

**UNIVERSITY OF CALGARY  
FACULTY OF SCIENCE  
DEPARTMENT OF CHEMISTRY  
COURSE SYLLABUS  
WINTER 2020**

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

LEC	DAYS	TIME	ROOM	PROFESSOR	OFFICE	EMAIL	OFFICE HOURS
L01	MWF	11:00-11:50	MFH 164	Warren Piers	EEEL 548	wpiers@ucalgary.ca	By Appointment or T,Th 11-noon; T,W 1-2pm

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 2020) - Inorganic Chemistry: Transition Metals  
<https://d2l.ucalgary.ca/d2l/home/295461>

Departmental Office: Room SA 229, Tel: (403) 220-5341, e-mail: [chem.info@ucalgary.ca](mailto: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", 5<sup>th</sup> Ed., Pearson, 2014 (available in the Bookstore)
- 4. Topics Covered and Suggested Readings:**

**Course Contents**

**Chapter in Textbook**

*(not all sections will be covered)*  
Chapters 2, 9, 10

**TRANSITION METAL COMPLEXES – General Aspects**

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**

Chapters 6, 9, 13

**Methods**

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 & Thermochromism  
    Magnetism & Magnetic Properties

Molecular Orbital Theory (MOT)  
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**

Bio-inorganic Chemistry

N/A

Organometallic Reactions & Catalysis

Primary reactions in organometallic chemistry

Chapters 13 and 14

Catalysis

Olefin isomerization, hydrogenation and polymerization

**5. Laboratory Experiments:** (10 weeks, 3 hours/ week)

*Students must perform all seven experiments.*

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  $\text{TiCl}_4$ , 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: January 6<sup>th</sup>, 2020