

CHEM 5331.001

Organometallic Chemistry

Dr. Jason Smee

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Office Hours

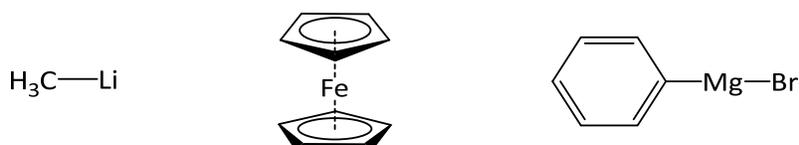
- MTWRF
10:30–11:30 am
- and by appointment
- [Zoom link for office hours](#) (please email me in advance so I can get Zoom running)

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Course Description

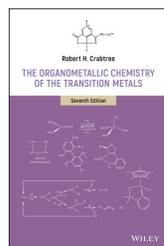
Synthesis, bonding, and reactivity of transition metal and main group organometallic compounds and their applications in organic synthesis, catalysis, and nature. A list of topics is provided later in the syllabus. A few example compounds, prepared in ChemDraw, are shown below.



Organometallic (adjective): of, relating to, or being an organic compound that usually contains a metal or metalloid bonded directly to carbon

- [Merriam-Webster dictionary](#)

Required & Recommended Materials



The **recommended** text is *The Organometallic Chemistry of the Transition Metals, 7/e* by Crabtree (ISBN: 9781119465867)

(Image from <https://www.wiley.com>.)

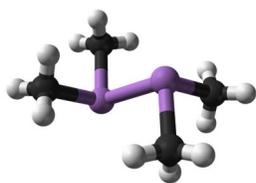


A scientific calculator (capable of exponents and logarithms) is **required**.

(Image from <https://www.schoolspecialty.com/casio-scientific-calculator-035399>.)

Other Useful References

- *Inorganic Chemistry* 4/e by Miessler and Tarr; ISBN 13:9780136128663
- *Inorganic Chemistry* 4/e by Housecroft and Sharpe; ISBN-13: 9780273742753
- *Inorganic Chemistry* 7/e by Weller et al. ISBN-13: 9780198768128.
- **The Organometallic Hyper Textbook** — <http://www.ilpi.com/organomet/index.html> (it's free!!!)
- We also look at some “classic papers” of organometallic chemistry. You will also give a 15-minute presentation on a current journal article of your choosing. Therefore, you will need to be able access, among others, the ACS journals through the UT Tyler library website (library.uttyler.edu). If you need to access the library while off campus please visit the [Connecting from Off-Campus: Welcome page](#)



Cacodyl, also known as tetramethyldiarsine, is widely considered the first organometallic compound; prepared by Cadet de Gassicourt in 1757.

(Image from Wikipedia.)

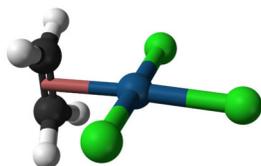
Recording of Class Sessions

I will not be recording my lectures unless student accommodations or extenuating circumstances require it. Please note that some recordings may contain personally identifiable information or other information subject to FERPA. They shall not be shared with individuals not enrolled in this course unless appropriate consent is obtained from all relevant students. Class recordings are reserved only for the use of students enrolled in the course and only for educational purposes. Course recordings should not be shared outside of the course in any form without express permission.

Student Learning Outcomes

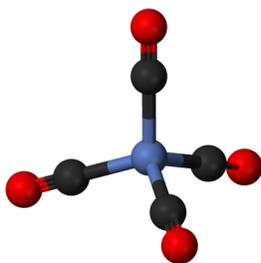
By the end of this course, students should be able to

- 1) Count electrons according to the neutral ligand and donor pair methods
- 2) Use Molecular Orbital (MO) theory to explain the bonding in a variety of transition metal complexes
- 3) Propose syntheses of organometallic complexes
- 4) Recognize fundamental organometallic reactions (e.g. b elimination)
- 5) Predict products of reactions catalyzed by organometallic complexes
- 6) Extract key concepts from classical and current journal articles
- 7) Effectively present a summary of the results of a journal article relating to organometallic chemistry.



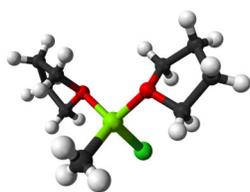
Zeise's salt, potassium trichloro(ethene)platinate (II) (the anion is shown) is the first organometallic complex containing a transition metal; prepared by Zeise in 1827. (Image from Wikipedia.)

Course Requirements

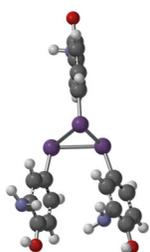


Tetracarbonylnickel(0), $\text{Ni}(\text{CO})_4$, was discovered by Mond in 1890. It is one of the first "carbonyl" compounds and is a gas at room temperature. The Mond process is used to purify crude nickel ore. (Image from Wikipedia.)

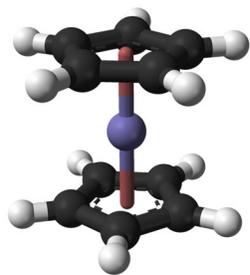
- 1) One semester of undergraduate inorganic chemistry similar to CHEM 3320 and/or CHEM 4330 is strongly suggested.
- 2) We meet Thursday from Aug 28 to December 4, except Thanksgiving week (Nov 24th–28th). Attendance will be taken and class participation will be sought to nurture student communication and presentation skills.
- 3) You will be required to give a 15-minute presentation over a journal article obtained from such journals as *Organometallics* (ACS), *The Journal of Organometallic Chemistry* (Elsevier), and *Applied Organometallic Chemistry* (Wiley).
- 4) The last regular class meeting (Dec 4th) and the "final exam" meeting (Dec 11th) will be dedicated to these presentations.
- 5) There will be 2 midterm exams, but no comprehensive final exam.



Grignard reagents, such as CH_3MgCl (shown above as the bis-tetrahydrofuran adduct) were developed in the late 1890s. (Image from Wikipedia.)



Salvarsan, shown above as the trimer of 2-amino-4-arsanylphenol, was developed in 1914 by Erlich as a treatment for syphilis and was one of the earliest chemotherapeutics. (Image created from Spartan '10.)



Ferrocene, $[\text{Fe}(\text{C}_6\text{H}_5)_2]$, was first isolated by Pauson in 1951 after a failed attempt to make fulvalene. This “sandwich” compound was the “catalyst” that really got organometallic chemistry going. (Image from Wikipedia.)

In-Class Work (10%)

We will do some in-class groupwork to help you get a better grasp of the material before you begin work on your individual homework

Homework (30%)

Homework (30% of your overall grade) is comprised of 1) problem sets; and 2) questions regarding assigned reading of classic and some contemporary papers. Each assignment will be due at the beginning of class.

Exams (20% per exam, 40% total)

- 1) Two mid-term exams will be given during class and are worth 20% of your overall grade each. They are mostly short answer/calculations and some multiple choice. I will notify you the week before where the material will be cut off.
- 2) Missed exams due to an unexcused absence will result in a 0. In the event of an excusable situation, please give me at least 2 days' notice to reschedule.
- 3) Cell phones, smart watches, and any similar electronic devices must be turned off and put away during exams. If they are observed in a visually accessible place (i.e., between legs, on the floor, etc.), it will be assumed you are cheating; your exam will taken away, you will receive a 0 for the test, and you will be referred to the Office of Judicial Affairs.

In-Class Presentation (20%)

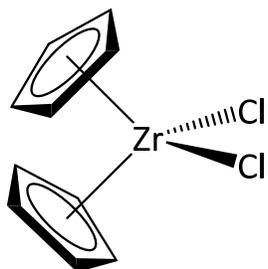
You are required to give a 10-15 minute presentation summarizing the results of an organometallic-related journal article. The paper should be 1) published within the last ~5 years; 2) must involve the synthesis of an organometallic compound or the use of such a compound as a catalyst; and 3) **must not be a review article!!!** If you are unsure of a paper's suitability, please ask. Some good journals focusing on organometallics: *Organometallics*, *Journal of Organometallic Chemistry*, and *Applied Organometallic Chemistry*. Others good journals include *Angewandte Chemie (English)*, *JACS*, *Inorganic Chemistry*, *Chemistry: A European Journal*, and *European Journal of Inorganic Chemistry*.

Your paper must be pre-approved by me, no later than two weeks before the date of the presentations. The grade will be based primarily on organization, style, clarity, and the ability to answer questions related to this course. A full rubric will be provided later in the semester to help with the planning of your presentation.

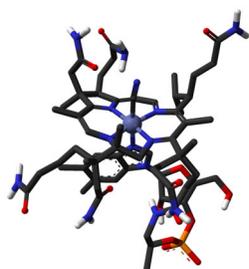
Grading

- All grades will be shown on Canvas.
- Grades will be tentatively based on a 90/80/70 scale, but they may be adjusted based upon my evaluation of the class's overall performance.

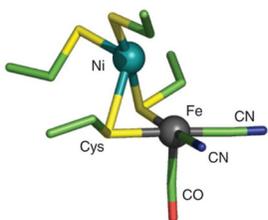
In-Class Work	10%
Homework	30%
2 In-class Exams	40%
Presentation	20%
Total	100%



Dichlorobis(cyclopentadienyl)zirconium(IV) is an example of a homogeneous catalyst used for the polymerization of polypropylene. (Image prepared in ChemDraw.)



Cobalamin, also known as vitamin B12 (shown here as the cyano complex), was the first known bioinorganic compound. It plays a significant role in many biological processes. (Image from Wikipedia.)



Using isotopic labeling, IR studies confirmed that the iron-only and nickel-iron hydrogenase (shown above) enzymes required “toxic” ligands such as CO and CN⁻ to function. (Image from Shriver 6/e.)

Canvas

I will utilize Canvas to post the following items

- 1) syllabus
- 2) lecture notes
- 3) grades (my Excel grade book has the official grades)

You may be asked to submit portions of homework assignments through Canvas as well.



Important Dates

(Note: exam and presentation dates are tentative; final exam date and time is fixed)

- September 8 (Monday): Census Date; last day to file for grade replacement
- **October 9: Exam 1**
- Nov 4 (Tuesday): Last Day to Drop with a “W”
- Nov 10 (Monday): Last day to schedule thesis/dissertation defense for Fall '25 Graduation
- **November 20: Exam 2**
- Nov 21 (Friday): Last day to submit completed thesis/dissertation for Fall '25 Graduation
- November 24—28: Thanksgiving, no classes
- **December 4: Presentations, part 1**
- **December 11: Presentations, part 2**

Topics to Be Covered (Chapter Numbers are from Crabtree)

- Review: quantum numbers; electron configurations; and molecular orbital (MO) Theory
- Chapter 1: Introduction (review of nomenclature; geometric and stereoisomers; Lewis acid-base theory; hard-soft acid-base theory; and crystal/ligand field theory)
- Chapter 2: Making Sense of Organometallic Complexes (18-electron rule; electron counting; oxidation state; coordination numbers; non-bonding d orbitals; *umpolung*)
- Chapter 3: Alkyls and Hydrides (b-hydride elimination and its prevention; M-C single bonds; other s-bonded M-X complexes; M-H complexes; Mⁿ(H₂) vs Mnⁿ⁺²(H)₂ complexes)
- Chapter 4: Carbonyls, Phosphines, and Substitution (CO and related compounds; phosphines; Tolman steric and electronic parameters; substitution reactions)
- Chapter 5: Pi-Complexes (alkenes; alkynes; allenes; cyclic/acyclic polyenes; metallocenes; and arenes)
- Chapter 6: Oxidative Addition and Reductive Elimination (OA and RE; mechanisms)
- Chapter 7: Insertion and Elimination (reactions with CO and alkenes; bond metathesis; and oxidative coupling/reductive fragmentation)
- Chapter 8: Addition and Abstraction (nucleophilic addition of CO and polyenes; nucleophilic abstraction of hydrides, alkyls, and acyls; Wacker process; why these electrophilic reactions are less useful)
- Chapter 9: Homogeneous Catalysis (alkene isomerization; hydroformylation; hydrogenation; cross coupling reactions)
- Chapters 11 Multiple Bonds (carbenes; carbynes; N-heterocyclic carbenes)
- Chapter 12: Metathesis, Polymerization, and Bond Activation (alkene metathesis; alkene dimerization, oligomerization, and polymerization; activation of CO, CO₂ and C-H bonds)

TENTATIVE SCHEDULE

(SUBJECT TO CHANGE)

Week	Dates (Thurs)	Topic(s)	Assignments* (due in-class or the next week)
1	Aug 28	Syllabus, Review material (“Ch 1”)	IC Ch 1a
2	Sept 4	Review material (cont.), Chap. 2	IC Ch 1b, HW Review due 9/11
3	Sept 11	Chap. 2 (cont.), Chap. 3	IC Ch 2, HW 2 due 9/18
4	Sept 18	Chap. 3 (cont.), Chap. 4	IC Ch 3, HW 3 due 9/25
5	Sept 25	Chap. 4 (cont.), Chap. 5	IC Ch 4, HW 4 due 10/2
6	Oct 2	Chap. 5 (cont.), Chap. 6	IC Ch 5, HW 5 due 10/9
7	Oct 9	Exam 1	
8	Oct 16	Chap. 6 (cont.), Chap. 7	IC Ch 6, HW 6 due 10/23
9	Oct 23	Chap. 7 (cont.), Chap. 8	IC Ch 7, HW 7 due 10/30
10	Oct 30	Chap. 8 (cont.), Chap. 9	IC Ch 8, HW 8 due 11/6
11	Nov 6	Chap. 9 (cont.), Chap. 11	IC Ch 9, HW 9 due 11/13
12	Nov 13	Chap. 11 (cont.), Chap. 12	IC Ch 11,12; HW 11, 12 due 11/20
13	Nov 20	Exam 2	Start working on presentation.
14	Nov 27	Thanksgiving Break—no classes	Keep working on presentation, but also relax during the week off (if possible)!
15	Dec 4	Presentations, Part 1	
16	Dec 11	Presentations, Part 2 (no final exam)	You need to attend class on both presentation days.

*Abbreviations used

IC = In-class homework (group work)

HW = individual HW assignment

University Policies and Information (Last Update – 5/30/2024)

WITHDRAWING FROM CLASS

Students may [withdraw](#) (drop) from this course using the [Withdrawal Portal](#). Withdrawing (dropping) this course can impact your Financial Aid, Scholarships, Veteran Benefits, Exemptions, Waivers, International Student Status, housing, and degree progress. Please speak with your instructors, consider your options, speak with your advisor, and visit the One-Stop Service Center (STE 230) or email enroll@uttyler.edu to get a complete review of your student account and the possible impacts to withdrawing. We want you to make an informed decision. UT Tyler faculty and staff are here for you and often can provide additional support options or assistance. Make sure to carefully [read the implications for withdrawing from a course and the instructions](#) on using the [Withdrawal portal](#).

Texas law prohibits students from dropping more than six courses during their entire undergraduate career.* The six courses dropped include those from other 2-year or 4-year Texas public colleges and universities. Consider the impact withdrawing from this class has on your academic progress and other areas, such as financial implications. We encourage you to consult your advisor(s) and Enrollment Services for additional guidance. CAUTION #1: Withdrawing before census day does not mean you get a full refund. Please see the [Tuition and Fee Refund Schedule](#). CAUTION #2: All international students must check with the [Office of International Programs](#) before withdrawing. All international students are required to enroll full-time for fall and spring terms. CAUTION #3: All UT Tyler Athletes must check with the Athletic Academic Coordinator before withdrawing from a course. CAUTION #4: All veterans or military-affiliated students should consult with the [Military and Veterans Success Center](#).

*Students who began college for the first time before 2007 are exempt from this law.

ARTIFICIAL INTELLIGENCE STATEMENT

UT Tyler is committed to exploring and using artificial intelligence (AI) tools as appropriate for the discipline and task undertaken. We encourage discussing AI tools' ethical, societal, philosophical, and disciplinary implications. All uses of AI should be acknowledged as this aligns with our commitment to honor and integrity, as noted in UT Tyler's Honor Code. Faculty and students must not use protected information, data, or copyrighted materials when using any AI tool. Additionally, users should be aware that AI tools rely on predictive models to generate content that may appear correct but is sometimes shown to be incomplete, inaccurate, taken without attribution from other sources, and/or biased. Consequently, an AI tool should not be considered a substitute for traditional approaches to research. You are ultimately responsible for the quality and content of the information you submit. Misusing AI tools that violate the guidelines specified for this course is considered a breach of academic integrity. The student will be subject to disciplinary actions as outlined in UT Tyler's Academic Integrity Policy. Refer to the About This Course section of the UT Tyler Syllabus Module for specific information on appropriate use of AI in your course(s), or see below.

For this course, you can use AI programs (ChatGPT, Copilot, etc.) for exam preparation (e.g., generating flashcards and sample test questions). Be aware that in cases where information provided by AI conflicts with the lecture material, the lecture material will take priority. You will NOT be permitted AI on exams. Remember, AI does make mistakes, so I recommend the "trust but verify" policy when it comes to using AI.

FINAL EXAM POLICY

Final examinations are administered as scheduled. If unusual circumstances require that special arrangements be made for an individual student or class, the Dean of the appropriate college, after consultation with the faculty member involved, may authorize an exception to the schedule. Faculty members must maintain student final examination papers for a minimum of three months following the examination date.

INCOMPLETE GRADE POLICY

If a student, because of extenuating circumstances, is unable to complete all the requirements for a course by the end of the semester, then the instructor may recommend an Incomplete (I) for the course. The "I" may be assigned in place of a grade only when all of the following conditions are met: (a) the student has been making satisfactory progress in the course; (b) the student is unable to complete all coursework or final exam due to unusual circumstances that are beyond personal control and are acceptable to the instructor, and (c) the student presents these reasons before the time that the final grade roster is due. The semester credit hours for an Incomplete will not be used to calculate the grade point average.

The student and the instructor must submit an Incomplete Form detailing the work required and the time by which the work must be completed to their respective department chair or college dean for approval. The time limit established must not exceed one year. Should the student fail to meet all the work for the course within the time limit, then the instructor may assign zeros to the unfinished work, compute the course average for the student, and assign the appropriate grade. If a grade has yet to be assigned within one year, then the Incomplete will be changed to an F, or NC. If the course was initially taken under the CR/NC grading basis, this may adversely affect the student's academic standing.

GRADE APPEAL POLICY

Disputes regarding grades must be initiated within sixty (60) days from the date of receiving the final course grade by filing a Grade Appeal Form with the instructor who assigned the grade. A grade appeal should be used when the student thinks the final course grade awarded does not reflect the grades earned on assessments or follow the grading scale as documented in the syllabus. The student should provide the rationale for the grade appeal and attach supporting document about the grades earned. The form should be sent via email to the faculty member who assigned the grade. The faculty member reviews the rationale and supporting documentation and completes the instruction section of the form. The instructor should return the form to the student, even if a grade change is made at this level. If the student is not satisfied with the decision, the student may appeal in writing to the Chairperson of the department from which the grade was issued. In situations where there is an allegation of capricious grading, discrimination, or unlawful actions, appeals may go beyond the Chairperson to the Dean or the Dean's designee of the college from which the grade was issued, with that decision being final. The Grade Appeal form is found in the [Registrar's Form Library](#).

NOTE: The Grade Appeal Form is different from the Application for Appeal form submitted to the Student Appeals Committee, which does not rule on grade disputes as described in this policy.

University Policies and Information (cont.)

DISABILITY/ACCESSIBILITY SERVICES

In accordance with Section 504 of the Rehabilitation Act, Americans with Disabilities Act (ADA) and the ADA Amendments Act (ADAAA), the University of Texas at Tyler offers accommodations to students with learning, physical, and/or psychological disabilities. If you have a disability, including a non-visible diagnosis such as a learning disorder, chronic illness, TBI, PTSD, ADHD, or a history of modifications or accommodations in a previous educational environment, you are encouraged to visit <https://hood.accessiblelearning.com/UTTyler/> and fill out the New Student application. The Student Accessibility and Resources (SAR) office will contact you when your application has been submitted and an appointment with the Assistant Director Student Accessibility and Resources/ADA Coordinator. For more information, including filling out an application for services, please visit the SAR webpage at <https://www.uttyler.edu/disability-services>, the SAR office located in the Robert Muntz Library, LIB 460, email saroffice@uttyler.edu, or call 903.566.7079.

MILITARY AFFILIATED STUDENTS

UT Tyler honors the service and sacrifices of our military-affiliated students. If you are a student who is a veteran, on active duty, in the reserves or National Guard, or a military spouse or dependent, please stay in contact with your faculty member if any aspect of your present or prior service or family situation makes it difficult for you to fulfill the requirements of a course or creates disruption in your academic progress. It is important to make your faculty member aware of any complications as far in advance as possible. Your faculty member is willing to work with you and, if needed, put you in contact with university staff who are trained to assist you. The [Military and Veterans Success Center \(MVSC\)](#) has campus resources for military-affiliated students. The MVSC can be reached at MVSC@uttyler.edu or via phone at 903.565.5972.

STUDENTS ON AN F-1 VISA

To remain in compliance with Federal Regulations requirements you must do the following:

- Traditional face-to-face classes: Attend classes on the regular meeting days/times.
- Hybrid Classes: Attend all face-to-face classes convened by the instructor according to the schedule set for your specific course.
- Online course: Only one online course can count toward your full-time enrollment. Students are expected to be fully engaged and meet all requirements for the online course.

ACADEMIC HONESTY AND ACADEMIC MISCONDUCT

The UT Tyler community comes together to pledge that "Honor and integrity will not allow me to lie, cheat, or steal, nor to accept the actions of those who do." Therefore, we enforce the [Student Conduct and Discipline policy](#) in the Student Manual Of Operating Procedures (Section 8).

FERPA

UT Tyler follows the Family Educational Rights and Privacy Act (FERPA) as noted in [University Policy 5.2.3](#). The course instructor will follow all requirements to protect your confidential information.

ABSENCE FOR OFFICIAL UNIVERSITY EVENTS OR ACTIVITIES

This course follows the practices related to [Excused Absences for University Events or Activities](#) as noted in the Catalog.

ABSENCE FOR RELIGIOUS HOLIDAYS

This course follows the practices related to [Excused Absences for Religious Holy Days as noted in the Catalog](#).

ABSENCE FOR PREGNANT STUDENTS

This course follows the requirements of Texas Laws SB 412, SB 459, SB 597/HB 1361 to meet the needs of pregnant and parenting students. Part of the supports afforded pregnant students includes excused absences. Faculty who are informed by a student of needing this support should make a referral to the Parenting Student Liaison. NOTE: Students must work with the Parenting Student Liaison in order to receive these supports. Students should reach out to the Parenting Student Liaison at parents@uttyler.edu and also complete the [Pregnant and Parenting Self-Reporting Form](#).

CAMPUS CARRY

We respect the right and privacy of students who are duly licensed to carry concealed weapons in this class. License holders are expected to behave responsibly and keep a handgun secure and concealed. More information is available at <http://www.uttyler.edu/about/campus-carry/index.php>.

