Analytical Chemistry

Bachelor's Degree in Biotechnology — 2nd year
University of Studies of Teramo · A.Y. 2026/2027

Lecturer: **Dr. Federico Fanti** · ffanti@unite.it

CHIM/01 | 5 CFU · 40 HOURS | ORAL EXAM



The Instructor

Contact Information

Dr. Federico Fanti
Office: 3rd floor, Dept. of Biosciences
Block B4, Polo Silvio Spaventa
Tel: 0861/266792
Email: ffanti@unite.it

Research Activities

The instructor's research focuses on the development of analytical methods based on **liquid chromatography coupled with mass spectrometry (LC-MS)** for the determination of bioactive compounds in biological matrices, with clinical and forensic interest.

Targeted (LC-QqQ, LC-QqQ-LIT) and **untargeted** (LC-HRMS, MALDI-TOF/TOF) approaches.

Course Information

Credits

5 credits

Hours

40 hours (lecture)

SSD

CHIM/01

Exam

Oral + written

Learning Objectives (Dublin Descriptors)

Knowledge

Theoretical principles of the main analytical techniques

Application

Select and interpret analytical methods in biotechnological contexts

Autonomy

Critically evaluate data, quality, and limitations of a method

Communication

Describe methods and results using appropriate terminology

Learning Assessment

1

Written Exam

Multiple choice questions and numerical problems. Assesses **theoretical knowledge** and applied skills.

2

Oral Exam

Discussion of course topics and critical analysis of laboratory results. Assesses **synthesis, technical language** and independent judgment.

3

Laboratory

Assessment of active participation, operational accuracy and **interpretation of experimental data**.

Evaluation criteria: completeness, clarity of exposition, appropriate scientific language, connection between theory and practice.

Course Structure: Roadmap

The course is structured into **two Teaching Units** covering methodological foundations and advanced applications.

Unit I — Methods and Applications

1

Introduction · Statistics · Data processing · Validation parameters

2

Unit II — Foundations

Extraction techniques · Chromatography (GC, HPLC) · Spectroscopy (UV/Vis, IR) · Mass spectrometry · High resolution

Midterm Tests

Ongoing assessments at the end of each Teaching Unit

Practical Sessions

Laboratory activities integrated with lectures

Attendance

Not mandatory, but strongly recommended



What is Analytical Chemistry?

> «A scientific discipline that develops and applies methods, instruments, and strategies to obtain information about the composition and nature of matter in space and time.» — Euroanalysis VII, 1993, Edinburgh

Qualitative Analysis

Reveals the **presence and chemical identity** of the analyte in a sample: *what is there?*

Quantitative Analysis

Establishes in numerical terms the **quantity** of one or more analytes in a sample: *how much is there?*

The Role of Analytical Chemistry

Analytical chemistry spans numerous application sectors, each with specific needs for identification and quantification.

Medicine

Clinical diagnostics and therapeutic monitoring

Food Safety

Detection of residues and contaminants

Environment

Monitoring of environmental pollution

Industry

Process control and production quality

Agriculture

Optimization of agronomic yields

Other Sciences

Biochemistry, microbiology, forensic sciences, food technologies

The Analytical Process: from Sample to Result

Every analysis follows a rigorous sequence that transforms the raw sample into a reliable result, progressively eliminating matrix and interferents.

Sample

Stabilization

Extraction

Purification

Analysis

Reporting

Sample Components

Analyte: the species of interest to be determined
Matrix: the medium in which the analyte is contained
Interferents: species that disturb the measurement

Process Objective

Isolate and quantify the **analyte** by eliminating or correcting the effect of matrix and interferents to obtain an accurate and precise result.

Fundamental Definitions

Technique

A set of theoretical principles and experimental approaches to obtain information about the nature of a sample.

Analytical Method

Application of a technique to a specific problem. Standard methods exist: ASTM, NIST, IUPAC, UNICHIM.

Procedure

A set of basic instructions required to correctly apply the method.

Protocol

Detailed instructions to be followed strictly so that the result is accepted.

Measurement (Result)

Information expressed as: **NUMBER + UNCERTAINTY + UNIT OF MEASUREMENT**

Measurement (Process)

The set of material and calculation operations used to assign a measurement value to the system being measured.

Analytical Methods: Classification

Gravimetric

A **mass** is determined

Volumetric

A **volume** of titrant reacting with the analyte is determined

Electroanalytical

Electrical properties are observed: potential *E*, current *I*, charge *Q*, resistance *R*

Spectroscopic

The **absorption or emission** of electromagnetic radiation is monitored

Chromatographic

Mixtures are separated by exploiting different affinity for **stationary and mobile phase**

Miscellaneous

Mass spectrometry, radioactive decay, heat of reaction, thermal conductivity, optical activity, refractive index

Instrument Types

Sensors for Process Control

In industrial process control, technological development is centered on **sensors** (electrochemical, optical, biological). They enable real-time monitoring at low cost.

Complex Instrumental Techniques

For the control of harmful substances, more advanced techniques are employed, capable of providing qualitative and quantitative information on **very small quantities**. Essential for pesticides and endocrine disruptors, which are toxic even at very low concentrations.

Data Evaluation and Uncertainty

> «No quantitative result has meaning unless it is accompanied by an estimate of the error inherent in the measurement performed.»

Any measurement of a physical quantity is associated with an **error**. It is necessary to know:

1 Degree of uncertainty

The result of the measurement and its reliability must always be explicitly stated.

2 Error propagation

The relationships between the uncertainty of the individual measurement and the reliability of the final result of the experiment.

The measurement is always expressed as: **NUMBER ± UNCERTAINTY [UNIT]**

The SI System: Base Units

The 7 Fundamental Quantities

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Most Common SI Prefixes

Factor	Prefix	Symbol
10^{12}	Tera	T
10^{9}	Giga	G
10^{6}	Mega	M
10^{3}	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

Detailed Structure of Teaching Units

Teaching Unit I

01

Introduction and Statistics

Essential concepts, error, accuracy, precision, linear regression

02

Extraction Techniques

From gaseous, liquid, and solid matrices

03

Chromatography

Separation techniques, GC, HPLC, couplings

04

Spectroscopy

UV/Vis, Infrared, NMR

05

Mass Spectrometry

Principles, high resolution, accurate mass, omic sciences

Teaching Unit II

01

Data Processing

Univariate, multivariate analysis, networking

02

Validation Parameters

IS, matrix effect, recovery, stability, linearity, reproducibility, robustness, guidelines

03

Applications

Food safety, forensic toxicology, proteomics, biomedical, metabolomics, lipidomics, imaging

Key Concepts of the Lesson

Summary of the fundamentals introduced in this first lecture of Analytical Chemistry.

🔬 Definition

Analytical chemistry develops methods to obtain information on the **composition and nature of matter**

⚗️ Analytical Process

From sample to result: stabilization → extraction → purification → analysis → reporting

📐 Measurement

Always expressed as **number + uncertainty + unit**. Without an error estimate, no result is meaningful

🗂️ Methods

Gravimetric, volumetric, electroanalytical, spectroscopic, chromatographic — each with a distinct physical principle

🌐 Applications

Medicine, food safety, environment, industry, agriculture, forensic sciences

📋 Course

5 CFU · 40 hours · CHIM/01 · 2 Teaching Units · Oral + written + laboratory exam

Next lecture: Statistics applied to analytical methods — error, accuracy, precision, and linear regression.