SYLLABUS

Intermediate Inorganic Chemistry

CHMC31Y3, Winter 2022

Instructors Information

Instructor	Email	Office	Office hours
Alen Hadzovic (lectures and course coordinator)	alen.hadzovic@utoronto.ca	EV568	considering current situation, office hours will be online and by appointment only (please e-mail me to set up the time)
Marco Zimmer-DeIuliis (labs)	m.zimmer.deiuliis@utoronto.ca	EV546	The announcement about office hours will be provided on Quercus in January
Sarah Forbes (librarian)	s.forbes@utoronto.ca	EV368	

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, we 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). The course covers 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), catalysis, introduction to green chemistry (from the perspective of CHMC31 material) and biological coordination chemistry. Unlike CHMB31H3, this course is oriented more towards the physical rather than descriptive inorganic chemistry.

A note on the course delivery for Winter 2022 semester: As you are aware the pandemic-related public health situation is changing frequently. University's current plan is to have on-line course delivery until January 31st, meeting on-line using either Zoom or MS Teams. After this date we would move to in-person delivery. The in-person labs would run in reduced capacity mode. Thus, you should be prepared to be on campus from February 1st. For all in-person activities strict public and university health measures and protocols will be followed. Some

general details can be found at Your guide to the 2021-22 school year at U of T | University of Toronto (utoronto.ca). *More course-specific details will be provided to you at the end of January.*

These are current plans for the Winter 2022 course delivery. The situation, however, can change rapidly so stay tuned!

Course Goals and Outline

As mentioned before, we'll need a solid knowledge from CHMB31 to be successful in CHMC31. This is particularly going to be evident in Topic 1 (se below) which we will use to review some earlier concepts and introduce the new material. If you have any trouble following our first topic, I strongly advise you to review the CHMB31 relevant material.

After successful completion of CHMC31Y3 you should:

- Augment your understanding of periodic trends by inserting d block elements to the previous knowledge of main groups.
- Be able to apply this knowledge to predict structures and reactivities of coordination compounds of d block elements.
- Understand the mechanisms of reactions that govern coordination compound reactivities.
- Solve intermediate problems in structure and reactivity of inorganic compounds.
- Improve your formal report writing skills (more on this in the evaluation section).
- Gain basic knowledge of organometallic chemistry.

These are some of the topics that will be covered in the course:

1. GENERAL INTRODUCTION TO D- AND F-BLOCK ELEMENTS:
    a. Position in the Periodic Table of Elements, relationship to main group (s- and p- block) elements, electronic configurations
    b. 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. Color 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. Isomerization
    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 TOPIC: 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

Evaluation

Formal lab report	12.5%
Midterm Exam	22.5%
Lab component	30%
Final Exam	35%

The dates for the exams and literature assignment will be announced during labs or classes. What follows are some details regarding the content of each.

Formal lab report. The formal lab report is based on your first lab experiment. The detailed description of the assignment parts is provided in the lab manual introduction and will be further elaborated during our first lab

session and during the semester. You will have to submit the components and completed assignment to Ouriginal, so please note the following:

Normally, students will be required to submit their course essays to the University's plagiarism detection tool 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 tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (https://uoft.me/pdt-faq).

Midterm Exam. The date 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 test is going to be distributed through Quercus and the submission is going to be in electronic format through Quercus. The exact material on the midterm exam will depend on the day the exam is scheduled. 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) and, like midterm, will be distributed through Quercus.

Past exam questions will be provided and posted on Quercus, but *no answers* will be provided. If you need help – come and ask!

Lab component. For more information on lab component see "Introduction" part of the lab manual. As mentioned above, the lab is also going to take place in an online environment.

Missed term test policies

If you **miss a term test**, you must declare your absence using ACORN tool available at:

https://www.utsc.utoronto.ca/registrar/acorn-absence-declaration-tool

You are also required to fill the departmental absence form available at:

https://www.utsc.utoronto.ca/physsci/self-declaration-absence-form-0

If clicking on the link above does not work, please copy the address, and paste it in your browser.

After you complete the declarations, you have two choices:

a) add the value of the missed test to your final exam (for example, if you miss a term test for a valid reason and chose this option, your final exam will be worth 35% + 22.5% = 57.5% of your final mark), *or*

b) a make-up test which this year is going to be in a form of oral (NOT written) exam due to scheduling issues.

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 required textbook below, we shall analyze selected journal articles relevant to the course materials, and particularly during our writing workshop for the labs (the details of which will be announced on quercus).

CHMC31Y3 library guide can be found at https://guides.library.utoronto.ca/chmc31.

Our required textbook is the same as for CHMB31H3:

Weller, Overton, Rourke, and Armstrong. *Inorganic chemistry*. 7th edition. Oxford University Press, 2018.

Recommended:
Hadzovic. *Solutions manual for Inorganic Chemistry*. 7th ed. Oxford University Press, 2018.

These are additional sources (*not required materials!*) 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):

Crabtree, R. H. *The Organometallic Chemistry of Transition Metals*. 4th ed. Wiley-Interscience, 2005 (Useful the organometallic topics)

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 about the elements and their reactivity).

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)

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)

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)

Academic Integrity

Academic integrity is one of the cornerstones of the University of Toronto. It is critically important both to maintain our community which honors the values of honesty, trust, respect, fairness and responsibility. It also protects you, the student within our community as well as the value of the degree towards which you are all working so diligently. Detailed information about how to act with academic integrity, the Code of Behavior on Academic Matters, and the processes by which allegations of academic misconduct are resolved can be found online Student Academic Integrity | Faculty of Arts & Science (utoronto.ca) and FAQ | Vice Principal Academic & Dean (utoronto.ca)

Section B of the University of Toronto's Code of Behaviour on Academic Matters (http://www.governingcouncil.utoronto.ca/policies/behaveac.htm) lists actions that are considered academic

offences. Some of the most common offences are:

- To use someone else's ideas or words in their own work without acknowledging that those ideas/words are not their own with a citation and quotation marks, i.e. to commit **plagiarism**.
- To include **false**, **misleading** or **concocted** citations in their work.
- To obtain **unauthorized** assistance on any assignment.
- To provide **unauthorized** assistance to another student. *This includes showing another student completed work*.
- To submit their own work for credit in **more than one course** without the permission of the instructor.
- To **falsify** or **alter** any documentation required by the University. This includes, but is not limited to, doctor's notes.
- To use or possess an unauthorized aid in any test or exam.

There are other offences covered under the Code, but these are by far the most common. Please respect these rules and the values which they protect. Offences against academic integrity will be dealt with according to the procedures outlined in the Code of Behavior on Academic Matters.

Accessibility

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the AccessAbility Services Office (ability@utsc.utoronto.ca) as soon as possible. I will work with you and AccessAbility Services to ensure you can achieve your learning goals in this course. Enquiries are confidential. The UTSC AccessAbility Services staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. More details are available at: http://www.utsc.utoronto.ca/ability/.