



Subject card

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| 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 2026 | Academic year of realisation of subject | | | | 2028/2029 | |
| 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 -> Faculties of Gdańsk University of Technology | | | | | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | prof. dr hab. inż. Jacek Czub | | | | | |
| | Teachers | | | | | | |
| Lesson types | 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 | | |
| Subject contents | Course content – lecture 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 Boltzmann 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 | | |
| Example issues/ example questions/ tasks being completed | (a) sample presentation topics | | |
| | <p>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 frequency of the absorbed and emitted radiation), fluorescence vs. phosphorescence, radiationless transitions, nonadiabatic dynamics, fluorescence yield)</p> <p>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</p> <p>3. Atomic force microscopy (working principle, anchoring biomacromolecules to the tip/surface, applications: protein unfolding, mechanical mapping)</p> <p>(b) sample projects</p> <p>1. Membrane proteins are crucial in the cell's response to the environment, e.g., through modulation of ion permmissivity. Here, we will see how the amino acid sequence affects the protein's interaction with the bilayer.</p> <p>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.</p> <p>Selected exam questions:</p> <p>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?</p> <p>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?</p> <p>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 $C_p = 0$. 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)?</p> | | |

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| Practical activities within the subject | Not applicable |
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