INTERAMERICAN UNIVERSITY OF PUERTO RICO
CAMPUS _____
DEPARTAMENT OF _____
CHEMISTRY PROGRAM

SYLLABUS

I. GENERAL INFORMATION

Course Title	:	Analitycal Chemistry
Cade and Number	:	CHEM 3320
Credits	:	4 credits
Academic term	:	
Professor	:	
Office hours	:	
Office phone	:	
Email	:	

I. DESCRIPTION:

Study, statistical treatment, and applications of quantitative analysis. Emphasis on volumetric, gravimetric, and electroanalytical methods. It also includes the fundamentals and basic applications of spectroscopic and separation analysis methods. It requires 45 hours of conference and 45 hours of closed laboratory in person. Requirement: CHEM 2212, MATH 1500 or 1512

II. TERMINAL OBJECTIVES

It is expected that, upon completion of the course, the student will be able to:

1. Apply and relate the principles of chemical equilibrium to experimentation
2. Acquire skills in quantitative analysis techniques.
3. Develop skills in quantitative instrumental analysis techniques.
4. Develop skills so that the student can select the most appropriate method and conditions for a quantitative analysis.
5. Apply ethical principles in solving problems of quantitative chemical analysis, both at a theoretical and practical level.

COMPETENCES OF THE GRADUATE PROFILE ATTENDED IN THIS COURSE

- Apply descriptive and inferential statistics in the analysis of experimental results.
- Know and manipulate acid-base, precipitate formation, complex formation, and reduction-oxidation chemical reactions.
- Correctly perform the most important calculations in chemistry, such as concentrations.
- Show willingness to actively work in a team and in interdisciplinary projects.
- Show a willingness to use new technologies and scientific developments, including the integration of the computer into analysis.
- Raise awareness about the ethical and cultural values necessary for the practice of the profession.

III. TRAINING OBJECTIVES

1. **General aspects of analytical chemistry:** name the general characteristics that involve a chemical analysis

   i) Explain and differentiate between qualitative and quantitative analysis principal, minor and trace components in a sample
   ii) Define and outline the fundamental steps of a quantitative analysis method

2. **Errors and statistical treatment of analytical data:** identify types of errors, calculate their numerical value, and their effect on precision and accuracy, identify possible sources of errors and propose strategies to reduce them.

   i) Differentiate between accuracy and precision
   ii) Apply the definition of error and explain its relationship to accuracy
   iii) Recognize and classify the determined and indeterminate errors associated with the analytical method, the instrumentation and the analyst performing the measurement
   iv) Explain the effect of the errors determined on the relative error of the final analysis result.
   v) Identify ways to correct, compensate or eliminate the determined errors of the analytical method, applying ethical principles in the process.
   vi) Apply the definition of standard deviation and explain its relationship to precision
   vii) Apply the definitions of mean and median
   viii) Apply the Q test to accept or reject experimental data
   ix) Apply statistical tests (student's t) to statistically compare experimental results
   x) Apply the rules of propagation of indeterminate errors for operations of addition, subtraction, multiplication, and division.
   xi) Apply the rules on the use of significant figures during the measurement of experimental data. Express the results with the appropriate number of significant figures, using appropriate rounding.
   xii) Apply computer programs, such as Microsoft Excel, to determine the slope and intercept of a straight line, the linear correlation coefficient, standard deviation of the slope, intercept, and regression
   xiii) Apply the equation of a straight line to obtain experimental results.

3. **Preparation of solutions and application of volumetric methods of analysis:** Handle concentration units, preparation of solutions of different concentrations, and determine concentrations from titration data.

   i) Describe the preparation of solutions in units of %w/w, %w/v, %v/v, molarity, parts per million
   ii) Use change of concentration units for the preparation of solutions or the presentation of results
   iii) Apply the concepts of analyte, titrant, standard solution or standard, standardization or titration, equivalence point and end point in analysis problems using titrations
   iv) Use the knowledge of Stoichiometry of a reaction to calculate the equivalence point in a titration.
   v) Calculate the content or concentration of analyte in a sample from experimental data obtained in a volumetric analysis
   vi) Apply the concept of sample dilution and that of titration of an aliquot of sample solution to concentration and content determination problems
   vii) Distinguish between direct and back-titling. Identify when one or the other is necessary.
   viii) Solve quantitative back-titling problems.

4. **Gravimetric methods of analysis.** Compare gravimetric analysis with volumetric analysis, calculate analyte concentrations and percentages from gravimetric analysis data. Mention problems present in gravimetric analysis and propose strategies to solve them

   i) Identify the differences between a gravimetric and a volumetric analysis, including the advantages and disadvantages of each.
   ii) Establish the necessary requirements for a gravimetric method
   iii) Apply the concept of gravimetric factor
   iv) Determine the percentage of an analyte in a sample using information obtained from a gravimetric analysis
   v) Describe and apply the theory of precipitate formation to minimize the formation of colloidal precipitates
   vi) Describe the methodology of digestion of precipitates and distinguish between different types of precipitates
   vii) Describe the co-precipitation process and the techniques most used to minimize it.
   viii) Describe the homogeneous precipitation technique and establish its advantages.

5. **Acid-base equilibrium.** Apply concepts of acid-base solutions to determine pH of solutions, predict the shape of titration curves, and formation of buffers. Use graphs to obtain information on a degree. Propose strategies for the preparation of buffer solutions

   i) Describe and apply the concept of strong or weak electrolyte to salts and compounds with acid-base properties
   ii) Formulate the expression for the acid-base equilibrium reaction and the equilibrium constant for any weak acid or base
   iii) Classify acids and bases in the categories of strong and weak
   iv) Apply the definition of acids and bases according to Arrhenius and Bronsted
   v) Derive the relationship between Kw, the concentration of hydronium and hydroxide in water, and the pH scale.
   vi) Calculate the pH of acid or base solutions (strong or weak) given the concentration and substance formula.
   vii) Predict the shape of the titration curve of an acid or base (strong or weak) with strong titrant.
   viii) In the titration of a monoequivalent acid or base (strong or weak), calculate the volume of titrant necessary to reach the equivalence point and the pH of the solution at this point.
   ix) Establish the relationship between the Ka and Kb of an acid-base conjugate pair
   x) Calculate the pH of a buffer solution using the Henderson-Hasselbach expression.
   xi) Calculate the concentration of the acid-base conjugate pair components necessary for the preparation of buffer solutions.
   xii) Describe the shape of the titration curve of a polyequivalent acid or base with strong titrant
   xiii) Apply the concept of acid-base visual indicator and explain the criteria used for its selection.
   xiv) Identify complex formation reactions
   xv) Recognize common ligand structures
   xvi) Classify ligands as mono, bi, tri or polydentate
   xvii) Describe advantages of complex formation reactions

6. **Equilibrium of solubility.** Apply concepts of chemical equilibrium to predict the formation of precipitates during a titration, or when mixing solutions. Express the consequences of the common ion effect.

    i) Calculate the solubility in water of a slightly soluble salt ignoring secondary reactions of the metal ion and the anion.
    ii) Explain the concept of “activity” and its relationship with concentration
    iii) Predicting how the solubility of a salt is affected when (a) a common ion salt is added (b) a ligand that forms a complex with the cation of the salt and (c) a buffer solution of a given pH.
    iv) Calculate the solubility of a salt in a solution with a common ion.

7. **Basic principles of photometric methods of analysis.** Describe application and analysis methods using UV and Visible absorption spectroscopy

    i) Describe the light absorption methodology and define transmittance. Identify differences between absorbance and transmittance
    ii) Establish the Beer-Lambert law and its parameters
    iii) Establish the main components of an ultraviolet - visible spectrophotometer
    iv) Establish the methodology to perform a quantitative analysis
    v) Recognize differences between atomic and molecular spectroscopy
    vi) Identify characteristics of atomic absorption spectroscopy.

8. **Oxidation-Reduction equilibrium.** Describe characteristics and components of electrochemical cells. Calculate analyte concentration from information from analysis methods using Redox reactions.

    i) Distinguish between half reduction and oxidation reactions
    ii) Distinguish between oxidizing agent and reducing agent
    iii) Determine the oxidation number of an element that is part of a polyatomic ion
    iv) Apply the Nernst equation to calculate the electrode potential, the concentration of a substance, or the equilibrium constant of a reaction
    v) Describe the most common reference electrodes, their schematic representation and their half reaction
    vi) Describe the different classes of indicator electrodes, including the glass membrane electrode.
    vii) Describe the use of the most common oxidizing and reducing agents used for the treatment of samples
    viii) Describe the properties and use of the most common titrators
    ix) Describe the application of the most common standards.

9. **Introduction to analytical separation methods.** Describe the characteristics of separation methods. List different methods of separation. Identify information obtained from common separation techniques, such as GC and LC.

    i) Recognize applications of separation methods for quantitative analysis
    ii) Apply the resolution and efficiency equation
    iii) Extract information from a chromatogram that allows quantitative and qualitative analysis
    iv) Describe the most common column chromatography techniques, including gas chromatography (GC) and liquid chromatography (LC)
    v) Describe the application of calibration methods for quantitative analysis used in chromatography.

IV. ACTIVITIES

A. Laboratory practices

Exp. #	Experiment Title
1	Instrumentation and introduction to standard operating procedures in the analytical chemistry laboratory
2	Use of Microsoft Excel for statistical data analysis
3	Calibration and handling of volumetric glass material: Calibration of a 50 mL buret
4	Determination of a colorant in a commercial drink by Visible Spectrophotometry. Beer's Law
5	Preparation of solutions
6	Determination of the molar mass and Ka of an unknown acid
7	Determination of chloride by argentometry
8	Determination of calcium with EDTA

B. Teaching Strategies

It is recommended to use strategies such as the following:

(a) Troubleshooting
(b) Use of the calculator and computer programs for data processing
(c) Group work
(d) Laboratory experiences
(e) Questions to the group
(f) Multiple-choice and problem-solving exams.

V. EVALUATION

Evaluation criteria	Punctuation	% of the final grade
Partial 1	100	17.5
Partial 2	100	17.5
Partial 3	100	17.5
Final Exam	100	17.5
Laboratory	100	30
Total	500	100 %

To establish the final grade for the course, the following scale will be used:

Scale:

Score Obtained	Score
100 – 85%	A
84 – 75 %	B
74 – 65%	C
64 – 55 %	D
Less than 55%	F

VI. SPECIAL NOTES

A. **Auxiliary services or special needs:** All students who require auxiliary services or special assistance must request them at the beginning of the course or as soon as they become aware that they need them, through the corresponding registry, in the Guidance Office with the _____.

B. **Honesty, fraud, and plagiarism:** Dishonesty, fraud, plagiarism, any other inappropriate behavior in relation to academic work constitute major infractions sanctioned by the General Student Regulations. Major offenses, according to the General Student Regulations, may result in suspension from the University for a defined period of more than one year or permanent expulsion from the University, among other sanctions.

C. **Use of electronic devices:** Cell phones and any other electronic device that could interrupt the teaching and learning processes or alter the environment conducive to academic excellence will be disabled. Urgent situations will be addressed, as appropriate. The handling of electronic devices that allow accessing, storing, or sending data during evaluations or exams is prohibited.

D. **Compliance with the provisions of Title IX:** The Federal Higher Education Law, as amended, prohibits discrimination based on sex in any academic, educational, extracurricular, athletic activity or in any other program or employment, sponsored or controlled by an institution of Higher education regardless of whether it is carried out on or off the premises of the institution, if the institution receives federal funds.

In accordance with current federal regulations, our academic unit has appointed an Assistant Title IX Coordinator who will aid and guidance in relation to any alleged incident that constitutes discrimination based on sex or gender, sexual harassment, or assault. You can contact the Assistant Coordinator _____, extension _____, or email _____.

The Normative Document entitled **Norms and Procedures to Address Alleged Violations of the Provisions of Title IX** is the document that contains the institutional rules to channel any complaint that is presented based on this type of allegation. This document is available on the website of the Inter American University of Puerto Rico (www.inter.edu).

VII. EDUCATIONAL RESOURCES

(a) Text book:

- Fundamentals of analytical chemistry, Ninth edition, Douglas A Skoog; Donald M West; F James Holler; Stanley R Crouch, Belmont, CA.: Brooks/Cole, Cengage Learning, © 2014

(b) Supplemental reading

- *Manual de Laboratorio de Química Analítica.* Rosa Brito. Agosto 2018

VIII. BIBLIOGRAPHY

(a) Text books:

- David, Harvey. *Modern Analytical Chemistry*. 2002. McGraw-Hill, Spain
- Rubinson, Judith y Rubinson, Keneth. *Contemporary Analytical Chemistry.* 2000. Prentice-Hall, México.
- Skoog, Douglas A. *Fundamentos de Química Analítica.* 2003. 4ta edición.
- González, Ángela. *Manual de laboratorio del curso*. Enero 2008.
- Whitten, K. W., Davis, R., Peck, M y Stanley, G. (2008) *Química*. 8va edición Cengage Learning Editors, S. A.
- Any General Chemistry book available.

(b) Electronic Resources:

- Analytical Chemistry Resources: http://home.nas.net/~dbc/cic_hamilton/anal.html, accedido el 18 de agosto 2008
- Analytical Chemistry Basics: http://www.chemistry.vt.edu/chem-ed/ac-basic.html, accedido el 18 de agosto 2008
- The Analytical Sciences Digital Library by ACS http://www.asdlib.org/list.php?mainCategory=Class%20Material, accedido el 18 de agosto 2008

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