VNIVERSITAT DE VALÈNCIA

# Course Guide
# 34231 Analytical Chemistry Laboratory I

## COURSE DATA

| Data Subject | |
|---|---|
| **Code** | 34231 |
| **Name** | Analytical Chemistry Laboratory I |
| **Cycle** | Grade |
| **ECTS Credits** | 6.0 |
| **Academic year** | 2020 - 2021 |

**Study (s)**

| Degree | Center | Acad. year | Period |
|---|---|---|---|
| 1110 - Degree in Chemistry | Faculty of Chemistry | 2 | Second term |

**Subject-matter**

| Degree | Subject-matter | Character |
|---|---|---|
| 1110 - Degree in Chemistry | 6 - Analytical Chemistry | Obligatory |

**Coordination**

| Name | Department |
|---|---|
| ESCUDER GILABERT, LAURA | 310 - Analytical Chemistry |

## SUMMARY

Analytical Chemistry Laboratory I is a core course taught in the second year (fourth semester) of the Degree in Chemistry for a total of 6 ECTS credits.

Through practice in the classical techniques of inorganic qualitative analysis and quantitative inorganic and organic analysis, which are common analyses in Chemical Analysis laboratories, students acquire the skills they will need to work in both general laboratories and in Analytical Chemistry laboratories.

The laboratory work will enable students to get used to preparing for their experimental practice, consolidate course contents and theoretical concepts, and teach them how to keep a laboratory notebook and produce an analytical report.

# PREVIOUS KNOWLEDGE

## Relationship to other subjects of the same degree

### 1108 - Degree in Chemistry V1-2009 :

### 1110 - Degree in Chemistry V2-2018 :

### 1929 - Double Degree in Physics and Chemistry :

R5-OBLIGATION TO PURSUE THE COURSE SIMULTANEOUSLY

36450 - Analytical Chemistry I

36450 - Analytical Chemistry I

36450 - Analytical Chemistry I

## Other requirements

To successfully complete this course, students should have acquired knowledge in the topics from the subject Analytical Chemistry I: Introduction to Analytical Chemistry. Ionic solutions. Acid-base, complex formation, solubility and redox equilibria. Introduction to titrimetric analysis. acid-base, complex formation, solubility and redox titrimetry. Gravimetric analysis. Also are required basic skills in laboratory work, statistics and computing that students should have acquired from General Chemistry I and II, Chemistry Laboratory I and II, and Computer Applications in Chemistry and Mathematics I and II.

# OUTCOMES

## 1108 - Degree in Chemistry

- Develop capacity for analysis, synthesis and critical thinking.
- Show inductive and deductive reasoning ability.
- Demonstrate leadership and management skills, entrepreneurship, initiative, creativity, organization, planning, control, leadership, decision making and negotiation.
- Solve problems effectively.
- Demonstrate ability to work in teams both in interdisciplinary teams and in an international context.
- Demonstrate ability to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences and using information technology, as appropriate.
- Demonstrate a commitment to ethics, equality values and social responsibility as a citizen and as a professional.
- Learn autonomously.
- Demonstrate the ability to adapt to new situations.

- Acquire a permanent sensitivity to quality, the environment, sustainable development and the prevention of occupational hazards.
- Demonstrate knowledge of the main aspects of chemical terminology, nomenclature, conventions and units.
- Interpret the variation of the characteristic properties of chemical elements according to the periodic table.
- Demonstrate knowledge of the main types of chemical reaction and their main characteristics.
- Demonstrate knowledge of the principles of thermodynamics and kinetics and their applications in chemistry.
- Demonstrate knowledge of the principles, procedures and techniques for the determination, separation, identification and characterisation of chemical compounds.
- Show knowledge of the metrology of chemical processes including quality management.
- Demonstrate knowledge and understanding of essential facts, concepts, principles and theories related to the areas of chemistry.
- Solve qualitative and quantitative problems following previously developed models.
- Recognise and analyse new problems and plan strategies to solve them.
- Evaluate, interpret and synthesise chemical data and information.
- Handle chemicals safely.
- Carry out standard experimental procedures involved in synthetic and analytical work, in relation to organic and inorganic systems.
- Handle the instrumentation used in the different areas of chemistry.
- Interpret data from observations and measurements in the laboratory in terms of their significance and the theories that underpin them.
- Evaluate the risks in the use of chemicals and laboratory procedures.
- Relate theory and experimentation.
- Recognise and evaluate chemical processes in daily life.
- Understand the qualitative and quantitative aspects of chemical problems.
- Develop sustainable and environmentally friendly methods.
- Relate chemistry with other disciplines.
- Students must be able to apply their knowledge to their work or vocation in a professional manner and have acquired the competences required for the preparation and defence of arguments and for problem solving in their field of study.
- Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.
- Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.

- Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.
- Express oneself correctly, both orally and in writing, in any of the official languages of the Valencian Community.
- Have basic skills in the use of information and communication technology and properly manage the information obtained.

## LEARNING OUTCOMES

The previous section includes the competences contained in the document VERIFICA. This subject addresses part of the learning results of the matter Analytical Chemistry that allow to acquire specific knowledge of chemistry, cognitive skills and general skills recommended by the EUROPEAN CHEMISTRY THEMATIC NETWORK (ECTN) for the Chemistry Eurobachelor® Label. The following table lists the learning outcomes acquired in the subject Analytical Chemistry Laboratory I related to the competences of the degree in Chemistry.

| **SPECIFIC KNOWLEDGE OF CHEMISTRY** | |
|---|---|
| **The learning process should allow the degree graduates to demonstrate:** | |
| | **Competences of the subject Analytical Chemistry Laboratory I that contemplate the learning outcomes EUROBACHELOR®** |
| The principles and procedures used in chemical analysis and the characterisation of chemical compounds. | Demonstrate knowledge of the principles, procedures and techniques for the determination, separation, identification and characterisation of chemical compounds.(CE8)<br><br>Show knowledge of the metrology of chemical processes including quality management..(CE10)<br><br>Handle the instrumentation used in the different areas of chemistry.(CE19).<br><br>Understand the qualitative and quantitative aspects of chemical problems..(CE24).<br><br>Develop sustainable and environmentally friendly methods.(CE25) |

| COMPETENCES AND COGNITIVE SKILLS | |
|---|---|
| **The learning process should allow the degree graduates to demonstrate:** | |
| | **Competences of the subject Analytical Chemistry Laboratory I that contemplate the learning outcomes EUROBACHELOR®** |
| Ability to apply this knowledge and understanding to the solution of common qualitative and quantitative problems. | Solve qualitative and quantitative problems following previously developed models..(CE14).<br>Recognise and analyse new problems and plan strategies to solve them..(CE15).<br>Understand the qualitative and quantitative aspects of chemical problems..(CE24). |
| Competences for the evaluation, interpretation and synthesis of information and chemical data. | Evaluate, interpret and synthesise chemical data and information..(CE16).<br>Interpret data from observations and measurements in the laboratory in terms of their significance and the theories that underpin them..(CE20). |
| Ability to recognize and implement science and the practice of measurement. | Show knowledge of the metrology of chemical processes including quality management..(CE10)<br>Interpret data from observations and measurements in the laboratory in terms of their significance and the theories that underpin them..(CE20). |
| Ability to calculate and process data, related to information and chemistry data. | Solve qualitative and quantitative problems following previously developed models..(CE14).<br>Recognise and analyse new problems and plan strategies to solve them..(CE15). |

| COMPETENCES AND COGNITIVE SKILLS RELATED TO THE PRACTICE OF CHEMISTRY |
|---|

| The learning process should allow the degree graduates to demonstrate: | |
|---|---|
| | **Competences of the subject Analytical Chemistry Laboratory I that contemplate the learning outcomes EUROBACHELOR®** |
| Capacities to handle chemical products safely, taking into account their physical and chemical properties, including any risk associated with their use. | Handle chemicals safely..(CE17).<br><br>Evaluate the risks in the use of chemicals and laboratory procedures..(CE21). |
| Capabilities necessary to perform standard laboratory procedures as well as to use instrumentation in synthetic and analytical works, in both cases in relation to both organic and inorganic systems. | Carry out standard experimental procedures involved in synthetic and analytical work, in relation to organic and inorganic systems..(CE18).<br><br>Relate theory and experimentation..(CE22).<br><br>Understand the qualitative and quantitative aspects of chemical problems..(CE24). |
| Capacities to monitor, observe and measure the chemical properties, facts or changes, and perform their registration (collection) and documentation in a systematic and reliable way. | Handle the instrumentation used in the different areas of chemistry.(CE19).<br><br>Relate theory and experimentation..(CE22).<br><br>Recognise and evaluate chemical processes in daily life..(CE23).<br><br>Understand the qualitative and quantitative aspects of chemical problems..(CE24). |
| Ability to interpret data derived from observations and laboratory measurements in terms of their relevance, and relate them to the appropriate theory. | Interpret data from observations and measurements in the laboratory in terms of their significance and the theories that underpin them..(CE20).<br><br>Relate theory and experimentation..(CE22).<br><br>Recognise and evaluate chemical processes in daily life..(CE23).<br><br>Understand the qualitative and quantitative aspects of chemical problems..(CE24).<br><br>Relate chemistry with other disciplines.(CE26). |

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|---|---|
| Ability to perform risk assessments of the use of chemical substances and laboratory procedures. | Understand the qualitative and quantitative aspects of chemical problems..(CE24).<br>Develop sustainable and environmentally friendly methods.(CE25).<br>Evaluate the risks in the use of chemicals and laboratory procedures..(CE21). |
| **GENERAL COMPETENCES** | |
| **The learning process should allow the degree graduates to demonstrate:** | |
| | **Competences of the subject Analytical Chemistry Laboratory I that contemplate the learning outcomes EUROBACHELOR®** |
| Ability to apply practical knowledge to solve problems related to qualitative and quantitative information. | Solve problems effectively..(CG4).<br>Solve qualitative and quantitative problems following previously developed models..(CE14).<br>Relate theory and experimentation..(CE22).<br>Recognise and evaluate chemical processes in daily life..(CE23).<br>Understand the qualitative and quantitative aspects of chemical problems..(CE24). |
| Calculation and arithmetic capabilities, including aspects such as analysis error, estimates of orders of magnitude, and correct use of the units. | Develop capacity for analysis, synthesis and critical thinking.. (CG1).<br>Show inductive and deductive reasoning ability..(CG2).<br>Solve problems effectively..CG4). |
| Planning and time management skills. | Develop capacity for analysis, synthesis and critical thinking. (CG1).<br>Demonstrate leadership and management skills, entrepreneurship, initiative, creativity, organization, |

| | |
|---|---|
| | planning, control, leadership, decision making and negotiation..(CG3).<br><br>Solve problems effectively..CG4). |
| Interpersonal skills to interact with other people and get involved in team work. | Demonstrate ability to work in teams both in interdisciplinary teams and in an international context..(CG5).<br><br>Demonstrate a commitment to ethics, equality values and social responsibility as a citizen and as a professional. (CG7).<br><br>Demonstrate the ability to adapt to new situations..(CG9). |

These learning outcomes should ensure that on successful completion of Analytical Chemistry Laboratory I students will be able to:

- use personal and collective safety and emergency equipment in the laboratory appropriately.
- predict observable and unobservable behaviours of common anions and cations when both general and specific reagents are added to an ionic solution.
- describe the effect of interferences and use common methods to eliminate them.
- develop the main stages used in carbonate systematics for the qualitative analysis of inorganic cations, including separation operations combined with identification tests based on acid-base, complexation, precipitation and redox reactions.
- perform and interpret the usual tests for identifying common inorganic anions and cations in the carbonate systematics of qualitative analysis.
- perform and interpret direct tests on the original sample.
- recognize the characteristic behaviour of chemical species by comparing them with blanks and witnesses: reaction rates, appearance and colour of the precipitates, adherence to surfaces (glass, porcelain, paper), and smell, etc.
- recognize the most common cases of redox incompatibility (between ions and with regard to the pH of the medium) and precipitation incompatibility (formation of insoluble residues in non-complexing acids).
- evaluate test sensitivity associated with the semi-quantitative estimation of concentrations.
- solve problems with identifying anions and cations in samples of known and unknown composition.
- write qualitative analytical reports, indicating the tests used and making semi-quantitative estimations of the ion concentrations.
- apply volumetric and gravimetric techniques in classical quantitative analysis.
- describe the importance of quantitative analysis in industry, health control and environmental control.
- describe the absolute nature of these methods, which are directly traceable to the mole as the basic unit of the international system of measurements.
- correlate the observations found with theoretical studies of the various types of titration curves and chemical indicators.
- take and prepare samples and standards, use volumetric and non-volumetric material correctly, and

use primary standards (sptp) and primary and secondary standard solutions, including their normalization.
- apply error estimation procedures and experimental techniques that guarantee the accuracy of the results within the expected range.
- write analytical reports that reflect the results of the experiments conducted, expressing the quantities with their appropriate units and significant figures.
- identify all the essential information to be included in an analytical report, including the masses of the standards and samples, the volumes of the sample and titrants, the atomic masses used, etc.
- perform the most common calculations in quantitative analysis (including the estimated amounts of sample or standard needed and the results that derive from the volumes or masses found) and express the results with their appropriate units and significant figures.
- use the statistics of small data sets correctly when solutions are standardized and results are reported, after removing any outliers and, if necessary, re-obtaining the lost data.
- justify the importance of reducing the environmental impact of the analytical methods by selecting reagents, minimizing their masses and volumes, and selecting residues that can be processed.

## DESCRIPTION OF CONTENTS

### 1. Classic Qualitative Analysis

1. Qualitative chemical analysis of anions and cations.

### 2. Quantitative Analysis: Titrimetry

2. Acid-base titrimetry: Standardization and application of a standard solution of HCl. Study of the titration error. 3. Acid-base titrimetry: Standardization and application of a standard solution of NaOH. Determination of polyphosphates. 4. Titrimetry using a solubility reaction: determination of chloride in mayonnaise by the Mohr method. 5. Redox and complexometric titrimetry: iodometric determination of copper and complexometric determination of copper and zinc in brass. 6. Redox titrimetry: determination of the chemical oxygen demand in water (consumption of permanganate).

### 3. Quantitative Analysis: Gravimetry

7. Gravimetry of calcium as oxalate: determination of calcium in milk. 8. Determination of moisture (drying) and ashes in food.

### 4. Quantitative Analysis: Instrumental

9. Spectrophotometric determination of iron in foods.

## WORKLOAD

| ACTIVITY | Hours | % To be attended |
|---|---|---|
| Laboratory practices | 48,00 | 100 |
| Tutorials | 12,00 | 100 |
| Development of group work | 15,00 | 0 |
| Development of individual work | 10,00 | 0 |
| Study and independent work | 28,00 | 0 |
| Readings supplementary material | 10,00 | 0 |
| Preparation of evaluation activities | 10,00 | 0 |
| Preparation of practical classes and problem | 15,00 | 0 |
| Resolution of online questionnaires | 2,00 | 0 |
| **TOTAL** | **150,00** | |

## TEACHING METHODOLOGY

The materials (scripts, guidelines, schedule, questions, etc.) will be made available to students via the

virtual classroom before the beginning of the introductory session. Before work in the laboratory, there will be a seminar to:

- explain the general rules of Analytical Chemistry Laboratory I.
- explain how the course will develop and discuss the various sections of this course guide.
- introduce skills students have not previously acquired but are necessary for the subject and, if appropriate, discuss any previous knowledge required.
- provide the information and materials students will need to prepare the first practice session or first block of sessions.

In addition, other seminars will be held to further the theoretical-practical aspects and data processing of each practice.

The course is structured around the following axes:

(i) preparation of the practice to be conducted, (ii) laboratory work, (iii) treatment of the results and (iv) laboratory notebook and analytical reports.

(i) Preparation of the practice to be conducted. With the script, the materials and the information provided by the lecturer, students prepare each practice session before coming to the laboratory.

The script will be accompanied by a series of questions on the practical session that students must write their answers to.

Students must prepare an outline of their work before they start their practice session. This serves to verify that they have understood the task and will prove useful when conducting their laboratory work.

Also in preparation for the practice session they must perform the calculations they need to prepare the solutions that will be used in the session.

The lecturer will review the material prepared by the student before the beginning of the practice session.

The aim of this preparation is to ensure that, before entering the laboratory, students understand what they need to do and why.

(ii) Laboratory work. After reviewing the students' materials, the lecturer will discuss any aspects that need to be clarified before the students start their practice session. The students will then prepare the solutions (reagents, standards and samples) and begin the session.

The sessions are conducted in pairs. Sometimes, however, in order to encourage teamwork, several pairs may share their results. At this stage of the work the lecturer will encourage a positive attitude from students toward their scientific work.

Keeping a laboratory notebook during their practical sessions is an important component of the students' laboratory work. At no time should the notes in the laboratory notebook be re-written.

(iii) Treatment of the results. The treatment of the results will begin in the laboratory. The lecturer will first guide the students in this task before the students complete the work by themselves. When presenting the results of the laboratory sessions, students must draw appropriate figures and tables to collect the data and use the correct units and significant figures. As the aim of this stage is to develop the students' analytical skills, they must not only calculate the results they obtain in the laboratory but also analyse them as well as their previous estimates.

(iv) Laboratory notebook and analytical reports. One aim of this course is to teach students to present their work appropriately by keeping a laboratory notebook and producing an analytical report.

Students must learn to keep a laboratory notebook of the work they carry out. The lecturer will periodically review the notebook. This notebook must be presented by the student when requested by the teacher.

When recording details in their notebook, students must remember that all scientific work should be capable of being reproduced by others. All raw data must be recorded with precision and information on the work conducted and observations found must be specified.

## EVALUATION

Learning will be evaluated by taking into account all the aspects outlined in the Methodology section of this course guide.

# FIRST CALL

Students' grades will be calculated from the weighted average of the following three activities:

1. Preparation, experimental technique and laboratory notebook: The following aspects will be evaluated:

(a) Preparation of the practice sessions before the beginning of the sessions.

(b) Laboratory work: the student's abilities, interest and attitude will be taken into account when continuously evaluating his or her progress and work during the practice sessions. In particular, the student's implementation of proper experimental techniques in all laboratory operations will be assessed.

(c) The laboratory notebook that will be developed following the guidelines previously established by the teacher. Students should bear in mind that all scientific work should be capable of being reproduced from the data and instructions in the notebook. The work expressed in the student's laboratory notebook must meet this condition. Students must therefore indicate all raw data, along with their uncertainty where appropriate, plus any incidents, relevant comments and details. Disorder and material that is irrelevant to the experimental work will be evaluated negatively

2. Results of analyses of the samples and analytical reports:

At each practice session, students must analyse a sample of unknown composition and/or concentration. The quality of the results is considered to reflect the quality of the student's experimental work. The analytical reports be written in accordance with the guidelines set by the lecturer.

3. Written examinations: There are two written examinations: one of these comprises classical qualitative analysis and the other comprises all the other aspects of the course.

The overall grade is calculated as the weighted average of the three above sections:

| Laboratory work and laboratory notebook | Reports and results | Examinations |
|---|---|---|
| 20% | 50 % | 30 % |

In all cases, classical qualitative analysis will be weighted as 1/3, and the other sections of the subject will be weighted jointly as 2/3. To pass the course, students must obtain a minimum overall score of 5.0 and in each of the sections of each block (qualitative analysis and quantitative analysis) a minimum score of 4.0 points out of 10 must be achieved.

Attendance at all seminars and laboratory sessions is compulsory. In the case of excused absences, students can recover up to three sessions by attending other practical groups provided the teaching requirements of the laboratories allow. The marks awarded for any session not recovered in this way will be zero. Students will fail the course if they are absent from or fail to recover more than three laboratory sessions.

# SECOND CALL

In the second call the final grade is obtained by applying the same weighting criteria as in the first call. The sections of each block with a grade lower than 4,0 must be recovered by performing a written and / or practical examination in the laboratory.

## REFERENCES

### Basic

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- BURRIEL, F.; LUCENA, F.; ARRIBAS, S. Y HERNÁNDEZ, J. Química Analítica cualitativa. Madrid: Paraninfo, 2003. ISBN 9788497321402
- KOLTHOFF, I.M.; SANDELL, E.B.; MEEHAN, E.J. Y BRUCKENSTEIN, S. Análisis Químico Cuantitativo (5ª ed.). Buenos Aires: Nigar, 1979. ISBN 9509019208
- BERMEJO, F.; BERMEJO, P. Y BERMEJO, A. Química Analítica general: cuantitativa e instrumental, 7ª edición. Madrid: Paraninfo, 1991. ISBN: 978-84-600-5965-3
- HARVEY, D. Química Analítica moderna. Madrid: McGraw-Hill, 2002.ISBN 9788448136352
- SKOOG, D.A.; WEST, D.M.; HOLLER, F.J. Y CROUCH, S.R. Fundamentos de Química Analítica, 8ª edición. Madrid: Thomson-Paraninfo, 2005.ISBN: 9788497323338

- SKOOG, D.A.; HOLLER, F.J. Y NIEMAN, T.A. Principios de Análisis Instrumental, 5ª Edición. Madrid: McGraw-Hill, 2001. ISBN 8448127757
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## ADDENDUM COVID-19

**This addendum will only be activated if the health situation requires so and with the prior agreement of the Governing Council**

**Contents**

*1.- The contents initially indicated in the teaching guide are maintained.*

**Workload and temporary teaching planning**

Regarding the workload:

*1.- The different activities described in the Teaching Guide are maintained with the intended dedication.*

Regarding the temporary teaching planning:

*1.- The material to follow the theory/tutoring/classroom-seminar classes allows to continue the temporary teaching planning both in days and schedule, whether the teaching is face-to-face in the classroom or not.*

3. There is not any variation with respect to the teaching guide

**Teaching Methodology**

*Laboratory courses:* Regarding laboratory courses, the maximum face-to-face teaching will be lying in compliance with the rules of distance and occupation of spaces fixed by the academic authorities. In this sense, the teaching type "L" will be 100% face-to-face, and the teaching type "U" will be non-face-to-face and will be taught through the tools offered by the virtual classroom.

In the case of students confined to home due to COVID, as far as possible, the experimental sessions will be recovered. In case it was not possible, the recovery of up to 4 experimental sessions in an on-line non-presential way will be proposed.

The methodology used for non-face-to-face classes shall be:

1. Synchronously using virtual classroom tools (preferably Teams)

2. Asynchronously using presentations with audio narration or other virtual classroom tools

3. Resolution of exercises and questionnaires

*In all subjects*

*If there is a closure of the facilities for health reasons that totally or partially affects the classes of the course, they will be replaced by non-face-to-face sessions following the established schedules and using the tools of the virtual classroom.*

**Evaluation**

*2. The evaluation system described in the Teaching Guide of the subject in which the various evaluable activities have been specified as well as their contribution to the final grade of the subject is maintained.*

*If there is a closure of the facilities for health reasons affecting the development of any face-to-face evaluable activity of the subject, it will be replaced by a test of a similar nature that will be carried out in virtual mode using the computer tools licensed by the University of Valencia. The contribution of each evaluable activity to the final grade of the subject will remain unchanged, as set out in this guide.*

**References**

*1.- The literature recommended in the Teaching Guide is maintained since it is accessible.*