SAGRADO
Universidad del Sagrado Corazón

SCHOOL OF HEALTH AND SCIENCES

SYLLABUS

TITLE:	Inorganic Chemistry
CODE:	QUI 405
PREREQUISITE:	QUI 401
COREQUISITE:	QUI 405L
CREDITS:	3 credits | 45 contact hours | 1 term

DESCRIPTION

Theoretical course that studies the application of modern concepts of atomic and molecular structure to the study of inorganic compounds. The fundamentals of molecular symmetry and its application to the understanding of the physical and chemical properties of matter are discussed. Acid-base reactions, oxy-reduction reactions, the solid state, chemical and physical properties of coordination compounds and the families of elements of the periodic table are studied. This course is conducted using lectures, simulations, article discussion, Web-supported education, literature research, and problem-based learning. This course is intended for students of the chemistry concentration. It is hoped that this course will give students a more complete view of the atomic and molecular structure of matter and its properties.

JUSTIFICATION

There are thousands of inorganic compounds of industrial and biological importance that participate in different processes of daily life. The Inorganic Chemistry course provides the future chemist with the theoretical tools necessary to be able to predict the chemical properties of the elements of the periodic table and to be able to better understand the important processes of daily life in which many of the inorganic compounds participate. An academic program with a specialization in Chemistry requires the integration of the knowledge acquired in basic and intermediate courses that allow mastering more advanced concepts of Chemistry. This course provides such integration.

COMPETENCES

The course develops the following competences in students:

- **Critical questioning**
- **Communication**
- **Research and exploration**

OBJECTIVES

After completion of the course, students will be able to:

1. Explain and illustrate with examples the different theories of the structure of the atom emphasizing the electronic structure.
2. Define and illustrate with examples the different elements of symmetry of a molecule that allow them to classify it in a specific group and predict, by means of the character table of that specific group, the physical and chemical properties of that molecule.
3. Describe, by means of the different theories of molecular structure, the chemical bond and the different states of aggregation of matter using these theories.
4. Explain the chemical properties of inorganic compounds based on the different acid-base and oxy-reduction chemical reactions that they can carry out.
5. Explain the physical and chemical properties of coordination compounds.
6. Explain how the chemical and physical properties of the elements in the periodic table vary.

CONTENTS

I. Atomic Structure
   A. Bohr's atom model
      1. Physical description of the model
      2. Quantization
      3. Total energy
      4. H emission spectrum
      5. Modifications and limitations of the Bohr model
   B. Broglie’s hypothesis
   C. Heisenberg’s uncertainty principle
   D. Quantum Mechanics
      1. The wave function and its properties
      2. The Schrödinger equation

3. The particle in the one-dimensional box

E. Quantum mechanical model of the H atom
   1. Spherical coordinates
   2. Radial part of the wave function
   3. Angular part of the wave function
   4. Radial distribution function
   5. Ψ^2
   6. Atomic orbitals s, p, d, and f

F. Electron spin
   1. Electron spin
   2. Electron spin wave function
   3. Pauli's exclusion principle
   4. Sub-level electronic configurations
   5. Hund's Rule and electron configurations by orbitals
   6. Pairing energy

G. Microstates
   1. Number of microstates
   2. L, S, and J vectors
   3. Spectroscopic terms
   4. Atomic spectroscopy

H. Effective nuclear charge
   1. Slater's rules
   2. Shielding constant
   3. Effective nuclear charge

II. Molecular Symmetry

A. Elements of symmetry
   1. Identity, E
   2. Proper axis, Cn
   3. Investment, i
   4. Improper axis, Sn
   5. Plane of symmetry, σ
      a. Horizontal (σh)
      b. Vertical (σv)

c. Dihedral (σ_d)

6. Examples

B. Point groups

1. C_{nv}, C_{nh}, C_n Groups
2. D_n, D_{nh}, D_{nd} Groups
3. $C_{\infty v}$, $D_{\infty h}$, T_d, O_h Groups
4. S_{2n} Groups

C. Point groups character table

1. Matrices
2. Irreducible representations
3. Character table properties
4. Reduction of reducible representations
5. Examples

D. Applications

1. IR spectroscopy
2. Raman spectroscopy
3. Active and inactive modes
4. Optical activity

III. Chemical Bonding and Intermolecular Forces

A. Covalent bond

1. Covalent bond formation
2. Lewis's structure
3. VSEPR Theory
    a. Linear, trigonal, planar, angular geometry
    b. Tetrahedral geometry, pyramidal trigonal
    c. Bipyramidal trigonal geometry, T-shape, distorted tetrahedron
    d. Octahedral geometry, square pyramid, flat square
    e. Bipyramidal pentagonal geometry, square antiprism
4. Valence Bond Theory
    a. Hybridizations sp, sp^2, sp^3
    b. Hybridizations dsp^2, dsp^3, and d^2sp^3
5. Theory of Molecular Orbitals
    a. Homonuclear and heteronuclear diatomic molecules

b. Water, borane, methane, ammonia
c. HF + F-, carbon dioxide and boron trifluoride

B. Ionic bond
1. Ionic Radium
    a. Definition
    b. Determination of ion bond
2. Unit cells
    a. Definitions
    b. Bravais cells
3. Crystal lattice structures
    a. ABAB packing and ABCABC
    b. NaCl structure
    c. CsCl structure
    d. Rutile structure
    e. Zinc blende structure
    f. Fluorite structure
4. Defects in the solid structure
    a. Vacancies and interstitials
    b. Substitutions
    c. Dislocations
5. Silicates
    a. Definitions
    b. Structures
6. Born-Haber cycle
    a. Definitions
    b. Madelung's Constant
    c. Computation of U
7. Conductivity in solids
    a. Band theory
    b. Drivers
    c. Semiconductors
    d. Insulators
8. Superconductors

a. Structure
b. Applications

C. Intermolecular forces
1. Internuclear distances
a. Definitions
b. Determination of internuclear distances
2. Chemical forces
a. Dipole ion
b. Dipole-dipole
c. Induced dipole-dipole
d. London forces
e. Theoretical treatment
3. Hydrogen bonds
a. a. Definitions
b. b. Systems that have H-bridges
c. Theoretical treatment

IV. Acids, Bases, Oxidizing and Reducing Agents
A. Acid-base concepts
1. Brønstead-Lowry
2. Lux-Flood
3. Lewis
4. Usanovich
5. Solvent system
6. Hard and soft acids and bases
B. Acid-base strength
1. Steric effect
a. Voltage F
b. Voltage I
2. Inductive effect on oxoacids
3. Proton affinity
C. Redox chemistry of inorganic compounds
1. Galvanic cells
a. Definitions

b. E^o of a half reaction

D. Gibbs free energy and the potential of a cell
   1. ΔG as a function of E
   2. K_{equil} of a redox reaction

E. Latimer diagrams in acid and base medium
   1. E^o_A and E^o_B
   2. Oxidation states
   3. Balancing in acid and base medium

F. Applications

V. Chemistry of Coordination Compounds

A. Structure of coordination compounds
   1. Coordination number
   2. Ligand
   3. Coordination sphere

B. Mono- and poly-toothed ligands
   1. Definitions
   2. Examples of polydentate ligands
   3. Chelated complexes

C. Nomenclature of coordination compounds

D. Isomerism in coordination compounds
   1. Bonding isomers
   2. Stereoisomers
   3. Facial and meridional isomers

E. Crystal Field and Ligand Field Theories
   1. Fundamentals of both theories
   2. 10Dq
   3. High spin and low spin complexes

F. Valence bonding theory of coordination compounds
   1. Octahedral complexes
   2. Tetrahedral complexes
   3. Flat square complexes

G. Molecular orbital theory of coordination compounds
   1. Octahedral complexes

2. Tetrahedral complexes
3. Flat square complexes

H. VIS spectrophotometry
1. Spectra of octahedral complexes
2. Spectroscopic terms of d^n configurations
3. Tanabe-Sugano charts

VI. Chemistry of the Families of the Elements of the Periodic Table

A. Periodic properties
1. Atomic radius
2. Ionization energy
3. Electronic affinity
4. Electronegativity
5. Ionic radium
6. Metallic character

B. Structure of the Periodic Table

C. Representative elements
1. Physical properties
2. Characteristic reactions
3. Applications

D. Transitional elements
1. Physical properties
2. Some characteristic reactions
3. Applications

E. Internal transition elements
1. Physical properties
2. Some characteristic reactions
3. Applications

METHODOLOGY

The following strategies from the active learning methodology are recommended:

- Problem-based learning
- Conferences
- Article discussion

- Simulations
- Oral and written report
- Solving a problem posed
- Web-supported education
- Ethics across disciplines
- Literature research

EVALUATION

Partial assignments	30%
Participation	10%
Oral presentation	30%
Final project or exam	30%
Total	**100%**

LEARNING ASSESSMENT

The institutional assessment rubric is applied to the course's core activity.

BIBLIOGRAPHY

Housecroft, C. (2018). *Inorganic Chemistry* (5th ed.). Pearson.

Kloprogge, J. T., Concepcion P. Ponce, C. P., & Loomis, T. (2020). *The Periodic Table: Nature's Building Blocks: An Introduction to the Naturally Occurring Elements, Their Origins and Their Uses* (1st ed.). Elsevier.

Perry, D. L. (2016). *Handbook of Inorganic Compounds* (2nd ed.). CRC Press.

Pfennig, B. W. (2015). *Principles of Inorganic Chemistry* (1st ed.), Wiley.

Pieter Thyssen, P., Ceulemans, A. (2017). *Shattered Symmetry: Group Theory from the Eightfold Way to the Periodic Table* (1st ed.). Oxford University Press.

Roat-Malone, R. M. (2020). *Bioinorganic Chemistry: A Short Course* (3rd ed). Wiley.

Strohfeldt, K. A. (2015). *Essentials of Inorganic Chemistry: For Students of Pharmacy,*

Pharmaceutical Sciences and Medicinal Chemistry (1st ed.). Wiley.

Weller, O., Armstrong, R. (2015). *Inorganic Chemistry*. (6th ed.) Oxford University Press.

Wulfsberg, G. (2016). *Inorganic Chemistry Paperback* (1st ed.) Viva Books.

Wulfsberg, G., Muller, L. (2017). *Foundations of Inorganic Chemistry* (1st ed.) University Science Books.

ELECTRONIC RESOURCES

American Chemical Society (n.d.) ACS Chemistry for Life.

https://www.acs.org/content/acs/en.html

International Union of Pure and Applied Chemistry. (n.d.). https://iupac.org/

For more information resources related to the course's topics, access the library's webpage http://biblioteca.sagrado.edu/

REASONABLE ACCOMMODATION

For detailed information on the process and required documentation you should visit the corresponding office. To ensure equal conditions, in compliance with the ADA Act (1990) and the Rehabilitation Act (1973), as amended, any student in need of reasonable accommodation or special assistance must complete the process established by the Vice Presidency for Student Affairs.

- Students participating in the Student Support Program (PAE, in Spanish) shall request their reasonable accommodation in PAE's offices.
- Students who do not participate in PAE shall request their reasonable accommodation at the Integral Wellness Center (*Centro de Bienestar Integral*, in Spanish).

ACADEMIC INTEGRITY

This policy applies to all students enrolled at Universidad del Sagrado Corazón to take courses with or without academic credit. A lack of academic integrity is any act or omission that does not demonstrate the honesty, transparency, and responsibility that should characterize all academic activity. Any student who fails to comply with the Honesty, Fraud, and Plagiarism Policy is exposed to the following sanctions: receive a

grade of zero in the evaluation and / or repetition of the assignment in the seminar, a grade of F (*) in the seminar, suspension, or expulsion as established in the Academic Integrity Policy effective in November 2022.