Intermediate Inorganic Chemistry (CHMC31)

Welcome to CHM338 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 give you a bit more information about what is in front of 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. 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

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*-) elements, electronic configuration;
        ii. Accessible oxidation states, main classes of compounds

2. COORDINATION COMPOUNDS (OR COMPLEXES):
        i. Definition;
        ii. Ligands;
        iii. Coordination numbers and geometries;
        iv. Isomers;
        v. Stability of coordination compounds.

3. BONDING IN COORDINATION COMPOUNDS:
    a. Ligand Field Theory;
    b. Crystal Field Theory;
    c. Molecular Orbital Approach;

d. Characterization of coordination Compounds I: UV-Vis Spectroscopy – theory and applications

4. CHARACTERIZATION OF COORDINATION COMPOUNDS II: INFRARED SPECTROSCOPY

5. SPECTROSCOPY III: NMR SPECTROSCOPY:
    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:
        i. In square planar complexes
        ii. In octahedral complexes
    c. Electron-transfer pathways

7. SPECIAL TOPICS I: TRANSITION METAL CHEMISTRY:
    a. First row (3*d*) metals;
    b. Second (4*d*) and third (5*d*) row metals (if time permits);
    c. Lanthanides and actinides (*f* elements) (if time permits).

8. 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

9. 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, reading the textbook is required as well because it does expand and build up on the material covered in class.

Textbook(s):

Either of these two textbooks is acceptable:

Housecroft, C.E. and Alan G. Sharpe. Inorganic Chemistry. 3rd ed. Harlow: Pearson – Prentice Hall, 2008.

Atkins, Overtone, Rouke, Weller, Armstrong and Hagerman. Shriver and Atkins' Inorganic chemistry. 5th ed. New York: W.H. Freeman and Company, 2010.

If you still have Housecroft from CHMB31, you can keep the textbook. You will be assigned readings and problems for both books – you follow readings and assignments from the book you have!

The following 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 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).

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)

Course Evaluation:

Midterm Exam:	20%
Problem Set I	5%
Problem Set II	5%
Final Exam	30%
Lab component	40%

Problem sets (homework) will be as follows:

- Problem set 1 is distributed on Friday, February 11 and is due in class on Friday, February 18
- Problem set 2 is distributed on Friday, March 25 and is due in class on Friday April 1.

The exact date of midterm test is going to be determined during the semester, but you can expect it to be scheduled between March 1st and March 9th.

As you have probably seen already, the labs are every week. The written reports for the lab component are going to be submitted through turnitin.com. When using turnitin.com, you should be aware of the following:

Normally, students will be required to submit their course essays to Turnitin.com for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the Turnitin.com reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of the Turnitin.com service are described on the Turnitin.com web site.