R O M Â N I A
MINISTERUL EDUCAŢIEI ŞI CERCETĂRII
Universitatea din Craiova
FACULTATEA DE ȘTIINȚE/ DEPARTAMENTUL DE CHIMIE
Craiova, Str. Calea București, nr. 107I
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Subject Description

1. Program information

1.1. Institution	University of Craiova
1.2. Faculty	Science
1.3. Department	Chemistry
1.4. Study field	Chemistry
1.5. Study level	Master
1.6. Type of education	full-time
1.7. Study program	Advanced Chemistry

2. Subject information

2.1. Subject			**Catalytic nanostructures**				
2.2. Course coordinator			Conf.dr. Nicoleta Cioateră				
2.3. Application coordinator			Conf.dr. Nicoleta Cioateră				
2.4. Year of study	I	2.5. Semester	2	2.6. Type of evaluation	E	2.7. Subject type	DS/DOB

3. Total estimated tipe (hours/semester)

3.1. Number of hours per week	4	from which: 3.2 course	2	3.3. seminar/lab	2
3.4. Total hours in curriculum	56	from which: 3.5 course	28	3.6. seminar/lab	28
Time allocation – hours/week					
Study using textbooks, course materials, bibliographies, and notes					20
Additional documentation in the library, on specialized electronic platforms, and in the field					20
Preparation of seminars/labs, assignments, reports, portfolios, and essays					20
Tutoring					5
Examinations					4
Other activities............................					
3.7. Total hours of individual study					69
3.8. Total hours per semester					125
3.9. Number of ECTS					5

4. Preconditions (if the case)

4.1. of curriculum	•
4.2. of competences	•

5. Conditions (if the case)

5.1. for course	• Lecture hall equipped with computer, video projection system, and internet connection
5.2. for labs	• Laboratory equipped with the materials, equipment, and reagents necessary to carry out experimental work

6. Course objectives - expected learning outcomes achieved by completing and passing the course

Knowledge	1. Graduates define, understand, explain, and apply advanced knowledge of chemistry from specialized literature in practice. 2. Graduates select and use appropriate experimental and theoretical methodologies to investigate complex scientific problems, assessing their impact on the environment and society. 3. Graduates write analysis and scientific reports, presenting the results of their research and experiments, in line with professional ethics and standards. 4. The graduate describes and integrates interdisciplinary knowledge into the implementation of research projects.
Skills	1. Graduates apply major concepts in analytical, inorganic, organic, and physical chemistry to chemical practice. 2. Graduates evaluate and analyze experimental techniques to conduct and design experiments, analyze and test (qualitatively and quantitatively) chemical elements and substances; design, coordinate, and conduct chemical experiments. 3. Graduates apply critical thinking, following the structure and principles of scientific writing to develop and present scientific reports. 4. Graduates apply interdisciplinary methods to solve complex theoretical and practical chemical problems in their professional and research activities.
Responsibility and authonomy	1. Graduates are able to adapt major scientific concepts in the field of chemistry to conduct research, improve or develop new concepts, knowledge, theories, and operational methods, products, and services in order to apply them in specific activities for product and process quality control. 2. Graduates use classical laboratory instruments/techniques and modern equipment independently, design experiments, and interpret and analyze the obtained results accurately. They design learning situations focused on developing experimental techniques and methods specific to chemical laboratories. 3. Graduates prepare and present scientific reports in line with ethical standards for collecting and interpreting results. 4. Graduates assume responsibility for managing interdisciplinary collaborations and coordinating activities within work and research teams..

7. Table of contents

7.1. COURSE	Mode of operation	Teaching methods	Allocated time (hours)
1. Introduction to Catalytic Nanostructures • Definition of catalysis at the nanoscale • Size-, shape-, and morphology-dependent effects • Metal, oxide, and hybrid nanocatalysts • Surface energy and active site engineering	On site (week 1)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	2
2. Fundamentals of Nanocatalysis • Electronic structure and quantum-size effects • Surface coordination, defects, and vacancies • Adsorption–desorption processes • Reaction pathways and kinetics at the nanoscale	On site (week 2)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	2
3. Methods of Synthesis of Catalytic Nanostructures	On site (week 3)	Lecture, explanation and interactive presentation,	2

• Bottom-up vs. top-down approaches • Sol–gel, hydrothermal, solvothermal synthesis • Co-precipitation, microemulsion, Pechini method • Chemical vapor deposition (CVD), atomic layer deposition (ALD) • Bio-inspired and green synthesis routes • Case study: TiO_2 nanotubes, CeO_2 nanorods, Pt nanoparticles on carbon		heuristic conversation, problem solving	
4. Characterization Techniques for Catalytic Nanomaterials • Structural characterization: XRD, TEM, SEM, AFM • Surface and chemical state: XPS, AES, FTIR • Optical and electronic characterization: UV-Vis, Raman • Surface area and porosity: BET, BJH, gas adsorption • Temperature-programmed methods: TPR, TPD, TPO • In situ/operando characterization and relevance in catalysis	On site (weeks 4-5)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	4
5. Metal Nanocatalysts • Noble metals (Pt, Pd, Au) and nanoalloys • Non-noble transition metal nanostructures (Fe, Co, Ni, Cu) • Core–shell nanoparticles, single-atom catalysts • Electronic effects and catalytic selectivity	On site (week 6)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	2
6. Metal Oxide and Mixed-Oxide Nanostructures • CeO_2, TiO_2, ZrO_2, ZnO, MnO_x catalytic nanostructures • Oxygen vacancies and redox-active surfaces • Perovskites, spinels, and complex oxide nanostructures • Doping and nanostructure stabilization	On site (weeks 7)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	2
7. Supported Nanocatalysts • Nanoparticles on carbon, zeolites, MOFs, silica, alumina • Metal–support interactions (MSI) • Stability, sintering, poisoning	On site (week 8)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	2

8. Photocatalytic Nanostructures • Mechanisms of photocatalysis • Bandgap engineering for visible-light catalysis • Doped TiO_2, heterojunctions, plasmonic nanostructures • Applications in wastewater treatment, air purification, solar fuels • LED-driven photocatalysis: principles and efficiency factors	On site (week 9)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	2
9.Electrocatalytic Nanomaterials • Principles of electrocatalysis; electron transfer mechanisms • Nanostructured catalysts for oxygen reduction reaction (ORR), oxygen evolution (OER), hydrogen evolution (HER) • Fuel cells, water splitting, CO_2 reduction • Emerging 2D electrocatalysts (MXenes, graphene, MoS_2)	On site (week 10)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	2
10. Biocatalytic and Bio-Inspired Nanostructures • Enzyme–nanomaterial hybrids • Nanozymes: catalytic nanostructures mimicking enzyme activity • Applications in biosensing and green chemistry	On site (week 11)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	2
11. Applications of Catalytic Nanostructures • Nanocatalysts for degradation of organic pollutants • Advanced oxidation processes (AOPs) • NO_x, SO_x, VOCs catalytic decomposition • Petrochemical and fine chemical synthesis • Catalytic converters and automotive catalysts • Renewable energy and sustainable technologies • Scale-up and challenges in industrial catalysis	On site (weeks 12-13)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	4
12. Safety, Ethics, and Sustainability Toxicity and environmental impact of nanomaterials Life-cycle assessment (LCA) in nanocatalysis Responsible research and innovation (RRI) Circular economy principles applied to nanocatalysts	On site (week 14)	Lecture, explanation and interactive presentation, heuristic conversation, problem solving	2

References:
1. Alves, A.K., Berutti, F.A., Sánchez, F.A.L. (2011). Nanomaterials and Catalysis. In: Bergmann, C.P., de Andrade, M.J. (eds) Nanostructured Materials for Engineering Applications. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-19131-2_7.
2. X. Li, X. Hao, A. Abudula, G. Guan, Nanostructured catalysts for electrochemical water splitting: current state and prospects, J. Mater. Chem A 31, 2016. https://doi.org/10.1039/C6TA02334G
3. G. Vile, D. Albani, N. Almora-Barrios et al, Advances in the Design of Nanostructured Catalysts for Selective Hydrogenation, CHemCatChem 8, 2016. https://doi.org/10.1002/cctc.201501269
4. Lecture notes, 2025

7.2. Lab	Mode of operation	Teaching methods	Allocated time (hours)
1. Safety rules in Catalytic Nanostructures lab	On site (week 1)	Experiment, explanation, discussion, debate, and questioning	4
2. Synthesis of metal oxide nanostructures (e.g., TiO_2, CeO_2).	On site (week 3)	Experiment, explanation, discussion, debate, and questioning	4
3. Preparation of supported nanocatalysts (metal on alumina) by impregation	On site (week 5)	Experiment, explanation, discussion, debate, and questioning	4
4. XRD and Raman analysis of synthesized nanostructures.	On site (week 7)	Experiment, explanation, discussion, debate, and questioning	4
5. Photocatalytic degradation experiment	On site (week 9)	Experiment, explanation, discussion, debate, and questioning	4
6. Electrocatalytic characterization (cyclic voltammetry, EIS).	On site (week 11)	Experiment, explanation, discussion, debate, and questioning	4
7. Lab Verification	On site (week 13)	Experiment, explanation, discussion, debate, and questioning	4
References:			
1. Lab work presentations, 2025.			

8. Corrrelation of the discipline content with the expectations of representatives of the epistemic community, professional associations, and representative employers in the field related to the program

The content of the course is in line with those of similar courses at universities in Romania and abroad, while also meeting the expectations of professional associations and representative employers in the field.

9. Evaluation

Activity	9.1. Evaluation criteria	9.2. Evaluation method	9.3. Contribution to final score
9.4. Course	theoretical concepts and mechanisms, critical analysis of literature or design of a catalytic system	Written Exam	50%
		Portofolio	20%
9.5. Lab	synthesis, characterization, data interpretation	Project Work	30%

9.6. Minimum performance standard
• Basic understanding of core concepts. • Knowledge of main types of catalytic nanostructures. • Elementary understanding of synthesis methods. • Simple correlation between structure and catalytic activity. • Completion of practical/project tasks

Date   Course coordinator,
22.09.2025   Conf.dr. Nicoleta Cioatera

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Date of approval   Head of Department,
25.09.2025   Conf.dr. Nicoleta Cioateră