UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Chemistry of Inorganic Materials

2627-1-FSM02Q005

Aims

This course describes and discusses the properties of inorganic solids and some advanced methods for the synthesis of functional inorganic materials.
This course aims at contributing to the specific theoretical and experimental knowledge on the properties of inorganic materials, as well as their application to their synthesis and characterization. Students will acquire basic knowledge about relevant advanced inorganic materials and synthetic methods with process parameters. This will enable the student to select approach, method and parameters best suited to fully control and optimize the synthesis of inorganic functional materials. This course logically completes the teachings of Chimica Inorganica delle Formulazioni and Chimica di Coordinazione e Metallorganica.

Knowledge and understanding: The course aims to develop a critical mindset focused on examining and understanding the typical processes for preparation of inorganic materials. Students will be enabled to confidently use concepts and interpretative tools for the topics discussed during the lectures.
Applying knowledge and understanding: By the end of the course, students will be proficient in concepts related to thermodynamics and kinetics applied to synthesis of varied types of inorganic materials, including exploitation of inorganic solids in industrial and research processes.
Making judgements: Through frequent interactions with students in class, the course will encourage the development of independent judgment.
Communication skills: the course aims to improve the communication skills. To this end, exams are performed with oral interaction between student and the instructors. Students are encouraged to focus on communication aspects during their learning process, with particular emphasis on technical and scientific language.
Learning skills: the course seeks to improve the learning abilities through the discussion of recent scientific publications related to its topics. The student will develop her/his learning skills by exploiting also the scientific literature, together with the communication skills, which will be evaluated during the exam.

Contents

Theory of chemical bonding in solids: metals, insulators, semiconductors. Advanced definitions of acids and bases, reactivity of molten salts, surface properties of inorganic materials. Distribution of chemical elements within the Earth's crust and their extraction. Advanced synthesis of functional materials (single crystals, polycrystalline powders, films, and ordered porous materials): synthesis of solids from the gas phase, from melts and solutions at low and high temperature, low and high pressure, exploitation of sol-gel processes.

Detailed program

Theory of chemical bonding in solids Band model, nearly-free electrons ad tight binding model, Hubbard model.

Availability and distribution of chemical elements within the Earth's crust: environmental and technological issues for extraction of elements involved in synthesis of inorganic materials.

Synthesis of solids from the gas phase: Chemical and Physical Vapor Deposition (with sister techniques such as sputtering, thermal evaporation, vapor phase epitaxy, Chemical Vapor Infiltration, ..) with kinetic models, reactor types, features od reactants

Synthesis of solids from melts and solutions: crystal growth from the melt: general features and special techniques (Verneuil, Bridgman-Stockbarger, Czochralski, Kyroupolos, Skull method, Floating zone). Growth from low and high temperature solutions (solvothermal and hydrothermal processes, flux growth). Precipitation reactions and control of crystal morphology. The role of additives/impurities.

Reactivity and stability of inorganic materials:: Advanced definitions of acids and bases, acid/base properties of inorganic material, redox properties of inorganic materials, phase diagrams and stability in water and other solvents

Surface Chemistry of inorganic materials: Differences in reactivity of various facets of inorganic materials. Effects of nanostructuring. Surface functionalization. Intercalation phenomena in layered materials-

Prerequisites

Chemistry of inorganic materials is based on an interdisciplinary approach exploiting general and inorganic chemistry, organic chemistry, physical chemistry (thermodynamics and chemical equilibria), general physics, and basic knowledge of crystallography.

Teaching form

The course provides 24 two-hour lectures, in person (Delivered Didactics). Lectures will be given in English supported by video projection of text, schemes, diagrams, pictures and movies.

Textbook and teaching resource

Reference general textbook:
Synthesis of inorganic materials - U. Schubert, N. Hüsing - (2019) - ebook

Reference textbooks:

- The inorganic chemistry of materials: how to make things out of elements - P.J. van der Put - (1998)
- Solid state chemistry. Compounds - Eds. A.K. Cheetham, P. Day - (1992)
- Modern inorganic chemistry synthesis – R. Xu, W. Pang, Q. Huo Eds. - (2017) – ebook
- Inorganic chemistry – D. F. Shriver, P. W. Atkins, C. H. Langford – Oxford University Press (1990)
- Inorganic chemistry – J. E. Huheey – Harper & Row Eds. (1983)

Lecture handouts will be provided as pdf files uploaded on the e-learning platform.

Semester

1?? semester, starting on September 2026

Assessment method

The examination is performed through an oral exam without midterm tests. The grade is attributed according to the following criteria:
High grades (28-30 cum laude):
Knowledge and understanding: The student acquired excellent and deep knowledge, and shows excellent capability of autonomous reasoning on the covered topics.
Applied knowledge and understanding: The student is able to analyze with full success a real case study, using the acquired conceptual tools.
Communication and learning skills The student can fluently and appropriately answer to the questions, recurring also to graphic and symbolic representations. Only small formal errors are reported.

Intermediate grades (23-27):
Knowledge and understanding: The student acquired good knowledge, and shows good capability of autonomous reasoning on the covered topics.
Applied knowledge and understanding: The student is able to analyze with partial success a real case study, using the acquired conceptual tools.
Communication and learning skills The student can partially answer to the questions, recurring also to graphic and symbolic representations. Few substantial errors are also reported.

Low grades (18-22):
Knowledge and understanding: The student acquired fair knowledge, and shows fair capability of autonomous reasoning on the covered topics.
Applied knowledge and understanding: The student is able, if assisted, to analyze a real case study, using the acquired conceptual tools.
Communication and learning skills The student can fairly answer to the questions, recurring also to graphic and symbolic representations if assisted. Several substantial errors are reported.

Insufficient grade (lower than 18):
Knowledge and understanding: The student did not acquire sufficient knowledge, and does not show sufficient capability of autonomous reasoning on the covered topics.
Applied knowledge and understanding: The student is not able to analyze a real case study, using the acquired conceptual tools.
Communication and learning skills The student cannot formulate appropriate answers.

Office hours

The teacher is available for help and discussion by arranging a meeting by email to: sergio.tosoni@unimib.it.

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION