COURSE DESCRIPTION CARD - SYLLABUS

Course name
Physical Chemistry

Course

Field of study
Pharmaceutical Engineering
Area of study (specialization)
-
Level of study
First-cycle studies
Form of study
full-time

Year/Semester
2/4
Profile of study
general academic
Course offered in
polish
Requirements
compulsory

Number of hours

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

Number of credit points

5

Lecturers

Responsible for the course/lecturer:
prof. dr. hab. Franciszek Główka

Responsible for the course/lecturer:

Prerequisites

Mastery of general chemistry, matemathics, and physics at a high school level.

Course objective

The aim of the course is to teach students the basics of physical chemistry, explain the issues related to phenomena in the field of phase equilibria, surface phenomena, kinetics, electrochemistry and colloidal systems. Providing the foundation for understanding the problems of chemical technology of medicinal products, pharmaceutical technology, and pharmaceutical engineering.

Course-related learning outcomes

Knowledge

1. The student has ordered general knowledge in the field of physical chemistry allowing understanding, description and investigation of phenomena and chemical processes related to pharmaceutical engineering. Student performs calculations of selected physicochemical parameters (K_W4).
2. The student knows the basics of kinetics, thermodynamics and catalysis of chemical processes (K_W11).

3. Student knows the fundamentals of pharmacokinetics (K_W1).

Skills

1. Student uses a specific equipment and research apparatus in determining selected physicochemical parameters, elaborates the experiment report (K_U8).
2. Student uses a correct chemical and pharmaceutical terminology in the field of physical chemistry (K_U3).

Social competences

3. The student is able to interact and work in a group of 3-4 people to carry out a specific experiment (K_K2).

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

METHODS FOR VERIFYING LEARNING OUTCOMES

Knowledge, points 1-3: Entrance quiz and oral answers during laboratory classes, tests, exam.
Skills, point 1: Observation of the student during the lab (performance of the task), assessment of the report from the experiment.
Skills 2: Entrance and oral answer during laboratory classes, evaluation of the report from the experiment, tests, exam.
Social competences, point 1: Observation of a student during the lab classes (task completion).

ASSESSMENT CRITERIA

After each part of lectures, i.e. I - kinetics and elements of pharmacokinetics, II - thermodynamics, III - selected properties of single- and multi-component systems and physicochemical phenomena, a test is carried out. The test may consist of closed single and multiple choice electronic questions (OpenOLAT) and open questions in writing. Obtaining at least 60% of the total number of points is required to pass the test.

During calculations, students are assessed for their ability to solve the calculation exercise on his/her own and for knowledge of the theory related to a given issue.

During each laboratory exercise, the students are assessed for the preparation of a theory (written entrance quiz or test), performance of the lab experiment and the way of presenting the results in the form of a report. The final grade of the exercises is the arithmetic mean.

The condition of passing the classes is attending them, demonstrating the ability to solve calculation exercises (obtaining positive grades and improving unsatisfactory grades), demonstrating knowledge of theoretical issues concerning the laboratory part of the exercises and obtaining credit for all the lab reports.

The course ends with an exam consisting of single or multiple-choice closed questions in an electronic form (OpenOLAT) and open questions in writing, which covers the material realized during lectures and lab classes. Obtaining at least 60% of the total number of points is required to pass the exam. The exam can be taken by students who have completed the classes and tests according to the course schedule.

Programme content

LECTURES

1. Chemical kinetics with elements of pharmacokinetics:

The concept of the rate, order, and molecularity of a chemical reaction. Determination of the reaction order. Zero-, first- and second-order reactions, second-order autocatalytic reaction. Reaction rate constant. Drug half-life t0.5 and shelf-life t0.1. Influence of temperature on a reaction rate, Arrhenius equation, activation energy. Homogeneous catalysis. Kinetics of enzymatic reactions according to the Michaelis-Menten model. The fate of drugs in the body (LADME). The concept of a compartment. Pharmacokinetic parameters. Determination of pharmacokinetic equations to describe changes in drug concentration in blood and the amount of drug in urine after a single intravenous and oral dose in a single-compartment model. Bateman's equation.

2. Elements of thermodynamics:

Expansion work, internal energy, the first law of thermodynamics. Enthalpy. Heat capacity of the system. Heat of chemical reaction, heat of formation, heat of combustion. Hess's law and Kirchoff's laws. Entropy. Reversible and irreversible processes, the second law of thermodynamics. Free energy and free enthalpy (Gibbs energy). Chemical potential. Dependence of equilibrium constants on temperature and pressure, van't Hoff isobar and isotherm. The third law of thermodynamics.

3. Selected properties of single- and multi-component systems and physicochemical phenomena:

Phase transitions. Clausius-Clapeyron equation. Two-component systems. Definition of a solution. Total pressure of gases in a gaseous solution. The gas mixing process as a spontaneous process. Derivation of equations for the change of entropy and free enthalpy during gas mixing. Solutions of gases in liquids. Henry's law. The effect of temperature on gas solubility in liquids.

Vapor pressure above a solution of two miscible liquids. Raoult's law and Henry's law for a solution of two liquids. Deviations from Raoult's law. The composition of the vapor above the solution of two liquids. Azeotropic mixtures. The boiling point of the solution of two miscible liquids. Distillation.

The effect of temperature on the solubility of partially miscible liquids. Lower and upper critical solution temperature. Vapor pressure and boiling point of partially miscible liquids. Immiscible liquids. Steam distillation. Dalton's law.

Vapor pressure above the solution of solids. Boiling point elevation and freezing point depression. Osmotic pressure, van't Hoff factor. The influence of solvent and temperature on the solubility of solids. Dissolution rate of solids. Solubility of sparingly soluble electrolytes. The effect of pH on the solubility of weak electrolytes.

Polymers and biomaterials in pharmacy and medicine; applications. Polymerization methods (chain-growth and step-growth polymerization). Polymer properties: polydispersity, methods for determination of the polymer molecular weight; viscosity, Stokes law, Mark-Houwink equation; glass transition temperature; contact angle.

Definition and classification of colloidal systems. Kinetic, optical and electrical properties of colloids. Brownian motion. Diffusion; Fick's first law; diffusion coefficient D. Sedimentation; determination of molar mass of macromolecules from the measurements of a sedimentation coefficient. Osmotic pressure. Light scattering. Electrokinetic potential; electrophoresis; Donnan equilibrium. Stability of colloidal systems; coagulation. Gold number. Emulsions. HLB number. Emulsion decomposition rate. Emulsifiers and solubilizers.

Equilibria in electrolyte solutions. Dissociation and the degree of dissociation. Definitions of acids and bases. Dissociation of weak acids and bases. Dissociation constant and exponent of dissociation constant. Dissociation constants for conjugate acid and base. Water dissociation, solubility constant Ks. Hydrogen ion exponent (pH). The effect of pH on the degree of dissociation of weak acids and weak bases. pH at acid-base equilibrium. Buffer solutions. Henderson-Hasselbalch equation. Buffer capacity. Buffer systems of a living organism. The effect of pH on drug solubility. Impact of pH on drug penetration across the biological membranes.

Electrochemistry. Half reactions. Types of half-cells and cells. Electrode processes - the convention of notation. Reactions occurring in the links. Cell potential. Relationship between the change of Gibbs energy and zero-current cell potential. Nernst equation. Cells in equilibrium. Ion selective electrodes. Measurement of standard potentials. Application of zero-current cell potential measurements. Determination of the equilibrium constant K and solubility constant Ks, pH measurement. Electrochemical corrosion. Fuel cells and batteries. Ion mobility. Ion transport numbers. Specific and equivalent conductance.Dependence of conductance on ion concentration and ion mobility. Electrolysis. Faraday's laws. Application of electrolysis. Conductometry and its application.

Physical and chemical adsorption. Isotherms: Freundlich, Langmuir, BET. Hysteresis phenomenon. Application of adsorption. Heterogeneous catalysis.

LABORATORY CLASSES - calculation part:
Properties of solutions. Ionic equilibria. Colloidal systems. Surface phenomena. Kinetics.

LABORATORY CLASSES - experimental part:
Determination of pKa of acetylsalicylic acid by potentiometric titration and determination of the solubility product of a sparingly soluble calcium salt.
Determination of the rate constant and thermodynamic parameters of acetylsalicylic acid hydrolysis.
Preparation and determination of emulsion types. Determination of the molecular weight of a polymer by viscometric method. Determination of the isoelectric point of gelatin.
Adsorption of acetaminophen on activated charcoal.

Teaching methods

LECTURES: Multimedia presentation, illustrated with examples on the board.

LABORATORY CLASSES - calculation part: Discussion on the calculation exercise solutions.

LABORATORY CLASSES - experimental part: Performing experiments under the supervision of the assistant - experimental exercises.

Bibliography

Basic
1. P.W. Atkins, Chemia fizyczna, Wydawnictwo Naukowe PWN, 2007.
2. P.W. Atkins, Podstawy chemii fizycznej, Wydawnictwo Naukowe PWN, 2009.
3. T.W. Hermann (ed.), Chemia fizyczna, Wydawnictwo Lekarskie PZWL, 2007.

Additional
1. A. Danek Chemia Fizyczna , Wydawnictwo Lekarskie PZWL, 1982.
2. A.G. Whittaker, A.R. Mount, M.R. Heal Chemia Fizyczna , Wydawnictwo Naukowe PWN, 2003.
3. F. Główka (red.) Farmacja fizyczna. Ćwiczenia laboratoryjne dla studentów farmacji i analityki medycznej , Wydawnictwo Naukowe Uniwersytetu Medycznego im. Karola Marcinkowskiego w Poznaniu, 2015.

Breakdown of average student's workload

	Hours	ECTS
Total workload	135	5,0
Classes requiring direct contact with the teacher	75	2,8
Student's own work (literature studies, preparation for laboratory classes, preparation for tests/exam) [1]	60	2,2

[1] delete or add other activities as appropriate