Appendix 3: Content and detailed description of the courses

Appendix 3.1. Content of the EM3E Master programme per semester.

Semester 1: UM2+UPS France (30 ECTS)			
Module 1.A.1 – 24 ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Characterization of porous materials	Mandatory	3	UM2-UPS
Colloid and surface engineering	Optional	3	UPS
Structural characterization of solids	Optional	3	UM2
Speciality 1 – Materials Science			UM2
Inorganic materials	Mandatory	3	UM2
Polymer materials	Mandatory	3	UM2
Hybrid and composite Materials	Mandatory	3	UM2
Materials for chemical reactions/ heterogeneous catalysis	Mandatory	3	UM2
Speciality 2 – Chemical Engineering			UPS
Transport phenomena	Mandatory	3	UPS
Thermodynamics, kinetics and reactivity	Mandatory	3	UPS
General chemistry and physico-chemical analytical methods	Mandatory	3	UPS
Separation science	Mandatory	3	UPS
Individual project (bibliographic and experimental study)	Mandatory	6	UM2-UPS
Module 1.A.2 – 6 ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Safety, Security, Health and Environmental Law	Mandatory	2	UM2-UPS
Quality Assurance and Laboratory Practice	Mandatory	2	UM2-UPS
International and European Working Law	Mandatory	2	UM2-UPS
French language and culture	Mandatory*	-	UM2-UPS

(*) Mandatory for at least one of first three semesters and associated with an oral presentation of the individual project in the corresponding national language.

Semester 2: ICTP, Czech Republic (30 ECTS)			
Module 2.1 – 24 ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Membrane processes	Mandatory	4	ICTP
Process design	Mandatory	5	ICTP
Applied reaction kinetics	Mandatory	4	ICTP
Separation Technology	Mandatory	5	ICTP
Individual project (bibliographic and experimental study)	Mandatory	6	ICTP
Module 2.2 – 6 ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Czech language and culture	Mandatory*	-	ICTP
Intellectual capital management	Mandatory	3	ICTP
Valorisation, commercialisation and enterpreneurship	Mandatory	3	ICTP/UTwente

Semester 3: UNL, Portugal (30 ECTS)			
Module 3.A.1 – 30 ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Membrane contactors and bioreactors	Mandatory	6	UNL
Membranes in downstream processing	Mandatory	6	UNL
Barrier membranes for food applications	Mandatory	6	UNL
Membranes in regenerative medicine	Mandatory	6	UNL
Individual project (bibliographic and experimental study)	Mandatory	6	UNL
Module 3.A.2 – - ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Portuguese language and culture	Mandatory*	-	UNL

Semester 3: UNIZAR, Spain (30 ECTS)			
Module 3.B.1– 30 ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Fundamental properties of nanostructured materials	Mandatory	6	UNIZAR
Preparation of nanostructured materials	Mandatory	6	UNIZAR
Assembly and fabrication of nanostructures	Mandatory	6	UNIZAR
Case studies of industrial applications	Mandatory	6	UNIZAR
Individual project (bibliographic and experimental study)	Mandatory	6	UNIZAR
Module 3.B.2 – - ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Spanish language and culture	Mandatory*	-	UNIZAR

Semester 3: UTwente, The Netherlands (30 ECTS)			
Module 3.C.1 – 30 ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Batteries, fuel cells and electrolysers	Mandatory	5	UTwente
Gas separation membranes and gas treatment	Mandatory	5	UTwente
Water treatment	Mandatory	5	UTwente
Membrane process plant design	Mandatory	5	UTwente
Microdevices and sensors	Mandatory	4	UTwente
Individual project (bibliographic and experimental study)	Mandatory	6	UTwente
Module 3.C.2 – - ECTS			
Course	***Type***	***ECTS***	***Responsibility***
Dutch language and culture	Mandatory*	-	UTwente

Semester 4: 30 ECTS
Module 4 - **24 weeks, research assignment in industry or university**

Appendix 3.2. Detailed description of the contents of the scientific courses

Course name					
Characterisation of porous materials					
ECTS Credits	3	**Semester**	S1	**Type**	Mandatory

Used sources	1. Lecture notes 2. Slide shows 3. Methods for the characterisation of porous structure in membrane materials" A. JULBE, J.D.F. RAMSAY, in "Fundamentals of Inorganic Membrane Science and Technology", Membrane Science and Technology Series 4, Ed. A.J. Burggraaf and L. Cot, Elsevier (Amsterdam, NL), Chapter 4, 1996, pp: 67-118.
Short description of course contents	1. Description of porous materials- Definitions 2. Static characterisation techniques 2.1. Stereology 2.2. Intrusive methods 2.3. Non intrusive methods 3. Dynamic characterisation techniques 3.1. Rejection measurements 3.2. Liquid displacement techniques
Competencies acquired by the student	**Specific Competencies** 1. To know general concepts about porous materials and porosity 2. To have a general knowledge about the main techniques for the characterization of porosity 3. To be able to develop an analytical strategy and analytical methods for the characterisation of porosity **Generic Competences** 4. Communication skills. Preparation and display of 'posters' reporting project work 5. To perform bibliographic searches and to process the acquired information 6. Ability to perform team-work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	0,6 (15)	Lectures by teaching staff	1, 2, 3
Seminars	0,2 (5)	Presentations by external professionals and researchers	1, 2, 3
Laboratory courses	0,4 (10)	Lab coursed in groups. Characterization of different types of porous materials	2, 3
Tutorials	0,4 (10)	Solving exercises Solving questions presented by the students. Direction of the self-learning of the student. Orientation in the personal assignments.	1, 2, 3
Collaborative project	0,4 (10)	Discussion and analysis of the results obtained in the laboratory.	2, 3, 4, 5, 6
Self-study, working individually	0,8 (20)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5, 6

System for assessment and evaluation	1. Assistance and participation in class and laboratory 2. Personal assignments 3. Oral Presentation 4. Examination

Course name					
Colloid and surface engineering					
ECTS Credits	3	**Semester**	S1	**Type**	Mandatory

Used sources	4. *R.F. Probstein, Physico-chemical hydrodynamics,* 5. *Hiemenz, Principles of colloid and surface chemistry, Deker, 1986* 6. *Mohamed Dauoud, Claudine E. Williams, Soft Matter Physics, Springer, 1999*
Short description of course contents	1. Intermolecular and surface forces and their consequences in term of surface interaction 2. Electro-kinetics phenomena (electrophoresis, electro-osmosis ...) 3. Colloidal properties (stability, coagulation, ...) 4. Practice of product formulation
Competencies acquired by the student	**Specific Competencies** 6. To know general concepts about surface forces and their consequences on colloids and nanoparticles properties 7. To be able to estimate electro-kinetics phenomena 8. To be able to estimate the stability of colloids 9. To know the effect of the suspendant fluid on the properties of dispersed particles 10. To know the practice of product formulation **Generic Competences** 7. To perform bibliographic searches and to process the acquired information 8. Ability to perform team-work 9. Ability to manage operators

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3, 4
Laboratory courses	0,6 (15)	Lab coursed in groups. Examples: Distillation, Absorption, Reactor, Extraction...	2, 3, 4, 5
Collaborative project "Lab course director"	0,6 (15)	A team-work manages a process and the students working on it. The team work analyse the whole data obtained on the process.	5, 6, 7, 8
Self-study, working individually	0,6 (15)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6, 7
Evaluation	0,2 (5)	Oral presentations of the "Lab course director" Examinations	1, 2, 3, 4, 5, 6, 7

System for assessment and evaluation	5. Assistance and participation in class and laboratory 6. Personal assignments 7. Oral Presentation 8. Examination

Course name					
Structural characterization of solids					
ECTS Credits	3	**Semester**	S1	**Type**	Mandatory

Used sources	7. Lecture notes 8. Slide shows
Short description of course contents	5. Fundamentals on interactions of radiation with matter 6. X-ray absorption spectroscopy (EXAFS and XANES) 7. Solid-state NMR 8. Vibrational spectroscopies (IR and Raman) 9. X-ray scattering and related techniques 10. Surface analysis techniques
Competencies acquired by the student	**Specific Competencies** 11. To know general concepts about interactions of radiation with solids 12. To have a general knowledge about the main techniques for the structural characterization of solids 13. To be able to develop an analytical strategy and analytical methods for the characterisation of solids **Generic Competences** 14. Communication skills. Preparation and display of 'posters' reporting project work 15. To perform bibliographic searches and to process the acquired information 16. Ability to perform team-work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	0,6 (15)	Lectures by teaching staff	1, 2, 3
Seminars	0,2 (5)	Presentations by researchers	1, 2, 3
Laboratory courses	0,4 (10)	Lab coursed in groups. Sample cross-testing programs of characterization	2, 3
Tutorials	0,4 (10)	Solving exercises Solving questions presented by the students. Direction of the self-learning of the student. Orientation in the personal assignments.	1, 2, 3
Collaborative project	0,4 (10)	Discussion and analysis of the results obtained in the laboratory.	2, 3, 4, 5, 6
Self-study, working individually	0,8 (20)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5, 6

System for assessment and evaluation	9. Assistance and participation in class and laboratory 10. Personal assignments 11. Oral Presentation 12. Examination

Course name					
Inorganic materials					
ECTS Credits	3	**Semester**	S1	**Type**	Homologation

Used sources	9. Lecture notes 10. Slide shows
Short description of course contents	1. Chemical bonding and solid state properties 2. Metals and alloys 2.1. Extractive metallurgical – examples of Fe and Al 2.2. Solidification and precipitation in solid solutions 2.3. Thermal treatments and transition curves 3. Glasses and vitreous state 3.1. Glass transition 3.2. Glass compositions 3.3. Glass properties 4. Ceramics 4.1. Particle packing and rheology of concentrated suspensions 4.2. Different stages of the ceramic process 5. Hydraulic binders, cements, mortars and concretes 6. Films and coatings 6.1. Liquid phase deposition methods 6.2. Vapour phase deposition methods 7. Different types of inorganic membranes
Competencies acquired by the student	**Specific Competencies** 17. To get basic knowledge about the main types of inorganic materials 18. To get basic knowledge about the deposition methods for the preparation of inorganic coatings and thin films 19. To get a first overview on the different types of inorganic membranes. **Generic Competences** 20. Communication skills. Preparation and display of 'posters' reporting project work 21. To perform bibliographic searches and to process the acquired information

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3
Seminars	0,2 (5)	Presentations by external professionals	1, 2, 3
Laboratory courses	0,4 (10)	Lab coursed in groups. Preparation of ceramic membranes.	1, 2, 3
Tutorials	0,4 (10)	Solving exercises Solving questions presented by the students. Direction of the self-learning of the student. Orientation in the personal assignments.	1, 2, 3
Self-study, working individually	0,8 (20)	Preparation of assignments Personal study	1, 2, 3, 4, 5
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5

System for assessment and evaluation	13. Assistance and participation in class and laboratory 14. Personal assignments 15. Oral Presentation 16. Examination

Course name					
Polymer materials					
ECTS Credits	3	**Semester**	S1	**Type**	Homologation

Used sources	11. Lecture notes 12. Slide shows
Short description of course contents	11. Introduction, Definitions & Nomenclature 12. Classification of Polymers & Basic Morphology 13. Polymer processing and synthesis 14. Mechanical and Thermal properties 15. Copolymers & Advanced Morphology 16. Smart polymers and polymeric materials 17. The world market of plastic industry 18. Polymers in membrane technologies 19. Current trends in polymer membranes
Competencies acquired by the student	**Specific Competencies** 22. To gain understanding in polymer materials. 23. To prepare and characterize the main polymers. 24. To be able to choose the right polymer in function of the application (eg. membrane application). 25. To understand the ties between chemical structure, morphology and properties 26. To know the world plastic market and the future trends **Generic Competences** 10. Communication skills. Preparation and display of 'posters' reporting project work 11. To perform bibliographic searches and to process the acquired information 12. Ability to perform team-work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	0,6 (15)	Lectures by teaching staff	1, 2, 3, 4, 5
Seminars	0,2 (5)	Presentations by external professionals	1, 3, 4, 5
Laboratory courses	0,4 (10)	Lab coursed in groups. Polymer syntheses and chaaracterization	2, 3, 4, 5
Tutorials	0,4 (10)	Solving exercises Solving questions presented by the students. Direction of the self-learning of the student. Orientation in the personal assignments.	1, 2, 3, 4, 5
Collaborative project	0,4 (10)	Discussion and analysis of the results obtained in the laboratory.	2, 3, 4, 5, 6, 7, 8
Self-study, working individually	0,8 (20)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6, 7, 8
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5, 6

System for assessment and evaluation	17. Assistance and participation in class and laboratory 18. Personal assignments 19. Oral Presentation 20. Examination

Course name					
Hybrid and composite materials					
ECTS Credits	3	**Semester**	S1	**Type**	Mandatory

Used sources	13. Lecture notes 14. Slide shows
Short description of course contents	20. General definitions of hybrid and composite materials a. Hybrid materials: definition and properties b. Composite materials: definition and main properties 21. Surface grafting 22. Preparation, shaping of hybrid and composite materials 23. Industrial applications of hybrid and composite materials 24. Hybrid and composite membranes
Competencies acquired by the student	**Specific Competencies** 27. To know general concepts about hybrid and composite materials and surface grafting 28. To be able to prepare hybrid and composite materials and apply the previous knowledge acquired in membrane technology **Generic Competences** 29. Communication skills. Preparation and display of 'posters' reporting project work 30. To perform bibliographic searches and to process the acquired information 31. Ability to perform team-work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	0,6 (15)	Lectures by teaching staff	1, 2
Seminars	0,2 (5)	Presentations by external professionals	1, 2
Laboratory courses	0,4 (10)	Lab coursed in groups. Preparation of hybrid and composite materials	2
Tutorials	0,4 (10)	Solving exercises Solving questions presented by the students. Direction of the self-learning of the student. Orientation in the personal assignments.	1, 2
Collaborative project	0,4 (10)	Discussion and analysis of the results obtained in the laboratory.	1, 2, 3, 4, 5
Self-study, working individually	0,8 (20)	Preparation of assignments Personal study	1, 2, 3, 4, 5
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5

System for assessment and evaluation	21. Assistance and participation in class and laboratory 22. Personal assignments 23. Oral Presentation 24. Examination

Course name					
Materials for chemical reactions – heterogeneous catalysis					
ECTS Credits	3	**Semester**	S1	**Type**	Mandatory

Used sources	15. Lecture notes 16. Slide shows
Short description of course contents	1. Catalysis et catalytic processes 1.1. Basic principles of heterogeneous catalysis 1.2. Preparation and characterisation of catalytic materials 1.3. Redox catalysis 1.4. Acid-base catalysis 1.5. Industrial processes based on heterogeneous catalysis 2. Membrane reactors using inorganic membranes 2.1. Basic concepts 2.2. Membrane materials 2.3. Studies of cases
Competencies acquired by the student	**Specific Competencies** 32. To know general concepts about heterogeneous catalysis, catalytic materials and membrane reactors 33. To be able to apply previous knowledge acquired in membrane reactors and catalytically active membranes with membranes 34. To prepare and to apply catalytically active membranes **Generic Competences** 35. Communication skills. Preparation and display of 'posters' reporting project work 36. To perform bibliographic searches and to process the acquired information

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3
Seminars	0,2 (5)	Presentations by external professionals	1, 2, 3
Laboratory courses	0,4 (10)	Lab coursed in groups. Preparation and application catalytic membranes	1, 2, 3
Tutorials	0,4 (10)	Solving exercises Solving questions presented by the students. Direction of the self-learning of the student. Orientation in the personal assignments.	1, 2, 3
Self-study, working individually	0,8 (20)	Preparation of assignments Personal study	1, 2, 3, 4, 5
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5

System for assessment and evaluation	25. Assistance and participation in class and laboratory 26. Personal assignments 27. Oral Presentation 28. Examination

Course name					
Transport phenomena					
ECTS Credits	3	**Semester**	S1	**Type**	Homologation

Used sources	*17. R.Byron Bird, Warren Stewart, et E.N. Lightfoot, Transport Phenomena, John Wiley & Sons Ltd, 2007*
Short description of course contents	25. Fluid dynamic (momentum transfer) 26. Mass transfer 27. Heat transfer 28. Coupled transfer phenomena in processes 29. Macroscopic mass and heat balance in processes
Competencies acquired by the student	**Specific Competencies** 37. To know general concepts about transport phenomena and the analogy between momentum, mass and heat transfer 38. To be able to develop momentum, mass and heat balances to determine velocity, concentration or temperature variation 39. To be able to use adimensional corelation to estimate friction, mass transfer or heat transfer coefficient at interface 40. To know the consequences of the coupling of transport phenomena in main processes 41. To be able to evaluate the limiting transport phenomena in a processes through the calculation of an adimensionnal number **Generic Competences** 13. To perform bibliographic searches and to process the acquired information 14. Ability to perform team-work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3, 4,5
Laboratory courses	0,6 (15)	Lab coursed in groups. Examples: Fluid dynamics, Mass transfer coefficient, Heat conductivity ...	2, 3, 4, 5
Collaborative project	0,4 (10)	Team-work on the description of transfer problem in a process	2, 3, 4, 5, 6, 7
Self-study, working individually	0,8 (20)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6, 7
Evaluation	0,2 (5)	Oral presentations of the project Examinations	1, 2, 3, 4, 5

System for assessment and evaluation	29. Assistance and participation in class and laboratory 30. Personal assignments 31. Oral Presentation 32. Examination

Course name					
Thermodynamic, kinetics and reactivity					
ECTS Credits	3	**Semester**	S1	**Type**	Mandatory

Used sources	*18. P.W. Atkins, Pysical Chemistry, Oxford, 1990* 19. 20.
Short description of course contents	30. Thermodynamic of ideal and non ideal phase 31. Kinetics of complex reactions (chain reaction, polymerisation, catalysis ...) 32. Processes at solid surface (adsorption, catalytic activity ...)
Competencies acquired by the student	**Specific Competencies** 42. To know general concepts about thermodynamics and changes of state 43. To be able to calculate equilibrium in solids or fluids 44. To be able to estimate reaction rates (in homogeneous and heterogeneous conditions) 45. To know how to describe non ideal solution 46. To know the application of surface reactivty in processes **Generic Competences** 15. To perform bibliographic searches and to process the acquired information 16. Ability to perform team-work 17. Ability to explain a concept

Activity	**Credits ECTS (h) 1ECTS=25h**	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3, 4, 5
Laboratory courses	0,6 (15)	Lab coursed in groups. Examples: Distillation, Absorption, Reactor, Extraction...	2, 3, 4, 5
Collaborative project "Physico-chemical course"	0,6 (15)	A team-work will prepare a course to explain a concept in physical chemistry. T	6, 7, 8
Self-study, working individually	0,6 (15)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6, 7
Evaluation	0,2 (5)	Oral presentations of the "Physico-chemical course" Examinations	1, 2, 3, 4, 5, 6, 7

System for assessment and evaluation	33. Assistance and participation in class and laboratory 34. Personal assignments 35. Oral Presentation 36. Examination

Course name					
General chemistry and physico-chemical analytical methods					
ECTS Credits	3	**Semester**	S1	**Type**	Mandatory

Used sources	21. *Daniel C. Harris, Quantitative Chemical Analysis, W.H.Freeman & Co Ltd,2006* 22.
Short description of course contents	33. General chemistry 34. Fundamental physical and chemical theories underlying analytical chemical measurements 35. Instrumentation for chemical and physical measurements 36. Development and application of analytical chemical methods
Competencies acquired by the student	**Specific Competencies** 47. To know general concepts about chemistry and the way to determine chemical composition and physical properties 48. To know the possible application of the physico-chemical methods 49. To be able to choose the correct instrumentation for an analysis 50. To be able to use an instrument for chemical and physical measurments 51. To know the good practice for an analysis **Generic Competences** 18. To perform bibliographic searches and to process the acquired information 19. Ability to perform team-work 20. To perform lab work with the Good Laboratory Practice

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3
Laboratory courses	0,6 (15)	Lab coursed in groups.	2, 4, 5, 7, 8
Collaborative project "An analysis for a problem"	0,6 (15)	A team-work has to find the instrumentation to use, the operating conditions, and the procedure for a fixed problem.	6, 7, 8
Self-study, working individually	0,6 (15)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6, 7
Evaluation	0,2 (5)	Oral presentations of the "An analysis for a problem" Examinations	1, 2, 3, 4, 5, 6, 7

System for assessment and evaluation	37. Assistance and participation in class and laboratory 38. Personal assignments 39. Oral Presentation 40. Examination

Course name					
Separation science					
ECTS Credits	3	**Semester**	S1	**Type**	Mandatory

Used sources	*23. Separation Process Engineering, Phillip C. Wankat 2006* *24. Separation Process Technology, Jimmy Humphrey, George Keller, 1997* *25. Chemical Engineering: Particle Technology and Separation Processes, J.M. Coulson, J.F. Richardson, J.R. Backhurst, J.H. Harker, 1996*
Short description of course contents	37. Role of separation science in industry 38. Physico-chemical processus involved in separation 39. Separating agents and associated technologies 40. Efficiency and capacity of separation processes 41. Elements for process selection
Competencies acquired by the student	**Specific Competencies** 52. To know general concepts about separation processes and their role in industry 53. To be able to associate a separating agent to a separation technology 54. To know the scientific fundaments of separation processes 55. To be able to estimate the efficiency and the capacity of a separation process (the modelling aspects of the processes will be given in semester 2 in the course Separation Technology) 56. To know simple criteria to choose a separation processes **Generic Competences** 21. To perform bibliographic searches and to process the acquired information 22. Ability to perform team-work 23. Ability to communicate

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3, 4, 5
Laboratory courses	0,6 (15)	Lab coursed in groups. Examples: Distillation, Absorption, Extraction...	1, 2, 4
Collaborative project "Physico-chemical course"	0,6 (15)	A team-work will work on a project to propose processes in regard to a "separation problem".	1, 5, 6, 7, 8
Self-study, working individually	0,6 (15)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6
Evaluation	0,2 (5)	Oral presentations of the "separation problem" Examinations	1, 2, 3, 4, 5, 7, 8

System for assessment and evaluation	41. Assistance and participation in class and laboratory 42. Personal assignments 43. Oral Presentation 44. Examination

Course name					
Individual project					
ECTS Credits	6	**Semester**	S1-S3	**Type**	Mandatory

Used sources	26. Data bases (like SciFinder Scholar – CAS), University library 27. Documents (papers, theses, books, patents) 28. Laboratory
Short description of course contents	In the individual project, the student conducts a bibliographic and/or experimental study. The project is formulated and carried out in consultation with a supervisor. A report is presented at the end of the project and the project presented orally and discussed publicly. External experts may be invited for monitoring the progress and/or attendance of oral presentations. 1. Bibliographic study 2. Experimental study 3. Preparation of a written report 4. Oral presentation and defense
Competencies acquired by the student	**Specific Competencies** 57. The ability to deal with and address specific problems, and to integrate previous knowledge acquired. **Generic Competences** 2. The ability to manage and/or conduct an individual project (bibliographic search and/or experimental study), and to process acquired information. 3. Communication skills; Oral presentation and group discussions.

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Self-study, working individually	5(125)	Preparation of assignment Personal study	1
Evaluation	1(25)	report Oral presentations	2, 3

System for assessment and evaluation	45. Written report 46. Oral Presentation and defense

Course name					
Membrane processes					
ECTS Credits	4	**Semester**	S2	**Type**	Mandatory

Used sources	29. Richard W. Baker Membrane Technology and Applications, 2nd Edition, John Wiley & Sons, Ltd., 2004 30. T. Sata, Ion Exchange Membranes: Preparation, Characterization, Modification and Application, RSC, 2004. 31. D. Pletcher, F.C. Walsh, Industrial Electrochemistry – Second Edition,Springer, 1990. 32. S.P.Nunes, K.-V. Peinemann,Membrane Technology in the Chemical Industry, Wiley-VCH Verlag GmbH, 2001 33. J.G. Sanchéz Marcano and T.T. Tsotsis, Catalytic Membranes and Membrane Reactors
Short description of course contents	a. Basic membrane types and their preparation b. Characteristic properties of membranes, methods of testing c. Membrane separation processes – classification according to the driving forces d. Membrane separation processes based on the concentration gradient - osmosis, dialysis e. Pressure membrane processes – reverse osmosis, ultrafiltration, microfiltration, nanofiltration f. Electromembrane processes – electrodialysis, electrodeionization g. Ion exchange membranes as a solid electrolyte – "zero-gap" membrane electrolysis h. Utilization of ion exchange membranes in fuel cells i. Micro- and mesoporous membranes for gas and liquid separation j. Mechanism of mass transfer in membranes k. Utilization of membranes in separation technologies, industrial applications l. Membrane reactors for homogeneous reactions m. Membrane reactors for heterogeneous catalytic reactions n. Membrane technologies in chemical industry, directions of development
Competencies acquired by the student	**Specific Competencies** 58. To understand general concepts of membrane technology 59. To be able to apply previous knowledge acquired in separation processes and transport phenomena in the separation processes with membranes 60. To understand transport mechanisms in membranes 61. To know the main applications of membranes in separation processes, reactor/separation processes and new applications of technological interest 62. To know basic of membrane preparation and characterization method **Generic Competences** 24. Communication skills. Preparation and display of 'posters' reporting project work 25. To perform bibliographic searches and to process the acquired information Ability to perform team-work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3, 4, 5
Seminars	1,2 (30)	Exercises by teaching staff	1, 3, 4, 5
Laboratory courses			
Tutorials	0,4 (10)	Solving questions presented by the students. Direction of the student self-learning. Orientation in the personal assignments.	1, 2, 3, 4, 5
Collaborative project	0,4 (10)	Discussion and analysis of the results obtained within the project.	2, 3, 4, 5, 6, 7, 8
Self-study, working individually	0,8 (20)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6, 7, 8
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5, 6

System for assessment and evaluation	47. Assistance and participation in class and laboratory 48. Personal assignments 49. Oral Presentation 50. Examination

Course name					
Process design					
ECTS Credits	5	**Semester**	S2	**Type**	Mandatory
Used sources		*34. R. Smith: Chemical Process: Design and Integration, Wiley, 2002* 35. Perry's Cemical Engineers' Handbook			
Short description of course contents		a. On the process view of chemical production, know-how. b. Selection of reactions' pathway, economical criterions, environmental protection. c. Technological schema, mass and energy balance. d. Application of design software. e. Chemical reactors, membrane reactors and their models. f. Pumps – characteristics and examples of selection. g. Compression devices – characteristics, exhausters. h. Filtration of suspensions, characteristics of filters and filtration membranes. i. Energy exchange – heat exchangers and their characteristics. j. Simulation of heat exchangers, design of optimal exchanger. k. Rectification and pervaporation – the fundamentals, characteristics of columns. l. Simulation of rectification and pervaporation. m. Process control – the regulation cycle, characteristics of regulators. n. Examples of complex design of a concrete process.			
Competencies acquired by the student		**Specific Competencies** 63. To understand general concepts of process design 64. To be able to apply previous knowledge acquired in chemical engineering, applied physical chemistry and separation processes to the process design 65. To understand synthesis of processes from the energy saving, waste minimization, construction material and equipment selection point of view. 66. Application of simulation software in solution of process design problems. **Generic Competences** 67. Communication skills. Preparation and display of 'posters' reporting project work 68. To perform bibliographic searches and to process the acquired information 69. Ability to perform team-work			

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1.6 (40)	Lectures by teaching staff	1, 2, 3, 4
Seminars	0.2 (5)	Industrial process presentation by external professionals	1, 2, 3, 4,
Laboratory courses	0.8 (20)	Lab courses - Application of flowsheeting software for solving of typical technology problems	2, 3, 4, 5
Tutorials	0.8 (20)	Discussion of problems presented by the students. Leadership of the student self-learning. Orientation in the personal assignments.	1, 2, 3, 4, 5
Collaborative project	0.6 (15)	Discussion and analysis of the results obtained in individual project	2, 3, 4, 5, 6, 7
Self-study, working individually	0.8 (20)	Preparation of assignments. Personal study	1, 2, 3, 4, 5, 6, 7
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5, 6

System for assessment and evaluation	51. Assistance and participation in class and laboratory 52. Personal assignments 53. Oral Presentation 54. Examination

Course name					
Applied reaction kinetics					
ECTS Credits	4	**Semester**	S2	**Type**	Mandatory
Used sources	36. Schmidt L D.: The Engineering of Chemical Reactions, Oxford University Press, 1998. 37. H.S.Fogler,Elements of Chemical Rection Engineering,2nd Edition,Prentice Hall, 1992 38. J.G. Sanchéz Marcano and T.T. Tsotsis, Catalytic Membranes and Membrane Reactors 39. WWW page of prof. H.Scott Fogler: http://www.engin.umich.edu/~cre/				
Short description of course contents	1. Reaction rate definition. Elementary reactions. Systems of chemical reaction. 2. Balances in isothermal reacting systems. Stoichiometry, conversion. 3. Basic models of chemical reactors for homogeneous systems. 4. Kinetic parameters estimation from isothermal kinetic data. 5. Energy balance in reacting systems. Models of homogeneous non isothermal reactors. 6. Dynamic behaviour of non isothermal homogeneous reactors. 7. Heterogeneous catalytic reactions in a gas phase. 8. Mass and heat transfer in porous catalyst. 9. Fixed bed reactor. 10. Simultaneous separations and reactions. 11. Catalytic membrane separation processes and reactors. 12. Pervaporation membrane reactors 13. Membrane bioreactors. 14. Industrial reactor design				
Competencies acquired by the student	**Specific Competences** 70. To understand general concepts of reacting system description and transfer of the knowledge to experimental data processing. 71. To be able to apply previous knowledge acquired in chemical engineering, physical chemistry and transport phenomena in the reacting systems. 72. To understand transport mechanisms in catalytic systems 73. To understand reacting systems with simultaneous separation and combination of reacting systems with membrane separation processes. 74. To know the main applications of membranes in reactor/separation processes and new applications of technological interest **Generic Competences** 26. Communication skills. Preparation, presentation and reporting of project work 27. To perform bibliographic searches and to process the acquired information 28. Ability to perform team-work				

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3, 4, 5
Seminars	0,6 (15)	Exercises by teaching staff	1, 2, 3, 4
	0.4 (10)	Practice in experimental or technology data treatment	1, 2, 3, 4, 5
Laboratory courses			
Tutorials	0.6 (15)	Solving questions presented by the students. Direction of the self-learning of the student. Orientation in the personal assignments.	1, 2, 3, 4, 5
Collaborative project	0,4 (10)	Discussion and analysis of the experimental results.	2, 3, 4, 5, 6, 7, 8
Self-study, working individually	0.8 (20)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6, 7, 8
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5, 6
System for assessment and evaluation	55. Assistance and participation in class and laboratory 56. Personal assignments 57. Oral Presentation 58. Examination		

Course name					
Separation technology					
ECTS Credits	5	**Semester**	S2	**Type**	Mandatory

Used sources	*40. Bird, Stewart, Lightfoot: Transport Phenomena, John Wiley & Sons, NY (2002).* *41. Separation Process Principles, 2nd edition, Seader, J.D., and Henley E.J.,.* 42. Perry's Chemical Engineers' handbook
Short description of course contents	a. Material and energy balances in chemical engineering applications. b. Basic numerical methods in chemical engineering c. Fluid mechanics for chemical engineers, momentum balances, laminar and turbulent flows in the pipes, equipment and porous media. d. Heat and mass transfer fundamentals, heat and mass transfer coefficients, heat exchangers, mass and heat transfer on phase interfaces. e. Separation processes, phase equilibria, rate processes. f. Adsorption and ion exchange – linear and nonlinear sorption. g. Membrane separation processes - fundamentals h. Ionic exchange and electroforetic separation methods. i. Selection and arrangement of separation methods, criteria for selection. Membrane processes design. j. Gas permeation, reverse osmosis. k. Ultrafiltration, dialysis. l. Electrodialysis, pervaporation. m. Crystallisation - basic principles, phase equilibria, nucleation, grow of crystals. Population balances, crystal size distributions and sieve analysis.
Competencies acquired by the student	**Specific Competencies** 75. To understand general concepts of heat and mass balances 76. To be able to apply previous knowledge acquired in applied physical chemistry and transport phenomena 77. To understand chemical engineering principles of processes 78. To know the basic method of numerical solution of equations resulting from material and energy balances 79. To be able to solve individually chemical engineering problems **Generic Competences** 29. Communication skills. Preparation and reporting project work 30. To perform bibliographic searches and to process the acquired information 31. Ability to perform team-work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1 (25)	Lectures by teaching staff	1, 2, 3, 4, 5
Seminars	0,6 (15)	Exercises by teaching staff	1, 3, 4, 5
	0.6 (15)	Practise in solving mass and energy balances equations	1, 2, 3, 4, 5
Laboratory courses			
Tutorials	1(25)	Solving questions presented by the students. Direction of the self-learning of the student. Orientation in the personal assignments.	1, 2, 3, 4, 5
Collaborative project	0,4 (10)	Discussion and analysis of the results obtained in the laboratory.	2, 3, 4, 5, 6, 7, 8
Self-study, working individually	1,2 (30)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6, 7, 8
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5, 6

System for assessment and evaluation	59. Assistance and participation in class and laboratory 60. Personal assignments 61. Oral Presentation 62. Examination

Course name					
Individual project					
ECTS Credits	6	**Semester**	S1-S3	**Type**	Mandatory

Used sources	43. Data bases (like SciFinder Scholar – CAS), University library 44. Documents (papers, theses, books, patents) 45. Laboratory
Short description of course contents	In the individual project, the student conducts a bibliographic and/or experimental study. The project is formulated and carried out in consultation with a supervisor. A report is presented at the end of the project and the project presented orally and discussed publicly. External experts may be invited for monitoring the progress and/or attendance of oral presentations. 1. Bibliographic study 2. Experimental study 3. Preparation of a written report 4. Oral presentation and defense
Competencies acquired by the student	**Specific Competencies** 80. The ability to deal with and address specific problems, and to integrate previous knowledge acquired. **Generic Competences** 2. The ability to manage and/or conduct an individual project (bibliographic search and/or experimental study), and to process acquired information. 3. Communication skills; Oral presentation and group discussions.

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Self-study, working individually	5(125)	Preparation of assignment Personal study	1
Evaluation	1(25)	report Oral presentations	2, 3

System for assessment and evaluation	63. Written report 64. Oral Presentation and defense

Course name					
Membrane contactors and bioreactors					
ECTS Credits	6	**Semester**	S3	**Type**	Mandatory

Used sources	specialized scientific journals
Short description of course contents	42. Introduction and general concepts 43. Cell Membrane Bioreactors 44. Enzymatic Membrane Bioreactors 45. Multiphasic Membrane Bioreactors 46. Momentum, mass and heat transport in Membrane Contactors 47. Selected case-studies of Membrane Contactors: liquid extraction, gas-liquid Membrane Contactors, membrane distillation, crystallization in Membrane Contactors, emulsification with Membrane Contactors 48. Hybrid processes and process integration 49. Process monitoring and control
Competencies acquired by the student	**Specific Competencies** 81. To acquire general concepts about Membrane Contactors and Bioreactors 82. To be able to design Membrane Bioreactors and Membrane Contactors 83. To be able to design process integration schemes 84. To acquire knowledge about emerging process monitoring tools and their use for process control 85. Understand how a specific problem may be approached by the Industry **Generic Competences** 86. Development of communication skills 87. Development of problem-solving competences 88. Ability to perform autonomous work 89. Ability to perform data mining 90. Ability to perform autonomous work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1.20 (30)	Lectures by teaching staff	1, 2, 3, 4
Seminars	0.24 (6)	Presentations by external academic lecturers, industrial professionals and students	1, 2, 3, 4, 5
Tutorials	0.68 (17)	Case-studies and problems discussion. Direction of the self-learning of the student. Orientation of individual assignments. Students recitation of individual assignments. Support of students for preparation of their individual seminar	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Self-study, working individually	3.24 (81)	Preparation of assignments Preparation of individual seminar Individual study	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Evaluation	0.64 (16)	Students Recitations Written Examination Individual oral presentations by the students Written reports of selected external seminar	1, 2, 3, 4, 5, 6, 7, 8, 9, 10

System for assessment and evaluation	65. Assistance and participation in class, Recitation sessions and in the seminars 66. Written reports of seminars 67. Individual seminar 68. Individual assignments 69. Examination

Course name					
Membranes in downstream processing					
ECTS Credits	6	**Semester**	S3	**Type**	Mandatory

Used sources	specialized scientific journals
Short description of course contents	50. Introduction and general concepts 51. Specificity of biological complex media and media /membrane interactions 52. Product recovery and fractionation 53. Product purification and polishing 54. Hybrid processes and process integration 55. Process monitoring and control
Competencies acquired by the student	**Specific Competencies** 91. To acquire general concepts about downstream processing 92. To be able to apply previous knowledge, acquired in separation processes and transport phenomena, in the processing of biological media 93. To be able to design process integration schemes 94. To acquire knowledge about emerging process monitoring tools and their use for process control 95. Understand how a specific problem may be approached by the Industry **Generic Competences** 96. Development of communication skills. 97. Development of problem-solving competences 98. Ability to perform autonomous work 99. Ability to perform data mining 100. Ability to perform autonomous work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1.20 (30)	Lectures by teaching staff	1, 2, 3, 4
Seminars	0.24 (6)	Presentations by external academic lecturers, industrial professionals and students	1, 2, 3, 4, 5
Tutorials	0.68 (17)	Case-studies and problems discussion. Direction of the self-learning of the student. Orientation of individual assignments. Students recitation of individual assignments. Support of students for preparation of their individual seminar	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Self-study, working individually	3.24 (81)	Preparation of assignments Preparation of individual seminar Individual study	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Evaluation	0.64 (16)	Students Recitations Written Examination Individual oral presentations by the students Written reports of selected external seminar	1, 2, 3, 4, 5, 6, 7, 8, 9, 10

System for assessment and evaluation	70. Assistance and participation in class, Recitation sessions and in the seminars 71. Written reports of seminars 72. Individual seminar 73. Individual assignments 74. Examination

Course name					
Barrier membranes for food applications					
ECTS Credits	6	**Semester**	S3	**Type**	Mandatory

Used sources	specialized scientific journals
Short description of course contents	56. Introduction and general concepts 57. Development of flakes (including reactive flakes) 58. Development of Barrier Membranes 59. Transport mechanisms in Barrier Membranes 60. Selected case-studies of Barrier Membranes for Food Applications 61. New challenges in Barrier Membranes development
Competencies acquired by the student	**Specific Competencies** 101. To acquire general concepts about Barrier Membranes 102. To be able to model mass transport in complex Barrier Membrane systems 103. To acquire knowledge about emerging materials for Barrier Membranes 104. To acquire knowledge about emerging applications for Barrier Membranes 105. Understand how a specific problem may be approached by the Industry **Generic Competences** 106. Development of communication skills 107. Development of problem-solving competences 108. Ability to perform autonomous work 109. Ability to perform data mining 110. Ability to perform autonomous work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1.20 (30)	Lectures by teaching staff	1, 2, 3, 4
Seminars	0.24 (6)	Presentations by external academic lecturers, industrial professionals and students	1, 2, 3, 4, 5
Tutorials	0.68 (17)	Case-studies and problems discussion. Direction of the self-learning of the student. Orientation of individual assignments. Students recitation of individual assignments. Support of students for preparation of their individual seminar	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Self-study, working individually	3.24 (81)	Preparation of assignments Preparation of individual seminar Individual study	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Evaluation	0.64 (16)	Students Recitations Written Examination Individual oral presentations by the students Written reports of selected external seminar	1, 2, 3, 4, 5, 6, 7, 8, 9, 10

System for assessment and evaluation	75. Assistance and participation in class, Recitation sessions and in the seminars 76. Written reports of seminars 77. Individual seminar 78. Individual assignments 79. Examination

Course name					
Membranes in regenerative medicine					
ECTS Credits	6	**Semester**	S3	**Type**	Mandatory

Used sources	specialized scientific journals
Short description of course contents	62. Introduction and general concepts 63. Preparation and characterization of membranes for Tissue Culture 64. Preparation and characterization of membranes for Artificial Organs 65. Transport phenomena in Tissue Culture and Artificial Organs 66. Selected case-studies in Tissue Culture and Artificial Organs 67. New challenges in Tissue Culture and Artificial Organs
Competencies acquired by the student	**Specific Competencies** 111. To acquire knowledge about development and characterization of membranes for Tissue Culture and Artificial Organs 112. To be able to model transport in complex Tissue Culture and Artificial Organs systems 113. To acquire knowledge about emerging materials for Tissue Culture and Artificial Organs 114. To acquire knowledge about emerging applications in Tissue Culture and Artificial Organs 115. Understand how a specific problem may be approached by the Industry **Generic Competences** 116. Development of communication skills 117. Development of problem-solving competences 118. Ability to perform autonomous work 119. Ability to perform data mining 120. Ability to perform autonomous work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1.20 (30)	Lectures by teaching staff	1, 2, 3, 4
Seminars	0.24 (6)	Presentations by external academic lecturers, industrial professionals and students	1, 2, 3, 4, 5
Tutorials	0.68 (17)	Case-studies and problems discussion. Direction of the self-learning of the student. Orientation of individual assignments. Students recitation of individual assignments. Support of students for preparation of their individual seminar	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Self-study, working individually	3.24 (81)	Preparation of assignments Preparation of individual seminar Individual study	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Evaluation	0.64 (16)	Students Recitations Written Examination Individual oral presentations by the students Written reports of selected external seminar	1, 2, 3, 4, 5, 6, 7, 8, 9, 10

System for assessment and evaluation	80. Assistance and participation in class, Recitation sessions and in the seminars 81. Written reports of seminars 82. Individual seminar 83. Individual assignments 84. Examination

Course name					
Individual project					
ECTS Credits	6	**Semester**	S1-S3	**Type**	Mandatory

Used sources	46. Data bases (like SciFinder Scholar – CAS), University library 47. Documents (papers, theses, books, patents) 48. Laboratory
Short description of course contents	In the individual project, the student conducts a bibliographic and/or experimental study. The project is formulated and carried out in consultation with a supervisor. A report is presented at the end of the project and the project presented orally and discussed publicly. External experts may be invited for monitoring the progress and/or attendance of oral presentations. 1. Bibliographic study 2. Experimental study 3. Preparation of a written report 4. Oral presentation and defense
Competencies acquired by the student	**Specific Competencies** 121. The ability to deal with and address specific problems, and to integrate previous knowledge acquired. **Generic Competences** 2. The ability to manage and/or conduct an individual project (bibliographic search and/or experimental study), and to process acquired information. 3. Communication skills; Oral presentation and group discussions.

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Self-study, working individually	5(125)	Preparation of assignment Personal study	1
Evaluation	1(25)	report Oral presentations	2, 3

System for assessment and evaluation	85. Written report 86. Oral Presentation and defense

Course name					
Fundamental properties of nanostructured Materials					
ECTS Credits	6	**Semester**	S3	**Type**	Mandatory

Used sources	1. Springer handbook of nanotechnology / Bharat Bhushan (ed.) Ed. Springer. 2. Nanotechnology: basic science and emerging technologies / Michael Wilson. et al. Ed. Chapman & Hall/CRC. Boca Raton, Florida. 3. The Chemistry Of Nanomaterials (Vols. 1 Y 2). C.N..R. Rao, A. Müller & A.K. Cheetham. Wiley-VCH
Short description of course contents	- Introduction to Nanoscience and Nanotechnology. Nanomaterials vs. macroscopic materials. - Optical, electric, magnetic, and mechanical properties of nanomaterials. Physical Chemistry of Surfaces: thermodynamic and electrical aspects of surface chemistry and interfaces. - Colloids, tensoactives, monolayers, micelles, vesicles, capsules. - Meso and microporous materials, zeolites. - Nanobiomaterials. Biomacromolecules. - Applications of nanoparticles in biomedicine. - Nanotoxicology and eco-nanotoxicology.
Competencies acquired by the student	**Specific Competencies** 1. To know the "state of the art" in Nanoscience and Nanotechnology, giving value to its multidisciplinary nature as well as its social, economic and legal implications. 2. To understand the conceptual differences between macro and nano systems, acquiring the needed knowledge to approach to nanoscale. 3. To identify materials and compounds of special relevance in the nanoscale, evaluating the achievements and the problems to solve. 4. To understand the importance of surface effects and the forces that appear at the nanoscale as well as their influence in the properties of the nanosystems. 5. To acquire basic knowledge to evaluate properties of special interest in nanostructured materials. 6. To know the legislation about nanostructured materials, analyzing its potential influence on health issues, environment and sustainability. **Generic Competences** 7. To relate previous knowledge acquired, in the field of science, to a new field such as nanoscience and nanotechnology. 8. Self-study and ability to gather information and summarize.

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	1,6 (40)	Lectures, open discussions, by teaching staff	1, 2, 3, 4, 5, 6, 7, 8
Self-study, working individually	3,6 (90)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6, 7, 8
E-teaching and new technologies	0,6 (15)	Use of new technologies, (e-teaching, e-learning, e-testing).	8
Evaluation	0,2 (5)	Evaluation of assignments, Examination	1, 2, 3, 4, 5, 6, 7, 8

System for assessment and evaluation	- Assistance and participation in class - Evaluation of assignemnts - Written exam

Course name					
Preparation of nanostructured materials					
ECTS Credits	6	**Semester**	S3	**Type**	Mandatory

Used sources	1. Handbook of Microlithography, Micromachining And Microfabrication, Vols 1 Y 2. P. Rai-Choudhury. SPIE 2. Nano and Microelectromechanical Systems (NEMS and MEMS) And Molecular Machines. David A. LaVan et al. Materials Research Society. 3. Fundamentals of Microfabrication. Marc. J. Madou. CRC Press 4. Principles of Lithography. Harry J. Levinson. SPIE Press 5. Principles of Chemical Vapor Deposition. Daniel M. Dobkin And Michael K. Zuraw (Eds.). Kluwer Academic Publishers 6. Materials Science of Thin Films: Deposition & Structur. Milton Ohring. Academic Press
Short description of course contents	Fabrication methods of nanostructured materials: top-down and bottom-up approaches. Vacuum technology. PVD. CVD. Liquid Phase Deposition. Electrochemical deposition. Optical lithography. Fabrication of MEMS/NEMS. Electron beam lithography. Ion beam lithography. Scanning probe lithography. Nanoimprint, micro-printing, step-and-flash lithography. Other lithography techniques. Lab demonstrations
Competencies acquired by the student	**Specific Competencies** 1. To get a general conception of the different techniques, physical and chemical, for the preparation of nanostructured materials. 2. To be able to correlate the unique properties of the raw material, the preparation technique and the final characteristics and properties of the obtained nanostructure. 3. To acquire the necessary skills to recognize the difficulties in the laboratory to fabricate nanostructured materials and to be able to develop strategies to solve these difficulties and choose the most convenient solution in each case. 4. –Planning, design and implementation of experiments for fabrication of nanostructured materials, assesing the problems and difficulties for doing so. **Generic Competences** 5. Organization and design of an experimental protocol 6. Self-study and ability to gather information and summarize.

Activity	**Credits ECTS (h) 1ECTS=25h**	**Methodology**	**Relationship with competences**
Lectures	1,6 (40)	Lectures by teaching staff	1, 2, 3, 4, 5
Self-study, working individually	3,0 (75)	Preparation of assignments Personal study	1, 2, 3, 4, 5, 6
Laboratory	1,2 (30)	Preparation of materials, tutored by teaching staff	4,5
Evaluation	0,2 (5)	Evaluation of assignments Examinations	1, 2, 3, 4, 5, 6

System for assessment and evaluation	- Assistance and participation in class - Evaluation of assignemnts - Written exam

Course name					
Assembly and fabrication of nanostructures					
ECTS Credits	6	**Semester**	S3	**Type**	Mandatory

Used sources	1. Self-Assembled Nanostructures. Jin Zhang et al. Kluwer Academic Publishers. 2. Three-Dimensional Nanoengineered Assemblies. Thomas M. Orlando et al.Materials Research Society 3. Nanoparticles. From Theory To Application.Günter Schmid.Wiley-VCH. 4. The Chemistry Of Nanomaterials (Vols. 1 Y 2). C.N..R. Rao, A. Müller & A.K. Cheetham Wiley-VCH
Short description of course contents	• Synthesis methods of nanoparticles. Synthesis of carbon nanotubes and graphitic structures. Nanocomposites. Mesoporous and microporous structures. • Jerarchical structures and molecular self-assembly. • Quirality in the nanoscale. Supramolecular chemistry and polymer chemistry. Intercalation chemistry. • Biofunctionalization of nanomaterials. • Lab demonstrations
Competencies acquired by the student	**Specific Competencies** 1. Theoretical knowledge of the preparation methods of nanostructures bottom-up (self-assembly) and top down (micro and nano-litography). 2. To acquire competences for the planification, design and implementation in the fabrication of nanomaterials, evaluating the problems, risks and the results. 3. To know the equipments for the preparation of nanostructures by bottom-up and top-down techniques. **Generic Competences** 4. Experimental design 5. Communication skills. Ability to present and discuss the obtained results in the laboratory

Activity	**Credits ECTS (h) 1ECTS=25h**	**Methodology**	**Relationship with competences**
Lectures	1,6 (40)	Lectures by teaching staff	1, 2, 3, 4
Self-study, working individually	2,8 (70)	Preparation of assignments Personal study	1, 2, 3, 4
Laboratory	1,2 (30)	Preparation of materials, tutored by teaching staff	2,4,5
Evaluation	0,4 (10)	Evaluation of assignments Examination Discussion of experimental results	1, 2, 3, 4, 5

System for assessment and evaluation	- Assistance and participation in class - Evaluation of assignemnts - Written exam

Course name					
Case studies of industrial applications					
ECTS Credits	6	**Semester**	S3	**Type**	Mandatory

Used sources	49. Commercialiizing Micro-nanotechnology Products. Tolfree, D., Jackson, M. J., Ed.CRC Press 50. World Wide Web to look for companies and products 51. Patent Database:, European Patent Office (esp@cenet), Derwent Innovation Index (ISI)
Short description of course contents	The course consists of a series of seminars taught by industrialists, in different fields, where nanotechnology has been applied as a solution to solve a problem or for the development of a new product. Several case studies of industrial applications will be analyzed. A detailed description of the market before the introduction of a certain nanotechnology product will be performed, followed by the identification of the opportunity, the design of the product or process together with its technological implementation and commercialisation. Representative case studies will be analyzed including the pharmaceutical, automotive, textile, cosmetic, and biotechnology industry as well as the fabrication of nanosensors. The students in a team-work will prepare a project for the development of a new product based on their acquired knowledge on nanotechnology/membranes.
Competencies acquired by the student	**Specific Competencies** 122. To evaluate the importante of the nanotechnology products in the market. 123. To understand the high potencial of nanotechnology as an horizontal discipline which is able to integrate in the fabrication process.- 124. To identify the distinctive characteristics that the application at the nanoscale give to certain commercial products. 125. To identify the difficulties for the implementation of the advances in the laboratory to the commercial practice. 126. To know directly from the companies and the "main actors" their industrial experience. 127. To recognize the main factors in product design in high technology and their main features that makes them successful commercial products. **Generic Competences** 32. Communication skills. How to present and idea. 33. Ability to perform team-work

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	0,6 (15)	Lectures by teaching staff	1, 2, 3, 4, 5
Seminars	0,2 (5)	Presentations by external professionals of industrial applications of membranes	1, 3, 4, 5
Collaborative project	0,4 (10)	Discussion and analysis of the results obtained in the laboratory.	5, 6
Evaluation	0,2 (5)	Oral presentations Examinations	1, 2, 3, 4, 5, 6

System for assessment and evaluation	87. Assistance and participation in class 88. Collaborative project 89. Oral Presentation

Course name					
Individual project					
ECTS Credits	6	**Semester**	S1-S3	**Type**	Mandatory

Used sources	52. Data bases (like SciFinder Scholar – CAS), University library 53. Documents (papers, theses, books, patents) 54. Laboratory
Short description of course contents	In the individual project, the student conducts a bibliographic and/or experimental study. The project is formulated and carried out in consultation with a supervisor. A report is presented at the end of the project and the project presented orally and discussed publicly. External experts may be invited for monitoring the progress and/or attendance of oral presentations. 1. Bibliographic study 2. Experimental study 3. Preparation of a written report 4. Oral presentation and defense
Competencies acquired by the student	**Specific Competencies** 128. The ability to deal with and address specific problems, and to integrate previous knowledge acquired. **Generic Competences** 2. The ability to manage and/or conduct an individual project (bibliographic search and/or experimental study), and to process acquired information. 3. Communication skills; Oral presentation and group discussions.

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Self-study, working individually	5(125)	Preparation of assignment Personal study	1
Evaluation	1(25)	report Oral presentations	2, 3

System for assessment and evaluation	90. Written report 91. Oral Presentation and defense

Course name					
Batteries, fuel cells and electrolysers					
ECTS Credits	5	**Semester**	S3	**Type**	Mandatory

Used sources	55. Lecture notes, slides 56. Fuel cell Handbook: U.S. Department of Energy, 2004.
Short description of course contents	68. Introduction, basic principles and theory 69. Thermodynamics of electrochemical cells, losses and efficiency 70. Electrolyte membranes, membrane electrode assemblies 71. Electrode kinetics 72. Different types of batteries and fuel Cells; SOFC, SAFC, PEMFC, DMFC, BioFC, AFC, primary and secondary batteries, etc. 73. Miniaturization and other recent trends 74. Societal relevance and acceptance
Competencies acquired by the student	**Specific Competencies** 129. To know basic concepts and design principles of state-of-the-art fuell cells and batteries. 130. To understand main transport mechanisms, electrode reactions and interfacial kinetics. 131. The ability to describe the different types of fuel cells and batteries, and to mention differences, application areas, operation conditions, and limitations. 132. To know major developments in the field of fuel cells and batteries, and future trends. **Generic Competences** 5. Communication skills; Oral presentation and group discussions. 6. The ability to conduct a bibliographic search, and how to process the acquired information 7. The ability to perform team-work.

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	0,8 (20)	Lectures by teaching staff	1, 2, 3, 4
Seminars	0,4 (10)	Presentations held by external/industrial professionals	1, 2, 3, 4
Assignment	1,6 (40)	Group assignment focused towards selected fuel cell development	4, 5, 6, 7
Laboratory course	0,2 (5)	Practice course organized in groups; testing of fuel cell	1,2
Tutorials	0,8 (20)	Solving exercises, Solving questions raised by the students. Offering support and orientation in assignments.	1, 2, 3, 4
Self-study, working individually	0,8 (20)	Individual preparations and study time. Preparation of assignments.	1, 2, 3, 4, 6, 7
Evaluation	0,4 (10)	Oral presentation and discussions. Examination	1, 2, 3, 4, 5, 6, 7

System for assessment and evaluation	92. Assignment 93. Oral presentation, and participation in discussions 94. Examination

Course name					
Gas separation membranes and gas treatment					
ECTS Credits	5	**Semester**	S3	**Type**	Mandatory

Used sources	57. Lecture notes, slides 58. Y. Yampolskii, I. Pinnau, B.D. Freeman, Materials Science of Membranes, John Wiley & Sons, Ltd. 2006. 59. R.W. Baker, Membrane Technology and Applications, John Wiley and Sons Ltd., 2004.
Short description of course contents	75. Introduction, basic principles and theory 76. Metallic membranes 77. Carbon, zeolite and micro-porous (sol-gel derived) ceramic membranes 78. Polymer membranes 79. Mixed conducting oxide membranes 80. Competitive technologies for gas separation and treatment (cryogenic distillation, pressure swing adsorption, absorption methods etc.) 81. Societal relevance and acceptance
Competencies acquired by the student	**Specific Competencies** 133. To know general concepts, state-of-the-art membranes and technology used for gas separation and gas treatment. 134. To understand main transport mechanisms in different types of gas separation membranes. 135. To know main applications of membranes in separation processes, (catalytic) membrane reactors, and new applications of technological interest. 136. To know competitive technologies for gas separation membranes and gas treatment. 137. To prepare and characterize selected membranes. 138. The ability to interpret experimental data and to draw conclusions. **Generic Competences** 7. Communication skills; Oral presentation and group discussions. 8. The ability to conduct a bibliographic search, and how to process the acquired information. 9. The ability to perform team-work. 10. Based on a general problem description the ability to design an experimental plan 11. Based on a general problem description and experimental plan the ability to conduct practical lab work in an independent way.

Activity	**Credits ECTS (h) 1ECTS=25h**	**Methodology**	**Relationship with competences**
Lectures	0,8 (20)	Lectures by teaching staff	1, 2, 3, 4
Seminars	0,4 (10)	Presentations held by external/industrial professionals	1, 2, 3, 4
Case Study	0,2 (5)	Demonstration	1, 2
Laboratory course	1,6 (40)	Practice course organized in pairs; membrane prepration and characterisation	5, 6, 9, 10, 11
Tutorials	0,8 (20)	Solving exercises, Solving questions as raised by the students. Offering support and orientation in assignments.	1, 2, 3, 4
Self-study, working individually	0,8 (20)	Individual preparations and study time. Preparation of assignments.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Evaluation	0,4 (10)	Oral presentation and discussions. Examination	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

System for assessment and evaluation	95. Assignment 96. Oral presentation, and participation in discussions 97. Examination

Course name					
Water treatment					
ECTS Credits	5	**Semester**	S3	**Type**	Mandatory

Used sources	60. Lecture notes, slides 61. J. Wesselingh, Multi-component mass transport
Short description of course contents	82. Introduction to Maxwell-Stefan description of mass transport 83. Application to membrane separation processes 84. Reverse Osmosis, Pervaporation 85. Ion exchange 86. Ultrafiltration 87. Membrane contactors for heavy metal removal 88. Membrane reactors for advanced oxidation
Competencies acquired by the student	**Specific Competencies** 139. To understand main transport mechanisms of multi-component transport through liquid separation membranes. 140. To know general concepts, state-of-the-art membranes and technology used for water treatment. 141. To know main applications of membranes in separation processes, and new applications of technological interest. 142. To characterize and describe mass transport properties of selected membranes. 143. The ability to interpret experimental data and to draw conclusions. **Generic Competences** 7. Communication skills; Oral presentation and group discussions. 8. The ability to conduct a bibliographic search, and how to process the acquired information. 9. The ability to perform team-work. 10. Based on a general problem description the ability to design an experimental plan 11. Based on a general problem description and experimental plan the ability to conduct practical lab work in an independent way.

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures	0,8 (20)	Lectures by teaching staff	1, 2, 3, 4
Seminars	0,4 (10)	Presentations held by external/industrial professionals	1, 2, 3, 4
Case study	0,2 (5)	demonstration	1, 2
Laboratory course	0,2 (40)	Practice course organized in pairs; membrane prepration and characterisation	1,2
Tutorials	0,8 (20)	Solving exercises, Solving questions raised by the students. Offering support and orientation in assignments.	1, 2, 3, 4
Self-study, working individually	0,8 (20)	Individual preparations and study time. Preparation of assignments.	1, 2, 3, 4, 6, 7, 8, 9, 10, 11
Evaluation	0,4 (10)	Oral presentation and discussions. Examination	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

System for assessment and evaluation	98. Assignment 99. Oral presentation, and participation in discussions 100. Examination

Course name					
Membrane process plant design					
ECTS Credits	5	**Semester**	S3	**Type**	Mandatory

Used sources	62. Lecture notes, slides 63. W.D. Seider, J.D. Seader, D.R. Lewin; Product and Process Design Principles: synthesis, analysis and evaluation. 64. R.W. Baker; Membrane Technology and Applications
Short description of course contents	89. Introduction to systematic process design 90. Introduction to process simulation (flowsheeting: Unisim or ..) 91. Introduction to cost estimation
Competencies acquired by the student	**Specific Competencies** 144. To know main applications of membranes in separation processes, (catalytic) membrane reactors, and new applications of technological interest. 145. Clearly define scope and design basis 146. generate process alternatives in systematic procedure: Combine membrane module(s) with additional unit operations to obtain an operational process. Make balanced choices. 147. Simulate (membrane) processes with a commercial flowsheeter. 148. To understand main transport mechanisms in different types of membranes. 149. The ability to design a (membrane) process (calculate membrane area, optimal module configuration etc. 150. technical en economical evaluation **Generic Competences** 8. Communication skills; Oral presentation and group discussions. 9. The ability to conduct a systematic bibliographic search, and to process the obtained information. 10. The ability to perform team-work. Phasing and project organization.

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Lectures + tutorials	1,0 (25)	Lectures by teaching staff	1, 2, 3, 4, 5, 6, 7
Seminars	0,2 (5)	Presentations held by external/industrial professionals	1, 2, 3, 4, 5, 6, 7
Assignment	3,5 (88)	Design of a membrane process in a systematic way.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Evaluation	0,3 (8)	Report and Oral presentation and discussions.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10

System for assessment and evaluation	101. Assignment 102. Report, oral presentation, and participation in discussions

Course name					
Individual project					
ECTS Credits	6	**Semester**	S1-S3	**Type**	Mandatory

Used sources	65. Data bases (like SciFinder Scholar – CAS), University library 66. Documents (papers, theses, books, patents) 67. Laboratory
Short description of course contents	In the individual project, the student conducts a bibliographic and/or experimental study. The project is formulated and carried out in consultation with a supervisor. A report is presented at the end of the project and the project presented orally and discussed publicly. External experts may be invited for monitoring the progress and/or attendance of oral presentations. 1. Bibliographic study 2. Experimental study 3. Preparation of a written report 4. Oral presentation and defense
Competencies acquired by the student	**Specific Competencies** 151. The ability to deal with and address specific problems, and to integrate previous knowledge acquired. **Generic Competences** 2. The ability to manage and/or conduct an individual project (bibliographic search and/or experimental study), and to process acquired information. 3. Communication skills; Oral presentation and group discussions.

Activity	**Credits ECTS** (h) 1ECTS=25h	**Methodology**	**Relationship with competences**
Self-study, working individually	5(125)	Preparation of assignment Personal study	1
Evaluation	1(25)	report Oral presentations	2, 3

System for assessment and evaluation	103. Written report 104. Oral Presentation and defense