Syllabus

Thermodynamics

Faculty of Fuels and Energy *(beginning in 2009 – Faculty of Energy and Fuels)*	***Field of study:***	Chemical Technology, Materials Science, Energy/Power Engineering, Environmental Engineering
	Specialisation:	
	Level of study:	I
	System of education:	

Proszę wpisać propozycje semestru (semestrów) w których przedmiot powinien być realizowany.

Course obligatory/~~optional~~				**ECTS points**: 6			
Fall or Spring semester	No. of hours	L	**C**	P	Lab	Seminar	Completion/Exam
Propozycja 1	30/15	30	15				C + E
Propozycja 2							

Course content (Lecture)

Spring semester

1. Introduction - basic properties and definitions. 1 h

   SI and non-SI base units. Thermodynamics vs. kinetics. Definition of a thermodynamic system. Open and isolated, homogeneous, and heterogeneous systems. Extensive and intensive properties of a system. Standard states and state variables. Equilibrium as a definite state.

2. The thermodynamic concept of temperature or the zeroth law of thermodynamics. 2 h

   State of thermal equilibrium. Equations of state. Ideal gas laws and the ideal gas temperature scale. Dalton's law for ideal gas mixtures. Real gases and the virial equation. P-V-T relationships for a one-component system. Triple point and critical point. The Van der Waals equation and the compressibility factor for gases.

3. First law of thermodynamics or the law of conservation of energy. 5 h

   Definitions and interrelations of work, internal energy, and heat. Joule's experiments. The first law of thermodynamics and internal energy. Various kinds of work. Joule-Thomson expansion. Heat capacities C_p and C_v. Adiabatic processes with gases. Thermochemistry; exothermic and endothermic reactions. Enthalpy of formation. Temperature dependence of enthalpy.

4. Second law of thermodynamics - spontaneity and reversibility of a process. 5 h

   Spontaneous and non-spontaneous changes. Carnot cycle. Thermodynamic temperature. Expressions of the second law. The fundamental equation for a closed system. Entropy for reversible and irreversible processes. Entropy of mixing ideal gases. Entropy and statistical probability. Calorimetric determination of entropies.

5. The third law of thermodynamics or the value of entropy at absolute zero. 2 h

   Standard reaction entropies. Entropy changes for phase changes and chemical reactions -

examples.

6. Helmholtz energy, A, and Gibbs energy, G. 5 h

   Legendre transforms. Thermodynamic functions for closed systems. Thermodynamic equations of state. Effect of temperature and pressure on the Gibbs energy. Fundamental equations for open systems. The additivity relation for the Gibbs energy. Partial molar quantities. The activity.

7. Chemical equilibrium. 4 h

   General equilibrium expression. Equilibrium constants expressions and their determination. Thermodynamics of a simple gas reaction. Effect of pressure, temperature, and initial composition on equilibrium constants. Homogeneous and heterogeneous chemical reactions.

8. Phase equilibria. 4 h

   One-component systems. First- and second-order phase transitions. The Clapeyron equation. The Clausius-Clapeyron equation. Phase rule. Multi-component systems. Thermodynamic properties of ideal liquid mixtures. Vapor pressure of nonideal mixtures. Raoult's law. Henry's law. Activity coefficients. Examples of phase diagrams.

9. Ionic equilibria. 2 h

   Dissociation of weak acids and bases: practical calculations, titration of a polyprotic acid, dissociation constants of complex ions.

Course content (Classes)

Spring semester

1. Introduction; basic properties and definitions. 1 h

   Interconversion of SI and non-SI base units. Values of gas constant R. Mole fractions and partial pressures.

2. The thermodynamic concept of temperature or the zeroth law of thermodynamics. 2 h

   Pressure and molar volume for ideal and real gases; comparison of the ideal gas law, virial equation, and the van der Waals equation.

3. The first law of thermodynamics or the law of conservation of energy. 4 h

   Work of compression/expansion of a gas. Changes in internal energy and enthalpy on heating. Work and internal energy changes in adiabatic processes. Standard enthalpy changes for reactions. Enthalpy of reactions at different temperatures. Calculations of bond energies.

4. The second law of thermodynamics; spontaneity and reversibility of a process. 4 h
   The third law of thermodynamics or the value of entropy at absolute zero.

   Changes in entropy of a gas in various processes (e.g. vaporization, heating at constant and variable pressures). Examples of entropy changes in irreversible processes via a reversible path from the initial state to the final state. Calculations of entropy of mixing. Determination of the entropy of a substance relative to its entropy at 0 K.

5. Helmholtz energy, A and Gibbs energy, G. 4 h

   Derivation of Maxwell relations. Calculations of molar thermodynamic quantities ΔU, ΔH, ΔG, ΔA, and ΔS for ideal gas expansion and gas mixing. Molar entropy and internal energy of isothermal expansion of a van der Waals gas. Activity of a substance at different pressures.

Course content (Project)
Fall semester Spring semester
Course content (Laboratory)
Fall semester Spring semester

Course content (Seminar)
Fall semester Spring semester

References (Basic):
Robert A. Alberty, Robert J. Silbey *Physical Chemistry, Second Edition*; John Wiley & Sons, Inc., New York **1996**.

References (Additional):
Robert A. Alberty, Robert J. Silbey *Solutions Manual to Accompany Physical Chemistry, Second Edition*; John Wiley & Sons, Inc., New York **1996**.

Expected learning outcome:	The course is designed as an overview of basic concepts of thermodynamics including the laws of thermodynamics and relationships for chemical reaction, phase, and ionic equilibria.
Language of instruction:	English
ERASMUS subject code:	
Prerequisites:	Prior course in mathematics (especially, concept of integrals and differentials)
Assessment method:	
Unit:	
Lecturer:	Prof. dr hab. Jerzy F. Janik
Lecturer (Project/Laboratory):	
Modified:	