COURSE DESCRIPTION CARD - SYLLABUS

Course name
Thermodynamics [S1TOZ1>TER]

Course

Field of study
Circular System Technologies

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
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

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

Course objective

To familiarize students with issues of thermodynamics at the academic level in the field of: thermodynamic principles and functions (thermodynamic potentials as a driving force of processes, thermochemistry, standardization of thermodynamic functions and mathematical thermodynamic relations), phase equilibria for single and multi-component systems, physicochemistry of solutions, chemical equilibria, Thermodynamic description of heat machines, thermodynamic cycles: Carnot cycle, Stirling cycle, heat pump.

Course-related learning outcomes

Knowledge:

the student has knowledge of physics and chemistry allowing them to understand the phenomena and changes occurring in technological and environmental processes (k_w02).
the student has an ordered, theoretically founded knowledge covering key problems in the field of technical thermodynamics (k_w17).

Skills:
the student is able to obtain information from literature, databases and other sources related to circular system technologies, also in a foreign language, to integrate them, interpret and draw conclusions and formulate opinions (k_u01).
the student has the ability to self-study, is able to use source information in polish and a foreign language in accordance with the principles of ethics, reads with understanding, conducts analyzes, syntheses, summaries, critical assessments and correct conclusions (k_u04).
the student correctly uses in the discussion and correctly uses the nomenclature and terminology in the field of circular system technology, chemistry, technology and chemical engineering, environmental protection and related disciplines, also in a foreign language (k_u05).

Social competences:
the student independently determines and implements the action plan entrusted to him, defining the priorities for its implementation, and critically assessing the level of advancement in the implementation of the assigned task (k_k03).
the student objectively assesses the level of their knowledge and skills, and understands the importance of improving professional and personal competences adequately to the changing social conditions and the progress of science (k_k05).
the student participates in discussions and is able to conduct discussions, is open to different opinions and ready to assertively express feelings and critical comments (k_k08).

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 3 open questions for the same number of points and 15 test questions. Minimum threshold: 53% points.

Programme content

Thermodynamic functions, phase and chemical equilibria, physicochemistry of solutions,

Course topics

Lecture:
1. Introduction and Basics Definitions
System and surroundings. Thermodynamic parameters. Variables and units. Energy distribution. Thermal energy. The average thermal energy of particles. Maxwell-Boltzmann distribution. Temperature, (zeroth Law of the thermodynamics). Temperature scales. Thermodynamic temperature scale. Perfect gas. Real gas. Definition of compression factor. Real gas description using a polynomial (Viral equation). Virial coefficient - Boyle temperature. Van der Waals molecular interactions. Real gas description using a van der Waals equation. Van der Waals isotherm, perfect gas isotherm.
2. 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? Volume work – equation. Work and Heat are not a function of the state. The total differential of internal energy. Heat capacity definition, Heat capacity – temperature dependence. Internal Energy description by T and P. Enthalpy definition.
3. Heat capacity
Heat capacity at constant p and V, CP and CV relation. Heat capacity for ideal gas. Expansion of the ideal gas to vacuum, Joule Experiment- internal energy as only temperature dependence parameter. Joule-Thompson experiments –ideal and real gases.
4. Adiabatic process

Reversible and irreversible adiabatic processes. Work and heat at the adiabatic process.
5. Second Law of thermodynamics
The concept of entropy as a chaos assessment. Total entropy may increase but cannot decrease. Total entropy changes as the sum of the entropy of the system and surroundings changes. Reversibility of the processes. Third law of thermodynamics. Entropy as a time arrow. The direction of the processes. Examples and calculations
6. Gibbs energy(G) and free energy (F) as entropy-derived parameters
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 Gibbs energy. Definition of Helmholtz energy. When to use which function (p = const. or v = const.).
7. Thermochemistry 1.
Standardization of thermodynamic functions. Standard enthalpies of formation. Specification of reference state. Standard entropy. The entropy of substances near Kelvin zero. Calorimetric measurement of entropy of a substance.
8. Thermochemistry 2
Temperature dependence of the heat reaction – Hess's Law. The equilibrium of the reaction. Free Enthalpy and equilibrium constant relation. Temperature influence of the equilibrium constant – van't Hoff equation. Pressure dependence of the equilibrium constant – van Laar equation
9. 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. The heat of evaporation, the 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 vapour pressure over a solid on temperature. Temperature dependence of vapour pressure for liquid-gas, liquid-solid and solid-gas equilibria. Phase diagram of a one-component system. Different solid phases
10. Phase equilibrium – multi-component systems
Thermal analysis. Phase diagrams. Liquid-gas phase equilibria for multi-component systems. Distillation, fractional distillation. Azeotropes. 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. Heat machines
Heat engine. Working principle - heat tank, cooler. Heat engine efficiency. Carnot cycle. Steam engine. Turbine engine. Stirling"s engine. Heat pumps, the principle of operation. The efficiency of the cooler and heat pump.
12. Solutions 1.
Ideal solutions and mixtures. Partial molar quantities, chemical potential, chemical potential dependence on pressure and temperature. Excess values of mixing. Types of solutions.
13. Solutions 2
Extraction, osmosis, reverse osmosis – description. Membranes. Boiling and melting points of solutions. Component dependency. Clausius-Clapeyron equation for vaporisation, cryoscopic and ebullioscopic constant.
14. Transport and Flows
Stimulus and flow. Transfer of mass, heat, load and momentum. Effusion. Knudsen equation. Diffusion, Fick"s first law of diffusion. Diffusion equation. Diffusion coefficient. Thermodiffusion. Thermal conductivity, heat conductions. Electric charge flow. Viscosity, viscosity coefficient. Non-Newtonian liquids. Ohm"s law. Conductivity.
15. Colloidal systems.
Dispersion, the definition of colloidal systems. Classifications of colloidal systems. Lyophilic and lyophobic colloids. Phase, molecular and micellar systems. Formation of colloidal systems: dispersion and condensation methods. Formation of an emulsion. The structure of the micelles. Protective charge. Zeta potential. Electrophoresis. Tyndall effect. The viscosity of colloidal systems. Destruction of colloidal systems. Coagulation.

Teaching methods

Lecture: multimedia presentation.

Bibliography

Basic
1. K. Pigoń, Z. Ruziewicz, Chemia Fizyczna, PWN, Warszawa 2013.
2. P. Atkins, Chemia Fizyczna, PWN, Warszawa 2019.
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	75	3,00
Classes requiring direct contact with the teacher	38	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	37	1,50