Chemistry 507—F21

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Classroom Sessions: M, W, F 10:00 – 11:00 a.m., 2200 School of Kinesiology Building (SKB)
Instructor Office Hours: Th 10 a.m. – noon *or by appointment* (subject to change)

Credits: 3

Course Content: Chem 507 demonstrates the interrelations of ideas presented in the fundamental inorganic chemistry curriculum. We will explore the role that electronic structure plays in governing the properties and reactivity of transition metal complexes. Starting from a foundational understanding of molecular symmetry and group theory, the course will build to cover contemporary topics in organometallic, bioinorganic, and energy science, as time allows. A more detailed outline of course content is provided below.

Required Texts:
Inorganic Chemistry Catherine Housecroft and Alan Sharpe, 5th Ed., Pearson
ISBN-13: 978-1292134147
Symmetry & Spectroscopy: an Introduction to Vibrational & Electronic Spectroscopy Daniel C. Harris & Michael D. Bertolucci, Dover
ISBN-13: 978-0486661445

Grading: Final grades will be determined by a combination of class participation, problem sets, and exams as follows:
Class Participation (15%)
Problem Sets (25%)
Exam 1 (30%)
Exam 2 (30%)

Class participation is comprised of multiple components designed to encourage student immersion in the course and provide professional development opportunities to hone skillsets that will be valuable throughout one's career as a scientist. To motivate critical evaluation of the primary literature, both contemporary and classic papers—relevant to the material being covered in class—will be posted on Perusall throughout the term. The use of Perusall (an available add-on in the course Canvas site) will encourage discourse by providing a platform for both individual and group annotations of chemistry article pdfs. In some instances, this might involve posting comments or responding to questions raised by the professor. In other cases, it will serve as a basis for open (but virtual) class discussion on a given work. Additionally, the Perusall platform can facilitate feedback, from both fellow students and the instructor. A second component of the participation grade aims to improve critical scientific thinking. At the end of the semester, students will be required to select a recently published scientific article and write a brief "peer review," mimicking the process journal publishers use prior to final publication. This process will be conducted iteratively with comments from both the student and the instructor.

Students are expected to complete problem sets throughout the term. **Collaborative work is encouraged** but each student must submit an individual assignment for grading. Assignments will be posted on Canvas and will be turned in prior to the start of lecture one week after they are released; answer keys will be posted two days after assignments are due. Late work turned in prior to the release of the answer key will be graded for a maximum of 50% credit. The problem sets will be graded on a scale of 1 to 5 with no partial credit. A grade of 5 represents a complete or near complete submission with entirely or almost entirely correct answers. A grade of 1 indicates serious gaps in knowledge demonstrated by incorrect answers and/or missing work. This grading scheme is clearly subjective; however, each assignment will be graded uniformly for every student in the course. Students are strongly encouraged to review the published answer keys even when scoring 4/5 on the homework sets to ensure complete understanding in preparation for the exams.

Chem 507 will have two take-home exams. Both will be cumulative—any material covered up to that point is fair game! The grading rubric for the exams will be clearly delineated, allowing students to make prudent decisions on the

best use of available time. Exams must be completed individually, within the constraints provided. The midterm exam will be closed book, with no resources permitted outside of those provided; the final exam will be open book and open to class notes. No collaboration is allowed on exams and no discussion of the exams with classmates is permitted until after the due date. Breaking these rules and cheating in any way is detrimental to your learning experience and disrespectful to your peers. It will not be tolerated (additional details below).

> ***Note:*** Students who have conflicts due to religious holidays, travel for U-M athletics, travel for your professional development, or health reasons may e-mail the instructor at least one week in advance to be excused from attending class and to make alternate arrangements for assignments due during your time away from class.
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> ***Note:*** Departmental policy indicates the first step in inquiring about the accuracy of a final grade should be directed to the lead instructor of the course. This initial inquiry should take place within the first fifteen University business days of the first full term following the term in which the disputed grade was issued. If, after this inquiry, the student is not satisfied with the instructor's response, the student may choose to initiate a formal grade grievance. To initiate a formal grade grievance, the student should contact the Associate Chair of Undergraduate Studies (ACUS) of the home department of the course in question before the end of the fifth week of classes in the first full term following the term in which the disputed grade was issued.

The problem sets and exams in Chem 507 are challenging, by design. As a graduate researcher in chemistry, you will be faced with questions that require deep analytical thinking and innovative problem solving. As a student in Chem 507, you will simulate these scenarios through the homework and exam questions—many of these are based off of topical literature content! Be mindful that pushing yourself aids in your development and, while challenging, the material and assessments in the course are doable with hard work, dedication to the class, and taking advantage of the resources available. This includes office hours, which are strongly encouraged. Often, a small hint or nudge in the right direction will save hours of frustration. The scheduling of both the exams is accomplished with student feedback but you should be prepared to dedicate at a *minimum* 15 hours of focused time for preparation for/execution of the exams. Note: no problem sets or Perusall papers will be assigned the week prior to an exam to facilitate test preparation.

Each student in Chem 507 has had a different academic journey *en route* to this course. This is both a challenge and privilege with respect to course preparation and presentation. **I am confident that every student can be successful in this class with sufficient dedication and effort.** Content on assessments is covered in class and reinforced with recommended reading. If you ever feel that there is a topic that is not making sense, please reach out to the instructor.

Academic Integrity: There is a clear expectation that students will perform with honor and integrity. Students are referred to the LSA policy on academic integrity available online at:

https://lsa.umich.edu/lsa/academics/academic-integrity.html

Any student found by the Assistant Dean's office to have engaged in academic misconduct on exams will automatically fail the course.

Accessibility and Accommodations:

If you need an accommodation for a disability, please let me know at your earliest convenience. Some aspects of this course, such as the assignments, in-class activities, or the way we teach may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, I can work with you, the Office of Services for Students with Disabilities, or the Adaptive Technologies Computing Site to help determine appropriate accommodations. I will treat any personal information with the utmost discretion.

Student Health and Well-Being:

LSA is committed to delivering our mission while aiming to protect the health and safety of the community, which includes minimizing the spread of COVID-19. Our entire LSA community is responsible for protecting the collective health of all members by being mindful and respectful in carrying out the guidelines laid out in our Wolverine Culture of Care and the University's Face Covering Policy for COVID-19. Individuals seeking to request an accommodation

related to the face covering requirement under the Americans with Disabilities Act should contact the Office for Institutional Equity.

In our classrooms all students are expected to adhere to the required safety measures and guidelines of the State of Michigan and the University of Michigan, including wearing a face covering that covers the mouth and nose in all public spaces, and not coming to class when ill or in quarantine. This course will also limit group gatherings while being thoughtful about classroom activities and exercises that require collaboration.

Any student who is not able and willing to comply with campus safety measures for this course should contact the the instructor to discuss alternate participation or course options. Students who do not adhere to these safety measures while in a face-to-face class setting, and do not have an approved exception or accommodation, may be asked to leave the classroom and/or disenroll from the class.

For additional information refer to the LSA Student Commitment to the Wolverine Culture of Care and the OSCR Addendum to the Statement of Student Rights and Responsibilities on the OSCR website.

The University of Michigan is committed to advancing the mental health and wellbeing of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. If you feel comfortable doing so, the first course of action should always be to speak with me. Open lines of communication are key to diagnosing and addressing problems. I will treat any personal information with the utmost discretion.

For a listing of other mental health resources available on and off campus, visit http://umich.edu/~mhealth/

Course Recording: The weekly lectures for Chem 507 will be held in person and simultaneously recorded for asynchronous posting online. As part of your participation in this course, you may be recorded. If you do not wish to be recorded, please contact the instructor during the first week of class (or as soon as you enroll in the course, whichever is latest) to discuss possible alternatives.

Class Conduct: A positive learning environment relies upon creating an atmosphere where diverse perspectives can be expressed and questions can be asked openly, without fear of negative repercussions. Each of us comes from a unique background and it is every member of the class's job to be understanding and respectful of differences in thought, prior training, viewpoint, and opinion. Respectful dialogue, be it in person or virtual, is expected and hostile or disrespectful behavior will not be permitted. Treat your peers as you would wish to be treated to establish a collaborative and supportive space for the exchange of ideas.

Requisite Background Knowledge: The list below constitutes prerequisite knowledge that will not be covered comprehensively in class. If you need to review, these topics are covered in the textbook and I am happy to discuss this material in additional depth at office hours.

- Electron configurations for atoms and ions
- Atomic orbitals: shapes & probability distribution functions
- Concept of effective nuclear charge & periodic trends (IE, EA, radii, electronegativity)
- Drawing 3-D representations of any molecule
- Balancing any chemical reaction (mass & charge)
- Using basic equations of thermodynamics & kinetics

You will find that these topics, and many other from your prior chemistry courses, will provide a foundation for the content in Chem 507. Connecting these concepts is critical to mastery of the material and success in this course.

Course Outline

I. Review of atoms & molecules, periodic properties, bonding in main group compounds, Lewis representations, and the VSEPR model. (**H&S Ch. 1 & Ch. 2**)

II. Symmetry
- A. Symmetry operations (**H&S 3.1-3.3 and H&B Ch. 1.1-1.3**)
- B. Point groups (**H&S 3.4 and H&B Ch. 1.4-1.5**)
- C. Matrix representations of symmetry operations (**H&B Ch. 1.6**)
- D. Character tables (**H&S 3.5-3.8 and H&B 1.7-1.8**)

III. Applications of group theory to LCAO/MO descriptions of polyatomics molecules (**H&S Ch. 5 and H&B Ch. 4.1-4.6**)

IV. Coordination chemistry of the transition metals
- A. Lewis acid – base theory (**H&S 7.7-7.13**)
- B. Dative bonding: σ donors, π donors, π acceptors (**H&S Ch. 20.4**)
- C. Ligand Field Theory (**H&S Ch. 20.4-20.5 & Ch. 20.11-20.13**)
- D. Classical complexes (**H&S Ch. 19 & Ch. 20**)
- E. π-Bonding in coordination compounds (**H&S Ch. 20.4, 24.2, & 24.5**)

V. Introduction to electronic spectroscopy of coordination compounds of high symmetry
- A. Electronic states and term symbols for free ions and metal complexes (**H&S 20.6 and H&B 5.3**)
- B. Selection rules (**H&S Ch. 20.7 and H&B Ch. 5.4**)
- C. Correlation diagrams (**H&S Ch. 20.7 and H&B Ch. 5.9**)
- D. Charge transfer spectra (**H&S Ch. 19.5 & Ch. 20.7 and H&B Ch. 5.9**)

VI. Strong field ligand systems
- A. Electron counting (**H&S Ch. 24.3**)
- B. The 18 electron "rule" (**H&S Ch. 24.3**)
- C. Formal oxidation states (**H&S Ch. 19.5-19.6**)

VII. Metal-ligand bonding, structure, and reactivity of important functional groups in transition metal compounds
- A. Carbonyl, isocyanide, nitrosyl, and dinitrogen complexes (**H&S Ch. 24.1-24.2**)
- B. Phosphine compounds (**H&S Ch. 24.1-24.2**)
- C. Cyclopentadiene compounds (**H&S Ch. 24.14-24.15**)
- D. Transition metal hydrides (**H&S Ch. 24.2**)
- E. Organometallic reactions [survey of elementary steps] (**H&S Ch. 24.8**)

VIII. Catalysis: Organometallics
- A. Reaction mechanism and kinetics (**H&S Ch. 25 & Ch. 26**)

VIV. Catalysis: Bioinorganic chemistry
- A. Balancing catalysis in metalloenzymes (**H&S Ch. 29**)

X. Special Topics (as time permits)