CHEM 430/530: Physical Organic Chemistry

M/W/F 1:30 – 2:20 pm, BAG 260
Th (Tutorial) 1:30 – 2:20, BAG 260

COURSE OBJECTIVES:

This course is designed for first year graduate students or advanced undergraduates with a desire to use fundamental principles of organic chemistry to predict structure and reactivity. A broad overview of organic reactions with an emphasis on mechanism will be covered. This course assumes a firm understanding of organic chemistry at the sophomore level and builds on that foundation. By the end of this course, students should be able to propose reaction pathways using arrow-pushing mechanisms and be able to justify these pathways using fundamental physical organic principles such as frontier molecular orbital theory, resonance, sterics, electrostatics, and thermodynamics. CHEM 430/530 is a prerequisite for CHEM 431/531.

INSTRUCTOR:

Professor Matthew Golder (goldermr@uw.edu)
CHB 204H
Office hours: Wednesdays (9 – 10a) and Fridays after class until ~3:30p in CHB204H

Teaching Assistant: Meredith Pomfret (mpomfr@uw.edu)
Teaching Assistant: Sarah Zeitler (szeitler@uw.edu)

COURSE WEBSITE, COMMUNICATION, & TECHNOLOGY:

The course will be run synchronously (M/W/F and optional Th tutorial). We will do our best to record all lectures with Panopto; you can find these recordings on Canvas.

Canvas: https://canvas.uw.edu/courses/1477114
Questions regarding content on problem sets and exams should be directed to the Canvas discussion board. Chances are high that if you have a question, someone else likely has a question as well. I will answer questions on Canvas for the whole class to see.

For all email correspondences, please include CHEM 430 or CHEM 530 in the subject line. Please only email from your @uw.edu account; emails from personal accounts may be inadvertently missed.

TEXTBOOKS:

E. V. Anslyn & D. A. Dougherty. *Modern Physical Organic Chemistry.* University Science Books: Sausalito, CA, 2006.
(Note: Anslyn & Dougherty is a "classic" reference book. You'll likely use it to look up information for the duration of your graduate career and beyond. However, due to shared textbook accessibility during COVID, we will do our best to post PDFs of the relevant sections on Canvas; the material should only be used for the purposes of this course).

I. Fleming. *Molecular Orbitals and Organic Chemical Reactions.* John Wiley & Sons: New York, 2010.
(Note: This book is available online through UW Libraries as a PDF from any UW-campus/VPN connection -- https://onlinelibrary.wiley.com/doi/book/10.1002/9780470689493)

Also recommended for graduate students:
F. A. Carey and R. A. Sundberg. *Advanced Organic Chemistry. Part A. Structure and Mechanism, 5th Ed.* Kluwer Academic/Plenum Publishers, New York, 2007.

A.J. Kirby, *Stereoelectronic Effects*. Oxford Scientific Publishers, 1996.
(Note: Readings from Kirby will be posted on Canvas for use in this course only).
Additional articles and handouts will be assigned periodically for reading.

WEEKLY TAKE HOME CHALLENGES (THCs):

Take home challenges (i.e., problem sets) will be assigned throughout the course, roughly weekly (nine in total). THCs are the main way to assess your newfound knowledge. You are welcome to work in groups but I ask that you only write down answers you are comfortable defending. Ultimately, this is an upper level course and your goal should be to learn and understand as much material as possible as opposed to simply "getting a good grade". You may use your notes and books for the THCs, but please do not use Scifinder, Reaxys, Google Scholar, etc to look up the original references. Except for religious reasons (see below), all other unavoidable conflicts will need to be approved by the Chemistry Department. You may submit a request here (please do not email staff directly): https://chem.washington.edu/student-absences

THCs will be graded and you will receive feedback. Electronic versions of the THCs will be posted on Canvas. Please hand in your neatly written (on as many pieces of 8.5"x11" paper as you need) to us at the beginning of class. Due dates/times will be listed on each THC and Canvas. Solutions will also be posted on Canvas prior to the Thursday tutorials. Your lowest grade will be dropped.

TUTORIALS:

We will go over problem sets during the optional tutorials (Thursdays, 1:30-2:20p).

FINAL TAKE HOME CHALLENGE (THC):

Cumulative, Assigned on M 12/13 and due TBA

PRESENTATIONS (CHEM 530 ONLY):

Graduate students will be responsible for preparing a short talk (~15 minutes) on a young (pre-tenure) organic chemistry faculty member. You will be broken into teams of 4 to prepare and present. Undergraduates in CHEM 430 will not prepare presentations but are expected to attend the sessions. These presentations will be periodically scheduled during the quarter (see dates below). I will provide a list of assigned "topics". One major goal of this assignment is to expose everyone to the broad/diverse nature of organic chemistry (both personnel and topics). You will peer review each presentation. ***Slides are due Friday 10/22; you will be randomly assigned to present on 10/22, 11/5, or 12/10 and should be prepared to present when it is your group's turn.***

GRADING:

430: Final THC (25%), weekly THCs (70%), presentation peer review (5%)
530: Final THC (25%), weekly THCs (60%), presentation (10%), presentation peer review (5%)

RELIGIOUS ACCOMODATIONS:

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at Religious Accommodations Policy (https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/). Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request form:
https://registrar.washington.edu/students/religious-accommodations-request/.

TENTATIVE SCHEDULE (SUBJECT TO CHANGE):

Lecture #	Date	Week #	Topics
1	W 9/29	1	Introduction, Bonding/Molecular Orbitals, Hybridization I
2	F 10/1	1	Hybridization II, Arrow Pushing
3	M 10/4	2	Molecular Orbital Trends, Energy Diagrams
4	W 10/6	2	"4 Types of Energy", Kinetics and Selectivity
5	F 10/8	2	TS Theory (Hammond Postulate/Curtin-Hammett), Carbocations (Empty p-orbital) I- SN1 Rxns, Stability
6	M 10/11	3	Carbocations (Empty p-orbital) II- Lone Pair v. Pi v. Sigma Donation, norbornyl cations, cyclopropyl cations
7	W 10/13	3	Carbocations (Empty p-orbital) III- More Sigma Donation (beta metal carbocations, neighboring group effects, solvent effects)
8	F 10/15	3	Addition to π* I- Additions to C=O (Cram model, Felkin-Anh)
9	M 10/18	4	Addition to π* II- Additions to C=O (Lewis Acid, Relative trends)
10	W 10/20	4	Addition to π* III- Additions to C=O + C=N (Organocatalysis/LUMO-lowering reactions, Reductive amination, Conjugate addition)
P	F 10/22	4	Presentations (3 groups present)
11	M 10/25	5	Addition to σ* I- Proton transfer, SN2 + Addition to σ* II- Steric effects, SN1 v. SN2 v. SN2'
12	W 10/27	5	Addition to σ* III- Migratory rearrangements (Pinacol, Tiffeneau-Demjanov, Wolff, Hofmann, Beckman, Baeyer-Villiger)
13	F 10/29	5	Finish σ* III (Hofmann, Beckmann, B-V, Migratory Apptitutde, Orbitals)
14	M 11/1	6	Elimination Reactions I- E1 v. E2 v. E1cb
15	W 11/3	6	Elimination Reactions II- Beta metals, Peterson Olefination, Grob, Thermal
P	F 11/5	6	No Class, Work on THC5
16	M 11/8	7	Nucleophlic filled n orbitals I- Acid/Base, pKa
P	W 11/10	7	Presentations (3 groups present)
17	F 11/12	7	Nucleophilic filled n orbitals II- Anions, Organometallics (-Li, -Mg, -Cu)
18	M 11/15	8	Nucleophilic π orbitals I- Heteroatom electrophiles (H-X addition, epoxidation, hydroboration/oxidation/migration)
19	W 11/17	8	Nucleophilic π orbitals II- Carbon-carbon bond formation (Prins, allylation/crotylation, enols/enamines/enolates: regioselectivity… thermodynamic v. kinetic) Nucleophilic π orbitals III- Carbon-carbon bond formation (Finish enols/enamines/enolates: C-alkylation v. O-acylation, Ireland TS, Z-T TS, stereoselectivity)

20	F 11/19	8	Nucleophilic σ orbitals- Hydrides Other Stereoelectronic Effects I- Definition, Anomeric Effect, Cyclic Structures
21	M 11/22	9	Other Stereoelectronic Effects II- Alkanes, Alkenes, Conformational analysis & A values, Baldwin's Rules
THANKSGIVING (No Class)	W 11/24	9	No Class
THANKSGIVING (No Class)	F 11/26	9	No Class
22	M 11/29	10	Pericyclic Reactions I- Introduction + Electrocyclization
23	W 12/1	10	Pericyclic Reactions II- Finish Electrocyclizations + Cycloaddition
24	F 12/3	10	Pericyclic Reactions III- Finish Cycloaddition, Sigmatropic
25	M 12/6	11	Pericyclic Reactions IV- Chelotropic + Group Transfer
26	W 12/8	11	Single-Electron Chemistry + Photoredox Catalysis
P	F 12/10	11	Presentations (3 groups present)
Final	M 12/14		Cumulative THC Assigned Today