

# Chemistry 503 : Organometallics (3 credits) Fall 2017

Monday, Wednesday, Friday 8:10-9 am in Troy G5

## Syllabus

**Instructor:** Prof. Zachariah Heiden Fulmer 40 509-335-0936 [zachariah.heiden@wsu.edu](mailto:zachariah.heiden@wsu.edu)

**Office Hours:** by appointment

**Website:** The course website and gradebook will be maintained in Blackboard (<http://learn.wsu.edu/>)

**Recommended:** Chemistry 401 (Inorganic Chemistry) or equivalent

**Required Text:** Crabtree The Organometallic Chemistry of the Transition Metals, 6th Ed.  
(ISBN : 978-1-118-13807-6)

**Recommended Resources:** These texts listed below may provide useful explanations, but are not required for the course.

Fundamentals of Organometallic Catalysis, Steinborn (ISBN : 978-3-527-32717-1)

Organometallics, Elsenbroich (ISBN : 978-3-527-29390-2)

Organotransition Metal Chemistry From Bonding to Catalysis, Hartwig (ISBN: 978-1891389535)

NMR in Organometallic Chemistry, Pregosin (ISBN: 978-3-527-33013-3)

### Student Learning Outcomes

Chemistry 503 is designed to advance students toward the WSU Learning Goals, especially Scientific Literacy, Critical and Creative Thinking, Quantitative Reasoning, Communication, and Information Literacy. This course will provide graduate students and senior undergraduates with a foundation in the theoretical principles and the descriptive chemistry of organometallic chemistry. The objective is to apply the concepts of symmetry, bonding, oxidation-reduction, molecular structure, and acid-base chemistry, to understand the chemistry of organometallic compounds. The level of the course assumes an entering graduate student with a B.S. in Chemistry with some experience with the topic of inorganic chemistry.

By the end of the course it is expected that every student will:

- 1) Be able to read, understand, and communicate about the current chemical literature.
- 2) Be able to predict the geometry of an organometallic molecule from spectroscopic data.
- 3) Be able to propose a plausible reaction mechanism for a chemical transformation from experimental data and chemical intuition.

### Expectation for Student Effort

For each hour of lecture equivalent, students should expect to have a minimum of two hours of work outside class.

## Assessment

<b>Student Learning Outcomes</b> At the end of this course, students should be able to:	<b>Course Topics/Dates</b> The following topic(s)/dates(s) will address this outcome:	<b>Evaluation of Outcome:</b> This outcome will be evaluated primarily by:
<i>Be able to read, understand, and communicate about the current chemical literature.</i>	<i>Discussions on Organometallic Complexes and their Reactivity (Lectures 6-39)</i>  <i>Special Topics Presentations (Lectures 35-39)</i>	<i>Class exercises, problem sets, exams, and the special topics presentations</i>
<i>Be able to predict the geometry of an organometallic molecule from spectroscopic data.</i>	<i>Physical Methods in Organometallic Chemistry (Lectures 30-31)</i>  <i>Solving NMR Problems in Organometallic Chemistry (Lecture 34)</i>	<i>Class exercises, problem sets, and exams</i>
<i>Be able to propose a plausible reaction mechanism for a chemical transformation from experimental data and chemical intuition.</i>	<i>Organometallic Catalytic Transformations (Lectures 21-29)</i>	<i>Class exercises, problem sets, exams</i>

<b>Grading Scheme:</b>	<b>Problem Sets (5)</b>	<b>100 pts</b> (bi-weekly)
	<b>Take-Home Midterm Exam</b>	<b>150 pts</b> (Monday, Oct. 23 <sup>rd</sup> , due at 5:00 pm)
	<b>Special Topics Presentation</b>	<b>50 pts</b>
	<b>Take-Home Final Exam</b>	<b>200 pts</b> (Tuesday, Dec. 12 <sup>th</sup> , due at 5:00 pm)

**Grade Ranges:** 500-450 pts A, 449-400 pts B, 399-350 pts C, 349-300 pts D, 299-0 pts F

## Assignments

**Problem sets:** The problem sets will be assigned bi-weekly on Monday and be due the following Monday at the start of class. Each problem set will count for 20 points and will consist of seven problems. Problems will be assigned from Crabtree or will be provided by Prof. Heiden. The first six problems will be graded on a 0-3 scale. Three points will be awarded for answers completely or mostly correct, two points for answers missing a couple of key concepts, one point will be awarded if the answer provided does not sufficiently answer the question, and zero points if the question was not attempted. The last problem will be graded on a 0-2 scale. Late problem sets will not be accepted.

**Problem Set Due Dates:** Problem Set #1 – September 11<sup>th</sup>, Problem Set #2 – September 29<sup>th</sup>, Problem Set #3 – October 13<sup>th</sup>, Problem Set #4 – November 13<sup>th</sup>, Problem Set #5 – December 8<sup>th</sup>.

**Special Topics Presentations:** The last five lectures will consist of special topics presentations. A group of two students will present a topic of their choice relevant to the topic of organometallic chemistry that has not been discussed in class. The presentation will last one 50 minute class period. The choice of group members and topic is due by the end of class on November 1<sup>st</sup>. Please provide Prof. Heiden with a sheet of paper listing the two group members and the top two topics from the list below. In the event that two groups have the same first choice, the group that turns in their choices first will receive their first choice and the other group will receive their second choice. A topic not listed can be chosen, but only after approval by Prof. Heiden. The presentation will be worth 50 points, where half of the grade will come from peer evaluations and the other half will come from Prof. Heiden. A question from each presentation will appear on the final exam.

Possible topics include: N<sub>2</sub> Fixation, C-C Linkage of Dienes, Allylic Substitutions, C-H Functionalization, Bioorganometallic Chemistry, Main Group Organometallic Chemistry, Heterogeneous Organometallic Chemistry, Paramagnetic Organometallic Compounds in Catalysis, Lanthanide and Actinide Organometallic Chemistry, Photochemical (non-carbonyl) Organometallic Reactions, Carbonylation of Epoxides/Aziridines, Non-innocent Ligands in Catalysis, CO<sub>2</sub> Reductions.

**Exams:** There will be one midterm exam given as a take-home exam, due at 5:00 pm on October 23<sup>rd</sup>. The midterm exam will cover lectures 1-20. The final exam will be a take-home final that will be due at 5:00 pm on December 12<sup>th</sup>. The final exam will be cumulative, with an emphasis on material from lectures 21-39. All exams will be short answer.

**Tentative Course Schedule:**

Date	Lecture Number/Topic	Textbook Sections
8/21/17	Dr. Heiden at ACS (No Class)	
8/23/17	Dr. Heiden at ACS (No Class)	
8/25/17	Dr. Heiden at ACS (No Class)	
8/28/17	1) Coordination Chemistry/Werner Complexes/Isomers	Chapters 1 & 2 (Crabtree)
8/30/17	2) Crystal & Ligand Field Theory	Chapter 1 (Crabtree)
9/1/17	3) Trans Effect/ Soft vs. Hard Donors	Chapter 1 (Crabtree)
9/4/17	Labor Day (No class)	
9/6/17	4) d-Electron Counts and Types of Ligands	Chapter 1 (Crabtree)
9/8/17	5) Electron Counting and 18 Electron Rule	Chapter 2 (Crabtree)
9/11/17	6) Metal Hydrides	Chapter 3 (Crabtree)
9/11/17	<b>Problem Set #1 Due</b>	
9/13/17	7) Metal Hydrides	Chapter 3 (Crabtree)
9/15/17	8) Metal Alkyls	Chapter 3 (Crabtree)
9/18/17	9) Metal Carbonyls	Chapter 4 (Crabtree)
9/20/17	10) Metal Carbonyls/Metal Phosphines	Chapter 4 (Crabtree)
9/22/17	11) Metal Phosphines	Chapter 4 (Crabtree)
9/25/17	12) $\pi$ Complexes	Chapter 5 (Crabtree)
9/27/17	13) $\pi$ Complexes	Chapter 5 (Crabtree)
9/29/17	Problem Set #2 Due	

<b>Date</b>	<b>Lecture Number/Topic</b>	<b>Textbook Sections</b>
9/29/17	14) Cyclopentadienyl/Metallocene Complexes	Chapter 5 (Crabtree)
10/2/17	15) Metal-Ligand Multiple Bonds	Chapter 11 (Crabtree)
10/4/17	16) Metal-Ligand Multiple Bonds/Metal Heteroatom Complexes	Chapter 11 (Crabtree)
10/6/17	17) Non-Innocent/Redox-Active Ligands	Literature Papers
10/9/17	18) Paramagnetic & High Oxidation State Complexes	Chapter 15 (Crabtree)
10/11/17	19) Oxidative Addition, Reductive Elimination, Insertion and Elimination Reactions	Chapters 6 & 7 (Crabtree)
10/13/17	Problem Set #3 Due	
10/13/17	20) Addition & Abstraction Reactions	Chapter 8 (Crabtree)
10/16/17	21) Catalytic Cycles	Chapter 9 (Crabtree)
10/18/17	22) Hydrogenation Reactions	Chapters 9 & 14 (Crabtree) & Chapter 4 (Steinborn)
10/20/17	23) Hydroformylation Reactions	Chapter 9 (Crabtree) & Chapter 5 (Steinborn)
10/23/17	<b>Take-Home Midterm Exam Due</b>	
10/23/17	24) Metathesis Reactions	Chapter 12 (Crabtree) & Chapter 7 (Steinborn)
10/25/17	25) Oligomerization of Olefins	Chapter 12 (Crabtree) & Chapter 8 (Steinborn)
10/27/17	26) Polymerization of Olefins	Chapter 12 (Crabtree) & Chapter 9 (Steinborn)
10/30/17	27) C-C Coupling Reactions	Chapters 9 & 14 (Crabtree) & Chapter 11 (Steinborn)
11/1/17	28) Hydrocyanation, Hydrosilylation, & Hydroamination	Chapter 9 (Crabtree) & Chapter 12 (Steinborn)
11/3/17	29) Oxidation of Olefins & Alkanes	Chapters 9 & 14 (Crabtree) & Chapter 6 (Steinborn)
11/6/17	30) Physical Methods in Organometallic Chemistry	Chapter 10 (Crabtree)
11/8/17	31) Physical Methods in Organometallic Chemistry	Chapter 10 (Crabtree)
11/10/17	Veteran's Day (No class)	
11/13/17	Problem Set #4 Due	
11/13/17	32) Chemical Shifts of Organometallic Compounds	Chapter 10 (Crabtree) & Chapter 6 (Pregosin)
11/15/17	33) Coupling Constants of Organometallic Compounds	Chapter 10 (Crabtree) & Chapter 7 (Pregosin)
11/17/17	Dr. Heiden at UC-Irvine and UC-Santa Barbara (No Class)	
11/20/17	Thanksgiving Break (No Class)	
11/22/17	Thanksgiving Break (No Class)	
11/24/17	Thanksgiving Break (No Class)	
11/27/17	34) Solving NMR Problems	Chapter 11 (Pregosin)
11/29/17	35) Special Topics Presentations	
12/1/17	36) Special Topics Presentations	
<b>Date</b>	<b>Lecture Number/Topic</b>	<b>Textbook Sections</b>

12/4/17	37) Special Topics Presentations	
12/6/17	38) Special Topics Presentations	
12/8/17	39) Special Topics Presentations	
12/8/17	Problem Set #5 Due	
12/12/17	<b>Take-Home Final Exam is due by 5:00 pm</b>	

**Students with Disabilities:** Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center (Washington Building 217; Phone: 509-335-3417) to schedule an appointment with an Access Advisor. All accommodations MUST be approved through the Access Center (335-3417, <http://accesscenter.wsu.edu>, [Access.Center@wsu.edu](mailto:Access.Center@wsu.edu)).

**Academic Integrity:** I encourage you to work with classmates on assignments. However, each student must turn in original work. No copying will be accepted. Students who violate WSU's Standards of Conduct for Students will receive an F as a final grade in this course, will not have the option to withdraw from the course, and will be reported to the Office Student Standards and Accountability. Cheating is defined in the Standards for Student Conduct WAC 504-26-010 (3). It is strongly suggested that you read and understand these definitions.

**Safety and Emergency Notification:** Classroom and campus safety are of paramount importance at Washington State University, and are the shared responsibility of the entire campus population. WSU urges students to follow the "Alert, Assess, Act," protocol for all types of emergencies and the "Run, Hide, Fight" response for an active shooter incident. Remain ALERT (through direct observation or emergency notification), ASSESS your specific situation, and ACT in the most appropriate way to assure your own safety (and the safety of others if you are able). Please sign up for emergency alerts on your account at MyWSU. For more information on this subject, campus safety, and related topics, please view the FBI's Run, Hide, Fight video and visit the WSU safety portal.

**Assigning Incompletes:** University policy (Acad. Reg. #90) states that Incompletes may only be awarded if: "the student is unable to complete their work on time due to circumstances beyond their control".

**Important Dates and Deadlines:** Students are encouraged to refer to the academic calendar often to be aware of critical deadlines throughout the semester. The academic calendar can be found at <http://registrar.wsu.edu/academic-calendar/>.