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 and 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	Liquid Crystals						
2.2. Holder of course activities		Prof. dr. habil. Viorel Cîrcu					
2.3. Holder of seminar/laboratory activities		Prof. dr. habil. Viorel Cîrcu, Lector dr. Monica Iliş					
2.4. Year of study	1	2.5. Semester	1	2.6. Type of evaluation	E	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					Hours
Study from the textbook, course materials, bibliography and notes					45
Additional documentation in the library, on specialized electronic platforms and in the field					25
Seminar/lab preparation, homework, assignments, reports, portfolios and essays					35
Tutoring					6
Other activities: Examination					8
3.7. Total hours of individual study					119
3.8. Total hours per semester (3.4 + 3.7)					175
3.9. Number of credits					7

4. Prerequisites (where applicable)

4.1. of curriculum	The comprehension of the subject matter addressed in this course is closely linked to the fundamental concepts of chemistry (coordinative chemistry, inorganic chemistry, organic chemistry) within the curricula of bachelor's degree programs in Chemistry, Biochemistry/Biology, and Physics.
4.2. of skills	1. Proficiency in computer operations, including data processing, graphical representations, and retrieving scientific information from databases. 2. Capacity to collaborate and engage in groups of 2-3 students to conduct experimental activities.

5. Conditions (where applicable)

5.1. of the course	Video display system in the classroom.

5.2. of the seminar/laboratory	Mandatory student attendance.

6. Learning outcomes

Knowledge	The student or graduate demonstrates the ability to identify and replicate concepts from the various fields of inorganic, physical, analytical, and materials chemistry. The student or graduate describes the chemical structure of mesogens and their associated chemical and structural properties, explaining and communicating the structure-property relationship to students, and other relevant socio-economic groups. The student or graduate identify and describe basic and modern experimental techniques used in the analysis and characterization of mesogens. The student or graduate explain the essential concepts and functioning of laboratory equipment, identification and employment of the suitable characterisation techniques to ascertain the chemical composition, structure, and characteristics of liquid crystals and of other advanced materials. The student or graduate is able to identify and design methods for synthesizing liquid crystalline materials with improved or novel qualities for specific applications, and collect and process the resulting data.
Skills	The student or graduate consistently examines, assesses and apply key scientific concepts in inorganic chemistry, physical chemistry, analytical chemistry, and materials chemistry within chemical practice. The student or graduate assesses and demonstrates the chemical and physical structural attributes unique to liquid crystalline materials, while applying knowledge to the physicochemical characterization and analysis of properties of liquid crystals produced through different processes. The student or graduate evaluates and analyzes experimental techniques to design and conduct experiments and to perform complex analyses and tests (qualitative and quantitative). The student or graduate employs modern and advanced characterization methods of liquid crystals accurately and effectively, selects appropriate analytical techniques, and elucidates and organizes the experimental results obtained. Understanding the chemistry involved in the development of liquid crystalline materials, mastering the control of their chemical and physical structural properties, and proposing innovative solutions for their applications.
Responsibility and autonomy	The student or graduate 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 or graduate employs logical, intuitive, and creative thinking in the

	description, comparison, and analysis of the structure and properties of liquid crystals that contribute to the learning of these concepts by groups of interested professional associations, including high school students. The student or graduate individually uses 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. Capability to develop work protocols and produce analytical reports, identify solutions and alternatives for the optimal operation of the laboratory or professional unit to which the student or graduate is affiliated. Capability to manage research activities, adhering to the predefined experimental protocol and timelines, while accepting accountability for the accuracy of interpretations and conclusions presented in scientific reports.

7. Contents

7.1. Course	**Teaching methods**	**Comments**
7.1.1. General introduction and historical development of liquid crystals – a special phase of matter.	Lecturing, class discussion and debate	2 h
7.1.2. Nomenclature and classification of liquid crystals. Calamitic and discotic materials.		2 h
7.1.3. Structure of liquid crystals phases. Molecular requirements for the generation of mesophases.		2 h
7.1.4. Chemical structure and mesogenic properties.		2 h
7.1.5. Nematic and chiral nematic liquid crystals (uniaxial, biaxial, nematic twist bend and blue phases). Investigation of chiral properties.		2 h
7.1.6. Non-chiral and chiral smectic phases.		2 h
7.1.7. Columnar liquid crystalline phases. Structure-property relationship.		2 h
7.1.8. Polycatenar and bent-core liquid crystals.		2 h
7.1.9. Characterization and identification of liquid crystalline phases (polarized optical microscopy and X-rays diffraction).		2 h
7.1.10. Characterization of phase transitions (differential scanning calorimetry).		2 h
7.1.11. Polymeric liquid crystals – macromesogens and lyotropic liquid crystals (amphiphiles).		2 h
7.1.12. Liquid crystals based on metal complexes – metallomesogens. The role of the metal ion on the physical properties of metallomesogens : structural, redox and optical properties.		2 h
7.1.13. General strategies for the synthesis of liquid crystals. Synthesis of metallomesogens.		2 h
7.1.14. Applications of liquid crystals: display devices, polymer dispersed liquid crystals (PDLC), temperature and pressure sensors.		2 h

Bibliography:
1. P.J. Collings, M. Hird, Introduction to Liquid Crystals Chemistry and Physics, Taylor&Francis, London and New York, (2004).
2. B. Donnio, D. Guillon, R. Deschenaux, D.W. Bruce in Comprehensive Coordination Chemistry II, J.A. McCleverty, T.J. Meyer (Eds). Vol. 7, Chap. 7.9, pp. 357–627, Elsevier, Oxford (2003).
3. B. Donnio, D. Guillon, R. Deschenaux and D. W. Bruce, in Comprehensive Organometallic Chemistry III, vol. 12, ed. R. H. Crabtree, and D. M. P. Mingos Elsevier, Oxford, UK, ch. 12.05, pp.195 – 293 (2006).
4. I. Dierking, Textures of Liquid Crystals, Wiley-VCH Verlag, Weinham (2003).
5. Handbook of Liquid Crystals, Second Edition, Eds. J.W. Goodby, P.J. Collings, T. Kato, C. Tschierske, H.F. Gleeson, P. Raynes, Wiley-VCH Verlag, (2014).
6. S. Kumar, Chemistry of Discotic Liquid Crystals: From Monomers to Polymers, CRC Press (2010).
7. A. Schenning, G. P. Crawford, D. J. Broer, Liquid Crystal Sensors, CRC Press (2017).

7.2 Laboratory	**Teaching methods**	**Comments**
7.2.1. Discussion of lab safety rules and guidelines for carrying out the experiments.	Lecturing, class discussion and debate Group discussion, direct instruction, experimental data processing, evaluation of experimental results Oral presentation of the experimental results, group project.	1 h
7.2.2. Experiment 1. Synthesis of Schiff bases with liquid crystals properties. Characterization of liquid crystalline phases by differential scanning calorimetry and polarizing optical microscopy.		6 h
7.2.3. Experiment 2. Synthesis and liquid crystalline properties of 4-alkyloxybenzoic acids. Chemical structure – liquid crystalline properties relationship. Characterization of liquid crystalline phases by differential scanning calorimetry and polarizing optical microscopy. Phase diagrams.		6 h
7.2.4. Experiment 3. Liquid crystals thermometers. Mixture of chiral liquid crystals.		4 h
7.2.5. Experiment 4. Physical properties of liquid crystals: measurement of refractive index		4 h
7.2.6. Experiment 5. Characterization techniques of liquid crystals: polarizing optical microscopy and differential scanning calorimetry.		5 h
7.2.7. Evaluation of the experimental results.		2 h

Bibliography:
1. P.J. Collings, M. Hird, Introduction to Liquid Crystals Chemistry and Physics, Taylor&Francis, London and New York, (2004).
2. I. Dierking, Textures of Liquid Crystals, Wiley-VCH Verlag, Weinham (2003).
3. V. Cîrcu, M. Ilis, Cristale lichide. Metalomezogeni. Aplicatii si caracterizare, Editura Printech, Bucuresti (2015).

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 subject matter of "Liquid Crystals" enhances the professional skills required for graduates to engage in advanced research activities in "Materials Science" and related areas. The discipline's content is incorporated into the "Advanced Materials Chemistry" master's degree program's curriculum and aligns with prevailing national and international trends in higher education and materials science research.

9. Evaluation

Type of activity	**9.1. Evaluation criteria**	**9.2. Evaluation methods**	**9.3. Share of final grade**
9.4. Course	Understanding of complex concepts associated with the structure and physical properties of liquid crystals.	Written examination	70%
9.5. Laboratory	The capacity to ascertain the	Final assessment,	30%

	mesophase type utilizing available investigation methods (optical microscopy, differential scanning calorimetry). The practical expertise acquired in the synthesis and purification of materials exhibiting mesomorphic characteristics.	oral examination	
Minimum performance standard	**Addressing specific challenges concerning the structure of certain chemical compounds and/or mixtures and their related liquid crystalline properties.**		

Date of completion **IUNIE 2025**	**Course holder's signature** **Prof. Dr. Habil. Viorel Cîrcu**	**Laboratory holder's signature** **Prof. Dr. Habil. Viorel Cîrcu** **Lector dr. Monica Iliş**
Date of approval in the department **IUNIE 2025**		**Signature of the Head of Department** **Prof. Dr. Habil. Ioan Cezar Marcu**

DISCIPLINE SHEET

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				**CATALYTIC MATERIALS**			
2.2 Holder of lecture activities				**Prof. dr. habil. Ioan-Cezar MARCU**			
2.3 Holder of laboratory/seminar activities				**Lect. dr. Adriana URDĂ**			
2.4 Year of study	**I**	2.5 Semester	**I**	2.6 Type of evaluation	**Written exam**	2.7 Discipline regime	**DAPROF/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 from the textbook, course materials, bibliography and notes					**70**
Additional documentation in the library, on specialized electronic platforms and work in the field					**14**
Seminar/lab preparation, homework, assignments, reports, portfolios and essays					**21**
Tutoring					**14**
Other activities					**-**
3.7 Total hours of individual study					**119**
3.8 Total hours per semester (3.4. + 3.7)					**175**
3.9. Number of credits					**7**

4. Prerequisites (where applicable)

4.1 of curriculum	General and Inorganic Chemistry Solid State Chemistry Elements of Catalysis
4.2 of skills	To know and apply the fundamental laws of chemistry. To know the principles of heterogeneous catalysis. To know elements of inorganic materials structure. To have laboratory skills.

5. Conditions (where applicable)

5.1 course conditions	Attendance at least 10 lectures is mandatory. Delay is accepted, within reasonable limits.
5.2 laboratory/seminar conditions	Laboratory attendance is mandatory. Students will get to the seminar/laboratory on time and will have scientific calculators with them. Students will come to the laboratory wearing protective equipment - lab coat, gloves, safety glasses - and will comply with labor protection regulations.

6. Learning outcomes

6.1 Knowledge	- Recognition and reproduction of scientific concepts in the field of heterogeneous catalysis and solid catalysts. - Description of the structure and catalytic properties of solids, understanding and communicating the structure-catalytic properties relationship in a scientific manner, to pupils, students and other interested socio-economic categories. - Identification and description of basic and modern experimental techniques used in the analysis and characterization of catalytic materials - Description of the fundamental principles and operation of equipment and devices in heterogeneous catalysis laboratories, identification and use of appropriate characterization techniques for determining the structure and catalytic properties of materials. - Identification and development of synthesis methods for catalytic materials with improved or new properties for specific applications; acquisition and processing of the obtained data.
6.2 Skills	- Correct analysis, evaluation and application of major scientific concepts in the field of catalytic materials in chemical practice. - Evaluation and demonstration of the chemical and physical structural characteristics specific to catalytic materials and adaptation of knowledge for the study of the catalytic properties of catalysts obtained via various methods. - Evaluation and analyzes of the experimental techniques to design and conduct experiments and to perform complex analyses and tests (qualitative and quantitative). - Correct and efficient use of modern and complex methods for characterizing the catalytic properties of materials, explaining and systematizing the results obtained. - Understanding the chemistry of solid catalyst preparation processes, understanding and controlling their chemical and physical structural characteristics, and developing creative solutions in the field of heterogeneous catalysis.
6.3 Responsibility and autonomy	- 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 use of logical, intuitive and creative thinking in describing, comparing and analyzing the structure and catalytic properties of materials to contribute to supporting the learning of these concepts by interested professional groups, including high 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 prepare analysis reports, identify solutions and formulate alternatives for the proper functioning of the laboratory/professional heterogeneous catalysis unit of which he/she is a part. - The ability to manage research activity, respecting both the established experimental plan and delivery deadlines, and to assume responsibility for the correctness of the interpretation and conclusions given in laboratory reports.

7. Contents

7.1 Course	**Teaching methods**	**Comments**
7.1.1 Introduction. Placing catalytic materials in the group of functional materials. Definition of the concepts of material, functional material and catalytic material. Definition of the catalytic action. Fundamental properties of the solid catalysts: activity, selectivity and stability. Classification of solid catalysts.	Lecture Explanation Conversation Description	1 h
7.1.2 Catalysts based on metals and metallic alloys. Preparation of metallic catalysts. Specific features regarding the structure and properties of metallic catalysts. The nature of the active sites. Structure sensitivity of catalytic reactions. Supported metal catalysts. Metal-support interaction. Reaction mechanisms in catalysis on metals. Fundamentals of kinetics of heterogeneous catalytic reactions. Case study: the ammonia synthesis catalyst and the reaction mechanism involved.	Lecture Explanation Conversation Description	7 h
7.1.3 Oxide-based catalytic materials. Preparation techniques. Structure of oxide catalysts. **Oxides with variable valence state**. Oxide non-stoichiometry – structural defects. Semiconductor character. Consequences for heterogeneous catalysis. Catalytic oxidation. The Mars – van Krevelen reaction mechanism and the corresponding rate law.	Lecture Explanation Conversation Description	6 h

7.1.4 Acidic oxides. Origin of acidity. Lewis and Brønsted acidity in oxides. Control of acidity. Reaction mechanisms of acid-catalyzed reactions. Examples of acid catalysts. Alumina – catalyst and support. Zeolites.	Lecture Explanation Conversation Description	5 h
7.1.5 Base oxides. Layered double hydroxydes – precursors for base oxides. Synthesis. Structure. Memory effect. Origin of basicity. Other base oxides. Applications in catalysis.	Lecture Explanation Conversation Description	2 h
7.1.6 Sulfide-based catalytic materials. Preparation. Structure. Nature of active sites. Applications in catalysis.	Lecture Explanation Conversation Description	1 h
7.1.7. Porous materials for catalyst supports. Ordered porous materials. Mesostructured silica.Techniques of preparation. Techniques of deposition of active component.	Lecture Explanation Conversation Description	4 h
7.1.8. Biocatalytic materials. Enzyme catalysts. Enzyme immobilization techniques. Biocatalytic aspects of immobilized enzymes. Applications of immobilized enzymes.	Lecture Explanation Conversation Description	2 h

Bibliography:

1. 1. G. Ertl, H. Knözinger, F. Schüth, J. Weitkamp (Eds.), *Handbook of Heterogeneous Catalysis*, 2nd Edition, Wiley-VCH, Weinheim, 2008.
2. 2. F. Schüth, K. S. W. Sing, J. Weitkamp, (Eds.), *Handbook of Porous Solids*, Wiley-VCH, Weinheim, 2002.
3. 3. J.M. Thomas, W.J. Thomas, *Principles and Practice of Heterogeneous Catalysis*, Wiley, 1996.
4. 4. J.A. Anderson, M. Fernandez Garcia (Eds.), *Supported Metals in Catalysis*, Imperial College Press, 2005.
5. 5. M.A. Vannice, *Kinetics of Catalytic Reactions*, Springer, 2005.
6. 6. G.C. Bond, *Metal-catalysed reactions of hydrocarbons*, Springer, 2005.
7. 7. M. Misono (Ed.), *Heterogeneous Catalysis of Mixed Oxides Perovskite and Heteropoly Catalysts*, Stud. Surf. Sci. Catal. 176 (2013) 1-181.
8. 8. J.L.G. Fierro (Ed.), *Metal Oxides - Chemistry and Applications*, CRC Press, 2006.
9. 9. A. Trovarelli (Ed.), *Catalysis by Ceria and Related Materials*, Imperial College Press, 2002.
10. 10. K. Kosuge, *Chemistry of non-stoichiometric compounds*, Oxford University Press, 2001.
11. 11. J.M. Herrmann, *Les techniques physiques d'étude des catalyseurs* (Imelik, B., Védrine, J.C. – éditeurs), Ed. Technip, Paris, 1988, Ch. 22.
12. 12. M.A. Vannice, *An analysis of the Mars – van Krevelen rate expression*, Catalysis Today, 123 (2007) 18-22.
13. 13. S.M. Coman, V.I. Pârvulescu, *Cataliză Acido-Bazică*, Editura Academiei Române, Bucureşti, 2010.
14. H. van Bekkum, E. M. Flanigen, J.C. Jansen (eds.), *Introduction to zeolite science and practice*, Elsevier, 1991.
15. The Website of International Zeolite Association: www.iza-online.org
16. 14. D.G. Evans, X. Duan (Eds.), *Layered Double Hydroxides*, Springer-Verlag Berlin, 2006.
17. 15. F. Cavani, F. Trifiro, A. Vaccari, *Hydrotalcite-type anionic clays: preparation, properties and applications*, Catalysis Today, 11 (1991) 173-301.
18. D. Trong On, D. Desplantier-Giscard, C. Danumah, S. Kaliaguine, *Perspectives in catalytic applications of mesostructured materials*, Applied Catalysis A: General, 253 (2003) 545-602.
19. A. Taguchi, F. Schüth, *Ordered mesoporous materials in catalysis*, Microporous and Mesoporous Materials, 77 (2004) 1-45.
20. A. S. Bommarius, B. R. Riebel, *Biocatalysis*, Wiley-VCH, Weinheim, 2004.

7.2 Laboratory/seminar	Teaching methods	Comments
7.2.1 Safety rules in the laboratory. Brief presentation of practical activities and experimental set-ups.	Explanation Conversation	2 h
7.2.2 Preparation of a mixed oxide catalyst by coprecipitation.	Experiment Explanation Conversation Problematization	6 h
7.2.3 Characterization of oxides with variable valence state by electrical conductivity measurements as a function of temperature and oxygen partial pressure. Determination of structural defects.	Experiment Explanation Conversation Problematization	8 h
7.2.4 Study of the catalytic oxidation of light alkanes over oxide-based catalysts in a continuous-flow reactor.	Experiment Explanation Conversation Problematization	6 h
7.2.5 Study of a multifunctional catalyst in the hydrodeoxygenation of	Experiment	4 h

model molecules for biofuels in a batch reactor.	Explanation Conversation Problematization	
7.2.6 Discussion of the practical work reports and experimental results. Conclusions.	Explanation Conversation Problematization	2 h

Bibliography:

1. S. Tanasoi, G. Mitran, N. Tanchoux, T. Cacciaguerra, F. Fajula, I. Săndulescu, D. Tichit, I.-C. Marcu, Transition metal-containing mixed oxides catalysts derived from LDH precursors for short-chain hydrocarbons oxidation, *Appl. Catal. A* 395 (2011) 78-86 (DOI: 10.1016/j.apcata.2011.01.028).
2. I. Popescu, E. Heracleous, Z. Skoufa, A. Lemonidou, I.-C. Marcu, Study by electrical conductivity measurements of semiconductive and redox properties of M-doped NiO (M = Li, Mg, Al, Ga, Ti, Nb) catalysts for the oxidative dehydrogenation of ethane, *Phys. Chem. Chem. Phys.* 16 (2014) 4962-4970 (DOI: 10.1039/C3CP54817A).
3. M. Răciulete, G. Layrac, F. Papa, C. Negrilă, D. Tichit, I.-C. Marcu, Influence of Mn content on the catalytic properties of Cu-(Mn)-Zn-Mg-Al mixed oxides derived from LDH precursors in the total oxidation of methane, *Catal. Today* 306 (2018) 276-286 (DOI: 10.1016/j.cattod.2017.01.013).
4. I. Popescu, J.C. Martínez-Munuera, A. García-García, I.-C. Marcu, Insights into the relationship between the catalytic oxidation performances of Ce-Pr mixed oxides and their semiconductive and redox properties, *Appl. Catal. A* 578 (2019) 30-39 (DOI: 10.1016/j.apcata.2019.03.021).
5. I. Popescu, I.-C. Marcu, Insights into the electronic and redox behavior of surface-phosphated ceria catalysts in correlation with their propane oxydehydrogenation performance, *Phys. Chem. Chem. Phys.* 23 (2021) 5897-5907 (DOI: 10.1039/D1CP00059D).
6. M.-A. Mihai, D.C. Culita, I. Atkinson, F. Papa, I. Popescu, I.-C. Marcu, Unraveling mechanistic aspects of the total oxidation of methane over Mn, Ni and Cu spinel cobaltites via in situ electrical conductivity measurements, *Appl. Catal. A* 611 (2021) 117901, pp. 1-11 (DOI: 10.1016/j.apcata.2020.117901).
7. C. Rizescu, C. Sun, I. Popescu, A. Urdă, P. Da Costa, I.-C. Marcu, Hydrodeoxygenation of benzyl alcohol on transition-metal-containing mixed oxides catalysts derived from layered double hydroxide precursors, *Catal. Today* 366 (2021) 235-244 (DOI: 10.1016/j.cattod.2020.04.055).
8. M.C. Stoian, C. Romanițan, G. Crăciun, D.C. Culiță, F. Papa, M. Badea, C. Negrilă, I. Popescu, I.-C. Marcu, Multicationic LDH-derived Co(x)CeMgAlO mixed oxide catalysts for the total oxidation of methane, *Appl. Catal. A* 650 (2023) 119001, pp. 1-12 (DOI: 10.1016/j.apcata.2022.119001).
9. A.-T. Toderașc, I. Atkinson, D.C. Culiță, P.E. Mereuță, F. Papa, A. Urdă, I.-C. Marcu, Transition metal-containing MgFe ex-LDH mixed oxides, effective catalysts in the hydrodeoxygenation of benzyl alcohol, *Appl. Catal. A* 653 (2023) 119063, pp. 1-14 (DOI: 10.1016/j.apcata.2023.119063).

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 mastering the theoretical and methodological concepts and addressing the practical aspects included in the Catalytic Materials 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.
The course is designed and structured in such a way as to allow the graduate, through the theoretical knowledge and practical skills acquired, to carry out research activity at a level necessary for the preparation of the dissertation work.

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 preparation of laboratory reports. N.B. Fraud or intent to fraud in the exam is punished according to art. 14 of the Regulation for the Evaluation and Grading of Students within the University of Bucharest.	70% provided that the grade obtained is at least 5 (five)
9.5 Laboratory/seminar	Correct acquisition and understanding of the issues	The laboratory activity will be graded with two separate grades:	

	studied in the laboratory. Solving practical tasks and correct interpretation of the results obtained. Preparing reports for each practical work.	- a grade for completing laboratory work, presenting results, and submitting them on time. - a grade for the reports prepared for each practical work.	10% 20%
Minimum performance standard			
Grade 5 (five) on the exam according to the rubric for grading. For a grade of 5 (five), the student must: i) define/explain the basic concepts associated with the discipline Catalytic Materials; ii) know the principles of the methods used for the preparation of different classes of catalytic materials; iii) know basic aspects regarding the structure and, in correlation with it, the catalytic properties of the studied materials.			

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

1.1. Higher Education Institution	University of Bucharest
1.2. Faculty	Faculty of Chemistry
1.3. Department	Physical Chemistry and Analytical 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 PHYSICS OF SOLID STATE MATERIALS**						
2.2. Holder of course activities	Lecturer, PhD MARIANA CHIONCEL Associate Professor, PhD BOGDAN JURCA						
2.3. Holder of seminar/laboratory activities	Lecturer, PhD MARIANA CHIONCEL Associate Professor, PhD BOGDAN JURCA						
2.4. Year of study	1	2.5. Semester	1	2.6. Type of evaluation	exam	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 distribution					hours
Study from the textbook, course materials, bibliography and notes					56
Additional documentation in the library, on specialized electronic platforms and in the field					42
Seminar/lab preparation, homework, assignments, reports, portfolios and essays					9
Tutoring					4
Other activities: Examination					8
3.7. Total hours of individual study					119
3.8. Total hours per semester (3.4 + 3.7)					175
3.9. Number of credits					7

4. Prerequisites (where applicable)

4.1. of curriculum	This course is a natural continuation of the undergraduate curriculum offered by the Faculty of Chemistry. Successful understanding and application of the concepts covered require prior knowledge acquired through the following foundational courses: • **Physics (Year I):** basic concepts of electromagnetism, and introductory quantum physics; • **Physical Chemistry (Years I and II):** molecular structure, chemical thermodynamics, physical equilibria, and chemical kinetics; • **Inorganic Chemistry (Years II and III):** chemistry of metals, crystalline structures, and inorganic stereochemistry.
4.2. of skills	Students are expected to possess: ▪ **Basic computer skills**, including: data processing using spreadsheet software (e.g., Microsoft Excel), creating graphs and visual representations, preparing written reports and slide-based presentations (e.g., Word, PowerPoint), searching for scientific information using scholarly search engines and databases • **Communication and teamwork skills**, necessary for collaborative work in small groups (2–

	3 students), including the ability to share tasks, actively participate in data interpretation, and contribute to group discussions. • **English language proficiency at minimum B2 level**, required for understanding the lectures and performing the lab work, reading scientific literature, understanding technical terminology, and engaging in discussions or presenting results in English when necessary. Most supporting materials, examples, and scientific references are provided in English.

5. Conditions (where applicable)

5.1. of the course	▪ The lecture room must be equipped with an **electronic board or projector**, **stable internet connection**, and **audio-visual capabilities** to enable the presentation of digital content, including **animations, scientific simulations**, and **web-based visual tools** relevant to the course. ▪ **Attendance at all lectures is mandatory**
5.2. of the seminar/laboratory	▪ Access to **computers or laptops** is required for laboratory sessions to allow for data analysis, graphing, and the use of spreadsheet and modeling software (e.g., Microsoft Excel, scientific calculators, or web platforms). ▪ **Attendance at all seminar/laboratory sessions is mandatory.** Active participation is essential to meet the learning objectives of the course and to complete continuous assessment tasks. ▪ During laboratory work, students must strictly follow **workplace safety regulations** in accordance with institutional guidelines. The use of **protective equipment** (e.g., lab coats, safety glasses) is compulsory where required, and all **chemical or electronic equipment** must be handled responsibly under the supervision of academic staff. ▪ Students are expected to arrive **on time**, **prepared**, and to demonstrate a **respectful and cooperative attitude** toward colleagues and instructors. ▪ Mobile phones must be **turned off or silenced** during class and laboratory activities unless specifically permitted for academic purposes

6. Learning outcomes

Knowledge	-Describes the chemical structure and the resulting chemical and structural properties; understands and communicates the structure–property relationship in a scientific manner, adapted to students, pupils, and other interested socio-economic groups. -Describes the fundamental principles and operating mechanisms of equipment and instruments used in chemical laboratories; identifies and applies appropriate characterization techniques for determining the chemical composition, structure, and properties of advanced materials. - Identifies and uses appropriate methods of information retrieval and documentation necessary for understanding chemical principles, molecular design, and molecular assembly in the design of advanced materials, and communicates these concepts in a scientific manner to interested audiences. - Formulates scientific reports on research strategies, presents and analyzes documentation results, and explains and interprets experimental findings for the development of research projects. - Describes and integrates specific and interdisciplinary knowledge into professional practice
Skills	- Evaluates and demonstrates the specific chemical and physical structural characteristics of advanced materials, and adapts knowledge for the physico-chemical characterization and study of the properties of materials obtained through various processing methods. - Uses modern and advanced methods for material characterization correctly and efficiently. - Responsibly interprets the results of documentation and communicates them to relevant audiences (students, pupils, other socio-economic groups).

	- Applies scientific principles and uses research outcomes to build specific and innovative competencies required for emerging occupations in the fields of materials science and nanotechnologies. - Acquires teamwork skills appropriate for interdisciplinary collaboration, aimed at solving theoretical and practical problems specific to the field of advanced materials science.
Responsibility and autonomy	- Applies logical, intuitive, and creative thinking in describing, comparing, and analyzing the structure and properties of advanced materials, in a way that supports the learning of these concepts by interested professional groups, including high school students. - Demonstrates the ability to develop work protocols and prepare analysis reports, identify solutions, and formulate alternatives to ensure the proper functioning of the laboratory or professional unit; selects specific analytical methods, explains, and systematizes the obtained results. - Demonstrates the ability to select the most relevant outcomes of documentation, to organize teams, and to collaborate in working groups for the implementation of educational and scientific activities. - Demonstrates the ability to draft and present scientific reports, and to autonomously and responsibly apply the knowledge and skills acquired in advanced materials chemistry, in full compliance with professional ethical standards. - Demonstrates the ability to autonomously and responsibly apply knowledge and skills related to coordinating a work or research team, including task allocation, resource management, and monitoring the achievement of project objectives.

7. Contents

7.1. Course	**Teaching methods**	**Comments**
1. Introduction to Solid State Physics (SSP) 1.1.Condensed Matter Physics (brief introduction): hard matter, soft matter etc 1.2. Solid State Physics (crystalline and amorphous solids; quasi crsytals) 1.3.. Brief history of SSP. Theoretical models. Latest scientific advancements	**Interactive lectures** with visual illustrations of material structures **Short video clips** or simulations of crystal formation, band structures, and quasi-crystals **Concept-mapping** exercises to relate historical developments to theoretical models **Quick diagnostic quizzes** to reinforce key concepts in classification and theory	**2 h**
2. Crystalline structure 2.1 Basic concepts of crystallography (lattice, motif, symmetry elements etc.) 2.2 Primitive vectors 2.3 Types of unit cell, crystal systems and Bravais lattices 2.3.Crystallographic notations: point coordinates, crystalographic directions, Miller indices; 2.4 Interplanar Spacing Using Miller Indices 2.4 Packing efficiency. 2.5.Theoretical density	Lecturing (PowerPoint Presentations supported, where applicable, by demonstrations and computer simulations). Explanation Reasoning. Collaborative interaction with students. Illustrated lectures using 3D digital crystal models.Problem-solving sessions focused on lattice geometry, directions, and plane identification Use of crystallographic tools for visualizing unit cells and symmetry	**2 h**

3. **X-Ray Diffraction and the Reciprocal Lattice** 3.1 Real space, reciprocal space and diffraction, Bragg condition 3.2. Primitive vectors of the reciprocal 1D, 2D, 3D reciprocal lattice 3.3.Wigner-Seitz cell. 3.4 Brillouin zones **Diffraction** 3.5 X-Ray Radiation 3.6 Laue equations 3.7 Bragg's law 3.8 Equivalence of Bragg's law and Laue's condition 3.9 X-Ray diffraction in Bragg-Brentano geometry 3.10Synchrotron radiation	Lecturing (PowerPoint Presentations supported, where applicable, by demonstrations and computer simulations). Explanation. Reasoning. Visual explanations using diagrams and lattice visualizations for reciprocal space concepts. **Simulation tools** to demonstrate Bragg diffraction and Brillouin zone construction. **Solving applied problems** involving real diffraction data and reciprocal lattice analysis.V**ideo demonstration** of X-ray diffraction experiments using Bragg-Brentano geometry, synchrotron radiation.	**4 h**
4. Free Electron Model 4.1. Drude Model; 4.2.Free electron Fermi gas model in 1D, 3D; 4.3.Electrical conductivity and Ohm's law 4.4 Wiedemann-Franz law 4.5 Heat capacity	Lecturing (PowerPoint Presentations supported demonstrations). Explanation Reasoning. Mathematical demonstration with step-by-step guidance. **Discussion-based sessions** on model assumptions and physical relevance**.** Collaborative interaction with students	**2 h**
5. Energy bands structure 5.1 Nearly Free electron model 5.2 Charge Carriers in Semiconductors (electrons-holes) 5.2 Electronic Band structures. Insulators, Metals, semiconductors	Lecturing (PowerPoint Presentations supported by demonstrations). **Step-by-step derivations** of band gaps **Simulations and animations** to visualize band evolution, carrier behavior in type p and n semiconductors. **Problem-solving sessions** involving Fermi levels, density of states, and carrier concentrations **Conceptual discussions** on real-world materials and their classification based on band theory Explanation Reasoning Collaborative interaction with students	**2 h**
6. Magnetic properties of materials 6.1.The origin of magnetic moments. Magnetic quantities. 6.2 Types of magnetic materials 6.3 Diamagnetism. Classical Theory of Diamagnetism 6.4 Paramagnetism. 6.5 Magnetic ordered materials (Ferromagnetism; Ferrimagnetism; Antiferromagnetism)	**Conceptual lectures** with diagrams explaining spin, orbital motion, and magnetic domains **Animated simulations** showing magnetic alignment in various materials. **Comparative analysis/ animated visualisation** of temperature dependence in different magnetic behaviors **Case studies and material examples**	**2 h**
7. Measurements in magnetic field I (magnetic susceptibility). 7.1 Ferromagnetism 7.2 Antiferromagnetism 7.3 Ferrimagnetism 7.4 Practical/technological applications of	Lecturing Explanation Conversation Description Reasoning	**4 h**

soft and hard magnatic materials. 7.4 Experimental setups for measurement of the magnetic susceptibility: Gouy/Faraday balance, vibrating sample magnetometer (VSM). 7.5 General notions on superconducting materials: characteristics, BCS theory. Application: SQUID magnetometer.		
8) Measurements in magnetic field II (electric measurements). 8.1 Hall effect. 8.2 Magnetoresistance. 8.3 Practical/technological applications of Hall elements and magnetoresistive materials.	Lecturing Explanation Conversation Description Reasoning	**4 h**
9) Measurements of X-ray diffraction: 9.1 Kinematic theory of diffraction 9.2 Structural informations. Structure refinement: Rietveld algorythm for powder X-ray diffraction data. 9.3 Instrumental configurations of X-ray diffraction setups (powder/single crystal).	Lecturing Explanation Conversation Description Reasoning	**4 h**
10) Synthsis techniques of solid-state phases: 10.1 Solid-state synthesis methods 10.2 Wet chemistry methods 10.3 Special methods 10.4 Analysis of the factors involved in each method exposed above, choice of the synthesis method based on the discussed factors, examples.	Lecturing Explanation Conversation Description Reasoning	**2 h**

Bibliography

1. Various electronic resources, scientific papers
2. Albert Hang – Theoretical solid state physics, Pergamon Press, Oxford, 1972.
3. Andersen J. C., Leaver K. D., Rawlings R. D., Alexander J. M., Materials Sciences, Van Nostrand Reinhold (UK) Co. Ltd, 1986.
4. Ashcroft N. W., Mermin N. D., Solid State Physics, Holt-Saunders International Editions Tokyo,1981.
5. Charles Kittel – Introduction to solid state physics, 8th edition, John Wiley and Sons, 2005 (avialable as pdf)
6. David Jiles, Introduction to Magnetism and Magnetic Materials, ISBN 9781482238877, 2015
7. Elliott S. R., The Physics and Chemistry of Solids, John Willey & Sons, 1998
8. Flin R A & Trojan P K, Engineering Materials and their Applications, John Wiley and Sons, Inc. NewYork 1995
9. H.M. Rosenberg – The solid state: an introduction to the physics of crystals for students of physics, material science and engineering, Oxford University Press, New York, 1985.
10. Ioan Licea – Fizica stării solide, Partea I-a, Tipografia Universităţii Bucureşti, 1991
11. Ioan Licea, Fizica Metalelor, Ed. Şt. şi Enciclopedică, Bucureti, 1986.
12. Ion Munteanu – Fizica solidului, Editura Universităţii din Bucureşti, 2004. ebooks.unibuc.ro/Fizica/Munteanu/FIZICA SOLIDULUI.pdf
13. John R. Hook, Henri Edgar Hall – Solid state physics (for students), J. Wiley, Chichester, 1991.
14. DeGraef and M.E. McHenry, Structure of Materials, Cambridge (2007)
15. Michael M. Woolfson - An Introduction to X-ray Crystallography, 2nd edition, Cambridge University Press, Cambridge, 1997
16. R. A. Young (editor) – The Rietveld Method – Oxford University Press, 1995
17. Richard J. D. Tilley – Crystals and Crystal Structures, John Wiley and Sons, Chichester, 2006
18. Terrel A. Vanderah - Chemistry of Superconductor Materials: Preparation, Chemistry, Characterization and Theory, Noyes Publications, New Jersey, 1992
19. Ulrich Müller – Inorganic Structural Chemistry – 2nd edition, John Wiley and Sons, Chichester, 2006

20. Vitalij K. Pecharsky, Peter Y. Zavalij - Fundamentals of Powder Diffraction and Structural Characterization of Materials, Springer, 2009

7.2 Seminar/laboratory	**Teaching methods**	**Comments**
Laboratory safety rules and regulations. Introduction to Crystal Structures.	Explanation. Interactive collaboration. Reasoning. Computer simulations	**2 h**
Crystallographic points, directions, lattice Planes and Miller Indices. Packing Efficiency. Reciprocal lattice. Applications Crystallographic structures. Crystallographic texture. Defects	Explanation. Interactive collaboration. Reasoning. Problem solving. Computer simulations	**4 h**
The study of the Photoresistor	Experiment. Data analysis. Explanation. Interactive collaboration. Reasoning	**2 h**
Temperature Dependence of Resistance in semiconductors Temperature Dependence of Resistance in Metals	Experiment. Data analysis. Explanation. Interactive collaboration. Reasoning	**4 h**
Study of the Hysteresis Loop in Ferromagnetic Materials	Experiment. Data analysis. Explanation. Interactive collaboration. Reasoning	**2 h**
Symmetry elements and operations. Schoenflies notation. Point groups. Classes of conjugated operations. Symmetry analysis of simple molecules; space group assignement.	Explanation; Conversation; Description Reasoning	**2 h**
Point-symmetry analysis of complex structures and platonian solids.	Explanation; Conversation; Description Reasoning	**2 h**
Hermann-Mauguin notation of the symmetry elements. Crystallographic symmetry groups. Wyckoff positions. Study of the fundamental crystal structures based on the symmetry analysis.	Explanation; Conversation; Description Reasoning	**6 h**
Powder X-ray diffraction: Indexation of experimental patterns, simulation of powder X-ray diffractograms for known crystal structures, analysis of the factors involved.	Explanation; Conversation; Description Reasoning	**4 h**

1. Various electronic resources, scientific papers
2. Albert Hang – Theoretical solid state physics, Pergamon Press, Oxford, 1972.
3. Andersen J. C., Leaver K. D., Rawlings R. D., Alexander J. M., Materials Sciences, Van Nostrand Reinhold (UK) Co. Ltd, 1986.
4. Ashcroft N. W., Mermin N. D., Solid State Physics, Holt-Saunders International Editions Tokyo,1981.
5. Charles Kittel – Introduction to solid state physics, 8th edition, John Wiley and Sons, 2005 (avialable as pdf)
6. David Jiles, Introduction to Magnetism and Magnetic Materials, ISBN 9781482238877, 2015
7. Elliott S. R., The Physics and Chemistry of Solids, John Willey & Sons, 1998
8. Flin R A & Trojan P K, Engineering Materials and their Applications, John Wiley and Sons, Inc. NewYork 1995
9. H.M. Rosenberg – The solid state: an introduction to the physics of crystals for students of physics, material science and engineering, Oxford University Press, New York, 1985.
10. Ioan Licea – Fizica stării solide, Partea I-a, Tipografia Universităţii Bucureşti, 1991
11. Ioan Licea, Fizica Metalelor, Ed. Şt. şi Enciclopedică, Bucureti, 1986.
12. Ion Munteanu – Fizica solidului, Editura Universităţii din Bucureşti, 2004. ebooks.unibuc.ro/Fizica/Munteanu/FIZICA SOLIDULUI.pdf
13. John R. Hook, Henri Edgar Hall – Solid state physics (for students), J. Wiley, Chichester, 1991.
14. DeGraef and M.E. McHenry, Structure of Materials, Cambridge (2007)
15. Michael M. Woolfson - An Introduction to X-ray Crystallography, 2nd edition, Cambridge University Press, Cambridge, 1997
16. R. A. Young (editor) – The Rietveld Method – Oxford University Press, 1995
17. Richard J. D. Tilley – Crystals and Crystal Structures, John Wiley and Sons, Chichester, 2006
18. Terrel A. Vanderah - Chemistry of Superconductor Materials: Preparation, Chemistry, Characterization and Theory, Noyes Publications, New Jersey, 1992
19. Ulrich Müller – Inorganic Structural Chemistry – 2nd edition, John Wiley and Sons, Chichester, 2006

Vitalij K. Pecharsky, Peter Y. Zavalij - Fundamentals of Powder Diffraction and Structural Characterization of Materials, Springer, 2009

8. The correlation of the course content with the expectations of the epistemic community, professional associations, and key employers in the field related to the programme

- This course has been designed in close alignment with the evolving expectations of the scientific community, professional bodies, and major employers operating in the fields of **material science, physical chemistry, nanotechnology, and applied research**. It integrates both theoretical and experimental dimensions, enabling students to approach scientific problems in a structured, analytical, and application-oriented manner.
- This course is carefully designed and structured to equip graduates with both the theoretical foundation and experimental expertise

required to understand essential scientific concepts, conduct meaningful experimental work, and process data at an advanced level within the field of materials science and related disciplines.

- The concepts acquired by students are necessary for the following courses provided in the curriculum of the Master in "Advanced Chemistry": Charcaterisation of Solid Materials; Nanomaterials; Catalytic Materials; Anorganic Clusters, Polymers and Heterocycles; Polinuclear compounds and Molecular Materials.
- The topics covered and the combined approaches used in this module (theory, applications, experimental work) will help students to: deepen understanding and apply concepts; experience basic phenomena; test important laws; develop critical, quantitative thinking; deepen experimental and data analysis skills; develop reporting skills (written and oral); practice collaborative problem solving; exercise curiosity, ability to search, understand scientific literature and structure it in a scientific presentation. In addition, students will enhance their ability to work collaboratively to solve problems, while cultivating intellectual curiosity and building confidence in searching, interpreting, and presenting information from scientific literature in a coherent, structured manner. This comprehensive approach supports the development of both technical competence and scientific maturity, preparing students for further study or professional engagement in research, development, and innovation-driven environments.

9. Evaluation

Type of activity	**9.1. Evaluation criteria**	**9.2. Evaluation methods**	**9.3. Share of final grade**
9.4. Course	The written exam will focus primarily on assessing **understanding**, not rote memorization. It will include conceptual questions, applied problem-solving, interpretation of data, and short analytical tasks. The aim is to evaluate how well students grasp key principles	▪ Part A. Written Exam (for the first seven lectures and laboratory sessions) ▪ Part B. Oral Exam (for the last seven lectures and laboratory sessions)	4 p - part A 7 p - part B
9.5. Seminar/laboratory	Part A. Throughout the course and laboratory sessions, students will be evaluated on their ability to **approach scientific questions using problem-solving strategies**.	Part A. Formative evaluation	1p – Part A 3p – Part B
	Each student will compile a **laboratory portfolio** documenting their practical work throughout the semester. For each lab session, students will submit a **short lab report** that includes a brief theoretical overview of the experiment, a table of the measured or simulated data, and a section dedicated to **data processing and interpretation**. Reports must demonstrate accuracy in recording results, correct use of analytical methods (including calculations or graphical analysis), and the ability to draw scientifically grounded conclusions.	Lab Portofolio.	2P – PART A
	Each student will deliver a short **scientific presentation**, based on a topic selected from a range of course-relevant themes. This task is designed to test the student’s ability	**I**ndividual Presentation (student's choice from a guided list of relevant topics**)**	3P – PART A

	to identify a subject of interest, search and critically review scientific literature, synthesize complex information, adapt it to a specific audience level, and present it clearly and confidently. Evaluation will consider the depth and accuracy of the content, the logical structure of the presentation, visual quality, and communication skills, including the ability to respond to questions. Part B. Continuous evaluation during the labworks when students are solving the laboratory tasks and a final oral evaluation to highlight the key concepts acquired by each student.		
Minimum performance standard			

Attendance at all lectures and laboratory sessions is mandatory. Active participation in course activities and group discussions will be monitored as part of the formative assessment process. Students are expected to engage with all course components in a timely and responsible manner.

- Understanding the basic concepts of crystallography (crystalline and amorphous materials, lattice, primitive vectors, ability to define the crystallographic coordinations for a given crystal point, a specific crystallographic direction, plane; packing efficiency for simple cubic unit cell; reciprocal lattice; Bragg law; Laues equations; Basic concepts of x-ray diffractometry in Bragg-Brentano geometry)
- The basic concepts of the Free electron Fermi gas model in 1D, 3D. Conductivity and Ohm's law
- Electronic Band structures. Basic concepts. Band structures and main characteristics of Insulators, Metals, semiconductors
- Types of magnetic materials.
- Basic concepts of the classical Theory of Diamagnetism and Paramagnetism.
- Electron arrangements in ferromegnetic, antiferromagnetic and ferrimagnetic materials.
- Basic description of the hysteresis loops coercive field, saturation, remanent magnetization
- Basic description of the main characteristics of a superconductor: Meissner effect, temperature and magnetic field Behaviour (type I and II superconductors)
- Basic description of: Hall effect, positive/negative magnetoresistance
- Basics of the kinematic diffraction theory: structure factors, systematic/structural extinctions, influence of the temperature.
- Classification of the synthesis methods for solid-state materials with examples; writing of correctly balanced chemical equations involved.

Date of completion	Course holder's signature	Seminar holder's signature
	Lecturer, PhD MARIANA CHIONCEL Associate Professor, PhD BOGDAN JURCA	Lecturer, PhD MARIANA CHIONCEL Associate Professor, PhD BOGDAN JURCA
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	Department of Inorganic and 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	Ethics and Academic Integrity						
2.2. Holder of course activities			Lecturer Dr. Delia-Laura Popescu				
2.3. Holder of seminar activities							
2.4. Year of study	1	2.5. Semester	1	2.6. Type of evaluation	V	2.7. Discipline regime	DAPROF /DOB

3. Total estimated time

3.1. Number of hours per week	1	3.2. Of which Course	1	3.3. Seminar	-
3.4. Total curriculum hours	14	3.5. Of which Course	14	3.6. Seminar	-
Time fund distribution					
Study from the textbook, course materials, bibliography and notes					14
Additional documentation in the library, on specialized electronic platforms and in the field					14
Seminar/lab preparation, homework, assignments, reports, portfolios and essays					14
Tutoring					5
Other activities: exams, participation in simulations and applied case studies etc.					14
3.7. Total hours of individual study					61
3.8. Total hours per semester (3.7 + 3.4)					75
3.9. Number of credits					3

4. Prerequisites (where applicable)

4.1. of curriculum	Not applicable
4.2. of skills	Not applicable

5. Conditions (where applicable)

5.1. of the course	Room (Amphitheater) equipped with multimedia facilities (computer, video projector, smart board etc.); internet connection; access to recommended bibliography.
5.2. of the seminar/laboratory	Not applicable

6. Learning outcomes

Knowledge	- The student/graduate identifies and uses appropriate documentation methods to understand and communicate the principles of ethics and academic integrity in a scientific and accessible manner to the target audience. - The student/graduate formulates appropriate solutions to complex academic ethics issues, in accordance with legal requirements and institutional codes of conduct. - The student/graduate prepares and presents scientific reports, accurately using

	documented information and respecting academic integrity standards. - The student/graduate describes and integrates specific and interdisciplinary knowledge from ethics, education, research, and law to support responsible behavior in the academic environment.
Skills	- The student/graduate responsibly interprets the information gathered through documentation and uses it to communicate issues related to academic and research ethics to various audiences (students, learners, professionals). - The student/graduate addresses and resolves complex ethical situations using methods from related fields (law, education, and research), demonstrating critical thinking and integrity. - The student/graduate applies the principles of academic ethics in writing, structuring, and presenting scientific reports, ensuring transparency and accuracy of results. - The student/graduate applies appropriate interdisciplinary methods to analyze and solve issues related to academic integrity and research ethics.
Responsibility and autonomy	- The student/graduate selects, synthesizes, and communicates the most relevant information on academic ethics and integrity clearly and concisely, adapting it to the audience's level of understanding. - The student/graduate takes responsibility for implementing proposed solutions in cases of academic misconduct and justifies decisions with coherent and well-founded arguments. - The student/graduate prepares scientific reports in which documentation, analysis, and communication of results comply with ethical norms and professional research standards. - The student/graduate takes responsibility for managing interdisciplinary collaborations and for coordinating training and promotion activities related to academic ethics and integrity within academic or research teams.

7. Contents

7.1. Course	Teaching methods	Comments
1. Foundations of Ethics and Integrity in Academia • Ethics, deontology, and integrity – definitions, history, terminology • Fundamentals of academic ethics and integrity: principles and values • The role of ethics and integrity in education, science, and research • The European Charter for Researchers and the European Code of Conduct for Research Integrity	Lecture, case studies, guided practical application, debate, critical analysis, examples	2 h
2. Scientific Communication and Authorship Ethics • Scientific dialogue and originality of research results • Intellectual fraud: terminology, legal regulations • Authorship and ownership in scientific research • Plagiarism, self-plagiarism and other academic dishonesty • Scientific communication and deontological rules	Lecture, case studies, guided practical application, debate, critical analysis, examples	2 h
3. Research Conduct and Methodology • Ethics of research methods • Ambiguity of scientific results and ethical dilemmas • The ethics behind research projects	Lecture, case studies, guided practical application, debate, critical analysis, examples	2 h

• Ethics in experimental research: risks, transparency, and responsibility • Sloppiness *vs* fabrication: data acquisition, management, and sharing		
4. Ethical Conduct in Academic Collaboration and Scientific Community Life • Ethics of teamwork in scientific research and the dissemination of results • Student conduct, academic relations, and responsibilities in academic settings • Academic freedom and ethical boundaries • The academic code of ethics and deontology • Structure and role of the university ethics committees	Lecture, case studies, guided practical application, debate, critical analysis, examples	2 h
5. Academic Integrity in the Digital Era • Ethical challenges in the digital environment • Use of technology in education and research • Plagiarism detection tools: advantages and limitations • Online databases of patents and scientific papers • Documentation and challenges posed by fast-evolving mass media	Lecture, case studies, guided practical application, debate, critical analysis, examples	2 h
6. Legal and Institutional Mechanisms for Ensuring Academic Integrity • Plagiarism: legal and academic perspectives • Standards and regulations in research and higher education • Defining academic integrity and institutional standards • Disciplinary procedures, sanctions and consequences: analysis of real case studies • Case studies of misconduct and their legal outcomes	Lecture, case studies, guided practical application, debate, critical analysis, examples	2 h
7. Industrial Property and Innovation Ethics • Industrial property: patents, utility models, designs, trademarks • International treaties in the field of patenting • Legal exploitation and rights management • Management of patenting in academic and industrial research	Lecture, case studies, guided practical application, debate, critical analysis, examples	2 h

Bibliography:

Legal and Institutional Documents

1. Law no. 206/2004 on good conduct in scientific research, technological development and innovation (Romanian legislation, updated)
2. Romanian Higher Education Law no. 199/2023 – with amendments and updates
3. Ministerial Order no. 3485/2016 – regarding software used to detect plagiarism in academic works
4. University of Bucharest – Code of Ethics and Academic Integrity
5. CIOMS & WHO – *International Ethical Guidelines for Health-related Research Involving Humans*, Geneva: CIOMS, 2016
6. The European Code of Conduct for Research Integrity – ALLEA, revised edition (2017)

General Works

7. Papadima, Liviu (ed.) – *Deontologie academică. Curriculum-cadru*, University of Bucharest Publishing House, 2017

8. Șercan, Emilia – *Deontologie academică. Ghid practic*, University of Bucharest Publishing House, 2017
9. Socaciu, Emanuel et al. – *Etică și integritate academică*, University of Bucharest Publishing House, 2018
10. Bretag, Tracey Ann (ed.) – *Handbook of Academic Integrity*, Springer Verlag, Singapore, 2016.
11. Macfarlane, Bruce – *Researching with Integrity: The Ethics of Academic Enquiry*, Routledge, London, 2009.
12. Shamoo, Adil E., Resnik, David B. – *Responsible Conduct of Research*, 3rd ed., Oxford University Press, Oxford, UK, 2015.
13. Sutherland-Smith, Wendy – *Plagiarism, the Internet and Student Learning: Improving Academic Integrity*, Routledge, New York, 2008.
14. Stebbins, Leslie F. – *Student Guide to Research in the Digital Age: How to Locate and Evaluate Information Sources*, Libraries Unlimited, Westport, CT, 2006.
15. Scientific articles and case studies provided by instructor.

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 "Ethics and Academic Integrity" is designed to familiarize master's students with the moral and ethical norms and standards that define the concept of integrity in academic and research activities. Students who successfully complete this course will be able to understand, interpret, and appropriately apply these standards, identify various forms of academic misconduct, and recognize the corresponding sanctions. The course aims to develop students' analytical and critical thinking skills necessary for evaluating relevant teaching and research actions and activities. The purpose of this course is to raise the level of integrity in students' intellectual work, not only to strengthen the academic environment and scientific community, but also to meet the expectations of future employers, by helping to shape professionals who can apply and uphold ethical and professional integrity in their careers. The course addresses issues of high relevance to today's higher education context, both in Romania and internationally.

9. Evaluation

Type of activity	9.1. Evaluation criteria	9.2. Evaluation methods	9.3. Share of final grade
9.4. Course	• Active participation in lectures, discussions, and ethical debates • Demonstrated interest and preparation regarding course topics • Clarity, coherence, and originality in formulating and expressing ideas • Ability to identify and interpret ethical issues in academic and research contexts • Application of relevant standards, regulations, and ethical codes • Critical thinking and ethical reasoning applied in analysis • Use of relevant examples and appropriate justification of arguments • Depth and structure of the case study analysis • Correct referencing and integration of academic sources • Respect for academic integrity principles, including originality and proper citation	Form of Assessment: Verification – the course is evaluated based on a Pass / Fail grading system. Continuous assessment: – Observation of participation in discussions and learning activities – Oral contributions during seminars and case debates Final assessment: – Presentation of a case study involving issues of academic ethics or research integrity – Evaluation based on content relevance, critical analysis, argumentation, and structure	Continuous assessment (active participation in course activities): 30% Final assessment (presentation and analysis of a case study relevant to academic ethics or research integrity): 70%

9.5. Seminar / laboratory			
Minimum performance standard	In order to receive a PASS grade, the student must demonstrate: • Basic understanding of the key concepts of ethics and academic integrity • Ability to identify at least one relevant ethical issue in the context of academic or research practice • Participation in course activities and discussions • Completion and oral presentation of a case study that is relevant, coherent, and reflects personal effort • Observance of academic integrity standards, including proper referencing and absence of plagiarism (case study must pass plagiarism screening) Failure to meet these minimum criteria will result in a FAIL outcome.		

Date of completion	Course holder's signature	Seminar/laboratory holder's signature
24.06.2025	Lecturer Dr. Delia-Laura Popescu	

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	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	I	2.5. Semester	1	2.6. Type of evaluation	V	2.7.Discipline regime	DAPROF/ DOB

3. Total estimated time

3.1. Number of hours per week	4	3.2. Of which Course	-	3.3. Laboratory	4
3.4. Total curriculum hours	56	3.5. Of which Course	-	3.6. Laboratory	56
Time fund distribution					hours
Study from the textbook, course materials, bibliography and notes					10
Additional documentation in the library, on specialized electronic platforms and in the field					60
Report writing					10
Tutoring					4
Other activities: Examination					10
3.7. Total hours of individual study					94
3.8. Total hours per semester (3.4 + 3.7)					150
3.9. Number of credits					6

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	- 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 - Presentation of reports and documentation results

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. - Describes the fundamental principles and operation of equipments and apparatus in chemical laboratories, identifies and uses appropriate characterization techniques to determine the chemical composition, structure and properties of advanced materials. - 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.
Skills	- Analyze and correctly evaluate 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. - Correctly and efficiently uses modern and complex methods of characterization of advanced materials, chooses specific methods of analysis, explains and systematizes the obtained results. - 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.
Responsibility and autonomy	- 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. - 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. - 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. - 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.

7. Contents

7.1. Course	Teaching methods	Comments
	NOT THE CASE	
Bibliography:		
7.2 Laboratory	**Teaching methods**	**Comments**
7.2.1. Proposal of a research topic and discussions with the scientific advisor on the importance of the topic in the context of current research in the field. Presentation of the existing infrastructure and establishment of a work plan to achieve the proposed objectives.	Explanation; Conversation; Description; Exemplification	6 h
7.2.2. Realization of an extensive literature study on the proposed topic. Critical analysis of specialized literature and identification of research paths and methods in the proposed topic.		30 h
7.2.3. Establishing the experimental work stages and associated timetable for the proposed objectives. For each stage the following shall be established: reagents/ consumables required availability of working technique; availability of analytical and physical-chemical investigation techniques; deadline for completion of the step		10 h
7.2.4. Establishment of new development directions in the context of the of current research in the field. Preparation by the master student of the written material related to the report 1. Preparation of the PowerPoint presentation for the defense of the		10 h

report 1.		

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
Literature research	The way in which the student has realized the report; The scientific quality of the report; The quality of the ppt presentation.	Verification by ppt presentation	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	Faculty of Chemistry
1.3. Department	Department of Analytical 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	Micro- and Nano-structured Polymer-based Materials. Thermal Analysis								
2.2. Holder of course activities				Assoc.Prof. Marin MICUȚ, Assoc.Prof. Bogdan JURCA					
2.3. Holder of of seminar/laboratory activities				Assoc.Prof. Marin MICUȚ, Assoc.Prof. Bogdan JURCA					
2.4. Year of study	I	2.5. Semester	2	2.6. Type of evaluation	E	2.7.Discipline regime	DAPROF/ DOB		

***Mandatory**

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					hours
Study from the textbook, course materials, bibliography and notes					100
Additional documentation in the library, on specialized electronic platforms and in the field					14
Seminar/lab preparation, homework, assignments, reports, portfolios and essays					10
Tutoring					10
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 curriculum	Bachelor's degree (Chemistry, Biochemistry/Biology, Physics or any other field of undergraduate studies requiring an adequate level of general knowledge of chemistry, physics and mathematics (especially mathematical analysis).
4.2. of skills	Computer operating (data processing in spreadsheet programs, making ppt presentations, searching for information on the Internet using scientific search engines. Relationship and communication adapted for team working (3-4 students).

5. Conditions (where applicable)

5.1. of the course	Minimum space/room conditions properly equipped with facilities for a lecture held by classical method (blackboard and chalk) and by video projection (ppt presentation).
5.2. of the seminar/laboratory	Mandatory presence of students in all laboratory activities. Adequate equipment of students with basic individual means of labor protection in the lab: lab coat, gloves, eye protection glasses, lab towels. A laboratory work behavior resulting from strict compliance with the requirements described in the lab report for each practical work, as well as those specified by the work coordinator. Access to and appropriate use of available software facilities (Excel, Origin, etc.) for processing the experimental results obtained.

6. Learning outcomes

Knowledge	- The student recognizes and reproduces scientific concepts associated with the physical chemistry of macromolecules and with the chemistry of polymer-based materials. - The student is able to describe the chemical structure and the associated physico-chemical properties of a macromolecular compound, to understand and communicate the structure-properties interrelationship in a scientific way to students and other interested individuals belonging to different socio-economic categories. - The student is able to identify and describe the basic and modern experimental techniques used in the analysis and characterization of polymeric materials - The student is able to feature the fundamental principles and operation of measurement/study equipment in the physical chemistry of polymeric materials laboratory, to identify and use possible experimental techniques adequate for studying some properties of advanced materials containing a macromolecular component. - Identifies and develops/adapts methods for obtaining/fabricating polymer-based materials with new/improved properties for specific applications, acquires and appropriately processes the experimental data obtained.
Skills	- The student properly analyzes, evaluates and applies some basic scientific concepts concerning the fields of physical chemistry, physical chemistry of polymers and chemistry of macromolecular materials implemented in chemical practice. - Evaluates and demonstrates the chemical and physical structural characteristics specific to the advanced materials domain and adapts knowledge for the physico-chemical characterization/study of the properties of materials obtained through 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 for characterizing advanced materials, chooses specific/adequate analysis methods, explains and rationally organizes the experimental results obtained. - Understanding the chemistry of the processes behind obtaining advanced polymer-based materials, logically correlates the chemical and physical structural characteristics and develops creative solutions in possible areas of application of advanced materials.
Responsibility and autonomy	- 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 use of logical, intuitive and creative thinking in describing, comparing and analyzing the structure and properties of advanced materials, in order to support the learning of these concepts by interested professional groups, including high school students. - The 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 prepare analysis reports, to identify solutions and propose alternatives for the proper functioning of the lab/professional entity where the student belongs to. - The ability to manage research activity, following both a pre-established experimental plan and delivery deadlines, to be entirely responsible for the correctness of the interpretation and conclusions formulated within the scientific activity report(s).

7. Contents

7.1. Course	**Teaching methods**	**Comments**
C1. Specifying the micrometer- and nanometer-size domains in obtaining structured materials. General and particular features of the top-down and bottom-up approaches in the manufacture of micrometer- and nano-structured materials.	Interactive, dialogued lecture, debates	2 h
C2. Thermodynamic stability of binary mixtures: regular solutions, polymer solutions, polymer mixtures.		2 h
C3. Phase separation – an optimal method for obtaining micro- and nano-structured polymer films.		2 h
C4. Binodal and spinodal curves. Obtaining micro and nano-structures by spinodal decomposition.		2 h
C5-6. Self-assembly of block copolymers and nanostructures formation.		4 h
C7. Polymer-based biomaterials applied in tissue repairing processes.		2 h
C8. General principles of thermal analysis. Presentation of commonly used methods (TG, DTA and DSC). Physico-chemical informations obtained from these methods (examples).		2 h
C9.1. Heterogeneous reactions with participation of solid phases. Kinetic influence of nucleation and diffusion. C9.2. Isothermal heterogeneous processes: derivation of kinetic equations, parallelism with the kinetic treatment of homogeneous systems, differential/integral forms of the conversion function.		2 h
C10. Nonisothermal heterogeneous processes: differential/integral forms of the kinetic equation, temperature integral evaluation problem.		2 h
C11.1. Calculation of the conversion degree from experimental TG and DSC data; classification of methods to determine the nonisothermal kinetic parameters. C11.2. Methods to determine the nonisothermal kinetic parameters from a single heating rate experiment: differential methods.		2 h
C12.1. Methods to determine the nonisothermal kinetic parameters from a single heating rate experiment: integral methods. C12.2. Drawbacks of the methods based on a single heating rate.		2 h

C13. Isoconversional methods to determine the activation energy: C13.1. Linear isoconversional (integral and differential) methods. C13.2. Nonlinear isoconversional (integral and differential) methods.		2 h
C14. Methods to discriminate the expression of the conversion function C14.1. Compensation effect in nonisothermal kinetics. C14.2. Invariant kinetic parameters method.		2 h

References:

1. W.T.S. Huck (Ed.) – *Nanoscale Assembly. Chemical Techniques*, Springer Science+Business Media, Inc., New York, 2005
2. B. Bhushan (Ed.) – *Springer Handbook of Nanotechnology*, Springer Science+Business Media, Inc., Heidelberg, 2004
3. M. Di Ventra, S. Evoy, J.R. Heflin, Jr. (Eds.) – *Introduction to Nanoscale Science and Technology*, Springer Science+Business Media, Inc., Boston, 2004
4. I.G. Murgulescu, E. Segal - *Introducere în Chimia Fizică, vol.II.1, Teoria Molecular- Cinetică a Materiei*, Editura Academiei, Bucureşti, 1979
5. I.G. Murgulescu, T. Oncescu, E. Segal - *Introducere în Chimia Fizică, vol.II.2, Cinetică Chimică şi Cataliză*, Editura Academiei, Bucureşti, 1981
6. E. Segal, D. Fătu - *Introducere în Cinetica Neizotermă,* Editura Academiei, Bucureşti, 1983
7. W. M. Groenewoud – Characterisation of Polymers by Thermal Analysis, Elsevier, 2001
8. Michael E. Brown (editor) – *Handbook of Thermal Analysis and Calorimetry – vol.1 – Principles and Practice*, Elsevier 1998
9. Stephen Z. D. Cheng (editor) - *Handbook of Thermal Analysis and Calorimetry – vol.3 – Applications to Polymers and Plastics*, Elsevier 2002
10. Michael E. Brown, Patrick K. Gallagher (editors) - *Handbook of Thermal Analysis and Calorimetry – vol.5 – Advances, Techniques and Application*, Elsevier 2008
11. Michael E. Brown (editor) – *Hot Topics in Thermal Analysis and Calorimetry – vol.1 – Introduction to Thermal Analysis – Techniques and Applications*, Kluwer Academic Publishers, 2001
12. Judit Simon (editor) – *Hot Topics in Thermal Analysis and Calorimetry – vol.7 – Thermal Decomposition of Solids and Melts*, Kluwer Academic Publishers, 2007
13. Paul Gabbott (editor) – *Principles and Applications of Thermal Analysis*, Blackwell Publishing, 2008
14. T. Hatakeyama, F.X. Quinn - *Thermal Analysis - Fundamentals and Applications to Polymer Science*, 2nd edition, John Wiley and Sons, 1999
15. P. J. Haines (editor) - *Principles of Thermal Analysis and Calorimetry*, Royal Society of Chemistry, 2002
16. Bernhard Wunderlich - *Thermal Analysis of Polymeric Materials*, Springer 2005
17. A. K. Galwey, M. E. Brown – *Thermal Decomposition of Ionic Solids*, Elsevier 1999

7.2 Seminar/laboratory practice	**Teaching methods**	**Comments**
L1. SSM (workplace safety and health) and PSI (fire safety in the workplace) regulations. Viscoelastic properties of a polymer hydrogel revealed by oscillatory/dynamic rheometry.	Explanation – conversation – experimental work	2 h (working teams of approx. 3 students)
L2. *In vitro* kinetics of collagen type I fibrillogenesis.		4 h (working teams of approx. 3 students)
L3. Obtaining monodisperse particles by the process of surfactant-free emulsion polymerization of methyl methacrylate.		4 h (working teams of approx. 3 students)
L4. Building up a colloidal crystal array, with optical properties of selective absorption of light in the visible electromagnetic spectrum, by quasistatic adsorption of monodisperse spherical polymer particles on a smooth solid substrate (clean glass plate).		4 h (working teams of approx. 3 students)
L5. Presentation of the thermal analysis experimental setup. Experimental study of the decomposition of calcium oxalate.		4 h (working teams of approx. 3 students)

Interpretation of the experimental curves (attribution and validation of the thermal decomposition mechanism).		
L6. Kinetic interpretation of the data obtained at thermal decomposition of calcium oxalate: methods based on a single heating rate. Critical analysis of the obtained results.		4 h (working teams of approx. 3 students)
L7. Study of the thermal decomposition of polyvinyl chloride by TG, DTG and DTA. Calculation of the kinetic parameters by isoconversional methods from multiple heating rate experiments. Critical analysis of the obtained results.		4 h (working teams of approx. 3 students)
L8. Discrimination of the conversion function expression for thermal decomposition of polyvinyl chloride in nonisothermal conditions.	Explanation – conversation – experimental data treatment and interpretation	2 h (working teams of approx. 3 students)

References:

Lab reports

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

1. The course is designed in a specific fashion to enable the graduate, according to the theoretical and experimental knowledge acquired, to carry out research activity at an advanced level, both in the field of materials science and related fields.
2. The concepts/knowledge acquired by the graduate are complementary to those provided by the other disciplines included in the curriculum of "Advanced Materials Chemistry", contributing to shapely/useful scientific development/evolution of the master's student.

9. Evaluation

Type of activity	9.1. Evaluation criteria	9.2. Evaluation methods	9.3. Share of final grade
9.4. Course	Understanding and rationally use of knowledge, ideas, fundamental concepts specific to the field. The ability to adapt knowledge, concepts, ideas presented and discussed in the course to similar/dissimilar contexts, particularly defined.	Exams: - written exam - oral exam	80%
9.5. Seminar/laboratory practice	Direct, participatory involvement in the practical implementation of lab work. Ease of understanding, processing and critical analysis of the results obtained.	2 evaluation tests	20%
Minimum performance standard	**Obtaining a grade of 5 (at least), both in the written and oral exam.**		

Date of completion	Course person(s) in charge signature,	Seminar person(s) in charge signature,
	Assoc.Prof. Marin MICUȚ	Assoc.Prof. Marin MICUȚ
	Assoc.Prof. Bogdan JURCA	Assoc.Prof. Bogdan JURCA

Date of approval in the Department

Signature of the Head of Department,
Lect.Dr. Adina RĂDUCAN

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	Polynuclear Complexes and Molecular Materials						
2.2. Holder of course activities	Lect. dr. Ruxandra GHEORGHE						
2.3. Holder of seminar activities	Lect. dr. Ruxandra GHEORGHE						
2.4. Year of study	I	2.5. Semester	II	2.6. Type of evaluation	Written examen	2.7.Discipline regime	DAPROF/ 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	56	3.5. Of which Course	28	3.6. Seminar	28
Time fund distribution					hours
Study from the textbook, course materials, bibliography and notes					40
Additional documentation in the library, on specialized electronic platforms and in the field					16
Seminar/lab preparation, homework, assignments, reports, portfolios and essays					55
Tutoring					18
Other activities:Examination					15
3.7. Total hours of individual study					144
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 and Inorganic Chemistry, Coordination Chemistry, Supramolecular Chemistry, Physical Chemistry
4.2. of skills	Understanding scientific publications of Inorganic and Molecular Materials Chemistry Lab skills Writing coherent lab reports and short scientific essays in English.

5. Conditions (where applicable)

5.1. of the course	Attendance at least at 10 lectures is mandatory. Delay is accepted, within reasonable limits.
5.2. of the seminar/laboratory	Laboratory/seminar attendance is mandatory. Students will come to the laboratory wearing protective equipment - lab coat, gloves, safety glasses - and will comply with labor protection regulations.

6. Learning outcomes

Knowledge	- Recognizes and applies advanced scientific concepts from inorganic, physical, and materials chemistry essential to the understanding of polynuclear complexes, coordination environments, and electronic structure. - Describes and explains the relationship between chemical structure and physical properties (magnetism) in molecular materials; communicates this knowledge scientifically and pedagogically. - Describes the working principles of key instruments (SQUID magnetometer, diffractometer, spectrometers), and selects appropriate methods to determine the composition, structure, and magnetic-optical properties of polynuclear complexes. - Identifies and designs synthetic routes to targeted molecular materials (single-molecule magnets, coordination polymers), and processes and interprets data to assess performance and stability. -Formulate solutions for complex problems in modern chemical research, including compliance with environmental standards, a process based on the knowledge, identification, and application of advanced concepts, methods and theories from the fields of inorganic chemistry, magnetism, and supramolecular chemistry
Skills	- Accurately analyze, evaluate and apply complex concepts from inorganic, physical, and materials chemistry as applied to the structure, bonding, reactivity, and magnetic properties of polynuclear complexes and molecular materials. - Evaluate and demonstrate the specific chemical and physical structural characteristics of polynuclear systems and apply this knowledge in the physicochemical characterization and understanding of structure–property relationships in molecular materials. - Correctly make use of modern techniques (single-crystal X-ray diffraction, SQUID magnetic susceptibility measurements, IR, UV-Vis-NIR) for the characterization of polynuclear complexes, select appropriate analytical methods, to interpret and systematize the data obtained. - Understand the synthetic strategies for polynuclear complexes and extended molecular materials, control and tailor their chemical and physical properties, and develop creative approaches for functional material design (molecular magnets). -Use creative and critical thinking to solve advanced problems related to the design, modeling, and experimental evaluation of polynuclear assemblies, employing concepts from inorganic chemistry, magnetism, and supramolecular chemistry.
Responsibility and autonomy	- Adapt major scientific concepts in the field of polynuclear complexes and molecular materials to conduct research, improve or develop new concepts, knowledge, theories and operational methods, products and services. - Able to use a logical, intuitive, and creative thinking in describing, comparing, and analyzing the structure–property relationships in molecular materials to support the learning of these concepts by interested professional groups, including high school students. - Able to develop work protocols, analysis reports and proposes solutions for the organization and optimization of laboratory activity in the field of coordination chemistry and molecular materials. - Able to manage laboratory and/or research activities responsibly, respecting experimental planning, timelines, and assuming accountability for data interpretation and scientific conclusions in the study of molecular materials. - Able 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 polynuclear complexes and molecular materials.

7. Contents

7.1. Course	Teaching methods	Comments

7.1.1. **Introduction** to Polynuclear Coordination Chemistry: role of polynuclear complexes in molecular materials; definition and scope; importance of bridging ligands for property tuning	Interactive lecture	2 h
7.1.2. **Ligand classification by bridging ability**: terminal vs. bridging vs. chelating ligands; examples of μ_2, μ_3, μ_4 bridges; terminology: syn/syn, syn/anti, etc.	Interactive lecture Case-based learning	2 h
7.1.3. **Polynucleating and polytopic ligands**: compartmental ligands, polyamines, polyketones, Schiff bases, rational design: rigid vs. flexible ligands	Interactive lecture Case-based learning	2 h
7.1.4. **Versatile ligands and synthetic strategies**: use of ligands with adaptable binding modes; serendipity vs. rational design; influence of reaction conditions: solvents, templates, counterions, pH	Interactive lecture Case-based learning	2 h
7.1.5. **Magnetic concepts in coordination compounds**: spin, orbital angular momentum, g-factor; magnetic moment, molar susceptibility; types of magnetic behavior (para-, dia-, ferro-, antiferro-)	Interactive lecture	2 h
7.1.6. **Magnetic measurements and theory**: Brillouin function, Curie law, van Vleck equation (qualitative), overview of experimental techniques (SQUID)	Interactive lecture Case-based learning Guided problem solving	2 h
7.1.7. **Magnetic coupling in binuclear complexes**: homobinuclear 3d–3d complexes; spin Hamiltonian formalism; exchange parameter J – sign and magnitude	Interactive lecture Case-based learning Guided problem solving	2 h
7.1.8. **Magnetic interaction in 3d–3d' and 3d-4f heterobinuclear systems: s**pin–orbit coupling, magnetic anisotropy; zero-field splitting, crystal field effects; magnetic impurities and intermolecular coupling	Interactive lecture Case-based learning Guided problem solving	2 h
7.1.9. **Trinuclear and higher-order spin systems**: spin frustration and irregular spin states; energy level diagrams, practical examples	Interactive lecture Case-based learning Guided problem solving	2 h
7.1.10. **Magneto-structural Correlations**: Kahn & Briat approach; role of geometry and orbital overlap; influence of terminal ligands and metal stereochemistry	Interactive lecture Case-based learning Guided problem solving	2 h
7.1.11. **Molecular magnetic materials**: classical 2D and 3D molecular magnets to modern single-molecule magnets	Interactive lecture Case-based learning	2 h
7.1.12. **Coordination polymers and MOFs**: from discrete to extended architectures; design of MOFs with magnetic properties; magnetic MOFs vs. purely structural MOFs	Interactive lecture Case-based learning	2 h
7.1.13. **Multifunctional materials and luminescent complexes**: luminescent lanthanide clusters; photomagnetic, magneto-chiral and magneto-conductive hybrids	Interactive lecture Case-based learning	2 h
7.1.14. **Integration and research outlook**: comparison of design strategies across materials; case studies from current literature; optional student presentations.	Interactive lecture Case-based learning Guided problem solving Literature-Based Seminars	2 h

Bibliography:

1. J.P. Launay, M. Verdaguer, "Electrons in Molecules. From Basic Principles to Molecular Electronics", Oxford Univ. Press, 2019.
2. O. Kahn, "Molecular Magnetism", VCH, 1993.
3. J. Ribas Gispert,, "Coordination Chemistry", Wiley-VCH, 2008
4. "Molecular Magnetic Materials", ed. B. Sieklucka, D. Pinkowicz, Wiley-VCH, 2017
5. Various scientific papers and reviews

7.2 Seminar/laboratory	**Teaching methods**	**Comments**
7.2.1. Laboratory safety rules and guidelines	Interactive lecture, leading discussion	2 h
7.2.2. $[Cr(AA)(C_2O_4)_2]^-$: building block in designing heterometallic coordination compounds (AA = α - diimine type ligand) Synthesis. Acquiring and analyzing IR and UV-Vis-NIR spectra.	Demonstrative Teaching Hands-On Learning Guided Data Analysis Problem-Based Learning Collaborative Learning	2 h
7.2.3. Binuclear Cu(II) complexes with carboxylate bridges $[Cu_2(salampy)_2(H_2trim)_2]$	Demonstrative Teaching Hands-On Learning	2 h

Synthesis. Acquiring and analyzing IR and UV-Vis spectra.	Guided Data Analysis Problem-Based Learning Collaborative Learning	
7.2.4. Model heterobinuclear compounds for studying the Cu(II)-Gd(III) and Ni(II)-Gd(III) magnetic interaction [M(valpn)Gd(O_2NO)$_3$] Synthesis. Acquiring and analyzing IR and UV-Vis-NIR spectra.	Demonstrative Teaching Hands-On Learning Guided Data Analysis Problem-Based Learning Collaborative Learning	2 h
7.2.5. Luminescent Zn(II)-Ln(III) heterometallic systems [Zn(valpn)Ln(O_2NO)$_3$] Synthesis. Acquiring and analyzing IR, UV-Vis-NIR, fluorescence spectra.	Demonstrative Teaching Hands-On Learning Guided Data Analysis Problem-Based Learning Collaborative Learning	2 h
7.2.6. Heterotrinuclear complexes with an irregular spin structure [(H_2O)LMn–NC–Fe(CN)$_4$–CN–MnL(NCS)]·2H_2O Synthesis. Acquiring and analyzing IR and UV-Vis-NIR spectra.	Demonstrative Teaching Hands-On Learning Guided Data Analysis Problem-Based Learning Collaborative Learning	2 h
7.2.7. Heterometallic clusters built with the hexacyanoferrate(III) anion [{Cu^{II}(saldmen)(H_2O)}$_6${Fe^{III}(CN)$_6$}](ClO_4)$_3$·8H_2O Synthesis. Acquiring and analyzing IR and UV-Vis-NIR spectra.	Demonstrative Teaching Hands-On Learning Guided Data Analysis Problem-Based Learning Collaborative Learning	2 h
7.2.8. Single molecule magnets [$Mn_{12}O_{12}$(CH_3COO)$_{16}$(H_2O)$_4$]-·2CH_3COOH ·4H_2O Synthesis. Acquiring and analyzing IR and UV-Vis-NIR spectra.	Demonstrative Teaching Hands-On Learning Guided Data Analysis Problem-Based Learning Collaborative Learning	2 h
7.2.9. Chain-like heteropolymetallic systems with thiocyanide bridges [CuvalpnCo(NCS)$_2$]$_n$ Synthesis. Acquiring and analyzing IR and UV-Vis-NIR spectra.	Demonstrative Teaching Hands-On Learning Guided Data Analysis Problem-Based Learning Collaborative Learning	2 h
7.2.10. Molecular Magnets (NH_4)[MnCr(ox)$_3$] Synthesis. Acquiring and analyzing IR and UV-Vis-NIR spectra.	Demonstrative Teaching Hands-On Learning Guided Data Analysis Problem-Based Learning Collaborative Learning	2 h
7.2.11. Metal organic frameworks $^3_\infty$[Cu_2(mand)$_2$(hmt)]·H_2O Synthesis. Acquiring and analyzing IR and UV-Vis spectra.	Demonstrative Teaching Hands-On Learning Guided Data Analysis Problem-Based Learning Collaborative Learning	2 h
7.2.12. Magnetic measurements: molar susceptibility (interpretation and fitting of experimental data)	Demonstrative Teaching Leading discussion Exercises Case-based learning Computer assisted	3 h
7.2.13. Magnetic measurements: magnetization (interpretation and fitting of experimental data)	Demonstrative Teaching Leading discussion Exercises Case-based learning Computer assisted	3 h
Bibliography: various scientific papers		

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 *"Polynuclear Complexes and Molecular Materials"* is aligned with the expectations and current developments promoted by the international epistemic community in the fields of coordination chemistry, molecular magnetism, and

advanced materials science. The discipline reflects the academic and research priorities outlined by professional associations such as the European Chemical Society (EuChemS), the American Chemical Society (ACS), and networks such as the European Institute of Molecular Magnetism (EIMM). Emphasis is placed on key topics such as ligand design, polynuclear complex formation, magnetic interactions, and the development of functional molecular materials (single-molecule magnets, metal-organic frameworks, multifunctional systems), all of which are considered strategic for innovation in material science and nanotechnology. At the same time, the discipline supports the development of competences required by representative employers in research institutes, advanced laboratories, and industries focused on magnetic and hybrid materials. Students are trained in rational design, synthesis, and physicochemical characterization of molecular materials, acquiring analytical and interpretive skills relevant to both academic and industrial contexts. The up-to-date scientific literature, case studies, and magnetic characterization techniques ensures the alignment of the course with both national and European standards of higher education and with the evolving needs of the labor market in the field of advanced materials.

9. Evaluation

Type of activity	**9.1. Evaluation criteria**	**9.2. Evaluation methods**	**9.3. Share of final grade**
9.4. Course	- understanding and application of key concepts (ligand classification, magnetic exchange, molecular materials) - ability to explain structure–property relationships - capacity to interpret magnetic behavior in polynuclear complexes - clarity, logic, and scientific accuracy of written answers	Written exam (final assessment) Weekly assignments	70%
9.5. Seminar/laboratory	- correct execution of synthesis procedures - accurate acquisition and interpretation of IR and UV-Vis spectra - active participation and problem-solving during seminar sessions	- continuous assessment during laboratory activity - final laboratory report in the format of a scientific journal article, based on one of the synthesized compounds.	30%
Minimum performance standard	- for the course: the student demonstrates the ability to explain basic concepts related to polynuclear complexes and magnetic interactions, describes general types of molecular materials, and applies fundamental principles to solve standard problems. - for the laboratory/seminar: the student correctly performs at least one synthesis, acquires valid IR or UV-Vis spectra, identifies key spectral features, and provides a basic interpretation supported by theoretical knowledge of the magnetic data.		

Date of completion	**Course holder's signature**	**Seminar/laboratory holder's signature**
23.06.2025	Ruxandra GHEORGHE	Ruxandra Gheorghe
Date of approval in the department		**Signature of the Head of Department**

COURSE SYLLABUS
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	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	Physical Chemistry of Mesogens						
2.2. Holder of course activities	Lecturer PhD Mariana Duca						
2.3. Holder of laboratory activities	Lecturer PhD Mariana Duca						
2.4. Year of study	I	2.5. Semester	II	2.6. Type of evaluation	E	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. Laboratory	2
3.4. Total curriculum hours	56	3.5. Of which Course	28	3.6. Laboratory	28
Time fund distribution					hours
Study from the textbook, course materials, bibliography and notes					50
Additional documentation in the library, on specialized electronic platforms and in the field					30
Laboratory preparation, homework, assignments, reports, portfolios and essays					50
Tutoring					7
Other activities: Examination					7
3.7. Total hours of individual study					144
3.8. Total hours per semester					200
3.9. Number of credits					8

4. Prerequisites (where applicable)

4.1. of curriculum	• Good knowledge of Physics and Chemistry. • Basic mathematical background (of Algebra and Mathematical Analysis)
4.2. of skills	• Good knowledge on PC (Office, scientific documentation using databases). • The ability to work in a team of 2-3 students.

5. Conditions (where applicable)

5.1. of the course	• The course takes place in a lecture room equipped with a video projector and computers with internet access. • During the lecture, the students will have their mobile phones turned off.
5.2. of the laboratory	• The attendance of the laboratory is compulsory.

6. Learning outcomes

Knowledge	- The student/graduate recognizes and reproduces scientific concepts in the field of

	physical chemistry of mesogenic materials. - The student/graduate identifies and utilizes appropriate methods of information and documentation in order to understand the physical chemistry principles in the design of advanced materials on which he/she transmits them in a scientific manner to those interested. - The student/graduate describes and integrates specific and interdisciplinary knowledge into professional activity.
Skills	- The student/graduate analyzes, evaluate and correctly apply major scientific concepts in the field of physical chemistry of mesogens in the chemical practice. - The student/graduate interprets responsibly the results of documentation in order to communicate them to those interested (high-school students, students, other socio-economic categories). - The student/graduate acquires skills to work in suitable interdisciplinary teams in order to solve theoretical and practical problems specific to the field of advanced materials science.
Responsibility and autonomy	- The student/graduate 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/graduate has the ability to select the most appropriate documentation results, to organize teams and to collaborate in working groups in order to carry out the educational and scientific activity. - The student/graduate has the ability to apply in an autonomous and responsible way the knowledge and aptitudes regarding the coordination of a work/research team by allocation of tasks and resources and monitoring the achievement of project objectives

7. Contents

7.1. Course	Teaching methods	Comments
7.1.1 Molecular self-organization in mesogenic compounds • Superstructures • Types of molecular alignment • Methods of alignment • Orientational ordering	Lecturing, Conversation, Explanation, Debate	4 h
7.1.2 Electrical properties of mesogenic compounds • Electrical polarization of mesogenic compounds • Anisotropy of dielectric properties • Electrical properties of nematic phase	Lecturing, Conversation, Explanation. Debate	2 h
7.1.3 Optical properties of mesogenic compounds • Structure of electromagnetic wave in anisotropic materials • Phenomenon of double refraction of light. Refractive indices ellipsoid • Birefringence of uniaxial materials • Optical birefringence dispersion by interferential methods • Anisotropy of optical absorption	Lecturing, Conversation, Explanation, Debate	4 h
7.1.4 Electro-optical effects in nematics. Guest – Host effect • Frederiks effect • Effect of electrically controlled birefringence • Schadt-Helfrich effect • Electro-hydrodynamic instabilities in continuous and alternative regimes. • Guest – Host effect.	Lecturing, Conversation, Explanation, Debate	4 h
7.1.5 Magnetic field effects in nematics • Molecular diamagnetism of nematics • Deformation effects of nematics in a magnetic field • Frederiks transition under the action of a magnetic field	Lecturing, Conversation, Explanation, Debate	2 h
7.1.6 Thermodynamics of thermotropic mesogenic compounds. The continuum theory	Lecturing, Conversation, Explanation, Debate	2 h

• Case I – A nematic • Case II – A cholesteric		
7.1.7 The polymorphism of the thermotropic mesogenic compounds from thermodynamic data.	Lecturing, Conversation, Explanation, Debate	2 h
7.1.8 Phase transitions. The variation of thermodynamic parameters.	Lecturing, Conversation, Explanation, Debate	4 h
7.1.9 Variation of transition temperature with pressure and impurity influence at phase transitions.	Lecturing, Conversation, Explanation, Debate	2 h
7.1.10 Thermometry and thermography with mesogenic compounds.	Lecturing, Conversation, Explanation, Debate	2 h

Bibliography:

1. Peter J. Collings, John W. Goodby, Introduction to Liquid Crystals – Chemistry and Physics (Second Edition), CRC Press, Taylor & Francis Group, 2019.
2. Shri Singh, Handbook of Liquid Crystals – vol I -Foundations and Fundamental Aspects, Springer, 2024.
3. P.G. de Gennes and J. Prost, The Physics of Liquid Crystals (Second Edition), Clarendon Press, 1995.
4. Iam-Choon Khoo, Liquid Crystals (Third Edition), John Wiley & Sons, Inc., 2022.
5. Shri Singh, Phase transitions in liquid crystals, Physics Reports 324 (2000) 107-269.
6. E. Lueder, P. Knoll, S.H. Lee, Liquid Crystal Displays: Addressing Schemes and Electro-Optical Effects (Third Edition), John Wiley & Sons, Inc., 2022.
7. L. Vicari, Optical Applications of Liquid Crystals. CRC Press, Taylor & Francis Group, 2016.
8. Robert H. Chen, Thermodynamics for Liquid Crystals, John Wiley & Sons, Inc., 2011.
9. Ingo Dierking, Textures of Liquid Crystals, John Wiley & Sons, 2003.
10. S. Chandrasekhar, Liquid Crystals, Cambridge University Press, Cambridge,1994.
11. Viorica Meltzer, Chemical Thermodynamics, Bucharest University Press, Bucharest, 2007 (in Rom).
12. Rodica Vîlcu, Chemical Thermodynamics, Technical Publishing House, Bucharest, 1994 (in Rom).
13. I. Muscutariu, Liquid Crystals and Applications, Technical Publishing House, Bucharest, 1981 (in Rom).
14. Carmina Plosceanu, Liquid Crystals, Bucharest University Press, Bucharest, 2001 (in Rom).

7.2 Laboratory	Teaching methods	Comments
7.2.1 Safety rules in the laboratory. Brief presentation of practical activities and experimental set-ups.	Explanation, Conversation, Description	2 h
7.2.2 The principle of optical microscopy with polarized light.	Experiment, Explanation, Conversation, Description, Demo	4 h
7.2.3 Optical birefringence of mesogenic compounds.	Explanation, Conversation, Description, Data processing and Analysis	2 h
7.2.4 Optical absorption of mesogenic compounds in polarized light.	Explanation, Conversation, Description, Data Processing and Analysis	2 h
7.2.5 Electric control of the optical birefingence in nematics.	Experiment, Explanation, Conversation, Description, Data Processing and Analysis	2 h
7.2.6 Electro-hydrodynamical phenomena in a nematic.	Experiment, Explanation, Conversation, Description	2 h
7.2.7 Cholesteric – nematic transition of the molecular order in cholesteric matrices.	Explanation, Conversation, Description, Data Processing and Analysis	2 h
7.2.8 - Type of light emerging a nematic with planar alignment. -Determination of the Williams domains periodicity in a nematic using a He – Ne laser.	Experiment, Explanation, Conversation, Description, Data Processing and Analysis	2 h
7.2.9 Relaxation processes in nematics.	Experiment, Explanation, Conversation, Description, Data Processing and Analysis	2 h
7.2.10 Magnetic birefringence in a mesogenic compound.	Explanation, Conversation, Description, Data processing and	2 h

	Analysis	
7.2.11 The establishment of polymorphism diagrams.	Experiment, Explanation, Conversation, Description	2 h
7.2.12 Thermal study of mesogenic binary mixtures. Phase diagrams.	Experiment, Explanation, Conversation, Description	4 h

Bibliography:

1. Mansoor B. A. Jalil, Liquid crystal experiment for undergraduate engineering students, Proceedings of SPIE 9663, Eighth International Topical Meeting on Education and Training in Optics and Photonics, 966321 (6 Oct. 2003).
2. Thomas Moses, Brian Durall, and Gregory Frankowiak, Magnetic birefringence in a liquid crystal : An experiment for the advanced undergraduate laboratory, Am. J. Phys. 68 (3), 2000.
3. Leontina Nasta, Rodica Moldovan, Mihaela Tintaru, Practical works of laboratory : Optoelectronic methods for display with liquid crystals, Bucharest University Press, Bucharest, 1997 (in Rom).
4. Open-access interactive applications, via INTERNET.
5. Laboratory work reports.

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

- By attending this course, the graduate students will learn new scientific concepts on material science and they will be able to integrate the specific and interdisciplinary knowledge into professional activity.

9. Evaluation

Type of activity	9.1. Evaluation criteria	9.2. Evaluation methods	9.3. Share of final grade
9.4. Course	• Correct understanding of the course topics. • The attendance of at least 10 lectures. • The final exam may be taken only if the student has accomplished all practical works	a written exam	70%
9.5. Laboratory	• The activity in the laboratory. • The quality of the laboratory reports.	a written test and the writing of a report on a topic related to the course.	30%
Minimum performance standard	Grades are from 1 to 10. The exam is passed only if the final grade is at least 5.		

Date of completion:

21.06.2025

Course holder's signature,
Lecturer PhD Mariana Duca

Laboratory holder's signature,
Lecturer PhD Mariana Duca

Date of approval in the

Signature of the Head of Department,

department:

Lecturer PhD Adina Raducan

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	I	2.5. Semester	2	2.6. Type of evaluation	V	2.7.Discipline regime	DAPROF /DOB

3. Total estimated time

3.1. Number of hours per week	4	3.2. Of which Course	-	3.3. Laboratory	4
3.4. Total curriculum hours	56	3.5. Of which Course	-	3.6. Laboratory	56

Time fund distribution	hours
Study from the textbook, course materials, bibliography and notes	10
Additional documentation in the library, on specialized electronic platforms and in the field	10
Laboratory research and report writing	60
Tutoring	4
Other activities: Examination	10
3.7. Total hours of individual study	94
3.8. Total hours per semester (3.4 + 3.7)	150
3.9. Number of credits	6

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. Establishing the experimental work stages and associated timetable. For each stage the following shall be established: reagents/ consumables required availability of working technique; availability of analytical and physical-chemical investigation techniques; deadline for completion of the step	Explanation; Conversation; Description; Exemplification; Experimental activity	6 h
7.2.2. Determination of factors relating to: how the established steps are conducted; what are the expected results; how to interpret the experimental data; verification of knowledge of the fundamental principles associated with the work/research used in the work step. Completion of the planned experimental steps.		30 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 2. Preparation of the PowerPoint presentation for the defense of the report 2.		10 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;	Verification through ppt presentation	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