transitions, nonadiabatic dynamics, fluorescence yield) 2. FRET (Forster resonance, efficiency of energy transfer vs chromophore distance and orientation, confocal microscopy, sample applications - conformational transitions in the ATP synthase or transcription initiation by DNAPol, smFRET)3 3. Atomic force microscopy (working principle, anchoring biomacromolecules to the tip/surface, applications: protein unfolding, mechanical mapping) (b) sample projects 1. Membrane proteins are crucial in the cell's response to the environment, e.g., through modulation of ion permissivity. Here, we will see how the amino acid sequence affects the protein's interaction with the bilayer. 2.By analyzing the effect of single amino acid mutations, we can gain indirect insight into the mechanisms of protein folding. In this case, we will investigate the impact of a single key residue on the folding and unfolding kinetics of an extremely stable protein. Selected exam questions: 1. Substrate A can be converted to two products B and C. The standard Gibbs energy and Gibbs energy of activation for product B are -50 and 80 kJ/mol, respectively, and for product C, -15 and 20 kJ/mol, respectively. Which product will dominate when the reaction is carried out at a low temperature, and which when at a high temperature allowing for reaching equilibrium? Why? How can the concentration ratio of both products be determined at low temperatures? 2. It is known that stretching a rubber band involves conformational ordering of polymer molecules in the rubber; the resulting entropy decrease accounts for the main force opposing the deformation. Is the force exerted by the rubber band greater or smaller after heating? Why? 3. The folding process of a certain protein was studied in a calorimeter with a heat capacity of 0.4 kJ K. It was found that at 330 K, unfolding of 0.01 mole of this protein is accompanied by a 1 K decrease in calorimeter temperature. Knowing that the entropy change upon folding of this protein is -0.1 kJ/(mol K), determine which form of the protein, folded or unfolded, dominates in the cell in equilibrium (T = 300 K). Assume that for the folding process Cp = 0. How can the molar fractions of the folded and unfolded forms be determined from these data (do not calculate the final values, just indicate the formula and plug in the data)?
Work placement	Not applicable