Advanced Separation Operations

Code: 102401
ECTS Credits: 9

2025/2026

Degree	Type	Year
Chemical Engineering	OT	4

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

It is recommended having reached the basic knowledge and fundamentals on: Separation processes, Heat transfer, Computer Applications and Simulation of Chemical processes.

Objectives and Contextualisation

This subject deals with separation processes based on mass transfer, both equilibrium and rate-controlled. In particular, Humidification, Adsorption, Ion Exchange, Chromatography and separation by Membranes. At all times it is intended a development of each block in a cumulatie way regrading the separation operations that the student already knows, using the concepts of equilibrium, transfer rate, transport coefficients, countercurrent systems, cross-flow, etc..., and making a synthesis of the common concepts among all of them. The student must finally know the basic concepts of these operations and the different methods and applications as a necessary basis on separation technologies in their *curriculum*.

Competences

- Analyse, evaluate, design and operate the systems or processes, equipment and installations used in chemical engineering in accordance with certain requirements, standards and specifications following the principles of sustainable development.
- Demonstrate knowledge of the different reaction, separation and processing operations for materials, and transport and circulation of fluids involved in the industrial processes of chemical engineering.
- Develop personal attitude.

- Develop personal work habits.
- Develop thinking habits.
- Observe ethics and professionalism.
- Show an understanding of the role of chemical engineering in the prevention and resolution of environmental and energy problems, in accordance with the principles of sustainable development.
- Understand and apply the basic principles on which chemical engineering is founded, and more precisely: balances of matter, energy and thermodynamic momentum, phase equilibrium and kinetic chemical equilibrium of the physical processes of matter, energy and momentum transfer, and kinetics of chemical reactions

Learning Outcomes

1. Apply the scientific and technological basics of balance and transfer of matter and separation operations.
2. Conceive and evaluate alternatives and perform design and operation calculations in binary and multicompound mixture separation processes.
3. Contribute to society's welfare and to sustainable development.
4. Critically evaluate the work done.
5. Develop curiosity and creativity.
6. Develop independent learning strategies.
7. Develop systemic thinking.
8. Generalise the concepts of the analysis and design of separation operations to apply them to different operations in the process industry.
9. Generate innovative and competitive proposals in professional activity.
10. Manage available time and resources. Work in an organised manner.
11. Manage information by critically incorporating the innovations of one's professional field and analyse future trends.
12. Solve environmental problems by applying different separation operations both during and at the end of the process.
13. Work autonomously.
14. Work in complex or uncertain surroundings and with limited resources.

Content

TOPIC 0.- INTRODUCTION

Separation processes based on mass transfer. Phase equilibria. Transfer rate. Configurations. Equilibrium-stage operations.

TOPIC 1.- HUMIDIFICATION

1.1. Introduction

1.2. Definitions and nomenclature

1.3. Phase Equilibria

1.4. Adiabatic-saturation Temperature (T_s)

1.5. Measurement of humidity and wet-bulb Temperature (T_w)

1.6. Psychometric or Humidity chart

1.7. Theory and calculation of cooling towers

1.7.1. Equations and balances for cooling towers

1.7.2. Estimation of the outlet gas temperature

TOPIC 2.- ADSORPTION

2.1. Introduction. Definition and types of adsorption processes

2.2. Adsorbents

2.3. Equilibria. Adsorption isotherms. Adsorption models.

2.4. Stage adsorption processes

2.4.1. Cross flow

2.4.2. Countercurrent

2.5. Continuous contact adsorption processes and equipment

2.5.1. Fixed bed

2.5.2. Moving bed

2.5.3. Fluidized bed

TOPIC 3.- IONIC EXCHANGE

3.1. Principles of ionicexchange

3.2. Ionic exchange resins

3.2.1. Physical structure

3.2.2. Chemical structure. Polymeric matrix

3.2.3. Functional groups

3.3. Ionic equilibria between S-L phases

3.4. Rate of Ionic exchange

3.5. Ionic exchange operations

3.5.1. Countercurrent

3.5.2. Fixed bed

3.6. Techniques and their uses

3.6.1. Water softening

3.6.2. Total demineralization. Deionization

3.6.3. Waste treatment and metal ions recovery

3.6.4. Chromatography

TOPIC 4.- CHROMATOGRAPHY

4.1. Introduction. Types, nomenclature and definitions

4.1.1. Retention theory

4.1.2. Separation efficiency

4.2. Continuous carrier flow

4.2.1. Dispersion models

4.2.2. Equilibrium-stage models

4.2.3. Gaussian solution

TOPIC 5.- MEMBRANES

5.1. Fundamentals and typesof membrane separation processes

5.2. Microfiltration

5.3. Osmosis, Reverse Osmosis and Ultrafiltration

5.3.1. Reverse Osmosis

5.3.2. Ultrafiltration

5.3.3. Configuration of membrane systems

5.3.4. Concentration polarization

5.4. Dialysis

5.5. Electrodialysis

5.6. Membrane modules

5.7. Equipment and applications

5.7.1. Metal ions recovery. Electrodialysis

5.7.2. Recycling of degreasing baths

5.7.3. Separation of enzymes produced by fermentation

5.7.4. Desalinization

5.7.5. Hemodialysis

5.7.6. Algae harvesting and preparation as food

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Expository lectures	44	1.76	1, 2, 3, 7, 5, 8, 9, 11, 12
Problem solving	19	0.76	1, 2, 7, 5, 8, 9, 10, 11, 12, 14
Seminars	4	0.16	1, 2, 5, 12
Type: Supervised			

Furhter tutorials	4	0.16	1, 4, 2, 7, 5, 8, 9, 11
Realization of theoretical works, problems and process simulation	8	0.32	1, 2, 5, 8, 11, 12, 14
Type: Autonomous			
Problem solving	63	2.52	1, 4, 2, 3, 7, 6, 5, 8, 9, 10, 11, 12, 13, 14
Study	73	2.92	1, 2, 3, 7, 6, 5, 8, 9, 10, 11, 12, 13, 14
Tutorials with professor	2	0.08	1, 4, 2, 8, 12

The teaching methodology and the proposed evaluation may be modified depending on the restrictions applied by health authorities to the presenciality.

Teaching strategies: Expository lectures/Answers to questions. Seminars. Tutorials in group and individual. Problem solving in the classroom and proposals to the student.

> Lectures and workshops: Students receive a set of, on one hand, theoretical concepts, and on the other hand practical skills for solving examples or easy problems. This learning will provide the basics for understanding the course and problem solving. In the workshop sessions the students will practice the concepts and skills acquired during the lectures. Small groups will easy the participation of the students in the problem solving process.
>
> Specific Seminars: In these sessions the students will receive more practical and specific concepts acquired during the lectures. Presentation of case-studies are emphasized, promoting the participation of the students in the discussion of concepts and alternatives.

Communication environments: Virtual Forum. e-mail. Materials for study and documentation. Structured material: dossiers, exercises, etc ... Bibliography and other complementary materials on-line. Other teaching resources: Optional Specific software with teaching purposes.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Delivery and presentation of problems, activities and exercises	25 %	0	0	1, 4, 2, 3, 7, 6, 5, 8, 9, 10, 11, 12, 13, 14
Partial tests	30 %	3	0.12	1, 4, 2, 3, 7, 6, 5, 8, 9, 10, 11, 12, 13, 14
Synthesis test	45 %	5	0.2	1, 4, 2, 3, 7, 6, 5, 8, 9, 10, 11, 12, 13, 14

The teaching methodology and the proposed evaluation may be modified depending on the restrictions applied by health authorities to the presentiality.

To consider the subject passed, it will be necessary to obtain a minimum overall mark of 50/100.

a) Evaluation process and programmed activities
The continuous evaluation will be made considering a series of activities:

- Problems, tasks, and exercises (PTE): 25 % of the final course mark.
- 1st partial test (PP1) (topic 1): 10 % of the final course mark.
- 2nd partial test (PP2) (topics 2 to 4): 10 % of the final course mark.
- 3rd partial test (PP3) (topic 5): 10 % of the final course mark.
- Synthesis test (PS) (topics 1 to 5): 45 % of the final course mark.

The problems, tasks, and exercises (PTE) will be done individually or in groups and may or may not be problems from the subject list, specific study cases and activities based on key theoretical concepts of the corresponding topics.

The partial tests (PP1, PP2 and PP3) will consist of a short problem and theoretical concepts of the corresponding topics (1h). The synthesis test (PS) will include all the content of the subject and will consist of a theoretical part and another with three problems (5h). In the partial tests and the problems of the synthesis test, support material can be used: notes, books, forms, solved problems, computer, calculation tools, etc ... In the theory part of the synthesis test no type of additional material can be used unless indicated by the teacher.

b) Time-scheduling of evaluation activities
The time-schedule of the evaluation and delivery of work activities will be published in the corresponding virtual platform (Moodle) and may be subject to possible programming changes for reasons of adaptation to possible incidents. Always being informed in the correspondingvirtual Platform about these changes, since it is understood that this is the usual platform for exchange of information between teachers and students.

Tests will not be held on dates, times, and places other than those scheduled and disseminated by the Degree Coordination/School of Engineering. No change may be introduced without the approval of the degree coordination. After 30 minutes of the scheduled time of the evaluation activity, if it has not started, it will be cancelled. Canceled activities will be rescheduled.

c) Recovery process
Students who have failed the continuous evaluation or want to raise the mark will be able to take the final recovery test (PR 75%) of all the partial and synthesis tests, not only of some of the tests. They must have been evaluated from a set of activities that represents a minimum of 2/3 parts of the total subject qualification. By taking this final recovery test, they waive the mark for all the partial and synthesis tests.
The final test will include all the content of the subject and will consist of a theoretical part and another with three problems (5h). In the problems of the final test, supporting material can be used: notes, books, forms, solved problems, computer, calculation tools, etc ... In the theory part of the final test no type of additional material can be used unless indicated by the teacher. In case of not taking the final test, the final course mark for the subject will be the obtained from the continuous evaluation.

d) Revision of the qualifications
For each evaluation activity, a place, date, and time of review will be indicated at the corresponding virtual platform (Moodle) in which the student can review the activity with the teacher.

e) Special qualifications
Granting a qualification of "matrícula de honor" (MH), apart from the minimum mark that can give access ($\geq$ 9.00), is the decision of the faculty responsible for the course that will take into account the proactivity towards the subject, the understanding of the fundamentals and their relationship with other subjects and the fluency, reliability, expression and rational thinking. Special attention will be paid to the theoretical part of the synthesis and final tests. The MH resulting from calculating the 5% or fraction of people enrolled may be granted.
Students will be considered Not Evaluable (NA) if have not been evaluated from a set of activities that represents a minimum of 2/3 parts of the total subject qualification.

f) Irregularities from the student, copying and plagiarism
If the student performs any irregularity that may lead to a significant variation in the grade of an evaluation act, this evaluation act will be graded with a 0, regardless of the disciplinary process that may be instructed. This evaluation activity will not be recoverable. The professor responsible for the subject will have to report these cases to the coordination of the degree that will record the fact.

g) Second registration or more
From the second registration, the student could choose between new continuous evaluation or a synthesis test that will be the same test (equal date and time) as the synthesis test (PS) for the students of first registration. It is mandatory to be communicated by e-mail to the teacher within the first 15 days of the course. Thus, the qualification of the course will correspond either to the continuous evaluation or just the mark of this test (PS 100%), replacing the continuous evaluation for all purposes. They could also do a final recovery test (PR 75% o 100%), according to requirements and conditions for the modality selected, and will be the same test (equal date and time) than the recovery test (PR 75%) for the students of first registration.

g) Single evaluation
This subject does not provide for a single evaluation system.

Bibliography

- Coulson, J.M., Richardson, J.F. ChemicalEngineering. Vol 2. Particle Technology andSeparation Processes. 5th ed. Butterworth-HeinemannLtd. UK. (2002).

  Geankoplis, C. J., Hersel, A.A., Lepek, D.H. Transport Processes andSeparation Process Principles. 5th ed. Prentice Hall PTR. USA (2018).

  McCabe, W. Unit operations of chemicalengineering. 7th ed. McGraw-Hill Education. UK. (2005).

  Perry'sChemicalEngineers' Handbook. 8th ed. McGraw-Hill Education. USA. (2008).

  Wankat, P. C. Ingeniería de procesos de separación (2a. ed.). PearsonEducación. (2008).

Software

- Pal, Nirupam & Siletti, Charles & Petrides, Demetri. (2008). Superpro Designer: An Interactive Software Tool for Designing and Evaluating Integrated Chemical, Biochemical, and Environmental Processes.

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	211	Catalan	first semester	morning-mixed
(SEM) Seminars	211	Catalan	first semester	morning-mixed

(TE) Theory	21	Catalan	first semester	morning-mixed