



## COURSE DESCRIPTION CARD - SYLLABUS

Course name

Chemia fizyczna (Physical Chemistry)

### Course

Field of study

Year/Semester

Technologia chemiczna (Chemical Technology)

II/4

Area of study (specialization)

Profile of study

-

general academic

Level of study

Course offered in

First-cycle studies

Polish

Form of study

Requirements

full-time

compulsory

### Number

#### of hours

Lecture

Laboratory classes

Other (e.g. online)

30

30

0

Tutorials

Projects/seminars

30

0

#### Number of credit points

5

### Lecturers

Responsible for the course/lecturer:

Responsible for the course/lecturer:

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Wydział Technologii Chemicznej

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### 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 homo- and heterogeneous catalysis, define the causes of corrosion, define the causes of surface phenomena.

K\_W03, K\_W10

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\_W03, K\_W10

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\_W03, K\_W10

#### 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\_U01

Students will be able to work individually and as part of a team; estimate the time needed to complete the assigned task. K\_U02

Students will have the self-study skills in the subject. K\_U05

Students will be able to elaborate, describe and present results of an experiment or theoretical calculations. K\_U09

Students will be able to distinguish between types of chemical reactions and to select them for specific chemical processes. K\_U018

#### Social competences

Students will understand the need for further training and developing their professional competences. K\_K01

Students will be able to properly prioritise the task. K\_K04

### **Methods for verifying learning outcomes and assessment criteria**

Learning outcomes presented above are verified as follows:

Lecture: exam



Laboratory classes: The course passing is based on points received for the individual exercise description. Passing exercises from 56% .

Excises: grade on the basis of points obtained for activity during classes, writing tests. Passing exercises from 60% .

## **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.

Exercises and Laboratory:

Mathematical description of the rate of chemical reactions. Determination of rates, constant rates of simple chemical reactions. Calculation of the order of chemical reactions based on experimental data. Methods for determining orders of chemical reactions. Complex reaction kinetics. Dependence of the reaction rate constant on temperature - calculation of the reaction activation energy from the Arrhenius equation. Eyring equation - determining the enthalpy and entropy of activation of the active complex. Calculations regarding the electrical properties of electrolyte solutions: transfer numbers, conductivity, ion mobility. Electrolysis, Faraday's laws, electrochemical calculations. Electrode potentials, determination of standard half-cell potentials - Nernst's equation. Construction of galvanic cells, calculation of electromotive forces. The equation of the process is the source of electrical work. Determination of the standard SEM. Calculation of standard thermodynamic functions of a chemical reaction based on SEM measurement of cells.

**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.



Exercises with discussion. Deductive method. The exercises involve solving partial tasks and solving detailed problems.

## 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. Kiszka, 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	150	5,0
Classes requiring direct contact with the teacher	100	3,3
Student's own work (literature studies, preparation for laboratory classes, preparation for tests and exam, preparation of report) <sup>1</sup>	50	1,7

<sup>1</sup> delete or add other activities as appropriate