UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Chimica Inorganica II e Laboratorio

2627-3-E2702Q073

Aims

The course aims to provide students with advanced conceptual tools in inorganic chemistry, exploring the topics of symmetry, molecular orbitals, and electronic and magnetic properties. These principles will be applied to the understanding and spectroscopic characterization of coordination compounds and inorganic solids.

- Knowledge and Understanding
  The course aims to develop a critical approach to the analysis and understanding of advanced inorganic chemistry phenomena. By the end of the course, students will have acquired a solid mastery of the theoretical models and interpretative tools of the discipline.
- Applied Knowledge and Understanding
  By the end of the course, students will be able to apply the tools of molecular symmetry and the analysis of electronic and magnetic properties to interpret and solve complex problems related to inorganic systems, correlating theoretical models with experimental data.
- Independent Judgment
  The course aims to develop the ability to collect and critically interpret theoretical and experimental data, using them to solve complex problems related to the molecular and spectroscopic properties of inorganic systems. Students will be able to integrate their acquired knowledge to formulate independent judgments and scientifically based conclusions, even when faced with incomplete information.
- Communication Skills
  The course promotes the acquisition of rigorous and appropriate scientific language. Students will be encouraged, both during lectures and in the oral exam, to present complex chemical concepts with appropriate language, clarity, and the use of appropriate specialized terminology.
- Learning Skills
  Students develop the learning skills necessary to undertake further studies and research activities, mostly on a self-directed or independent basis.

Contents

Fundamentals: Group theory, point groups, symmetry, character tables, reducible and irreducible representations. Molecular orbital theory and perturbation theory. Crystal field theory and ligand field theory. Magnetism.
Physical methods in inorganic chemistry: Electron spectroscopy, vibrational spectroscopy, nuclear magnetic resonance spectroscopy, electron magnetic resonance spectroscopy.
Solid state of inorganic compounds: Synthesis and properties of some classes of inorganic solids, defects, micro- and macroporous structures, low-dimensional materials, nanostructures, nanoparticles.
Laboratory: Experiments in analyzing and recognizing symmetries in inorganic systems using dedicated software.

Detailed program

Fundamentals: Group theory, point groups, symmetry, elements/operations, matrix representation, character tables, reducible and irreducible representations. Molecular orbital theory, LCAO, projection operators, perturbation theory. Crystal field theory and ligand field theory. Magnetism and related interactions (magnetic field, electronic spin – nuclear spin, spin-orbit).
Physical Methods in Inorganic Chemistry: Electronic Spectroscopy (electronic transitions, Franck-Condon principle, transition dipole strength, spin-selection and symmetry rules, term symbols, Jahn-Teller effect, d-d transitions, vibronic coupling, Orgel and Tanabe-Sugano diagrams, spectrochemical series), Vibrational Spectroscopy (transition dipole moment, symmetry selection rules, normal modes of vibration), Nuclear Magnetic Resonance Spectroscopy (active nuclei, chemical shift, relaxation processes and mechanisms, relaxation times), Electron Magnetic Resonance Spectroscopy (Zeeman effect, hyperfine interaction, spin-orbit coupling, g-tensor, hyperfine tensor, anisotropy).
Solid state of inorganic compounds: Synthesis and properties of some classes of inorganic solids, defects, micro- and macroporous structures (zeolites, MOFs), low-dimensional materials (graphene, 2D materials), nanostructures and nanoparticles (gold, oxides, or carbon-based).
Laboratory: Three experiments analyzing and recognizing symmetries in inorganic systems using dedicated software.

Prerequisites

Basic knowledge of general, physical and inorganic chemistry.

Teaching form

28 two-hour lectures in person, Delivered Didactics
3 four-hour lab activities in person with mandatory attendance, Interactive Teaching

Textbook and teaching resource

Teaching resources in terms of slides and notes.

Textbooks:

Physical methods in chemistry by R. S. Drago (Saunders).

Symmetry and spectroscopy by D. C. Harris and M. D. Bertolucci (Dover).

Solid state chemistry by L. E. Smart and E. A. Moore (CRC Press).

Inorganic Chemistry by J. E. Huheey, E. A. Keiter, R. L. Keiter (Harper Collins).

Semester

From the teaching break of the first semester to the teaching break of the second semester.

Assessment method

The exam consists of a preliminary test to recognize the symmetry of a compound and an oral exam on the topics covered in class.

A passing grade (18-30L) is determined according to the following criteria:
18-19: knowledge of a limited number of topics covered in the course syllabus, with limited discussion and analysis skills that, in the oral exam, emerge only with the instructor's assistance and questions; presentation skills and vocabulary not always correct, with limited critical thinking skills;
20-23: knowledge of a portion of the topics covered in the course syllabus, independent analysis skills only on purely practical and executive issues, use of correct, though not entirely accurate and clear, vocabulary, and sometimes uncertain presentation skills;
24-27: knowledge of a wide range of topics covered in the course syllabus, ability to independently conduct argumentation and critical analysis, ability to apply knowledge to contexts and connect themes to concrete cases, use of correct vocabulary, and proficiency in the use of disciplinary language;
28 – 30/30L: complete and comprehensive preparation on the exam topics, ability to independently address and critically analyze topics, ability to reflect and self-reflect, and ability to connect themes to concrete cases and different contexts, excellent critical and independent thinking skills, full command of disciplinary vocabulary and rigorous and detailed presentation skills, ability to argue, reflect, and self-reflect, and ability to make connections to other disciplines.

Office hours

The professor receives by appointment.

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY | RESPONSIBLE CONSUMPTION AND PRODUCTION