4th Semester

Inorganic Materials Chemistry

1. GENERAL			
SCHOOL	Faculty of Sciences in collaboration with Faculty of Engineering, Aristotle University of Thessaloniki		
DEPARTMENT	Materials Science and Engineering		
LEVEL OF STUDIES	ISCED level 7 (5-year Integrated Master's programme) ISCED level 6 (4-year BSc programme)		
COURSE CODE	**MSEN 401**	**SEMESTER**	4th Semester
COURSE TITLE	**Inorganic Materials Chemistry**		
TEACHING ACTIVITIES Lectures, tutorials/problem sessions, laboratory/computer exercises (where applicable), case studies and guided self-study.		**TEACHING HOURS PER WEEK**	**ECTS CREDITS**
		4	6
COURSE TYPE	Background, General Knowledge		
PREREQUISITES	No prerequisities		
TEACHING AND EXAMINATION METHODS	English		
COURSE OFFERED TO ERASMUS STUDENTS	Yes		
COURSE URL	https://elearning.auth.gr/course/view.php?id=xxxxx		

2. LEARNING OUTCOMES	
Learning Outcomes	By the end of this course, students will be able to: • Understand and explain the structures of various types of inorganic materials (metals, ionic materials, molecular materials, and nanostructured materials). • Describe the factors that control the stability of inorganic materials. • Interpret electronic structure concepts in inorganic materials (band theory, conductivity, and semiconduction). • Summarize the range of synthesis routes for inorganic materials. • Understand the principles of major characterization tools of inorganic materials. • Connect structures to function for key classes of inorganic materials used in catalysis, energy storage, optics, semiconductors, and nanotechnology. By the end of this course, students will acquire skills to:

	• Describe crystal structures of inorganic materials. • Predict structure types of inorganic materials. • Evaluate band structures and relate them to conductivity and semiconducting behavior. • Choose suitable synthesis and characterization techniques for a given inorganic material. • Interpret experimental data from characterization methods of inorganic materials. • Assess how structural features influence ionic transport, catalytic activity, optical performance, and nanoscale behavior. By the end of the course, students will be able to: • Propose synthesis and characterization strategies for specific inorganic materials. • Critically judge structure property relationships in advanced solids, including nanostructures and porous frameworks. • Apply foundational concepts to emerging materials for energy, electronics, catalysis, and storage. • Communicate materials chemistry concepts clearly in written and oral formats.
General Skills	By the end of this course, students will be able to: Upon successful completion of the course, students will strengthen their: • Analytical thinking and quantitative reasoning. • Problem solving using chemical principles applied to inorganic real materials. • Ability to connect theory with practical characterization data. • Scientific communication skills, both written and spoken. • Ability to work with structured information such as diagrams, models, and datasets. • Capacity to engage in self-directed learning and literature exploration.

3. COURSE CONTENT

Part 1 – Structures of inorganic materials

- Description of the structures of inorganic materials - Unit cells and the description of crystal structures; Symmetry in crystal structures; The close packing of spheres; Holes in close-packed structures.
- The structures of metals and alloys - Polytypism; Nonclose-packed structures; Polymorphism of metals; Atomic radii of metals; Alloys and interstitials.
- The structures of ionic materials - The rationalization of structures; The

energetics of ionic bonding; Lattice enthalpy and the Born-Haber cycle; The calculation of lattice enthalpies; Comparison of experimental and theoretical values; The Kapustinskii equation; Consequences of lattice enthalpies.

- Defects and nonstoichiometry - The origins and types of defects; Nonstoichiometric compounds and solid solutions.

Part 2 – Electronic structures of inorganic materials

- The conductivities of inorganic solids; Band theory in inorganic solids; Semiconduction.

Part 3 – Synthesis and characterization of inorganic materials

- Synthesis of inorganic materials - Direct synthesis at high temperatures; Solution methods.
- Physical methods for characterizing inorganic materials – Diffraction methods; Absorption and emission spectroscopies; Ionization-based techniques; Chemical analysis; Magnetometry and magnetic susceptibility; Electrochemical techniques; Microscopy

Part 4 – Key classes of inorganic materials

- Defects and ion transport - Extended defects; Atom and ion diffusion; Solid electrolytes.
- Metal oxides, nitrides, and fluorides: Monoxides of the 3d metals; Higher oxides and complex oxides; Oxide glasses; Nitrides, fluorides, and mixed-anion phases.
- Sulfides, intercalation compounds, and metal-rich phases - Layered MS_2 compounds and intercalation; Chevrel phases and chalcogenide thermoelectrics.
- Framework structures and heterogeneous catalysis in porous materials - Structures based on tetrahedral oxoanions; Structures based on linked octahedral and tetrahedral centres; Zeolites and microporous structures in heterogeneous catalysis.
- Hydrides and hydrogen-storage materials - Metal hydrides; Other inorganic hydrogen-storage materials.
- Optical properties of inorganic materials - Colored solids; White and black pigments; Photocatalysts.
- Semiconductor chemistry - Group 14 semiconductors; Semiconductor systems isoelectronic with silicon.
- Molecular materials - Molecular materials chemistry.
- Nanomaterials - Synthesis and characterization of nanomaterials.
- Nanostructures and properties - One-dimensional: carbon nanotubes and inorganic nanowires; Two-dimensional: graphene, quantum wells, and solid-state superlattices; Three-dimensional: mesoporous materials and composites; Special optical properties of nanomaterials.

Heterogeneous nanoparticle catalysts - The nature of heterogeneous catalysts; Reactions involving heterogeneous nanoparticle catalysts

4. LEARNING & TEACHING METHODS - EVALUATION	
Teaching method	Face-to-face.

<table>
<tr><td>Use of ICT</td><td>ICT will be used in teaching the course, and in communication with students:
• teaching of the course with modern distance learning (ZOOM) and asynchronous education tools via elearning platform of AUTH,
communication with students via email, ZOOM, and elearning platform of AUTH.</td></tr>
<tr><td>Teaching organization</td><td>The supervised and unsupervised workload per activity is indicated below (total workload complies with ECTS standards).
<table>
<tr><th>Activity</th><th>Workload/semester (hours)</th></tr>
<tr><td>Lectures</td><td>52</td></tr>
<tr><td>Bibliographic written, research and problem solving</td><td>32</td></tr>
<tr><td>Tutorial</td><td>32</td></tr>
<tr><td>Written assignments</td><td>32</td></tr>
<tr><td>Exams</td><td>2</td></tr>
<tr><td>Total</td><td>150</td></tr>
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<tr><td>Student evaluation</td><td>Assessment language
The assessment language is English.
Assessment methods
The course uses the following methods:
• Multiple choice tests: two midterm exams to check recall of definitions, concepts, and terminology on core concepts on inorganic materials.
• Problem solving assignments: two written assignments in which students review course material, analyze literature data, and solve problems on inorganic materials.
• Final written exam: it combines short answers, problem solving, and data interpretation questions to evaluate cumulative understanding on core concepts of inorganic materials.
Weighting
• Multiple choice tests): 20%
• Problem solving assignments: 20%
• Final written exam: 60%

Student information
Students are informed about the assessment process through:
• The course outline distributed in the first lecture.
• Detailed instructions for the written assignment and presentation posted on the course website.
• A dedicated assessment briefing during tutoring time where expectations and criteria are explained.</td></tr>
<tr><td colspan="2">5. SUGGESTED BIBLIOGRAPHY</td></tr>
<tr><td colspan="2">EUDOXUS</td></tr>
<tr><td colspan="2">M.T. Weller, J. Rourke, F.A. Armstrong, S. Lancaster, T. Overton, Inorganic chemistry. 8th edn. Oxford University Press (2025)</td></tr>
</table>

E.A. Moore and L.E. Smart, Solid state chemistry: an introduction. 5th ed. CRC Press (2020). A.R. West, Solid state chemistry and its applications, 2nd edn. John Wiley & Sons (2014). M.T. Weller, Inorganic materials chemistry. Oxford Chemistry Primers 23. Oxford University Press (1994).
Additional bibliography for study
• Teaching material slides