POZNAN UNIVERSITY OF TECHNOLOGY
EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)
pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Solid State Chemistry

Course

Field of study
Chemical Technology

Area of study (specialization)

Level of study
First-cycle studies

Form of study
full-time

Year/Semester
II/4

Profile of study
general academic

Course offered in
English

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

5

Lecturers

Responsible for the course/lecturer:
dr hab. inż. Sławomir Borysiak, prof. PP

Responsible for the course/lecturer:

Prerequisites

The student should have a basic knowledge of inorganic and organic chemistry, mathematics and physics. Student should also be able to search for information from literature, databases and other properly selected sources.

Course objective

Providing knowledge in the field of solid structure, reactions and transition phases in solids as well as learning the methods of morphological and structural research. Understanding the relationship between the structure of a solid and its physicochemical properties. The ability to identify solids based on diffractometric investigations.

Course-related learning outcomes

Knowledge

1. Student has the necessary knowledge of chemistry to enable understanding of chemical reactions occurring in the solid state as well as phase and polymorphic transformations occurring in the condensed phase [K_W03]

2. Student has the necessary knowledge of chemistry to enable understanding of the principles and laws of symmetry during describing the structure of solids, including defects and molecular orientation [K_W03]

3. The student has the necessary knowledge in the field of identification and characterization of the molecular structure and morphology of chemical substances in the condensed phase using diffractometric and microscopic techniques [K_W11]

Skills

1. Student has the skills to search information from literature and modern databases enabling identification and determination of the structure of solids [K_U01]

2. The student uses computer programs to understand issues related to the correlation of solids properties with their structure [K_U07]

3. Student is able to determine the structure of chemical compounds using diffractometric and microscopic techniques, and is able to describe structure based on knowledge of symmetry elements and the ability to apply the laws of symmetry [K_U19]

Social competences

1. The student understands the need for further training and improving their professional competences [K_K01]

2. The student is able to work in a group and cooperate during performing practical tasks [K_K03]

3. Student is able to define priorities for the implementation of assigned tasks [K_K04]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lectures:

Knowledge acquired in the lecture is verified in the form of a written exam after the end of the lecture cycle. The exam consists of 20-30 test questions and 5-10 open questions. Passing threshold: 50% of points. Exam issues will be sent to students via e-mail using the university e-mail system.

Laboratory:

The skills in the laboratory classes are verified on the basis of a test of theoretical issues, consisting of 3-5 questions. Theoretical issues for all exercises are passed on during the organizational meeting. Passing threshold: 50% of points. In addition, reports containing a description of the experiment and calculations are evaluated.

Programme content

1. The essence of solid state. Classifications of solids. Ionic, covalent, molecular and metallic crystals. Assumptions of the simplified crystal lattice model. Coordination number and structure type. Coordinating polyhedron. Principles for the formation of ionic crystals. Ionic radius and three-dimensional arrangement of balls. Physicochemical properties of crystals.

2. Supermolecular structure - basic definitions, concepts and laws. Definition of a unit cell, crystallographic systems, elements of symmetry, crystallographic classes, Bravais lattices, space groups. Miller index, methods for determining Miller index, spacing d between lattice planes, Scherer formula and its application.

3. Defects in solids, types of defects: point, line, surface, volume, dislocations: edge, screw, mixed. The importance of defects. Orientation and texture in solids. Water in crystals - importance on the physicochemical properties of solids.

4. Solid phase reactions, reaction mechanism between solids, reactions in single and multiphase systems, reactions occurring at interphase, reactions between monocrystals, reactions in polycrystalline systems, double exchange reactions, reactions of solids with gases, topochemical reactions. Thermal solids destruction, sintering and grain growth.

5. Phase equilibria in solids. Systems of two substances showing unlimited or limited solubility in solid state - solid solutions. Phase transitions of I-order and II-order, phase transitions under high pressure

6. Solid surface - the structural and chemical nature of surfaces and surface layers in solids.

7. Diffusion in condensed phase, description of the diffusion process, network, surface and grain interphase diffusion, reaction diffusion, diffusion and ionic conductivity, Kirkendall-Frenkel effect, chemical diffusion coefficient and effective diffusion coefficient, reactions controlled by diffusion.

8. Phenomenological description of the crystallization process, stages of the crystallization process: nucleation and crystallization, homogeneous and heterogeneous nucleation, thermal and athermal nucleation, surface and volumetric energy of the nuclei, free energy of the nucleation process, interfacial energy, critical radius of the nuclei. Polymorphism. Crystallization processes of monocrystals and semicrystalline systems. Methods of monocrystal crystallization: growth of single crystals from aqueous solutions, growth of single crystals from flux, hydrothermal method, Bridgman-Stockbarger process, Czochralski method, monocrystallization by the Verneuil method, increase of monocrystals from the gas phase, crystallization from solution.

9. Liquid crystal materials - basic concepts, definition. Structure of a liquid crystal compound - thermotropic and lyotropic mesophase, types of mesogens. The degree of order in liquid crystals. Interaction of liquid crystal compounds in an electric field. The use of liquid crystal materials in many industries. Liquid crystal thermography.

10. Presentation on selected examples of the realtionships between the structure and properties of the condensed phase. Methods for modeling the structure during the synthesis and processing of chemical substances in context of obtaining the assumed macroscopic properties of the products.

11. X-ray diffraction on the crystal structure, Bragg diffraction conditions. X-ray diffraction methods. Position and intensity of diffraction reflections. Construction and operation of a horizontal diffractometer. The use of x-ray techniques. Identification and quantitative analysis by X-ray diffraction in wide angles, the use of the PDF-4 database in identification analysis. Studies of morphology and topography of solid surfaces by microscopic techniques.

As part of the laboratory classes, the following exercises are performed:

1. Investigation of the crystallization process and morphology of condensed phase.

2. Elements of closed symmetry.

3. Elements of open symmetry.

4. Identification analysis of solids by X-ray diffeaction method.

5. Qualitative analysis using the PDF-4 database.

6. Supermolecular structure of polymers.

Teaching methods

1. Lecture: multimedia presentation

2. Laboratory: practical classes using chemical reagents and research equipment

Bibliography

Basic

1. J.Dereń, J.Haber, R.Pampuch, Chemia ciała stałego, PWN,1975.

2. P.Luger, Rentgenografia strukturalna monokryształów, PWN, 1989

3. Z. Bojarski, M. Gigla, K.Stróż,M. Surowiec, Krystalografia, podręcznik wspomagany komputerowo", PWN, 2007.

4. Ch. A. Wert, R. M. Thomson, Fizyka ciała stałego, PWN 1974.

Additional

1. International Tables for Crystallography, The International Union of Crystallography, Kluwer Academic Publishers - Dordrecht/Boston/London 1992

2. Von Meerssche, J.Feneau-Dupont, Krystalografia i chemia strukturalna, PWN, 198492

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,0
Classes requiring direct contact with the teacher	75	3,0
Student's own work (literature studies, preparation for laboratory classes, preparation for tests, preparation for exam, preparation of reports from laboratory classes) [1]	50	2,0

[1] delete or add other activities as appropriate