POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

COURSE DESCRIPTION CARD - SYLLABUS

Course name

Chemical and Process Thermodynamics

Course

Field of study

Chemical Technology

Area of study (specialization)

-

Level of study

First-cycle studies

Form of study

full-time

Year/Semester

II/3

Profile of study

general academic

Course offered in

English

Requirements

compulsory

Number of hours

Lecture

30

Laboratory classes

30

Other (e.g. online)

0

Tutorials

0

Projects/seminars

0

Number of credit points

6

Lecturers

Responsible for the course/lecturer:

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Wydział Technologii Chemicznej

ul. M. Skłodowskiej-Curie 5, 60-965 Poznań

Responsible for the course/lecturer:

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 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 theories of surface phenomena, heat engines and energy sources. 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 be able to plan and carry out measurements of basic physicochemical parameters. K_U22, K_U23

Students will be able to apply the principles of thermodynamics in the implementation of chemical processes. K_U23

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

Social competences

Students will be aware of the responsibility for jointly performed tasks. They will be able to work as a team. K_K03

Students will understand the need for further training and developing their professional competences. K_K01

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% .

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. Properties of gases

Perfect gas. Real gas. Definition of compression factor. Real gas description using a polynomial (virial equation). Virial coefficient - Boyle temperature. Determination of the virial coefficient. Van der Waals molecular interactions. Real gas description using a van der Waals equation. Van der Waals isotherm, perfect gas isotherm. Critical isotherm. Reduced variables.

8. 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.

9. 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.

10. 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.

11. 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.

12. 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.

13. 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.

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. Flows

Stimulus and flow. Transfer of mass, heat, load and momentum. Diffusion, Fick's first law of diffusion. Diffusion equation. Diffusion coefficient. Thermodiffusion. Thermal conductivity, Fourier equation. Momentum transfer, Newton's equation. Viscosity coefficient. Non-Newtonian liquids. Ohm's law. Conductivity.

16. Heat machines

Heat engine. Working principle - heat tank, cooler. Heat engine efficiency. Carnot cycle. Steam engine. Turbine engine. Stirling's engine. Heat pumps, principle of operation. The efficiency of the cooler and heat pump.

17. 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.

Laboratory:

PHASE EQUILIBRIUM

Liquid – Vapour transition. Temperature dependence of vapour pressure, Clausius-Clapeyron equation. Raoult's law and Henry's law. Phase diagrams: liquid – vapour. Distillation, fractional distillation. Aseotropes. Gibbs phase rule. Phase diagrams: liquid - solid for the two component systems. Two and multi component systems. Thermal analysis. Cooling curves. Chemical potential of a component in ideal and real solution. Activity coefficients. Nernst's distribution law. Three component system. Phase diagrams: liquid – liquid. Extraction. Application of extraction process.

CHEMICAL EQULIBRIUM

Chemical equilibrium and thermodynamics functions. Thermal dependency of chemical equilibrium. Heat reaction and temperature dependence. Solubility equilibrium. Conductometry. Conductivity measurements of the electrolytes. Measurement cell construction. Heat reaction and determination. General principles of thermodynamics. Laws of thermodynamics. Internal energy and enthalpy. Molar enthalpy of formation, combustion, dissolution dilution. Calorimetry. Construction and types of calorimeters. Cells and cell types. Methods for measuring the electromotive force of a cell.

Teaching methods

Lecture: multimedia presentation

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

Bibliography

Basic

1. P. Atkins, Physical Chemistry, Oxford University Press

2. RS. Barry, SA. Rice, J. Ross, Physical Chemistry, Wiley & Sons, New York 1980.

Additional

1. Physical Chemistry Instructions: http://zchf.fct.put.poznan.pl.

2. Thermodynamics Lab Instructions http://moodle.put.poznan.pl

Breakdown of average student's workload

	Hours	ECTS
Total workload	150	6,0
Classes requiring direct contact with the teacher	80	3,2
Student's own work (literature studies, preparation for laboratory classes, preparation for exam, preparation of the report.) [1]	70	2,8

[1] delete or add other activities as appropriate