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| **Basic description of the subject** |
| **Academic unity:**  | **FNSM: Chemistry Department** |
| **Title of the subject:** | **Thermodynamics for chemical engineering** |
| **Level:** | **Bachelor - Engineering** |
| **Status of the subject:** | **Obligatory** |
| **Year of studies:** | **3rd / V Semester** |
| **Hours per week:** | **3 + 2** |
| **ECTS points:** | **5** |
| **Time / place:** | **-** |
| **Teacher:** | **Dr.sc. Fetah PODVORICA, full professor** |
| **Contact details:**  | **Email:** fetah.podvorica@uni-pr.edu/ **Tel:** /038229964/ |
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| **Description of the subject** | This modul describes the use of thermodynamic laws in closed and open systems. It gives information for energy conversion, calculation of different thermodynamic parameters on engineering systems. |
| **Objectives of the subject:** | The modul introduces to the students of chemical engineering the use of basic laws of thermodynamics and mathematical methods for the solution of fundamental problems in chemical engineering: assesment of thermodynamic properties of pure compounds, mixtures and solutions and the calculation of phase and chemical equilibria.  |
| **Expected results of learning:** | *At the end of the courses the student will be able:**1. to introduce basic principles of chemical thermodynamics**2. to understand the laws of chemical thermodynamics and their use in chemical engineering**3. to interpret rules and principles of phase equilibria**4. to learn equilibria for chemical reactions and their importance for engineering processes* *5. to know gas-liquid equilibria* |
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| **Student workload** |
| **Activity** | **hour** |  **day/week**  | **Total** |
| Lectures | 2 | 2/ 15 | 30 |
| Exercices theoritical/laboratory | 1 | 1/15 | 15 |
| Consulti ng | 2 | 2/15 | 30 |
| **Total** | **5** | **5/15** | **75** |
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| **The methodology of learning:**  | lectures, seminars, in-class discussion, group work, experimental work |
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| **The methodology of evaluation:** | 1st evaluation: 15%2nd evaluation: 15%attendance: 5%Final exam: 65%Total: 100% |
| **Literature**  |
| **Basic Literature:**  |

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1. S.I. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 4ed Ed Wiley, New York, 2006. 2. J. M. Smith, H.C. Van Ness, M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th Ed., McGraw-Hill, New York, 2005. |
| **Additional Literature:**  | 3. P. Atkins and J. de Paula, Physical Chemistry, 9th Ed., Oxfor Univ Press, Oxford, 2010. |

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| **Week** | **Lecture**  |
| ***First week:*** | Thermodynamics : basic concepts |
| ***Second week:*** | Heat and energy, internal energy, work in mechanics, enthalpy  |
| ***Third week*:** | Thermodynamic laws, thermodynamic functions |
| ***Fourth week:*** | Ideal and real gases, Equation of state, thermodynamic functions of real gases and their mixtures |
| ***Fifth week:***  | Ideal and real solutions, standard state, thermodynamic functions of real solutions, partial molar properties, activity |
| ***Sixth week*:** | Phase equilibria, calculation of thermodynamic functions of phase change, gas-liquid equilibria |
| ***Seventh week:***  | Gas solubility, azeotropic mixtures**First preliminary assessment** |
| ***Eight week:***  | Liquid-liquid equilibria, calculation of component composition for phase equilibrium |
| ***Ninth week:***  | Chemical equilibria, thermodynamic functions and chemical equilibrium constant |
| ***Tenth week:*** | Determination of the composition of the chemical equilibrium for homogeneous and heterogeneous equilibria |
| ***Eleventh week*:** | Thermodynamic bases for irreversible processes, open systems |
| ***Twelfth week*:**  | Entropy, phenomenological equations and Onsager coefficients |
| ***Thirteenth week*:**  | Diffusion and processes of thermic diffusion. Irreversible chemical reactions. |
| ***Fourteenth week*:**  | Equilibrium of simultaneous reactions |
| ***Fifteenth week*:**  | **Second preliminary assessment** |
| **Week** | **Laboratory** |
| ***First and second week:*** | Exercices – gas laws and work  |
| ***Third and fourth week:*** | Calculation of thermodynamic functions, internal energy, work, enthalpy  |
| ***Fifth and sixth week:*** | Verification of first law of thermodynamics by using thermal capacity  |
| ***Seventh and eighth week:*** | Measurement of heat capacity of water  |
| ***Ninth and tenth week:*** | Enthalpy change during chemical reactions  |
| ***Eleventh and twelfth week:*** | Enthalpy measurement of of magnesium oxide  |
| ***Thirteenth week:*** | Calculation of entropy and Gibbs free energy  |
| ***Fourteenth week*** | Entropy measurement during water heating at different temperatures  |

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| **Academic policies and rules of conduct:** |
| The students must attend the classes regularly and be active. |