SC/CHEM 3030 3.0 Transition Metal Chemistry

Term	Fall 2023		
Location and Time	Lectures	MWF (HNE 030)	12:30PM – 1:20PM
	Tutorials	T (ACW 306)	12:30PM – 1:20PM
Prerequisite	SC/CHEM 2030 3.0		Basic Inorganic Chemistry; and
	SC/CHEM 2021 3.0		Introductory Organic Chemistry II

Contact Information

Course Director:	Prof. Gino G. Lavoie
E-mail:	glavoie@yorku.ca
Phone:	ext. 77728
Office:	CB 408
Office hour:	Tuesdays 1:30PM – 2:20PM to address questions/concerns that cannot be covered in tutorials; please email to confirm availability or to set another time; you **must** bring and wear a medical-grade mask to all meetings during office hours as you might **not** be allowed in the office unless you wear a medical-grade mask

Course Description

The chemistry of the transition metals is discussed from an historical perspective and within the context of modern theories of bonding, structure and spectroscopy. Topics include classical coordination compounds and their spectroscopy, organometallic complexes (including metallocenes, metal carbonyls and metal alkyls), their reactivity and use in catalysis. The course is a continuation of lower level SC/CHEM 1000 and 2000 inorganic (and organic) chemistry courses, and builds upon concepts learned therein.

Purpose and Objectives of the Course

The purpose of the course is to further expand the knowledge gained in general chemistry, and in introductory inorganic and organic chemistry courses. The course focuses on the chemistry of d-block transition metals. At the end of the course, students should be able to:

1. communicate effectively with chemists in the field using proper nomenclature, including knowing the first-row transition metals and their respective group number (Groups 3–12);
2. assign group points and derive the irreducible representation of transition metal complexes;
3. derive the ground-state electronic configuration (using microstates and term symbols) for any transition metals with one or more d-electrons, and predict/explain absorption in UV-Vis spectra;
4. use the crystal field theory, the angular overlap model and the molecular orbital theory (using ligand group orbitals) to derive energy diagrams for transition metal complexes;
5. assign oxidation state of metals, determine the total number of valence electron in complexes, and explain the binding mode of ligands;
6. name and assign reaction classes that complexes undergo, and draw catalytic cycles for well-known transition metal-mediated transformations;
7. describe other concepts presented in class, such as the electroneutrality principle, the Kepert model, the isolobal analogy, the turnover number and turnover frequency, etc.

Course Outline (subject to minor changes)

1. Molecular Symmetry (Chap. 3 from Housecroft and Sharpe's *Inorganic Chemistry*, 5th Ed.)
    a) Symmetry operations and elements
    b) Point groups and character tables
    c) Reducible and irreducible representations
2. Bonding in Polyatomic Molecules (Chap. 5)
    a) Molecular orbital theory (polyatomics)
    b) Application of character tables
    c) Ligand group orbitals/symmetry-adapted linear combinations
    d) Linear combination of atomic orbitals
3. *d*-Block Metal Chemistry (general consideration) (Chap. 19)
    a) Ground-state electronic configurations
    b) Electroneutrality principle
    c) Kepert model
    d) Coordination numbers (incl. isomerism)
    e) Total valence electron count
4. Coordination Complexes (Chap. 20)
    a) Crystal field theory
    b) Angular overlap model
    c) Molecular orbital theory (transition metal complexes)
    d) Microstates and term symbols
    e) Electronic absorption spectroscopy
5. Organometallic Complexes (Chap. 24)
    a) σ- and π-Ligands
    b) 18-Valence electron rule
    c) Isolobal analogy
    d) Reaction classes
6. Catalysis (Chap. 25)
    a) Homogeneous and heterogeneous catalysis
    b) Catalytic reactions and catalytic cycles (polymerization, hydrogenation, hydroformylation and metathesis of alkenes, oxidation, cross-coupling, etc.)
7. Reaction Mechanisms (Chap. 26)
    a) Dissociation, association and interchange mechanisms
    b) Thermodynamics and kinetics
    c) Substitutions in square planar complexes
    d) Inner- and outer-sphere electron transfers

Organization of the Course

A number of pedagogical approaches will be used to deliver the course and achieve the objectives. Lectures will be delivered by the course director using slides. A copy of the slides with missing keywords will be provided on eClass. The course will require active participation from students using polls held during each class. It is the student's responsibility to sign up for an account for both iClicker (and possibly Zoom) and eClass.

Sample problems will be assigned on a regular basis to facilitate learning of the concepts presented in class. These problems will be taken mostly from *Inorganic Chemistry*, 5th Edition by C.E. Housecroft and A.G. Sharpe. The problems will NOT be graded as the answers are included at the end of the textbook. This is NOT part of the final grade for the course.

Important Dates

Sept. 6	First CHEM 3030 class
Sept. 20	Last date to enrol in CHEM 3030 without permission (no permission will be granted to enrol past this date)
Oct. 3	**Test 1 (held during tutorial)**
Oct. 8–14	Fall reading week (no classes held)
Oct. 31	**Test 2 (held during tutorial)**
Nov. 8	Last date to drop a course without receiving a grade
Nov. 9–Dec. 5	Course withdrawal period (and receive a grade of "W" on transcript)
Nov. 21	**Test 3 (held during tutorial)**
Dec. 4	Last CHEM 3030 class
Dec. 7–20	**Final examination**. Students are expected to be available at all times during the Fall examination period and must not make travel plans within that period.

Evaluation

Class Polls	10%
Tests (3 in total; each 50 min long and held during tutorials)	3 × 20%
Final exam (up to 3 h)	30%

The instructor may use an **online proctoring** service during the final exam, which would be administered through the Learning Management System (e.g. eClass, Canvas, etc.). Students are required to have access to minimum technology requirements to complete examinations. If an online proctoring service is used, students will need to become familiar with it at least five days before exam(s). For technology requirements, Frequently Asked Questions (FAQs) and details about the online proctoring service visit https://registrar.yorku.ca/proctortrack-faq. Students are required to share any IT accommodation needs with the instructor as soon as they are able.

No make-up tests will be available. The weight of **up to 2 missed tests** will be added to a **modified version** of the final exam. This modified final exam will have extra questions to ensure that knowledge of all material presented in class is properly assessed.

Students who have a conflict with a religious holiday must contact the course director at least two weeks prior to the exam to learn how they will be accommodated. Late requests will likely not be accepted for consideration.

Class Polling

Polling exercises will begin on September 11th but will only count towards the final grade after September 22nd, the first class after the last day to enroll in the course without permission. It is the responsibility of the student to install the Reef application on their devices to participate in those exercises and to become proficient in its use.

There are 29 lectures from September 22nd to December 4th. No polling for marks will be performed during tutorials (or tests). Each class provides a chance to earn 1 “raw mark”. Three quarters (75%) of these marks will come from participation and 25% will come from actual performance (i.e., for giving the correct answer). Thus, if **ALL questions** during a lecture are answered (with a reasonable answer), the minimum “raw mark” for this lecture will be 0.75.

The raw marks accumulated will be converted into your final course polling grade in a bracketed scheme as follows:

≥75.0% raw marks acquired: full polling credits (10% towards final course mark)
≥65.0% and <75.0% raw marks: 70% of the total polling credits (7% towards final course mark)
≥55.0% and <65.0% raw marks: 50% (5% towards final course mark)
<55.0% raw marks: no polling credit

There will be **no make-up polls** for anyone unable to answer the poll. This bracketed policy accounts for occasional absences due to illness, forgotten devices, religious obligations and other unforeseen circumstances. The course director will not accept documentation for absences related to this course component. No accommodation will be granted for absences during class polling.

eClass/Moodle Forum

Students should post any questions related to the material covered in CHEM 3030 to eClass, under "Forum: question posed by students". Anyone enrolled in the course can provide any insight into those questions. The course director will monitor these on a regular basis and add further information and/or correct any erroneous statements provided by student peers.

E-mail Communications

E-mail messages must have "CHEM 3030" as the beginning of the subject line, otherwise, the course director will NOT reply to them. For example, the subject line of an email message could be "CHEM 3030: medical emergency". Most course-related questions and issues will however be addressed during class or during tutorial.

Any administrative questions and issues should be directed to the Undergraduate Program Assistant (ChemAsst@yorku.ca) in the Chemistry Building (CB 124).

Textbooks/Course Kit

Much of the course will be based on the following textbook, including recommended practice problems to enhance concepts presented in class:

Housecroft, C. E.; Sharpe, A. G. *Inorganic Chemistry.* 5th Ed. (2018) Wiley-Interscience Publication.

In addition to the above textbook, materials from the following textbook will also be presented, with relevant sections available on eClass **free of charge**.

Miessler, G. L.; Fischer, P. J.; Tarr, D. A. *Inorganic Chemistry.* 5th Ed. (2014) Pearson.

There are many other excellent textbooks presenting concepts of transition metal chemistry (see below). Unfortunately, e-versions of textbooks are particularly difficult for academic libraries to acquire. Approximately 85% of existing course textbooks are simply unavailable to libraries in any other format than print.

Miessler, G. L.; Tarr, D. A. *Student Solution Manual: Inorganic Chemistry.* 4th Ed. (2011) Pearson.

Shriver, D.; Weller, M.; Overton, T.; Rourke, J; Armstrong, F. *Inorganic Chemistry.* 6th Ed. (2014) Freeman.

Cotton, F. A. *Chemical Applications of Group Theory*. 3rd Ed. (1990) Wiley-Interscience.

Douglas, B.; McDaniel D.; Alexander, J. *Concepts and Models of Inorganic Chemistry*. 3rd Ed. (1994) Wiley.

Crabtree, R. H. *The Organometallic Chemistry of the Transition Metals*. 5th Ed. (2010) Wiley. Available online at https://onlinelibrary.wiley.com/doi/book/10.1002/9781118788301.

Grading Scheme and Academic Integrity

The grading scheme for the course conforms to the point system used in other undergraduate programs at York. The final grade for the course will be calculated using the grading scheme listed above under "**Evaluation**".

Academic Integrity

Assessments, whether in person or online, are intended to be individual pieces of work. Collaborating with other students is not permitted. Please note the instructors have full access to Chegg and other similar websites and will be used if needed to prosecute academic misconduct. Please also note that online proctoring software could be used (should the part of the course need to be delivered remotely/online). Any decision on this matter will be clearly communicated to all students before an assessment.

Numerous students in Faculty of Science courses have been charged with academic misconduct when materials they uploaded to third-party repository sites (e.g. Course Hero, One Class, Chegg, etc.) were taken and used by unknown students in later offerings of the course. The Faculty's Committee on Examinations and Academic Standards (CEAS) found in these cases that the burden of proof in a charge of aiding and abetting had been met, since the uploading students had been found in all cases to be wilfully blind to the reasonable likelihood of supporting plagiarism in this manner. Accordingly, to avoid this risk, **students are urged not to upload their work to these sites**. Whenever a student submits work obtained through Course Hero, Chegg or One Class, the submitting student will be charged with plagiarism and the uploading student will be charged with aiding and abetting.

Note also that exams, tests and other assignments are the copyrighted works of the professor assigning them, whether copyright is overtly claimed or not (i.e. whether the © is used or not). Scanning these documents constitutes copying, which is a breach of Canadian copyright law, and the breach is aggravated when scans are shared or uploaded to third party repository sites.

Students are required to make themselves aware of school policies relating to Academic Honesty and Integrity, Access, Religious Accommodation, Student Conduct and other matters, including the use of generative artificial intelligence technology (https://www.yorku.ca/unit/vpacad/academic-integrity/wp-content/uploads/sites/576/2023/03/Senate-ASCStatement_Academic-Integrity-and-AI-Technology.pdf). Plagiarism and other academic offenses will be sanctioned to the fullest extent in accordance with university and Faculty policies.

You MUST digitally sign on the agreements below on eClass

- **Academic Honesty Agreement:** I understand York University's *Senate Policy on Academic Honesty* and will abide by this policy. The full policy can be found at: https://secretariat-policies.info.yorku.ca/policies/academic- honesty-senate-policy-on/.
- The following website (https://spark.library.yorku.ca/academic-integrity-what-is-academic-integrity/) is a good resource to learn about "academic integrity". Students are strongly encouraged to go through the self-guided website.
- Note that ignorance of these policies and of academic integrity is not an acceptable excuse for academic misconduct.
- I acknowledge that academic honesty requires that I do not cheat (attempt to gain an improper advantage in an academic evaluation), plagiarize, aid and abet others in academic dishonesty, nor attempt or actually alter, suppress, falsify or fabricate documents.
- Suspected breaches of academic honesty will be investigated and charges shall be laid if reasonable and probable grounds exist and lead to the range of penalties described in the guidelines of the policy.

Online Delivery of the Course

Due to the ever-evolving COVID-19 virus, the course **might** need to shift from in person to online. In this scenario, the following is a list of requirements of what students will need to complete the course.

- A **working and stable internet connection** (high speed greatly preferred***)*** to attend remotely lectures delivered through Zoom. eClass and Crowdmark also require stable internet connections. The instructors cannot accommodate if students run into technical problems relating to your internet connections.
- **Access to the email account linked to the eClass profile** as *o*nline assessments through Crowdmark will only be sent to the email address linked to that specific account (where course announcements are also sent). The actual email account is listed on eClass, under Profile (pull-down menu on the top right page).
- **A document scanning app capable of producing PDF files** as exams need to be submitted in PDF format only. This will require you to write your answers on paper, then digitally capture your work in PDF using a document scanning app. Both Apple and Android phones contain native scanning apps that should be used. The instructors will NOT accept camera photos as they tend to be too large in file size, rotated incorrectly, taken at an improper angle and suffer from many image artifacts. Failure to submit your work properly may result in it not being graded.

  A sample assessment will be given (if needed) to allow you to practice a submission and to become familiar with our expectations.

  For students who may be using a tablet computer with a stylus to annotate provided PDF files:

  - Tablet computers such as the Microsoft Surface are able to annotate PDF files using a stylus. Unfortunately, the instructors have run into issues with eClass and Crowdmark whereby the annotations is lost when uploaded for grading, depending on the program used to annotate the PDF files.
  - If a tablet computer is used to annotate files, it is the student's responsibility to make sure the annotations show up after the file is uploaded. Otherwise, it will be treated as a missed assessment or as late submission, with penalty as per the course syllabus.

Important Information Regarding Platforms Used for the Course

Several platforms will be used in this course (e.g., eClass, Zoom, etc.) through which students will interact with the course materials, the course director / TA, as well as with one another. Students shall note that:

- **eClass** (also known as Moodle) will be used extensively throughout the course. More information about the platform, its technology requirements and FAQs can be found online at https://lthelp.yorku.ca/moodle.
- **Zoom** is hosted on servers in the U.S. This includes recordings done through Zoom. If you have privacy concerns about your data, provide only your first name or a nickname when you join a session. The system is configured in a way that all participants are automatically notified when a session is being recorded. In other words, a session cannot be recorded without you knowing about it.
- This course might require the use of online proctoring (e.g., **Proctortrack**) for examinations. In this scenario, students will need to have access to common IT technology (computer with a camera and mic with stable internet connection). Further details will be shared in due course if needed. Students will be required to share any IT accommodation needs with the instructor as soon as possible.

Accessibility

York University is committed to principles of respect, inclusion, and equality of all persons with accessibility needs across campus. The University provides services for students with accessibility needs (including physical, medical, learning, and psychiatric needs) needing accommodation related to teaching and evaluation methods/materials. These services are made available to students in all Faculties and programs at York University.

Students in need of these services are asked to register with accessibility services as early as possible to ensure that appropriate academic accommodation can be provided with advance notice. You are encouraged to schedule a time early in the term to meet with each professor to discuss your accommodation needs. Please note that registering with accessibility services and discussing your needs with your professors is necessary to avoid any impediment to receiving the necessary academic accommodations to meet your needs. Additional information is available at the following websites:

- **Student Accessibility Services**: https://accessibility.students.yorku.ca
- **York Accessibility Hub**: http://accessibilityhub.info.yorku.ca/

Assistance

Attending university and coping with all the expectations, over and above other responsibilities you may have outside school, can be very challenging. A number of options are available to students, on and off campus, to assist you in your learnings and to help deal and cope with difficult situations. As always, in case of an emergency, students should **call 911**.

- **Academic Advising**: https://www.yorku.ca/science/academic-advising/ Departments also offer program-specific advising. Check with your Department's Undergraduate Office.
- **Centre for Human Rights, Equity, and Inclusion:** https://rights.info.yorku.ca
- **Centre for Indigenous Students Services:** https://aboriginal.info.yorku.ca/
- **Good2Talk 24-hour Ontario Student Helpline:** 1-866-925-5454 /Text: GOOD2TALKON to 686868
- **Keep.meSAFE:** https://myssp.app/keepmesafe/ca/home
- **Learning Commons** (general academic learning supports including library research, time management, study skills, career planning, etc.): https://learningcommons.yorku.ca/
- **Peer Assisted Study Sessions (PASS):** https://www.yorku.ca/colleges/bethune/get-help/pass/
- **Peer Tutoring**: https://www.yorku.ca/colleges/bethune/help/tutoring/
- **Sexual Violence Response and Support:** https://thecentre.yorku.ca
- **Student Counselling, Health & Well-being:** https://counselling.students.yorku.ca/
- **Support Services for International Students:** https://yorkinternational.yorku.ca/international-student-support/
- **Writing Services**: https://www.yorku.ca/colleges/bethune/get-help/writing/
- **York University Student Services:** https://family.yorku.ca/student-services/#SCD
- **York University Student Well-being Resources:** https://www.yorku.ca/well-being/resources/students/

Religious Accommodation

York University is committed to respecting the religious beliefs and practices of all members of the community and making accommodations for observances of special significance to adherents. Should any of the dates specified in this syllabus for an in-class test or examination pose such a conflict for you, contact the Course Director within the first three weeks of class.

Similarly, should an assignment to be completed in a lab, practicum placement, workshop, etc., scheduled later in the term pose such a conflict, contact the Course Director immediately. To arrange an alternative date or time for an examination scheduled in the formal examination periods (December and April), students must complete and submit an accommodation request form at least 3 weeks before the exam period begins.

Late requests will likely not be accepted for consideration.

https://secure.students.yorku.ca/pdf/religious-accommodation-agreement-final-examinations.pdf

(updated on August 28th, 2023)