Course guide
230864 - BMSC - Biophysical and Materials Science Characterisation

Last modified: 14/12/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: MASTER'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2018). (Optional subject).
ERASMUS MUNDUS MASTER'S DEGREE IN BIO & PHARMACEUTICAL MATERIALS SCIENCE (Syllabus 2021). (Optional subject).

Academic year: 2023 **ECTS Credits:** 4.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS

Knowledge of thermodynamics and solid state physics

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Basic:
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context

TEACHING METHODOLOGY

The weekly teaching hours are distributed in theoretical and practical classes, including laboratory sessions. During the theoretical classes, the main concepts and results are explained, with examples to help their understanding. During the practical lessons, typical problems are solved, as well as more conceptual questions.

LEARNING OBJECTIVES OF THE SUBJECT

The aim of the course is to provide an introduction to chemical physics, especially to: liquid solutions (both electrolyte & nonelectrolyte), polyelectrolyte biopolymers, hybrid materials, solid solutions, and heterogenous materials, and on the relevant characterization techniques. On successful completion of the course students will be able to choose the appropriate experimental techniques for a specific purpose, and have a basic knowledge of the chemical physics of aqueous & biological solutions and complex materials.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	30.00
Self study	64,0	64.00
Hours small group	6,0	6.00

Total learning time: 100 h

CONTENTS

Physicochemistry of solutions

Description:
Introduction to inorganic chemical physics of electrolyte & nonelectrolyte solutions: Types of solutions. Thermodynamics of solutions (entropy, free energy and chemical potential; phase diagrams).
Properties of water: The hydrogen bond, solubility of molecules in water, polar and non-polar solvents. Electrical permeability of water. Dissociation: acids and bases, protonation.
Properties of solutions: functional groups, hydrophilic and hydrophobic interactions; solubility; diffusion. Colligative properties: boiling-point elevation, freezing point depression, osmotic pressure. Surface tension, capillarity. Water phase diagram and anomalies; aqueous electrolytes; non-electrolyte solutions.
Electrostatics for salty solutions: biopolymers (polyelectrolytes) and biomembranes in water; Poisson-Boltzmann equation, Debye-Hückel model, electric double layers, ion and proton conduction; transport properties.

Specific objectives:
Be able to understand the fundamentals of electrolyte and non-electrolyte solutions, including technical literature in this area

Related activities:
Hand-in exercises
Reading and discussion of a technical paper on this topic

Full-or-part-time: 39h
Theory classes: 14h
Self study : 25h

Applications to pharmaceutics, drug formulation, & biophysical pharmacology

Description:
- Optical microscopy: bright field, dark field, fluorescence, and confocal microscopy. Superresolution microscopy
- Experimental techniques for electrolyte and non-electrolyte solutions
- Small Molecules (drugs): HPLC, Chromatography, Mass spectroscopy, ICP-MS
- Characterization of Nanoparticles: Molecular sizes (Dynamics light scattering, DLS), Surface charge (zeta potential, with conductivity measures)
- Characterization of Biomolecules: chromatography, gel electrophoresis, Western Blot

Specific objectives:
To have knowledge and understanding of different experimental techniques used in biophysical characterization

Related activities:
Hand-in exercises
Presentation of a report on one of the experimental techniques studied

Full-or-part-time: 11h
Theory classes: 4h
Self study : 7h

Physicochemistry of solids

Description:
Introduction to inorganic solid-state chemical physics (cohesive interactions; organic solids and salts); structural and mechanical properties of homogeneous solids; non-miscible systems: morphology and properties of phase-separated materials

Specific objectives:
Be able to understand the fundamentals of solid-state physical chemistry, including technical literature in this area

Related activities:
None

Full-or-part-time: 21h
Theory classes: 7h
Self study : 14h

Laboratory techniques

Description:
- Elemental analysis: photoelectron & mass spectroscopy (XPS, UPS, Auger, secondary ion mass spectroscopy)
- Chemical analysis: optical and vibrational spectroscopy (UV-vis, IR, Raman), nuclear magnetic resonance (NMR)
- Morphological analysis: contact angle, powder X-ray diffraction (XRD), tomography (microCT), NMR-imaging, electron microscopy (SEM, TEM, energy loss/secondary electron spectroscopy)
- Phase-change analysis
- Mechanical, electrical and optical characterization
- A pharmaceutical application: optical measurement of the dissolution kinetics and solubility of a drug

Specific objectives:
To have knowledge, understand, and know how to use different experimental techniques of materials characterization

Related activities:
Three laboratory sessions:

E1- Identification of Additives in Aspirin by FTIR spectroscopy
E2- SEM observation and analysis of a Bone implant
E3- Identification of Noble Metal Nanoparticles by UV-Vis spectrophotometry

Full-or-part-time: 29h
Theory classes: 1h
Laboratory classes: 10h
Self study : 18h

GRADING SYSTEM

To compute the final mark (FM) of the course, we will consider hand-in exercices (HE), a project during the first part of the course (P), laboratory reports (LR), and a final exam (FE), according to the formula:

FM=0.15*HE+0.2*P+0.35*LR+0.3*FE

EXAMINATION RULES.

The final exam has to be completed without the help of any notes
There are no activities that can be reevaluated

BIBLIOGRAPHY

Basic:
- Leake, Mark C. Biophysics : tools and techniques [on line]. Boca Raton, Fl: CRC Press, Taylor & Francis Group, 2016 [Consultation: 02/06/2022]. Available on: https://www-taylorfrancis-com.recursos.biblioteca.upc.edu/books/mono/10.1201/9781315381589/biophysics-mark-leake. ISBN 9781315381589.
- Norde, Willem. Colloids and interfaces in life sciences and bionanotechnology [on line]. 2nd ed. Boca Raton, FL: CRC Press, 2011 [Consultation: 02/06/2022]. Available on: https://www-taylorfrancis-com.recursos.biblioteca.upc.edu/books/mono/10.1201/9781439873038/colloids-interfaces-life-sciences-bionanotechnology-willem-norde. ISBN 9781439817186.

Complementary:
- Barrick, D.E. Biomolecular thermodynamics: from theory to application. Boca Raton: CRC Press, 2018. ISBN 9781439800195.
- Kjellander, R. Statistical mechanics of liquids and solutions: intermolecular forces, structure and surface interactions. Boca Raton: CRC Press Taylor & Francis Group, 2020. ISBN 9781482244014.

RESOURCES

Other resources:
Course notes and guides for the laboratory sessions