

**UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF
CHEMISTRY COURSE
SYLLABUS
WINTER
2021**

1. Course: CHEMISTRY 433, Inorganic Chemistry: Transition Metals

LEC	DAYS	TIME	ROOM	PROFESSOR	OFFICE	EMAIL	OFFICE HOURS
L01	MWF	11:00-11:50	remote	Warren Piers	EEEL 548	wpiers@ucalgary.ca	contact by email.

To avoid IT problems, it is recommended that the students use their U of C account for all course correspondence. Please use "CHEM 433 inquiry" as the Subject of your e-mail.

Desire 2 Learn (D2L): CHEM 433 L01 - (Winter 2021) - Inorganic Chemistry: Transition Metals
<https://d2l.ucalgary.ca/d2l/home/358277>

Undergraduate Science Centre: 403-220-8600; e-mail: chem.info@ucalgary.ca

- 2. Course Description: Lectures:** Bonding models for metals and for transition metal compounds; interpretation of redox and thermodynamic properties based on ligand field theory; coordination and organometallic compounds of the transition metals; metal complexes as catalysts in industry and biology. **Laboratory:** Synthesis, analysis, and physical investigations of transition metal compounds that illustrate their important properties.
- 3. Recommended Textbook:** Miessler, G. L.; Fischer, P. J., and Tarr, D. A., "Inorganic Chemistry", 5th Ed., Pearson, 2014 (available in the Bookstore)
- 4. Topics Covered and Suggested Readings:**

TRANSITION METAL COMPLEXES – General Aspects (Chapters 2, 9, 10)

Electronic Configuration of Transition Metal Atoms/ Ions (Review)
 Oxidation States
 Trends in 1st Ionization Energy, Atomic/ Ionic Size of d-block Elements
 Inner- vs. Outer-sphere Coordination
 Classification of Ligands Chelation
 Nomenclature

TRANSITION METAL COMPLEXES – Structural Aspects & Characterization Methods (Chapters 6, 9, 13)

Coordination Number & Coordination Geometry X-ray Crystallography
 Isomerism/Symmetry (Review)
 IR Spectroscopy
 Multinuclear NMR spectroscopy 18 Electron Rule
 Organometallic complexes

TRANSITION METAL COMPLEXES – Properties & Bonding Theories (Chapters 10, 11)

Crystal Field Theory (CFT)
 Splitting, Spectrochemical Series, high and low spin, Jahn-Teller Effect
 Color and Electronic Absorption (UV-vis.) Spectra
 Electronic Transitions & Selection Rules Charge Transfer
 Solvatochromism & Thermochemistry
 Magnetism & Magnetic Properties
 Molecular Orbital Theory and MO diagrams
 σ and π -bonding
 Experimental Evidence for π -bonding (IR & Crystallography)

TRANSITION METAL COMPLEXES – Reactions & Mechanisms (Chapter 12)

Kinetic vs. Thermodynamic Factors Inert vs. Labile Complexes Mechanisms

Substitution Reactions The Trans Effect

Redox Reactions Electron Transfer

TRANSITION METAL COMPLEXES – Applications (Chapters 13, 14)

Bio-inorganic Chemistry

Organometallic Reactions & Catalysis

Primary reactions in organometallic chemistry Catalysis

Olefin isomerization, hydrogenation and polymerization

5. Laboratory Experiments: (5 weeks, 3 hours/ week) Students must perform **all five experiments**, 1, 2, 4, 5, 7;

experiments 3 and 6 are not offered this year.

1. Chemistry of Titanium (III) (in aqueous solution)

Synthesis of $[\text{Ti}(\text{H}_2\text{O})_6]\text{Cl}_3$ by electrolytic reduction of TiCl_4 , and measuring its UV-vis. spectrum; analyzing %Ti(III) in solution using titration; chemical reactions of Ti(III)

2. Coordination Complexes of Cobalt (III) Amine Complexes

Syntheses of $[\text{Co}(\text{NH}_3)_4(\text{CO}_3)]\text{NO}_3$ and $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$, comparing their electrical conductance

3. Optical Activity at an Octahedral Cobalt Complex (2 weeks)

Preparation of a racemic mixture of $[\text{Co}(\text{en})_3](\text{SO}_4)\text{Cl}$ (en = ethylenediamine); separation of enantiomers using barium (+)-tartarate; cleaving the resolving agent from $[(+)\text{-Co}(\text{en})_3] [(+)\text{-tart}]\text{Cl}$ and formation of $[(+)\text{-Co}(\text{en})_3]_3\cdot\text{H}_2\text{O}$; using a polarimeter to determine $[\alpha_D]$ for the later complex

4. Carbonyl Complexes (2 weeks)

Syntheses of $\text{Mo}(\text{CO})_4(\text{bpy})$ (bpy = 2,2'-bipyridine) and two isomers of $\text{Mo}(\text{CO})_4(\text{PPh}_3)_2$ from $\text{Mo}(\text{CO})_6$ under inert atmosphere; their structural characterization using IR spectroscopy

5. Coordination Complexes - Geometrical Isomerism

Syntheses of *cis*- and *trans*- isomers of $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$, comparing their UV-vis. spectra

6. The Paramagnetic Complex $\text{Mn}(\text{acac})_3$

Synthesis of $\text{Mn}(\text{acac})_3$ complex (Hacac = acetylacetonate) and finding its spin state (high-spin or low-spin) by measuring its magnetic susceptibility

7. Syntheses, Characterization and IR Study of DMSO Complexes

Syntheses of $\text{CuCl}_2\cdot 2\text{DMSO}$ (DMSO = dimethylsulfoxide); comparing its IR spectrum with those of $\text{PdCl}_2\cdot 2\text{DMSO}$ and $\text{RuCl}_2\cdot 2\text{DMSO}$

Department Approval: Approved by Department Head

Date: