DISCIPLINE SHEET
Academic year 2025/2026

1. Data about the program

1.1. Higher Education Institution	University of Bucharest
1.2. Faculty	Chemistry
1.3. Department	Inorganic Chemistry, Organic Chemistry, Biochemistry and Catalysis
1.4. Field of study	Chemistry
1.5. Study cycle	Master
1.6. Study program	Chemistry of Advanced Materials

2. Data about the discipline

2.1. Discipline name	Characterization of solid materials						
2.2. Holder of course activities	Lecturer Dr. Bogdan Cojocaru						
2.3. Holder of seminar/laboratory activities	Lecturer Dr. Bogdan Cojocaru						
2.4. Year of study	II	2.5. Semester	I	2.6. Type of evaluation	Summative assessment	2.7.Discipline regime	DSIN/DOB

3. Total estimated time

3.1. Number of hours per week	4	3.2. Of which Course	2	3.3. Seminar/Laboratory	2
3.4. Total curriculum hours	56	3.5. Of which Course	28	3.6. Seminar/Laboratory	28
Time fund distribution					
Study from the textbook, course materials, bibliography and notes					50
Additional documentation in the library, on specialized electronic platforms and in the field					30
Seminar/lab preparation, homework, assignments, reports, portfolios and essays					50
Tutoring					10
Other activities: Examination					4
3.7. Total hours of individual study					144
3.8. Total hours per semester (3.4 + 3.7)					200
3.9. Number of credits					8

4. Prerequisites (where applicable)

4.1. of curriculum	
4.2. of skills	Ability to recognize, describe and relate notions, concepts, models and theories in the field of materials. • Elements of structure, kinetics and thermodynamics • Practical skills in carrying out laboratory experiments. • Ability to analyze and interpret the conduct of laboratory experiments and the results obtained.

5. Conditions (where applicable)

5.1. of the course	• Students actively participate in the course by solving exercises and problems proposed on the topic discussed and homework assignments.
5.2. of the seminar/laboratory	• Protective equipment (lab coat, gloves, safety glasses) is mandatory. • Students must demonstrate knowledge of the risk factors and safety measures for the substances they are working with at the beginning of the respective laboratory session. • Students present the laboratory report to the instructor in the session following the work.

6. Learning outcomes

Knowledge	• The student recognizes and reproduces scientific concepts from the branches of inorganic chemistry, physical chemistry, analytical chemistry and materials chemistry • The student identifies and describes the basic and modern experimental techniques used in the analysis and characterization of advanced materials • The student describes the fundamental principles and operation of equipment and apparatus in chemical laboratories, identifies and uses appropriate characterization techniques to determine the chemical composition, structure and properties of advanced materials. • The student identifies and use appropriate information and documentation methods necessary for understanding chemical principles, molecular design and molecular assembly in the design of advanced materials, which they transmit in a scientific manner to interested parties. • The student formulates solutions for complex problems in solid state materials research, including compliance with environmental standards, a process based on the knowledge, identification, and application of advanced concepts, methods and theories from the field of solid materials physical-chemical characterization.
Skills	• The student correctly analyze and evaluate major scientific concepts in the fields of inorganic chemistry, physical chemistry, analytical chemistry and materials chemistry in chemical practice. • The student evaluates and analyzes the experimental techniques to design and conduct experiments and to perform complex analyses and tests (qualitative and quantitative). • The student correctly and efficiently uses modern and complex methods for characterizing advanced materials, chooses specific analysis methods, explains and systematizes the results obtained. • The student responsible interprets the results of the documentation in order to communicate them to those interested (students, students, other socio-economic categories). • The student use logical, intuitive, and creative thinking to solve complex problems of advanced solid state materials structure, employing specific techniques of characterization.
Responsibility and autonomy	• The student has the capacity to adapt major scientific concepts in the field of materials chemistry and related fields to conduct research, improve or develop new concepts, knowledge, theories and operational methods, products and services. • The student has the capacity to individually uses the classical laboratory instruments/techniques and modern equipment, designs experiments, interprets and analyzes the results obtained accordingly. Designs learning situations focused on the development of experimental techniques and methods specific to chemical laboratories. • The student has the ability to develop work protocols and prepare analysis reports, identify solutions and formulate alternatives for the proper functioning of the

	laboratory/professional unit of which it is part. • The student has the ability to select the most appropriate documentation results, to organize teams and collaborate in working groups to carry out educational and scientific activities. • The student has the ability to take responsibility for implementing proposed solutions and to justify the approaches used by assessing risk and safety factors in operation for the development of new projects in resource management and the quality of advanced materials.

7. Contents

7.1. Course	Teaching methods	Comments
Textural characterization of materials: adsorption. Adsorption isotherms	Lecture. Explanation. Conversation. Questioning	2 h
Methodologies to determine the surface area. Characterization of microporous materials: Langmuir method, limits and applications. Characterization of meso- and macroporous materials: BET method, limits and applications. t-plot method; α-S method.		3 h
Determination of the pore diameter and pore volume. Microporous materials: Dubinin method and Horwath-Kawazoe method. Meso- and macroporous materials: de Boer method.		3 h
Textural characterization using microscopy techniques		3 h
Determination of the particle size: Light radiation dispersion techniques. Electroacustic method		2 h
Characterization of materials using chemisorption and thermal methods. Determination of metal surface and dispersion. Determination of surface acidity and basicity. TPR and TPD techniques.		4 h
Structural characterization of materials using diffractometric techniques SAXS. LEED		4 h
Structural characterization of materials using spectral techniques: FTIR, DRIFT, Raman. DR-UV-Vis. XPS. EXAFS		7 h
Bibliography: 1. C. R. Brundle, C. A. J. Evans and S. Wilson, eds., Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films, Elsevier, 1992. 2. R. M. A. Roque-Malherbe, The physical chemistry of materials - Energy and environmental applications, Taylor and Francis Group, LLC, 2010. 3. J. W. Niemantsverdriet, Spectroscopy in Catalysis - An introduction, Wiley-VCH Verlag GmbH, 2000. 4. C.S. Jr. Johnson, D.A. Gabriel, Laser Light Scattering, Dover Publications, Inc., New York 1981. 5. M. Che, J.C. Vedrine (Eds) , Characterization of Solid Materials and Heterogeneous Catalysts: From Structure to Surface Reactivity, Volume 1&2., Wiley-VCH Verlag GmbH & Co., KGaA, 2012. 6. Y. Leng, Materials characterization introduction to microscopic and spectroscopic methods, JohnWiley & Sons (Asia) Pte Ltd, 2008. 7. E. N. Kaufmann, Characterization of Materials, Volume 1&2, John Wiley & Sons, Inc., Hoboken, New Jersey, 2003.		
7.2 Seminar/Laboratory	Teaching methods	Comments
Laboratory work safety and fire protection.	Conversation, experimentation, discovery, problem solving	4 h
Textural characterization of materials using adsorption isotherms		4 h
Structural characterization of materials using XRD		4 h
Structural characterization of materials using DRIFT and Raman.		4 h
Textural characterization of materials using DLS		4 h
Characterization using TPD techniques		4 h
Evaluating the results of the laboratory work	Test. Conversation.	4 h

Bibliography:
1. C. R. Brundle, C. A. J. Evans and S. Wilson, eds., Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films, Elsevier, 1992.
2. R. M. A. Roque-Malherbe, The physical chemistry of materials - Energy and environmental applications, Taylor and Francis Group, LLC, 2010.
3. J. W. Niemantsverdriet, Spectroscopy in Catalysis - An introduction, Wiley-VCH Verlag GmbH, 2000.
4. C.S. Jr. Johnson, D.A. Gabriel, Laser Light Scattering, Dover Publications, Inc., New York 1981.
5. M. Che, J.C. Vedrine (Eds) , Characterization of Solid Materials and Heterogeneous Catalysts: From Structure to Surface Reactivity, Volume 1&2., Wiley-VCH Verlag GmbH & Co., KGaA, 2012.
6. Y. Leng, Materials characterization introduction to microscopic and spectroscopic methods, JohnWiley & Sons (Asia) Pte Ltd, 2008.
7. E. N. Kaufmann, Characterization of Materials, Volume 1&2, John Wiley & Sons, Inc., Hoboken, New Jersey, 2003.

8. The correlation of the subject contents with the expectations of the representatives of the epistemic community, professional associations and representative employers in the field related to the program

Mastering the theoretical-methodological concepts and addressing the practical aspects included in the CHARACTERIZATION OF SOLID MATERIALS discipline leads to the acquisition of a consistent body of knowledge, in accordance with the partial competencies required for the possible occupations provided for in the Classification of Occupations in Romania (COR). . At the end of the course, students will possess the basic concepts necessary for physico-chemical evaluation and use of materials in various areas of strategic importance.

9. Evaluation

Type of activity	9.1. Evaluation criteria	9.2. Evaluation methods	9.3. Share of final grade
9.4. Course	Correctness of answers – correct acquisition and understanding of the issues covered in the course, argumentation of solutions to problems. Correct problem solving.	Written exam - access to the exam is conditional on passing the laboratory colloquium and at least 7 attendances in the course.	70% of the final grade provided that a grade of 5 is obtained on the written paper
9.5. Seminar/Laboratory	Correctness of answers – correct acquisition and understanding of the issues addressed in the laboratory.	10 attendances during the semester, completing all practical laboratory work and passing the laboratory colloquium are conditions for access to the exam.	30%
Minimum performance standard	Grade 5 (five) on the exam according to the scale. Knowledge of the basic concepts of solid materials characterization techniques.		

Date of completion — Course holder's signature — Seminar holder's signature

17.06.2025

Date of approval in the department — Signature of the Head of Department

DISCIPLINE SHEET

1. Data about the program

1.1 Higher Education Institution	**UNIVERSITY OF BUCHAREST**
1.2 Faculty	**FACULTY OF CHEMISTRY**
1.3 Department	**ANALYTICAL CHEMISTRY and PHYSICAL CHEMISTRY**
1.4 Field of study	**CHEMISTRY**
1.5 Study cycle	**MASTER**
1.6 Study program	**CHEMISTRY OF ADVANCED MATERIALS**

2. Data about the discipline

2.1 Discipline name				**CHEMICAL SENSORS AND BIOSENSORS**			
2.2 Holder of lecture activities				**Prof. dr. Camelia BALA**			
2.3 Holder of laboratory/seminar activities				**Conf. dr. Lucian ROTARIU**			
2.4 Year of study	**II**	2.5 Semester	**III**	2.6 Type of evaluation	**Written exam**	2.7 Discipline regime	**DSIN/DOB**

3. Total estimated time

3.1 Number of hours per week	**4**	3.2 of which lectures	**2**	3.3 laboratory/seminar	**2**
3.4 Total curriculum hours	**56**	3.5 of which lectures	**28**	3.6 laboratory/seminar	**28**
Time distribution					hours
Study the textbook, course materials, bibliography, and notes.					**70**
Additional documentation in the library, on specialized electronic platforms, and work in the field					**30**
Seminar/lab preparation, homework, assignments, reports, portfolios, and essays					**20**
Tutoring					**14**
Other activities: Examinations					**10**
3.7 Total hours of individual study					**144**
3.8 Total hours per semester (3.4. + 3.7)					**200**
3.9. Number of credits					**8**

4. Prerequisites (where applicable)

4.1 of the curriculum	Strong foundation in Analytical Chemistry and potentially biochemistry or related fields like materials science. Applicants should possess a background in chemistry, particularly analytical and physical chemistry, as well as some knowledge of biochemistry.
4.2 of skills	Demonstrate proficiency in common laboratory techniques, including titration, filtration, and sample preparation. Accurately use laboratory instruments such as pH meters, burettes, and spectrophotometers. Record, analyze, and interpret experimental data following the scientific method. Practice safe handling and disposal of chemicals in accordance with safety protocols guidelines.

5. Conditions (where applicable)

5.1 Course Conditions	Attendance at least ten lectures is mandatory. Students are prohibited from participating in classes with their mobile phones turned on or using them in any way. Additionally, disturbing fellow students in any manner is not tolerated. Being late to class will not be tolerated.
5.2 Laboratory/Seminar conditions	Laboratory attendance is mandatory.

	Students will arrive at the seminar/laboratory on time and will have their scientific calculators with them. Students will come to the laboratory wearing protective equipment - lab coat, gloves, safety glasses - and will comply with laboratory protection regulations.

6. Learning outcomes

6.1 Knowledge	-The student/graduate will be able to understand the fundamental principles and concepts in the field of sensors and biosensors. - The student/graduate will be able to explain and underlying chemical and physical principles of chemical sensors and biosensors, including transduction mechanisms (electrochemical, optical, piezoelectric, etc.). Descrie structura chimica si proprietatile chimice si structurale generate, intelege si comunica relationarea structura - proprietate într-o manieră științifică, spre elevi, studenți și alte categorii socio-economice interesate. -The student/graduate will be able to analyze the role of materials (e.g., nanomaterials, polymers, biomolecules) in sensor performance and apply this understanding to select appropriate materials for specific applications. -The student/graduate will be able to describe and evaluate various biorecognition elements (enzymes, antibodies, aptamers, DNA, etc.) and their integration into biosensor platforms. They will compare different types of signal transduction (potentiometric, amperometric, impedimetric, colorimetric, etc.) and assess their suitability for detecting specific analytes. -The student/graduate will be able to demonstrate knowledge of sensor fabrication techniques and apply methods for characterization of sensor properties (e.g., sensitivity, selectivity, limit of detection, reproducibility). -The student/graduate will be able to apply appropriate data analysis techniques, including calibration methods, signal-to-noise optimization, and statistical validation of biosensor outputs.
6.2 Skills	-Ability to explain core concepts; differentiate between sensor types; articulate how chemical reactions lead to measurable signals. -Select suitable materials for sensor applications; justify material choices; propose modifications to enhance performance. -Choose appropriate biorecognition elements for specific analytes; evaluate immobilization techniques; assess biocompatibility. -Match transduction techniques to applications; interpret sensor output signals; evaluate the trade-offs between methods. -Use laboratory tools to fabricate and characterize sensors; interpret characterization data (e.g., CV, EIS, SEM); assess device reproducibility and robustness. -Perform data fitting and statistical analysis; calculate detection limits and sensitivity; troubleshoot noisy or inconsistent data.
6.3 Responsibility and autonomy	- Work independently to study and apply scientific theories. - Take initiative in applying fundamental principles to novel problems. - Make informed decisions on material choices in interdisciplinary contexts. - Adapt to new materials and technologies through self-directed learning. - Take responsibility for the biological component of sensor design. - Work collaboratively across biology and engineering disciplines. - Independently assess performance trade-offs. - Justify methodological choices to expert audiences.

7. Contents

7.1 Course	**Teaching methods**	**Comments**
Introduction: Definition of chemical sensors and biosensors, historical perspective, physico-chemical and biological transducers, terminology, and working vocabulary. Factors influencing sensor performance include selectivity, dynamic range, sensitivity, detection limit, reproducibility, response time, shelf life, and operational lifetime.	Lecture Explanation Conversation Description	2 h
Biological material used in biosensors. Immobilization of biological material: adsorption, covalent linkage, physical entrapment, microencapsulation, cross-linking. Surface Modification of Transducers: Limitations and Problems.	Lecture Explanation Conversation Description	6 h
Catalytic biosensors. Substrate detection and inhibition-based enzyme biosensors.	Lecture	4 h

	Explanation Conversation Description	
Electrochemical transducers (amperometric, potentiometric, conductimetric). Construction and action principle. Applications in chemical sensors and biosensors.	Lecture Explanation Conversation Description	2 h
Optical transducers (absorption, fluorescence, bio/chemiluminescence, Surface Plasmon Resonance); construction and principle of action. Applications in chemical sensors and biosensors	Lecture Explanation Conversation Description	2 h
Surface acoustic wave transducers. Applications of piezoelectric crystals in quartz crystal microbalance. Limitations & problems to be addressed. Overview of performance and applications	Lecture Explanation Conversation Description	2 h
Affinity-based biosensors; Immunosensors.	Lecture Explanation Conversation Description	2 h
Biosensor engineering. Methods for biosensors fabrication: self-assembled monolayers, screen printing, photolithography, and micro contact printing.	Lecture Explanation Conversation Description	2 h
Enhancing the biosensors' response through nanomaterials. Applications of chemical sensors and biosensors include medicine, production control, quality assurance in the food industry, control of biotechnological processes, environmental monitoring, defense and security, forensic analysis, sports medicine, and scientific research. Addressing problems and limitations.	Lecture Explanation Conversation Description	4 h
Commercialization. Biomimetic sensors: electronic nose, electronic tongue, molecular imprinting. Miniaturization of biochip arrays of sensors.	Lecture Explanation Conversation Description	2 h

Bibliography:

1. **P**alleschi, G., Compagnone, D. (Eds.), *Biosensors in Food Safety and Quality,* Royal Society of Chemistry (2022)
2. Anthony Turner, I. Karube, G. Wilson, Biosensors: Fundamentals and Applications (1987)
3. Brian R. Eggins “Chemical Sensors and Biosensors” (2002)
4. Florinel-Gabriel Bănică, Chemical Sensors and Biosensors: Fundamentals and Applications (2012)
5. Elizabeth Hall “Biosensors” (1991)
6. Methods in biotechnology—immobilization of enzymes and cells; Edited by G F Bickerstaff. pp 367. Humana Press, New Jersey (1996)
7. Affinity Biosensors: Techniques and Protocols, Vol. 7 / Edition 1 by Kim Rogers, Ashok Mulchandani (1998)

7.2 Laboratory/seminar	**Teaching methods**	**Comments**
Safety rules in the laboratory. Brief presentation of practical activities and experimental setups.	Explanation Conversation	2 h
The selection of the electrode materials and suitable characterization methods. Cleaning: Use physical polishing (e.g., alumina slurry) and chemical cleaning (e.g., acid or solvent washes). Surface Activation and Functionalization (if needed): Modify the surface with nanomaterials or linker molecules (e.g., chitosan, carbon nanotubes, graphene oxide, AuNPs) to enhance conductivity and enzyme binding.	Experiment Explanation Conversation Problematization	4 h
The selection of the specific biomolecule (e.g., glucose oxidase, lactate oxidase) is based on the target analyte and the enzyme activity measurement.	Experiment Explanation Conversation Problematization	6 h
Selection of the best immobilization method on the selected transducers to preserve the enzyme activity, ensure stable and reproducible attachment.	Experiment Explanation Conversation Problematization	6 h
Construction of the biosensors and Analytical Performance Evaluation. Determine the key performance metrics, such as Sensitivity, linear range,	Experiment Explanation	8 h

Limit of Detection (LOD), and Response time.	Conversation Problematization	
Discussion of the practical work reports and experimental results. Conclusions.	Written Assessments	2 h

Bibliography:

1. Elizabeth Hall “Biosensors” (1991)
2. Methods in biotechnology—immobilization of enzymes and cells; Edited by G F Bickerstaff. pp 367. Humana Press, New Jersey (1996)

8. The correlation of the subject contents with the expectations of the representatives of the epistemic community, professional associations and representative employers in the field related to the program

The course **"Chemical Sensors and Biosensors"**, included in the master's program curriculum, has been developed to align closely with the expectations of the **epistemic community**, relevant **professional associations**, and **representative employers** in the field of chemical and biosensing technologies and align with the competencies needed for potential careers outlined in Grid 1 - RNCIS. The course demonstrates a strong correlation with the current and evolving expectations of the scientific, professional, and industrial communities related to chemical and biosensor technologies. It equips students with both deep disciplinary knowledge and transferrable skills, ensuring that graduates are prepared for advanced research, development, and professional practice in this critical and growing field.

1. Alignment with the academic and scientific communities engaged in sensor research and biosensing innovation emphasize:

- Mastery of fundamental scientific principles underlying sensor technologies, including electrochemical, optical, and piezoelectric transduction mechanisms.
- Interdisciplinary integration of knowledge from chemistry, materials science, biology, and electronics.
- Competence in scientific methodology, critical analysis of the literature, experimental design, and data interpretation.
- Familiarity with current and emerging trends, such as nanomaterials, wearable biosensors, and point-of-care diagnostic devices.

The course addresses these expectations through:

- A structured curriculum combining theoretical lectures with applied laboratory sessions.
- Critical reading assignments and student-led literature reviews on recent advances in sensor technologies.
- A project-based approach that fosters independent research and innovation aligned with contemporary scientific directions.

2. Compliance with Professional Association Standards

The course content and learning outcomes reflect the guidance and competency frameworks established by professional bodies such as:

- The **IEEE Sensors Council**
- The **American Chemical Society (ACS)**, Division of Analytical Chemistry
- The **International Union of Pure and Applied Chemistry (IUPAC)**
- The **Biosensors and Bioelectronics Society**

These organizations emphasize:

- Technical proficiency in sensor design, fabrication, and analytical validation.
- Ethical responsibility in research and application, including data integrity and regulatory compliance.
- Familiarity with standards for device performance evaluation, including sensitivity, specificity, and reproducibility.
- Exposure to international terminology, classification, and best practices.

In response, the course integrates:

- Modules on fabrication and characterization of sensors using electrochemical techniques.
- Emphasis on ethical considerations in biosensor deployment in healthcare and environmental monitoring.

3. Relevance to Representative Employers’ Needs

The curriculum is informed by consultations with stakeholders from the biotechnology, environmental, healthcare diagnostics, and agri-food industries. Employers in these sectors seek graduates who can:

- Design, validate, and optimize sensor systems for real-world applications.
- Collaborate in multidisciplinary teams, often integrating software, engineering, and biochemical expertise.
- Communicate effectively across technical and managerial roles.
- Translate laboratory research into scalable, market-ready solutions.

The course supports these expectations by:

- Providing practical training in sensor development using industry-relevant materials and methods (e.g., screen-printed electrodes, nanocomposites, enzyme immobilization).
- Embedding case studies and real-world scenarios within assessments.
- Preparing students to work independently and with autonomy on complex projects, while also developing team-based

problem-solving skills.

9. Evaluation

Type of activity	9.1 Evaluation criteria	9.2 Evaluation methods	9.3 Share of final grade
9.4 Course	Correctness of answers – understanding and correct application of the issues covered in the course. Correctly solving exercises and problems, and arguing the proposed solutions.	Written exam. Access to the exam is conditional on attendance at courses (minimum 10 lectures) and to execute all of the laboratory ativities.	70% provided that the grade obtained is at least 5 (five)
9.5 Laboratory/seminar	Accurate acquisition and comprehension of the issues explored in the laboratory. Addressing practical tasks and properly interpreting the results achieved. Compiling reports for every practical exercise.	Laboratory colloquium	30%
Minimum performance standard			
To obtain the passing grade (minimum grade 5 out of 10), the student must demonstrate the fulfillment of the following minimum competencies, in accordance with the level 7 requirements of the National Qualifications Framework (CNC) and ARACIS: -ability to recall and describe key concepts in sensors and biosensors with limited detail. -familiarity with laboratory workflow and basic interpretation of results. -ability to apply knowledge in structured, well-defined contexts. -clarity in basic written scientific communication.			

Date of completion **Course holder's signature** **Laboratory/Seminar holder's signature**

Prof. dr. Camelia BALA **Associated Prof. dr. Lucian Rotariu**

Date of approval in the department **Signature of the Head of Department**

Lecture dr. Adina Liana Răducan

DISCIPLINE SHEET
Academic year 2025/2026

1. Data about the program

1.1. Higher Education Institution	University of Bucharest
1.2. Faculty	CHEMISTRY
1.3. Department	CHEMISTRY
1.4. Field of study	CHEMISTRY
1.5. Study cycle	MASTER
1.6. Study program	CHEMISTRY OF ADVANCED MATERIALS

2. Data about the discipline

2.1. Discipline name	RESEARCH ACTIVITY						
2.2. Holder of course activities	-						
2.3. Holder of laboratory activities	Coordinator Each teacher coordinating the dissertation						
2.4. Year of study	II	2.5. Semester	3	2.6. Type of evaluation	V	2.7.Discipline regime	DAPROF/ DOC

3. Total estimated time

3.1. Number of hours per week	7	3.2. Of which Course	-	3.3. Laboratory	7
3.4. Total curriculum hours	98	3.5. Of which Course	-	3.6. Laboratory	98

Time fund distribution	hours
Study from the textbook, course materials, bibliography and notes	5
Additional documentation in the library, on specialized electronic platforms and in the field	5
Laboratory research and report writing	50
Tutoring	7
Other activities: examination	10
3.7. Total hours of individual study	77
3.8. Total hours per semester (3.4 + 3.7)	175
3.9. Number of credits	14

4. Prerequisites (where applicable)

4.1. of curriculum	Fundamentals of chemistry.
4.2. of skills	Chemistry laboratory working skills PC operating skills, Skills in using Microsoft Word, Excel / Origin, PowerPoint and software Communication skills using expressions/terms associated with statistical parameters Knowledge of English

5. Conditions (where applicable)

5.1. of the course	Not the case
5.2. of the laboratory	- Laboratory attendance is compulsory - Students will come to the lab with protective equipment (lab coat, gloves, goggles) - Documenting by accessing scientific articles in libraries and electronic databases. Providing access to PC equipment with appropriate software - Systematizing information from the literature; Performing the required tasks according to the specified requirements and in the required stages, with respecting the rules of professional ethics, following a work plan following a predetermined work plan - Permanent information and documentation in the field of activity - Involvement in conducting laboratory experiments. - Presentation of reports and results

6. Learning outcomes

Knowledge	- Describes the chemical structure and the chemical and structural properties generated, understands and communicates the structure-property relationship in a scientific manner to pupils, students and other socio-economic stakeholders. - Identifies and describes the basic and modern experimental techniques used in the analysis and characterization of advanced materials - Describes the fundamental principles and operation of equipment and apparatus in chemical laboratories, identifies and uses appropriate characterization techniques to determine the chemical composition, structure and properties of advanced materials. - Identify and develop methods for synthesizing materials with improved or new properties for specific applications, acquire and process the obtained data. - Identifies and uses appropriate methods of information and documentation necessary to understand chemical principles, molecular design and molecular assembly in the design of advanced materials and communicates them in a scientific manner to interested parties. - Formulates solutions to complex problems of modern chemical research including environmental compliance, a process based on the knowledge, identification and application of advanced concepts, methods and theories in the field of molecular materials, simple nanomaterials, nanocomposites and catalytic (nano)materials. - Formulates scientific reports on scientific research strategies, presents and analyzes the results of the documentation, explains and analyzes the obtained experimental results, for the elaboration of research projects. - Describes and integrates specific and interdisciplinary knowledge in professional activity.
Skills	- Evaluates and demonstrates the specific chemical and physical structural characteristics of advanced materials and adapts knowledge for physicochemical characterization and the study of properties of materials obtained by various

	processes. -Evaluation and analyzes of the experimental techniques to design and conduct experiments and to perform complex analyses and tests (qualitative and quantitative). - Correctly and efficiently uses modern and complex methods of characterization of advanced materials, chooses specific methods of analysis, explains and systematizes the obtained results. - Understands the chemistry of advanced materials synthesis processes, understands and controls the chemical and physical structural and chemical-physical characteristics and develops creative solutions in advanced materials application areas. - Responsibly interprets the results of documentation in order to communicate them to interested parties (pupils, students, other socio-economic groups). - Utilizes logical, intuitive and creative thinking in solving complex problems characteristic of advanced materials chemistry using methods specific to related fields. - Applies the principles of science and utilizes the results of research for the formation of specific and innovative skills necessary for new occupations arising in the field of materials science and nanotechnologies. - Develops skills to work in appropriate interdisciplinary teams to solve theoretical and practical problems specific to the field of advanced materials science.
Responsibility and autonomy	- Use of logical, intuitive and creative thinking in describing, comparing and analyzing the structure and properties of advanced materials to help support the learning of these concepts by interested professional groups, including secondary school students. - Individually uses of classical laboratory instruments/techniques and modern equipment, designs experiments, interprets and analyzes the results obtained accordingly. Designs learning situations focused on the development of experimental techniques and methods specific to chemical laboratories. - The ability to develop work protocols and to prepare analysis reports, identify solutions and formulate alternatives for the proper functioning of the laboratory/professional unit to which it belongs. - Ability to manage the research activity, respecting both the established experimental plan and deadlines, to assume responsibility for the correctness of the interpretations and conclusions given in the scientific activity reports. - The ability to select the most appropriate results of the documentation, to organize teams and to collaborate in working groups to carry out educational and scientific activities. - Ability to assume responsibility for the implementation of proposed solutions and justify the approaches used with the assessment of risk and safety factors in operation for the development of new advanced materials quality and resource

	management projects. - Ability to prepare and present scientific reports and to apply autonomously and responsibly the knowledge and skills acquired in chemistry of advanced materials respecting the rules of professional ethics. - Ability to autonomously and responsibly apply knowledge and skills in the coordination of a work/research team, by allocating tasks, resources and following up the achievement of project objectives.

7. Contents

7.1. Course	Teaching methods	Comments
	NOT THE CASE	
Bibliography:		
7.2 Laboratory	Teaching methods	Comments
7.2.1. Analysis of the possible repetition of the experimental stages realized in second semester of the first year of the master. Identification of procedural flaws that led to obtaining unsatisfactory results and their elimination, if necessary.	Explanation; Conversation; Description; Exemplification; Experimental activity	18 h
7.2.2. Continuation of the experimental steps set out in the work plan. Systematization of experimental data as they are obtained. Completion of the planned experimental steps.		40 h
7.2.3. Comparison of expected results with those obtained in practice. Analysis of real situations in which the results obtained coincide/disprove the assumed premises. Systematization of experimental data as obtained and analysis critical analysis of those to be presented.		10 h
7.2.4. Establishment of new development directions in the context of the progressive obtaining of experimental results. Preparation by the master student of the written material related to the report 3. Preparation of the PowerPoint presentation for the defense of the report 3.		10 h
7.2.5. Realization of a draft publication/poster by the master student; Discussions with the scientific advisor regarding the quality of the proposed material (article, poster, presentation); Preparation for the participation of the master student in scientific events (local, national, international) -example: the student scientific communication session, national and international symposia;		20 h
Bibliography: - Specialized literature depending on the topic; Electronic databases AnelisPlus, Science Direct; Scopus, etc.		

8. The correlation of the subject contents with the expectations of the representatives of the epistemic community, professional associations and representative employers in the field related to the program

By grasping the theoretical-methodological concepts and approaching the practical aspects included in the discipline

Research Activity, the graduates will be provided with an additional knowledge useful for a quick and easy integration in highly specialized and performing fields of activity, in accordance with the partial competences required for the possible occupations provided in the RNCIS Grid.

9. Evaluation

Type of activity	9.1. Evaluation criteria	9.2. Evaluation methods	9.3. Share of final grade
Report research	The way in which the student has realized the theoretical and experimental part of the report; The scientific quality of the report; The quality of the ppt presentation;	Check	100%
Minimum performance standard			
Attendance to at least 80% of the hours of research activity foreseen in the syllabus. Admitted –"sufficient"			

Date of completion	Course holder's signature	Seminar holder's signature
June 2025		
Date of approval in the department		Signature of the Head of Department

DISCIPLINE SHEET
Academic year 2025/2026

1. Data about the program

1.1. Higher Education Institution	University of Bucharest
1.2. Faculty	CHEMISTRY
1.3. Department	CHEMISTRY
1.4. Field of study	CHEMISTRY
1.5. Study cycle	MASTER
1.6. Study program	CHEMISTRY OF ADVANCED MATERIALS

2. Data about the discipline

2.1. Discipline name	RESEARCH ACTIVITY						
2.2. Holder of course activities	-						
2.3. Holder of laboratory activities	Coordinator Each teacher coordinating the dissertation						
2.4. Year of study	II	2.5. Semester	3	2.6. Type of evaluation	V	2.7.Discipline regime	DAPROF/ DOC

3. Total estimated time

3.1. Number of hours per week	7	3.2. Of which Course	-	3.3. Laboratory	7
3.4. Total curriculum hours	98	3.5. Of which Course	-	3.6. Laboratory	98

Time fund distribution	hours
Study from the textbook, course materials, bibliography and notes	5
Additional documentation in the library, on specialized electronic platforms and in the field	5
Laboratory research and report writing	50
Tutoring	7
Other activities: examination	10
3.7. Total hours of individual study	77
3.8. Total hours per semester (3.4 + 3.7)	175
3.9. Number of credits	14

4. Prerequisites (where applicable)

4.1. of curriculum	Fundamentals of chemistry.
4.2. of skills	Chemistry laboratory working skills PC operating skills, Skills in using Microsoft Word, Excel / Origin, PowerPoint and software Communication skills using expressions/terms associated with statistical parameters Knowledge of English

5. Conditions (where applicable)

5.1. of the course	Not the case
5.2. of the laboratory	- Laboratory attendance is compulsory - Students will come to the lab with protective equipment (lab coat, gloves, goggles) - Documenting by accessing scientific articles in libraries and electronic databases. Providing access to PC equipment with appropriate software - Systematizing information from the literature; Performing the required tasks according to the specified requirements and in the required stages, with respecting the rules of professional ethics, following a work plan following a predetermined work plan - Permanent information and documentation in the field of activity - Involvement in conducting laboratory experiments. - Presentation of reports and results

6. Learning outcomes

Knowledge	- Describes the chemical structure and the chemical and structural properties generated, understands and communicates the structure-property relationship in a scientific manner to pupils, students and other socio-economic stakeholders. - Identifies and describes the basic and modern experimental techniques used in the analysis and characterization of advanced materials - Describes the fundamental principles and operation of equipment and apparatus in chemical laboratories, identifies and uses appropriate characterization techniques to determine the chemical composition, structure and properties of advanced materials. - Identify and develop methods for synthesizing materials with improved or new properties for specific applications, acquire and process the obtained data. - Identifies and uses appropriate methods of information and documentation necessary to understand chemical principles, molecular design and molecular assembly in the design of advanced materials and communicates them in a scientific manner to interested parties. - Formulates solutions to complex problems of modern chemical research including environmental compliance, a process based on the knowledge, identification and application of advanced concepts, methods and theories in the field of molecular materials, simple nanomaterials, nanocomposites and catalytic (nano)materials. - Formulates scientific reports on scientific research strategies, presents and analyzes the results of the documentation, explains and analyzes the obtained experimental results, for the elaboration of research projects. - Describes and integrates specific and interdisciplinary knowledge in professional activity.
Skills	- Evaluates and demonstrates the specific chemical and physical structural characteristics of advanced materials and adapts knowledge for physicochemical characterization and the study of properties of materials obtained by various

	processes. -Evaluation and analyzes of the experimental techniques to design and conduct experiments and to perform complex analyses and tests (qualitative and quantitative). - Correctly and efficiently uses modern and complex methods of characterization of advanced materials, chooses specific methods of analysis, explains and systematizes the obtained results. - Understands the chemistry of advanced materials synthesis processes, understands and controls the chemical and physical structural and chemical-physical characteristics and develops creative solutions in advanced materials application areas. - Responsibly interprets the results of documentation in order to communicate them to interested parties (pupils, students, other socio-economic groups). - Utilizes logical, intuitive and creative thinking in solving complex problems characteristic of advanced materials chemistry using methods specific to related fields. - Applies the principles of science and utilizes the results of research for the formation of specific and innovative skills necessary for new occupations arising in the field of materials science and nanotechnologies. - Develops skills to work in appropriate interdisciplinary teams to solve theoretical and practical problems specific to the field of advanced materials science.
Responsibility and autonomy	- Use of logical, intuitive and creative thinking in describing, comparing and analyzing the structure and properties of advanced materials to help support the learning of these concepts by interested professional groups, including secondary school students. - Individually uses of classical laboratory instruments/techniques and modern equipment, designs experiments, interprets and analyzes the results obtained accordingly. Designs learning situations focused on the development of experimental techniques and methods specific to chemical laboratories. - The ability to develop work protocols and to prepare analysis reports, identify solutions and formulate alternatives for the proper functioning of the laboratory/professional unit to which it belongs. - Ability to manage the research activity, respecting both the established experimental plan and deadlines, to assume responsibility for the correctness of the interpretations and conclusions given in the scientific activity reports. - The ability to select the most appropriate results of the documentation, to organize teams and to collaborate in working groups to carry out educational and scientific activities. - Ability to assume responsibility for the implementation of proposed solutions and justify the approaches used with the assessment of risk and safety factors in operation for the development of new advanced materials quality and resource

	management projects. - Ability to prepare and present scientific reports and to apply autonomously and responsibly the knowledge and skills acquired in chemistry of advanced materials respecting the rules of professional ethics. - Ability to autonomously and responsibly apply knowledge and skills in the coordination of a work/research team, by allocating tasks, resources and following up the achievement of project objectives.

7. Contents

7.1. Course	Teaching methods	Comments
	NOT THE CASE	
Bibliography:		
7.2 Laboratory	Teaching methods	Comments
7.2.1. Analysis of the possible repetition of the experimental stages realized in second semester of the first year of the master. Identification of procedural flaws that led to obtaining unsatisfactory results and their elimination, if necessary.	Explanation; Conversation; Description; Exemplification; Experimental activity	18 h
7.2.2. Continuation of the experimental steps set out in the work plan. Systematization of experimental data as they are obtained. Completion of the planned experimental steps.		40 h
7.2.3. Comparison of expected results with those obtained in practice. Analysis of real situations in which the results obtained coincide/disprove the assumed premises. Systematization of experimental data as obtained and analysis critical analysis of those to be presented.		10 h
7.2.4. Establishment of new development directions in the context of the progressive obtaining of experimental results. Preparation by the master student of the written material related to the report 3. Preparation of the PowerPoint presentation for the defense of the report 3.		10 h
7.2.5. Realization of a draft publication/poster by the master student; Discussions with the scientific advisor regarding the quality of the proposed material (article, poster, presentation); Preparation for the participation of the master student in scientific events (local, national, international) -example: the student scientific communication session, national and international symposia;		20 h
Bibliography: - Specialized literature depending on the topic; Electronic databases AnelisPlus, Science Direct; Scopus, etc.		

8. The correlation of the subject contents with the expectations of the representatives of the epistemic community, professional associations and representative employers in the field related to the program

By grasping the theoretical-methodological concepts and approaching the practical aspects included in the discipline

Research Activity, the graduates will be provided with an additional knowledge useful for a quick and easy integration in highly specialized and performing fields of activity, in accordance with the partial competences required for the possible occupations provided in the RNCIS Grid.

9. Evaluation

Type of activity	9.1. Evaluation criteria	9.2. Evaluation methods	9.3. Share of final grade
Report research	The way in which the student has realized the theoretical and experimental part of the report; The scientific quality of the report; The quality of the ppt presentation;	Check	100%
Minimum performance standard			
Attendance to at least 80% of the hours of research activity foreseen in the syllabus. Admitted –"sufficient"			

Date of completion	Course holder's signature	Seminar holder's signature
June 2025		
Date of approval in the department		Signature of the Head of Department

DISCIPLINE SHEET
Academic year 2025/2026

1. Data about the program

1.1. Higher Education Institution	University of Bucharest
1.2. Faculty	Chemistry
1.3. Department	Inorganic Chemistry, Organic Chemistry, Biochemistry and Catalysis
1.4. Field of study	Chemistry
1.5. Study cycle	Master
1.6. Study program	Chemistry of Advanced Materials

2. Data about the discipline

2.1. Discipline name	NANOMATERIALS						
2.2. Holder of course activities				Assoc. Prof. Dr. Habil. Octavian D. PAVEL			
2.3. Holder of seminar/laboratory activities				Lecturer Dr. Bogdan E. COJOCARU			
2.4. Year of study	II	2.5. Semester	II	2.6. Type of evaluation	Summative assessment	2.7.Discipline regime	DSIN/DOB

3. Total estimated time

3.1. Number of hours per week	4	3.2. Of which Course	2	3.3. Seminar/Laboratory	2
3.4. Total curriculum hours	40	3.5. Of which Course	20	3.6. Seminar/Laboratory	20
Time fund distribution					
Study from the textbook, course materials, bibliography and notes					50
Additional documentation in the library, on specialized electronic platforms and in the field					30
Seminar/lab preparation, homework, assignments, reports, portfolios and essays					50
Tutoring					10
Other activities: Examinations					20
3.7. Total hours of individual study					160
3.8. Total hours per semester (3.4 + 3.7)					200
3.9. Number of credits					8

4. Prerequisites (where applicable)

4.1. of curriculum	Characterization of solid materials; Preparation of catalysts
4.2. of skills	-

5. Conditions (where applicable)

5.1. of the course	1. Questions/debates regarding the course content are encouraged. 2. Any curiosities about the notions taught in the course will be discussed during the laboratories (within the available time) and/or after the course hours. 3. It is forbidden for students to participate in classes with their mobile phones turned on or to manipulate them. Also, disturbing other colleagues in any form is not tolerated 3. It is forbidden for students to participate in classes if their attention is altered from various reasons.

	4. Students will not be tolerated to be late for class.
5.2. of the seminar/laboratory	1. The results / processing of the data obtained during the laboratory work will be presented at the end of it. 2. However, in exceptional cases (e.g. minor accidents) it is acceptable to submit the results to the next laboratory. 3. Students are prohibited from participating in laboratory activities if their attention / motor skills are altered for different reasons.

6. Learning outcomes

Knowledge	- The student/graduate recognizes and reproduces basic scientific concepts from the branches of inorganic chemistry, organic chemistry, physical-chemistry, analytical chemistry and especially materials chemistry. - The student/graduate describes the physicochemical properties of nanomaterials, understands and communicates the relationship between structure/texture vs. specific property in a scientific manner both pupils and students but also other socio-economic categories interested in the subject. - The student/graduate identifies and describes the basic and modern experimental techniques used in the analysis and characterization of nanomaterials - The student/graduate describes the fundamental principles and operation of equipment and devices in advanced materials laboratories, identifies and uses appropriate characterization techniques to determine the chemical composition, structure, texture and properties of nanomaterials. - The student/graduate identifies and uses specific and appropriate information and documentation methods necessary to understand the physicochemical principles of nanomaterial, with the aim of designing advanced materials, that they transmit in a scientific manner to those interested.
Skills	- The student/graduate analyzes and evaluates in a correct and coherent manner the major scientific concepts in the field of inorganic chemistry, organic chemistry, physical-chemistry, analytical chemistry and especially materials chemistry in chemical practice. - The student/graduate evaluates and demonstrates the specific physicochemical characteristics of nanomaterials and adapts the knowledge acquired for the physicochemical characterization and study of the properties of nanomaterials obtained through various methods. - The student/graduate evaluates and analyzes the experimental techniques to design and conduct experiments and to perform complex analyses and tests (qualitative and quantitative). - The student/graduate correctly and efficiently uses modern and complex methods for characterizing nanomaterials, chooses appropriate analysis methods, explains and systematizes the results obtained. - The student/graduate responsibly interprets the results of the documentation in order to communicate them to those interested (e.g., pupils, students, other socio-economic categories).
Responsibility and autonomy	- The student/graduate adapts major scientific concepts in the field of nanomaterials and related fields to conduct research, improve or develop new concepts, knowledge, theories and operational methods, products and services. - The student/graduate uses logical, intuitive and creative thinking in describing, comparing and analyzing the physicostructural properties of nanomaterials to contribute to supporting the learning of these concepts by interested professional groups, including high school students. - The student/graduate is able to use in an individually way the classical laboratory instruments/techniques and modern equipment, to designs

	experiments, to interprets and analyzes the results obtained accordingly. Designs learning situations focused on the development of experimental techniques and methods specific to chemical laboratories. - The student/graduate demonstrates the ability to develop work protocols and prepare analysis reports, identify solutions and formulate alternatives for the proper functioning of the laboratory, respectively the professional unit, of which he/she is a part. - The student/graduate demonstrates the ability to select the most appropriate documentation results, to organize teams and to collaborate in working groups to carry out educational and scientific activities.

7. Contents

7.1. Course	Teaching methods	Comments
States of the art: the concept of nanomaterials, nanoscale, nanopores and nanostructures.	Lecture (face-to-face)	2h
Classification of nanomaterials. Challenges of the size. Present and future applications of nanomaterials	Lecture (face-to-face)	2h
Nanomaterials synthesis (e.g., chemical, physical, biomimetics approaches). The relationship between structure and nanomaterial properties.	Lecture (face-to-face)	6h
Nanoparticles / nanopowder - description, properties and applications.	Lecture (face-to-face)	2h
Nanocomposites - description, properties, applications.	Lecture (face-to-face)	2h
Nanocapsules - description, properties, applications.	Lecture (face-to-face)	2h
Nanodots - description, properties, applications.	Lecture (face-to-face)	2h
Carbon nanomaterials - description, properties, applications.	Lecture (face-to-face)	2h

Bibliography:

1. Nanomaterials Handbook 2nd Edition; Yury Gogotsi (Ed.) (2017), CRC Press Taylor & Francis Group, ISBN 9781498703062
2. Springer Handbook of Nanomaterials; Robert Vajtai (Ed.); (2013); Springer Dordrecht Heidelberg London New York; ISBN: 978-3-642-20594-1; doi:10.1007/978-3-642-20595-8
3. Handbook of Nanoparticles; Mahmood Aliofkhazraei (Ed.); (2016); Springer Cham Heidelberg New York Dordrecht London; doi:10.1007/978-3-319-15338-4; ISBN 978-3-319-15337-7
4. Nanomaterial Characterization – An Introduction; Ratna Tantra (Ed.); (2016) Published by John Willey & Sons, Inc., Hoboken, New Jersey; ISBN: 978-1-118-75359-0
5. Nanomaterials – Mechanics and Mechanisms; K.T. Ramesh, (2009); Springer Dordrecht Heidelberg London New York; doi:10.1007/978-0-387-09783-1
6. Nanomaterials and Nanochemistry; C. Brechignac, P. Houdy, M. Lahmani (Eds.); (2007) Springer Berlin Heidelberg New York; ISBN 978-3-540-72992-1
7. Nanomaterials Chemistry - Recent Developments and New Directions ; C.N.R. Rao, A. Muller, A.K. Cheetham (Eds.); (2007) ISBN 978-3-527-31664-9; doi:10.1002/9783527611362

7.2 Seminar/Laboratory	Teaching methods	Comments
Presentation of the laboratory: practical concepts, equipment and facilities. Laboratory work safety rules and fire protection.	Lectures and Presentations	2h
A simple method for the ZnO nanoparticles preparation / Core-shell magnetic nanocomposites synthesis	Case study	4h
“Green” and “Non-green” aspects of silver nanoparticles (AgNPs) synthesis	Case study	4h
Determination of the physicochemical properties of nanoparticles using advanced techniques	Case study	4h
Nanomaterials with catalytic properties. Photodegradation of pollutants in the presence of photo-nanoparticles	Case study	4h
Laboratory knowledge evaluation	Written Assessments	2h

Bibliography:

1. Introducing “Green” and “Nongreen” Aspects of Noble Metal Nanoparticle Synthesis: An Inquiry-Based Laboratory Experiment for Chemistry and Engineering Students; Sesha L. A. Paluri, Michelle L. Edwards, Nhi H. Lam, Elizabeth M. Williams, Allie Meyerhoefer, Ioana E. Pavel Sizemore; *Journal of Chemical Education - ACS Publications* 2014, *92*, 350–354; doi:10.1021/ed5004806.
2. Synthesis of ZnO Nanoparticles and Investigation of the Ionic Template Effect on Their Size and Shape; Kamellia Nejati, Zolfaghar Rezvani, Rafat Pakizevand; *International Nano Letters* 2011, *1(2)*, 75–81.
3. Role of (3-aminopropyl)tri alkoxysilanes in grafting of chlorosulphonic acid immobilized magnetic nanoparticles and their application as heterogeneous catalysts for the green synthesis of α-aminonitriles; Harminder Singh, Jaspreet Kaur Rajput, Priya Arora, Jigyasa Sachdeva, *RSC Advances* 2016, *6*, 84658–84671; doi:10.1039/C6RA20095H.
4. Magnetite core and ZnO shell – What is in between and how does it affect on nanoparticles properties?; Viktoriia Zheltova, Kirill Korolev-Zeleniy, Anton Mazur, Valentin Semenov, Natalia Bobrysheva, Mikhail Osmolowsky, Mikhail Voznesenskiy, Olga Osmolovskaya, *Applied Surface Science* 2023, *641*, 158530; doi:10.1016/j.apsusc.2023.158530.
5. Cr-Doped ZnO Nanoparticles: Synthesis, Characterization, Adsorption Property, and Recyclability; Alan Meng, Jing Xing, Zhenjiang Li, Qingdang Li, *ACS Applied Materials & Interfaces* 2015, *7(49)*, 27449–2745; doi:10.1021/acsami.5b09366.
6. Characterization of Nanoparticles by Solvent Infrared Spectroscopy; Johannes Kiefer, Janet Grabow, Heinz-Dieter Kurland, Frank A. Müller, *Analytical Chemistry* 2015, *87(24)*, 12313–12317; doi:10.1021/acs.analchem.5b03625.
7. Size Determination of Nanoparticles by Dynamic Light Scattering; Haruhisa Kato; Book Editor(s): Dr. Subhash Chandra Singh, Prof. Haibo Zeng, Prof. Chunlei Guo, Prof. Weiping Cai; https://doi.org/10.1002/9783527646821.ch8
8. Synthesis of silver nanoparticles (AgNPs) from leaf extract of *Salvia miltiorrhiza* and its anticancer potential in human prostate cancer LNCaP cell lines; Ke Zhang, Xiaodong Liu, Samson Oliver Abraham Samuel Ravi, Arunkumar Ramachandran, Ibrahim Abdel Aziz Ibrahim, Anmar M. Nassir, Jiapei Yao, Artificial Cells, *Nanomedicine, and Biotechnology An International Journal* 2019, *47*, 2846–2854; doi:10.1080/21691401.2019.1638792.
9. Chapter 9 - Surface Area Analysis of Nanomaterials; Ashin Shaji, Ajesh K. Zachariah, *Thermal and Rheological Measurement Techniques for Nanomaterials Characterization Micro and Nano Technologies* 2017, 197–231; doi:10.1016/B978-0-323-46139-9.00009-8.
10. Photocatalytic activity of ZnO nanoparticles and the role of the synthesis method on their physical and chemical properties; *Journal of Photochemistry and Photobiology A: Chemistry* 2021, *404*, 112866; doi:10.1016/j.jphotochem.2020.112866.

8. The correlation of the subject contents with the expectations of the representatives of the epistemic community, professional associations and representative employers in the field related to the program

The content of the course entitled "Nanomaterials" is in line with the current requirements for research and development of new materials with peculiar properties. Many of the preparation methods listed in the course are already widely used both in the country and abroad. Furthermore, these materials are evaluated from a physicochemical point of view with advanced characterization techniques, many of which are present in both universities and research institutes. At the end of the course, students will possess the basic concepts necessary for synthesizing, physico-chemical evaluation, and using these materials in various areas of strategic importance.

9. Evaluation

Type of activity	9.1. Evaluation criteria	9.2. Evaluation methods	9.3. Share of final grade
9.4. Course	1. Basic knowledge of nanomaterials 2. Ability to use nano concepts in a suitable approach 3. Ability to generate pros and cons a concept	Examination	70%
9.5. Seminar/Laboratory	1. Properly grasping the questions 2. The ability to use in a correct manner of the methods / models 3. Problems resolving	Laboratory colloquium	30%
Minimum performance			

standard	

Date of completion 15.06.2025	Course holder's signature	Seminar holder's signature
Date of approval in the department		Signature of the Head of Department

DISCIPLINE SHEET
Academic year 2025/2026

1. Data about the program

1.1. Higher Education Institution	UNIVERSITY OF BUCHAREST
1.2. Faculty	FACULTY OF CHEMISTRY
1.3. Department	INORGANIC & ORGANIC CHEMISTRY, BIOCHEMISTRY & CATALYSIS
1.4. Field of study	CHEMISTRY
1.5. Study cycle	MASTER
1.6. Study program	CHEMISTRY OF ADVANCED MATERIALS

2. Data about the discipline

2.1. Discipline name	Clusters, polymers and inorganic rings chemistry						
2.2. Holder of course activities	Conf.Dr.Habil.Marilena Ferbinteanu Cimpoesu						
2.3. Holder of seminar activities	Conf.Dr.Habil.Marilena Ferbinteanu Cimpoesu						
2.4. Year of study	II	2.5. Semester	4	2.6. Type of evaluation	Ex.	2.7.Discipline regime	DSIN/ DOB

3. Total estimated time

3.1. Number of hours per week	4	3.2. Of which Course	2	3.3. Seminar	2
3.4. Total curriculum hours	40	3.5. Of which Course	20	3.6. Seminar	20

Time fund distribution	hours
Study from the textbook, course materials, bibliography and notes	90
Additional documentation in the library, on specialized electronic platforms and in the field	30
Seminar/lab preparation, homework, assignments, reports, portfolios and essays	30
Tutoring	10
Other activities	-
3.7. Total hours of individual study	160
3.8. Total hours per semester (3.7 + 3.4)	200
3.9. Number of credits	8

4. Prerequisites (where applicable)

4.1. of curriculum	• General knowledge of General Chemistry, Inorganic Chemistry, Solid state Chemistry Organic Chemistry, Physical Chemistry, Catalysis, Materials Science
4.2. of skills	• Communication and understanding of specialized chemistry terms in English

5. Conditions (where applicable)

5.1. of the course	• Classroom with blackboard, screen, computer and projector or smartboard. • Attendance at least 7 lectures and all laboratory sessions is mandatory. • Objectively justified absences from the laboratory will be

	made up by mutual agreement between the lecturer and the student • Delay is accepted, within reasonable limits, avoiding the disruption of the educational process.
5.2. of the seminar/laboratory	• Laboratory equipped with inert atmosphere working equipment, niche and specific reagents, individual workstations and computers, access to databases and scientific literature provided by the University and the department. Note: currently all resources come only from research projects of the course holder. Each laboratory work will end with a report. The deadline for submitting the report will be established by the holder in agreement with the students, without however accepting unjustified delays. • Laboratory sessions attendance is mandatory.

6. Learning outcomes

Knowledge	• Recognizes and reproduces scientific concepts from the fields of inorganic chemistry, physical chemistry, analytical chemistry, and materials chemistry • Describes the chemical structure and the generated chemical and structural properties, understands and communicates the structure-property relationship in a scientific manner, to students and other interested socio-economic groups. • Identify and develop methods for synthesizing materials with improved or new properties for specific applications, acquire and process the obtained data. • Identifies and uses appropriate methods of information gathering and documentation necessary to understand the chemical principles, molecular design, and molecular assembly in the design of advanced materials, which are communicated in a scientific manner to interested parties. • Formulate scientific reports on scientific research strategies, present and analyze the results of documentation, explain and analyze the obtained experimental results, for the development of research projects.
Skills	• Accurately analyze and evaluate major scientific concepts from the fields of inorganic chemistry, physical chemistry, analytical chemistry, and materials chemistry • Evaluate and demonstrate the specific chemical and physical structural characteristics of advanced materials and adapt the knowledge for the physicochemical characterization and the study of the properties of materials obtained through various processes. • Understand the chemistry of advanced material synthesis processes, understand and control structural, chemical, and physical characteristics, and develop creative solutions in the fields of advanced material applications. • Interpret the documentation results responsibly before communicating them to interested parties (students, high school students, other socio-economic groups). • Apply scientific principles and use research results to develop specific

	and innovative skills required for the new occupations emerging in the field of materials science and nanotechnologies.
Responsibility and autonomy	• The ability for continuous self-improvement, in order to ensure that professional training adapts to the requirements of the labor market and to scientific progress in the field of advanced materials chemistry and related domains. • The use of logical, intuitive, and creative thinking in describing, comparing, and analyzing the structure and properties of advanced materials to support the learning of these concepts by interested professional groups, including high school students. • The ability to manage research activity, complying with both the established experimental plan and delivery deadlines, and to assume responsibility for the accuracy of interpretations and the conclusions presented in scientific activity reports. • The ability to select the most appropriate research results, to organize teams and collaborate in working groups for carrying out educational and scientific activities. • The ability to draft and present scientific reports, and to autonomously and responsibly apply the knowledge and skills acquired in advanced materials chemistry, while adhering to the standards of professional ethics.

7. Contents

7.1. Course	Teaching methods	Comments
1. Current concepts in the modern inorganic chemistry regarding the structure and properties of the inorganic systems with different dimensionality (from molecular to the nanoscale). From hystory science notes toward current technological tendencies.	• Lecture, • Explanation, • Conversation, • Description, • Problematization • Debate	2h
2. Classification of inorganic clusters, polymers, and cycles. Types of bonds, ligands, connectivity, dimensionality. Examples. Structural variety as a consequence of the fundamental aspects in the chemistry of inorganic clusters, cycles and coordinative polymers. Electronic structure criterium in the extended inorganic structures.		1h
3. Electronic density as global determinant of the molecular structure. Density Functional Theory -a Nobel prize story. Electronic density descriptors (Laplacian and Hessian). The Atom-in-Molecule Theory and the critical points as absolute method to distinguish structures. Molecular graphs. Graph theory elements and models.		2h
4. Molecular energy chemical descriptors. Electronegativity and hardness. Hard and Soft Acid and Bases factors in the molecular structure. The affinity concept in the donor-acceptor interactions. Synthesis against HSAB rules as a precondition of acquiring special properties		2h
5. Cluster compounds of the main group elements. Organolithium cluster in special synthesis. Organoaluminium clusters in catalysis.		2.5h
6. Cluster compounds of the main group elements. Electron deficient species. Boron hydrides and carboranes. Application in material science and cancer therapy. Boroxine and borazine rings.		2.5h
7. Cluster compounds of the main group elements. Fullerene-a		2.5h

Nobel prize story. Vibrational analysis in fullerene. Fuleride, graphene, carbon nanotubes.		
8. Bonding in metal clusters. Rules for cluster structure-electron counting correlation. The inert-gas shell configuration approach. Polyhedral Skeletal Electron Pair Theory.		2h
9. Isolobal principle. Isomerization in cluster chemistry and related phenomena. Dynamic stereochemistry, fluxional geometry and crystal disorder.		1.5h
10. Advanced materials. Magnetism in cluster chemistry. Molecular clusters as Single molecule magnets. Extended monodimensional structures as single chain magnets. Nanoscale device application.		1h
11. Advanced materials. Mixed valence Extended systems. Metal-organic frameworks with special properties.		1h

Bibliography:

1. M. Ferbinteanu, F. Cimpoesu, *Aspecte teoretice şi practice în chimia clusterilor, polimerilor şi ciclurilor anorganice*, Ed. Univ. Bucureşti, 2002 (ISSN 973-575-672-2)
2. M.V. Putz, F. Cimpoesu, M. Ferbinteanu, M. *Structural Chemistry Principles, Methods, and Case Studies*, Springer, 2018 (ISBN 978-3-319-55873-8)
3. I. Haiduc, D.B. Sowerby, *The Chemistry of Inorganic Homo- and Heterocycles*, Academic Press, London, New York, 1987 (2 vols.)
4. I. Haiduc, F. T. Edelmann, *Supramolecular Organometallic Chemistry*, Wiley-VCH, Weinheim, New York, 1999.
5. D. M. P. Mingos, D. J. Wales, *Introduction to Cluster Chemistry*, Prentice Hall, 1990.
6. J. Derek Woollins, *Non-metal rings, cages, and clusters*, John Wiley &Sons, Chichester, 1988.
7. G. González-Moraga, *Cluster chemistry: introduction to the chemistry of transition metal and main group element molecular clusters*, Springer-Verlag, Berlin, 1993.
8. M. S. Dresselhaus, G. Dresselhaus, P. C. Eklund, *Science of Fullerenes and Carbon Nanotubes: Their Properties and Applications*, Academic Press, San Diego 1996
9. C. E. Housecroft, *Cluster molecules of the p-block elements*, Oxford University Press, Oxford 1994.
10. M. Bochman, *Organometallics 1*, Oxford University Press, Oxford 1994.
11. A. Antoniu, M. Cimpoesu, M. Andruh, E. Cristurean, Sinteze *în chimia compusilor metal-organici şi în chimia heterociclurilor anorganice*, Ed. Univ.Bucureşti, 1995 (ISSN 973-9160-80-8).
12. Selectie de articole de specialitate din reviste recente cu factor de impact ridicat

7.2 Seminar/laboratory	Teaching methods	Comments
1. Safety rules. Inorganic synthesis methods. Equipments and instruments used in the proposed synthesis (including inert atmosphere synthesis).	• Frontal work	1h
2. Synthesis and spectral characterization for a inorganic cluster/ polymer/cycle system.	• Team work	6h
3. The analysis and handling of the crystallographic data obtained by single crystal X-ray diffraction method. CCDC database access. Impact factor journals ranking. Structural analysis of a cluster or inorganic polymer or cycles at molecular and supramolecular levels using cif files.	• Individual work, course extension with study case	2h
4. Structural analysis, optimization structure, electron density (DFT) and critical points calculation for carbon based organic cluster type (tetrahedran, cuban) and inorganic clusters (P4)		2h
5. Structural analysis, optimization structure, electron density (DFT), critical points and molecular orbital calculation for boron hydride clusters with high symmetry.		2h
6. Atom-in Molecule with critical points calculation for organolithium compounds with different association degree level. New chemical bond.		2h
7. IR spectral analysis and vibration frequency calculation for C60. Icosahedral group symmetry aplications.		2h
8. Isolobal principle-theoretical experiment		1h
9. Analysis work reports and evaluation.	• Presentations,	2h

	debates	

Bibliography:

1. M.V. Putz, F. Cimpoesu, M. Ferbinteanu, M. *Structural Chemistry Principles, Methods, and Case Studies*, Springer, 2018 (ISBN 978-3-319-55873-8)
2. M. Ferbinteanu, F. Cimpoesu, *Aspecte teoretice şi practice în chimia clusterilor, polimerilor şi ciclurilor anorganice*, Ed. Univ. Bucureşti, 2002 (ISSN 973-575-672-2)
3. M. Bochman, *Organometallics 1*, Oxford University Press, Oxford 1994.
4. A. Antoniu, M. Cimpoesu, M. Andruh, E. Cristurean, *Sinteze în chimia compusilor metal-organici şi în chimia heterociclurilor anorganice*, Ed. Univ.Bucureşti, 1995 (ISSN 973-9160-80-8, Îndrumar de laborator).
5. Protocoale experimentale propuse si adaptate dupa cele prezentate in articole de specialitate din jurnale cu factor de impact ridicat (Nature, Science, Angew. Chem Int. Ed., J. Am. Chem. Soc; Inorg. Chem; Organometallics, etc.).
6. Baza de date cristalografice CCDC

8. The correlation of the subject contents with the expectations of the representatives of the epistemic community, professional associations and representative employers in the field related to the program

- The course offers a coherent and consistent corpus of fundamental knowledge, causal relationships whose assimilation constitutes a functional organon in various fields, including related applied ones.
- By mastering the theoretical and methodological concepts included in the *Cluster, polymers and inorganic ring systems* discipline, students acquire specialized knowledge as well as practical skills, in accordance with the partial competencies required for the possible occupations provided in Grid 1 - RNCIS.

9. Evaluation

Type of activity	9.1. Evaluation criteria	9.2. Evaluation methods	9.3. Share of final grade
9.4. Course	• Correct use of specialized terms; • The ability to adapt to problems in the chemistry of clusters, polymers and inorganic heterocycles by applying the acquired chemistry knowledge. • Explanation and interpretation of the theoretical and practical contents of the discipline • Explanation and interpretation of complex physicochemical properties specific to clusters, inorganic polymers in relation to their structure. • Generalization, particularization, integration of other fields of chemistry in the chemistry of clusters, polymers and inorganic heterocycles.	Written exam • Questions based on course and laboratory assignments • Problemati-zation and exemplifica-tion of course and laboratory concepts	70%
9.5. Seminar/laboratory	• Explanation and interpretation of the theoretical and practical contents of the discipline • Research skills in the field of cluster chemistry, polymers and inorganic heterocycles	• The laboratory activity will be graded by completing laboratory work,	30%

		presenting the results as a reports, and submitting the final reports on time.	
Minimum performance standard			
Grading is done on a scale of 1-10. The exam is considered passed with a grade of 5. Written exam. Mandatory attendance at the course and laboratory Solving research topics by identifying and judiciously using information sources. Elaborating work reports for each laboratory work in specialized terms, analyzing the results obtained by using methods for determining physico-chemical properties and correlating them with the structure of the investigated materials.			

Date of completion	Course holder's signature	Seminar/laboratory holder's signature
23.06.2025	Conf.Dr.Habil. Marilena Cimpoesu	Conf.Dr.Habil. Marilena Cimpoesu
Date of approval in the department		Signature of the Head of Department Prof. dr. habil. Ioan-Cezar MARCU

DISCIPLINE SHEET
Academic year 2025/2026

1. Data about the program

1.1. Higher Education Institution	University of Bucharest
1.2. Faculty	CHEMISTRY
1.3. Department	CHEMISTRY
1.4. Field of study	CHEMISTRY
1.5. Study cycle	MASTER
1.6. Study program	CHEMISTRY OF ADVANCED MATERIALS

2. Data about the discipline

2.1. Discipline name	Writing the dissertation						
2.2. Holder of course activities	-						
2.3. Holder of laboratory activities	Coordinator Each teacher coordinating the dissertation						
2.4. Year of study	II	2.5. Semester	4	2.6. Type of evaluation	V	2.7.Discipline regime	DAPROF/ DOB

3. Total estimated time

3.1. Number of hours per week	5	3.2. Of which Course	-	3.3. Laboratory	5
3.4. Total curriculum hours	50	3.5. Of which Course	-	3.6. Laboratory	50

Time fund distribution	hours
Laboratory research	50
Additional documentation in the library, on specialized electronic platforms and in the field	50
Dissertation preparation - writing dissertation paper and ppt presentation	140
Tutoring	50
Other activities:Examination	10
3.7. Total hours of individual study	300
3.8. Total hours per semester (3.4 + 3.7)	350
3.9. Number of credits	14

4. Prerequisites (where applicable)

4.1. of curriculum	Conducting research activities in semesters I-III
4.2. of skills	Practical skills acquired in the research laboratory

5. Conditions (where applicable)

5.1. of the course	Not the case
5.2. of the laboratory	- Laboratory attendance is compulsory - Students will come to the lab with protective equipment (lab coat, gloves, goggles) - Students will know the principles of operation of equipment used; - Documenting by accessing scientific articles in libraries and electronic databases

	- Systematizing information from the literature; Performing the required tasks according to the specified requirements and in the required stages, with respecting the rules of professional ethics, following a work plan following a predetermined work plan - Completion of required tasks in line with the overall objectives set - Permanent information and documentation in the field of activity

6. Learning outcomes

Knowledge	- Recognize and reproduce scientific concepts from the branches of inorganic chemistry, physical chemistry, analytical chemistry and materials chemistry - Describes the chemical structure and the chemical and structural properties generated, understands and communicates the structure-property relationship in a scientific manner to pupils, students and other socio-economic stakeholders. - Identifies and describes the basic and modern experimental techniques used in the analysis and characterization of advanced materials - Describes the fundamental principles and operation of equipment and apparatus in chemical laboratories, identifies and uses appropriate characterization techniques to determine the chemical composition, structure and properties of advanced materials. - Identify and develop methods for synthesizing materials with improved or new properties for specific applications, acquire and process the obtained data. - Identifies and uses appropriate methods of information and documentation necessary to understand chemical principles, molecular design and molecular assembly in the design of advanced materials and communicates them in a scientific manner to interested parties. - Formulates solutions to complex problems of modern chemical research including environmental compliance, a process based on the knowledge, identification and application of advanced concepts, methods and theories in the field of molecular materials, simple nanomaterials, nanocomposites and catalytic (nano)materials. - Formulates scientific reports on scientific research strategies, presents and analyzes the results of the documentation, explains and analyzes the obtained experimental results, for the elaboration of research projects. - Describes and integrates specific and interdisciplinary knowledge in professional activity.
Skills	- Analyze, evaluate and correctly apply the major scientific concepts in inorganic chemistry, physical chemistry, analytical chemistry and materials chemistry in chemical practice. - Evaluates and demonstrates the specific chemical and physical structural characteristics of advanced materials and adapts knowledge for physicochemical characterization and the study of properties of materials obtained by various processes.

	-Evaluation and analyzes of the experimental techniques to design and conduct experiments and to perform complex analyses and tests (qualitative and quantitative). - Correctly and efficiently uses modern and complex methods of characterization of advanced materials, chooses specific methods of analysis, explains and systematizes the obtained results. - Understands the chemistry of advanced materials synthesis processes, understands and controls the chemical and physical structural and chemical-physical characteristics and develops creative solutions in advanced materials application areas. - Responsibly interprets the results of documentation in order to communicate them to interested parties (pupils, students, other socio-economic groups). - Utilizes logical, intuitive and creative thinking in solving complex problems characteristic of advanced materials chemistry using methods specific to related fields. - Applies the principles of science and utilizes the results of research for the formation of specific and innovative skills necessary for new occupations arising in the field of materials science and nanotechnologies. - Develops skills to work in appropriate interdisciplinary teams to solve theoretical and practical problems specific to the field of advanced materials science.
Responsibility and autonomy	- Adapt major scientific concepts in the field of advanced materials chemistry and related fields to conduct research, improve or develop new concepts, knowledge, theories and operational methods, products and services. - Use of logical, intuitive and creative thinking in describing, comparing and analyzing the structure and properties of advanced materials to help support the learning of these concepts by interested professional groups, including secondary school students. - Individually uses of classical laboratory instruments/techniques and modern equipment, designs experiments, interprets and analyzes the results obtained accordingly. Designs learning situations focused on the development of experimental techniques and methods specific to chemical laboratories. - The ability to develop work protocols and to prepare analysis reports, identify solutions and formulate alternatives for the proper functioning of the laboratory/professional unit to which it belongs. - Ability to manage the research activity, respecting both the established experimental plan and deadlines, to assume responsibility for the correctness of the interpretations and conclusions given in the scientific activity reports. - The ability to select the most appropriate results of the documentation, to organize teams and to collaborate in working groups to carry out educational and scientific activities. - Ability to assume responsibility for the implementation of proposed solutions and justify the approaches used with the assessment of risk and safety factors in

	operation for the development of new advanced materials quality and resource management projects. - Ability to prepare and present scientific reports and to apply autonomously and responsibly the knowledge and skills acquired in chemistry of advanced materials respecting the rules of professional ethics. - Ability to autonomously and responsibly apply knowledge and skills in the coordination of a work/research team, by allocating tasks, resources and following up the achievement of project objectives

7. Contents

7.1. Course	Teaching methods	Comments
	NOT THE CASE	
Bibliography:		
7.2 Laboratory	Teaching methods	Comments
7.2.1. Summative evaluation of the experimental results obtained and the extent to which the results obtained and the conclusions verify the premises of the dissertation paper	Explanation; Conversation; Description; Exemplification; Experimental activity	5 h
7.2.2. Completion/restoration of certain experimental steps		10 h
7.2.3. Assessment of how the topic can be taken up at a higher stage of training; e.g. the completion of a doctoral thesis;		10 h
7.2.4. Writing the dissertation according to the regulations for the completion of studies - Faculty of Chemistry		20 h
7.2.5. Realization of the ppt presentation for the dissertation defense.		5 h
Bibliography: - Specialized literature depending on the topic; Electronic databases AnelisPlus, Science Direct; Scopus, etc.		

8. The correlation of the subject contents with the expectations of the representatives of the epistemic community, professional associations and representative employers in the field related to the program

The content of the subject is in accordance with the partial competences required for the possible occupations provided in the Grid - RNCIS.

9. Evaluation

Type of activity	9.1. Evaluation criteria	9.2. Evaluation methods	9.3. Share of final grade
Dissertation research	The way in which the student has realized the theoretical and experimental part of the dissertation; The quality of the dissertation; The quality of the ppt presentation;	Power point presentation in the front of the official commision	100%
Minimum performance			

standard	

Date of completion	Course holder's signature	Seminar holder's signature
June 2025 Date of approval in the department		Signature of the Head of Department