Universidad de Alcalá

COURSE GUIDE

ANALYTICAL TECHNIQUES I

(Revisada en CD el 01.06.26)

DEGREE IN PHARMACY
University of Alcalá

Academic Year 2026-2027
2nd Year – 1st Semester

Universidad de Alcalá

COURSE DESCRIPTION

Name of the course:	**Analytical Techniques I**
Code:	**577009**
Degree:	**DEGREE IN PHARMACY**
Department and Area of Knowledge:	**Analytical Chemistry, Physical Chemistry and Chemical Engineering / Analytical Chemistry**
Type of course:	**Compulsory**
ECTS:	**6 ECTS (4.5 theory + 1.5 experimental)**
Course and period	**Second / First semester**
Instructor:	Dra. Ana Mª Díez Pascual
Coordinator:	**Dra. Merichel Plaza del Moral**
Schedule for Tutorials:	Appointment with the instructor
Language of Instruction:	**English**

1. PRESENTATION

The aim of this subject is to introduce students to the analytical process and enable them to develop scientific criteria in the evaluation of analytical results. Learning this subject will allow the student to know the role of chemical equilibria in Analytical Chemistry, manage the equilibrium constants of chemical reactions to calculate concentrations of various species in solution, know the fundamentals of volumetric and gravimetric analysis from a theoretical and experimental point of view and know different electroanalytical techniques. All this aimed at the student being able to reasonably solve analytical and numerical problems related to the indicated contents. This subject is an essential element in the professional training of pharmacists in the field of drug, food, environmental and clinical analysis.

Prerequisites and Recommendations (if applicable)

It is highly recommended an adequate comprehension of the English language to easily follow the lectures.

2. COMPETENCES AND LEARNING OUTCOMES

General Competences (Orden CIN/2137/2008, 3 de julio)

1. Identify, design, obtain, analyze, control and produce drugs and medicines, as well as other products and materials of sanitary interest for human or veterinary use.
2. Know how to apply the scientific method and acquire skills in managing legislation, sources of information, bibliography, elaboration of protocols and other aspects that are considered necessary for the design and critical evaluation of clinical and preclinical trials.
3. Develop hygienic-sanitary analysis, especially those related to food and the environment.
4. Develop communication and information skills, both oral and written, to deal with patients and users involved in the future professional activity of the graduates. Promote work and collaboration skills in multidisciplinary teams and those related to other health professionals.
5. Recognize one's own limitations and the need to maintain and update professional competence, paying special attention to the self-learning of new knowledge acquired in the available scientific evidence.

Specific competences:

1. Identify, design, obtain, analyze and produce active ingredients, drugs and other products and materials of interest sanitary.
2. Select the appropriate techniques and procedures in the design, application and evaluation of reagents, methods and techniques analytics.
3. Carry out standard laboratory processes including the use of scientific equipment for synthesis and analysis, appropriate instrumentation included.
4. Know the origin, nature, design, production, analysis and control of medicines and medical devices.
5. Know the principles and procedures for the analytical determination of compounds: analytical techniques applied to the analysis of water, food and environment.
6. Know and apply the main structural research techniques, including spectroscopy.

3. CONTENTS

Lectures:

THEMATIC UNIT I - INTRODUCTION AND BACKGROUND OF ANALYTICAL TECHNIQUES.

Chapter 1.- Introduction to Analytical Chemistry. Objectives of Analytical Chemistry. Analytical Chemistry in today's society. The analytical problem. The vocabulary of Analytical Chemistry. Classification criteria of Analytical Chemistry. Sources of Information in Analytical Chemistry.

Chapter 2.- The Analytical Process. General steps of the analytical process: sampling, previous operations, measurement and signal transduction, data acquisition and processing. Errors in Analytical Chemistry. Analytical properties. Resolution of practical problems.

Chapter 3.- The measurement in Analytical Chemistry: standards and traceability. Types of standards: basic chemicals and chemical-analytical. General properties and use of different standards.

Chapter 4.- General characteristics and objectives of qualitative analysis. Analytical properties in qualitative analysis. General characteristics and objectives of quantitative analysis. Quantification methodologies. Resolution of practical problems.

THEMATIC UNIT II – TITRIMETRIC AND GRAVIMETRIC ANALYSIS.

Chapter 5.- Introduction to titrimetric techniques. Overview of titrimetry. Equivalence point and end point. Titration errors. Titration curves.

Chapter 6.- Acid-base titration. Titration curves of strong acids and bases and weak monoprotic acids and bases. Titration curves of polyprotic acids and bases. Titration of mixtures. Factors affecting the titration curves. Acid-base indicators. Acidic and basic titrants. Buffer solutions: buffer capacity and handling. Titration in nonaqueous media. Applications.

Chapter 7.- Complexation titrations. EDTA complexes of metal ions. EDTA titration curves. Conditional formation constant. Factors affecting the titration curves. Metallochromic indicators. EDTA titration methods. Applications.

Chapter 8.- Redox titrations. Overview. Calculating the titration curves. Factors affecting the titration curves. Redox indicators. Previous treatments in redox titrations: auxiliary reagents. Applications with oxidizing and reducing titrants.

Chapter 9.- Precipitation titrations. Titration curves. Effect of the concentration and the solubility of the precipitate. End point detection: Mohr, Volhard and Fajans methods. Applications.

Chapter 10.- Gravimetric methods. Overview. Types of gravimetric methods. Precipitation gravimetry: theory and practice. Formation and properties of precipitates. Homogeneous precipitation. Applications.

THEMATIC UNIT III – ELECTROANALYTICAL TECHNIQUES.

Chapter 11.- Overview of electrochemical methods. Electrochemical cells. Classification of electroanalytical techniques. Conductivity and Conductometry. Applications. Resolution of practical problems.

Chapter 12.- Potentiometric techniques. Reference electrodes. Indicator electrodes: metallic and Ion selective electrodes (ISEs). Measurement of pH. Gas sensing electrodes. Quantitative applications. Applications. Resolution of practical problems.

Chapter 13.- Voltammetric methods: fundamentals and key processes. Voltammetric techniques: Polarography, Hydrodynamic voltammetry, Cyclic voltammetry, Stripping voltammetry. Quantitative applications. Amperometry. Applications. Resolution of practical problems.

Laboratory:

1. Complexometric titrations. Standardization of EDTA. Determination of Ca^{2+} and Mg^{2+}: water hardness.
2. Determination of a mixture of nickel and zinc ions by sample pretreatment by ion exchange and complexometric titration
3. Back redox titration. Determination of vitamin C in tablets.
4. Precipitation titrations. Determination of chloride content of a soil sample by potentiometric titration with silver ions.

5. Conductimetric titration of acids.
6. Determination of paracetamol in pharmaceuticals products by cyclic voltammetry.

Seminars:

Seminars 1-2. - Exercises and case studies on chapters 1-4
Seminars 3-7. - Exercises and case studies on chapters 5-10.
Seminars 8-9. - Exercises and case studies on chapters 11-13.

3.1. Organization of the course

Thematic Unit	Topics	Hours
Part I. INTRODUCTION AND BACKGROUND OF ANALYTICAL TECHNIQUES	• Chapters 1-4 • Seminars 1-2	• 8 hours (lectures) • 2 hours (seminars)
Part II. TITRIMETRIC AND GRAVIMETRIC ANALYSIS	• Chapters 5-10 • Seminars 3-7 • Practical work 1-3	• 15 hours (lectures) • 4 hours (seminars) • 12 hours (laboratory)
Part III. ELECTRO-ANALYTICAL TECHNIQUES	• Chapters 11-13 • Seminars 8-9 • Practical work 4-5	• 5 hours (lectures) • 2 hours (seminars) • 6 hours (laboratory)

4. TEACHING-LEARNING METHODOLOGIES. TRAINING ACTIVITIES

4.1. Distribution of the teaching (Number of hours)

Number of classroom hours	• Number of lecture hours: 28 hours • Number of hours in seminars: 8 hours • Number of hours in laboratory: 18 hours

4.2. Methodological strategies

Presential activities	• **Large group (T):** lecture classes and discussion with the students. The contents of the chapters will be presented, the most important concepts will be explained and questions that help to understand the concepts will be solved. Some theoretical content will be illustrated with computer and / or audiovisual materials. Participative dynamics may be used to encourage student participation and interaction with the teacher. The resolution of numerical problems and questions previously provided and related to the subject will be undertaken. Some group activity may be proposed so that students solve small cases or proposed problems. • **Laboratory group (P):** the student will develop experiments to learn, with real systems, to apply and interpret the basic principles developed in the theoretical classes, contributing to develop their observation capacity, the analysis of results, critical thinking and understanding of the scientific method. **Materials and resources to be used for the development of each activity:** mainly blackboard, complemented with audiovisual material prepared by the teacher (slides, PowerPoint presentations), printed materials (fact sheets with numerical exercises and questions, complementary examples), laboratory related materials (specific contents for each practice and practice scripts), online materials (Virtual Classroom Platform, My Portal, specialized websites for simulation and practices), etc.
Remote activities	**Autonomous study.** Analysis and assimilation of the contents of the subject, problem solving, bibliographic search and reading, recommended reading, use of virtual simulation applications, preparation of individual and/or group assignments and self-evaluation tests. Use of the virtual classroom to promote the interaction of the students facilitate their access to selected information useful for their non-classroom work.with the subject outside the classroom, as well as to
	facilitate their access to selected information useful for their non-classroom work.

5. ASSESSMENT

PROCEDURES FOR EVALUATION

In each academic year the student has the right to have two calls, one ordinary and one extraordinary. The ordinary call will be based on continuous evaluation, except in those cases contemplated in the regulations for the evaluation of the UAH and students will have access to the final evaluation. To benefit from this final evaluation procedure, the student will have to request it in writing to Dean or Center Director in the first two weeks of the subject, explaining the reasons why the continuous assessment system will continue. In case there are students who for justified reasons have not formalized their registration on the date of the start of the course or the period of delivery of the subject, the term indicated is a computation from its incorporation to the degree.

Regular call:

Continuous assessment

The continuous assessment will follow the regulations for the evaluation of the UAH. Attendance to classes, seminars and tutoring is mandatory and only a maximum of 20% of absents will be allowed. The active participation of students in all face-to-face activities and work carried out, as well as the skills developed during the practical lessons, will be evaluated. The students must demonstrate a minimum level in the acquisition of the corresponding competences so that their global qualification is obtained.

The theoretical knowledge of the subject will be evaluated by carrying out two written tests corresponding to Chapters 1-6 and Chapters 7-13, all constituting 75% of the overall grade. To pass the ordinary call, it will be essential to have obtained a grade equal or higher than 5.0 in each of the tests.

The practical contents of the subject will be evaluated by carrying out a practical-written test, also considering the student's performance in the laboratory, as well as the preparation of reports, all of which constitute 25% of the overall grade. To pass the practices the grade obtained in the assessment should be equal or higher than 5.0.

Participation in the continuous assessment implies to consume the ordinary call. Continuous assessment students who wish to appear as not presented in this call must communicate it through writing to the Department's secretariat within the established deadline

In case of not participation in the ordinary call, students will have the right to perform a final exam in the extraordinary call.

Final assessment

Exceptionally, students who have not opted for continuous assessment and are registered in the Dean's Office, will perform a global examination consisting of questions, problems and / or practical exercises that allow assessing the acquisition of the skills included in the teaching guide.

Extraordinary call:

A global exam will be carried out that will consist of questions, problems and/or practical exercises that allow assessing the acquisition of the skills included in the teaching guide. They

will be evaluated by completing a written test corresponding to Chapters 1 to 13. Students who have completed the internships and have failed them must pass a specific test to pass the subject in this call.

ASSESSMENT CRITERIA

1. Attendance and participation in seminars.
2. Assimilation and understanding of course's content.
3. Ability to apply acquired knowledge.
4. Integration and communication of knowledge.
5. Interpretation of results and resolution of questions and problems.
6. Time management for planning activities and laboratory experiments.

RATING CRITERIA

Attendance to the laboratory practices is mandatory for all the students taking the course because this subject has experimental and technical character. The students must also pass the corresponding exam, regardless of the type of exam they take.

Passing the course will require:

Continuous assessment. Normal and extraordinary calls: theoretical content (75%) and practical work (25%). This percentage will be distributed 50% between the two partial exams to be carried out.

Final assessment. Normal and extraordinary calls: theoretical content (75%) and practical work (25%). Due to the different competences pursued with theoretical content and practical work and lacking information from continuous assessment, students will have to demonstrate sufficient knowledge and abilities within each part, separately.

During the development of the evaluation tests, the guidelines set out in the Regulations establishing the Rules of Coexistence of the University of Alcalá must be followed, as well as the potential implications of the irregularities committed during such tests, including the Consequences for committing academic fraud according to the Regulation of Disciplinary Regime of the Student Body of the University of Alcalá.

The teaching-learning methodology and the assessment process will be adapted as needed, in accordance with the guidelines of the Diversity Support Unit, to implement curricular adaptations for students with specific needs.

6. BIBLIOGRAPHY

[1] Quantitative Chemical Analysis, Daniel C. Harris. Eighth edition, 2010. W.H. Freeman & Company. New York. BAF543.062HAR

[2] Analytical Chemistry 2.1 (eText), David Harvey. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Analytical_Chemistry_2.1_(Harvey)

[3] Fundamentals of Analytical Chemistry. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch. Ninth edition, 2014. Thomson – Brooks/Cole. BAF543SKO

[4] Principles of Analytical Chemistry: A Textbook. M. Valcárcel, 2000. Springer.