SYLLABUS 21:160:108 •Organic Biochemistry•Spring 2022•Rutgers University/Newark

COURSE INFORMATION

When: Tuesday & Thursday 10:00 - 11:20 am
Where: Center for Urban & Public Service (CPS) Room 104, 111 Washington Street, Newark; Building Number: 7488
Office Hours: Tuesday 11:30 am -12:30 pm
Life science center 1, 3rd floor office suite reading room

Textbook: “Introduction to General, Organic and Biochemistry” Bettelheim, Cengage 12th edition (see below)

Description: Basic organic chemistry with emphasis on molecules and reactions encountered in biochemistry. Principles of structure and reactivity of organic molecules.

Modality: This course is delivered in person, material available via Canvas

INSTRUCTOR INFORMATION

Instructor: Professor Elena Galoppini
Office: Life Science Center I, 3rd floor office suite LSC 301d
Email: galoppin@newark.rutgers.edu
Office Hours: Tuesday 11:30 am -12:30 pm
Life Science Center I, 3rd floor office suite reading room

IMPORTANT DATES SPRING 2022

Academic Calendar: https://scheduling.rutgers.edu/scheduling/academic-calendar
Classes begin: Tuesday, 18 January
Classes end: Monday 2 May
Spring Break: 12 – 20 March
Spring Exams: 5 – 11 May
Add/Drop/Withdraw: Add/Drop period: January 18 - January 25; Last day to drop with a "W": March 21
# COURSE SCHEDULE

T = Tuesday; Th = Thursday

## JANUARY

<table>
<thead>
<tr>
<th>Day</th>
<th>Subject</th>
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<tbody>
<tr>
<td>T 18</td>
<td>Introduction: Refresher chemistry notions</td>
<td>Virtual via Zoom (Canvas)</td>
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<td>Th 20</td>
<td>Chapt. 10 Intro-Organic Chemistry</td>
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<td>T 25</td>
<td>Chapt. 11 Alkanes</td>
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<tr>
<td>T 1</td>
<td>Chapt. 12 Alkenes &amp; Alkynes &amp; Aromatics</td>
<td>In person CPS 104</td>
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<td>Th 3</td>
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<td>T 8</td>
<td>Chapt. 12</td>
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<td>Th 10</td>
<td>Exam 1: Chapters: Introduction, 10, 11, 12</td>
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<tr>
<td>T 15</td>
<td>Chapt. 13 Alcohols, ethers, thiols</td>
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<td>T 22</td>
<td>Chapt. 14 Chirality</td>
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<td>Th 10</td>
<td>Exam 2: Chapters: 13, 14, 15</td>
<td>12 -20 March Spring Break no classes</td>
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<tr>
<td>T 22</td>
<td>Chapt. 16 Aldehydes and ketones</td>
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<td>Th 24</td>
<td>Chapt. 17 Carboxylic acids</td>
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<td>T 29</td>
<td>Chapt. 17</td>
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<tr>
<td>Th 31</td>
<td>Chapt. 18 Carbox. Anhydrides, esters amides</td>
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<tr>
<td>T 5</td>
<td>Chapt. 19 Carbohydrates</td>
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<td>T 12</td>
<td>Chapt. 20 Lipids</td>
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<td>Th 14</td>
<td>Chapt. 20</td>
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<td>T 19</td>
<td>Exam 3: Chapters: 16, 17, 18, 19, 20</td>
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<td>Chapt. 21 Proteins</td>
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<td>T 26</td>
<td>Chapt. 21</td>
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<td>Th 28</td>
<td>Chapt. 22 Enzymes</td>
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<td>Mon 3</td>
<td>Review session</td>
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May 10 starts at 8:30 comprehensive FINAL EXAM (chapters: Introduction + 10-22)
GRADING POLICY

Exam 1: 30%
Exam 2: 30%
Exam 3: 30%
Final: 40 %

*Two 80-minute exams will count for 60% of the course grade; Make up Policy: The lowest score of the 80-minute exams will be dropped (or an 80-minute exam missed for any reason). The comprehensive final exam will count for the other 40% of the course grade.

About Exam 1,2,3

There will be 3 eighty-minute exams on selected chapters (Exam 1, Exam 2, Exam 3). These will be administered in person and during class period unless University policy changes due to COVID. In-person exams will be closed book, closed note. Of these three, the exam with the worse score OR one missed for any reason, will be dropped. The remaining two will constitute 60% of your grade. By dropping the lowest score/missed exam there will be NO need for additional make-up exams.

- Each exam (Exam 1, Exam 2, Exam 3) will consist of 30 multiple-choice questions (1 point per question, only one answer choice for each question is correct, no open ended questions, 4 choices each question) + 3 bonus questions.
- Everyone, in each exam, will receive 3 bonus questions then the score will be normalized to 30 questions, and the 3 additional questions will be on the top of it. This also means that you can simply skip the 3 questions that you do not wish to answer and still get 100%. (Example: a score of 33 counts as 33/30 = 110%; if 21 then counts as 21/30 = 70%).

About the Final

- The comprehensive (= all material, all chapters) final examination will count for 40% of your grade The exam will be administered at the time and day indicated in the syllabus It will be in person unless University policy changes due to COVID. In-person exams will be closed book, closed note.
- The final will consist of 40 multiple-choice questions (1 point per question, only one answer choice for each question is correct, no open ended questions) + 4 bonus questions.
- Everyone, in the final, will receive 4 bonus questions then the score will be normalized to 40 questions, and the 4 additional questions will be on the top of it. This also means that you can simply skip the 4 questions that you do not wish to answer and still get 100%.

Letter grades will be assigned according to the following scale (scores are percentages of the maximum possible points):

A (100-85), B+ (84-78), B (70-77), C+ (69-65), C (64-55), D (54-45), F (44-0)
SOME COURSE RULES...

- Please be punctual: classes start at 10:00 am exactly
- Emails that do not have proper salutation and signature will be ignored.
- Please feel free to email (galoppin@newark.rutgers.edu) if you need to make an appointment with me

TEXTBOOK & OTHER RESOURCES

Textbook:
Bettelheim/Brown/Campbell/Farrell/Torres Cengage Learning 12th edition

Alternative options:
- The Bookstore has listed Cengage Unlimited as it is the most cost effective option. Students pay $119.99 and have access to All Cengage ebooks as well as all technologies such as OWLv2, WebAssign, MindTap, etc.
- The bookstore has the hardcover book as an option, and a used rental price of $123.99.

Other resources:
- Powerpoints used in class will be made available ahead of time on Canvas
- A summary of lecture will be updated every week and made available on Canvas
SUGGESTED END OF CHAPTER HOMEWORK PROBLEMS FROM TEXTBOOK

Homework will not be graded but selected problems will be in exams. Selected End-of-Chapter Problems from the textbook 12th edition. (note that these numbers do not match the homework EOC problems online)

Solutions to even numbers is provided in a PDF in CANVAS

Chapter 10 (organic)
9, 11, 20, 22, 24, 38, 40, 43, 46, 48, 49, 53.

Chapter 11 (alkanes)
4, 5, 6, 8, 10, 11, 14, 16, 18, 19, 21, 23, 24, 29, 30, 31, 40, 42, 45, 49, 54, 57, 58, 59, 61, 62, 66

Chapter 12 (alkenes, alkynes, aromatics)
1, 4, 5, 6, 9, 10, 12, 13, 14, 15, 16, 19, 21, 22, 24, 29, 31, 32, 36, 40, 42, 46, 55, 56, 58, 59, 60, 61, 62, 65, 67, 68, 76, 81, 89, 94, 98

Chapter 13 (alcohols ethers thiols)
3, 5, 6, 7, 9, 10, 11, 15, 17, 19, 21, 22, 25, 30, 31, 36, 38, 40, 41, 44, 49, 51, 53, 55, 58, 61, 63, 64, 65, 66.

Chapter 14 (chirality)
1, 2, 4, 5, 6, 12, 13, 15, 17, 18, 19, 20, 21, 22, 25, 27, 28, 31, 32, 33, 41, 42, 43.

Chapter 15 (amines)
1, 2, 6, 7, 8, 9, 11, 16, 20, 21, 22, 23, 25, 27, 32, 36, 40, 41, 43, 45, 47, 48, 49, 50, 54.

Chapter 16 (aldehydes and ketones)

Chapter 17 (carboxylic acids)
4, 5, 6, 7, 8, 11, 12, 15, 16, 19, 21, 23, 25, 26, 28, 31, 32, 34, 38, 39, 41, 42, 43, 44, 46.

Chapter 18 (anhydride, esters, amides)
1, 2, 4, 5, 6, 8, 10, 3, 32, 38, 40, 41.

Chapter 19 (carbohydrates)
3, 6, 8, 11, 15, 16, 18, 25, 26, 2936, 41, 42, 43, 44, 54, 57, 60, 61, 68.

Chapter 20 (Lipids)
10, 11, 12, 14, 17, 19, 21, 24, 32, 36, 43, 44, 71, 82, 86, 88, 93, 94

Chapter 21 (Proteins)
6, 14, 19, 26, 39, 51, 55, 56, 59, 62, 75, 85, 87.

Chapter 22 (Enzymes)
1, 4, 5, 10, 11, 15, 17, 23, 25, 61, 67, 70, 77
ACADEMIC POLICIES AND PROCEDURES

ATTENDANCE POLICY.
- Please, review Rutgers University attendance policy, which can be found at http://policies.rutgers.edu/view-policies/academic-%E2%80%93-section-10#2
- You are responsible for material covered in any class that you do not attend. If you miss a class, you must contact a classmate or me for the missed information. If you have a situation that might cause you to miss an entire week of class, discuss it with me as soon as possible.

STUDENT CODE OF CONDUCT AND ACADEMIC INTEGRITY
This course adheres to Rutgers University policies on academic integrity. Please see: http://academicintegrity.rutgers.edu/academic-integrity-policy and http://academicintegrity.rutgers.edu/resources-for-students/

Students are required to adhere to the University Student Code of Conduct delineated in the Rutgers Student Affairs website Student Conduct page: http://studentconduct.rutgers.edu/student-conduct-processes/university-code-of-student-conduct/#1495568095620-2f5ce77d-17dd

ACCOMMODATIONS AND SUPPORT STATEMENT
Rutgers University Newark (RU-N) is committed to the creation of an inclusive and safe learning environment for all students and the University as a whole. RU-N has identified the following resources to further the mission of access and support:

For Individuals with Disabilities: The Office of Disability Services (ODS) is responsible for the determination of appropriate accommodations for students who encounter barriers due to disability. Once a student has completed the ODS process (registration, initial appointment, and submitted documentation) and reasonable accommodations are determined to be necessary and appropriate, a Letter of Accommodation (LOA) will be provided. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at ods.rutgers.edu. Contact ODS at (973)353-5375 or via email at ods@newark.rutgers.edu.

For Individuals who are Pregnant: The Office of Title IX and ADA Compliance is available to assist with any concerns or potential accommodations related to pregnancy. Students may contact the Office of Title IX and ADA Compliance at (973) 353-1906 or via email at TitleIX@newark.rutgers.edu.

For Absence Verification: The Office of the Dean of Students can provide assistance for absences related to religious observance, emergency or unavoidable conflict (e.g., illness, personal or family emergency, etc.). Students should refer to University Policy 10.2.7 for information about
expectations and responsibilities. The Office of the Dean of Students can be contacted by calling (973) 353-5063 or emailing deanofstudents@newark.rutgers.edu.

For Individuals with temporary conditions/injuries: The Office of the Dean of Students can assist students who are experiencing a temporary condition or injury (e.g., broken or sprained limbs, concussions, or recovery from surgery). Students experiencing a temporary condition or injury should submit a request using the following link: https://temporaryconditions.rutgers.edu.

For English as a Second Language (ESL): The Program in American Language Studies (PALS) can support students experiencing difficulty in courses due to English as a Second Language (ESL) and can be reached by emailing PALS@newark.rutgers.edu to discuss potential supports.

For Gender or Sex-Based Discrimination or Harassment: The Office of Title IX and ADA Compliance can assist students who are experiencing any form of gender or sex-based discrimination or harassment, including sexual assault, sexual harassment, relationship violence, or stalking. Students can report an incident to the Office of Title IX and ADA Compliance by calling (973) 353-1906 or emailing TitleIX@newark.rutgers.edu. Incidents may also be reported by using the following link: tinyurl.com/RUNReportingForm. For more information, students should refer to the University’s Student Policy Prohibiting Sexual Harassment, Sexual Violence, Relationship Violence, Stalking and Related Misconduct located at http://compliance.rutgers.edu/title-ix/about-title-ix/title-ix-policies/.

For support related to interpersonal violence: The Office for Violence Prevention and Victim Assistance can provide any student with confidential support. The office is a confidential resource and does not have an obligation to report information to the University’s Title IX Coordinator. Students can contact the office by calling (973) 353-1918 or emailing run.vpva@rutgers.edu. There is also a confidential text-based line available to students; students can text (973) 339-0734 for support.

For Crisis and Concerns: The Campus Awareness Response and Education (CARE) Team works with students in crisis to develop a support plan to address personal situations that might impact their academic performance. Students, faculty and staff may contact the CARE Team by using the following link: tinyurl.com/RUNCARE or emailing careteam@rutgers.edu.

For Stress, Worry, or Concerns about Well-being: The Counseling Center has confidential therapists available to support students. Students should reach out to the Counseling Center to schedule an appointment: counseling@newark.rutgers.edu or (973) 353-5805. If you are not quite ready to make an appointment with a therapist but are interested in self-help, check out TAO at Rutgers-Newark for an easy, web-based approach to self-care and support: https://tinyurl.com/RUN-TAO.

Rutgers Student Health Services:
For more information visit: http://health.rutgers.edu/
Veteran Services:
Please visit the Office of Veteran and Military Programs and Services website for more information: https://veterans.rutgers.edu/

For emergencies, call 911 or contact Rutgers University Police Department (RUPD) by calling (973) 353-5111.

ADDITIONAL INFORMATION ON STUDENT SUPPORT SERVICES

Academic Services:
- For academic support visit Rutgers Academics Student Support at https://www.rutgers.edu/academics/student-support
- Any student can obtain tutoring and other help at the Learning Centers on each campus. Check the website at https://rlc.rutgers.edu/
- For coaching help with writing skills and assignments visit the Writing Coaching webpage at https://rlc.rutgers.edu/student-services/writing-coaching
- Many library resources are available online. Assistance is available through phone, email, and chat. For information, check the Rutgers Libraries website at https://www.libraries.rutgers.edu/
LETTURES OUTLINE (MAY BE ADAPTED DURING THE COURSE)

INTRODUCTION

- The atom
- Ionic vs. Covalent bonds
- Lewis structures, valence electrons, Lone pairs of electrons
- Classify Organic and inorganic compounds
- Electronegativity of atoms
- Polar bonds, polar molecules. $\delta^+$ and $\delta^-$ notations (polarization of a bond)
- Shape of molecules VSEPR
- Intermolecular forces (vdW, H-bonding...)
- Phase transitions (boiling, melting sublimation)
- Colligative properties
- Different types of arrows (resonance, equilibrium, arrow pushing)
- different ways of writing structure of molecules especially condensed and line structures
- Use of wedged and dashed bonds to indicate 3D structure

CHAPTER 10. ORGANIC CHEMISTRY

10.1. Introduction to Organic Chemistry
10.2. Obtaining Organic Compounds
   A. Isolation from Nature
   B. Synthesis in the Laboratory
10.3. Writing Structural Formulas of Organic Compounds
10.4. Functional Groups
   A. Alcohols
   B. Amines
   C. Aldehydes and Ketones
   D. Carboxylic Acids
   E. Carboxylic Esters
   F. Amides

CHAPTER 11. ALKANES

11.1. Introduction to Alkanes
11.2. Writing Structural Formulas of Alkanes
11.3. Constitutional Isomers
11.4. Naming Alkanes
   A. The IUPAC System
   B. Common Names
11.5. Obtaining Alkanes
11.6. Cycloalkanes
11.7. Shapes of Alkanes and Cycloalkanes (CONFORMERS)
A. Alkanes
B. Cycloalkanes
11.8. Cis-Trans Isomerism in Cycloalkanes
11.9. Physical Properties of Alkanes and Cycloalkanes
   A. Melting and Boiling Points
   B. Solubility: A Case of “Like Dissolves Like”
   C. Density
11.10. Characteristic Reactions of Alkanes
   A. Reaction with Oxygen: Combustion
   B. Reaction with Halogens: Halogenation
11.11. Some Important Haloalkanes
   A. Chlorofluorocarbons
   B. Solvents

MEMORIZE
Memorize root name from meth- (1C) to dodeca- (12C)
Memorize structure of: methyl- ethyl, propyl, isopropyl, butyl isobutyl, sec-butyl, tert-butyl, phenyl (abbreviated as Ph)

REACTIONS
Combustion reaction write and balance; In excess of oxygen you form CO2 when oxygen is scarce you form CO.
Example:
\[
\begin{align*}
\text{CH}_4 & + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \\
2\text{CH}_4 & + 3\text{O}_2 \rightarrow 2\text{CO} + 4\text{H}_2\text{O}
\end{align*}
\]

CHAPTER 12. ALKENES, ALKYNES, AND AROMATIC COMPOUNDS
12.1. Introduction to Alkenes and Alkynes
12.2. Structures of Alkenes and Alkynes
   A. Alkenes
      • \( \sigma \) (sigma) and \( \pi \) (pi) bonds, bond distances, bond angles in C-C; C=C, C≡C
   B. Cis-Trans Stereoisomerism in Alkenes
12.3. Naming Alkenes and Alkynes
   A. IUPAC Names
   B. Common Names
   C. Cis and Trans Configurations of Alkenes
   D. Cycloalkenes
   E. Dienes, Trienes, and Polyenes
12.4. Physical Properties of Alkenes and Alkynes
12.5. Characteristic Reactions of Alkenes
   A. Addition of Hydrogen Halides (Hydrohalogenation)
B. Addition of Water: Acid-Catalyzed Hydration
C. Addition of Bromine and Chlorine (Halogenation)
D. Addition of Hydrogen: Reduction (Hydrogenation)

12.6. Important Polymerization Reactions of Ethylene and Substituted Ethylenes
A. Structure of Polyethylenes
B. Low-Density Polyethylene (LDPE)
C. High-Density Polyethylene (HDPE)

12.7. The Structure of Benzene
A. Kekulé’s Structure of Benzene
B. Resonance Structure of Benzene

12.8. Naming Aromatic Compounds
A. One Substituent
B. Two Substituents (ortho, meta, para)
C. Three or More Substituents

12.9. Reactions of Benzene and Its Derivatives
A. Halogenation
B. Nitration
C. Sulfonation

12.10. Phenols
A. Structure and Nomenclature
B. Acidity of Phenols
C. Oxidation of Phenols

Summary of Key Reactions

MEMORIZE:
Structure and common names of

\[
\begin{align*}
\text{Toluene} & \quad \text{Phenol} & \quad \text{Aniline} & \quad \text{Benzoic acid} & \quad \text{Benzaldehyde} \\
\end{align*}
\]

REATIONS:
Addition reactions of alkenes

1. **Hydration (H}_2\text{O, and H}_+\text{ cat)**
   Synthesis of alcohols
   \[\text{R}_2\text{C} = \text{CH}_2 + \text{H}_2\text{O} \quad \text{cat. H}_+ \rightarrow \text{R}_2\text{COH-CH}_3\]

2. **Hydrohalogenation (HX X= Br, Cl, I)**
   Synthesis of halogenated alkanes
   \[\text{R}_2\text{C} = \text{CH}_2 + \text{HBr} \quad \text{cat. H}_+ \rightarrow \text{R}_2\text{CBr-CH}_3\]

3. **Hydrogenation (H}_2, \text{ Pd cat)**
   Synthesis of saturated hydrocarbons This is also a “reduction” reaction because increases the H content in a molecule.
   \[\text{R}_2\text{C} = \text{CH}_2 + \text{H}_2 \quad \text{cat Pd} \rightarrow \text{R}_2\text{CH}_2\text{-CH}_3\]
Hydrogenation of alkynes

\[
\text{CH}_3\text{C:CCH}_3 + 2\text{H}_2 \xrightarrow{\text{Pd, Pt, or Ni, 3 atm}} \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3
\]

1. \[\text{CH}_3\text{C:CCH}_3 + \text{H}_2 \xrightarrow{\text{Lindlar catalyst}} \text{CH}_3\text{CH} = \text{CH}_2\text{H} \]

2. Note: remember that \(\text{H}_2\) does not reduce an aromatic ring.

Substitution reactions of aromatic compounds

1. Nitration

\[
\text{H} + \text{HNO}_3 \xrightarrow{\text{H}_2\text{SO}_4} \text{HNO}_2 + \text{H}_2\text{O}
\]

2. Halogenation (also with Br2)

\[
\text{H} + \text{Cl}_2 \xrightarrow{\text{FeCl}_3} \text{Cl} + \text{HCl}
\]

Reaction of phenols with base

\[
\text{PhOH} + \text{NaOH} \xrightarrow{\text{Sodium hydroxide (stronger base)}} \text{PhO^−Na^+} + \text{H}_2\text{O}
\]

\(\text{pK}_a 9.95\) (stronger acid)
\(\text{(only slightly soluble in water)\}

\[
\text{PhOH} + \text{NaOH} \xrightarrow{\text{Sodium phenoxide (weaker base)}} \text{PhO^-} + \text{H}_2\text{O}
\]

\(\text{pK}_a 15.7\) (weaker acid)

CHAPTER 13. ALCOHOLS, ETHERS, AND THIOLS

13.1. Structures, Names, and Physical Properties of Alcohols

A. Structure of Alcohols
B. Nomenclature
C. Physical Properties of Alcohols

HYDROGEN BONDING VERY well.

13.2. Characteristic Reactions of Alcohols

A. Acidity of Alcohols
B. Acid-Catalyzed Dehydration of Alcohols
C. Oxidation of Primary and Secondary Alcohols

13.3. Structures, Names, and Physical Properties of Ethers

A. Structure
B. Nomenclature (simple common name like methyl ethyl ether)
C. Physical Properties

13.4. Structures, Names, and Physical Properties of Thiols

A. Structure
B. Nomenclature
C. Physical Properties
D. Reactions of Thiols (Oxidation of thiols to disulfides and reduction of disulfides to thiols)
13.5. Commercially Important Alcohols

**REACTIONS**

1. **Dehydration of alcohols** (it is an Elimination reaction, and it is the reverse of the hydration!!)
   Remember Markovnikov Note regioselectivity of the reaction

   ![Chemical reaction diagram]

   - 2-Butanol → 2-Butene (80%) + 1-Butene (20%)
   - 3-Methyl-2-butanol → 2-Methyl-2-butene (major product) + 3-Methyl-1-butene

2. **Oxidation of primary and secondary alcohols using K₂Cr₂O₇/H₂SO₄**

   Increasing the oxygen content of an organic molecule or decreasing its hydrogen content is **oxidation** ([O]).
   **The opposite reaction is reduction** ([H]) It is RARE to be able to stop the reaction at aldehyde so assume that with the reagent indicated one gets the acid.

   **Oxidation**
   - Oxidation of a 1° alcohol gives a carboxylic acid (aldehyde is an intermediate step but almost never isolated)
   - Oxidation of a 2° alcohol gives a ketone.
   - No reaction with 3° alcohols; they are resistant to oxidation.

3. **Oxidation of thiols to disulfides and reduction of disulfides to thiols**:

   ![Chemical reaction diagram]

   **CHAPTER 14. CHIRALITY: THE HANDEDNESS OF MOLECULES**
   - Chirality in biological world, in objects and organic molecules
   - *Understand, really really, but really understand the following:*
     *chiral, diastereomer, enantiomer, Racemic mixture (racemate)*
14.1. Enantiomerism
14.2. Specifying the Configuration of a Stereocenter **Must be able to assign an R or S configuration to a stereocenter in a given molecule**.

14.3. Possible Stereoisomers for Molecules with Two or More Stereocenters
   A. Molecules with Two Stereocenters
   B. Molecules with Three or More Stereocenters

14.4. Optical Activity and Chirality in the Laboratory: Optical activity: a pair of enantiomers rotates planar polarized light in opposite directions (+) or (−) and by the same amount but for a given enantiomer you cannot predict if + or − or the angle until you measure it experimentally.
   A. Plane-Polarized Light
   B. A Polarimeter

14.5. Significance of Chirality in the Biological World
   A. Chirality in Biomolecules
   B. How an Enzyme Distinguishes Between a Molecule and Its Enantiomer

**CHAPTER 15. AMINES**

15.1. Structure of Amines
15.2. Names of Amines
   A. IUPAC Names
   B. Common Names

15.3. Physical Properties of Amines
15.4. Basicity of Amines
15.5. Characteristic Reactions of Amines (selected see below)

**MEMORIZE:**

- Identify the amphetamine backbone (phenylethylamine moiety) in a molecule

**REACTIONS:**

1. Reaction with water
   
2. Reaction with acids (2 examples below)
Note: an ammonium salt is more water soluble than a “free” amine. This is used to solubilize drugs in water; example:

CHAPTER 16. ALDEHYDES AND KETONES

16.1. Aldehydes and Ketones
16.2. Naming Aldehydes and Ketones
   A. IUPAC Names
   B. Common Names
16.3. Physical Properties of Aldehydes and Ketones
16.4. Characteristic Reactions of Aldehydes and Ketones
   A. Oxidation
   Be able to rank in order of oxidation level the following functional groups
   \[
   \begin{align*}
   \text{H-C-H} & < \text{H-C-OH} < \text{O=C-H} < \text{O=C-O} \\
   \end{align*}
   \]
   B. Reduction
   C. Addition of Alcohols and Formation of Hemiacetals and Acetals
16.5. Keto-Enol Tautomerism

MEMORIZE:

\[
\begin{align*}
\text{formaldehyde} & \quad \text{acetaldehyde} & \quad \text{acetone} \\
\end{align*}
\]

REATIONS

1. Formation of acetals (from aldehydes) and ketals (from ketones) and the back reaction hydrolysis of acetals and ketals to aldehydes and ketones, respectively.

\[
\begin{align*}
\text{aldehyde (R' = H)} & \quad \text{hemi-acetal (R' = H)} & \quad \text{acetal (R' = H)} \\
\text{ketone (R' = alkyl)} & \quad \text{hemi-ketal (R' = alkyl)} & \quad \text{ketal (R' = alkyl)} \\
\end{align*}
\]

2. Aldehydes oxidation to carboxylic acids using potassium dichromate
3. **Aldehydes oxidation using Tollens’ reagent**

\[
\begin{align*}
R - C - H & \quad + \quad 2Ag(NH_3)_2^+ \quad + \quad 2OH^- \quad \rightarrow \quad R - C - O^+NH_4^+ \quad + \quad 3NH_4^+ \quad + \quad 2Ag \quad + \quad H_2O \\
\text{an aldehyde} & \quad \text{Tollens'} & \quad \text{reagent} & \quad \text{a carboxylate} & \quad \text{salt} & \quad \text{silver}
\end{align*}
\]

4. **Aldehydes and ketones reduction to alcohols using NaBH}_4

\[
\begin{align*}
\text{aldehyde (R' = H)} & \quad \text{reduction} & \quad \text{primary alcohol (R' = H)} & \quad \text{secondary alcohol (R' = alkyl)}
\end{align*}
\]

**MEMORIZE**

**CHAPTER 17. CARBOXYLIC ACIDS**

17.1. Carboxylic Acids

17.2. Names of Carboxylic Acids

A. IUPAC Names

B. Common Names

17.3. Physical Properties of Carboxylic Acids

17.4. Soaps and Detergents

A. Fatty Acids

B. Structure and Preparation of Soaps

C. How Soap Cleans

D. Synthetic Detergents

17.5. Characteristic Reactions of Carboxylic Acids

A. Acidity

B. Reaction with Bases

C. Reduction

D. Fischer Esterification

E. Decarboxylation

**VERY IMPORTANT (WILL BE IN EXAMS):**

- Acidity of the carboxylic acid: pKa of RCOOH is about 4 to 5
- RCOOH are weak acids (partially dissociate) compared to strong acids like HCl (fully dissociate)
- Inductive effects (electron withdrawing groups on R) and resonance effects (RCOO⁻ vs RO⁻) on acidity.

**MEMORIZE**

- Acetic acid
- Formic acid
- Benzoic acid
- Citric acid
REACTIONS:

1. Water Hydrolysis (dissociation) of carboxylic acid

\[
\text{CH}_3\text{C-OH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{C-O}^- + \text{H}_3\text{O}^+
\]

Acetic acid  \quad \text{Acetate ion}

2. Neutralization of acid by strong base (used to make soaps when R is a long fatty chain)

\[
\text{R-C-O-H} + \text{NaOH} \rightarrow \text{R-C-O-Na}^- + \text{H}_2\text{O}
\]

Carboxylic acid  \quad \text{Sodium carboxylate}

3. Fisher Ester synthesis (or Esterification)

\[
\text{CH}_3\text{CH}_2\text{C-OH} + \text{HOCH}_3 \underset{\text{H}^+}{\rightleftharpoons} \text{CH}_3\text{CH}_2\text{C-OCH}_3 + \text{H}_2\text{O}
\]

CHAPTER 18. CARBOXYLIC ANHYDRIDES, ESTERS, AND AMIDES

18.1. Carboxylic Anhydrides, Esters, and Amides

A. Anhydrides
B. Esters
C. Amides

18.2. Preparation of Esters
18.3. Preparation of Amides from anhydrides and amines
18.4. Characteristic Reactions of Anhydrides, Esters, and Amides
A. Reaction with Water: Hydrolysis
B. Reaction with Alcohols
C. Reaction with Ammonia and Amines

18.5. Phosphoric Anhydrides and Phosphoric Esters
A. Phosphoric Anhydrides
B. Phosphoric Esters

18.6. Step-Growth Polymerization
A. Polyamides
B. Polyesters
C. Polycarbonates

REACTIONS:
1. Synthesis of Esters by Fischer Esterification (this is also in chapter of RCOOH)

\[
\begin{align*}
\text{Ethanoic acid (Acetic acid)} & \quad + \quad \text{Ethanol (Ethyl alcohol)} \quad \xrightarrow{\text{H}_2\text{SO}_4} \quad \text{Ethyl ethanoate (Ethyl acetate)} \\
\text{CH}_3\text{C-OH} & \quad + \quad \text{H-OCH}_2\text{CH}_3 \quad \xrightarrow{} \quad \text{CH}_3\text{COCH}_2\text{CH}_3 + \text{H}_2\text{O}
\end{align*}
\]

Note that RCOOH, an acid, and an amine, a bases, form a salt (not an amide) this is important

2. Synthesis of amides from anhydrides and amines

\[
\begin{align*}
\text{acid anhydride} & \quad + \quad \text{amine} \quad \xrightarrow{} \quad \text{amid} \\
\text{R-C-O-C-R} & \quad + \quad \text{R'-N-H} \quad \xrightarrow{} \quad \text{R-C-N-R'} + \text{R-C-OH}
\end{align*}
\]

Content to be determined after Exam 1

CHAPTER 19. CARBOHYDRATES

19.1. Monosaccharides: The Simplest Carbohydrates
A. Structure and Nomenclature
B. Fischer Projection Formulas
C. D- and L-Monosaccharides
D. Important Monosaccharides

19.2. Cyclic Structures of Monosaccharides
A. Haworth Projections
B. Mutarotation

19.3. Characteristic Reactions of Monosaccharides
A. Formation of Glycosides (Acetals)
B. Reduction to Alditols
C. Oxidation to Aldonic Acids (Reducing Sugars)
D. Oxidation to Uronic Acids
E. The Formation of Phosphoric Esters

19.4. Disaccharides and Oligosaccharides
A. Sucrose
B. Lactose
C. Maltose
D. Relative Sweetness

19.5. Polysaccharides
A. Starch: Amylose and Amylopectin
B. Glycogen
C. Cellulose

19.6. Acidic Polysaccharides
A. Hyaluronic Acid
B. Heparin

Chapter Summary
Summary of Key Reactions
Problems: 19.1 Monosaccharides: The Simplest Carbohydrates
Problems: 19.2 Cyclic Structures of Monosaccharides
Problems: 19.3 Characteristic Reactions of Monosaccharides
Problems: 19.4 Disaccharides and Oligosaccharides
Problems: 19.5 Polysaccharides
Problems: 19.6 Acidic Polysaccharides

CHAPTER 20. LIPIDS
20.1. Importance of Lipids
A. Classification by Function
B. Classification by Structure
20.2. Fatty Acids
20.3. Triglyceride Structure
20.4. Properties of Triglycerides
A. Physical State
B. Hydrogenation
20.5. Structures of Complex Lipids
20.6. Lipids and Membrane Structure
20.7. Glycerophospholipids
20.8. Sphingolipids
20.9. Glycolipids
20.10. Steroids
A. Cholesterol
B. Lipoproteins: Carriers of Cholesterol
C. Transport of Cholesterol in LDL
D. Transport of Cholesterol in HDL
E. Levels of LDL and HDL
F. Membrane Cholesterol Functions
20.11. Physiological Roles of Steroid Hormones
A. Adrenocorticoid Hormones
B. Sex Hormones
20.12. Bile Salts
20.13. Prostaglandins, Thromboxanes, and Leukotrienes
20.14. Molecular Transport Across Membranes
   A. Passive Transport
   B. Active Transport
   C. Membrane Receptors

Chapter Summary
Problems: 20.1 Importance of Lipids
Problems: 20.2 Fatty Acids
Problems: 20.3 Triglyceride Structure
Problems: 20.4 Properties of Triglycerides
Problems: 20.5 Structures of Complex Lipids
Problems: 20.6 Lipids and Membrane Structure
Problems: 20.7 Glycerophospholipids
Problems: 20.8 Sphingolipids
Problems: 20.9 Glycolipids
Problems: 20.10 Steroids
Problems: 20.11 Physiological Roles of Steroid Hormones
Problems: 20.12 Bile Salts
Problems: 20.13 Prostaglandins, Thromboxanes, and Leukotrienes

CHAPTER 21. PROTEINS
21.1. The Many Functions of Proteins
21.2. Amino Acids
21.3. Amino Acids Exist as Zwitterions
21.4. Amino Acids Combine to Form Proteins
21.5. Amino Acid Characteristics
21.6. Uncommon Amino Acids
21.7. Protein Properties
21.8. Protein Primary Structure
21.9. Protein Secondary Structure
21.10. Protein Tertiary Structure
Myoglobin: An Example of Protein Structure
21.11. Protein Quaternary Structure
Hemoglobin: A Classic Example of Quaternary Structure
21.12. Protein Denaturation

Chapter Summary
Problems: 21.1 The Many Functions of Proteins
Problems: 21.2 Amino Acids
Problems: 21.3 Amino Acids Exist as Zwitterions
Problems: 21.4 Amino Acids Combine to Form Proteins
Problems: 21.5 Amino Acid Characteristics
Problems: 21.6 Uncommon Amino Acids
Problems: 21.7 Protein Properties
Problems: 21.8 Protein Primary Structure
Problems: 21.9 Protein Secondary Structure
Problems: 21.10 Protein Tertiary Structure
Problems: 21.11 Protein Quaternary Structure
Problems: 21.12 Protein Denaturation

CHAPTER 22. ENZYMES

22.1. Enzymes are Biological Catalysts
22.2. Enzyme Nomenclature
22.3. Enzyme Activity
   A. Enzyme and Substrate Concentration
   B. Temperature
   C. pH
22.4. Enzyme Mechanisms
   A. Lock-and-Key Model
   B. Induced-Fit Model
   C. Enzyme Inhibition
   D. Active Sites
   E. Catalytic Power of Enzymes
22.5. Enzyme Regulation
   A. Feedback Control
   B. Zymogens
   C. Allosterism
   D. Protein Modification
   E. Isozymes
22.6. Enzymes in Medicine
Chapter Summary