

Piano didattico a.a. 2026/2027 Corso: 6250-MATERIALS SCIENCE AND BATTERIES

Anno 1	Attività formativa	TIP	SSD	Ore fro.	Ore ese.	Ore lab.	Ore n.d.	Freq.	Ver.	CFU	CFU Sede	TAF	Amb.	TAF 2	Amb. 2	Obiettivi
Gruppo: Compulsory learning activities (TAF: Ambito: TAF seconda classe: Ambito seconda classe: CFU min: CFU max:)																
6250 000 000 C9271 - 0 - ADVANCES IN MATERIALS SYNTHESIS		CHIM/03		32	24	0	0		Voto	6		B				The objective of this course is to develop interdisciplinary expertise in battery materials. Students will explore the synthesis, structure, and electrochemical properties of key materials, both established and emerging in the field of research. Special emphasis is placed on nanostructured components for batteries
6250 000 000 C9266 - 0 - BATTERIES ENGINEERING (I.C.)				72	0	0	0		Voto							At the end of the course, the student will know how to manage battery systems and their interfaces with other conversion systems, including safety functions and reference regulations
Modulo integrato: C9267 - BATTERY MANAGEMENT AND MAINTENANCE: SYSTEMS, SENSORS AND SIGNAL ANALYSIS TOOLS		ING-IND/32		48	0	0	0			6		B				At the end of the course, the student will be aware of battery materials engineering fundamentals, from well-established metal-based solutions (i.e. lithium, cobalt, nickel, and graphite), towards the new perspectives of Organic Electrode Materials (OEMs) and nanomaterials. The full value chain of battery materials will be explored (sourcing, supply, processing, manufacturing and recycling)
Modulo integrato: C9268 - BATTERIES MATERIALS ENGINEERING		ING-IND/22		24	0	0	0			3		B				At the end of the course the student has acquired the theoretical and experimental basis for the comprehension and investigation of the physical-chemical processes associated to the heterogeneous electron transfer processes and their application in materials science, analytical chemistry and energy storage/conversion
6250 000 000 C9257 - 0 - ELECTROCHEMISTRY: FUNDAMENTALS AND APPLICATIONS		CHIM/02		24	24	16	0		Voto	6		B				The course provides educational experiences which challenge students to: i) become familiar with X-ray methods of analysis for the structural characterisation of materials; ii) understand their advantages, disadvantages, and applicability in materials chemistry and in battery materials; iii) perform a preliminary data reduction; iv) design and interpret spectroscopic operando/in-situ experiments
6250 000 000 C9272 - 0 - IN SITU AND IN OPERANDO TECHNIQUES CHARACTERIZATION		CHIM/01		32	24	0	0		Voto	6		B				The aim of the course is to learn about, understand and apply LCA (Life Cycle Assessment) methodology to estimate the environmental effects associated with products, manufacturing systems and services, with a specific focus on the life cycle of batteries; to know common software and databases to model industrial processes and to predict potential environmental impacts; to acquire knowledge to support process design and sustainable material procurement planning; to interpret and use sustainability indicators
6250 000 000 C9261 - 0 - LIFE CYCLE ASSESSMENT OF BATTERIES		CHIM/12		48	0	0	0		Voto	6		C				The aim of the course is to learn about, understand and apply LCA (Life Cycle Assessment) methodology to estimate the environmental effects associated with products, manufacturing systems and services, with a specific focus on the life cycle of batteries; to know common software and databases to model industrial processes and to predict potential environmental impacts; to acquire knowledge to support process design and sustainable material procurement planning; to interpret and use sustainability indicators
6250 000 000 C9269 - 0 - MATERIALS AND ELECTROCHEMISTRY (I.C.)				80	12	16	0		Voto							This module provides an overview of the available technologies for the conversion and storage of renewable energy, e.g. solar energy technologies, thermoelectrics, and mechanical energy harvesting. Special emphasis is devoted to electrochemical energy conversion and storage technologies. Students will explore the most important parameters that define their efficiency and environmental impact, as well as the materials properties required to their optimization. The course highlights the comparison of specific figures of merit for the discussed technologies, providing the students with a complete overview of the topic, spanning from the underlying physical processes involved, to the engineering of the device
Modulo integrato: C9264 - RENEWABLE SOURCES AND ENERGY CONVERSION SYSTEMS		FIS/03		40	12	0	0			6		B				At the end of the course the student has acquired basic and technological knowledge of the most advanced battery, battery materials and components, with a view to sustainability e safety
Modulo integrato: C9263 - ELECTROCHEMICAL STORAGE/CONVERSION SYSTEMS		CHIM/02		40	0	16	0			6		B				This course explores the synergy between machine learning, artificial intelligence, and materials research, aiming to accelerate the discovery, optimization, and deployment of advanced materials and technologies. Students will explore data-driven methodologies to design and analyze materials and solutions for next-generation batteries, with a primary focus on Lithium-ion systems. Key topics include data collection and mining, machine learning techniques, data-driven materials discovery and structure-property relationships. The course includes practical, hands-on labs where students will apply ML techniques to selected problems and case studies. By the end of the course, participants will be equipped with the skills to harness AI and ML tools to drive innovation in battery research and development.
6250 000 000 C9270 - 0 - MATERIALS INFORMATICS (I.C.)				48	24	64	0		Voto							Understanding of thermodynamic and kinetic processes in complex heterogeneous interfaces. Knowledge of main computational tools to model interfacial phenomena at the nanoscale. Ability to integrate modelling and experimental techniques to derive structure-property relationships.
Modulo integrato: C9259 - AI AND DATA DRIVEN MATERIALS		FIS/03		24	12	32	0			6		B				The class provides a comprehensive introduction to the field of interfaces linking fundamental principles with applications and laboratories. The class focuses on the essential concepts rather than specific details, on intuitive understanding rather than learning facts. Students will acquire the ability to: i) apply fundamental thermodynamic and kinetic principles to describe and analyze interfaces in liquids, solids, and soft matter systems; ii) interpret and model key interfacial behaviors, such as wetting, adsorption, surface tension, and friction, using simplified but robust physical frameworks; iii) evaluate the role of interfaces in real-world technologies, including batteries, microelectronic devices, sustainable materials, and biotechnological systems; iv) solve practical problems involving interfaces through structured reasoning and analytical methods practiced in exercise sessions; v) critically assess experimental data related to surface and interfacial phenomena and understand the principles behind relevant laboratory techniques
Modulo integrato: C9260 - MODELLING OF MATERIALS INTERFACES		CHIM/02		24	12	32	0			6		B				The class provides a comprehensive introduction to the field of interfaces linking fundamental principles with applications and laboratories. The class focuses on the essential concepts rather than specific details, on intuitive understanding rather than learning facts. Students will acquire the ability to: i) apply fundamental thermodynamic and kinetic principles to describe and analyze interfaces in liquids, solids, and soft matter systems; ii) interpret and model key interfacial behaviors, such as wetting, adsorption, surface tension, and friction, using simplified but robust physical frameworks; iii) evaluate the role of interfaces in real-world technologies, including batteries, microelectronic devices, sustainable materials, and biotechnological systems; iv) solve practical problems involving interfaces through structured reasoning and analytical methods practiced in exercise sessions; v) critically assess experimental data related to surface and interfacial phenomena and understand the principles behind relevant laboratory techniques
6250 000 000 C9255 - 0 - MATERIALS INTERFACES		FIS/03		40	12	0	0		Voto	6		B				The class provides a comprehensive introduction to the field of interfaces linking fundamental principles with applications and laboratories. The class focuses on the essential concepts rather than specific details, on intuitive understanding rather than learning facts. Students will acquire the ability to: i) apply fundamental thermodynamic and kinetic principles to describe and analyze interfaces in liquids, solids, and soft matter systems; ii) interpret and model key interfacial behaviors, such as wetting, adsorption, surface tension, and friction, using simplified but robust physical frameworks; iii) evaluate the role of interfaces in real-world technologies, including batteries, microelectronic devices, sustainable materials, and biotechnological systems; iv) solve practical problems involving interfaces through structured reasoning and analytical methods practiced in exercise sessions; v) critically assess experimental data related to surface and interfacial phenomena and understand the principles behind relevant laboratory techniques
Anno 2	Attività formativa	TIP	SSD	Ore fro.	Ore ese.	Ore lab.	Ore n.d.	Freq.	Ver.	CFU	CFU Sede	TAF	Amb.	TAF 2	Amb. 2	Obiettivi
Gruppo: Compulsory learning activities (TAF: Ambito: TAF seconda classe: Ambito seconda classe: CFU min: CFU max:)																
6250 000 000 C9508 - 0 - FINAL EXAMINATION				0	0	0	0			3		E				At the end of the activity, the student has gained critical capabilities, communication skills and the ability to write and discuss in English, clearly and autonomously, the results obtained during the research project. The final test will consist in the discussion in English in front of a jury of the thesis that will be written in English
6250 000 000 C9379 - 0 - HOW TO WRITE A RESEARCH PROJECT				12	0	0	0		Giudizio	2		F				At the end of the course, students are able to identify the steps that lead to the construction of a research project and will have an understanding of how to write projects in terms of background, state-of-the-art, workpackages, milestones, and deliverables
6250 000 000 95999 - 0 - INTERNSHIP				0	0	250	0		Giudizio	10		F				At the end of the activity, the student develops an original scientific project at a research laboratory, in Italy or abroad, at either a public or private institution, working in the field of materials, acquiring data for the dissertation and final examination. The students acquire the competencies to work independently, carry out experimental investigations by means of synthetic, characterization and/or computational tools, and make operational proposals, both from an experimental and theoretical point of view, to increase the knowledge on the topic under investigation

6250 000 000 C9509 - 0 - INTERNSHIP FOR THE PREPARATION FOR THE FINAL EXAMINATION		0	0	425	0	Giudizio	17	E	At the end of the activity, the students are able to present results related to the processing, organization, and use of independently produced data in order to prepare scientific reports. They will be able to critically evaluate their own work and be proactive regarding the continuation of their research work
6250 000 000 C9378 - 0 - SEMINARIO DI ITALIANO		6	0	0	0	Giudizio	1	F	At the end of the course the student is able to contextualize, analyze and rework in Italian - using web resources - the information collected in the activities of bibliographic research
Gruppo: Elective Learning Activities (TAF: C Ambito: 999 TAF seconda classe: Ambito seconda classe: CFU min: 12 CFU max: 12)									
6250 000 000 C9514 - 0 - ADVANCED MATERIALS MODELLING FOR BATTERIES	FIS/03	32	12	16	0	Voto	6	C	At the end of the course the students will learn how to design materials for batteries and simulate their functioning by means of advanced computational methods that extend the capabilities of current battery modelling methodology. The atomistic and nanometer length scales processes occurring in batteries will be described by means of machine learning molecular dynamics, affording quantum-mechanical accuracy yet being many orders of magnitude faster. Improved materials for batteries will be searched by means of high throughput calculations that allow to screen thousands of materials in parallel in an automatized way. The generated databases will be analyzed by artificial intelligence to identify general trends and predict key features to guide the experimental design of batteries
6250 000 000 C9510 - 0 - BIG DATA ANALYSIS	CHIM/02	24	24	16	0	Voto	6	C	At the end of the course, the student has the fundamental knowledge needed to work with large databases and move forward with an exploratory analysis of the data that has been produced. A student will also be able to de-noise a data set and identify stationary and non-stationary time series. With the latter, the student will be able to learn more about the fundamental mechanisms that a data set describes and apply this understanding to either direct forecasting or as the starting feed to an AI model
6250 000 000 C9511 - 0 - BIO-BASED MATERIALS AND ELECTROCHEMISTRY	CHIM/02	32	12	16	0	Voto	6	C	By the end of the course, students have acquired knowledge necessary to understand: the chemical and biological basis of bio-based and biofabricated materials; the functioning and applications of bioelectrochemical systems; biotechnological strategies to engineer functional material; the environmental and industrial implications of biologically derived materials
6250 000 000 C9518 - 0 - INDUSTRIAL LECTURES	FIS/03	48	0	0	0	Voto	6	C	This course will introduce students to relevant aspects related industrial R&D and, in general, serves a critical role in bridging academic knowledge with real-world industrial applications. Through direct engagement with professionals from the relevant industrial sectors, students are expected to acquire a combination of technical, professional, and transferable skills that enhance their readiness for employment or further research in the field
6250 000 000 C9516 - 0 - INTELLECTUAL PROPERTY AND TECHNOLOGY TRANSFER	CHIM/01	48	0	0	0	Voto	6	C	The course provides theoretical knowledge and practical tools on intellectual property (IP) management and technology transfer (TT), focusing on how academic and industrial inventions are protected, valorized and commercialized
6250 000 000 C9515 - 0 - LABORATORY OF MATERIALS AND SUSTAINABLE FABRICATION PROCESSES	FIS/03	32	0	32	0	Voto	6	C	The course aims to provide students with an advanced understanding of the main physical techniques for materials characterization, with a strong emphasis on experimental practice and applications in energy-related materials (batteries, fuel cells, catalysts). Upon completion of the course, students will be able to: • understand the physical principles behind the most relevant characterization techniques for energy materials; • select and apply appropriate experimental methods depending on the material and the analysis objectives targeting sustainability of processes; • communicate experimental outcomes clearly, both in written reports and oral presentations
6250 000 000 C9512 - 0 - MULTISCALE MODELLING FOR INDUSTRIES	ING-IND/26	32	12	16	0	Voto	6	C	The course provides an overview of key simulation tools for systems of industrial relevance—such as reactive, multiphase, and soft matter systems—across multiple scales, from discrete to continuum. Emphasis is placed on macroscopic modeling approaches, including fluid dynamics simulations and porous media theory. By the end of the course, students will be able to identify the most appropriate modeling approaches for simulating systems at different relevant scales—from the molecular level to the mesoscale and up to the macroscale—and will have gained a foundational understanding of methods for coupling different modeling techniques
6250 000 000 C9517 - 0 - POLYMERS, COMPOSITE MATERIALS AND SUSTAINABLE INDUSTRIAL CHEMICAL PRODUCTION FOR BATTERIES	CHIM/04	48	0	0	0	Voto	6	C	Sustainable and green industrial chemical production of the materials and chemicals used in batteries components, such as electrodes and electrolytes, including active materials, solvent, conductive materials, matrix and binders and their potential sustainable alternatives. Chemistry and technology of polymers and polymer-based composite materials for battery applications. The peculiar polymer properties, such as their lightness, robustness, low cost, flexibility and easy processability in terms of potential energy storage. Application of polymer-based materials as electrolytes, separators and electrodes
6250 000 000 C9513 - 0 - SPECTROSCOPY OF MATERIALS	CHIM/02	32	12	16	0	Voto	6	C	Basics and advanced theoretical and experimental approaches to the spectroscopic investigation and characterization of material properties. Knowledge of key methodologies for interpreting, modeling, and measuring spectroscopic observables of molecules and materials in a variety of spectral windows. Ability to combine theoretical modelling and experiments to infer structure-property relationships

Gruppo: Free choice learning activities (TAF: D Ambito: 999 TAF seconda classe: Ambito seconda classe: CFU min: 12 CFU max: 12)