LEARNING MODULE DESCRIPTION (SYLLABUS)

I. General information

1. Module title – Heterogeneous Catalysis
2. Module code - KHT
3. Module type – optional
4. Programme title - Chemistry
5. Cycle of studies - 2nd cycle of studies
6. Year of studies (where relevant)
7. Terms in which taught (summer/winter term) – winter semester
8. Type of classes and the number of contact hours – lectures: lectures:15 hours; laboratory: 30 hours
9. Number of ECTS credits - 5
10. Name, surname, academic degree/title of the module lecturer/other teaching staff
    Prof. Maria Ziółek
    Dr Katarzyna Stawicka
    Dr Anna Wojtaszek-Gurdak
11. Language of classes - English

II. Detailed information

1. Module aim (aims)
    a. Transfer of knowledge in the field of preparation, characterization and catalytic activity of heterogeneous catalysts as well as safety rules in laboratory work
    b. Development of ability to select catalysts to desired processes
    c. Development of skills to apply research methods fitted to effective operation of catalytic converters
    d. Prepare for proper interpretation of experimental results
    e. Development of writing skills in the range of reports from project laboratory work
    f. Skills development in literature searching

2. Pre-requisites in terms of knowledge, skills and social competences (where relevant)
    n.d.

3. Module learning outcomes in terms of knowledge, skills and social competences and their reference to programme learning outcomes

Learning outcomes symbol*	Upon completion of the course, the student will:	Reference to programme learning outcomes#
KHT_01	explain how to prepare and characterize the catalysts	CH2_W01; CH2_W11; CH2_K01; CH2_K02
KHT_02	clarify the fundamentals of catalyst action	CH2_W04; CH2_U02
KHT_03	apply the most important techniques for characterization of the catalysts and catalytic processes	CH2_W09; CH2_U04; CH2_U08; CH2_U09
KHT_04	interpret the experimental results and draw conclusions	CH2_W03; CH2_W04; CH2_U06; CH2_U11; CH2_U16
KHT_05	use the new literature data for the interpretation of experimental results	CH2_U12; CH2_U13; CH2_U17
KHT_06	write report from the research project	CH2_U01; CH2_U11; CH2_U16; CH2_U19
KHT_07	apply safety rules in the laboratory work	CH2_W09; CH2_U10

** module code, e.g. KHT_01 (KHT – module code in USOS; stands for Polish "Kataliza Heterogeniczna" /Heterogeneous Catalysis/)*
 # programme learning outcomes (e.g. K_W01, K_U01, …); first K stands for programme title symbol in Polish, W for "wiedza" (knowledge) in Polish, U – for "umiejętności" (skills) in Polish, K – for "kompetencje społeczne" (social competences) in Polish
01, 02… - learning outcome number

4. Learning content

Module title		
Learning content symbol*	Learning content description	Reference to module learning outcomes #
TK_01	Safety rules in the catalytic laboratory	KHT_07
TK_02	Introduction to catalysis (history, catalysis division, definitions, essence of catalyst action)	KHT_02
TK_03	Fundamentals of heterogeneous catalysis (classification of catalysts, texture, structure, steps of catalytic reaction, diagnostics of catalyst function)	KHT_02
TK_04	Structure of catalysts (particles, components of catalysts)	KHT_02
TK_05	Catalytic materials (metals, semiconductor, insulators)	KHT_01
TK_06	Preparation of catalysts (general information and details concerning anchoring of active species on supports)	KHT_01
TK_07	Characterization of composition, phase structure and properties of catalyst particles – methods and analysis of study results	KHT_01; KHT_03; KHT_04
TK_08	Characterization of surface properties – parameters, methods, analysis of results, conclusions)	KHT_01; KHT_03; KHT_04; KHT_05
TK_09	Catalytic activity and deactivation of catalysts; performance of catalytic processes	KHT_04
TK_10	Design of catalysts for the desired products	KHT_02
TK_11	Interpretation and discussion of experimental results, writing of scientific report from research project	KHT_06

** e.g. TK_01, TK_02, … (TK stands for "treści kształcenia" /learning content/ in Polish)*
 # e.g. KHT_01 – module code as in Table in II.3

5. Reading list

1) P. Decyk, I. Sobczak, M. Trejda „A course in heterogeneous catalysis – selected methods for determination of catalysts behaviour", Adam Mickiewicz University, Faculty of Chemistry, Poznań, 2009
2) M. Ziółek, I. Sobczak, M. Trejda, „Niobium species in heterogeneous catalysis used for oxidation processes – selected aspects" , Nova Science, 2011
3) Bartholomew, C. H., Farrauto, R. J. "Fundamentals of Industrial Catalytic Processes" John Wiley & Sons Inc., 2006
4) Heiz, U., Landman, U. (Eds.), „Nanocatalysis", Springer, 2008
5) New articles in international journals indicated by teachers conducting course

6. Information on the use of blended-learning (if relevant)
7. Information on where to find course materials
   http://www.staff.amu.edu.pl/~zkh/

III.Additional information

1. Reference of learning outcomes and learning content to teaching and learning methods and assessment methods

Module title HETEROGENEOUS CATALYSIS			
Symbol of module learning outcome*	Symbol of module learning content#	Methods of teaching and learning	Assessment methods of LO achievement&
KHT_01	TK_05; TK_06; TK_07; TK_08	Lectures and laboratory project – performance of catalyst modification and measurements of catalyst properties	Knowledge and skills tests during laboratories (F); final written exam (S)
KHT_02	TK_02; TK_03; TK_04; TK_10	Lectures and discussion during conducting of laboratory project	Knowledge and skills tests during laboratories (F); final written exam (S)
KHT_03	TK_07; TK_08	Lectures and laboratory project – performance of experiments for characterization of catalysts, collection of results and their interpretation	Test of skills in the conducting of experimental measurements (F), understanding and interpretation of experimental results (F) Practical test (S), evaluation of project report (S), final written exam (S)
KHT_04	TK_07; TK_08; TK_09	Lectures and discussion of experimental results obtained during conducting the research project within laboratory	Evaluation of skills in discussion of study results and evaluation of project report (S)
KHT_05	TK_08	Laboratory – discussion of the new literature data searched by students and being in line with the topic of research project	Evaluation of skills in using literature data for interpretation of results obtained in project (S)
KHT_06	TK_11	Discussion during laboratory	Evaluation of project report (S)
KHT_07	TK_01	Safety rules in the catalytic laboratory – observation of students' skills in their application	Test of knowledge in the field of safety rules and evaluation of skills in their usage (F)

** e.g. KHT_01 – module code as in Table in II.3 and II.4*
 # e.g. TK_01 – learning content symbol as in II.4
& Please include both formative (F) and summative (S) assessment

It is advisable to include assessment tasks (questions).

Example:

Your task is the characteristic of texture, structure and surface properties of white powder which you have got for analysis. Please indicate which techniques you will apply to specify the following features:

a) surface area of the solid
b) pore diameter in the catalyst
c) evaluation if the material is amorphous or crystalline
d) size and shape of particles
e) identification of Lewis and BrØnsted acid sites on the surface of the catalyst
f) estimation of acidic strength on the catalyst surface

Explain your choice and for each technique indicate which information you can obtain from the indicated results.

2. Student workload (ECTS credits)

Module title:	
Activity types	Mean number of hours* spent on each activity type
Contact hours with the teacher as specified in the programme	45
Preparation for laboratory project	15
Study of the results from laboratory	15
Reading of the indicated literature	10
Writting of the project report	22
Preparation for exam	20
Total hours	127
Total ECTS credits for the module	5

** Class hours – 1 hour means 45 minutes*

#Independent study – examples of activity types: (1) preparation for classes, (2) data analysis, (3) library-based work, (4)writing a class report, (5) exam preparation, etc.

3. Assessment criteria

Learning outcomes symbol*	Upon completion of the course, the student will:	Assesment criteria (determination of acceptable level) Student:
KHT_01	explain how to prepare and characterize the catalysts	1) clarifies fundamentals of methods used for catalysts modification 2) selects techniques appropriate for characterization of indicated catalyst properties 3) lists the most import applications of heterogeneous catalysts
KHT_02	clarify the fundamentals of catalyst action	1) lists and explains steps of the catalytic process 2) is able to relate the catalytic properties to the composition and structure of catalysts

		3) explains the role of catalyst components
KHT_03	apply the most important techniques for characterization of the catalysts and catalytic processes	1) is able to use spectroscopic methods for characterization of surface properties of catalysts 2) conducts catalytic test reactions 3) applies gas chromatography for analysis of substrates and products of catalytic reaction
KHT_04	interpret the experimental results and draw conclusions	1) analyses results of structure study and acidic-basic properties of catalysts 2) estimates catalytic activity in relation to surface properties 3) draws conclusions concerning the course of the catalytic reaction conducted
KHT_05	use the new literature data for the interpretation of experimental results	1) searches new publications in the field of research project conducted within laboratory 2) uses results from publication for the discussion of results obtained in his/her own project
KHT_06	write report from the research project	1) writes short research report basing on his/her own project conducted
KHT_07	apply safety rules in the laboratory work	1) knows and uses safety rules

The course is performed in the block system: 4 weeks lectures 2 times per week and next 6 weeks only laboratory project – once a week. Laboratory project is different for each student