Intermediate Inorganic Chemistry (CHMC31Y3)

Welcome to CHMC31Y3 course, a course that brings to you the exciting, rich and colorful 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 and Goals

Intermediate Inorganic Chemistry (CHMC31Y3) builds up on the material covered in Introduction to Inorganic Chemistry (CHMB31H3) 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 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 catalysis. In general, 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 d- and f-block elements:
        i. Position in the Periodic Table of Elements, relationship to main group (s- and p- block) elements, electronic configurations;
        ii. Physical and chemical properties of the d- and f-block elements

2. COORDINATION COMPOUNDS (OR COMPLEXES):
    a. Definition and brief history;
    b. Ligand Classes;
    c. Coordination numbers and geometries;
    d. Isomers;

3. LIGANDS, STABILITY AND SYMMETRY
    a. Relationships between ligand structure and complex geometry
    b. Complex stability:
        i. Thermodynamic stability of complexes
        ii. Chelating and macrocyclic effects
    c. Introduction to symmetry:
        i. The concept of symmetry
        ii. Symmetry elements and symmetry operations
        iii. Point groups

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

5. 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.

6. CHARACTERIZATION OF COORDINATION COMPOUNDS II: INFRARED SPECTROSCOPY (THEORY AND APPLICATIONS);

7. CHARACTERIZATION OF COORDINATION COMPOUNDS 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.

8. REACTIVITY OF COORDINATION COMPOUNDS:
    a. General introduction (thermodynamics, kinetics, mechanisms);
    b. Substitution reactions:
        i. In square planar complexes,
        ii. In octahedral complexes;

c. Izomerization;

d. Electron-transfer mechanisms.

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 I: CATALYSIS - CHEMISTRY AND INDUSTRY:

a. Energy considerations, green chemistry and atom economy principles;

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.

11. SPECIAL TOPICS II: BIOINORGANIC COORDINATION CHEMISTRY

a. The elements of life: s-, p- and d-block elements in living systems

b. Criteria for element selection: abundance, availability and usefulness

c. Most important biological ligands: amino acids, corrins and small inorganic molecules

d. Metal – protein symbiosis in living systems

Suggested reading materials

Your lecture notes, which will be available on the Blackboard, should be your major guides to mastering the material for this course. **However, the knowledge of both textbook and lecture materials is required**.
Apart from the textbook below, we shall analyze selected journal articles relevant to the course materials. The required references will be posted on the blackboard as citations.

Our required textbook is the same as for CHMB31H3:

Atkins, Overtone, Rouke, Weller, Armstrong and Hagerman. **Shriver and Atkins' Inorganic chemistry**. 6th edition. New York: W.H. Freeman and Company, 2014.

These are additional sources for those of you who would like to explore more and can be found in the library (some texts are available in electronic format through the UofT library catalogue):

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 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 (Useful the 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:

Problem Sets	10%
Midterm Exam	20%
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 Sets. These are take-home assignments. You will be given two weeks to finish one assignment (from the day the assignment is actually posted) and submit your answers. The assignments are designed to help you go over the course material and apply it on specific chemistry problems. In parallel it should point you the topics and concepts you do not fully understand.

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 the Blackboard portal and "Introduction" part of the lab manual.

Since you have to submit your formal lab report to turnitin.com, please make a note 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.

My office hours and contact information are available on the Blackboard under "Contact" link.