Curriculum - Academic Year 2018-19
Characteristics of the Course Units

Name	*Adsoption*
ECTS credits	*6*
Year / Semester	*I /1°*
Specific learning outcomes	*On successful completion of this module students should be able to:* *1. will be able to explain the importance of gas adsorption method. 1.1. determines the concepts of physical and chemical adsorption. 1.2. expresses the pysical adsorption forces. 1.3. expresses the physisorption of gases by clays and zeolites. 1.4. determines the energetics of physisorption. 1.5. describes the effect of pore size on adsorption potential energy.* *2. will be able to interpret and and classify the adsorption isotherms and hysteresis loops . 2.1. describes the adsorption hysteresis 2.2. expresses the Freundlich Theory. 2.3. explain the Langmuir Theory. 2.4. determines the specific surface area from the Langmuir Equation. 2.5. describes the Brunauer-Emmet-Teller (BET) Theory. 2.5.1. expresses the BET plot. 2.5.2. determines the applicability the BET Theory. 2.5.3. Explain the surface area from the BET equation.* *3. will be able to explain the physical adsorption methods. 3.1. explain the experimental techniques for physical adsorption mesurements. 3.2. describes the reference standarts. 3.3. explain the sample conditioning: Outgassing of the adsorbent. 3.4. expresses the elutration and its prevention.* *4. will be able to analyse the Vacuum Volumetric Measurement (Manometry) Method 4.1. explain the basic properties of volumetric adsorption measurements. 4.2. explain the deviations from ideality. 4.3. explain the void volume determination. 4.4. expresses the coolant level and temperature control. 4.5. expresses the saturation vapor pressure (Po) and temperature of the sample cell. 4.6. determines the sample cells. 4.7. expresses the low surface area. 4.8. expresses the volumetric sorption analyzer instruments (Autosorb-1C and Nova concepts.* *5. will be able to explain the thermal properties of clays and zeolites. 5.1. explain the Thermogravimetric Analysis (TGA) and Derivative Thermogravimetric Analysis (DTG) techniques of porous solids. 5.2. explain the Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry Tecniques (DSC) of porous solids.* *6 – Participate in class discussions with colleagues and with teachers*
Contents	*I. Introduction to industrial adsorption: Fundamentals of adsorption, Separation process, Definition, Types of adsorption, Adsorbents (microporous solids): Pore, The different classes of pore sizes, Pore size distribution, Specific surface, Internal porosity, External interfacial area, Main industrial adsorbents (Activated carbon, zeolites, Silica gels, Activated alumina, Polymer adsorbents); Formatting adsorbents, Criteria for evaluating the qualities of an adsorbent (Capacity, selectivity, regenerability, Kinetic, Mechanical, chemical and thermal resistance, Manufacturing costs, Industrial Uses of Adsorption, Gas separations, Liquid separations, Regeneration (Stripping), General laws of physical adsorption.* *II. Adsorption equilibria; Mode of representation of adsorption equilibria, Adsorption isotherms, Models of adsorption isotherms (Langmuir model, Freundlich model, BET*

	model) *III. Characterization of porous adsorbents: Porosity of adsorbents, Porous network, Types of adsorbent grains, Particles (grains), Aggregates (bi-dispersed adsorbents), Pore characterization factors (Porosity, Capacity, Empty ratio, Density, Apparent volumetric mass, Average pore diameter, Specific surface.* *IV. Transfer in porous solids: Introduction, Kinetics of adsorption, External mass transfer, Internal mass transfer, Adsorption proper, Diffusion in porous solids, Reminder of Fick's Law, Diffusion in the pores, Diffusion in macropores (Diffusion in the gases, Diffusion in liquids), Diffusion in the micropores, External limiting mass transfer.* *V. Adsorption in a fixed bed: Definition, Use of fixed bed adsorption In the industrial field, In the environmental field, Soil pollution control, Evolution of concentrations in a fixed bed.*
Teaching and learning methods	*Face to face, 72 hours*
Teaching techniques	*Lectures, 24 hours* *Practical classes, 48 hours*
Assessment methods	*Written and practical.* *Consulting with lecturer during office hours.* *Consulting with teaching assistant during office hours.* *Private sessions for redelivering the lecture contents.*
Assessment criteria	*In the mid-term test students should demonstrate their ability to identify:* *-The ability to utilize the theoretical and practical expertise acquired in technology.* *-The ability to create new knowledge by integrating knowledge from different fields; ability to resolve problems that require expertise by using scientific research methods.* *-The ability to develop new strategies and solutions by taking responsibility in unforeseen complex problems in process engineering.* *-The ability to present own studies and recent developments written, oral and visual form.* *-The ability to communicate in at least one foreign language, in both oral and written forms.* *-The ability to teach, protect and control social, scientific and ethical values in their research areas as they collect, analyze and present related data.* *-The ability to apply the knowledge and problem-solving skills acquired in chemical process to interdisciplinary studies.* *-Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.*
Assessment metrics	*Attribution of a final grade*
Criteria of attribution of the final grade	*The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments.* *The final grade will be determined according to the following rules:* *Midterm Evaluation: (30%)* *Final exam: (40%)* *practical classes assessments: (30%)*
Preparatory course	*N.A.*

units	
Didactic material	*SUN (L.-M.) et MEUNIER (F.). – Adsorption. Aspects théoriques. J 2 370 Techniques de l'Ingénieur (2003). CHEREMISINOFF (N.P.) et CHEREMISINOFF (P.N.). – Carbon adsorption for pollution control. PTR Prentice Hall, Englewood Cliffs, NJ (1993). COONEY (D.O.). – Adsorption Design for Wastewater Treatment. CRC Press, Boca Raton (1999). CRITENDEN (B.) et THOMAS (W.J.). – Adsorption Technology and Design. Butterworth Heinemann, Oxford (1998). DABROWSKI (A.). – Adsorption and its Applications in Industry and Environmental Protection. Elsevier, Amsterdam (1999). FAUST (S.D.) et ALY (O.M.). – Adsorption processes for water treatment. Butterworth, Boston (1987). GUÉRIN DE MONTGAREUIL (P.) et DOMINÉ (D.). – Procédés de séparation d'un mélange gazeux binaire par adsorption. Brevet français, 1 223 261 (Air Liquide), 21 nov. 1957.*