Confined effects of liquids in nanoporous matrices

Educational subject description sheet

Basic information

Study programme Fizyka (Physics of Advanced Materials for Energy Processing) **Speciality** - **Organizational unit** Faculty of Physics and Astronomy **Study level** Second-cycle programme **Study form** Full-time **Education profile** General academic	**Didactic cycle** 2024/25 **Subject code** 04FENS.21S.03246.24 **Lecture languages** English **Course type** Elective **Block** specialty subjects

Subject coordinator	Małgorzata Śliwińska-Bartkowiak
Lecturer	Małgorzata Śliwińska-Bartkowiak

Period	**Activities and hours**	**Number of ECTS points**
Semester 1	• Lecture: 30, Graded credit	3

Goals

Code	Goal
C1	Making students aware of the problems of the nanophases behawior. Molecular nanophases confined in porous materials of pore size in nanometric scale exhibit physical and chemical properties much different from those of the free substances. Spatial restriction of a substance as a result of the reduced dimensionality of the system and strong interactions between the molecules of the confined phase and the porous matrices are the problem of key importance in many fields. They are particularly important in heterogeneous catalysis , drugs delivery, construction of sensors, hydrogen storage , construction of electrodes of supercapacitors , production of nanomaterials, like e.g. nanowires or insulators in microcircuits. The problems of the surface-driven high pressure processing in pores, influenced the nanophases behavior
C2	Aquainting students with some research methods used to study the characteristics of the new nanophases, their structure and dynamics
C3	Acquiring the ability to understand the results of experiments, proper interpretation and possibility of comparison of the results of various techniques used
C4	Acquisition of the ability to select and use appropriate experimental techniques to study new nanophases appearing in nanoporous media

Subject learning outcomes

Code	Outcomes in terms of	Learning outcomes	Examination methods
Knowledge – Student:			
W1	The student will be able to applied the obtained knowledge in the range of searching of a new materials and technologies	FEN_K2_W01, FEN_K2_W02, FEN_K2_W04	Test
W2	The student will be able to understand the basic issues of forming of the new nanophases in nanoporous matrices	FEN_K2_W01, FEN_K2_W02, FEN_K2_W04, FEN_K2_W05	Test, Multimedia presentation
W3	The student will be able to make comparison of the discussed problems with the literature existing description	FEN_K2_W01, FEN_K2_W02, FEN_K2_W04	Multimedia presentation
W4	The student will be able to choose the experimental techniques relevant to the searching problems	FEN_K2_W01, FEN_K2_W02, FEN_K2_W04	Test
Skills – Student:			
U1	The student will be able to analyze his scientific work, discuss the uncertainty of the experiments	FEN_K2_U01, FEN_K2_U03	Test, Multimedia presentation
U2	The student will be able to prepare poster or conference presentation	FEN_K2_U01, FEN_K2_U02, FEN_K2_U04, FEN_K2_U05	Multimedia presentation
U3	The student should be active in scientific discussions	FEN_K2_U04, FEN_K2_U05	Test
Social competences – Student:			
K1	The student should be able to critically analyze the discussed problems	FEN_K2_K01, FEN_K2_K02	Test, Multimedia presentation
K2	The student will have the ability to work in a research team	FEN_K2_K02, FEN_K2_K05	Multimedia presentation

Study content

No.	Course content	Subject learning outcomes	Activities
1.	**B**asic issues of the phase transitions (n-dimensionality of phase transitions)) thermodynamics of liquids and liquids mixtures,	W1, W2, U3, K1	Lecture
2.	Adsorption in nanoporous matrices, intermolecular interactions, intermolecular potentials, adhesion/cohesion forces	W1, W3, U3, K1	Lecture
3.	Structure and characterization of some silica porous matrices (silica pores: MCM-41, SBA-15, Controlled Pore Glasses, KIT and nanocarbons: carbon fibres nanotubes, ordered nanocarbons –CMK-3, CMK-8 , funcionalized nanomaterials and MOF	W1, W3, U3, K1	Lecture
4.	2D melting effects in substances confined in nanopores; Kosterlitz-Thoulesse –Halperin-Young description – the existence of hexatic intermediate phase in nanopores; experimental results	W1, W2, U3, K1	Lecture
5.	The influence of the fluid-wall / fluid-fluid interactions on the nanophases formation and their properties. Theory and experimental results	W1, W3, W4, U3, K1	Lecture
6.	Wettability parameter in pores. Influence of the pore roughness on the nanophases formation. Wenzel and Casie-Baxter models of wettability in porous matrices. Experimental results	W1, W2, W3, U3, K1	Lecture
7.	Pressure tensor in cylindrical and slit shape pores; surface-driven high pressure processing effects in nanopores, theoretical and experimental evidences	W1, W2, U3, K1	Lecture
8.	Structures of ice confined in nanoporous matrices, the novel phases of ice; the influence of hydrophobicity of the pore surface on the structures of confined ice. Results of diffractions experiments	W2, W3, U1, K1	Lecture
9.	Mixtures of liquids confined in nanoporous matrices. Theoretical description and experimental results using DSC and dielectric spectroscopy methods	W2, W3, U3, K1	Lecture
10.	Experimental methods in application for the analysis of the structure and dynamics of the confined nanophases: WAXS, Neutron Diffraction, Dielectric and Raman Spectroscopy, Dielectric Saturation (NDE), Tensiometric Techniques, Scanning Probe Microscopy (STM, AFM and related techniques)	W2, W4, U1, K1	Lecture
11.	Properties of ionic liquids confined in nanocarbons pores studied using dielectric and diffractions methods	W2, W4, U1, K1	Lecture
12.	Phenomena of spatial constraint of molecules in energy storage problems.	W1, W4, U2, U3, K1, K2	Lecture

Additional information

Activities	Teaching and learning methods and activities

Activities	Teaching and learning methods and activities
Lecture	Lecture with a multimedia presentation of selected issues, Conversation lecture, Discussion

Activities	Credit conditions
Lecture	oral test

Literature

Obligatory

1. P. Debenedetti, „Metastable Liquids”, Princeton University Press, 1999
2. H. E.Stanley, „Introduction to Phase Transitions and Critical Phenomena”, Oxford Univ. Press, 1971;
3. Materials provided by teacher(selected publications)

Optional

1. I.Brovchenko, A., Oleinikova, Interfacial and confined water, Elsevier, 2008

Calculation of ECTS points

Activities	Activity hours*
Lecture	30
Reading the indicated literature	10
Preparation for the exam	35
Student workload	**Hours** 75
Number of ECTS points	**ECTS** 3

* academic hour = 45 minutes

Efekty uczenia się dla kierunku

Kod	Treść
FEN_K2_K01	The graduate is ready to critically evaluate own knowledge and received content
FEN_K2_K02	The graduate is ready to recognize the importance of knowledge in solving cognitive and practical problems and seeking expert opinion (also from other scientific disciplines) to overcome difficulties during independent problem solving
FEN_K2_K05	The graduate is ready to responsibly perform professional roles, incorporating changing social needs, including advancing the achievements of the profession and maintaining its ethos, as well as the observance and development of the principles of professional ethics and actions to comply with these principles
FEN_K2_U01	The graduate can use their knowledge to formulate and solve complex and unusual problems in the field of physical sciences; select and apply appropriate methods and tools necessary to solve a given problem (including advanced IT techniques), as well as adapt existing methods and tools or develop completely new ones
FEN_K2_U02	The graduate can find the necessary information in the professional literature, databases and other sources, in particular in scientific journals basic to physics, and perform critical analysis, synthesis and creative interpretation of the collected information
FEN_K2_U03	The graduate can formulate and test hypotheses related to simple research problems in physics (plan and perform observations, experiments, theoretical calculations or computer simulations and critically evaluate and discuss the results obtained)
FEN_K2_U04	The graduate can prepare, for various audiences, oral presentations and written studies presenting specialized topics in the field of physical sciences in a communicative way, as well as debate on such topics
FEN_K2_U05	The graduate can use English in accordance with the requirements set out for level B2+ of the Common European Framework of Reference for Languages, as well as specialist English terminology in the field of physical sciences
FEN_K2_W01	The graduate knows and understands in-depth selected facts, phenomena, concepts and theories specific to physics and complex relationships between them (constituting advanced general knowledge in the field of physical sciences and representing both key and other selected issues in the field of advanced detailed knowledge in this discipline)
FEN_K2_W02	The graduate knows and understands in-depth selected research methods and tools as well as mathematical models used in physics
FEN_K2_W04	The graduate knows and understands main development trends in the discipline of physical sciences
FEN_K2_W05	The graduate knows and understands the role of physical sciences in the context of fundamental dilemmas and challenges of modern civilization