

FACULTY OF CHEMISTRY					
SUBJECT CARD					
Name of subject in Polish:	Zjawiska powierzchniowe i kataliza stosowana				
Name of subject in English:	Surface phenomena and applied catalysis				
Main field of study (if applicable):	Chemical technology				
Specialization (if applicable):	Technology of fine chemicals				
Profile:	academic and practical				
Level and form of studies:	2 nd level, full-time				
Kind of subject:	obligatory				
Subject code:	TCC024010				
Group of courses:	NO				
	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	examination		crediting with grade		
For group of courses mark final course with (X)	X				
Number of ECTS points	3		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BK) classes	1		1		
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.					
SUBJECT OBJECTIVES					
C1 To acquaint the student with basic concept of heterogeneous catalysis. C2 To familiarize the student with phenomena occurring on catalyst surface. C3 To enable the student with different methods of catalyst preparation and ways of its characterization. C4 To acquaint the student with application of heterogeneous catalysis in environmental protection and fine chemicals production.					
SUBJECT LEARNING OUTCOMES					
relating to knowledge:					
PEK_W01 The student knows the fundamental definitions used in heterogeneous catalysis.					
PEK_W02 The student understands the surface phenomena occurring on the catalyst during reaction.					
PEK_W03 The student understands the mechanisms of catalytic reaction.					
PEK_W04 The student knows the methods of catalysts preparation and their characterization.					
PEK_W05 The student knows the main problems occurring during catalytic processes linked to catalyst deactivation.					
PEK_W06 The student can describe popular types of catalysts and reactions used for fine chemicals production and environmental protection.					
PEK_W07 The student can describe basic catalytic processes used for fine chemicals production and environmental protection.					
relating to skills:					
PEK_U01 The student can synthesize solid catalyst on the grounds of literature data.					

PEK_U02 The student is able to carry out the catalytic test of hydrocarbon steam reforming and desulfurization, calculate the conversion, selectivity and yields of reaction products.
 PEK_U03 The student knows how to calculate the rate of catalytic reaction and activation energy.
 PEK_U04 The student can determine the chemical composition of catalyst and describe its structure features on the basis of results of its characterization.

relating to social competences:

PEK_K01 The student is aware of the need for continuous training.
 PEK_K02 The student develops the ability to behave properly in his learning and working environment, and beyond those.
 PEK_K03 The student is able to work with others and develops his leadership skills.
 PEK_K04 The student is aware of the non-technical effects associated with chemical processes.

PROGRAM CONTENT		
Lectures		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.	2
Lec 2	Thermodynamics and kinetics of catalytic reaction. Activation energy, equilibrium constant, rate constant, reaction order.	4
Lec 3	Reaction steps in heterogeneous catalysis. active sites, reaction mechanism (Eley-Rideal, Langmuir-Hinshelwood).	2
Lec 4	Adsorption process. Types of adsorption. Energy of adsorption. The significance of surface structure of the catalyst for adsorption process.	2
Lec 5	Crystallographic structure of metals and metal oxides. Classification of crystal imperfections and their impact on catalyst activity.	2
Lec 6	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.	4
Lec 7	Preparation of solid catalysts. Description of sol-gel method, impregnation, precipitation and co-precipitation. Supported catalyst.	2
Lec 8	Characterization of solid catalyst. Surface structure and chemical composition of catalysts - description of methods and procedures of solid catalysts characterization.	4
Lec 9	Catalyst deactivation. Poisoning, formation of deposits, thermal degradation. Prevention of catalyst deactivation. Catalyst regeneration.	2
Lec 10	Catalysis in environmental protection. Desulfurization, reduction of NO _x , methane reforming, VOC's oxidation.	2
Lec 11	The role of catalysis in fine chemicals production.	4
	Total hours	30
Laboratory		Number of hours
Lab 1	Preparation of solid catalyst.	4
Lab 2	Preparation of solid catalyst.	4
Lab 3	Determination of acidic and basic active sites of the catalyst.	4
Lab 4	Determination of catalyst chemical composition and structural morphology on the basis of results of its characterization (XRD, XPS, TEM, Sbet of 5 different catalysts).	4
Lab 5	Determination of surface species by infrared spectroscopy.	2

Lab 6	Catalytic steam reforming of hydrocarbons.	4
Lab 7	Catalytic desulfurization.	4
Lab 8	Excursion to BASF.	4
	Total hours	30
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. Excursion.		
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
F1 (lecture)	PEK_W01 - PEK_W07 PEK_K01 - PEK_K04	Exam.
F2 (laboratory)	PEK_U01 - PEK_U04 PEK_K01 - PEK_K04	Report of the laboratory exercise.
PRIMARY AND SECONDARY LITERATURE		
<u>PRIMARY LITERATURE:</u>		
[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.		
<u>SECONDARY LITERATURE:</u>		
[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.		
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)		
dr inż. Agata Łamacz (agata.lamacz@pwr.edu.pl)		