Future Materials for Sustainability

Educational subject description sheet

Basic information

Field of study Joint Bachelor in Sustainability	**Education cycle** 2025/26
Speciality Sustainable Physics & Chemistry	**Subject code** UJ.WPAJBSSPCS.8100.16411.25
Organizational unit Faculty of Law and Administration	**Lecture languages** english
Study level first cycle (joint degree programme)	**Subject related to scientific research** Yes
Study form full-time degree programme	**Disciplines** Chemical sciences, Physical sciences
Education profile General academic	**ISCED classification** 0588 Interdisciplinary programmes involving broad field 05
Mandatory obligatory	**USOS code**

Subject coordinator	Marlena Gryl
Lecturer	Andres Guerrero, Arantzazu Mascaraque, Albertina Cabañas, Maria Josefa Herrero, Miguel Angel Gonzalez, Piotr Kuśtrowski, Sebastian Jarczewski, Dariusz Matoga, Elżbieta Szostak, Ewelina Lipiec, Jakub Rysz, Timo Leskinen, Mohammad Alzeer

Period	**Examination**	**Number of ECTS points**
Semester 5	exam **Activities and hours** Discussion class: 42	5.0

Goals

C1	The course explores the vital role of raw materials in modern technologies and their environmental impact, while aligning with circular economy principles. The course provides a foundation to green materials science concepts, the environmental implications of new materials, and their contribution to a sustainable society. In addition, students will be introduced to the legal, economic, and sociological dimensions of emerging sustainable materials as well as the evolving paradigms of technological advancement for driving meaningful change.

Subject's learning outcomes

Code	Outcomes in terms of	Effects	Examination methods
Knowledge – Student knows and understands:			
W1	raw materials and their utilization, including in green energy technologies.	JBS_K1_W05, JBS_K1_W06	written exam, credit with grade
W2	nanomaterials, catalysts, and adsorbents for environmental applications.	JBS_K1_W07	written exam, credit with grade
W3	sustainable polymers, gas storage materials, and photovoltaic cells.	JBS_K1_W04	written exam, credit with grade
W4	bioaspects of future materials, materials characterization techniques, and materials for environmental remediation	JBS_K1_W05	written exam, credit with grade
Skills – Student can:			
U1	evaluate the environmental impact of raw materials and relate their demand to circular economy principles and integration into green technologies, along with analytical skills to evaluate the impact of new materials on the environment and the remediation and obtaining of resources.	JBS_K1_U01, JBS_K1_U03	written exam, credit with grade
U2	analyze how current applications and developing future materials contribute to a sustainable society.	JBS_K1_U02	written exam, credit with grade
U3	apply general concepts related to green materials science and its metrics.	JBS_K1_U04	written exam, credit with grade
Social competences – Student is ready for:			
K1	to engage in discussions on the legal, economic, and sociological dimensions of emerging sustainable materials, along with the ability to associate evolving paradigms of technological advancement and their societal implications.	JBS_K1_K01, JBS_K1_K03	written exam, credit with grade
K2	to explore the role of future materials in circular economy and sustainability, particularly in the European context.	JBS_K1_K02	written exam, credit with grade
K3	to participate in discussions on micro-problems of the macro-world, such as sustainable development challenges in the plastic era.	JBS_K1_K04	written exam, credit with grade

Calculation of ECTS points

Activity form	Activity hours*
Discussion class	42
preparation for classes	41
paper preparation	20
preparation for the exam	38

Student workload	Hours 141	ECTS 5.0

* hour means 45 minutes

Study content

No.	Course content	Subject's learning outcomes
1.	Raw materials, definition, current and future utilization of raw materials – examples (3h)	W1, U1
2.	Priority raw materials, strategic raw materials, raw materials utilized in green energy technologies (1.5h)	W1, U1
3.	Sustainable strategies for the applications of raw materials (1.5 h)	W1, U1, U2
4.	Inorganic and carbon-based nanomaterials for sustainable future (definition, general information, controversy, health risk) (1.5 h)	W2, U1, U2
5.	Innovative catalysts, adsorbents and hybrid systems for elimination of VOCs and other purposes (1.5h)	W2, U1, U2
6.	Sustainable polymers and microplastics, challenges, environmental aspects and applications (3h)	W3, U1, U2
7.	Novel gas storage materials (nanoporous materials, metal hydrides) (1.5h)	W3, U1
8.	Proton-conducting materials (MOFs, COFs, HOFs) related to proton-exchange membrane fuel cells (1.5h)	W3, U1, U2
9.	Third generation photovoltaic cells, materials and technology 3h	W3, U1
10.	Bioaspects of future materials, biological materials for environmental protection; biomass (3h)	W4, U1
11.	Materials Characterization Techniques (1.5 h)	W4, U1
12.	Energy-efficient electronics and spintronics for the future digital society (1.5h)	U2, U3
13.	Sustainable structural materials for construction (1.5h)	W3, U1, U2
14.	Applications of materials in a green economy: advanced sensors, rear-earth free permanent magnets, energy harvesting (3h)	W2, W3, U1, U2
15.	Toxicity, pollution and environmental legislation for new materials (1.5h)	U1, K1
16.	Materials for environmental remediation (3 h)	W2, U1
17.	Fly ashes from energy sector as valuable anthropogenic resources useful for synthesis of advanced functional materials (1.5h)	U1
18.	Phenolic-enabled assembly of functional nanomaterials as versatile and powerful strategy for biomedicine (1.5h)	W2, U1, U2
19.	Materials for efficient valorization of CO2 (1.5h)	U1, U2
20.	Challenges facing the chemical technology and industry (sustainable development goals, green chemistry rules, European green deal, etc.) (discussion session 1.5h)	K1, K2
21.	Circular Economy and Sustainability in Europe: the role of the future materials. (discussion Session 1.5h)	K2
22.	Micro-problems of the macro-world, or how to follow the path of sustainable development in the ubiquitous plastic era (discussion Session 1.5h)	K3

Course advanced

Teaching methods :

conversation lecture, discussion

Activities	Examination methods	Credit conditions
Discussion class	written exam, credit with grade	final exam (50%) credit for group work: assignments (30%) & discussion session (20%)

Entry requirements

None

Literature

Obligatory

1. Lecture notes and provided scientific articles during lectures

Effects

Code	Content
JBS_K1_K01	The graduate can encourage sustainability-driven practices in the workplace and appraise sustainability of own values, perceptions, roles, and actions, with a special focus on environmental wellbeing.
JBS_K1_K02	The graduate can demonstrate considerable entrepreneurial initiative, autonomy, and readiness to act in complex and changing environments, especially in the context of supporting, undertaking, and co-organising activities beneficial for a sustainable society.
JBS_K1_K03	The graduate can consider different visions of the future and develop own evidence-based opinions in reference to the balance of values linked to economic development, social welfare, and environmental protection.
JBS_K1_K04	The graduate can critically assess and verbalize own competencies and skills related to different aspects of sustainability as well as their need for development.
JBS_K1_U01	The graduate can critically analyse academic literature, formulate research questions and conduct research under supervision.
JBS_K1_U02	The graduate can present and report knowledge, methodologies, ideas, problems and solutions, clearly and comprehensively, in different forms destined for different audiences – including discussions and debates which require defending a substantiated opinion, as well as conversations in a foreign language at the CEFR B2 level.
JBS_K1_U03	The graduate can apply adequate methods and tools, including selected IT tools, to solve problems related to data collection, analysis, and management in the context of sustainability.
JBS_K1_U04	The graduate can plan and effectuate simple sustainability-related projects under supervision and in the context of personal lifelong learning, both individually and in a team, using appropriate transversal skills and taking shared responsibility for the outcome.
JBS_K1_W04	The graduate can identify sustainability-related problems specific to selected cultural, geographical, and political contexts.
JBS_K1_W05	The graduate can identify essential international instruments and institutions related to sustainability and explain their potential role in resolution of a given problem.
JBS_K1_W06	The graduate can describe interconnections between various aspects of sustainability and identify their significance in the context of natural and social sciences, with a special focus on disciplines included in the selected specialisation track (law and politics; chemistry and physics; chemistry and biology; economics and geography; economics, management and engineering; humanities).
JBS_K1_W07	The graduate can apply the theory and methodology of disciplines included in the selected specialisation track to sustainability-related problems, taking into consideration practical limitations such as protection of intellectual property.