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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/](mailto: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:** | |  | | --- | |  |   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. |