1. Module identification code.	
Name of the institution:	Universidad Autónoma de Nuevo León
Name of the school:	School of Medicine
Name of the degree program:	Clinical Chemistry
Name of the course (learning unit):	Applied Analytical Chemistry
Total number of class hours-theory and practice:	160
Class hours per week:	8
Independent study:	50
Course modality:	Face-to-face instruction
Module level:	Fourth semester
Core/elective module:	Core
Curriculum area:	ACFP-F
UANL credit points:	7
Create date:	14/02/2018
Date of last amendment made:	25/01/2024
Person(s) responsible for the design and amendment of the module:	Diseño: Dra. Rocío Castro Ríos, Dra. Marsela Garza Tapia Actualización: Dra. Rocío Castro Ríos, Dra. Marsela Garza Tapia, Dra. Graciela Granados, Dra. Magdalena Escabar Saucedo, QCB Alejandra B. Fraga López, QCB Jahaziel J. Eufracio de la Garza

2. Presentation:
Applied Analytical Chemistry is taught in the fourth semester of the Bachelor's degree in Clinical Chemistry Biology. This UA is divided into three stages focused on classical quantification techniques, analytical separation techniques and the evaluation of methods and their results. During the first stage, the importance of the evaluation of analytical methods and their results is reviewed by applying quality control guidelines to ensure the reliability of the analysis of chemical-biological samples. In the second stage, the bases of analytical separation techniques are analyzed, considering the intermolecular interactions that occur between solutes and extraction phases to base their application in analysis methods. In the third stage, the application of the fundamentals of chemical equilibrium to titration, gravimetry and potentiometry techniques for the determination of analytes in biochemical samples is reviewed. The integrative learning product consists of a written evaluation that is presented at the end of the course and in which the student solves problems of quantification of compounds in biochemical samples using methods based on titrations, potentiometry, gravimetry and/or separations.

3. Purpose:

The Applied Analytical Chemistry learning unit (LU) aims to contribute to the development of skills that allow students to apply the fundamentals of Analytical Chemistry to the selection, development, and validation of analysis methods for compounds of biochemical interest.

Regarding UANL general competences, in this LU students will develop effective communication skills in both oral and written forms by conveying the outcomes of their laboratory work for the development, evaluation, and application of titration, gravimetric, potentiometric, and separation methods. In addition, they strengthen their participation and commitment to their work group, fulfilling the assigned responsibilities and respecting the rules and regulations established for both the theoretical course and the practical work. Likewise, they will develop leadership capabilities through collaborative efforts, including organizing team activities, planning strategies, and fostering cooperation to achieve personal goals and contribute to collective success.

In this LU, students develop specific theoretical and practical skills when carrying out chemical analysis procedures to separate and quantify analytes in different matrices, generating reliable results according to national and international regulations, when handling and arranging chemical compounds following the procedures established in the laboratory, when evaluating the performance of analytical methods following the recommendations of the guidelines of national and international organizations, and when evaluating the results obtained with statistical methods to ensure their reliability.

Applied Analytical Chemistry is a mandatory LU pertaining to the fourth semester of the Bachelor's Degree in Clinical Chemistry, which uses the skills acquired in Fundamentals of Analytical Chemistry LU, applying chemical equilibrium principles to quantitation methods. It uses the knowledge acquired in General Chemistry LU for the formulation of reactions and equations balancing as well as for concentration calculations. In addition, the development and evaluation of analytical methods requires knowledge of descriptive statistics, hypothesis testing, and linear regression, acquired in Biostatistics LU.

Applied Analytical Chemistry LU provides the basic knowledge for analytical methods development and evaluation required for Instrumental Analysis, Clinical Biochemistry, and Food Analysis LUs.

4. Competences of the graduate profile:

General competences to which this module (learning unit) contributes:

- *Instrumental skills:*

To master their mother tongue orally and in writing with correctness, relevance, timeliness and ethics, adapting their message to the situation or context, for the transmission of ideas and scientific findings.Competencias personales y de interacción social.

- *Personal and social interaction skills*

To maintain an attitude of commitment and respect towards the diversity of social and cultural practices that reaffirm the principle of integration in the local, national and international context in order to promote environments of peaceful coexistence.

- *Integrative skills::*

To assume leadership roles committed to social and professional needs in order to promote relevant social change.

Specific competences of the graduate profile to which this module (learning unit) contributes:

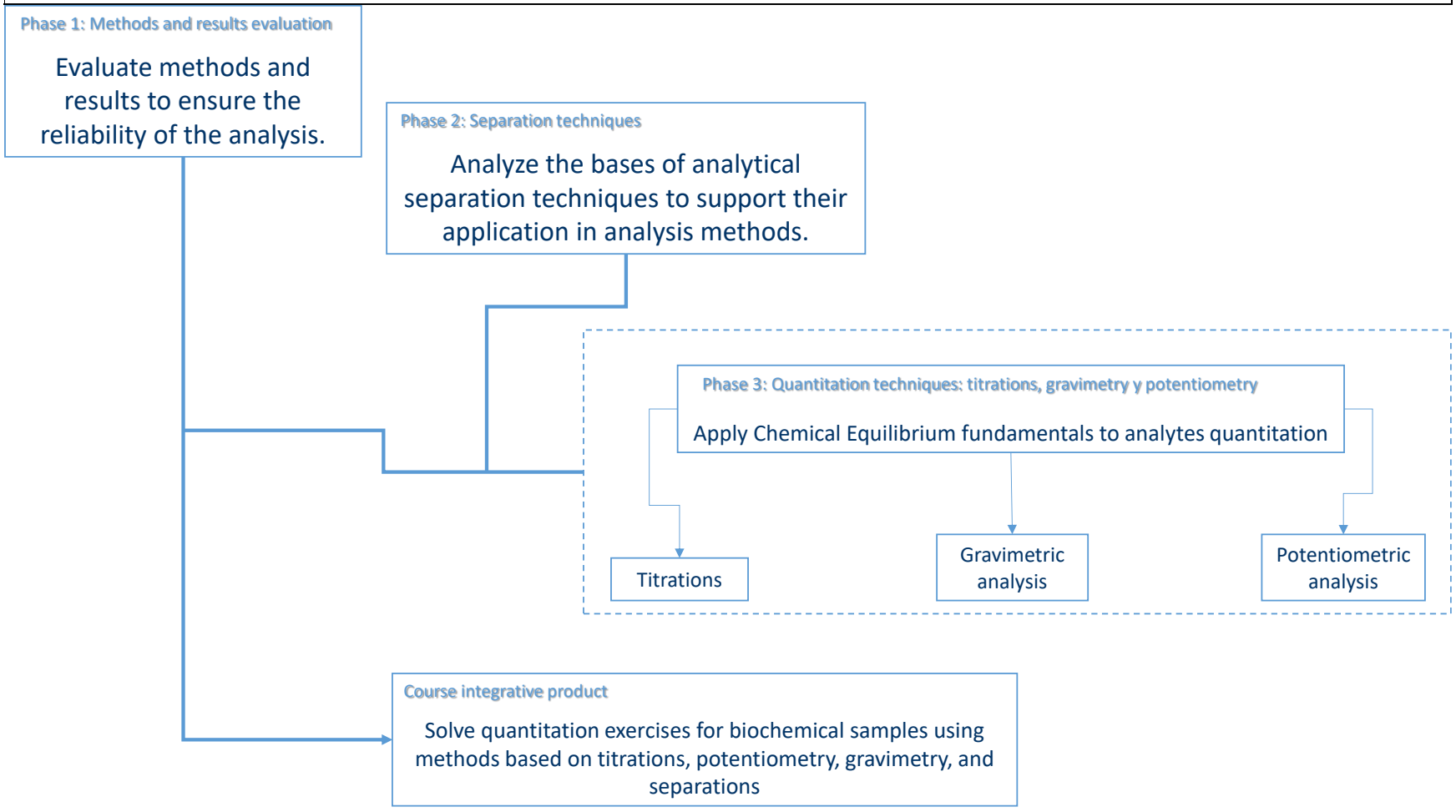
To execute physical, chemical and/or biological procedures in the collection, handling, storage and analysis of samples to contribute to a reliable clinical, toxicological, chemical, food, forensic and environmental diagnosis.

To handle chemical and biological materials following official Mexican and/or international standards that guarantee their correct use and disposal to preserve health and the environment.

To validate bioanalytical methods under established performance criteria that allow reliability of the results obtained in chemical-biological samples.

To guarantee the reliability of the analytical results obtained by applying quality control guidelines as established by laboratory policies for correct decision-making.

5. Course roadmap:



6. Structuring into stages or phases::

Phase 1: *Methods and results evaluation*

Component(s) of the competence:

Analytical methods and results evaluation applying quality control guidelines to guarantee the reliability of chemical and biological samples.

Evidence of student learning	Performance criteria	Learning activities	Content	Resources
1. Analytical methods and results evaluation activities and exercises portfolio.	▪ Uses concepts, laws, and formulas related to analytical methods validation and results evaluation to solve tasks and exercises. ▪ Submits individual or group work, as indicated, on the date and time established by the teacher. ▪ All the activities follow a logical order and ensure a coherent narrative or explanation. ▪ Images are properly inserted and aligned, are not distorted or overly compressed, and have sufficient contrast and	Before class, students read the Applied Analytical Chemistry lesson script and the bibliography related to Phase 1: *Methods and results evaluation*. <u>*In the classroom:*</u> ▪ The professor presents the course: program, methodologies used, and evaluation methods of the LU. ▪ The professor presents the theoretical concepts of the topics. ▪ The students participate in a discussion guided by the facilitator.	▪ Introduction: the analytical perspective and steps. ▪ Quantitation methods, calibration curves, types and applications. ▪ General principles on analytical quality and validation. ▪ Normal distribution, central and dispersión tendency measures. ▪ Error: concepts, clasification and calculations. ▪ Analytical methods accuracy, precision and linearity: general concepts and evaluation.	▪ UANL e-mail ▪ Microsoft Teams ▪ MS Forms ▪ Edpuzzle App ▪ Nearpod App ▪ Web pages: Khan Academy, Youtube ▪ Textbooks ▪ Applied Analytical Chemistry Lab Manual ▪ Applied Analytical Chemistry lesson script.

	brightness for readability. ▪ Both the substance of the document and its presentation adhere to established guidelines. ▪ Includes authors identification data.	▪ Individually, with the professor's guidance, the students will perform mathematical calculations to obtain the concentration of analytes from calibration curves, evaluate the accuracy, precision, and linearity of a method, and detect outliers.	▪ Outliers: definitions ans evaluation. ▪ Analytical instruments calibration.	
2. Integrative written assessment: Methods and results evaluation	▪ Answer questions individually ▪ Respect the established schedule ▪ Provide complete and logical answers ▪ Perform the required calculations ▪ Submit documents following LU guidelines	*Laboratory sessions:* ▪ Before each laboratory session, students read the lab manual and the information on MS Teams. Also, students perform the activities indicated: reading experiments in the Lab Manual, creating flowcharts, performing calculations, proposing reactions, searching for requested information, etc. ▪ Students attend the scheduled session punctually according to their laboratory group, meeting the specific requirements for the sessions. During lab sessions: • Professors explain relevant aspects of experiments and pose questions to guide		

		students' understanding and critical thinking. • Students independently complete a quiz assessing their understanding of the theoretical principles and experimental development covered in the session. • Students engage in guided group discussions focused on theoretical principles and experimental aspects of the session. • Students carry out the assigned activities either individually or in teams, depending on the specific instructions for each lab sesión: “Laboratory Introduction” (Accredited activity 1), “Workshop on Basic Calculations in Analytical Chemistry” (Accredited activity 2), “Workshop on Report Writing” (Accredited activity 3), “Verification of Volumetric Materials” (Accredited activity 4), “Workshop on analytical methods validation” (Accredited activity 5) y “Methods validation and analytical results evaluation” (Accredited activity 6). • During laboratory sessions, instructors oversee and		

		engage students through questioning to facilitate learning and understanding. • The student individually prepares the written report		

Phase 2: *Separation techniques*

Component(s) of the competence:

Analyze the foundations of analytical separation techniques, considering the intermolecular interactions occurring between solutes and extraction phases, to justify their application in analysis methods

Evidence of student learning	Performance criteria	Learning activities	Content	Resources
3. Separation techniques activities and exercises portfolio.	▪ Uses concepts, laws, and formulas related to separation techniques to solve tasks and exercises. ▪ Submits individual or group work, as indicated, on the date and time established by the teacher ▪ All the activities follow a logical order and ensure a coherent narrative or explanation. ▪ Images are properly inserted and aligned, are not distorted or overly	Before class, students read the Applied Analytical Chemistry lesson script and the bibliography related to Phase 2: *Separation techniques*. *In the classroom:* • The professor explains the theoretical concepts of the phase. • Students participate by answering questions inserted by the facilitator. • Students conduct a group discussion, guided by the	• Separation Techniques, Definitions, Description, and Classification • Liquid-Liquid Extraction, Partition Coefficient, Distribution Ratio, Recovery, and Efficiency of Extraction	▪ UANL e-mail ▪ Microsoft Teams ▪ MS Forms ▪ Edpuzzle App ▪ Nearpod App ▪ Web pages: Khan Academy, Youtube ▪ Textbooks ▪ Applied Analytical Chemistry Lab Manual ▪ Applied Analytical Chemistry lesson script.

Evidence of student learning	Performance criteria	Learning activities	Content	Resources
4. Integrative written assessment: Separation techniques	compressed, and have sufficient contrast and brightness for readability. ▪ Both the substance of the document and its presentation adhere to established guidelines. ▪ Includes authors identification data. ▪ Answer questions individually ▪ Respect the established schedule ▪ Provide complete and logical answers ▪ Perform the required calculations ▪ Submit documents following LU guidelines	professor, on fundamental concepts. • Students individually solve, with the teacher's guidance, exercises on the use of liquid-liquid extraction and chromatographic separations <u>*Laboratory sessions:*</u> ▪ Before each laboratory session, students read the lab manual and the information on MS Teams. Also, students perform the activities indicated: reading experiments in the Lab Manual, creating flowcharts, performing calculations, proposing reactions, searching for requested information, etc. ▪ Students attend the scheduled session punctually according to their laboratory group, meeting the specific requirements for the sessions. During lab sessions: • Professors explain relevant aspects of experiments and pose questions to guide	• Simple Liquid-Liquid Extraction, Sequential Liquid-Liquid Extractions, Liquid-Liquid Extraction with Concurrent Equilibria. • Chromatographic Techniques: Fundamentals, Separation Mechanisms, and Classification. • Variables Affecting Chromatographic Separations. • Chromatographic Parameters (Capacity Factor, Selectivity, Resolution, Theoretical Plates): Definitions, Application in Optimizing Chromatographic Separations. • Solid Phase Extraction: Concepts and Applications. • Micro-Solid Phase Extraction: Basic Principles and Applications. • New Trends in Extraction Techniques: Miniaturization of Processes, Modes, and Applications.	

Evidence of student learning	Performance criteria	Learning activities	Content	Resources
		students' understanding and critical thinking. • Students independently complete a quiz assessing their understanding of the theoretical principles and experimental development covered in the session. • Students engage in guided group discussions focused on theoretical principles and experimental aspects of the session. • Students carry out the assigned activities either individually or in teams, depending on the specific instructions for each lab sesión: “Reagents preparation” (Accredited activity 7), “Log P determination” (Accredited activity 8), “Determination of caffeine in a tea extract by solid phase extraction and thin layer chromatography” (Accredited activity 9). • The student individually prepares the written report		

Phase 3: *Quantitation techniques: titrations, gravimetric and potentiometric análisis.*

Component(s) of the competence:

Apply chemical equilibrium principles to titration, gravimetry, and potentiometry for determining analytes in biochemical samples.

Evidence of student learning	Performance criteria	Learning activities	Content	Resources
5. Activities and exercises portfolio: a) Titrations b) Gravimetric analysis c) Potentiometric analysis	▪ Uses concepts, laws, and formulas related to titrations, gravimetrc and potentiometric analysis to solve tasks and exercises. ▪ Submits individual or group work, as indicated, on the date and time established by the teacher ▪ All the activities follow a logical order and ensure a coherent narrative or explanation. ▪ Images are properly inserted and aligned, are not distorted or overly compressed, and have sufficient contrast and brightness for readability. ▪ Both the substance of the document and its presentation adhere to established guidelines.	Before class, students read the Applied Analytical Chemistry lesson script and the bibliography related to Phase 1: *Methods and results evaluation*. <u>*In the classroom:*</u> ▪ The professor presents the course: program, methodologies used, and evaluation methods of the LU. ▪ The professor presents the theoretical concepts of the topics. ▪ The students participate in a discussion guided by the facilitator. ▪ Individually, with the professor's guidance, the students will perform mathematical calculations to obtain the concentration of analytes from calibration curves, evaluate the accuracy, precision, and	**a) Introduction to Titration Techniques:** ▪ Titration Techniques: Description of the process, definition, and classifications ▪ General characteristics of a reaction for use in Titration Techniques ▪ End point and equivalence point, methods for detecting the end point ▪ Primary standard, secondary standard, standardization. **b) Application of Chemical Equilibrium to Titration** i.Acid-Base Titrations: ▪ Definitions, characteristics of the reaction and titrant, classification, common titrants, theoretical calibration curve (shape,	▪ UANL e-mail ▪ Microsoft Teams ▪ MS Forms ▪ Edpuzzle App ▪ Nearpod App ▪ Web pages: Khan Academy, Youtube ▪ Textbooks ▪ Applied Analytical Chemistry Lab Manual ▪ Applied Analytical Chemistry lesson script.

Evidence of student learning	Performance criteria	Learning activities	Content	Resources
6. Integrative written assessment: a) Acid-base and complexometric titrations b) Precipitation and redox titrations, gravimetric and potentiometric analysis.	▪ Includes authors identification data. ▪ Answer questions individually ▪ Respect the established schedule ▪ Provide complete and logical answers ▪ Perform the required calculations ▪ Submit documents following LU guidelines	linearity of a method, and detect outliers. <u>*Laboratory sessions:*</u> ▪ Before each laboratory session, students read the lab manual and the information on MS Teams. Also, students perform the activities indicated: reading experiments in the Lab Manual, creating flowcharts, performing calculations, proposing reactions, searching for requested information, etc. ▪ Students attend the scheduled session punctually according to their laboratory group, meeting the specific requirements for the sessions. During lab sessions: • Professors explain relevant aspects of experiments and pose questions to guide students' understanding and critical thinking. • Students independently complete a quiz assessing their understanding of the	species present in each zone) ▪ Detection of the end point in acid-base titrations: instrumental methods, visual indicators (mechanism, range, selection) ▪ Calculations for quantifying analytes using acid-base titrations ▪ Acid-base titrations in non-aqueous media: classification of solvents based on their acid-base properties, influence of solvent on ionization of solutes, importance of solvent in titrations ▪ Applications of acid-base titrations ii. Complexometric Titrations: ▪ General concepts of titrations ▪ Monodentate and polydentate ligands, chelating effect ▪ Methods for determining the end point in complex	

Evidence of student learning	Performance criteria	Learning activities	Content	Resources
		theoretical principles and experimental development covered in the session. • Students engage in guided group discussions focused on theoretical principles and experimental aspects of the session. • Students carry out the assigned activities either individually or in teams, depending on the specific instructions for each lab sesión: • "Titrations Workshop" (Accredited activity 10), "Determination of acidity in vinegar using alkalimetry" (Accredited activity 11), "Determination of the alkalinity of a sample by acidimetry" (Accredited activity 12), "Determination of water hardness by complexometry" (Accredited activity 13), "Determination of sodium hypochlorite in bleach by iodometric titration" (Accredited activity 14), "Determination of ascorbic acid in tablets by iodometric titration" (Accredited activity 15), "Gravimetric determination of moisture in	formation titrations, metalochromic indicators ▪ EDTA titrations and applications of complexometric titrations ▪ Calculations for quantifying analytes using complex formation titrations iii. Precipitation Titrations: ▪ Applications of precipitation equilibria ▪ Precipitation titrations, characteristics ▪ Detection of the end point ▪ Calculations for quantifying analytes using precipitation titrations iv. Redox Titrations: ▪ Characteristics of oxidation-reduction equilibria ▪ Oxidation-reduction titrations: definitions, description of procedure, classification of redox titrations, requirements of the reaction, characteristics of titrants in redox titrations	

Evidence of student learning	Performance criteria	Learning activities	Content	Resources
		flour" (Accredited activity 16), "Determination of acidity in vinegar by potentiometric titration" (Accredited activity 17).	▪ Detection of the end point, types of visual indicators and mechanisms, selection of indicator ▪ Shape of the theoretical calibration curve and species present in each zone ▪ Calculation of concentration from redox titrations **c) Gravimetry:** ▪ Gravimetric methods: definition, description, and classification ▪ Precipitation gravimetry. Stages in the formation of a precipitate ▪ Calculations of species concentrations from gravimetric data **d) Potentiometry:** ▪ Foundations of electrochemistry: redox reactions, electrochemical cells, cell potential, hydrogen electrode	

Evidence of student learning	Performance criteria	Learning activities	Content	Resources
			▪ Potentiometry: definition, advantages, experimental setup, applications ▪ Reference electrodes and indicators: types, characteristics, functions ▪ Calculation of analyte concentrations using potentiometric measurements	

	7. Summative evaluation:	
Phase 1 23%	**Evidence 1.** Analytical methods and results evaluation activities and exercises portfolio.	2.5%
	Evidence 2. Integrative written assessment: Methods and results evaluation	12.5%
	Accredited activities (1-6)	9.0%
Phase 2 20%	**Evidence 3**. Separation techniques activities and exercises portfolio.	2.5%
	Evidence 4. Integrative written assessment: Separation techniques	12.5%
	Accredited activities (7-9)	6.0%
Phase 3 44.5%	**Evidence 5.** Activities and exercises portfolio: Titrations, gravimetric and potentiometric analysis.	2.5%
	Evidence 6. Integrative written assessments: Titrations, gravimetric and potentiometric analysis	25%
	Accredited activities (10-17)	15.0%
	Course integrative product	12.5%

	Total	**100%**

8. Course integrative project/product:

Solving problems related to titrations, potentiometry, gravimetry, separations, and validation of analytical methods: 12.5% (Criteria for evaluation of the Integrated Learning Product, annex 1)

9. . References::

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