Universitat Autònoma de Barcelona

2019/2020

Physics and Chemistry of Surfaces

Code: 103299
ECTS Credits: 6

Degree	Type	Year	Semester
2501922 Nanoscience and Nanotechnology	OB	3	1

Contact

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Use of Languages

Principal working language: spanish (spa)
Some groups entirely in English: No
Some groups entirely in Catalan: No
Some groups entirely in Spanish: No

Teachers

José Antonio Ayllón Esteve

Prerequisites

It is recommended to have passed the first full course (Introducció a la Nanociència i la Nanotecnologia, Enllaç Químic i Estructura de la Matèria, i Reactivitat Química) and the followong form the second course: Termodinàmica, Cinètica i Transformacions de Fase, Química Orgànica, Química del Elements i laboratori de microscòpies i caracterització.
It is also recommended to be studying at the same time, or previously, the third year course: Síntesi i Estructura de Materials Cristal·lins i Amorfs.

Objectives and Contextualisation

The objective of this course is to introduce the Surface Science to students, an interdisciplinary science and boundary between physics, chemistry, biology and engineering. The most basic aspects of the chemophysical phenomena that take place at the liquid-gas, solid-liquid, solid-gas and solid-solid interfaces will be treated. Several concepts previously introduced in previous years to students, in course like "Introduction to Nanoscience and Nanotechnology" and "Laboratory of microscopes and characterization of materials" will be deepen in this course. Knowledge in chemistry and Thermodynamics will be used to address surface phenomena, interface and heterogeneous catalysis, discussing also the different types of catalysts. Surface structure of solids as well as their modification, will be studied along with main surface characterization techniques. Surface characterization from a structural, morphological, microstructural and compositional point of view will be described in detail. The techniques for thin film deposition will be introduced, highlighting the importance of epitaxial growth in nanotechnology applications.

Competences

- Adapt to new situations.
- Apply the concepts, principles, theories and fundamental facts of nanoscience and nanotechnology to solve problems of a quantitative or qualitative nature in the field of nanoscience and nanotechnology.

- Apply the general standards for safety and operations in a laboratory and the specific regulations for the use of chemical and biological instruments, products and materials in consideration of their properties and the risks.
- Communicate orally and in writing in ones own language.
- Demonstrate knowledge of the concepts, principles, theories and fundamental facts related with nanoscience and nanotechnology.
- Handle the standard instruments and materials of physical, chemical and biological testing laboratories for the study and analysis of phenomena on a nanoscale.
- Interpret the data obtained by means of experimental measures, including the use of computer tools, identify and understand their meanings in relation to appropriate chemical, physical or biological theories.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
- Operate with a certain degree of autonomy.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise and analyse physical, chemical and biological problems in the field of nanoscience and nanotechnology and propose answers or suitable studies for their resolution, including when necessary the use of bibliographic sources.
- Recognise the terms used in the fields of physics, chemistry, biology, nanoscience and nanotechnology in the English language and use English effectively in writing and orally in all areas of work.
- Resolve problems and make decisions.
- Work correctly with the formulas, chemical equations and magnitudes used in chemistry.
- Work on the synthesis, characterisation and study of the properties of materials on a nanoscale from previously established procedures.

Learning Outcomes

1. Adapt to new situations.
2. Apply the acquired theoretical contents to the explanation of experimental phenomena.
3. Communicate orally and in writing in ones own language.
4. Correctly handle standard instruments and materials of physics and chemistry laboratories in nanoscience and nanotechnology.
5. Correctly observe protocols for using instrumentation, reagents and chemical waste in laboratories related to the subject.
6. Critically evaluate experimental results and deduce their meaning.
7. Describe solid and liquid surfaces and the phenomenon of the double layer in loaded interfaces.
8. Describe the mechanisms of surface reactivity and catalysis and distinguish the most important heterogeneous catalysis processes.
9. Draft and present reports on the subject in English.
10. Explain the thermodynamics and kinetics of adsorption.
11. Identify the different types of defect on solid surfaces and recognise the processes of adsorption and modification of surfaces.
12. Identify the thermodynamic and kinetic bases of surfaces and interfaces.
13. Interpret and rationalise the results obtained in the laboratory in processes related with physics and chemistry in nanoscience and nanotechnology.
14. Interpret texts in English on aspects related with the physics and chemistry of nanoscience and nanotechnology.
15. Learn autonomously.
16. Make calculations with chemical reactions or catalysis on surfaces.
17. Make relative correct calculations of the thermodynamics and kinetics of surfaces and interfaces.
18. Manage the organisation and planning of tasks.
19. Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
20. Operate with a certain degree of autonomy.
21. Perform and characterise surface modification processes

22. Perform bibliographic searches for scientific documents.
23. Perform reactivity and catalysis tests on surfaces
24. Predict the modification of surfaces on the basis of their composition and the reagents used.
25. Propose creative ideas and solutions.
26. Rationalise the results obtained in the laboratory in terms of physical magnitudes and their relation with the observed physical phenomena.
27. Reason in a critical manner
28. Recognise the risks for the health and environment associated with the manipulation of chemicals and material compounds in general.
29. Recognise the terms used in topics related to nanoscience, nanotechnology and society.
30. Resolve problems and make decisions.
31. Resolve problems with the help of the provided complementary bibliography.
32. Work correctly with the formulas, chemical equations and magnitudes used in chemistry.

Content

Module A (Dr. José A. Ayllón)

1. Introduction to surfaces.

- Liquid surfaces. Surface tension. Techniques measure surface tension. Capillary condensation.

- Thermodynamics of interfaces. Gibbs Isotherm.

2. Adsorption. Electrified surface

- Physisorption and chemisorption. Adsorption isotherms. Gas adsorption. Adsorption kinetics

- Electrode solution interface. Corrosion Electrolysis

3. Heterogeneous catalysis.

- Mechanism. Bifunctional catalysts. Examples of heterogeneous catalysis processes : Cracking Reforming

- Catalytic oxidation.

Module B (Dr. Gemma Garcia)

4. Structure and modification of solid surfaces

- 4.1. Notation of surface structures

- 4.2. Superficial reconstruction

- 4.3. Structure of adsorbed monolayers

5. Techniques of surface characterization

- 5.1. Spectroscopy AES, XPS

- 5.2. Proximity microscopies: AFM, STM, SPM

6. Crystalline growth of thin layers.

- 6.1. Nucleation and growth from vapor phase - Epitaxy

Methodology

The course consists of: 28 hours of theory + 14 hours of problems + 10 hours of laboratory, per student.

Lectures

They will be carried out combining the use of material in digital format and the board. The teaching staff will present practical cases in order to exemplify the application of various theories and models.

Problem sessions

Participation of the students during the classes of problems will be promoted. Some problem sessions will take place in a group. When the teacher determines it, the delivery of resolved problems will be mandatory. When the teacher determines it, hours of problems can be used to carry out continuous evaluation tests.

Laboratory practices

The practices are compulsory, no unjustified absence will be accepted.

The previous work of reading scripts and revision of the theoretical contents will be fundamental for the good resolution of the problems and the practices.

- Module A will carry out two laboratory practices sessions of 3 hours.

- Module B will hold a practical session of 4 hours.

Tutorials

The faculty staff will be available for consulting queries of students. The use of this didactic resource is strongly recommended.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practice Activities	10	0.4	1, 2, 15, 6, 3, 21, 22, 16, 17, 18, 13, 14, 4, 19, 20, 24, 25, 26, 27, 23, 29, 9, 32, 5
Problem solving	14	0.56	2, 8, 10, 16, 17, 18, 14, 19, 24, 27, 31, 30, 32
Theory letures	28	1.12	8, 7, 10, 16, 17, 11, 12, 24
tutorized learning	12	0.48	2, 6, 3, 10, 18, 13, 19, 20, 29
Type: Autonomous			
Individual study	36	1.44	1, 2, 15, 6, 8, 7, 10, 22, 18, 11, 12, 20, 25, 27, 9
Practice guides reading and preparation	6	0.24	2, 15, 18
Practice report	12	0.48	2, 6, 3, 22, 16, 17, 18, 13, 14, 19, 24, 25, 26, 27, 29, 9, 32
Problems solving	26	1.04	2, 3, 10, 16, 17, 20, 24, 27, 31

Assessment

The global assessment will be carried out continuously and consists of:

- 1 partial about the contents of Module A, whose mark will be 40% of the final grade. (obligatory)

- 1 partial on the contents of Module B, whose mark will be 40% of the final grade. (obligatory)

- 1 delivery of problems and / or reports of practices, individual or in group, of Module A, whose mark will be of 10% of the final grade.

- 1 delivery of problems and / or reports of practices, individual or in group, whose note will be of 10% of the final grade.

In order to pass , it will be necessary to have a global grade score of 5.0 or higher and at least 5.0 points out of 10 on the average of the two partial tests. When the continuous evaluation is not passed, if you fail to comply with any of these two criteria, you will be entitled to a written proof of recovery on the contents of both modules (partial). In this case, the final mark of the written test, which will count for 80% of the final mark, will be the average of the note of the partial and the proof of recovery. Delivery of problems and practices do not include proof of recovery.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Parcial Test Module A	40	3	0.12	3, 8, 7, 10, 16, 17, 12, 14, 24, 26, 29
Parcial Test Module B	40	3	0.12	2, 3, 7, 11, 12, 14, 24, 27, 29, 30
Problem and Practice solution report Module A	10	0	0	1, 2, 15, 6, 3, 8, 7, 21, 10, 22, 16, 17, 18, 12, 13, 14, 4, 19, 20, 24, 25, 26, 27, 23, 28, 29, 9, 31, 30, 32, 5
Problem and Practice solution report Module A	10	0	0	1, 2, 15, 6, 3, 7, 21, 22, 18, 11, 13, 14, 4, 19, 20, 24, 25, 26, 27, 28, 29, 9, 31, 30, 32, 5

Bibliography

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