CHEMISTRY (CHEM:3530:0AAA)  
INORGANIC CHEMISTRY (SYNTHESIS) LABORATORY  

Fall 2021

Prof. Lou Messerle
Office: E457 Chemistry Building (CB); Phone (cell): 319-331-6212
Course email: lou-messerle@uiowa.edu (please place “CHEM:3530” in title)

Graduate Teaching Assistants: James Earl, Grant Forsythe, Holly Huther, Jacob Schuely

Course Delivery: Our course will meet, at present, subject to UI covid policy changes, face-to-face in classroom and drop-in office hours with Prof. Messerle, and in-person/face-to-face in laboratory. Drop-in hours for Teaching Assistants may occur via Zoom

Lectures: 11:30 AM-12:20 PM, Monday and Wednesday, Room C10 of Pomerantz Center

Laboratory Location, Times
Section A01: Tuesday and Thursday, 2:00-4:50 PM, CB E414
(Grant Forsythe and Jacob Schuely)
Section A02: Monday and Wednesday, 2:30-5:20 PM, CB E414
(James Earl and Holly Huther)

(rarely, a lab may be extended ≤ 30 min in order to reach optimal experiment stopping point)

Course credit: 3 hours: lab reports, pre-lab assignments, homework, midterm and final exams

Faculty Drop-in Hours: (face-to-face, in conference room CB E427; the following times were determined after Prof. Messerle examined your course meeting times calendar in MAUI):
Monday 9:30-10:30 AM  
Wednesday 9:30-11:20 AM
Thursday 11:00 AM – 12:00, 12:30 – 1:45 PM

Alternate Drop-in hours for individual students, for any reason, can be arranged by emailing Prof. Messerle at lou-messerle@uiowa.edu

TA Drop-in Hours (not all confirmed as in person or via Zoom):
James Earl:  
Tuesday, Thursday 10:30-11:30 AM
Grant Forsythe:  
Tuesday, Wednesday 11:30 AM-12:30 PM
Holly Huther:  
Tuesday, Thursday 9:30-10:30 AM via Zoom
Jacob Schuely:  
Monday, Wednesday 9:30-10:30 AM

Course Website
CHEM:3530:0AAA Fall2021 Inorganic Chemistry Laboratory, Iowa Courses Online (ICON) website URL = http://icon.uiowa.edu/. Use your HawkID and HawkID password to log in to ICON. Syllabus, lecture notes, experiment background info and directions, practice exams, course announcements, exam announcements and room assignments, exam keys, and other info will be posted on ICON, so the instructors encourage you to check ICON frequently.

Textbook: Any good practical laboratory techniques manual, such as those used in organic lab courses; documents for experiments will be provided on ICON for all experiments.

Course Reserves: Several excellent but older inorganic lab technique books, an eReference, and textbooks with older experiments, will be on reserve in Science Library Annex, and possibly, for extra copies held by the Sciences Library, in CB E237, Conrad Bendixen, 467-1395, conrad-bendixen@uiowa.edu; Monday-Friday 8:00-5:00). The eReference is available online through the Library web site. For most techniques:
Course Description

Chemical synthesis represents the beginning of the science of Chemistry and is indisputably it’s foundation. Pure compounds are used in a wide variety of practical applications, from materials to pharmaceuticals, and in research in a wide variety of sciences. Important compounds are often unavailable commercially (or too costly) and need to be synthesized, purified, and characterized for applications, analytical chemistry, and physical chemistry. Theories about the properties, uses, structures, and reactivities of unknown molecules can only be tested by first synthesizing a previously-unreported target molecule, and such synthesizes and their reaction products test and expand our knowledge and theories about chemical bonding, especially in inorganic chemistry.

Inorganic chemistry is the original Chemical Science and is the foundation for many materials that form the basis for our technological society, from metals and alloys such as bronze (first discovered millenia ago) to iron and steel, efforts to transmute base metals to gold by the alchemists (as a way to fool their leader/king/queen into funding their actual research), uranium in the nuclear age, catalysts for petrochemical refining, and solid-state materials and devices. From its practical origins in metallurgy, inorganic chemistry has exploded over the last 70 years to cover bioinorganic, organometallic, and materials chemistries. Part of the reason for this expansion is the considerable landscape, only explored in minimal detail, of the chemistry of the multitude of elements beyond carbon, combined with oxygen and nitrogen, and its nearly infinite hydrocarbon combinations.

This laboratory course is designed to teach students safe, advanced synthetic chemistry laboratory techniques complementary to those learned in organic laboratory courses for the preparation, purification, and characterization of inorganic compounds and materials, air-sensitive organometallics, and compounds via macroscale and microscale methods. Approaches to searching and finding literature procedures by SciFinder for compound preparation will be reviewed. This course will emphasize inorganic and organometallic compounds and materials of the transition elements, but many of the techniques are applicable to organic synthesis (e.g., a palladium-catalyzed Suzuki coupling to make a new C-C bond for a new ligand). Particular course emphases include:

1. developing student confidence in designing and safely executing molecular syntheses at macro and micro synthetic scales, solving real-lab problems along the way,
2. taking students beyond the cookbook approaches of earlier lab courses in the sciences,
3. developing hands-on, advanced practical (as opposed to abstract physical principles in other courses) experience in modern spectroscopic characterization techniques, especially high field multinuclear 1D FT NMR spectroscopies, powder and single-crystal X-ray diffractometry, spectrofluorimetry, combustion/elemental analysis, and new synthetic techniques involving Schlenk lines, glove bags, glove boxes, and microscale approaches (also relevant to pharmaceutical synthesis and radiochemistry).
4. learning the basics of borosilicate glassblowing in order to design, construct and repair scientific glassware

Pre-lab lectures will include discussion of the upcoming experiments (including safety aspects required for safe execution of the experiment), bench and spectroscopic techniques used in the experiments, demonstration of related topics in synthesis/characterization, and discussion of results.

Several multi-step synthetic experiments in contemporary inorganic/organometallic chemistry are planned for the semester. Portions of the last experiment, if completed, will involve collaborative research with inorganic chemists at the California Institute of Technology (Caltech, where Prof. Messerle spent 9 months on a Career Development Award) and may result in a paper to be submitted to a journal with contributing students’ names as coauthors. The tentative lecture, lab experiment, due dates, and exam schedule (subject to change as new experiments are designed and older experiments re-evaluated) are shown later in this handout. Their order is modified from previous years in case the covid-19 delta variant leads to a return to virtual instruction for lectures and drop-in office hours; in this case, the lab experiments will still be performed (hopefully) face-to-face with masks as we did in 2020 with lab room modifications.
Lecture topics to be covered include: recrystallization, inert-atmosphere compound manipulations by Schlenk line/glove box/glove bag techniques, Soxhlet extraction, sublimation, mechanical stirring, rotary evaporation, vacuum pump and trap utilization, practical FT NMR spectroscopy, practical IR spectroscopy, practical mass spectrometry, interpretation of IR/NMR/mass spectra, introduction to powder and single-crystal X-ray diffractometry, tube and muffle furnace use in high-temperature solid-state inorganic synthesis, spectrofluorimetry, and polarimetry.

Materials to be purchased by student: lab notebook (inexpensive bound notebook/composition book, with pages numbered by student), rubber gloves, and comfortable goggles or safety glasses with splash shields. A lab coat is highly recommended, and makes one feel "professional".

**Learning Outcomes**

Appended to this syllabus are general Chemistry program educational outcomes for undergraduates, with some slight editing by Prof. Messerle. More specific learning outcomes for CHEM:3530 are:

**Laboratory Skills:**
1) Learning the logic of chemical synthesis; choosing best synthetic approach depending on defined constraint(s) (costs, time, availability of starting reagents, etc.)
2) Proper use and legal aspects (outside of UI) of laboratory notebooks
3) Handling of air- and moisture-sensitive reagents and reagent solutions by syringe, cannula, Schlenk line, glovebag, and research-grade glove box methods
4) Sol-gel synthesis of solid-state materials, muffle and tube furnace use, preparing pellets of solid-state materials by hydraulic press
5) Microscale techniques for synthesis using expensive reagents (e.g., platinum group metals) and/or for radiochemical synthesis (e.g., nuclear medicine)
6) Advanced purification strategies including recrystallization, sublimation, Soxhlet extraction, and drying or removal of volatile contaminants by use of an Abderhalden drying pistol
7) Characterization of inorganic and organometallic compounds (and, by extension, organic compounds) by various approaches to multinuclear 1D NMR spectroscopies, UV-vis spectrophotometry, basic mass spectrometry, infrared spectroscopy, spectrofluorimetry, elemental analysis, powder X-ray diffractometry, and single-crystal X-ray diffractometry; caveats about over-reliance on a single characterization technique
8) Preparation of a Grignard reagent

**Chemical Information Skills:**
1) Specific approaches for using SciFinder for finding syntheses and/or molecular characterization data, with some caveats.

**Miscellaneous**

Please feel free to discuss with Prof. Messerle any aspect of the course that concerns you or is causing you problems. **DON’T HESITATE** to come to Prof. Messerle’s or the lab Teaching Assistants’ drop-in hours, arranged if necessary, to ask questions that are not adequately covered from your perspective during class or laboratory. If you require course adaptations or test-taking allotted times because of a recognized disability, contact Prof. Messerle who will work diligently to accommodate your needs.

**Course Administration**

Please go to the Chemistry Center, E225 CB, for drop/add signatures. M–F, 8:00 AM-12:00, 1:00-5:00 PM (F, 4:30 PM). Manager: Trent Tappan (335-1351, trenton-tappan@uiowa.edu). Please drop off lab reports there by 3:30 Friday (or, if closed for some reason, slid under Prof. Messerle’s office (CB E457) door.
Grading

The overall grade will be based on laboratory reports, homework, quizzes, and exams, with the laboratory reports constituting the major portion of the grade. An approximate breakdown is:

- **Homework** (3-4 assignments) 37 points
- Midterm exam (during an October class) 100 points
- Final exam (includes lab practical exam) 200 points
- Pre-lab assignments 63 points
- Cobalt coordination chemistry report 80 points
- Re₂ quadruple bond/microscale report 90 points
- High Tc superconductor synthesis report 80 points
- Dimolybdenum organometallic chemistry report 90 points
- Hexatungsten/molybdenum cluster chemistry report 80 points
- Solar fuels-relevant WL₆ chemistry report 100 points
- Single-crystal XRD report 80 points

1000 points total

Laboratory reports are due on the scheduled date, generally one week after experiment completion; 10 points will be deducted for each day that the report is late. The reports should be closely modeled after the style for full articles in the *Journal of the American Chemical Society* (please consult a recent issue on Science Library journals website), with the following sections: Abstract; Introduction; Experimental Section; Results; Discussion; References. A sample lab report will be available on ICON for an experiment. The laboratory report should be concise (≤ 8 pages printed or 16 pages hand-written; no credit for illegible lab reports; appendix pages do not count in total) and must append spectra and copies of the lab notebook pages. Each report will be graded by teaching assistants according to the following criteria:

- **Evidence of thought** .......................................................... 25-30 points
- **Quantitative results** ......................................................... 15 points
- **Treatment of data** ............................................................ 15 points
- **Performance in laboratory** ................................................ 15-20 points
- **Organization of report and laboratory notebook** ............. 10 points

TOTAL..................................................................................... 80-90 points

1. **Evidence of thought**
   The Abstract should be a single paragraph explaining the basic purpose(s) and result(s) of the experiment. The Introduction should elaborate on the basic purpose of the experiment, with relevant literature references, and give balanced chemical equations. The Experimental Section should discuss techniques, list reagents used in the experiment, and include a matter flowchart, a concise way for demonstrating your understanding of the experiment. Flowcharting is a method for showing the logical flow of the steps and compounds/by-products/solvents in the experiment, and as such it is preferable to a simple listing (i.e., copying) of the experimental procedure from the laboratory handout. The Discussion section should answer questions that may be posed in the handout for each experiment, detail your ideas on how to improve yields and the experiment in general, give the stoichiometry of the principal and side reactions in the experiment with balanced equations, and demonstrate that you understood the purpose(s) of the experiment.

   We are looking for evidence that you did more than simply "cookbook" the experiment. This is not the “Joy of Cooking” (an old, classic gourmet cookbook) for chemists.

2. **Quantitative results**
   The Results section should give percentage yield and data concerning purity and characterization of any compound prepared. All other data and observations should be provided.

3. **Treatment of data**
   The experimental data must be analyzed in the Discussion section in terms of error analysis and use of significant figures (if applicable). Sample calculations and graphs should be included.
4. Performance in laboratory
This portion of the grade is determined by your TAs; it is based on their evaluation of the degree of preparation that you demonstrated during execution of the experiment, understanding of the techniques employed in the experiment, and organization of time spent in the laboratory. Knowledge and use of appropriate safety precautions will be especially noted, in particular the wearing of goggles, face mask, and face shields and following physical distancing guidelines whenever you are in the lab. Grade reductions for repeated failure to observe safety and Covid-19 precautions will be used in the grading of the lab report, in addition to the possible banning of you from the laboratory and the resulting forfeiture of credit for the experiment. This has actually happened in other lab courses.

5. Report/notebook organization
The lab report should be patterned after the format used for full articles in the Journal of the American Chemical Society (JACS). Please go to the Library website and, under ejournals, select this journal and review a synthesis-related full paper (not a Communication to the Editor). Things that are required in the report should be easily found and properly organized, and all data should be present in the Results section. Copies of lab notebook pages must be appended to the report.

The proper use of a laboratory notebook is the mark of a good experimentalist (and Chemistry is, after all, an experimental science). The notebook need not be a work of art but must be legible. It is NOT appropriate to recopy your data/observations in the lab notebook from the day’s work AFTER the lab period, and it is NOT appropriate to set it up for filling in data BEFORE the lab period. The notebook should be liberally covered with observations (e.g., color changes), raw data, drawings of apparatus, and your ideas and/or thinking during the course of the experiment, in addition to the inevitable water stains.

Safety
Chemical synthesis involves potential hazards outside of other areas of chemistry. You must comply always with lab safety rules for your personal safety and the safety of others. You must complete lab safety training and pass a quiz before you will be allowed to perform experiments. If you fail to comply with safety rules, you will be asked to leave the laboratory and your grade will be lowered. You are strongly encouraged before the lab, as part of your pre-lab assignment, to look up the Material safety data sheets (MSDS) online for all chemicals and solvents to be used in the experiment. While in the laboratory, you must wear safety goggles or other positive eye protection at all times, along with a face mask and face shield; a face shield is not required while performing glassblowing. During your first laboratory period, locate the positions of the fire extinguishers, showers, and face sprays/eye washes. Be certain that you know how to use them, or please ask us. Water-cooled equipment such as condensers that must operate unattended between lab periods must be set up in fume hoods and also must have the water hoses secured with metal clips (supplied by us) in order to account for changes in water pressure and prevent room flooding and water damage below. All organic solvents are assumed to be flammable and to have some degree of toxicity. Waste solvents and reagents are to be disposed of in accordance with TA instructions. For safety reasons, you are to work in the lab only during your scheduled lab period. Missed labs cannot be made up (except for documented medical reasons), so you should not cut (miss) lab. Arrangements for short-term use of instruments outside of lab periods may be made with the teaching assistants.

Pregnancy: Many chemicals pose potential hazards to a fetus or baby (mutagenic, toxic, carcinogenic). Women who are pregnant, nursing, or who expect to become pregnant are strongly advised to consult with their physician about the hazards of possible exposure to chemicals used in this course. Consult Material safety data sheets (MSDS) and other safety information.

Complaints
Complaints and appeals regarding this course and instructor can be filed with the Departmental Executive Officer (DEO, Prof. Leonard MacGillivray) at the Department of Chemistry administrative office, Room E331 CB (335-1350). Students are encouraged to meet first with Prof. Messerle (no impact on your grade) with their concerns about course aspects, lectures, or assignments.
Helpful Hints (to help you get the most out of the course and to earn a good grade)

1. Make efficient use of your time in the lab! Reading your experiment beforehand and answering pre-lab questions will help you plan your work for the next laboratory period. Know exactly what the experiment requires and estimate how long each step will take based on the experimental procedures. Certain reactions require several hours to go to completion. Begin these first, so that you can work on other parts of the experiment while those reactions are proceeding. Efficient multi-tasking is an important skill to develop in multiple-step chemical synthesis.

2. When handing in products from your preparations, remember that a smaller amount of pure product is generally better than a large amount of contaminated product. Please fill in the supplied labels and attach these to your vials of compounds as well as to reaction vessels in use after class.

3. Your reports should be scientific papers, not novels. Write exactly what you mean, no more and no less. Avoid verbose and flowing descriptions without omitting essential information. Make it easy for the reader to determine exactly what you did, how they could reproduce it, and your results.

4. Your instructors are here for the sole purpose of teaching you advanced synthetic techniques than you were exposed to in organic chemistry laboratory courses, in addition to laboratory safety. **Do not hesitate to ask questions** when you are unsure of some aspect of the experiment, even if you fear that your question is “stupid”; **no question is stupid**, especially involving a question about safety, and will not impact your grade. **Don’t hesitate** to bring questions to Prof. Messerle’s drop-in hours, arranged alternate times, or while Prof. Messerle is in the lab room (often). Synthesis is a major aspect of the chemical sciences, and we want to help you develop proper, safe laboratory techniques for future technical work in graduate school or industrial/government employment.

Course-Specific Academic Honesty (in addition to CLAS policies on next page)

**Examinations:** You are expected to work alone. Out of fairness for all students, cheating and plagiarism will not be tolerated. Prof. Messerle believes strongly in fairness for all students and objective appraisal of individual performance and understanding of material.

**Laboratory:** All data must be collected during the lab period, unless there is a short-term use of an instrument arranged with a teaching assistant. Use of data not collected by the lab report’s author, data not acquired during lab period, and/or fabricated data constitute serious academic misconduct. We encourage you to discuss technique and lab questions in groups, but questions in the lab report must be answered individually by you.
ATTENDANCE AND CLASSROOM EXPECTATIONS: You are responsible for attending class and for knowing an instructor’s attendance policies. You are expected to attend class and to contribute to its learning environment in part by complying with University policies and directives regarding appropriate classroom behavior or other matters.

ABSENCES: You are responsible for communicating with instructors as soon as possible if you know that an absence might occur for an illness or unavoidable circumstance. You can use the CLAS absence form to communicate with instructors who will decide if the absence is excused or unexcused; the form is located on ICON within the top banner under "Student Tools.” Your delay in communication with an instructor could result in a forfeit of what otherwise might be an excused absence (https://clas.uiowa.edu/students/handbook/attendance-absences).

ABSENCES: ILLNESS, UNAVOIDABLE CIRCUMSTANCES, AND UNIVERSITY SPONSORED ACTIVITIES: If you are ill, in an unavoidable circumstance affecting academic work, or miss class because of a University-sponsored activity (e.g., athletics), you are allowed by UI policy to make up a missed exam. Documentation is required by the instructor except in the case of a brief illness. You are responsible for communicating with instructors as soon as the absence is expected: (https://opsmanual.uiowa.edu/students/absences-class#8.1).

ABSENCES: HOLY DAYS: Reasonable accommodations for you are allowed when religious holy days coincide with your classroom assignments, tests, and attendance if you notify the instructor in writing of any such religious Holy Day conflicts within the first days of the semester and no later than the third week. (See the UI Operations Manual, https://opsmanual.uiowa.edu/students/absences-class#8.2).

ABSENCES: MILITARY SERVICE OBLIGATIONS: If you are absent from class because of U.S. veteran or military service obligation (including military service-related medical appointments, military orders, and National Guard Service obligations), then you will be excused without penalty. Instructors must make reasonable accommodations to allow you to make-up exams or other work. You must communicate with your instructors about the expected possibility of missing class as soon as possible. For more information, see https://opsmanual.uiowa.edu/iv-8-absences-class%C2%A0-%200.

ACADEMIC MISCONDUCT: All undergraduates enrolled in courses offered by CLAS have, in essence, agreed to the College’s Code of Academic Honesty. Academic misconduct affects a student’s grade and is reported to the College, which applies an additional sanction such as suspension. Outcomes about misconduct are communicated through UI email. (https://clas.uiowa.edu/students/handbook/academic-fraud-honor-code).

ACADEMIC ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES: UI is committed to providing an educational experience that is accessible to all students. You may request academic accommodations for a disability (such as a mental health, attention, learning, vision, and/or a physical or health-related condition) through the Student Disability Services (SDS) office. You are responsible for discussing specific accommodations with the instructor. Note that accommodations are not granted retroactively but from the time of your request to the instructor onward; additionally, you must request accommodations at least two weeks in advance of the related assignment or exam (https://sds.studentlife.uiowa.edu/).

CLASS RECORDINGS: PRIVACY AND SHARING: Course lectures and discussions are sometimes recorded or live-streamed. These are only available to students registered for the course and are the intellectual property of the faculty member. These materials may not be shared or reproduced without the explicit written consent of the instructors. You may not share these recordings with those not enrolled in the course; likewise, you may not upload recordings to any online site. Doing so is a breach of the Code of Student Conduct and could be a violation of the Federal Education Rights and Privacy Act (FERPA); https://dos.uiowa.edu/policies/code-of-student-life/.
COMMUNICATION: UI EMAIL: You are responsible for all official correspondences sent to your UI email address (uiowa.edu) and must use this address for any communication with instructors or staff in the UI community (Operations Manual, III.15.2). Emails should be respectful and brief, with complex matters addressed during the instructor’s drop-in office hours. Faculty are not required to answer email after 6:00 PM or during weekends, unless in an emergency.

COVID: “The University of Iowa strongly encourages students, faculty, and staff to be vaccinated against COVID-19. The university also encourages students, faculty, and staff to wear a face mask while on campus, and strongly encourages the use of face masks in all classroom settings and during in-person office (drop-in) hours. However, face mask usage is not required except on CAMBUS and in specified research and healthcare settings.”

“You should feel comfortable in wearing a mask if you choose. Prof. Messerle will be wearing a mask during in-person classes, labs, and drop-in hours because he provides care for his 93 year-old mother who, while vaccinated, could become sick from breakthrough infection by coronavirus variants.”

COMPLAINTS ABOUT ACADEMIC MATTERS: If you have a complaint about a grade or a related academic issue, please first visit with the TA instructors, then with Prof. Messerle, and next with the Chemistry Department DEO. If not resolved, you may bring your concerns to the College of Liberal Arts and Sciences: https://clas.uiowa.edu/students/handbook/student-rights-responsibilities.

FINAL EXAMINATION POLICIES: The final exam schedule is published during the fifth week of the fall and spring semesters or on the first day of summer classes; you are responsible for knowing the date, time, and place of your final exams. You should not make travel plans until knowing this information. If you have exams scheduled on the same day and time or have more than two final exams on the same day, please visit this page in order to resolve these problems by the given deadline: https://registrar.uiowa.edu/makeup-final-examination-policies. No exams may be scheduled the week before finals; some exceptions, however, have been made for labs, language courses, and off-cycle courses (https://registrar.uiowa.edu/final-examination-scheduling-policies).

FREE SPEECH AND EXPRESSION: The University of Iowa supports and upholds the First Amendment protection of freedom of speech and the principles of academic and artistic freedom. All instructors and faculty are committed to open inquiry, vigorous debate, and creative expression inside and outside of the classroom. Visit Free Speech at Iowa for more information on the University’s policies on free speech and academic freedom (https://freespeech.uiowa.edu/).

HOME OF THE COURSE: The College of Liberal Arts and Sciences (CLAS) is the course home, and CLAS governs the course’s add and drop deadlines, the “second-grade only” option (SGO), and other undergraduate policies and procedures. Different UI colleges may have other policies or deadlines. See https://clas.uiowa.edu/students/handbook. Contact CLAS at clasps@uiowa.edu or 319-335-2633.

MENTAL HEALTH: You are strongly encouraged to seek help as a preventive measure if you are feeling stressed or overwhelmed. You should talk to your instructors for guidance with specific class-related concerns, and you are encouraged to contact University Counseling Service (UCS) at 319-335-7294 during regular business hours to schedule an appointment. USC offers group and individual therapy as well as counseling for couples about relationships while making referrals to other resources (https://counseling.uiowa.edu/). Student Health can also address related concerns (https://studenthealth.uiowa.edu/). These visits are all free to you. After hours, you are encouraged to call the Johnson County Community Crisis Line at (319) 351-0140 or dial 911 in an emergency. HELP IS ALWAYS AVAILABLE!

COVID-19:

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NONDISCRIMINATION IN THE CLASSROOM: The University of Iowa is committed to making the classroom a respectful and inclusive space for people of all gender, sexual, racial, religious, and other identities. Toward this goal, you are invited in MyUI to optionally share your names and pronouns that you would like your instructors and advisors to use to address you. The University of Iowa prohibits discrimination and harassment against individuals based on race, class, gender, sexual orientation, national origin, and other identity categories indicated by the University’s Human Rights policy. Contact the Office of Equal Opportunity and Diversity at https://diversity.uiowa.edu/division/office-equal-opportunity-and-diversity-eod.

It is Prof. Messerle’s and all course Teaching Assistants’ intentions that students from diverse backgrounds and perspectives will be well-served by this course, that your learning needs are addressed both in and out of class, and that the diversity that you and others bring to this class is viewed as a resource, strength, and benefit. It is our intention to present materials and activities that are respectful of diversity: gender, sexual orientation, disability, age, socioeconomic status, ethnicity, race, culture, perspective, and other background characteristics. Your suggestions about how to improve the value of diversity and inclusiveness in this course are both encouraged and greatly appreciated. Please let Prof. Messerle know, in confidence, ways to improve the effectiveness of the course for you personally or for future students or student groups.

In addition, in scheduling exams, Prof. Messerle will attempt to avoid conflicts with your religious holidays. If, however, he has inadvertently scheduled an exam or major deadline that creates a conflict with your religious observances, please let Prof. Messerle know as soon as possible so that he can reschedule or make other arrangements.

RESOURCES FOR STUDENTS (please check for updates to these long-term web addresses)
1) Writing Center: 110 English-Philosophy Building (EPB), 335-0188, www.uiowa.edu/~writingc
2) Speaking Center: 412 EPB, 335-0205, clas.uiowa.edu/rhetoric/for-students/speaking-center
4) Tutor Iowa: tutor.uiowa.edu
5) College of Engineering Tutoring Program: www.engineering.uiowa.edu/sdc/tutoring.php
6) Supplemental Instruction: tutor.uiowa.edu/supplemental-instructions/
7) University Housing Tutoring: housing.uiowa.edu/departments/reslife/academic_initiatives.html

SEXUAL HARASSMENT: Sexual harassment subverts the mission of the University and threatens the well-being of students, faculty, and staff; all members of the UI community are expected to conduct themselves in a manner that maintains an environment free from sexual harassment and/or sexual misconduct. If you experience sexual harassment, you are strongly encouraged to report the incidents and to seek help (https://osmrc.uiowa.edu/).

WEATHER EMERGENCIES: In increasingly-severe weather related to climate change, you should seek appropriate shelter immediately, leaving the classroom if necessary. The class will continue if possible when the emergency is over. For more information on Hawk Alert and the siren warning system, please visit the Public Safety web site: https://police.uiowa.edu/emergency-preparedness.
<table>
<thead>
<tr>
<th>DAY/DATE</th>
<th>A02 SECTION</th>
<th>A01 SECTION</th>
<th>LABORATORY COMPONENT</th>
<th>LECTURE TOPIC(S) for Monday, Wednesday @ 11:30 AM</th>
<th>ASSIGNMENT DUE DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>M Aug 23</td>
<td>Tu Aug 24</td>
<td></td>
<td>Check-in, safety training, lab tour; glassblowing</td>
<td>Safety, glassblowing tools and glass components</td>
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<tr>
<td>W Aug 25</td>
<td>Th Aug 26</td>
<td></td>
<td>Glassblowing</td>
<td>Synthesis strategies and criteria; lab notebook; SciFinder use in searching for syntheses</td>
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<tr>
<td>M Aug 30</td>
<td>Tu Aug 31</td>
<td></td>
<td>Glassblowing</td>
<td>Purification methods: fractional distillation; recrystallization, how to modify approach; sublimation</td>
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<tr>
<td>W Sept 1</td>
<td>Th Sept 2</td>
<td></td>
<td>Glassblowing; making a gas bubbler</td>
<td>Co(en)$_3^{3+}$ experiment: enantiomers, diastereomers, polarimetry, racemization</td>
<td>Turn in glass bubbler</td>
</tr>
<tr>
<td>W Sept 8</td>
<td>Th Sept 9</td>
<td></td>
<td>Co(en)$_3^{3+}$ synthesis: enantiomers</td>
<td>Molecular characterization approaches, pitfalls: How do you know you have what you think you made?</td>
<td>SciFinder homework due F Sept 10, 3:30 PM</td>
</tr>
<tr>
<td>M Sept 13</td>
<td>Tu Sept 14</td>
<td></td>
<td>Co(en)$_3^{3+}$ synthesis: resolution by forming diastereomers and separating by crystallization; polarimetry</td>
<td>Practical FT NMR spectroscopy</td>
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<tr>
<td>W Sept 15</td>
<td>Th Sept 16</td>
<td></td>
<td>Co(en)$_3^{3+}$ synthesis: conversion of least-soluble diastereomer to enantiomer; racemization; polarimetry</td>
<td>Practical FT NMR spectroscopy</td>
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<tr>
<td>M Sept 20</td>
<td>Tu Sept 21</td>
<td></td>
<td>Co(en)$_3^{3+}$ synthesis: finish any remaining synthesis step; polarimetry if needed</td>
<td>YBa$_2$Cu$_3$O$_7$-$d$ experiment; superconductivity, Meissner effect, solid-state synthesis, powder XRD</td>
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<tr>
<td>W Sept 22</td>
<td>Th Sept 23</td>
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<td>YBa$_2$Cu$_3$O$_7$-$d$ superconductor: sol-gel synthesis; muffle furnace</td>
<td>Metal clusters, utility, approaches to their synthesis; glove bags; M$_6$(µ-Cl)$_8$Cl$_6$$_2$ experiment</td>
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<tr>
<td>M Sept 27</td>
<td>Tu Sept 28</td>
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<td>YBa$_2$Cu$_3$O$_7$-$d$ superconductor: pellet press; tube furnace; M$_6$(µ-Cl)$_8$Cl$_6$$_2$ clusters: Mo$_6$ W$_6$, or Mo$_3$W$_3$, cluster solid-state syntheses: practice ampule sealing; glove bag use; tube furnace</td>
<td>Practical FT NMR spectroscopy</td>
<td>Co(en)$_3^{3+}$ report due Friday Oct 1, 3:30 PM</td>
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<tr>
<td>W Sept 29</td>
<td>Th Sept 30</td>
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<td>YBa$_2$Cu$_3$O$_7$-$d$ superconductor: Meissner M$_6$(µ-Cl)$_8$Cl$_6$$_2$ clusters: Mo$_6$ W$_6$, or Mo$_3$W$_3$, cluster isolation and recrystallization; Soxhlet extraction with metathesis to Bu$_4$N$^+$ salts</td>
<td>UV spectroscopy, spectrofluorimetry</td>
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<tr>
<td>M Oct 4</td>
<td>Tu Oct 5</td>
<td></td>
<td>M$_6$(µ-Cl)$_8$Cl$_6$$_2$ clusters: Mo$_6$ W$_6$, or Mo$_3$W$_3$, cluster compound characterization (UV, spectrofluorimetry)</td>
<td>Air-sensitive technique: Schlenk line; iSchlenk; Schlenk techniques</td>
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<tr>
<td>Date</td>
<td>Week Days</td>
<td>Activity</td>
<td>Notes</td>
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<tr>
<td>W Oct 6</td>
<td>Th Oct 7</td>
<td>iSchlenk</td>
<td>Organotransition metal chemistry; M-CO and M–M bonding; organodimolybdenum experiment</td>
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<tr>
<td>M Oct 11</td>
<td>Tu Oct 12</td>
<td>Organodimolybdenum chemistry: synthesis of (η-C₃H₅)(OC)₃MoMo(CO)₂(η-C₃H₅) with Mo–Mo bond</td>
<td>Infrared spectroscopy: KBr pellets, demountable solution cells, sealed solution cells</td>
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<tr>
<td>W Oct 13</td>
<td>Th Oct 14</td>
<td>Organodimolybdenum chemistry: isolation, recrystallization</td>
<td>Mass spectrometry, parent and molecular ions, fragmentation, isotope patterns for non monoisotopic elements</td>
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<tr>
<td>M Oct 18</td>
<td>Tu Oct 19</td>
<td>Organodimolybdenum chemistry: characterization ('H and ¹³C NMR; IR; mass spectrometry)</td>
<td>Dirhenium experiment; M-M multiple bonding; microscale techniques</td>
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<tr>
<td>W Oct 20</td>
<td>Th Oct 21</td>
<td>Microscale dirhenium metal-metal quadruple bond synthesis: Re metal conversion to Re₂Cl₅⁻</td>
<td>MIDTERM EXAM Wednesday during lecture time</td>
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<tr>
<td>M Oct 25</td>
<td>Tu Oct 26</td>
<td>Microscale Re⁺⁺Re⁻⁻: preparation of Re₂Cl₅(µ-O₂CR)₄</td>
<td>Unusual, little studied metal-metal bonds: unbridged Re₂(η³-allyl)₆ W₂(CH₃CMe₃)₆</td>
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<tr>
<td>W Oct 27</td>
<td>Th Oct 28</td>
<td>Microscale Re⁺⁺Re⁻⁻: Grignard reagent preparation, reaction with Re₂Cl₅(µ-O₂CR)₄</td>
<td>Solar energy conversion; Excited-state photochemistry; W(CNAr⁻)₄ experiment</td>
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<td>M Nov 1</td>
<td>Tu Nov 2</td>
<td>Microscale Re⁺⁺Re⁻⁻: new compound isolation, characterization</td>
<td>Further details on W(CNAr⁻)₄ experiment</td>
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<td>W Nov 3</td>
<td>Th Nov 4</td>
<td>W(CNArAr'⁻⁻)₄, (CNArAr' = isocyanide) solar fuel chemistry: Suzuki-Miyaura coupling to prepare ArAr'NHCHO (coupled formamide)</td>
<td>Metal-catalyzed cross-coupling chemistry in organic synthesis</td>
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<td>M Nov 8</td>
<td>Tu Nov 9</td>
<td>W(CNArAr'⁻⁻)₄: Coupling reaction workup; removal of PPh₃ by flash column chromatography; elute coupled formamide</td>
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<td>W Nov 10</td>
<td>Th Nov 11</td>
<td>W(CNArAr'⁻⁻)₄: Dehydration of coupled formamide to isocyanide by use of Burgess reagent</td>
<td>Dirhenium report due F Oct 29 at 3:30 PM</td>
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<tr>
<td>M Nov 15</td>
<td>Tu Nov 16</td>
<td>W(CNArAr'⁻⁻)₄: Isolation and purification of isocyanide ligand by flash chromatography</td>
<td>Glove box design and techniques; safe handling of Hg and alkali metal reductants</td>
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<td>W Nov 17</td>
<td>Th Nov 16</td>
<td>W(CNArAr'⁻⁻)₄: reductive coupling of isocyanide with WCl₆(THF)₂ in glove box using Na amalgam</td>
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<td>Th Nov 25</td>
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<td><strong>CHARACTERIZE CRANBERRY SAUCE, MASHED POTATOES</strong></td>
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<td>M Nov 29</td>
<td>Tu Nov 30</td>
<td>W(CNArAr'⁻⁻)₄: isolation, purification by low T crystallization in glove box</td>
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<td>W Dec 1</td>
<td>Th Dec 2</td>
<td>W(CNArAr'⁻⁻)₄: characterization, elemental analysis, UV, spectrofluorimetry</td>
<td>Single-crystal X-ray diffractometry; SHELX and OLEX software</td>
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<td>Date</td>
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<td>M Dec 6</td>
<td>Tu Dec 7</td>
<td>SCXRD, single-crystal solid-state molecular structure determination of a</td>
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<td>student’s crystalline W(CNArAr’)₆</td>
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<td>W Dec 8</td>
<td>Th Dec 9</td>
<td>Lab-practical exam portion of final exam, in lab</td>
<td>Review course</td>
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<td>F Dec 11: Simple SCXRD report</td>
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</table>
University of Iowa's Chemistry Department Educational Program Outcomes

Our Values

Our Department is committed to maintaining excellence in teaching and mentoring and achieving maximal learning benefit for each student. In order to do so, we as a Department must determine those things that make an undergraduate education successful, and then determine the things we do well all the time, some of the time, and rarely.

Program Outcomes

The graduate with a Bachelor’s Degree in Chemistry will be able to use their knowledge and skills obtained in the educational program to demonstrate:

Knowledge and Understanding of Chemistry. As evidence of knowledge, you should be able to:

- Master major concepts, theoretical principles, and experimental findings in chemistry, including fundamental concepts in each of the subdisciplines of Chemistry (organic, inorganic, analytical, physical, and biological)
- Understand the relationships between molecular structure and physical/chemical properties
- Understand the relationships between the microscopic, macroscopic, and symbolic descriptions of matter and the changes that matter can undergo
- Understand the conditions that affect molecular stability and factors that control the rates of molecular change

Laboratory Skills. As evidence of laboratory skills, you should be able to:

- Assess chemical and procedural hazards involved in laboratory work, including retrieval and analysis of MSDS (material safety data sheet) information
- Use proper personal protective equipment (PPE), responsibly handle and dispose of chemicals, and prepare for emergencies to minimize the risks associated with laboratory work
- Maintain a clearly-organized laboratory notebook as a record of experimental procedures and findings
- Use a variety of synthesis techniques, such as using principles of green chemistry, air-sensitive compound manipulation, solid-state and material synthesis methods, and microscale methods
- Use instrumentation and laboratory techniques to separate, purify, identify, quantify, and characterize chemical species
- Use computers as tools for data acquisition, management, and analysis

Scientific Reasoning. As evidence of your ability to reason scientifically, you should be able to:

- Pose scientific questions
- Plan and carry out scientific investigations
- Analyze data in order to make inferences about chemical and physical behaviors and properties, and construct scientific arguments to support conclusions
- Use scientific theory and/or interpretations of experimental results to explain chemical phenomena in the context of health, energy, technology, environment, agriculture, etc.
- Use mathematics and computational methods to understand and predict chemical behavior
- Identify and quantify uncertainties in measurements and limitations in methods
- Use graphs, diagrams, and other models to communicate chemical information to others

Chemical Information Skills: As evidence of chemical information skills, you should be able to:

- Use modern library search tools such as the American Chemical Society (ACS) Chemical Abstracts Service’s SciFinder to locate and retrieve chemical literature and information including reported molecular syntheses, reactivities, characterization data, structures, physical properties, toxicities, etc.
- Read, analyze, and critically evaluate journal articles, meeting abstracts, and books in various subfields of chemistry
- Reference and cite chemical literature appropriately using ACS or other citation styles
**Professional Skills:** As evidence of professional skills, you should be able to:

- Report scientific findings in oral presentations in a clear and organized fashion using appropriate visual tools
- Describe experimental work and scientific findings in written reports, for instance through formal laboratory reports or technical memos
- Communicate results of scientific work to non-technical audiences
- Work collaboratively with peers to plan and conduct experiments, interpret chemical information, and solve problems
- Engage in responsible and ethical scientific conduct such as appropriately citing sources, reporting findings accurately such that others can duplicate the scientific work, and not plagiarizing the work of others