# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Physical chemistry [S1IChiP1>CF1]

## Course

Field of study
Chemical and Process Engineering

Year/Semester
2/3

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
30

Laboratory classes
0

Other
0

Tutorials
15

Projects/seminars
0

## Number of credit points

4,00

## 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). have knowledge in mathematics and physics enabling the introduction of problems in physical chemistry (basic laws of physics, differential calculus). are aware of further development of their competences.

## Course objective

To familiarise students with basic problems in physical chemistry at the academic level in the field of: thermodynamic functions (the first and second laws of thermodynamics, the Gibbs free energy, thermochemistry,the thermodynamic equation of state), phase equilibrium – one-component and multi-component systems, surface and chemical equilibrium, colloidal systems and energy sources.

## Course-related learning outcomes

Knowledge:
students will be able to formulate and explain the basic principles, theories in the field of physical chemistry, give simple examples of their aplication in the surrounding world. k_w03, k_w10
students will be able to define the basic concepts and laws of thermodynamics, determine the basic limitations and scope of their applicability; describe phenomena and processes in thermodynamics.

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 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_u07, k_u08

Social competences:
students will be aware of the responsibility for jointly performed tasks. they will be able to work as a team. k_k04

## 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: on the basis of passing exercises.
Exercises: grade on the basis of points obtained for activity during classes, writing tests. Passing threshold: 60%.
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.First law of thermodynamics
Internal energy – total energy of a system. Energy balance of the reaction (process) - internal energy balance. The difference of energy contained in products and substrates exchanged with the environment. Varieties of work: electrical, surface expansion, volumetric. How internal energy is stored. Thermal energy. Average thermal energy of particles. Maxwell-Boltzman distribution. Temperature, its various scales. Thermodynamic temperature scale.
2. Second law of thermodynamics
The concept of entropy as a measure of chaos. Total entropy may increase but cannot decrease. Total entropy change as the sum of entropy system and environment changes. Zero (third) law of thermodynamics.
3. Gibbs energy – the fundamental equation of chemical thermodynamics. Work and heat depend on how the process is carried out. State function. Isobaric and isochoric process. Adiabatic changes. Definition of enthalpy. Heat transferred at constant pressure. Heat transferred at constant volume. Definition of Gibbs energy. Definition of Helmholtz energy. When to use which function (p = const or v = const).
4. Thermochemistry
Heat capacity. Calorimeter is a device for measuring energy transferred as heat. Dependence of heat capacity on temperature. The difference between Cp and Cv and qp and qv. Thermochemical equations. Substance heat and reaction heat. Temperature dependence of isobaric and isochoric processes.
5. Standardization of thermodynamic functions
Standard enthalpies of formation. Specification of reference state. Standard entropy. Entropy of substances near Kelvin zero. Calorimetric measurement of entropy of a substance.
6. Thermodynamic equation of state
The variation of Helmholtz energy with T and V. The variation of Gibbs energy with T and p. Variation of enthalpy with p. Variation of pressure with T and p. Variation of internal enthalpy with volume. Maxwell relations.
7. Phase equilibrium – one component system
Gibbs phase rule. Melting, evaporation, sublimation. Phase diagrams: liquid – vapour. Temperature dependence of vapour pressure, Clausius-Clapeyron equation. Liquid heating curves. Boiling phenomenon - boiling point. Dependence of boiling point on pressure. Heat of evaporation, heat of condensation. Cooling by evaporation of water. Cavitation. Liquid - solid transformation. Dependence of melting point on pressure. Solid state –vapour transition: sublimation. Dependence of the vapor pressure over a solid on temperature.

8. Phase equilibrium– one component system, phase diagrams
Temperature dependence of vapour pressure for liquid-gas, liquid-solid and solid-gas equilibria. Phase diagram of a one component system. Different solid phases. Examples of phase diagrams. Glassy condition. Glass transition temperature. Glass structure. Supercritical fluid. Supercritical CO2 - phase diagram, applications.
9. Phase equilibrium -multi component systems
Thermal analysis. Phase diagram. Liquid-gas phase equilibria for multi component systems. Distillation, fractional distillation. Aseotropes. Crude oil distillation, agricultural alcohol distillation. Liquid-solid phase equilibria for multi component systems. Crystallization, purification. Simple eutectic mixture. Eutectics of solid solutions, phase diagram. Eutectic mixture with a chemical connection between the components. Peritectic mixture. Structure of eutectic alloys. Metal alloys, examples.
10. Chemical equlibrium
The equilibrium constant for reaction K. Dependence of the equilibrium constant for reaction K on temperature - van"t Hoff"s isotherm. Dependence of equilibrium position on temperature, isobar and isochor van’t Hoff. Pressure dependence of the equilibrium position, van Laar"s isotherm.
11. Thermodynamic description of mixtures
Mixture and solution. Volume changes when mixing liquids - no additivity. Partial molar volume. In general: partial molar quantities. General lack of additivity of partial molar quantities. Gibbs-Duhem equation. Chemical potential, its dependence on the amount of substance and temperature. Thermodynamics of mixing. Ideal solutions. Real solutions. Excess functions.
12. 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.
13. Solid -liquid adsorption
Solid-liquid adsorption. Physical and Chemical Adsorption. Heat of adsorption. Single- and multilayer adsorption. Identical adsorption centers. Isotherms of adsorption: Linear, Freundlich, Langmuir, BET equations. Adsorbents – properties. The structure of adsorbents, micro-, meso and macro-pores. Activated carbons. Capillary gas condensation. Determination of the adsorbent specific surface area from the BET isotherm. Surface modification of solid adsorbents. The use of solid adsorbents. Adsorption at the interface: liquid - liquid, liquid - gas. Gibbsa adsorption isotherm. Surfactants.
14. 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.
15. Energy sources
Mass defect (nuclear reactions) as the only source of "extra" energy. The sun as "Earth"s nuclear power plant". Solar constant.Perpeutum mobile of the first and second type. Hydrogen as a future energy source is perpetual motion machine. Fossil and renewable fuels. Fuel parameters depending on the application. Fuel for internal combustion engines. Gasoline, Diesel. Octane number. Fossil fuel resources. The possibility of obtaining solar energy via renewable fuels.
Exercises:
Physicochemical calculations in the field of:
Chemical thermodynamics
First law of thermodynamics. Heat balance of chemical reactions. Calculation of thermal effects based on table values. Heat capacity Cv and Cp and their dependence on temperature. Standardization of thermal effects of chemical reactions.
Second law of thermodynamics. Determining the direction of chemical transformation. Entropy as a state function of direction.
Chemical kinetics
General Concepts of Kinetics. Determination of the rate law. Determination of the rate of chemical reaction. Determination of rate constant of chemical reaction. Temperature dependence of the rate constant. Calculation of activation energy from the Arrhenius equation.

## Course topics

Basic topics in physical chemistry.

## Teaching methods

Lecture: multimedia presentation
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. H. Buchowski, W. Ufnalski, Podstawy termodynamiki, WNT Warszawa 1998
4. H. Buchowski, W. Ufnalski, Fizykochemia gazów i cieczy, WNT, Warszawa 1998
5. W. Ufnalski, Równowagi chemiczne, WNT, Warszawa 1998
6. L. Sobczyk , Eksperymentalna Chemia Fizyczna, PWN Warszawa 1982
7. P.W. Atkins, C.A Trapp, M.P.Cady, C.Giunta Chemia fizyczna. Zbiór zadań z rozwiązaniami
8. J. Demichowicz-Pigoniowa Obliczenia fizykochemiczne, Wydawnictwo Politechniki Wrocławskiej Wrocław 1997

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

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 90 | 4,00 |
| Classes requiring direct contact with the teacher | 45 | 2,00 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 45 | 2,00 |