Module Descriptions

Master of Science Advanced Materials

Absorption: Biomaterials

Examination Regulations in the Version of: 2012
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# Materials Science I - Lecture and Laboratory

Modules referring to Materials Science

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## Coordinator
Prof. Dr. U. Herr, Faculty of Engineering and Computer Science

## Instructor(s)
Prof. Dr. U. Herr, Faculty of Engineering and Computer Science
Lecturers of the Faculty of Engineering and Computer Science

## Allocation of study programmes
First semester MSc Advanced Materials

## Recommended prerequisites
Fundamentals of mathematics, physics and chemistry

## Learning objectives
**Materials Science I**

Students should be able to

- classify metallic, ceramic and polymeric materials based on their structure on the atomic scale, microstructure and macroscopic properties.
- analyze different materials with respect to mechanical strength.
- understand the physical basis for thermal, electrical and magnetic properties of solid materials.

**Laboratory Materials Science I**

Students should be able to

- operate modern instruments
- apply their fundamental knowledge of Materials Science
- present and report own experimental work/results

## Syllabus
**Materials Science I**

- Classification of materials with respect to chemical bond and structure.
- Crystal structure: Symmetry classes, lattices, reciprocal lattice, diffraction.
- Defects in solids: Point defects, dislocations, grain and phase boundaries.
• Characterization of the microstructure: Microscopic methods (optical, SEM),
diffraction techniques (XRD, TEM), scanning probe techniques (introduction).
• Phase diagrams: Thermodynamics of solutions, chemical potential, phase
equilibrium, basic types of phase diagrams, important examples.
• Transport: Diffusion (macroscopic and microscopic description), diffusion at
surfaces and interfaces, electromigration, thermotransport.
• Phase transformations: Thermodynamics and kinetics, diffusive transformations,
non-diffusive transformations.
• Mechanical properties: Elasticity, plastic deformation, viscous flow and creep,
fracture.

Laboratory Materials Science I

• X-ray diffraction (2 sessions)
• Phase transformations
• Atomic force microscopy
• Microstructure (2 sessions)
• Mechanical properties

Literature

• Ashby M. F. and D. R. H. Jones: Engineering Materials 1. 2nd ed., Butterworth-
• Ashby, M.F. and D. R. H. Jones: Engineering Materials 2. 2nd ed., Butterworth-
• Callister, W.D.: Materials Science and Engineering: An Introduction. 6th ed.,

Teaching and learning methods

Materials Science I

5 credit points
Lecture 3 h/week
Solving problems 1 h/week

Laboratory Materials Science I

5 credit points
Laboratory: 3 h/week
Seminar: 1 h/week

Workload

Materials Science I: Total 150 h

Lecture:
48 h presence
38 h preparation and revision

Solving problems:
16 h presence
32 h revision

Exam:
16 h preparation

Laboratory Materials Science I: Total 150 h

42 h presence
65 h preparation, revision, writing reports
43 h preparation of presentation, presentation, paper writing
Assessment

No english version available yet.

Grading procedure

Grading: Result of the written examination and the seminar presentation grade, each one with 1/2 of the module weight.

Basis for

Modules Materials Science II, Nanomaterials I and II, Biomaterials I and II
### Materials Science II - Lecture and Laboratory

Modules referring to Materials Science

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Biology and Cell Biology
Modules referring to Chemistry, Physics, Biology and Cell Biology

Code 8822871409

ECTS credits 5

Attendance time 4

Language of instruction English

Duration Semester

Cycle keine Angaben

Coordinator Prof. Dr. Bernhard Koch

Instructor(s) Prof. Dr. B. Koch
Prof. Dr. P. Walther, PD Dr. A. Ziegler, Electron Microscopy

Allocation of study programmes First semester MSc Advanced Materials, focus Biomaterials

Recommended prerequisites Fundamentals of biology

Learning objectives Introductory Biology and Cell Biology

Students should be able to

• understand central problems of biology and cell biology.
• understand links between different fields of Biosciences
• follow the Biomaterials lectures in 2nd and 3rd semester

Syllabus Introductory Biology and Cell Biology

1. Basics and ecosystems
   • Secondary production in ecosystems
   • Cycling of chemical elements in ecosystems

2. Biomolecules
   • Water and the fitness of the environment
   • Carbon and the molecular diversity of life
   • Major classes of biomolecules
   • Structure and function of macromolecules
   • Introduction to metabolism, enzymes
3. Cellular respiration
   • Harvesting chemical energy
4. Cell morphology and gene expression
   • A tour of the cell
   • Membrane structure and function
   • The cell cycle
   • The molecular basis of inheritance
   • From gene to protein
   • Regulation of gene expression
5. Organismic and animal diversity
   • The major lineages of life
   • Prokaryotes and the origins of metabolic diversity
   • The origin and early diversification of eukaryotes
   • Details from animal evolution and groups of invertebrates
6. Development
   • Animal development
   • Development genes and their detection
7. Functional anatomy
   • An introduction to animal structure and function
   • Muscle function
   • Nervous system
8. Endocrinology
   • Chemical signals in animals
   • Blood glucose and adrenal gland hormones in non-vertebrates
9. Circulation and gas exchange
   • Circulation and gas exchange
   • Gas exchange in animals
10. Intracellular compartments and protein sorting
    • Vesicular transport
    • Cytoskeleton and mitosis
11. Structure and function of cellular membranes
    • Cell-cell contacts and cell adhesion
    • Structure and function of the extracellular matrix

**Literature**
- Handouts

**Teaching and learning methods**
5 credit points
Lecture, 4 h/week
| **Workload**       | Total 150 h  
|                   | 64 h presence 
|                   | 70 h preparation and post-processing 
|                   | 16 h exam preparation |
| **Assessment**    | not specified |
| **Grading procedure** | not specified |
| **Basis for**     | Modules *Biomaterials I* and *Biomaterials II* Elective courses focus Biomaterials |
Chemistry for Advanced Materials  
Modules referring to Chemistry, Physics, Biology and Cell Biology

**Code**  
8822871397

**ECTS credits**  
11

**Attendance time**  
8

**Language of instruction**  
English

**Duration**  
1 Semester

**Cycle**  
each Winter Semester

**Coordinator**  
N.N.

**Instructor(s)**  
Prof. Dr. T. Bernhardt, Prof. Dr. M. Fichtner, Dr. E. Mena-Osteritz, Faculty of Natural Sciences

**Allocation of study programmes**  
First and second semester of MSc Advanced Materials

**Recommended prerequisites**  
Bachelor Degree

**Learning objectives**  
Introductory Chemistry

Students should be able to

- discuss a given chemical element with respect to its position in the periodic table of elements, structure of its electron shell and its ability to form chemical bonds
- describe the equilibrium of a given reaction according to the mass action law
- use the idea of the pH-value and the acid/base-pKa/pKb-value to analyze the properties of water, oxo-acids, weak acids and bases, buffers and indicators
- identify a redox reaction and analyze it with respect to the redox potential of the individual reactants and the difference in redox potential of the overall reaction

Physical Chemistry

Students should be able to

- apply the laws and principles of thermodynamics and of reaction kinetics when analyzing chemical reactions with respect to energy conversion, equilibrium and reaction rate.
- describe the influence of external parameters on chemical reactions.
- describe atomic structures and the formation of bonds between atoms in terms of quantum mechanics.
• understand and describe the principles of selected spectroscopy techniques in chemistry, and interpret simple spectra.

Materials Chemistry

Students should be able to

a) Chemistry of Inorganic Solids:

• describe the structure, bonding and the electronic structure of an inorganic solid
• decide which method of characterization can be applied for different inorganic solid materials
• describe basic synthetic methods for the fabrication of inorganic materials
• correlate the electrical, optical and magnetic properties of the material with its nanostructure, defect structure

b) Organic Materials

• describe the fundamentals in organic materials formation
• represent and understand the different classes of organic materials
• describe the application’s spectrum in material chemistry

Syllabus

Organic Materials and Structure Formation

including Inorganic Chemistry: Atoms, Hydrogen, Halogens, Chalcogens
Interaction: Van der Waals, interaction forces, electrostatic interaction between systems

Physical Chemistry:

Quantum Chemistry: Some simple systems, postulates and Schrödinger equation, atomic structure and qualitative molecular orbital theory. Practical Aspects of the Laws of Thermodynamics, Boltzmann and Fermi-Dirac statistics

Reaction kinetics and catalysis: Concept of activation energy, interfaces, electrocatalysis, application on fuel cells

Fundamental concepts of spectroscopy and photochemistry: Correlation between molecular structures and spectra, principle of Laser, applications for solar cells.

Solid State Chemistry:

Structure of solids, basic crystallography, characterization of solids
Bonding in solids, Real structure of crystals Solid state reaction, sol-gel method, hydrothermal synthesis, vapor phase transport, methods for crystal growth, structure-property relations

Literature

### Teaching and learning methods

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<td>Physical Chemistry</td>
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<td>Lecture 2 h/week, Problem solving 1 h/week</td>
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<td>Materials Chemistry</td>
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<td>Lecture 3 h/week</td>
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### Workload

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<td>90 h</td>
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<td>Physical Chemistry</td>
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<td>32 h</td>
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<td>Problem solving</td>
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<td>Materials Chemistry</td>
<td>120 h</td>
<td>42 h</td>
<td>62 h</td>
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### Assessment

The grade of the module will be the grade of the written exams. No prerequisites are necessary for exam registration for 10952 and 12372. Prerequisite for exam registration for 10875 is passing the pre-course (to be defined by the examiner).

### Grading procedure

The grade of the module will be the average of the individual exam grades weighted by the credit points of the individual exams.

### Basis for

MSc Advanced Materials
Physics
Modules referring to Chemistry, Physics, Biology and Cell Biology

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| Syllabus      | **Organic Materials and Structure Formation**

*Including Inorganic Chemistry: Atoms, Hydrogen, Halogens, Chalcogens*
*Interaction: Van der Waals, interaction forces, electrostatic interaction between systems*

**Physical Chemistry:**

*Quantum Chemistry*: Some simple systems, postulates and Schrödinger equation, atomic structure and qualitative molecular orbital theory. Practical Aspects of the Laws of Thermodynamics, Boltzmann and Fermi-Dirac statistics

*Reaction kinetics and catalysis*: Concept of activation energy, interfaces, electrocatalysis, application on fuel cells

*Fundamental concepts of spectroscopy and photochemistry*: Correlation between molecular structures and spectra, principle of Laser, applications for solar cells.

**Solid State Chemistry:**

Structure of solids, basic crystallography, characterization of solids
Bonding in solids, Real structure of crystals, Solid state reaction, sol-gel method, hydrothermal synthesis, vapor phase transport, methods for crystal growth, structure-property relations

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# Biomaterials I

Modules referring to Biomaterials

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**Coordinator**  
Prof. Dr. A. Ignatius, Faculty of Medicine

**Instructor(s)**  
Prof. Dr. A. Ignatius, Faculty of Medicine

**Allocation of study programmes**  
Second semester MSc Advanced Materials, focus Biomaterials

**Recommended prerequisites**  
Module Biology and Cell Biology

**Learning objectives**  
Students should be able to
- give an overview on human tissues (structure and properties) that can be replaced or supported by synthetic materials and devices
- describe relevant properties of currently used biomaterials
- outline current fields of application for biomaterials
- discuss the demands and risks for new biomaterials as resulting from clinical problems

**Syllabus**  
1. Biological tissues to be replaced/supported by biomaterials (tissue composition, structure, properties and function)
   - Cartilage
   - Tendon and ligament
   - Bone
   - Teeth
   - Skin
   - Blood vessels and heart
   - Blood
   - Kidney
   - Liver and pancreas
   - Eyes
2. Biomaterials used to replace/support biological tissues (chemical composition, mechanical and biological properties, processing)

- Polymers
- Ceramics
- Metals
- Hydrogels
- Natural materials
- Composites

3. Application of Biomaterials (dental, orthopedic, trauma, cardiovascular, plastic surgery, ophthalmology)

- Drug-delivery
- Materials for bone, cartilage and ligament replacement
- Materials for tooth repair
- Blood and blood vessel replacement
- Artificial liver and pancreas
- Eyes, eye implants

**Literature**


**Teaching and learning methods**

- 5 credit points
- Lecture, 4 h/week

**Workload**

- Total 150 h
- 56 h presence

**Assessment**

- not specified

**Grading procedure**

- not specified

**Basis for**

- Module *Biomaterials II*
# Biomaterials II

**Biomaterials II**

## Modules referring to Biomaterials

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<td>Prof. Dr. A. Ignatius, Faculty of Medicine</td>
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<td>Modules <em>Biology and Cell Biology</em>, <em>Biomaterials I</em></td>
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## Learning objectives

**Biomaterials II**

Students should be able to

- describe the desired or undesired degradation of different biomaterials in a biological environment
- describe the interaction between biomaterials and human tissues into which they have been introduced or implanted
- discuss the process of successful integration as well as problems that may lead to dysfunction of biomaterials employed to replace or support tissues or structures of the human body
- refer to the regulatory standards for approval of biomaterials

**Commercial Production of Biomaterials**

Students should be able to

- depict production, processing and employment of biocompatible materials and devices designed for implantation in the human body using a product of one of the companies visited as an example

**Laboratory Biomaterials**

Students should be able to
• understand how research on biomaterials is organized in a specialized laboratory and carried out by experienced researchers

### Syllabus

**Biomaterials II**

1. Degradation of biomaterials (changes in chemical composition and biological and mechanical properties)
   - Corrosions of metals
   - Degradation of polymers

2. Host reactions to biomaterials (integration, inflammation and foreign body reactions)
   - Blood reactions to biomaterials
   - In vitro cell-biomaterials reactions
   - In vivo tissue reactions to biomaterials
   - Systemic effects of biomaterials

3. Testing of biomaterials used in medical devices prior to their employment in order to avoid risks for recipients
   - Properties tested: Mechanical strength, biological degradation
   - In vitro testing of biomaterials (decreasing necessity for animal experiments)
   - In vivo testing of biomaterials

### Literature

- Handouts

### Teaching and learning methods

**Biomaterials II**

3 credit points
Lecture series, 2 h/week

Commercial Production of Biomaterials (Excursion)

2 credit points
1 h/week
Laboratory Biomaterials

3 credit points

### Workload

**Biomaterials II**: Total 90 h

32 h presence
42 h preparation and post processing
16 h exam preparation

Commercial Production of Biomaterials:

24 h presence (4 excursions, half a day to a whole day)
Laboratory Biomaterials:
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*including* Inorganic Chemistry: Atoms, Hydrogen, Halogens, Chalcogens

*Interactions*: Van der Waals, interaction forces, electrostatic interaction between systems

**Physical Chemistry:**

Quantum Chemistry: Some simple systems, postulates and Schrödinger equation, atomic structure and qualitative molecular orbital theory. Practical Aspects of the Laws of Thermodynamics, Boltzmann and Fermi-Dirac statistics

Reaction kinetics and catalysis: Concept of activation energy, interfaces, electrocatalysis, application on fuel cells

Fundamental concepts of spectroscopy and photochemistry: Correlation between molecular structures and spectra, principle of Laser, applications for solar cells.

**Solid State Chemistry:**

Structure of solids, basic crystallography, characterization of solids
Bonding in solids, Real structure of crystals Solid state reaction, sol-gel method, hydrothermal synthesis, vapor phase transport, methods for crystal growth, structure-property relations

Literature


Teaching and learning methods

- not specified

Workload

- not specified

Assessment

- not specified

Grading procedure

- not specified

Basis for

- MSc Advanced Materials
## Additive Key Qualifications

Modules referring to Additive Key Qualification

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### Additive Key Qualifications

Modules referring to Additive Key Qualifications

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<tr>
<td>Workload</td>
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<tr>
<td>Grading procedure</td>
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Basis for

No english version available yet.
### German Language

Modules referring to Additive Key Qualifications

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Master Thesis
Modules referring to Master Thesis

Code: 8822880000

ECTS credits: 30

Attendance time: 30

Language of instruction: not specified

Duration: 1 Semester

Cycle: each Semester

Coordinator: not specified

Instructor(s): not specified

Allocation of study programmes: not specified

Recommended prerequisites: not specified

Learning objectives: not specified

Syllabus: not specified

Literature: not specified

Teaching and learning methods: not specified

Workload: not specified

Assessment: not specified

Grading procedure: not specified

Basis for: not specified