Basic Sciences

Division

Department of Chemistry

Inorganic Chemistry II

CUCEI

UNIVERSIDAD DE GUADALAJARA
CENTRO UNIVERSITARIO DE CIENCIAS EXACTAS E INGENIERÍAS

1.- GENERAL INFORMATION				
Learning unit: Inorganic Chemistry II		**Department:** Chemistry		**Course format** Lecture
Prerequisites(P) Inorganic Chemistry I	**Corequisites (CO)** Inorganic Chemistry Lab II	**Ascribed Academy** Chemistry	**Module** M2: Synthesis, purification and chemical transformation.	
Type Basic particular mandatory	**Lecture hours** 4 hrs./per week	**Practice hours** 0 hrs.	**Total hours** 68 hrs.	Credits 9
Degree in which this class is taught: B.S in Chemistry.				

2.- GENERIC COMPETENCIES
Students… -Are able to apply the main concepts related to the theories, models, and approaches used to describe chemical structures and bonds of the compounds with metals of blocks d and f. - Are able to then synthesize this type of compounds by analyzing their chemical, magnetic and spectroscopic properties. -Recognize the transcendence and application of coordination chemistry in labs and industries.

3.- SPECIFIC CHARACTERISTICS OF THE COMPETENCY	
Knowledge	Students know, discuss and predict… • … descriptive chemistry of transition metals (block d) • … structures and isomers of coordination complexes. • … bond theories for the coordination complexes. • …reactions and mechanisms of the coordination complexes. • … electronic spectra of the coordination complexes. • …descriptive chemistry of lanthanides and actinides (block f).
Skills	Students… • …identify the general properties of transition metals. • …use the appropriate nomenclature to name the coordination complexes. • … determine the main characteristics of the coordination complexes. • …outline the possible isomers for a coordination complex. • …explain the bond of coordination complexes according to the current theories. • … interpret the absorption spectra base on electronic transitions. • … distinguish the typical reactions of the coordination complexes.
Aptitudes	• Autonomous learning

	• Ability to analyze, synthesize, and evaluate. • Ability to identify and solve problems. • Creativity • Critical thinking • Use of digital resources. • Work culture
Values	Students develop and exercise values such as responsibility, honesty, tolerance, respect, solidarity, willingness and positive attitude towards individual and group work.

4.- TRANSVERSAL COMPETENCIES

☑	Foreign Language (English)
☑	Critical, analytical and synthetic thinking.
☑	Oral and written expression
☑	Professional ethics
☐	Administration of human and material resources
☐	Leadership and sustainability
☑	Creativity, innovation and entrepreneurship
☐	Other

5.- COURSE CONTENT OF THE LEARNING UNIT

1. **Chemistry of transition metals (block d)**
   - 1.1. Abundance of transition metals on the earth's crust.
   - 1.2. Electronic configurations and oxidation states.
   - 1.3. Physical properties of transition metals.
   - 1.4. Atomic radii and lanthanide contraction.
   - 1.5. Variation of the ionization energies and the inert pair effect.
   - 1.6. Magnetism and measurement of magnetic susceptibility.

2. **Structures of coordination complexes.**
   - 2.1. Parts and classification of coordination complexes.
   - 2.2. Types of binders (L and X)
   - 2.3. Determination of the main characteristics of coordination complexes:
     - 2.3.1. Number of valence electrons (NVE) and the 18 electron rule.
     - 2.3.2. Number of non-bonding electrons (NNBE).
     - 2.3.3. Oxidation state (OS) and charge (q)
     - 2.3.4. Coordination number (CN) and the main geometries of the coordination complexes. (1-8).
   - 2.4. Nomenclature of coordination complexes.
   - 2.5. History of coordination chemistry
   - 2.6. Importance of the coordination complexes.

3. **Isomerism of coordination complexes.**
   - 3.1. Definition and types of isomers
   - 3.2. Structural isomers.
     - 3.2.1. Linkage, ionization, hydration and coordination isomers.
   - 3.3. Stereoisomers
     - 3.3.1. Geometric isomers in square planar compounds. BPT and octahedral.
     - 3.3.2. Optical isomers, chirality and optical activity.
     - 3.3.3. Absolute configuration of tetrahedral (R and S) and octahedral compounds (Δ and λ).
   - 3.4. Changes in the stereochemistry with no bond breaking.
     - 3.4.1. Inversion in tri-coordinate systems
     - 3.4.2. Pseudorotation in tetra-coordinate, penta-coordinate and hexa-coordinate systems

4. **Coordination chemistry: bonding theories**
   - 4.1. Evidences of electronic structure
     - 4.1.1. Magnetic properties of the coordination complexes.
     - 4.1.2. Optical properties of the coordination complexes.
   - 4.2. Valence bond theory
     - 4.2.1. Complexes with sp3, sp2d, sp3d, dsp3, sp3d2 and dsp3 hybridization
     - 4.2.2. Inner and outer orbital complexes.
   - 4.3. Crystal field theory
     - 4.3.1. Crystal field stabilization energy (CFSE)
     - 4.3.2. CFSE variations: Geometry, metal and ligand identities.
     - 4.3.3. Spectrochemistry series
     - 4.3.4. Experimental evidences of orbital splitting.
   - 4.4. Ligand field theory
     - 4.4.1. Construction of the MO diagram. Octahedral and tetrahedral geometries.
     - 4.4.2. σ and π interactions and donors
     - 4.4.3. π interactions and acceptors
     - 4.4.4. Magneto chemical series.
     - 4.4.5. Angular overlap method

5. **Coordination chemistry; reactions and mechanisms**
   - 5.1. Reactivity of the coordination complexes.
     - 5.1.1. Thermodynamic factors: stable and unstable complexes.
     - 5.1.2. Formation constants
     - 5.1.3. Chelate effect
     - 5.1.4. Kinetic factors: labile and inert compounds.
   - 5.2. Substitution reactions
     - 5.2.1. Substitution mechanisms; dissociative, associative and exchange.
     - 5.2.2. Substitution reactions in square planar complexes: stereochemistry and factors that influence speed. Entering group, leaving group, central ion and ligands. Trans effect.

5.2.3. Substitution reactions of octahedral complexes: stereochemistry, dependency of the Number of non-bonding electrons (NNBE) and effects of the ligands. Steric ligand spectators, Tolman's cone angle.

5.3. Oxide reduction reactions

5.3.1. Inner sphere and outer sphere mechanism.

5.3.2. Conditions for high and low oxidation states.

6. **Coordination chemistry: electronic spectra**

6.1. Atom quantic numbers of poly electronic atoms.

6.2. Spin-orbit coupling

6.3. Microstates and their reduction to terms

6.4. Electronic spectra of the coordination complexes.

6.4.1. Selection rules

6.4.2. Correlation diagrams

6.4.3. Tanabe–Sugano diagrams

6.4.4. Jahn–Teller effect in absorption spectra

6.4.5. Charge transference spectra

7. **Lanthanide and actinide chemistry (Block f)**

7.1. Properties of lanthanide elements.

7.2. Properties of actinide elements

6.- ASSESSMENT

☑	Numeric grade
☐	
☐	

7.- GRADING CRITERIA OF THE LEARNING UNIT

Indicator of evaluation	Percentage
Departmental exams	30
Partial exam	40
Homework	10
Research activities	10
Practice reports	0
Class participation	10

8.- REQUIRED MATERIAL (for students)	
☑	Calculator
☑	Periodic table
☐	Lab coat
☑	Text book
☐	Workbook
☐	Tables of standard potential, table of mobility, etc.

9.-SPECIFIC CONTENT BY LEARNING UNITS						
Content unit	**Generic competency of the content unit**	**Topics**	**Class hours**	**Professor activities**	**Student activities**	**Bibliography**
Unit 1 Chemistry of transition metals (block d)	Recognize and predict the physical and chemical properties of the block d elements.	1.1 Abundance of transition metals on the earth's crust.	30 min	Professor… -lectures -creates and corrects homework. -designs the exam.	Students… - develop online and paper activities such as: ✓ forums ✓ homework ✓ exam	Brown Le May *Química General*,
		1.2 Electronic configurations and oxidation states.	30 min			
		1.3 Physical properties of transition metals.	30 min			
		1.4 Atomic radii and lanthanide contraction.	30 min			
		1.5 Variation of the ionization energies and the inert pair effect	30 min			
		1.6 Magnetism and measurement of magnetic susceptibility.	30 min			

Unit 2 Structures of coordination complexes	Understand the structure and predict the properties of coordination complexes.	2.1 Parts and classification of coordination complexes.	30 min	Professor… -lectures -creates and corrects homework. -designs the exam.	Students… - develop online and paper activities such as: ✓ forums ✓ homework ✓ exam	Shriver, Atkins 2009 *Inorganic Chemistry*, 5th Ed., W. H. Freeman.
		2.2 Types of binders (L and X)	1 h			
		2.3 Determination of the main characteristics of coordination complexes.	3.5 h			
		2.4 Nomenclature of coordination complexes.	2 h			
		2.5 History of coordination chemistry	30 min			
		2.6 Importance of the coordination complexes.	30 min			
Unit 3. Isomerism of coordination complexes .	Define and distinguish the different types of isomerism that occur in the	3.1 Definition and types of isomers	1 h	Professor… -lectures -creates and corrects homework.	Students… - develop online and paper activities such as: ✓ forums ✓ homework ✓ exam	Shriver, Atkins 2009 *Inorganic Chemistry*, 5th Ed., W. H. Freeman,
		3.2 Structural isomers: Linkage, ionization, hydration and	1 h			

	coordination complexes.	coordination isomers.		-designs the exam.		
		3.31 Stereoisomers Geometric isomers in square planar compounds. BPT and octahedral.	2 h			
		3.32 Stereoisomers Optical isomers, chirality and optical activity	2 h			
		3.33 Absolute configuration of tetrahedral (R and S) and octahedral compounds (Δ and λ).	2 h			
		3.34 Changes in the stereochemistry with no bond breaking. Inversion in tri-coordinate systems Pseudorotation in tetra-coordinate, penta-coordinate and hexa-coordinate systems.	1 h			

Unit 4. Coordination chemistry: bonding theories	Apply current theories to describe chemical bonding in the compounds with metals from block b	4.1 Evidences of electronic structure Magnetic properties of the coordination complexes. Optical properties of the coordination complexes.	1 h	Professor… -lectures -creates and corrects homework. -designs the exam.	Students… - develop online and paper activities such as: ✓ forums ✓ homework ✓ exam	Miessler, Gary L., Tarr, Donald, A. *Inorganic Chemistry* 2014. 5th Ed., Pearson.
		4.2 Valence bond theory Complexes with sp3, sp2d, sp3d, dsp3, sp3d2 and dsp3 hybridization	1 h			
		4. 3 Crystal field theory 4.31 Crystal field stabilization energy (CFSE) 4.32 CFSE variations: Geometry, metal and ligand identities. 4.33 Spectrochemistry series 4.34 Experimental evidences of orbital splitting.	8 h			

		4.4 Ligand field theory 4.41 Construction of the MO diagram. Octahedral and tetrahedral geometries. 4.42 σ and π interactions and donors 4.43 π interactions and acceptors 4.44 Magneto chemical series.	10 h			
		4.45 Angular overlap method	2 h			
Unit 5 Coordination chemistry, reactions and mechanisms	Evaluate the reactivity of the coordination complexes	5.1 Reactivity of the coordination complexes. 5.11 Thermodynamic factors Formation constants Chelate effect 5.12 Kinetic factors: labile and inert compounds.	2 h	Professor… -lectures -creates and corrects homework. -designs the exam.	Students… - develop online and paper activities such as: ✓ forums ✓ homework ✓ exam	, Shriver, Atkins 2009 *Inorganic Chemistry*, 5th Ed., W. H. Freeman,
		5.2 Substitution reactions	3 h			

		5.2.1 Substitution mechanisms: dissociative, associative and exchange. 5.2.2 Substitution reactions in square planar complexes: stereochemistry and factors that influence speed. Entering group, leaving group, central ion and ligands. Trans effect. 5.2.3 Substitution reactions of octahedral complexes: stereochemistry, dependency of the Number of non-bonding electrons (NNBE) and effects of the ligands. Steric ligand spectators, Tolman's cone angle.				
		5.3 Oxide reduction reactions 5.3. 1 Inner sphere and outer sphere mechanism.	2 h			

		5.3. 2 Conditions for high and low oxidation states				
Unit 6 Coordination chemistry: electronic spectra	Determine the spectroscopic properties of the coordination complexes.	6.1 Atom quantic numbers of poly electronic atoms.	1 h	Professor… -lectures -creates and corrects homework. -designs the exam.	Students… - develop online and paper activities such as: ✓ forums ✓ homework ✓ exam	Miessler, Gary L., Tarr, Donald, A. *Inorganic Chemistry* 2014. 5ª Ed., Pearson.
		6.2 Spin-orbit coupling	1 h			
		6.3 Selection rules	1 h			
		6.4 Correlation diagrams and Tanabe-Sugano diagrams. Their use in the determination of Δo	2 h			
		6.5 Jahn-Teller's distortion	1 h			
		6.6 Charge transfer complexes	1 h			
Unit 7 Lanthanide and actinide chemistry (Block f)	Recognize the basic properties of lanthanide and actinide compounds.	7.1 Properties of lanthanide elements.	2	Professor… -lectures -designs the exam.	Students… - develop online and paper activities such as: ✓ forums ✓ homework	Geoff Rayner-Canham *Química Inorgánica Descriptiva*. 2nd Ed. Prentice Hall
		7.2 Properties of actinide elements	2			
COURSE EVIDENCES (Deliverables) - **Partial Exam** - **Departmental exam** - **Research tasks** - **Problem and concept solutions**						

10.-PROFESSOR'S PROFILE

Bachelor degree in Chemistry.
Graduate degrees in chemical synthesis (inorganic)
Specific knowledge of Inorganic Chemistry.
Teaching experience in Coordination Chemistry.

11.-AUTHORS OF THE LEARNING UNIT

Sara Cortes Llamas
Irma Idalia Rangel
José Miguel Velázquez López

12.-MODIFICATION AND UPDATE

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