



Universidad  
de Huelva

Escuela Técnica Superior  
de Ingeniería

GENERAL SPECIFICATIONS



## COURSE 23/24

### Subject Data

**Name:**

Operaciones Básicas de Ingeniería Química II

**English name:**

Unit Operations of Chemical Engineering II

**Code:**

606210216

**Type:**

Compulsory

**Hours:**

|                          | Total | In class | Out class |
|--------------------------|-------|----------|-----------|
| <b>Time distribution</b> | 150   | 60       | 90        |

**ECTS:**

| Standard group | Small groups |     |           |                    |
|----------------|--------------|-----|-----------|--------------------|
|                | Classroom    | Lab | Practices | Computer classroom |
| 4.14           |              |     |           | 1.86               |

**Departments:**

Chemical Engineering, Physical Chemistry and Materials Science

**Knowledge areas:**

Chemical Engineering

**Year:**

3°

**Semester**

2°

**ANEXO I****TEACHING STAFF**

| <b>Name:</b>          | <b>E-mail:</b>           | <b>Telephone</b> |
|-----------------------|--------------------------|------------------|
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|                       |                          |                  |
|                       |                          |                  |

**Others Data (Tutoring, schedule... )**

ETSI building, ETP033 (floor -1)

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### SPECIFIC INFORMATION OF THE COURSE

#### I. Contents description:

##### 1.1 In English:

Separation operations involving mass transfer between phases will be studied: distillation, steady state and batch rectification, gas absorption, and liquid-liquid and solid-liquid extractions. They will be further classified into equilibrium-staged and continuous contact processes.

##### 1.2 In Spanish:

Se estudian operaciones de separación que implican la transferencia de materia entre fases (destilación, rectificación en estado estacionario y por lotes, absorción de gases, extracción líquido-líquido y extracción sólido-líquido) y se hace la distinción entre procesos que se producen por etapas de equilibrio y aquéllos que se llevan a cabo por contacto continuo.

#### 2. Background:

##### 2.1 Situation within the Degree:

This course addresses mass transfer separation operations; thus, previously gained knowledge on mass and enthalpy balances, fluid mechanics, heat transmission and phase equilibrium are applied.

##### 2.2 Recommendations

For the course contents to be properly understood, students must have previous knowledge on mass and enthalpy balances, estimation of equilibrium data, phase diagrams and fluid dynamics on packed beds. Moreover, students should be familiar with the use of advanced engineering calculation software.

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### 3. Objectives (as result of teaching, or skills or abilities and knowledge):

To provide students with knowledge on how to analyze, select, design, calculate and optimize industrial chemical processes based on heat and mass transfer, and controlled by phase equilibrium.

### 4. Skills to be acquired

#### 4.1 Specific Skills:

E01: knowledge on mass and enthalpy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, reactors design, raw materials and energy resources valorization and transformation.

#### 4.2 General, Basic or Transversal Skills:

CB2: students are expected to develop professionalism in their study field

CB5: students are expected to develop self-learning capability with a view to their further postgraduate studies

G01: Solving problem

G02: Making decisions

G04: Putting theoretical knowledge into practice

G09: Creativity

CT2: Analysis capability

CT4: ICT competences

### 5. Training Activities and Teaching Methods

#### 5.1 Training Activities:

- Theoretical contents lectures.
- Solving problem seminars.
- Computer aided case studies workshops.
- Teacher-guided assignments.

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### 5.2 Teaching Methods::

- Master class.
- Computer aided case studies, in small groups.
- Problem solving.
- Assessments and exams.

### 5.3 Development and Justification:

**1. Master class**, which will address theoretical contents and will promote acquisition of competences E01 and G04. It may be supported by the app Quizizz (gamification).

**2. Problem solving:** this methodology will be used to put the theoretical contents into practice through the resolution of numerical problems. These seminars are related to competences E01, G01, G04, G09 and CT2. The problems will be solved with **MS Excel** (built-in functions and macros). For certain exercises, **Mathcad Prime** may be also considered.

**3. Computer aided case studies**, in small groups: the process design simulator **Aspen Plus** will be used to analyze the effect of process variables through specific case studies on distillation, rectification, absorption and extraction. Teaching will be assisted with the use of own-creation **video-tutorials**. These workshops will be aimed to the acquisition of competences E01, G01, G02, G04, G09, CB2, CB5, CT2 and CT4. Virtual activity with overseas Universities may be also considered (**COIL**).

**4. Assessments and exams**, in couple or individually, on the computer workshops or on problem solving exercises; they address competences E01, G01, G02, G04, G09, CB2, CB5, CT2 and CT4.

## 6. Detailed Contents

## ANEXO I

### **BLOCK I: Introduction to mass transfer separation operations**

#### CHAPTER 1. GENERAL CONCEPTS

1. Introduction
2. Operations. Description and equilibrium data
  - 2.1. Distillation and rectification (fractional distillation)
  - 2.2. Absorption/stripping
  - 2.3. Liquid-liquid extraction
  - 2.4. Leaching (solid-liquid extraction)

#### CHAPTER 2. CONTACT TYPES AND FLUID DYNAMICS

##### 1. Equilibrium staged columns

- 1.1. Description
- 1.2. Diameter calculation
- 1.3. Efficiency concept

##### 2. Packed columns

- 2.1. Description
- 2.2. Diameter calculation

#### CHAPTER 3. EQUILIBRIUM DISTILLATION. DIFFERENTIAL DISTILLATION

1. Equilibrium or “flash” distillation
2. Differential or “open” distillation

### **BLOCK II: Equilibrium staged separations**

#### CHAPTER 4. PONCHON-SAVARIT BASED METHODS

1. Application to binary rectification
2. Application to leaching
  - 2.1. Single stage
  - 2.2. Crosscurrent flow
  - 2.3. Countercurrent flow

#### CHAPTER 5. McCABE-THIELE BASED METHODS

1. Application to binary rectification
  - 1.1. Continuous rectification
  - 1.2. Batch rectification
2. Application to absorption
3. Application to L-L extraction (immiscible liquids)

#### CHAPTER 6. TRIANGULAR DIAGRAM METHODS

1. Application to L-L extraction
  - 1.1. Single stage
  - 1.2. Crosscurrent flow
  - 1.3. Countercurrent flow
2. Application to leaching

### **BLOCK III: Continuous contact (rate based) separations**

#### CHAPTER 7. TRANSFER UNIT BASED METHOD

1. Introduction
2. Mass transfer coefficients. Concept and estimation
3. Packed column height calculation
  - 3.1. Application to binary rectification
  - 3.2. Application to absorption

## **7. Bibliography**

### **7.1 Basic Bibliography:**

## ANEXO I

### *PROBLEMAS DE INGENIERÍA QUÍMICA: OPERACIONES BÁSICAS. TOMOS I y II*

J. Ocon, G. Tojo. Ediciones Aguilar, Madrid, 1966

### *EQUILIBRIUM STAGED SEPARATIONS*

P.C. Wankat. Prentice Hall, New Jersey, 1988

### *OPERACIONES DE TRANSFERENCIA DE MASA (2nd ED.)*

R.E. Treybal. McGraw-Hill, México D.F., 1991

### *OPERACIONES DE SEPARACIÓN EN INGENIERÍA QUÍMICA. MÉTODOS DE CÁLCULO*

P.J. Martínez de la Cuesta, E. Rus Martínez. Prentice Hall, Madrid, 2004

### *PRINCIPLES OF CHEMICAL SEPARATIONS WITH ENVIRONMENTAL APPLICATIONS*

R.D. Noble, P.A. Terry. CUP, Cambridge, 2004

### *SEPARATION PROCESS PRINCIPLES (2nd ED.)*

J.D. Seader, E.J. Henley. John Wiley & Sons, New York, 2006

### *MASS TRANSFER AND SEPARATION PROCESSES. PRINCIPLES AND APPLICATIONS (2nd ED.)*

D. Basmadjian. CRC Press, Boca Raton, 2007

### *PRINCIPLES AND MODERN APPLICATIONS OF MASS TRANSFER OPERATIONS (2nd ED.)*

J. Benitez. John Wiley & Sons, New Jersey, 2009

### *MASS TRANSFER OPERATIONS FOR THE PRACTICING ENGINEER*

L. Theodore, F. Ricci. John Wiley & Sons, New Jersey, 2010

### *MASS TRANSFER CONCEPTS*

K. Asokan. CRC Press, Boca Raton, 2011

### *SEPARATION PROCESS ENGINEERING: INCLUDES MASS TRANSFER ANALYSIS (4th ED.)*

P.C. Wankat. Prentice Hall, Boston, 2017

### *MASS TRANSFER II (16th ED.)*

K.A. Gavhane. Nirali Prakashan, Pune, 2017

### *PROBLEMAS RESUELTOS DE OPERACIONES DE SEPARACIÓN*

F.J. Montes. Paraninfo Universidad, Madrid, 2019

## 7.2 Additional Bibliography:

### *HANDBOOK OF SEPARATION TECHNIQUES FOR CHEMICAL ENGINEERS*

P.A. Schweitzer. McGraw-Hill, New York, 1997

### *CHEMICAL ENGINEERING, VOL. 2, PARTICLE TECHNOLOGY AND SEPARATION PROCESSES (5th ED.)*

J.F. Richardson, J.H. Harker. Butterworth-Heinemann, Oxford, 2002

### *TRANSPORT PROCESSES AND SEPARATION PROCESS PRINCIPLES (INCLUDES UNIT OPERATIONS) (4th ED.)*

C.J. Geankoplis. Prentice Hall, New Jersey, 2003

### *ASPEN PLUS V8.0. GETTING STARTED BUILDING AND RUNNING A PROCESS MODEL*

Aspen Technology Inc., Burlington, 2012

### *DISTILLATION DESIGN AND CONTROL USING ASPEN SIMULATION (2nd ED.)*

W.L. Luyben. Wiley, New Jersey, 2013

### *DISTILLATION: EQUIPMENT AND PROCESSES*

A. Gorak, Z. Olujić. Elsevier, Amsterdam, 2014

### *DISTILLATION: FUNDAMENTALS AND PRINCIPLES*

A. Gorak, E. Sorensen. Elsevier, Amsterdam, 2014

### *TUTORIAL DE ASPEN PLUS. INTRODUCCIÓN Y MODELOS SIMPLES DE OPERACIONES UNITARIAS*

F. Espinola. Universidad de Jaén, Jaén, 2015

### *USING ASPEN PLUS IN THERMODYNAMICS INSTRUCTION: A STEP-BY-STEP GUIDE*

S.I. Sandler. Wiley: AICHE, New Jersey, 2015

### *ASPEN PLUS: CHEMICAL ENGINEERING APPLICATIONS*

Kamal I.M. Al-Malah. Wiley, New Jersey, 2017

### *CHEMICAL PROCESS DESIGN AND SIMULATION: ASPEN PLUS AND ASPEN HYSYS APPLICATIONS*

J. Haydary. Wiley: AICHE, New Jersey, 2019

## ANEXO I

### 8. Systems and Assessment Criteria

#### 8.1 System for Assessment:

- Theory/Problems Exam
- Practical assignment
- Individual student monitoring

#### 8.2 Assessment Criteria and Marks:

##### 8.2.1 Examinations Convocatory I

**1. Theory/Problems Exam (70 %):** competences E01, G01, G04 and CT2 will be assessed through a **final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.

**2. Practical assignment (20 %):** competences E01, CB2, CB5, G01, G02 G04, G09, CT2 and CT4 will be evaluated through an **Aspen Plus assignment**, in couples, which will deal with the computer sessions contents (10 %). The students will be also asked to prepare a **video-report**, in English language (10 %).

**3. Individual student monitoring (10 %):** The students will be asked to complete an **online multiple choice test** (10-20 questions) on the Aspen Plus simulations.

Please, do NOTE that:

- **100 % attendance to computer sessions is compulsory.**
- A minimum overall mark of 5 over 10 is required to pass.
- If a minimum mark of 4 over 10 is not attained in part 1, parts 2 and 3 will not be considered. Likewise, parts 2 and 3 will not be considered if their marks are lower than part 1's. In both cases, part 1 will represent 100 %.
- Students are free to opt for maintaining part 2 and/or 3 marks forever (as long as they reach a minimum mark of 5 over 10) or repeating them the following academic course.
- Mobile phones are forbidden in class, computer sessions and exams.

##### 8.2.2 Examinations Convocatory II

**1. Theory/Problems Exam (70 %):** competences E01, G01, G04 and CT2 will be assessed through a **final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.

**2. Practical assignment (20 %):** Convocatory I (June) grades will be applied.

**3. Individual student monitoring (10 %):** Convocatory I (June) grades will be applied.

Please, do NOTE that:

- **100 % attendance to computer sessions is compulsory.**
- A minimum overall mark of 5 over 10 is required to pass.
- If a minimum mark of 4 over 10 is not attained in part 1, parts 2 and 3 will not be considered. Likewise, parts 2 and 3 will not be considered if their marks are lower than part 1's. In both cases, part 1 will represent 100 %.
- Students are free to opt for maintaining part 2 and/or 3 marks forever (as long as they reach a minimum mark of 5 over 10) or repeating them the following academic course.

Mobile phones are forbidden in class, computer sessions and exams.

##### 8.2.3 Examinations Convocatory III

**1. Theory/Problems Exam (70 %):** competences E01, G01, G04 and CT2 will be assessed through a **final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.

**2. Practical assignment (20 %):** Convocatory I (June) grades will be applied.

**3. Individual student monitoring (10 %):** Convocatory I (June) grades will be applied.

Please, do NOTE that:

- **100 % attendance to computer sessions is compulsory.**
- A minimum overall mark of 5 over 10 is required to pass.
- If a minimum mark of 4 over 10 is not attained in part 1, parts 2 and 3 will not be considered. Likewise, parts 2 and 3 will not be considered if their marks are lower than part 1's. In both cases, part 1 will represent 100 %.
- Students are free to opt for maintaining part 2 and/or 3 marks forever (as long as they reach a minimum mark of 5 over 10) or repeating them the following academic course.

Mobile phones are forbidden in class, computer sessions and exams.



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### 8.2.4 Extraordinary Convocatory

**1. Theory/Problems Exam (70 %):** competences E01, G01, G04 and CT2 will be assessed through a **final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.

**2. Practical assignment (20 %):** Convocatory I (June) grades will be applied.

**3. Individual student monitoring (10 %):** Convocatory I (June) grades will be applied.

Please, do NOTE that:

- **100 % attendance to computer sessions is compulsory.**
- A minimum overall mark of 5 over 10 is required to pass.
- If a minimum mark of 4 over 10 is not attained in part 1, parts 2 and 3 will not be considered. Likewise, parts 2 and 3 will not be considered if their marks are lower than part 1's. In both cases, part 1 will represent 100 %.
- Students are free to opt for maintaining part 2 and/or 3 marks forever (as long as they reach a minimum mark of 5 over 10) or repeating them the following academic course.

Mobile phones are forbidden in class, computer sessions and exams.

### 8.3 Single Final Evaluation:

**Theory/Problems Exam (100 %):** competences E01, G01, G04 and CT2 will be assessed through a **final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.