INTER AMERICAN UNIVERSITY OF PUERTO RICO
_____ CAMPUS
DEPARTMENT OF _____
CHEMISTRY PROGRAM

SYLLABUS

I. GENERAL INFORMATION

Course title	:	General Chemistry II
Code and number	:	CHEM 2212
Crédits	:	4 credits
Academic term	:	
Professor	:	
Office hours	:	
Office telephone	:	787-250-1912, ext. 2323
Email	:	

II. DESCRIPTION

Fundamental principles of chemistry and its applications with emphasis on the quantitative study of the structural and energetic properties associated with matter and its transformations. Includes topics related to solid and liquid states, solutions, thermodynamics, chemical kinetics, equilibrium and electrochemistry among others. Requires 45 hours of lecture and 45 hours of closed presential lab. Prerequisites: MATH 1500 or MATH 1511 and CHEM 1111.

III. OBJECTIVES

Macro level vision

1. Apply the concepts of molecular geometry, polarity of molecules, and intermolecular forces to explain the macroscopic properties of matter.
2. Differentiate between the solid, liquid and gas states of matter physically and thermodynamically.
3. Demonstrate skills in the preparation, dilution and determination of concentration of solutions.
4. Apply the fundamental laws of thermodynamics to chemical systems.
5. Apply concepts of reaction kinetics to determine the order of the reaction, the factors that affect the rate of the reaction, and the mechanism.
6. Apply the basic principles of chemical equilibrium to predict the direction, spontaneity of a reaction and the conditions that affect an equilibrium.
7. Differentiate theoretically and experimentally, between acids and bases.
8. Determine and calculate degrees of acidity and basicity of different solutions (pH).
9. Differentiate between galvanic cells and electrolytic cells experimentally and thermodynamically.

Terminal and Instructional

1. Use the electronic configuration of atoms and their properties to determine types of chemical bonds and the structure of substances.

1.1. Distinguish between ionic, covalent, polar covalent, and metallic bonds.

1.2. Distinguish between ionic compounds and molecular compounds.
1.3. Write Lewis structures based on the number of valence electrons of representative elements including formal charge and exceptions to the octet rule.
1.4. Predict the geometry of the electron pair arrangement of the molecule using VSEPR.
1.5. Compare geometry when there are bonding electrons and when there are non-bonding electrons.
1.6. Associate VSEPR with hybridization.
1.7. Predict the polarity of bonds based on the electronegativities of the atoms in a bond.
1.8. Predict the polarity of molecules using bond polarity and molecular geometry.

2. Describe the intermolecular forces and laws to explain the macroscopic properties that explain the states of matter and their transformations. Visualize the geometric structures of common compounds and ions.

2.1. Intermolecular forces

2.1.1. Explain the physical properties of compounds and solutions: solubility, surface tension, vapor pressure, viscosity, boiling point, capillarity, etc. based on intermolecular forces.
2.1.2. Explain a simple phase diagram.

2.2. Solid state

2.2.1. Identify the cubic crystal lattices of solids.
2.2.2. Determine the number of atoms per unit cell, according to their position in the cell.
2.2.3. Recognize and give examples of the different crystalline solids based on the intermolecular forces involved.

3. Describe the process of preparation, dilution and determining the concentration of solutions.

3.1. Solutions

3.1.1. Prepare solutions of desired molarity.
3.1.2. Calculate the molarity of a solution, given the mass of solutes and volume of solution.
3.1.3. Use percent by mass or volume to prepare a solution or calculate its concentration.
3.1.4. Calculate the amounts of solute needed to prepare solutions, given the concentration in units of molarity (M), percent by mass, and percent by volume.
3.1.5. Prepare solutions whose concentrations are given in units of molarity, percent by mass, or percent by volume.
3.1.6. Determine the relationship between the different units of concentration.
3.1.7. Prepare solutions by dilution.
3.1.8. Define colligative properties and their applications.
3.1.9. Solve problems associated with colligative properties.

4. Describe, analyze and apply the principles and variables that govern chemical kinetics (speed, order, Activation Energy, Transition State and catalysis) to chemical reactions and decide their mechanisms.

4.1. Kinetic variables and velocity equations

4.1.1. Write expressions for the speed of the reaction.
4.1.2. Recognize the expression for speed for a zero-order, first-order, and second-order reaction.
4.1.3. Calculate the order of the reaction using the initial rate experimental data.
4.1.4. Determine the rate of reaction using a graph of concentration versus time.
4.1.5. Use mathematical expressions that describe zero-, first-, and second-order reactions to find constants for rate, half-life, reaction time, and reactant concentrations at a given time.

4.2. Reaction Mechanism Theory

4.2.1. Describe the collision theory of reactions.
4.2.2. Determine the factors that affect the collision frequency.
4.2.3. Describe a reaction in terms of the reaction profile (reaction diagram) that includes activated complexes, intermediates, activation energy, energy changes, and the effect of catalytic agents.

5. Describe and apply the concepts of chemical equilibrium and its mathematical expression. Evaluate the equilibrium constant and apply it in determining the concentration of the species present. Establish the relationship between chemical equilibrium and chemical thermodynamics.

5.1. Equilibrium constant, expression and calculation

5.1.1. Describe the equilibrium condition in a reversible reaction.
5.1.2. Write the expression for the equilibrium constant, Kc, given the chemical equation for a reversible reaction.
5.1.3. Derive the value of Kc for situations where the chemical equations have been inverted or multiplied by constant coefficients or added.
5.1.4. Write an expression for the equilibrium constant in terms of gas partial pressures, Kp.
5.1.5. Relate the value of Kp to the corresponding value of Kc.
5.1.6. Given the balanced equation and the equilibrium concentrations for a chemical reaction, calculate the numerical value for the equilibrium constant.
5.1.7. Predict the direction in which the equilibrium moves by comparing the reaction quotient Q with Kc.
5.1.8. Calculate the final equilibrium concentrations in a reversible reaction given the initial conditions, the chemical equation, and Kc.
5.1.9. Qualitatively predict the direction in which equilibrium shifts by altering reaction conditions.

6. Know and categorize acidic and alkaline solutions, their relative strength and neutralization reactions. Assess the acid-base balance.

6.1. Definitions and categorization of acids and bases.

6.1.1. Establish the different definitions of acid, base and their implications, namely: Arrhenius, Lewis, Brönsted-Lowry.
6.1.2. Establish the strength of an acid or a base using the constants Ka and Kb.
6.1.3. Name and write the formula for common acids and bases.
6.1.4. Explain the equilibrium of the autoionization of water, Kw.
6.1.5. Use the basic relationships between $[H_3O^+]$, $[OH^-]$, pH, and pOH in numerical calculations.
6.1.6. Identify a weak acid or base given a name or formula.
6.1.7. Recognize polyprotic acids and their conjugate passages.

6.2. Equilibrium application to acid-base solutions

6.2.1. Write a chemical equation to represent the dissociation of an acid or base; weak or strong.
6.2.2. Calculate dissociation constants, undissociated acid and base concentrations, and concentrations of their ions in solutions.
6.2.3. Predict the relative strength of acids and bases knowing their molecular structure.
6.2.4. Predict which common salt solutions will be acidic basic or neutral.
6.2.5. Write ionic equations to represent hydrolysis and calculate the pH of a solution of a salt in which hydrolysis occurs given Ka or Kb and concentration of the solution.

7. Evaluate the calculation of buffer solutions.

7.1. Buffer Solutions

7.1.1. Describe the common ion effect in solutions composed of weak acids or bases and their corresponding salts.
7.1.2. Explain how species in solution act to exert the buffer function.
7.1.3. Use the Henderson Hasselbach equation to determine the pH of a buffer and prepare a buffer of a given pH.
7.1.4. Calculate the extent to which a buffer works by monitoring the change in pH.

8. Know and describe the electrochemical processes by electron transfer in aqueous solution and evaluate cell potentials.

8.1. Voltaic Cells

8.1.1. Determine the oxidation state of atoms in compounds.
8.1.2. Balance oxidation-reduction equations in acidic and basic medium.
8.1.3. Write the oxidation and reduction half reactions.
8.1.4. Describe a voltaic cell and its components (galvanic).
8.1.5. Describe the standard hydrogen electrode and explain how standard reduction potentials are established.
8.1.6. Evaluate cell potentials using the Nernst equation.
8.1.7. Use E ° values to determine E ° cell for a redox reaction. Predict the spontaneity of a reaction, as written.
8.1.8. Describe the effect of varying conditions (concentration, pressure of gases) on the values of E ° cell, qualitatively and quantitatively.
8.1.9. Apply the relationships between ΔG °, E ° cell and K.
8.1.10. Describe some common voltaic cells.

8.2. Electrolytic Cells

8.2.1. Describe an electrolytic cell.
8.2.2. Describe how a voltaic cell differs from an electrolytic one.
8.2.3. Calculate relationships between the amount of substance that reacts and the amount of electrons involved in electrolysis.

9. Apply the concepts covered in the conference experimentally, in a research-based environment.

9.1. Formulate and demonstrate a hypothesis and the importance of the accuracy, precision, and reproducibility of such experimentation.

9.2. Generate and analyze data using concrete and / or abstract reasoning for interpretation and how to effectively communicate the results of the analyzes.
9.3. Develop laboratory skills and how to use them according to laboratory safety procedures.

GRADUATE PROFILE COMPETENCES ADDRESSED IN THIS COURSE

- Predict the physical properties and chemical behavior of matter based on its composition and structure.
- Know the procedures and regulations for the handling, use and disposal of chemical products.
- Analyze qualitative and quantitative problems in chemistry using the appropriate instrumentation and technology.

IV. THEMATIC CONTENT

Topics-Chapter	Thematic Content- Subtopics	Chapter (4th Edition)
1. Covalent bonds and molecular structure	*Types of chemical bonds, Lewis and Lewis representations of ionic compounds, ionic bonding and electron transfer, Lewis structure of covalent compounds, electronegativity and polarity in the bond, Lewis structures of polyatomic compounds, formal charge and resonance, exceptions to the octet rule , VSEPR theory (basic structures, lone pair effect, geometry prediction), molecular structure and polarity, dipole moment, valence bond theory, hybridization of atomic orbitals.*	Ch. 9 (9.2-9.9) Ch. 10 (10.2-10.7)
2. Intermolecular forces, liquids and solids	*Intermolecular forces, surface tension, viscosity, capillarity. States of matter, vaporization and vapor pressure, critical point, sublimation, melting, phase diagrams, unit cells, types of crystalline solids, molecular solids, ionic solids, covalent atomic solids, metallic bonding.*	Ch. 11 (11.2-11.8) Ch. 12 (12.3-12.6, 9.11)
3. Solutions	*Types of solutions-saturation, solubility, energy associated with solution formation, factors affecting solubility (temperature and pressure), concentration units (molarity, molality, percent by mass, percent by volume, molar fraction, colligative properties (decrease in vapor pressure, freezing point decrease, boiling point increase and osmotic pressure).*	Ch. 13 (13.2-13.6)
PARTIAL EXAM # 1		
4. Chemical kinetics	*Reaction speed (definition and measurements), factors affecting reaction speed, speed law, determination of reaction orders, integrated equations, half-life, temperature effect - Arrhenius, activation energy, reaction mechanisms, catalysis.*	Ch. 14 (14.2-14.7).
5. Chemical Equilibria	*Basic concepts of dynamic equilibrium, equilibrium constant, equilibrium constant in terms of partial pressures, relationship between Kc and Kp, heterogeneous equilibrium, calculation of the constant, reaction quotient, calculation of concentrations, Le*	Ch. 15 (15.2-15.9)

Topics-Chapter	Thematic Content- Subtopics	Chapter (4th Edition)
	Chatelier's principle (concentration effect , volume or pressure and temperature).	
PARTIAL EXAM # 2		
6. Acids and bases	*Acids and bases (Arrhenius and Bronsted-Lowry definitions), acid strength, acid ionization constant (Ka), water autoionization, pH scale and other p scales, calculation of hydronium concentration and pH in acid solutions, strength of bases, base ionization constant (Kb), calculation of hydroxide concentration and pH in basic solutions, acid-base properties of ions and salts,*	Ch. 16 (16.2-16.8)
7. Ionic Balance in Aqueous Solutions	*Buffer pH - Henderson-Hasselbalch equation, buffer effectiveness, acid-base titration curves, indicators, solubility balance, and solubility product constant (Kps).*	Ch. 17 (17.2-17.5)
8. Electrochemistry	*Balancing oxidation-reduction equations, voltaic or galvanic cells, potential, parts of the electrochemical cell, electrochemical cell notation, standard potentials, spontaneity of the oxidation-reduction reaction.*	Ch. 19 (19.2-19.4)
PARTIAL EXAM # 3		
COMPREHENSIVE FINAL EXAM: Topics 1-8		

V. ACTIVITIES

A. Laboratory practices

1. Introduction to the General Chemistry Laboratory: Safety Rules, SDS, Standards and Evaluation Criteria
2. Numerical analysis
3. What are the molecules like?
4. Why is alcohol soluble in water and oil not?
5. How can we describe a solution?
6. How long does it take?
7. Can an equilibrium be altered?
8. How does a buffer work?
9. How sour is vinegar?
10. What is an active metal?
11. How active are metals?
12. Practical test

B. Teaching Strategies

It is recommended to use strategies such as the following:

1. team work
2. cooperative learning
3. directed discovery
4. demonstrations

5. group data collection and discussion
6. films
7. Simulations
8. application of software for data processing and group discussions
9. conceptual maps

VI. EVALUATION

1. The course evaluation consists of:

    A. A theory part composed of three (3) partial exams (100 points each) and a final exam of 125 points. These exams correspond to 70% of the final grade.
    B. A part of experimental practice that corresponds to 30% of the final grade.

Evaluation Criteria	Points	%
Partial Exam # 1	100	17.5
Partial Exam # 2	100	17.5
Partial Exam # 3	100	17.5
FINAL Exam (comprehensive)	125	17.5
Laboratory	100	30

2. A poor grade (54.4% or less in either of the two parts of the course: theory or laboratory) means failure of the course.

3. The following evaluation scale will be applied in the final grade.

    100-85 A
    84-75 B
    74- 65 C
    64-55 D
    54-0 F

VII. 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 _____.

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 on the basis of 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 provide assistance and guidance in relation to any alleged incident that constitutes discrimination based on sex or gender, sexual harassment or sexual assault. . You can contact the Assistant Coordinator_____ at 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).

VIII. EDUCATIONAL RESOURCES

- **Text book**

  Tro, N.J.; *Chemistry: A Molecular Approach*; 4th Edition, Pearson Education, Inc: USA, 2017.
  ISBN-10: 0134112830
  ISBN-13: 978-0134112831

- *General Chemistry II Laboratory Manual;* Rosario, B., Ed .; Inter American University of Puerto Rico, Metropolitan Campus: San Juan, PR, 2018.

IX. BIBLIOGRAPHY

A. Textbooks:

1. Flowers, P., Theopold K., Langley, R., Robinson, W.R. OpenStax, Rice University, 2019. Free at: https://openstax.org/details/books/chemistry-2e.
2. Zumdahl, S.S, Zumdahl, S.A.; DeCoste, D.J.; *Chemistry*; 10th Edition, Cengage Learning, 2017.
3. Tro, N.J., *Chemistry: A Molecular Approach*, 3rd Edition, Pearson Education, Inc. USA, 2016.
4. Chang, R. and Goldsby, K., *Chemistry*, 12th Edition, McGraw Hill Co., 2015.
5. Burdge, J. *Chemistry,* Third Edition, McGraw Hill Co., 2014.
6. Chang, R. and Goldsby, K., *General Chemistry: The Essential Concepts*, th Edition, McGraw Hill Co., 2013.
7. Petrucci, R.H.; Herring, F.G.; Madura, J.D.; Bissonnette, C.; *General Chemistry*: Principles and Modern Applications; 10th Edition, 2010.

B. Electronic resources:

1. Senese, F.; General Chemistry Online. https://antoine.frostburg.edu/chem/senese/101/index.shtml, 13/7/2020
2. Chemtutor Atomic Structure, http://www.chemtutor.com, 2/7/2020.
3. Chemistry Tutorials & Drills, http://www.chemistry-drills.com, 2/7/2020.
4. Modelos, http://www.chemeddl.org/resources/models360/models.php 19/7/2020
5. VSEPR Rules, http://www.chem.purdue.edu/gchelp/vsepr/rules2.html, 2/7/2020.

6. How do I solve it? (Chemical Equilibrium, Kinetics, Solutions, electrochemistry, Thermodynamics) https://www.chem.purdue.edu/gchelp/howtosolveit/index.html, 2/07/2020.
7. UNCChem Glossary, http://www.shodor.org/unchem/glossary.html, 2/07/2020.
8. Explore Chemistry with ChemEd DL http://www.chemeddl.org/ 19/7/2020.
9. LibreTexts Chemistry: Map: A Molecular Approach (Tro), https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_A_Molecular_Approach_(Tro), 2/7/2020.
10. LibreTexts Chemistry: General Chemistry Supplement (Eames) https://chem.libretexts.org/Bookshelves/General_Chemistry/Book%3A_General_Chemistry_Supplement_(Eames), 2/7/2020.
11. LibreTexts Chemistry: Exercises General Chemistry, https://chem.libretexts.org/Bookshelves/General_Chemistry/Exercises%3A_General_Chemistry, 2/07/2020.
12. The Measure of Matter all about units, measurements, and error, http://www.chem1.com/acad/webtext/virtualtextbook.html, 2/07/2020.
13. Journal of Chemical Education, http://jchemed.chem.wisc.edu/, 2/07/2020.
14. International Chemical Safety Cards (ICSC) en las páginas web de International Labour Organization http://www.ilo.org/dyn/icsc/showcard.listCards2 19/7/2020.
15. Fichas Internacionales de Seguridad Química (FISQ) del Ministerio de Empleo y Seguridad http://www.insht.es/portal/site/Insht/menuitem.a82abc159115c8090128ca10060961ca/?vgnextoid=4458908b51593110VgnVCM100000dc0ca8c0RCRD 19/7/2020.
16. Seguridad MSDS http://www.msdsonline.com/msds-search 19/7/2020.

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