

Intermediate Inorganic Chemistry (CHMC31Y3)

Welcome to CHMC31 course, a course that brings to you the exciting, rich and colourful world of transition elements. Below you will find a more detailed course scope and outline which will, I hope, give you a bit more information about what is in front of us and what is expected from us all this semester.

Course Scope

Intermediate Inorganic Chemistry (CHMC31) builds up on the material covered in Introduction to Inorganic Chemistry (CHMB31) and will cover topics from the general and special chemistry of transition elements. Thus, the main goal of this course is to provide you with knowledge and understanding of transition elements, their compounds and coordination chemistry. General topics will include: overview of transition metal properties (their position in the 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), and introduction to organometallic chemistry. Thus, the course is oriented more towards the physical rather than descriptive inorganic chemistry.

Detailed Course Outline

These are some of the topics that will be covered in the course. We will not cover them necessarily in this order.

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*- block) elements, electronic configurations;
 - 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.
3. SYMMETRY AND BONDING IN COORDINATION COMPOUNDS:
 - a. Symmetry: general concepts;
 - b. Symmetry: point groups;
 - c. Ligand Field Theory;
 - d. Crystal Field Theory;
 - e. Molecular Orbital Approach.
 4. CHARACTERIZATION OF COORDINATION COMPOUNDS I: UV-VIS SPECTROSCOPY
 - a. Colour of transition metal complexes;
 - b. Spectral terms and selection rules;
 - c. Correlation diagrams;
 - d. Charge transfer: metal-to-ligand and ligand-to-metal.
 5. CHARACTERIZATION OF COORDINATION COMPOUNDS II: INFRARED SPECTROSCOPY (THEORY AND APPLICATIONS);
 6. 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.
 7. REACTIVITY OF COORDINATION COMPOUNDS:
 - a. General introduction (thermodynamics, kinetics, mechanisms);
 - b. Substitution reactions:
 - i. In square planar complexes,
 - ii. In octahedral complexes;
 - c. Isomerization;
 - d. Electron-transfer pathways.
 8. 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).

9. ORGANOMETALLIC COMPOUNDS:

- a. Ligands in organometallic chemistry;
- b. 18-electron rule and structure of organometallic compounds.
- c. Basic classes of organometallic compounds:
 - i. σ - bonded alkyl and aryl complexes
 - ii. π -bonded systems (alkenes, alkynes, cyclopentadienyl and other aromatic systems)
 - iii. Other common ligands in organometallic chemistry: hydride, dihydrogen, and phosphines

10. 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

Your lecture notes, which will be available on the CHMC31 intranet site, should be your major guides to mastering the material for this course. **However, the knowledge of both textbook and lecture materials is required.**

Our textbook is still:

Atkins, Overton, Rouke, Weller, Armstrong and Hagerman. **Shriver and Atkins' Inorganic chemistry**. 5th edition. New York: W.H. Freeman and Company, 2010. (if you used it for CHMB31, keep it for this course as well).

These are additional sources for those of you who would like to explore more and can be found in the Chemistry Library:

Wilkinson, A. and A. Cotton. Advanced Inorganic Chemistry. 5th ed. New York; Toronto: Wiley, 1988 (a very detailed descriptive inorganic chemistry – for those who need or would like to learn more about the chemistry of certain elements)

Greenwood, N.N. and A. Earnshaw. Chemistry of the Elements. 2nd ed. Oxford: Butterworth Heinemann, 1998. (Probably one of *the best* and most detailed descriptive inorganic chemistry textbook out there, but does not cover in great detail spectroscopic techniques and bonding. Useful to learn a lot about the elements and their reactivity).

Miessler, G.L., and D.A. Tarr. Inorganic Chemistry. 3rd ed. Upper Saddle River: Pearson Prentice Hall, 2004. (A good text for our topics 2, 3 (UV-Vis), 6, and 8; it is on course reserves in UTSC library)

Huheey, J.E., E.A. Keiter, and R.L. Keiter. Inorganic Chemistry: Principles of structure and reactivity. 4th ed. Upper Saddle River: Pearson Prentice Hall, 1993-94 (a classic textbook, covers many relevant topics for our course)

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

The additional readings are not required materials, but are sources that can provide you with more detail on the topics you would like to explore further on your own.

Course Evaluation:

Midterm Exam:	20%
Problem Set	10%
Final Exam	30%
Lab component	40%

The dates for the exams and problem set will be announced during classes. What follows are some details regarding the content of each.

Problem Set. This is a take-home assignment. You will be given two weeks to finish the assignment (from the day the assignment is actually posted) and submit your answers. The assignment is designed to help you go over the course material and apply it on specific chemistry

problems. In parallel it should point show you the topics and concepts you do not fully understand. Everybody should submit their own work but you can work in groups and help each other.

Midterm exam. The date/location of the midterm exam will be announced once the campus-wide scheduling of midterms has been completed. The duration of this exam is 90 minutes (1.5 h). The exact material on the midterm exam will depend on the day the exam is scheduled. Any aids that you might need (i.e. calculators and such) will be announced in advance of the exam. As mentioned above, the knowledge of material from both the lecture notes and your textbook is expected and as such is testable material.

Final exam. The final exam is cumulative meaning that material covered before and after midterm is going to be on the exam. The duration of the final exam is 180 minutes (3 hours).

Lab component. For more information on lab component see the “Lab information” announcement on CHMC31 intranet page and your lab manual.