

Intermediate Inorganic Chemistry (CHMC31Y3)

Course Scope

Intermediate Inorganic Chemistry (CHMC31Y3) builds up on the material covered in Inorganic Chemistry (CHMB31) and will cover topics from the general and special chemistry of transition elements. General topics will include: overview of transition metal properties (their position in Periodic Table of Elements, relationships to the main group elements, etc.) main classes of compounds, coordination compounds (structure and bonding, general reactivity, magnetic properties), spectroscopic methods in inorganic chemistry (UV, IR, NMR), and basic organometallic chemistry of transition elements. Special topics will include reactivity of some transition metal complexes (through important examples), homogeneous and heterogeneous catalysis (with a look at the concepts of "green chemistry" and "atom economy").

Detailed Course Outline

1. INTRODUCTION

a. General introduction to transition elements:

- i. Brief history, their position in Periodic Table of Elements, relationship to main group (*s*- and *p*-) elements, electronic configuration;
- ii. Accessible oxidation states, main classes of compounds (binary, salts, complex, organometallic).

2. COORDINATION COMPOUNDS (OR COMPLEXES):

- i. Definition and brief history;
- ii. Ligand Classes;
- iii. Coordination numbers and geometries;
- iv. Isomers;
- v. Stability of coordination compounds.
- vi. Overview of some applications in analytical chemistry.

3. ORGANOMETALLIC COMPOUNDS:

- a. Ligands in organometallic chemistry;
- b. 18-electron rule and structure of organometallic compounds.

4. STRUCTURE AND BONDING IN COORDINATION COMPOUNDS:

- a. Ligand Field Theory;

- b. Crystal Field Theory;
 - c. Molecular Orbital Approach;
 - d. Spectroscopy I: UV-Vis (theory and applications);
 - e. Metal – ligand bond strength – Spectroscopy II: Infra-red (theory and applications).
5. SPECTROSCOPY III: NMR SPECTROSCOPY IN INORGANIC AND ORGANOMETALLIC CHEMISTRY:
- a. General introduction to NMR spectroscopy;
 - b. NMR active nuclei;
 - c. Chemical shifts, coupling constants and fundamentals of interpretation of NMR spectra of coordination and organometallic compounds (NMR in inorganic vs. organic chemistry);
 - d. Fluxional compounds.
6. REACTIVITY OF COORDINATION COMPOUNDS:
- a. General introduction (thermodynamics, kinetics, mechanisms);
 - b. Substitution reactions;
 - c. Basic reactivity of organometallic compounds (oxidative addition and reductive elimination);
 - d. Introduction to inorganic and organometallic syntheses.
7. SPECIAL TOPICS I: TRANSITION METAL CHEMISTRY:
- a. First row (*3d*) metals;
 - b. Second (*4d*) and third (*5d*) row metals;
 - c. Lanthanides and actinides (*f* elements).
8. SPECIAL TOPICS II: CATALYSIS - CHEMISTRY AND INDUSTRY IN ACTION TOGETHER:
- a. Energy considerations, “green chemistry” and “atom economy” principles (i.e. “Why bother with catalysis);
 - b. Heterogeneous catalysis;
 - i. Principles;
 - ii. Mechanisms;
 - iii. Examples;
 - c. Homogeneous catalysis;
 - i. Principles;
 - ii. Mechanisms;
 - iii. Examples;
 - d. Homogeneous vs. heterogeneous catalysis: which way to go?
 - e. Industry.

Suggested reading materials

Housecroft, C.E. and Alan G. Sharpe. Inorganic Chemistry. 3rd ed. (**Recommended text:** generally a good textbook – if you used it for CHMB31 keep it for this course as well).

Wilkinson, A. and A. Cotton. Advanced Inorganic Chemistry. 5th ed. New York; Toronto: Wiley, 1988 (QD 151.2 .C68 1988 SCAR; advanced text for those interested in the chemistry of elements)

Greenwood, N.N. and A. Earnshaw. Chemistry of the Elements. 2nd ed. Oxford: Butterworth Heinemann, 1998. (QD 466 .G74 1997 SCAR; Probably one of *the best* inorganic chemistry textbooks out there: but does not cover in great detail spectroscopic techniques and bonding. Useful to learn a lot about the elements and their reactivity, this book is on reserve in your Library).

Crabtree, R. H. The Organometallic Chemistry of Transition Metals. 4th ed. Wiley-Interscience, 2005 (Online resource 382320; useful for the NMR and organometallic topics)

Mathey, J.F. Molecular Chemistry of the Transition Elements: An Introductory Course. Chichester; New York: John Wiley, 1996 (QD 411.8 .T73M38 1996 SCAR; useful for the organometallic and special topics).

AND of course Lecture Notes

Note: The lecture notes will contain frequent references to the materials from which the content has been taken. It is not necessary for the students to go through every reference provided. The references are there to: **1)** acknowledge the authorship of the material and **2)** provide additional sources for those who are interested to explore the particular topic in detail.

Course Evaluation:

Midterm Exam:	14%
Problem Set I	8%
Problem Set II	8%
Final Exam	30%
Lab component	40%