POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Physical chemistry [S1IFar1>CF]

Course

Field of study
Pharmaceutical Engineering

Year/Semester
2/4

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
30	30	0
Tutorials	**Projects/seminars**	
0	0	

Number of credit points

5,00

Coordinators

dr hab. inż. Agnieszka Świderska-Mocek
agnieszka.swiderska-mocek@put.poznan.pl

Lecturers

Prerequisites

Students: have knowledge in general chemistry (writing chemical reactions, converting concentrations, knowledge of laboratory glassware and basic laboratory equipment). have knowledge in mathematics and physics enabling the introduction of problems in physical chemistry (basic laws of physics, differential calculus). are able to prepare solutions of specific concentrations. are aware of further development of their competences.

Course objective

To familiarise students with basic problems in physical chemistry and electrochemistry at the academic level in the field of: chemical kinetics, simple and complex reactions, homo- and heterogeneous catalysis and electrolysis, type of half-cells and type of cells.

Course-related learning outcomes

Knowledge:
students will be able to characterise, list and identify simple and complex reactions, define hommo- and heterogeneous catalysis, define the causes of corrosion, define the causes of surface phenomena.
k_w1, k_w4

students will be able to define and explain the basic principles, theories in the field of chemical kinetics, such as: rate of chemical reaction, order and molecularity, half-life, activation energy, collision and activated-complex theory. k_w1, k_w4
students will be able to define and explain the basic principles, theories in the field of electrochemistry, such as: types of half-cells, types of cells, the concept of electrolysis or corrosion. k_w1, k_w4

Skills:
students will be able to obtain information from literature, databases and other sources; interpret it as well as draw conclusions and formulate and substantiate opinions. k_u1
students will be able to work individually and as part of a team; estimate the time needed to complete the assigned task. k_u2
students will have the self-study skills in the subject. k_u3
students will be able to elaborate, describe and present results of an experiment or theoretical calculations. k_u2
students will be able to distinguish between types of chemical reactions and to select them for specific chemical processes. k_u2, k_u10

Social competences:
students will understand the need for further training and developing their professional competences. k_k1
students will be able to properly prioritise the task. k_k5

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
Lecture: The knowledge acquired during the lecture is verified during the written exam. The exam consists of 4-5 open questions for the same number of points. Minimum threshold: 60% points.
Laboratory classes: The course passing is based on points received for the individual exercise description. Passing exercises from 56% .
If the classes will be held remotely, the forms of course assessments will remain unchanged and will be carried out with the use of tools provided by the Poznań University of Technology (the e-courses platform).

Programme content

Lecture:
1 Solution physics and chemistry
Activity coefficients. Nernst's distribution law. Extraction. Osmosis. Reverse osmosis. Membranes. Boiling and freezing point of the non-volatile solution. Boiling-point constant of solvent. Freezing-point constant of solvent. Solubility of gases in liquids - dependence on temperature and pressure. Solubility of solids in liquids, dependence on temperature.
2. Solid adsorption
Solid adsorption. Physical and Chemical Adsorption. Heats of adsorption. Isotherms of adsorption: Linear, Freundlich, Langmuir, BET equations. Adsorbents – properties (micro-, meso- and macropores). Activated carbons. Capillary condensation of gases. Determination of the adsorbent specific surface area from the BET isotherm. Surface modification of solid adsorbents. The use of solid adsorbents. Surfactancs.
3 Colloidal systems
Dispersion, definition of colloidal systems. Divisions of colloidal systems. Gasozole, liozole, solid zols. Lyophilic and lyophobic colloids. Phase, molecular and micellar systems. Creating colloidal systems: dispersion and condensation methods. Emulsion formation. Structure of micelles. Protective load. Zeta potential. Electrophoresis. Tyndall effect. Viscosity of colloidal systems. Destruction of colloidal systems. Peptizing-coagulation.
4 Chemical kinetics - basic concepts
General Concepts of Kinetics. Collision Theory. Mechanisms of the Chemical Reactions – unimolecular, bimolecular and termolecular reactions. Rate of chemical reaction. Rate constant. Half-life. Order of the Chemical Reaction. Zero, first, second, and third-order rate equations. Pseudo-first-order reactions. Temperature dependence of the rate constant - Arrhenius formula. Activation Energy.
5 The reaction product is formed directly not from the substrates but from the active complex

Activated-Complex Theory. Temperature dependence of the rate constant – Arrhenius and Eyring's equations. Enthalpy and entropy of activation. The relationship between the parameters of the Arrhenius equation and Eyring. Two barriers to the course of the reaction: energetic and structural (energy and entropy of activation). Influence of pressure on the rate of gas reactions.
6 Complex reactions
Reversible reactions - equations for equilibrium concentrations. The equilibrium constant results from kinetics. Efficiency of reversible reactions. Parallel reactions, kinetic equations, under given conditions we observe a product that is formed in the fastest reaction. The speed of individual parallel reactions can be adjusted using: temperature changes, concentration changes or using a selective catalyst. Consecutive reactions. Intermediate product.
7 Chain reactions
Straight and branched chain. Initiating chain reactions. Examples of chain reactions. Establishment of steady state. The slowest reaction rate determines the speed of the whole process. Examples of kinetic methods for solving the reaction mechanism. Activation energy of consecutive processes.
8 Homogenous Catalysis in solution
Mechanism of catalyst operation. Reaction inducer. Heterogeneous and Homogenous Catalysis. Types of homogeneous catalysts in liquid solution. The dependence of rate of catalysis on the amount of catalyst. Acid-base catalysis. Enzymes.
9 Heterogeneous Catalysis
The principle of operation of heterogeneous solid catalysts. Catalyst, catalyst supports (powder and monolithic). Influence of diffusion and adsorption on the rate of catalytic reaction. Examples of different mechanisms of contact catalysis. Diffusion as the rate determining step. TON and TOF coefficients.
10 Explosive reactions
Explosions. Blast power. Detonation, deflagration. Propelling and crushing materials. Initiators. Mathematical description of radical reaction with branched chain - balance of radicals, acceleration factor. Oxygen balance. Explosive composites. Cumulation phenomenon, Monroe effect.
11 Kinetics of the electrode reaction - equilibrium conditions
Double electrical layer. Transition Reaction.Eyring equation for the electrode process. Equilibrium condition - electrochemical potential. Equilibrium chemical reaction - Nernst equation. Exchange current.
12 Kinetics of the electrode reaction - non-equilibrium conditions
Eyring equation for an unbalanced electrode. Butler-Volmer equation. Activation polarization. Ohmic and diffusion (concentration) polarization.
13 Electrochemical corrosion
Steel corrosion mechanism. Construction of Pourbaix charts. Pourbaix charts for chromium, iron, stainless steel. Stress corrosion, in macrocells, in oxygen concentration cells. Protection from Corrosion. Cathodic and anodic protection.
14 Chemical power sources.
Thermodynamics of cell reaction, cell efficiency. Primary batteries. Reserve batteries. Secondary cells (batteries): acid, alkaline, nickel-hydride. Lithium-ion batteries. Fuel cells, their types. Hydrogen-oxygen cell. Low temperature alcohol oxidation.
Laboratory:
CHEMICAL KINETICS General Concepts of Kinetics. Collision Theory, Activated-Complex Theory. Mechanisms of the Chemical Reactions – unimolecular, bimolecular and termolecular reactions. Rate of chemical reaction. Rate constant. Order of the Chemical Reaction. Zero, first, second, and third-order rate equations. Temperature dependence of the rate constant. Activation Energy. Ionic strength of an electrolyte. Influence of the ionic strength on the chemical reaction rate. Spectrophotometer construction. Principles of the spectrophotometric measurements. Lambert-Beer law.
ELECTROCHEMISTRY Electrolysis. Chemical and electrochemical depositions of metal coating. Corrosion. Protection from Corrosion. Types of half-cells. Methods of EMF (electromotive force) determination. Types of the galvanic cells. Primary and Secondary Cells. Deposition potential. Overpotential varieties. Hydrogen overpotential. Ion mobility. Transfer number. Electric Double-Layer. Electrokinetic phenomena. Diffusion potential. Concentration cells.
SURFACE EQUILIBRIUM Physical and Chemical Adsorption. Isotherms of adsorption: Linear, Freundlich, Langmuir, BET equations. Adsorbents – properties. Spectrophotometer construction. Principles of the spectrophotometric measurements. Lambert-Beer law. Surface tension and measurement methods. Gibbs adsorption isotherm. Flotation. Surfactants. Foams and emulsions.

Teaching methods

Lecture: multimedia presentation
Laboratory- practical method - laboratory exercises. Planning, execution and analysis of the results of physicochemical experiment.

Bibliography

Basic
1. K. Pigoń, Z. Ruziewicz, Chemia Fizyczna, PWN Warszawa 2013
2. P. Atkins, Chemia Fizyczna, PWN Warszawa 2019
3. A. Molski, Wprowadzenie do kinetyki chemicznej, WNT Warszawa 2000
4. L. Sobczyk , Eksperymentalna Chemia Fizyczna, PWN Warszawa 1982
Additional
1. P. Atkins, Podstawy Chemii Fizycznej, PWN, Warszawa 1999
2. L. Sobczyk, A. Kisza, Chemia fizyczna dla przyrodników, PWN Warszawa 1977
3. J. Minczewski, Chemia analityczna, PWN Warszawa 2005
4. H. Buchnowski, W. Ufnalski Wykłady z chemii fizycznej, WNT Warszawa 1998
5. Instrukcje do ćwiczeń laboratoryjnych z chemii fizycznej

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	75	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	50	2,00