SYLLABUS

CHEM 331
Sections 02 (M/W/F 10:00 – 10:50 am) and 03 (M/W/F 11:00 – 11:50 am)
Spring 2023
DeMille Hall 103

Instructor's Name: Dr. Allegra Liberman-Martin
Instructor's Email: libermanmartin@chapman.edu
Instructor's office hours: Mondays and Wednesdays, 4:00 pm to 6:00 pm in Keck 236

Textbooks/Materials: Organic Chemistry, Author: Klein, Publisher: John Wiley & Sons, Incorporate, Edition: 3rd, Year Published: 2017 (**required**)

Course Description: *Prerequisites, Chem 230, 230L.* CHEM 331 is the second semester of a two-semester (one year) lecture course in organic chemistry; a continuation of learning some of the fundamentals of organic chemistry. Topics of discussion will again be structure and properties of organic compounds, with additional functional groups, nomenclature, stereochemistry, and spectroscopic methods of analysis. There will be an emphasis on the relationship between structure, functionality and reactivity in organic compounds; as well as the reaction mechanism for many of these organic reactions. Synthetic organic chemistry will be an important part of this course.

Course-Wide Intended Learning Outcomes: At the end of this course, each student will be able to:

- Describe, and give examples of the basic principles, concepts, and theories from the year of organic chemistry, including the central role of the scientific method and the importance of observation.
- Apply reasoning skills acquired in the classroom to solve problems through assigned homework sets, guided inquiries and laboratory exercises.
- Apply the scientific method to evaluate and analyze data and draw conclusions based upon that analysis.

Program-Wide Intended Learning Outcomes: In addition to the above learning outcomes, CHEM 331 supports, in part, the learning outcomes for the B.Sc. in Chemistry:

- Apply the scientific method to solve problems
- Demonstrate written, visual and oral presentation skills to communicate scientific knowledge
- Apply critical thinking and analytical skills to design and execute a scientific experiment, thoroughly analyze the results, and arrive at well-reasoned scientific conclusions.
- Demonstrate an understanding of core knowledge in chemistry

Class Structure:
Prior to each class time, you will be expected to:

- Watch the **pre-class videos** made by the instructor
- Complete the assigned **pre-class readings**
- Take the **pre-class quiz**

During class, you will complete an **in-class worksheet** in groups with guidance from the instructor.

After each class, you will be expected to:

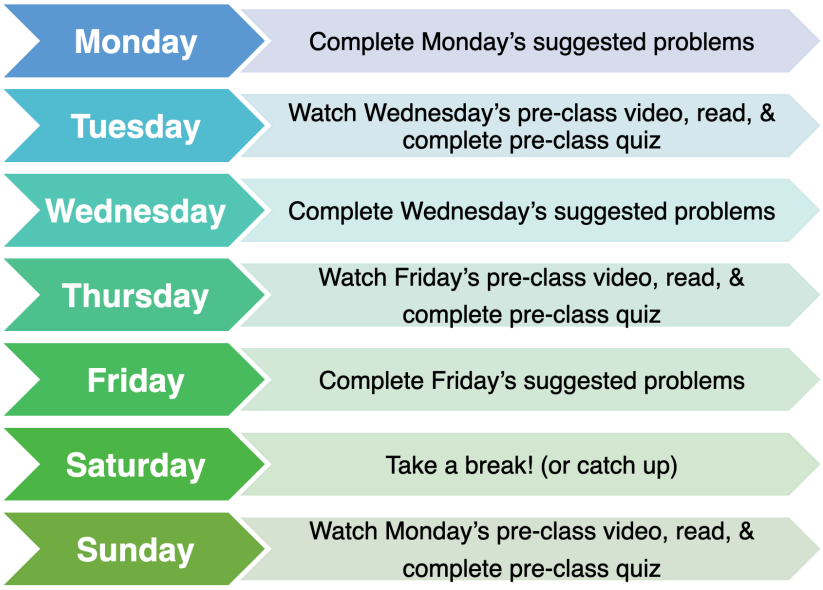
- Solidify your learning by **solving the suggested problems**.

- **Attend office hours and SI sessions** with questions you have on any of the concepts introduced in the pre-class materials, in-class worksheets, or in the suggested problems.

Success Strategies: Your deep understanding of fundamental organic chemistry concepts **coupled** with frequent and consistent practice of conceptual and algorithmic problems is crucial for success in this course. And as we progress through the course material, you will build on, and reinforce, fundamental concepts from previous chapters. As a result, your instructor has designed this course to encourage necessary **daily** practice (see Class Structure). In addition, here are some additional best-practices that you are encouraged to implement:

- Dedicate 2 hours to studying and solving organic chemistry problems every day.
- Attend each class prepared to solve more problems. Ask questions!
- Attend office hours frequently with specific questions on concepts or problems you have attempted.
- **Attend Supplemental Instructor (SI) Sessions Once Per Week**: All SIs are students who not only excelled in the course in previous years but are also trained to teach effectively. Each SI will engage you in instructor-approved practice problems. They will also answer any ongoing questions you have.

Recommended workflow:



Pre-class Quizzes: An online quiz will be assigned before every class (except on test days). Pre-class quizzes will be posted on Canvas ≥24 hours before the upcoming class and will be **due at 8:30 am the day of class**. Use this to assess your understanding of the assigned pre-class reading/video. **There are no make-up quizzes and your lowest six pre-class quizzes will be dropped**.

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Test and Final Exam Authorizations: Before each test or the final exam, your instructor will provide you with one 4 x 6-inch notecard. You must write your name on the notecard, and you may write any information that you choose on both sides of the notecard. You must submit this notecard when you turn in your test.

During tests and the final exam:

- You are authorized to use your notecard along with a calculator of your choice.
- You are not authorized to speak with anyone other than your instructor or use the internet while completing tests.

Course Policy on Unauthorized Assistance during Tests: The organic chemistry faculty take cases of academic integrity violations very seriously. All suspected academic integrity violations for any tests or the final exam will be investigated fully according to Chapman's Academic Integrity Policy. The baseline sanction for an academic integrity violation on a test or the final exam is an 'F' in the course.

Students with Testing Accommodations who take accommodated exams at the Testing Center will reserve a time on the scheduled test and final exam dates of February 17, 2023; March 03, 2023; March 17, 2023; April 07, 2023; April 28, 2023; and May 18, 2023.

Make-Up Policy for Tests ONLY: The only reasons that qualify for a make-up test or final exam are: (1) serious illness with proper documentation (i.e., doctor's note or Dean of Students' Letter), or (2) required attendance at an OFFICIAL University event with written notification to the professor PRIOR to the exam and as early as possible. Please note that Greek events are not considered official University events.

Evaluation: Your grade in this course is based on:

- Pre-class quizzes (lowest six quiz scores dropped) (11%)
- Five tests (lowest test score dropped) (64%)
- Final exam (25%)

Assessment	**Date**
Pre-class quizzes	Before each class day
Test 01	Friday, February 17
Test 02	Friday, March 03
Test 03	Friday, March 17
Test 04	Friday, April 07
Test 05	Friday, April 28
Final cumulative exam	**Section 02** (class at 10:00 am): Thursday, May 18, 1:30 pm – 4:00 pm **Section 03** (class at 11:00 am): Friday, May 19, 8:00 am – 10:30 am

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Course Grading Rubric:

Score (%)	Grade	Score (%)	Grade
92 – 100	A	71 – 75	C
89 – 92	A–	67 – 71	C–
86 – 89	B+	62 – 67	D+
82 – 86	B	52 – 62	D
78 – 82	B–	47 – 52	D–
75 – 78	C+	< 47	F

Extra Credit Policy: After Tests 1–5, a link to a post-test survey will be provided. This survey is designed to help you analyze your test performance and find strategies that work best for you in learning the material. Completing the post-test survey one time after a given test will result in one percentage point of extra credit being added to your test percentage score.

Course Electronic Access: Course materials including the syllabus are available on Canvas. The Canvas site will be the primary repository of all course components, including pre-class videos, weekly assignments, and answer keys.

Academic Integrity Policy: Chapman University is a community of scholars that emphasizes the mutual responsibility of all members to seek knowledge honestly and in good faith. Students are responsible for doing their own work and academic dishonesty of any kind will be subject to sanction by the instructor/administrator and referral to the university Academic Integrity Committee, which may impose additional sanctions including expulsion. Please see the full description of Chapman University's policy on Academic Integrity at www.chapman.edu/academics/academicintegrity/index.aspx.

Students with Disabilities Policy: In compliance with ADA guidelines, students who have any condition, either permanent or temporary, that might affect their ability to perform in this class are encouraged to contact the Disability Services Office. If you will need to utilize your approved accommodations in this class, please follow the proper notification procedure for informing your professor(s). This notification process must occur more than a week before any accommodation can be utilized. Please contact Disability Services at (714) 516–4520 or visit www.chapman.edu/students/student-health-services/disability-services if you have questions regarding this procedure or for information or to make an appointment to discuss and/or request potential accommodations based on documentation of your disability. Once formal approval of your need for an accommodation has been granted, you are encouraged to talk with your professor(s) about your accommodation options. The granting of any accommodation will not be retroactive and cannot jeopardize the academic standards or integrity of the course.

Equity and Diversity Policy: Chapman University is committed to ensuring equality and valuing diversity. Students and professors are reminded to show respect at all times as outlined in Chapman's Harassment and Discrimination Policy. Please see the full description of this

policy at http://www.chapman.edu/faculty-staff/human-resources/eoo.aspx. Any violations of this policy should be discussed with the professor, the dean of students and/or otherwise reported in accordance with this policy.

Student Support at Chapman University: Over the course of the semester, you may experience a range of challenges that interfere with your learning, such as problems with friend, family, and or significant other relationships; substance use; concerns about personal adequacy; feeling overwhelmed; or feeling sad or anxious without knowing why. These mental health concerns or stressful events may diminish your academic performance and/or reduce your ability to participate in daily activities. You can learn more about the resources available through Chapman University's Student Psychological Counseling Services here: https://www.chapman.edu/students/health-and-safety/psychological-counseling/

TENTATIVE SCHEDULE
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Wk	Day	Date	Topic	Readings **Chapter:** Subchapters	Suggested Problems **Chapter**: Questions
01	M	01/30/23	**Spectroscopy 1**: Syllabus + intro to spectroscopy	**14**: 01	
	W	02/01/23	**Spectroscopy 2**: IR wavenumber, intensity, shape	**14**: 02–05	**14**: 01–02, 03(a,b), 04-11, 52
	F	02/03/23	**Spectroscopy 3**: IR spectrum + HDI/ DOU	**14**: 06, 07, 16	**14**: 12–17, 29–37, 42(a,b,d) 45, 48, 49, 51, 56
			Integrated and Challenge Problems: **14**: 61, 63, 65, 69, 71–73		
02	M	02/06/23	**Spectroscopy 4**: NMR spectrum, # of signals + topicity + chemical equivalence	**15**: 01–04	**15**: 1–7, 32, 35, 41, 45, 46, 50
	W	02/08/23	**Spectroscopy 5**: Chemical shifts: inductive and anisotropic effects; integration	**15**: 05–06	**15**: 8–14, 47, 51, 52
	F	02/10/23	**Spectroscopy 6**: Multiplicity + 1H NMR analysis + pattern recognition	**15**: 07–10	**15**: 15–25, 38, 42, 49, 53, 57, 58
03	M	02/13/23	**Spectroscopy 7**: ^{13}C NMR + DEPT ^{13}C NMR	**15**: 10–13	**15**: 26–31, 33, 34, 36, 37, 39, 40, 43, 44, 48, 54–56, 59–62
	W	02/15/23	**Spectroscopy 8:** Review		
			Integrated and Challenge Problems: **15**: 63–69, 71–77, 81		
	F	02/17/23	**Test 01**		
04	M	02/20/23	**Conjugated Pi Bonds**: Structure + stability + MOT + UV-Vis	**16**: 01–03, 11	**16**: 1–5, 27, 28, 31–33, 41, 47–49, 59
	W	02/22/23	**Pericyclics 1**: Diels-Alder reaction + stereochemical outcomes	**16**: 06–07	**16**: 13–17, 39, 40, 42, 43, 44, 45, 46, 57
	F	02/24/23	**Pericyclics 2**: Diels-Alder reaction + regiochemical outcomes + cycloaddition MO	**16**: 07–08	**16**: 18, 19
			Integrated and Challenge Problems: **16**: 60, 61, 64, 66–69, 74–78		
05	M	02/27/23	**Aromatics 1**: Introduction + Structure + Stability	**17**: 01–05	**17**: 1(a–d), 2, 3, 6–15, 24, 25, 30–41, 47
	W	03/01/23	**Aromatics 2**: Reactions at the benzylic position + reduction + spectroscopic considerations	**17**: 06–08	**17**: 17, 18(a–e), 20–23, 42, 43, 45, 46
			Integrated and Challenge Problems: **17**: 48, 49, 51–54, 57–60, 61, 63, 66, 68, 69, 71		

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	F	03/03/23	**Test 02**		
06	M	03/06/23	**Aromatics 3a**: Electrophilic aromatic halogenation, Friedel-Crafts alkylation	**18**: 01, 02, 05	**18**: 1, 5, 6, 7, 48, 49(a,d,e), 50, 58
	W	03/08/23	**Aromatics 3b:** Friedel-Crafts acylation, electrophilic aromatic sulfonation + nitration	**18**: 03, 04, 06	**18**: 2, 3, 4, 8–10, 49(b,c)
	F	03/10/23	**Aromatics 4**: Activating + deactivating groups	**18**: 07–10	**18**: 11–17, 39–41, 43, 44, 60–62
07	M	03/13/23	**Aromatics 5**: Directing + blocking effects + synthesis strategies	**18**: 11–12	**18**: 18–22, 24–29, 38, 42, 45(a,d–h), 46, 47, 52–55, 63–65, 67(b,c,d,e,g,h), 69–71
	W	03/15/23	**Aromatics 6**: Synthesis strategies		
			Integrated and Challenge Problems: **18**: 73, 74, 75b, 76–80, 82–85, 88–90, 93		
	F	03/17/23	**Test 03**		
08	M	03/20/23	**SPRING BREAK**		
	W	03/22/23	**SPRING BREAK**		
	F	03/24/23	**SPRING BREAK**		
09	M	03/27/23	**Carbonyls 1**: Aldehydes/ketones preparation, nucleophilic addition reactions, and spectroscopy	**19**: 01–04, 13	**19**: 5, 6, 49
	W	03/29/23	**Carbonyls 2**: Oxygen nucleophiles (nucleophilic addition + hydrolysis)	**19**: 05, 07(start)	**19**: 7–9, 11–13, 23(a,c,f), 24, 55, 56, 58, 61(c,d), 63(c), 65, 68, 71, 72
	F	03/31/23	**Carbonyls 3**: Nitrogen nucleophiles (nucleophilic addition + hydrolysis)	**19**: 06, 07(end)	**19**: 14, 15, 17–21, 23(b,d,e), 25, 59, 60, 61(a,b), 62, 63(a,b), 70
10	M	04/03/23	**Carbonyls 4**: Hydrogen and carbon nucleophiles	**19**: 09, 10	**19**: 28–31, 34–38, 50–52
	W	04/05/23	**Carbonyls 5**: Tools for synthesis (desulfurization, Wolff-Kishner reduction, cyanohydrin formation, and Baeyer-Villiger oxidation)	**19**: 08, 06(end), 10(mid), 11, 12	**19**: 22 (predict the product only; not the mechanism), 26, 27, 32, 33, 39, 40(a-f), 42, 54, 57, 64, 66, 67a, 69, 73
			Integrated and Challenge Problems: **19**: 74–80, 82–84, 88, 91–94		
	F	04/07/23	**Test 04**		
11	M	04/10/23	**Carbonyls 6**: Carboxylic acid acidity + preparation + reactions	**20**: 03–05	**20**: 4-6, 9-11, 35, 36(a,b,d), 43, 45(b,c), 46a

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	W	04/12/23	**Carbonyls 7**: Introduction and reactivity of carboxylic acid derivatives	**20**: 06–07	**20**: 14, 15
	F	04/14/23	**Carbonyls 8**: Preparation and reactions of acid chlorides	**20**: 08–09	**20**: 16–18, 44, 45a, 46b, 57, 61(a,d)
12	M	04/17/23	**Carbonyls 9**: Preparation and reactions of esters	**20**: 10–11	**20**: 20–23, 45d, 46(e,h), 47, 52, 55, 58(a), 61(b,c,e), 62, 63, 64(a)
	W	04/19/23	**Carbonyls 10**: Preparation and reactions of amides and nitriles	**20**: 12–13	**20**: 24–29, 46(c,g), 60
	F	04/21/23	**Carbonyls 11**: Synthesis and spectroscopy	**20**: 14–15	**20**: 30(a,b,d,e,g,h,i,j), 31–34, 41, 42, 48, 49, 50(a,b,c), 51, 53, 54, 56, 59, 69
			Integrated and Challenge Problems: **20**: 71–80, 82, 87–89		
13	M	04/24/23	**Carbonyls 12**: Introduction to alpha carbon chemistry: enols + enolates	**21**: 01	**21**: 1–7, 47–56, 59, 60, 70
	W	04/26/23	**Carbonyls 13**: Review		
			Integrated and Challenge Problems: **21**: 89, 98		
	F	04/28/23	**Test 05**		
14	M	05/01/23	**Carbonyls 14**: Alpha halogenation, alpha alkylation	**21**: 02, 05(start)	**21**: 8–13, 29, 30, 65, 74(a,b)
	W	05/03/23	**Carbonyls 15**: Aldol addition and condensation	**21**: 03	**21**: 14–23, 57, 58, 61–64, 66, 71, 75, 81
	F	05/05/23	**Carbonyls 16**: Claisen condensation, acetoacetic acid + malonic ester synthesis	**21**: 04, 05(end)	**21**: 24–28, 31, 33, 67–69, 79, 80
15	M	05/08/23	**Carbonyls 17**: Conjugate additions: Michael addition + Stork enamine synthesis	**21**: 06 (except Robinson Annulation)	**21**: 35–39, 83, 84
	W	05/10/23	**Carbonyls 18:** Synthesis strategies	**21**: 07	**21**: 42, 43, 45, 72, 73, 76–78, 82, 87, 88
			Integrated and Challenge Problems: **21**: 91–94, 96, 97, 99, 101, 103–108, 110, 113–115		
	F	05/12/23	**Carbonyls 19:** Review		

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Intended Learning Outcomes	Textbook chapter	Unit Test
Spectroscopy: Define electromagnetic radiation.	**14**	**1**
Spectroscopy: Determine the relationship between wavelength, frequency, and energy of electromagnetic radiation.	**14**	**1**
Spectroscopy: Define IR spectroscopy; determine the associated region in the electromagnetic spectrum, the method of generating IR spectra, and the information obtained from each spectrum.	**14**	**1**
Spectroscopy: Predict the wavenumber, intensity, and shape of an IR absorption from its molecular structure.	**14**	**1**
Spectroscopy: Identify the absorption bands of X–H, triple, double, and single bonds on an IR spectra.	**14**	**1**
Spectroscopy: Distinguish between compounds based on their IR spectra.	**14**	**1**
Spectroscopy: Use degree of unsaturation (in addition to other spectroscopic tools) to identify molecular structure.	**14**	**1**
Spectroscopy: Define diamagnetism and identify its implications in NMR spectroscopy.	**15**	**1**
Spectroscopy: Explain how diamagnetic anisotropy affects the chemical shifts of protons near pi (π) bonds.	**15**	**1**
Spectroscopy: Explain the relationship between the external magnetic field (B_0), the energy difference (ΔE) between α and β spin states, and the operating frequency of an NMR.	**15**	**1**
Spectroscopy: Determine whether two protons in a molecule are homotopic, enantiotopic, or diastereotopic.	**15**	**1**
Spectroscopy: Identify chemically equivalent protons in any compound.	**15**	**1**
Spectroscopy: Predict the number of signals in an NMR spectrum for any compound.	**15**	**1**
Spectroscopy: Predict the chemical shifts for all protons in an compound.	**15**	**1**
Spectroscopy: Determine the number of protons giving rise to each signal on an NMR.	**15**	**1**
Spectroscopy: Interpret the splitting patterns of each signal on an ^{1}H NMR spectrum.	**15**	**1**
Spectroscopy: Predict the ^{1}H NMR spectrum for any compound.	**15**	**1**
Spectroscopy: Propose the structure for a compound consistent with a given ^{1}H NMR spectrum.	**15**	**1**
Spectroscopy: Predict the number of signals and the location of each signal in a ^{13}C NMR spectrum.	**15**	**1**
Spectroscopy: Use data from multiple spectra (IR, ^{1}H NMR, and/or ^{13}C NMR) to identify unknown compounds.	**15**	**1**

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Intended Learning Outcomes	Textbook chapter	Unit Test
Conjugated Pi Bonds: Predict the relative stability of conjugated pi (π) systems.	**16**	**2**
Conjugated Pi Bonds: Draw molecular orbitals for conjugated pi (π) systems in their ground and excited states.	**16**	**2**
Conjugated Pi Bonds: Estimate λ_{max} for simple conjugated pi (π) systems using the Woodward-Fieser rules.	**16**	**2**
Conjugated Pi Bonds: Describe the information obtained from a UV-Vis spectrum.	**16**	**2**
Pericyclics: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for Diels-Alder reactions.	**16**	**2**
Pericyclics: Predict the major product(s) and propose reasonable mechanisms for cycloaddition reactions.	**16**	**2**
Pericyclics: Determine if a cycloaddition is symmetry allowed or symmetry forbidden by using MO theory.	**16**	**2**
Aromatics: Identify benzene and its common derivatives.	**17**	**2**
Aromatics: Identify ortho, meta, and para relationships on benzene rings.	**17**	**2**
Aromatics: Determine whether a lone pair participates in aromaticity.	**17**	**2**
Aromatics: Identify aromatic, nonaromatic, and antiaromatic compounds and rationalize experimental observations involving aromatic stabilization.	**17**	**2**
Aromatics: Predict the major product(s) and propose the appropriate reagents for aromatic reductions.	**17**	**2**
Aromatics: Predict the major product(s) and propose the appropriate reagents for free-radical bromination, eliminations, oxidations, and substitutions at the benzylic position.	**17**	**2**
Aromatics: Analyze spectroscopic data of aromatic compounds.	**17**	**2**
Aromatics: Use reactions at the benzylic position and aromatic reductions in synthesis.	**17**	**2**
Aromatics: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms of electrophilic aromatic halogenation, Friedel-Crafts alkylations, Friedel-Crafts acylations, sulfonation, and nitration reactions.	**18**	**3**
Aromatics: Use sigma complex resonance structures to explain reactivity differences in electrophilic aromatic substitution reactions.	**18**	**3**
Aromatics: Identify whether a benzene substituent is activating or deactivating in an electrophilic aromatic substitution reaction.	**18**	**3**

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Aromatics: Identify whether a benzene substituent is *ortho/para* or *meta* directing in an electrophilic aromatic substitution reaction.	**18**	**3**
Aromatics: Identify when blocking groups are needed in synthesis strategies involving electrophilic aromatic substitutions.	**18**	**3**
Aromatics: Determine how steric effects control the regioselectivity of electrophilic aromatic substitutions.	**18**	**3**
Aromatics: Use electrophilic aromatic substitution reactions in synthesis.	**18**	**3**
Carbonyls: Predict the major product(s) and propose the appropriate reagents for the preparation of aldehydes and ketones.	**19**	**4**
Carbonyls: Rationalize the reactivity of aldehydes and ketones.	**19**	**4**
Carbonyls: Analyze spectroscopic data for aldehydes and ketones.	**19**	**4**
Carbonyls: Propose reasonable mechanisms of nucleophilic addition to aldehydes and ketones under acidic and basic conditions.	**19**	**4**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for the nucleophilic addition of oxygen, sulfur, nitrogen, carbon, and hydrogen nucleophiles to aldehydes and ketones.	**19**	**4**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for the hydrolysis of acetals, hemiacetals, imines, and enamines.	**19**	**4**
Carbonyls: Predict the major product(s) and propose the appropriate reagents for desulfurization and Wolff-Kishner reduction of aldehydes and ketones.	**19**	**4**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for cyanohydrin formation.	**19**	**4**
Carbonyls: Predict the major product(s) and propose appropriate reagents for cyanohydrin reduction and cyanohydrin hydrolysis.	**19**	**4**
Carbonyls: Predict the major product(s) and propose appropriate reagents for Baeyer-Villiger oxidations.	**19**	**4**
Carbonyls: Use nucleophilic addition reactions to aldehydes and ketones in synthesis.	**19**	**4**
Carbonyls: Rationalize the acidity of carboxylic acids.	**20**	**5**
Carbonyls: Predict the major product(s) and propose the appropriate reagents for the preparation of carboxylic acids.	**20**	**5**

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Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for the reduction of carboxylic acids.	**20**	**5**
Carbonyls: Rationalize the relative reactivity of carboxylic acid derivatives.	**20**	**5**
Carbonyls: Propose reasonable mechanisms of nucleophilic substitution of carboxylic acid derivatives using strong and weak nucleophiles, and under acidic and basic conditions.	**20**	**5**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for nucleophilic acyl substitution reactions with acid chlorides, esters, amides, and nitriles.	**20**	**5**
Carbonyls: Use reactions with carboxylic acids and carboxylic acid derivatives in synthesis.	**20**	**5**
Carbonyls: Analyze spectroscopic data of carboxylic acid derivatives.	**20**	**5**
Carbonyls: Predict and rank the acidity of alpha protons.	**21**	**5**
Carbonyls: Identify keto-enol tautomers.	**21**	**5**
Carbonyls: Propose reasonable mechanisms of tautomerizations under acidic and basic conditions.	**21**	**5**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for the preparation of enols and enolates.	**21**	**5**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for alpha alkylation reactions.	**21**	**6**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for alpha halogenation reactions.	**21**	**6**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for aldol addition and aldol condensation reactions.	**21**	**6**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for Claisen condensation reactions.	**21**	**6**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for acetoacetic acid ester and malonic ester synthesis.	**21**	**6**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for Michael addition reactions.	**21**	**6**
Carbonyls: Predict the major product(s), propose the appropriate reagents, and propose reasonable mechanisms for Stork enamine reactions.	**21**	**6**
Carbonyls: Use reactions at the carbonyl alpha and beta positions in synthesis.	**21**	**6**

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