Liquids in confinement; the novel phases of substances in nanopores

Educational subject description sheet

Basic information

Study programme Fizyka (Physics of Advanced Materials for Energy Processing) **Speciality** - **Organizational unit** Faculty of Physics **Study level** Second-cycle programme **Study form** Full-time **Education profile** General academic	**Didactic cycle** 2023/24 **Subject code** 04FENS.24S.05205.23 **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 3	• Laboratories: 15, Graded credit	2

Goals

Code	Goal
C1	Providing students with knowledge about the properties of substances (nanophases) under the conditions of spatial constraint of molecules. Nanophases confined in porous matricec 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, energy storage or construction of electrodes of supercapacitor, hydrogen storage ,production of nanomaterials, like e.g. nanowires in microcircuits.The problems of the surface-driven high pressure processing in pores,influenced the nanophases behavior are also recently considered.
C2	Acquisition by the student of the ability to understand the results of experiments, their proper interpretation and the ability to compare the results obtained using different techniques
C3	Acquisition by the student of the ability to select the appropriate experimental techniques to study the structure and dynamics of nanophases
C4	Performance of experiments by students, critical analysis of the results obtained

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, Project, Report, Multimedia presentation
W2	The student will be able to understand the basic issues related to the formation of nanophases in nanoporous matrices	FEN_K2_W01, FEN_K2_W02, FEN_K2_W04, FEN_K2_W05	Test, Project, Report
W3	The student will be able to choose the appropriate experimental techniques suitable for elucidation of exploration problems,	FEN_K2_W01, FEN_K2_W02, FEN_K2_W04	Test, Project, Report, Multimedia presentation
W4	The student will be able to perform experiments and analyze the obtained results.The student will also be able to determine the uncertainties of the experiments	FEN_K2_W01, FEN_K2_W02, FEN_K2_W07	Project, Report
W5	The student will be able to compare the obtained experimental results with descriptions existing in the literature	FEN_K2_W01, FEN_K2_W04, FEN_K2_W05	Report
Skills – Student:			
U1	The student will be able to make a proper presentation of the obtained results	FEN_K2_U01, FEN_K2_U02, FEN_K2_U04, FEN_K2_U05	Report, Multimedia presentation
U2	The student will be able to prepare the scientific poster or conference presentation	FEN_K2_U01, FEN_K2_U02, FEN_K2_U03, FEN_K2_U04, FEN_K2_U05, FEN_K2_U07	Report, Multimedia presentation

Code	Outcomes in terms of	Learning outcomes	Examination methods
U3	The student will be able to actively participate in scientific discussions	FEN_K2_U01, FEN_K2_U02, FEN_K2_U04, FEN_K2_U05, FEN_K2_U07	Test, Project, Multimedia presentation
Social competences – Student:			
K1	The student should be able to cooperate well with the research team	FEN_K2_K01, FEN_K2_K02, FEN_K2_K05	Project, Report, Multimedia presentation
K2	The student has the ability to critically analyze their results and expand their knowledge	FEN_K2_K01, FEN_K2_K02	Test, Report, Multimedia presentation

Study content

No.	Course content	Subject learning outcomes	Activities
1.	Structure and characterization of some nanoporous matrices (silica pores: : MCM-41, SBA-15, Controlled Pore Glasses and nanocarbon pores: activated carbon fibres , nanotubes, ordered nanocarbons materials: CMK-3, CMK-8 , funcionalized nanoporous materials and MOF using Scanning Probe Microscopy techniques (STM, AFM and related techniques)	W1, W2, W3, W5, U3, K2	Laboratories
2.	The influence of the fluid-wall / fluid-fluid interactions on the nanophases formation confined in porous systems., 2D melting effects of the substances confined in nanopores studied by dielectric and DSC methods	W2, W3, W4, U3, K2	Laboratories
3.	Wetting properties of the liquids of walls of the nanopores; influence of pore roughness on the adhesion processes measured by Tensiometric Techniques, analyzis of the wetting mechanism (Wenzel or Cassie-Baxter models) of liquids in pores .	W2, W3, W4, W5, U1, U3, K2	Laboratories
4.	Surface-driven high pressure processing effects in nanopores deformation of the pore walls –those effects will be analysed using Raman Spectroscopy, FTIR and WAXS methods. The quasi-high pressure effects in nanopores are recently considered in the literature	W1, W3, W4, U1, U3, K1, K2	Laboratories
5.	Investigation of the melting phenomenon of the ionic liquid confined in carbon nanoporous matrices using the dielectric method	W1, W2, W4, W5, U1, U3, K2	Laboratories
6.	Discussion and comparison of the results of experimental methods used for the analysis of the properties of confined nanophases: WAXS, Neutron Diffraction, Dielectric and Raman Spectroscopy, Dielectric Saturation (NDE), Tensiometric Techniques, Scanning Probe Microscopy (STM, AFM and related techniques)	W1, W2, W4, W5, U1, U2, K1, K2	Laboratories
7.	Preparing a preliminary report on the performed experimental research (possibility of presentation in the form of a poster)	W1, W2, W3, W4, W5, U2, U3, K2	Laboratories

Additional information

Activities	Teaching and learning methods and activities
Laboratories	Lecture with a multimedia presentation of selected issues, Problem-based lecture, Solving tasks (e.g. computational, artistic, practical), Laboratory method, Workshop method, Demonstration and observation, Work in groups

Activities	Credit conditions
Laboratories	Presentation of the report on the performed experiment (multimedia presentation) Test on experimental methods applied to the study of the properties of nanophases

Literature

Obligatory

1. Material provided by teacher
2. E.Mikuli, A.Migdał-Mikuli, „Phase Transitions studies”,UJ 2006

Optional

1. Theory of Molecular Fluids: Volume 2: Applications, CG Gray, KE Gubbins, CG JoslinOxford University Press,2011
2. Interfacial and Confined Water, Ivan Brovchenko, Alla Oleinikova, Elsevier 2008

Calculation of ECTS points

Activities	Activity hours*
Laboratories	15
Report preparation	15
Preparation of a multimedia presentation	10
Reading the indicated literature	10
Student workload	**Hours** 50
Number of ECTS points	**ECTS** 2

* 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_U07	The graduate can independently determine the directions of further learning and implement a self-education program, learn throughout lifetime using the available international literature and be able to guide others in this regard
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
FEN_K2_W07	The graduate knows and understands workplace health and safety principles to the extent that allows independent work in the research workplace