FACULTY OF CHEMISTRY

**SUBJECT CARD**

Name of subject in Polish: Inżynieria reaktorów chemicznych
Name of subject in English: Chemical reaction engineering
Main field of study: Chemical technology
Specialization: Technology of fine chemicals
Profile: academic and practical
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code ICC024020
Group of courses NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | | 15 | |
| Number of hours of total student workload (CNPS) | 60 | | | 60 | |
| Form of crediting | crediting with grade | | | crediting with grade | |
| For group of courses mark final course with (X) | | | | | |
| Number of ECTS points | 2 | | | 2 | |
| including number of ECTS points for practical (P) classes | | | | 2 | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 0.5 | | | 0.5 | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge of physical chemistry: thermodynamics, kinetics.
2. Knowledge of mathematics: differentiation, integration, differential equations.

**SUBJECT OBJECTIVES**

C1 Getting to know the equations kinetic of real processes.
C2 Getting to know the ideal reactor models.
C3 Learning basic concepts in reactor design and ideal reactor models.

**SUBJECT LEARNING OUTCOMES**

**relating to knowledge:**

PEK_W01 Student has a basic knowledge of kinetic equations of simple and complex reactions.
PEK_W02 Student knows the basic models of ideal reactors.
PEK_W03 Student has information about the simplest models of real reactors.

**relating to skills:**

PEK_U01 Student is able to solve kinetic equations of simple reactions.
PEK_U02 Student is able to prepare components balances (for ideal reactors) in a steady state system.
PEK_U03 Student is able to solve design equations for ideal reactors.

**PROGRAM CONTENT**

| **Lectures** | **Number of hours** |
|---|---|

| | | |
|---|---|---|
| Lec1 | The rate of chemical reaction. Definition of the reaction rate: elementary reaction, simple stoichiometric reaction and complex reaction. The dependence of rate on the concentration. The elementary reaction rate constant. Dimension of rate constant. Differential and integrated form of rate laws. Order of the reaction and molecularity of the reaction. | 2 |
| Lec2 | Methods of the determining the reaction rate, the rate law, order and rate constant. Temperature dependence of reaction rates. The effect of temperature on the rate constant and the rate. Collision theory and transition state theory. | 2 |
| Lec3 | General mass balances equation. Models of ideal reactors. The differential and integral form of the design equation for BATCH. Dependence of volume on concentration (conversion) and reaction time, first and second order reaction, unsteady-state. | 2 |
| Lec4 | Continuous Stirred Tank Reactor - CSTR.<br>The design equation for a CSTR. The assumption of perfect mixing. Component continuity equation-product or substrate. The components of the balance equation. The system's working conditions in steady-state, dependence of reactor volume on concentration (conversion), the residence time. | 2 |
| Lec5 | Plug-flow reactor - PFR. Ideal system, plug flow. The differential and integral form of the design equation for PFR. The component balance. Dependence of reactor volume on concentration (conversion) in steady-state, the residence time. | 2 |
| Lec 6 | The battery of reactors. Conversion in the first-order reaction case. Comparison of conversion in the battery of CSTRs and single CSTR. The battery of n-CSTRs and single PFR. | 2 |
| Lec 7 | A detailed comparison of various chemical reactors. The design of an industrial chemical reactor. Comparison of ideal reactors. Reactors' volume, volumetric flow rates, conversions. Graphic illustration. | 2 |
| Lec 8 | Final exam. | 1 |
| | Total hours | **15** |
| **Project** | | **Number of hours** |
| Pr1 | The kinetic equation; first, second and fractional-order reactions, irreversible and reversible reactions. Conversion and concentration as a functions of time. Elementary and complex reactions. | 2 |
| Pr2 | Irreversible and reversible reactions in a BATCH. Determination of the reactor volume necessary to obtain specified daily product stream with a given conversion. Analysis of volume - conversion - reaction time connection. | 2 |
| Pr3 | CSTR. The system's working conditions in steady-state, dependence of reactor volume on concentration (conversion) and calculation of residence time. Specific reaction order and volumetric flow rate with a given conversion. | 2 |
| Pr4 | CSTR. Specific reaction order and volumetric flow rate with a given volume. Sequence of CSTRs and volume differences. | 2 |
| Pr5 | PFR. Specific reaction order and volumetric flow rate with a given conversion or with a given volume. | 2 |
| Pr6 | Comparison of conversion in a sequence of CSTRs and a PFR. PFR with volume change (reaction in a gas phase). | 2 |
| Pr7 | Final exam. | 2 |
| Pr8 | Second term of the exam and additional project presentations. | 1 |
| | Total hours | **15** |

**TEACHING TOOLS USED**

N1. Lecture with multimedia presentation.
N2. Solving tasks and problems for elaborated project.
N3. Preparation and presentation of a project.

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Learning outcomes number | Way of evaluating learning outcomes achievement |
|---|---|---|
| F (project) | PEK_U01- PEK_U03 | project presentation |
| P (project) | PEK_U01- PEK_U03 | final test |
| P (lecture) | PEK_W01- PEK_W03 | final test |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] O. Levenspiel, Chemical Reaction Engineering, 3rd ed., John Wiley & Sons, New York, 1999.
[2] H.S. Fogler, Elements of Chemical Reaction Engineering, 3rd ed., Prentice Hall PTR, New Jersey, 1999.

**SECONDARY LITERATURE:**

[1] S. Kucharski, J. Głowiński, Podstawy obliczeń projektowych w technologii chemicznej, 3 wyd., Oficyna Wyd. PWr, Wrocław 2010.
[2] Praca zbiorowa: Przykłady i zadania do przedmiotu Podstawy technologii chemicznej, Oficyna Wyd. PWr, Wrocław 1991.
[3] J. Szarawara i in., Podstawy inżynierii reaktorów chemicznych, WNT, Warszawa 1991.

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

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**and Z-14 teaching assistants**