Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish Zjawiska powierzchniowe i kataliza heterogeniczna

Name of subject in English: Surface Phenomena and Heterogenous Catalysis

Main field of study (if applicable): Chemical Engineering and Technology
Specialization (if applicable): Advanced Chemical Technologies
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03CET-SM2013W, W03CET-SM2013L, W03CET-SM2013S
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		15
Number of hours of total student workload (CNPS)	75		50		25
Form of crediting (Examination / crediting with grade)	Examination		Crediting with grade		Crediting with grade
For group of courses mark (X) final course					
Number of ECTS points	3		2		1
including number of ECTS points for practical classes (P)			2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,2		1,2		0,6

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of English language (B2 level).
2. The knowledge of organic and inorganic chemistry.
3. The knowledge of physical chemistry.

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SUBJECT OBJECTIVES

C1. To fmilalise the student with basic concept of heterogeneous catalysis.
C2. To familiarise the student with phenomena occurring on catalyst surface.
C3. To train the student in different methods of catalyst preparation, ways of its physicochemical characterization and determination of its performance.
C4. To bring the student up to date with the catalytic processes applied in the chemical, fuel and energy industry.
C5. To familiarise the student with the state-of-the-art catalytic processes for environmental protection.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 The student knows the fundamental definitions used in heterogeneous catalysis.
PEU_W02 The student understands the surface phenomena occurring on the catalyst during

reaction.
PEU_W03 The student understands the mechanisms of catalytic reaction.
PEU_W04 The student knows the methods of catalysts preparation and their characterization.
PEU_W05 The student knows the main problems occurring during catalytic processes linked to catalyst deactivation.
PEU_W06 The student can describe popular types of catalysts and reactions used in different branches of chemical industry.
PEU_W07 The student can describe basic catalytic processes used in different branches of chemical industry (i.e., for production of chemicals, fuels, energy and in automotive sector).

relating to skills:
PEU_U01 The student can synthesize solid catalyst on the grounds of literature data.
PEU_U02 The student is able to carry out the catalytic test of specific reaction, calculate the conversions, selectivities and yields of reaction products.
PEU_U03 The student can determine the chemical composition of catalyst and describe its structure features on the basis of results of its characterisation.
PEU_U04 The student is able to prepare a multimedia presentation, perform in public, and share the knowledge with the group.
PEU_U05 The student can work with research data provided through journals, books, and patents.
PEU_U06 The student can determine the role of the active sites required for the individual reaction.
PEU_U07 The student is able to select research methods regarding the characteristics of a given group of heterogeneous catalysts and determining their activity.

relating to social competences:
PEU_K01 The student is aware of the need for continuous training.
PEU_K02 The student develops the ability to behave properly in their learning and working environment, and beyond those.
PEU_K03 The student is able to work with others and develops their leadership skills.
PEU_K04 The student is aware of the non-technical effects associated with chemical processes.

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	Catalysis and catalyst - introduction. The significance of catalysis in everyday life. Catalysis in industry. Description of types of catalysis. Definitions of conversion, selectivity, activity, yield, turnover frequency. Thermodynamics and kinetics of catalytic reaction. Activation energy, equilibrium constant, rate constant, reaction order.	4
Lec 2	Reaction steps in heterogeneous catalysis. active sites, reaction mechanism (Eley-Rideal, Langmuir-Hinshelwood).	2
Lec 3	Adsorption process. Types of adsorption. Energy of adsorption. The significance of surface structure of the catalyst for adsorption process.	2
Lec 4	Crystallographic structure of metals and metal oxides. Classification of crystal imperfections and their impact on catalyst activity.	2
Lec 5	Active sites. Crystallography of active sites, geometrical factor, saturation of active sites. The acid-base character of catalyst surface. Electronic properties of active sites. Bifunctional catalysts.	2

Lec 6	Preparation of solid catalysts. Description of sol-gel method, impregnation, precipitation and co-precipitation. Supported catalyst.	4
Lec 7	Characterization of solid catalyst. Surface structure and chemical composition of catalysts - description of methods and procedures of solid catalysts characterization.	2
Lec 8	Catalyst deactivation. Poisoning, formation of deposits, thermal degradation. Prevention of catalyst deactivation. Catalyst regeneration.	2
Lec 9	Catalysis for the production of chemicals.	2
Lec 10	Catalysis for the production of fuels.	4
Lec 11	Catalysis in environmental protection. Desulfurization, reduction of NOx, methane reforming, VOC's oxidation.	4
	Total hours	30

Classes		**Number of hours**
Cl 1		
Cl 2		
Cl 3		
Cl 4		
..		
	Total hours	

Laboratory		**Number of hours**
Lab 1	Introduction.	2
Lab 2	Preparation of supported catalysts via wetness incipient impregnation method.	4
Lab 3	Preparation of Metalorganic frameworks via ultrasound assisted solvothermal method.	4
Lab 4	Determination of physicochemical properties of catalysts (determination of phase composition, morphology, textural properties, thermal stability and surface chemistry using XRD, STEM, N_2 sorption, TGA and FTIR).	8
Lab 5	Diffusion in catalytic bed.	4
Lab 6	Catalytic processes in the fixbed flow reactor - determiantion of the activity of heterogeneous catalyst in the reaction of synthesis gas production.	4
Lab 7	Catalytic processes in the batch reactor - determiantion of the activity of MOFs in the reaction of CO_2 conversion.	4
	Total hours	30

Project		**Number of hours**
Proj 1		
Proj 2		
Proj 3		
Proj 4		
…		
	Total hours	

Seminar		**Number of hours**
Semin 1	Methods for determining catalytic activity.	2

Semin 2	Temperature-programmed techniques for assessing the surface properties of the catalysts.	2
Semin 3	Zeolites – structure, properties and application in adsorption and catalysis.	2
Semin 4	Oxidation reactions on oxide catalysts.	2
Semin 5	Reactions in the hydrogen presence on metallic catalysts.	2
Semin 6	Reactions over acid-base catalysts.	2
Semin 7	Advanced materials in catalysis and adsorption.	3
	Total hours	15

TEACHING TOOLS USED

N1. Lecture with a multimedia presentation.
N2. Executive instructions for laboratory classes.
N3. Laboratory classes carried out with the use of research facilities.
N4. Individual consultations with the student.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P (lecture)	PEU_W01-PEU_W07	Grade from the exam: grade 2.0: 0-50% grade 3.0: 51- 60% grade 3.5: 61-70% grade 4.0: 71- 80% grade 4.5: 81- 90% grade 5.0: 91- 100%
F1 (laboratory)	PEU_U01-PEU_U03	Grade form the test (T)
F2 (laboratory)	PEU_U01-PEU_U03, PEU_K01-PEU_K04	Grade from the report (R)
P (seminar)	PEU_U04-PEU_U07, PEU_K01-PEU_K04	Grade of the student's presentation (S).
P (laboratory) Grade = 0.5xT + 0.5xR		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] „Handbook of Heterogeneous Catalysis", Editors: G. Erti, H. Knözinger, F. Schüth, J. Weitkamp, 2014, Wiley-VCH, ISBN: 9783527610044.
[2] J. Ross „Heterogeneous catalysis. Fundamentals and Applications." 2011, Elsevier, ISBN: 978-0-444-53363-0.
[3] „Heterogeneous Catalysis and Fine Chemicals II", Editors: M. Guisnet et al.,1991, Elsevier, 978-0-444-88514-2.

SECONDARY LITERATURE:

[1] G. Rothenberg „Catalysis: Concepts and Green Applications" 2008, Wiley-VCH, ISBN 978-3-527-31824-7.
[2] M. Ziółek, I. Nowak „Kataliza heterogeniczna. Wybrane zagadnienia" Wydawnictwo Naukowe UAM
[3] Electrionic sources / Elsevier

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

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