COURSE OUTLINE

Course Number
CHE202

Course Title
Organic Chemistry II

Credits
5

Class Hours: 3/4
Lecture/Lab/Other

Co- or Pre-requisite
CHE 201 passed with a grade of C or better.

Implementation
sem/year

Catalog description:
A continuation of CHE 201. Theoretical principles and underlying reaction mechanisms are presented along with descriptive aspects of the preparation, reactions and major uses for key classes of organic compounds. Topics covered include: aromatic hydrocarbons and their electrophilic substitution products, aldehydes and ketones, carboxylic acids and their derivatives, amines, phenols, and carbohydrates. Laboratory work includes methods of synthesis, purification and identification of organic compounds.

Note: Participation in Biology, Chemistry and Physics laboratory courses is permitted provided the student has completed the required prerequisites, is a minimum of 16 years of age or by the permission of the instructor and the Dean of the division.

Is course New, Revised, or Modified? Revised

Required texts/other materials:

ORGANIC CHEMISTRY
Authors: T.W. Graham Solomons and Craig B. Fryhle

PUSHING ELECTRONS
Author: D.P. Weeks
Publisher: Thomson Learning

EXPERIMENTAL ORGANIC CHEMISTRY, a Miniscale and Microscale Approach
Authors: John C. Gilbert, and Stephen F. Martin
Publisher: Thomson Brooks/Cole Publishing
Edition: Sixth, 2016

STUDENT LAB NOTEBOOK With Spiral Binding
(100 carbon duplicate sets)
ISBN 1930882742
Publisher: Hayden-McNeil Specialty Products

Suggested Supplementary Book:
STUDY GUIDE AND SOLUTIONS MANUAL TO ORGANIC CHEMISTRY MENTARY BOOK: TWELFTH EDITION
Authors: T.W. Graham Solomons
Supplies:
1. Goggles or other approved eye protection is REQUIRED in the laboratory at all times.
2. Light weight rubber or plastic gloves are required for use in certain experiments.
3. A three ring binder is recommended for organization of lecture handouts.

Revision date: February, 2019
Course coordinator: Helen V. Tanzini,
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609-570-3349

Information resources:
The library has a collection of books that students may use for reinforcement of the content being taught in this course. The lecture and laboratory textbooks and solution manual are available in the library.

Other learning resources:
Tutors: The learning center is located on the second floor behind the bookstore. Students are accommodated on a walk in basis. Consult http://www.mccc.edu/student_services_learncenter_ww.shtml for tutor schedules
www.rider.edu.nmr
www.INCHEM.org
http://web.doh.state.nj.us/rtkhsfs/indexfs.aspx?lan=english
ChemDraw®

Accommodations:
Eligible students at Mercer County Community College are assured services under the Americans with Disabilities Act and Section 504 of the Rehabilitation Act of 1973. Contact Arlene Stinson, Director of Academic Support Services. 570-3525.

Course Competencies/Goals
The student will be able to:
1. Explain and interpret key concepts of organic chemistry including aromaticity, enolate, spectroscopy, organic multi-step synthesis and reaction mechanisms [GE Goal 3; Core Skills A and B]

2. Predict/discuss types of reactions that organic molecules will undergo based on functional groups and acid/base behavior of complex compounds including stereochemical implications [GE Goals 1, 3 and 4; Core Skills A and B]

3. Design multi-step, complex synthetic methods by use of retro-synthetic analysis.[GE Goal 3; Core Skills B, E and F]

4. Evaluate synthetic methods for feasibility, practicality and expense [GE Goals 3 and 9; Core Skills A, B, C and D]
5. Create and evaluate organic reaction mechanisms using curved arrows including stereochemistry and adaptation of this skill to new situations [GE Goal 3; Core Skills B and E]

6. Use scientific instruments and interpret data from instrumental analysis of synthesized compounds (IR, NMR, mass spec) and unknowns (IR, NMR) [GE Goals 2, 3 and 4; Core Skills A, B and E]

7. Conduct multistep laboratory synthesis and characterization of organic compounds [GE Goals 2, 3, 4; Core Skills A, B, D, E]

8. Demonstrate safety in the organic laboratory setting [GE Goals 3 and 9; Core Skills B, C and D]

9. Practice environmentally sound waste disposal methods [GE Goals 3 and 9; Core Skills B, C and G]

10. Communicate scientific information in the form a laboratory reports [GE Goal 1 and 3; Core Skills A, B and D]

11. Conduct literature searches then evaluate and analyze their findings [GE Goals 1, 2 and 3; Core Skills A, B, C, D]

**Course-specific General Education Knowledge Goals and Core Skills.**

**General Education Knowledge Goals**

**Goal 1. Communication.** Students will communicate effectively in both speech and writing.

**Goal 2. Mathematics.** Students will use appropriate mathematical and statistical concepts and operations to interpret data and to solve problems.

**Goal 3. Science.** Students will use the scientific method of inquiry, through the acquisition of scientific knowledge.

**Goal 4. Technology.** Students will use computer systems or other appropriate forms of technology to achieve educational and personal goals.

**Goal 9. Ethical Reasoning and Action.** Students will understand ethical issues and situations.

**MCCC Core Skills**

**Goal A. Written and Oral Communication in English.** Students will communicate effectively in speech and writing, and demonstrate proficiency in reading.

**Goal B. Critical Thinking and Problem-solving.** Students will use critical thinking and problem solving skills in analyzing information.

**Goal C. Ethical Decision-Making.** Students will recognize, analyze and assess ethical issues and situations.

**Goal D. Information Literacy.** Students will recognize when information is needed and have the knowledge and skills to locate, evaluate, and effectively use information for college level work.

**Goal E. Computer Literacy.** Students will use computers to access, analyze or present information, solve problems, and communicate with others.

**Goal F. Collaboration and Cooperation.** Students will develop the interpersonal skills required for effective performance in group situations.

**Units of study in detail. The student will be able to:**

**UNIT 13 Alcohols**

1. Given the structure of an alcohol, write an appropriate IUPAC name or given a name draw the corresponding structure. [Core Comp #1]
2. Classify any given alcohol as primary (1°), secondary (2°) or tertiary (3°). [Core Comp #1]
3. Explain why alcohols have boiling points which are much higher than those of hydrocarbons of corresponding molecular weight. [Core Comp #1]
4. Write equations for at least two processes by which alcohols are made in large scale commercial quantities. [Core Comp #1]
5. Show, by suitable equations, how primary, secondary, and tertiary alcohols can be made via the Grignard reagent and alkyl lithium reagents. [Core Comp #1,2,3]
6. Show, by suitable equations, how alcohols can be made from alkenes using the hydroboration-oxidation reaction. [Core Comp #1,2,3]
7. Write a mechanism for the hydroboration-oxidation reaction which accounts for primary alcohol formation (Syn addition). [Core Comp #1,2,5]
8. Show, by suitable equations, how alcohols can be made from alkenes by the oxymercuration-demercuration reaction. [Core Comp #1,2,3]
9. Show, by suitable equations, how alcohols can be converted into alkenes and alkyl halides (include mechanisms). [Core Comp #1,2,3,5]
10. Show, by suitable equations, how alcohols can be oxidized into aldehydes, ketones, and carboxylic acids. [Core Comp #1,2,3]
11. Describe what the Lucas test is; what its limitations are; and how it can be used to differentiate primary, secondary, and tertiary alcohols. [Core Comp #1,2,3]
12. Write an equation for the conversion of alcohols to mesylates and tosylates followed by SN2 reactions. [Core Comp #1,2,3]

UNIT 14  Ethers and Epoxides

1. Given the structure of an ether and write an appropriate name, or given a name, draw the corresponding structure. [Core Comp #1]
2. Write equations for two methods of preparing ethers. [Core Comp #1,2,3]
3. Given a particular ether, choose the appropriate reagents and create a synthesis of the ether by the Williamson synthesis. [Core Comp #1,2,3]
4. Show, by suitable equations, how ethers may be cleaved by selected strong acids. [Core Comp #1,2,3]
5. Name and draw the structures of at least two cyclic ethers. [Core Comp #1]
6. Draw the structure of an epoxide. [Core Comp #1]
7. Given the structure of an epoxide, write an appropriate name; or given a name, draw the corresponding structure. [Core Comp #1]
8. Write equations illustrating at least two general methods for epoxide preparation. [Core Comp #1,2,3]
9. Write equations for the reaction of epoxides with at least three classes of active hydrogen compounds. [Core Comp #1,2,3]
10. Describe how alcohol protecting groups are used (tert-butyl and trimethylsilyl groups). [Core Comp #1,2,3]
11. Write mechanisms for acid catalyzed and base catalyzed opening of an epoxide (symmetrical and unsymmetrical). [Core Comp #1,2,3,5]

UNIT 15  Alcohols from Carbonyl Compounds

1. Write a mechanism illustrating nucleophilic addition to a carbonyl compound. [Core Comp #1,2,5]
2. Write equations for the formation of an alcohol from the reduction of a carboxylic acid, ester, aldehyde and ketone. [Core Comp #1,2,3]
3. Write equations for the oxidation of alcohols to form various carbonyl compounds. [Core Comp #1,2,3,4]
4. Write an equation for the reaction of a primary alcohol with pyridinium chlorochromate. [Core Comp #1,2,3,4]
5. Write equations and mechanisms for organolithium and organomagnesium (Grignard) reactions, and plan a synthesis using these reagents. [Core Comp #1,2,3,4]
6. Write an equation for the reaction of an epoxide with organometallic compounds such as Grignard reagents. [Core Comp #1,2,3]

UNIT 16  Spectroscopy and Structure

1. Describe the kind of changes which may take place in a molecule as a result of absorption of energy in the ultraviolet region of the electromagnetic spectrum. [Core Comp #1,6]
2. Describe the kinds of changes which may take place in a molecule as a result of absorption of energy in the infrared region of the electromagnetic spectrum. [Core Comp #1,6]
3. Define and differentiate among the terms: WAVELENGTH, WAVE NUMBERS, FREQUENCY, AND RECIPROCAL CENTIMETERS as used in infrared spectroscopy. [Core Comp #1,6]
4. Given the typical infrared region of interest to the organic chemist lies between 2 and 15 microns (or between 650 and 5000 cm⁻¹) indicate which part of this is considered the "characteristic group absorption region" and which the "fingerprint region." [Core Comp #1,6]
5. Define what is meant by the "characteristic group absorption region" of the infrared spectrum. [Core Comp #1,6]
6. Define what is meant by the "fingerprint region" of the infrared spectrum. [Core Comp #1,6]
7. Given the infrared spectrum of a pure simple organic compound, the molecular formula of the compound, and a table of characteristic infrared absorption frequencies, draw the likely structure of the compound. [Core Comp #1,6]
8. Define the term chemical shift as it applies to nuclear magnetic resonance (NMR) spectroscopy. [Core Comp #1,6]
9. Explain the role of shielding and deshielding in NMR spectroscopy with respect to compound identification. [Core Comp #1,6]
10. Generate a representative NMR spectrum labeling it with appropriate delta scale of an organic compound. [Core Comp #1,6]
11. a. Name and draw the structure of the most commonly used compound for establishing the reference point from which chemical shifts are measured in NMR spectroscopy. [Core Comp #1,6]
   b. State why this particular compound is chosen for such use.
12. Explain the "cause" of signal splitting in the NMR spectrum. [Core Comp #1,6]
13. Given a proton and its environment, predict whether that proton will show a single peak, a doublet, a triplet, a quartet, etc., in the NMR spectrum. [Core Comp #1,6]
14. Given the molecular formula and integrated NMR spectrum of a pure compound, predict the probable structure of the compound. [Core Comp #1,6]
15. State the kind of information about molecules which can be obtained from carbon-13 NMR spectroscopy. [Core Comp #1,6]
16. Define the term molecular ion (m/e value) as used in mass spectroscopy. [Core Comp #1,6]
17. State the kind of structural information about an organic compound that is obtainable by mass spectroscopy.
18. Given a mass spectrum, identify the base peak, the molecular ion or parent peak, and the M + 1 and M + 2 peaks if present. [Core Comp #1,6]

UNIT 17 Resonance and Dienes

1. Write a mechanism for substitution reactions of alkenes leading to allylic compounds. [Core Comp #1,5]
2. Describe why allylic substitution reactions can be made to take place as opposed to vinyl substitution reactions or alkene addition reactions. [Core Comp #1]
3. Explain the principles of the concept of resonance connected to compound reactivity. [Core Comp #1]
4. Define the terms resonance energy or delocalization energy. [Core Comp #1]
5. Describe and illustrate what is meant by the resonance structures of the allylic radical. [Core Comp #1]
6. Analyze the concept of hyperconjugation of alkyl radicals. [Core Comp #1]
7. Given a structure, name any given diene using the IUPAC system of nomenclature, or given an IUPAC name draw the corresponding structure. [Core Comp #1]
8. Using appropriate structural formulas, illustrate what is meant by CONJUGATED, CUMULATED and ISOLATED double bonds in a diene structure. [Core Comp #1]
9. Write a mechanism for the electrophilic addition reaction of dienes differentiating between 1,2-, and 1,4-addition. [Core Comp #1,5]
10. Differentiate between rate (kinetic) controlled yields and equilibrium (thermodynamic) controlled yields in organic reactions. [Core Comp #1]
11. Predict then evaluate the outcome of kinetic and thermodynamically controlled reactions [Core Comp #1,2,3]
12. Design multi-step synthesis of compounds using Diels Alder reaction. [Core Comp #1,3,4]

UNIT 18 Benzene and Aromatic Compounds

1. Give the original meanings for the terms aliphatic and aromatic compounds. [Core Comp #1]
2. Define aromatic compounds in terms of current practice. [Core Comp #1]
3. Illustrate the Kekule structure of benzene. [Core Comp #1]
4. Compare the principles of the concept of resonance with reactivity of aromatic compounds. [Core Comp #1]
5. Define the terms resonance energy or delocalization energy. [Core Comp #1]
6. Describe what is meant by the resonance structure of benzene and its stability. [Core Comp #1]
7. Cite at least four pieces of experimental evidence in support of the resonance structure of benzene. [Core Comp #1]
8. Draw a molecular orbital representation of benzene. [Core Comp #1]
9. Using the Hückel 4n + 2 rule, determine whether or not a given structure should have aromatic character. [Core Comp #1]
10. Given a substituted benzene structure, assign an appropriate name or given a name draw the correct structure. [Core Comp #1]
11. Use NMR and IR spectroscopy for structure assignment of aromatic compounds. [Core Comp #1, 6]

UNIT 19  Electrophilic Aromatic Substitution

1. Write equations to show the halogenation, nitration, sulfonation, and Friedel-Crafts alkylation of given aromatic compounds indicating the preferred isomers to be expected. [Core Comp #1, 2, 3, 4]
2. List atoms or groups which when present on an aromatic ring can activate the ring toward further substitution reactions as compared to the reactivity of benzene itself. [Core Comp #1, 2, 3]
3. List atoms or groups which when present on an aromatic ring can deactivate the ring toward further substitution reactions as compared to the reactivity of benzene itself. [Core Comp #1, 2, 3]
4. Write a series of structures and equations to illustrate the mechanism by which electron withdrawing groups deactivate aromatic rings toward further substitution. [Core Comp #1, 2, 3]
5. Define and illustrate the term inductive effect. [Core Comp #1]
6. List atoms or groups which, when present on an aromatic ring, will direct subsequent incoming substituents into ortho- and para- positions. [Core Comp #1, 2, 3]
7. List atoms or groups which, when present on an aromatic ring, will direct subsequent incoming substituents into the meta positions. [Core Comp #1, 2, 3]
8. Explain, in mechanistic terms and using suitable illustrative structures and equations, the basis for ortho-, meta-, and para-directive effects. [Core Comp #1, 2, 3, 5]
9. Write a mechanism for the halogenation, nitration, sulfonation, and the Friedel-Crafts alkylation of aromatic compounds.
10. Define the term and give an example of an arene. [Core Comp #1]
11. Given the structure of a typical arene write an appropriate name or given a name draw the correct structure. [Core Comp #1]
12. Name two major sources of arenes and indicate the typical kinds of arenes obtainable from each. [Core Comp #1]
13. Write balanced equations for at least two general methods of arene synthesis. [Core Comp #1, 2, 3]
14. Write a balanced equation for a Friedel-Crafts alkylation reaction. [Core Comp #1, 2, 3]
15. Write out one of the two generally accepted mechanisms for a Friedel-Crafts alkylation reaction and indicate how it differs from the other generally accepted mechanism. [Core Comp #1, 2, 3, 5]
16. Write balanced equations for at least two reactions of arenes: one of which involves reaction of the ring; and the other of which involves reaction of the alkyl group. [Core Comp #1, 2, 3]
17. Define the term benzylic hydrogen. [Core Comp #1]
18. Identify the benzylic hydrogens of a given arene. [Core Comp #1]
19. State or illustrate what factors or conditions favor side-chain halogenation of an arene. [Core Comp #1, 2, 3]
20. Write a mechanism for the free radical side-chain halogenation of an arene. [Core Comp #1, 2, 3, 5]
21. State the factors responsible for the stability of a benzylic free radical. [Core Comp #1, 2, 3]
22. Write equations to show the carbocation mechanism for the addition reactions of alkenylbenzenes. [Core Comp #1, 2, 3]
23. List in decreasing order of stability the free radicals and or carbocation derived from allyl groups, benzyl groups, methane, primary, secondary or tertiary alkyl groups, and vinyl groups. [Core Comp #1, 2, 3]

UNIT 20  Aldehydes and Ketones

1. By means of a generalized structure, distinguish between aldehydes and ketones. [Core Comp #1]
2. Draw a molecular orbital representation of the carbonyl group of an aldehyde or ketone and indicate the type of hybridization undergone by the carbonyl carbon atom. [Core Comp #1]

3. Given the structure of an aldehyde or ketone, write the corresponding IUPAC name; or given a name, draw the corresponding structure. [Core Comp #1]

4. Write balanced equations for at least three methods for preparing aldehydes and ketones. [Core Comp #1,2,3,4]

5. Write balanced equations for the reaction of aldehydes or ketones with hydrogen, water, alcohols, and Grignard reagents. Given a specific aldehyde or ketone, be able to write an appropriate equation involving reaction with the reagents noted above; draw the structure of the resulting products; and, name the product or products. [Core Comp #1,2,3,4]

6. Write balanced equations for the reaction of aldehydes or ketones with hydroxylamine, semicarbazide, phenylhydrazine, hydrazine, 2,4-dinitrophenylhydrazine and hydrogen cyanide and be able to name the products formed. [Core Comp #1,2,3]

7. Write a balanced equation for the Wittig reaction and create multi-step syntheses using Wittig reaction. [Core Comp #1,2,3]

8. Write equations illustrating the Reformatsky reaction and Baeyer-Villiger Oxidation reaction and create multi-step syntheses. [Core Comp #1,2,3]

9. Know the chemical tests for aldehydes and ketones. [Core Comp #1,2,3]

10. Generate a structural formula for a compound by evaluating the IR, NMR and molecular formula. [Core Comp #1,6]

UNIT 21  Aldehydes and Ketones II

1. Explain why hydrogens that are alpha to a carbonyl group, nitro group, or nitrile are acidic. [Core Comp #1]

2. Write equations illustrating keto and enol tautomers formed via an enolate ion. [Core Comp #1,2,3]

3. Explain for racemization when a ketone or aldehyde is left in an acid or base. [Core Comp #1]

4. Write equations for acid or base catalyzed halogenation of a ketone, the haloform reaction, and the iodoform test. [Core Comp #1,2,3]

5. Create reaction mechanisms for acid or base catalyzed Aldol reaction and crossed Aldol reaction. [Core Comp #1,2,3,5]

6. Synthesize new compounds containing rings via Aldol condensations. [Core Comp #1,2,3]

7. Write equations and mechanisms for simple addition and conjugate addition of nucleophiles to α,β unsaturated aldehydes and ketones. [Core Comp #1,2,3,5]

UNIT 22  Carboxylic Acids

1. Given a structure of carboxylic acid, write an appropriate name, including IUPAC names of aliphatic carboxylic acids; or given a name, draw the corresponding structure. [Core Comp #1]

2. Given the structure of a dicarboxylic acid, write an appropriate name; or given a name, draw the corresponding structure. [Core Comp #1]

3. Explain why carboxylic acids have boiling points higher than alcohols and significantly higher than hydrocarbons of corresponding molecular weight. [Core Comp #1]

4. Define the term acidity constant, Ka, for a carboxylic acid. [Core Comp #1]

5. Explain the acidity of carboxylic acids in terms of carboxylate anion stability. [Core Comp #1]

6. Analyze role inductive effects play on the acidity of a given carboxylic acid. [Core Comp #1]

7. Explain why some substituents increase the acidity of a carboxylic acid and other substituents decrease the acidity. [Core Comp #1]

8. Given a list of carboxylic acids, predict, on the basis of structural features or substituents present, an order of probable increasing or decreasing acid strength as requested. [Core Comp #1]

9. Given a list of carboxylic acids, and their Ka values, classify the acids in order of increasing or decreasing acid strength as requested. [Core Comp #1]

10. Given the structure of nitrile, write an appropriate name; or given a name draw the corresponding structure. [Core Comp #1]

11. Write equations for three methods of preparing carboxylic acids, including dicarboxylic acids. [Core Comp #1,2,3]

12. Write equations for four reactions of carboxylic acids. [Core Comp #1,2,3]

13. Name a reagent which can be used for the direct reduction of a carboxylic acid to an alcohol and write an equation illustrating its use. [Core Comp #1,2,3]
UNIT 23  Carboxylic Acid Derivatives

1. Given the structure of a carboxylic acid amide, anhydride, ester, or halide, write an appropriate name; or given a name, draw the corresponding structure [Core Comp #1] .
2. Write an equation for at least one method of preparation of an acid amide, anhydride, and halide. [Core Comp #1,2,3]
3. Write an equation for at least one reaction which can be undergone by an acid amide, anhydride, or halide. [Core Comp #1,2,3]
4. Write an equation for the Friedel-Crafts acylation of aromatic ring-containing compounds. [Core Comp #1,2,3]
5. Create a mechanism which shows how the carbonyl group of a carboxylic acid or carboxylic acid derivative becomes involved in nucleophilic substitution reactions. [Core Comp #1,2,3,5]
6. Evaluate equations for three methods of preparing esters for use in synthesis. [Core Comp #1,2,3,4]
7. Evaluate equations for four kinds of reactions esters can undergo. [Core Comp #1,2,3,4]
8. Create a mechanism for the alkaline hydrolysis of an ester. [Core Comp #1,5]
9. Create a mechanism for the acidic hydrolysis of an ester. [Core Comp #1,5]
10. Describe in detail, with suitable equations, at least one method which can be used to establish the fate of the non-carboxyl oxygen during ester hydrolysis. [Core Comp #1,2,3,4]
11. Write an equation for the preparation of tertiary alcohols using the reaction of an ester with a Grignard reagent. [Core Comp #1,2,3,4]

UNIT 24  Chemistry of Enolate Ions

1. Explain why β-keto esters are stronger acids than ethanol. [Core Comp #1]
2. Write equations and create mechanisms for the following reactions: Claisen condensation, crossed Claisen condensation, acetoacetic ester synthesis, malonic ester synthesis, and the Knoevenagel condensation. [Core Comp #1,2,3,4]
3. Illustrate what is meant by “active hydrogen compounds.” [Core Comp #1]
4. Write equations for direct alkylation of esters and nitriles. [Core Comp #1,2,3,4]
5. Describe what is meant by “Michael addition.” [Core Comp #1]
6. Use Michael Addition reactions in multi-step synthesis or organic compounds. [Core Comp #1,2,3,4]

UNIT 25  Amines

1. Define primary (1°), secondary (2°), and tertiary (3°) amine, and be able to correctly classify any given amine as 1°, 2°, or 3°. [Core Comp #1]
2. Given the structure of an amine, write an appropriate name, or given a name, draw the corresponding structure. [Core Comp #1]
3. Illustrate, by suitable equations, how the basicity constant, Kb, of an amine is derived. [Core Comp #1]
4. Describe and illustrate, with appropriate structures and equations, factors which tend to increase the basicity of an amine and factors which tend to decrease the basicity of the amine. [Core Comp #1]
5. Given a list of amines and their Kb values, evaluate the amines in order of decreasing or increasing basic strengths as requested. [Core Comp #1]
6. Given a series of closely related amines, predict, on the basis of structural features or substituents an order of probable increasing or decreasing basic strength as requested. [Core Comp #1]
7. Write equations, including all key reagents involved, for at least three methods of preparing amines. Critique the methods for feasibility and application to multi-step synthesis [Core Comp #1,2,3]
8. Draw the structure of a quaternary ammonium salt; name it and by means of suitable equations indicate how it can be made. [Core Comp #1,2,3,5]
9. Show, by means of suitable equations, the products, if any, of the reaction of 1°, 2°, and 3° amines with acid halides. [Core Comp #1,2,3]
10. Write an equation for the preparation of an amine from an amide. [Core Comp #1,2,3]
11. Describe and differentiate between the results of the reaction of nitrous acid with 1°, 2°, and 3° aliphatic and aromatic amines. [Core Comp #1,2,3]
12. Draw a general structure for a diazonium salt. [Core Comp #1]
13. Distinguish between the stability of diazonium salts derived from 1° aliphatic or aromatic amines and indicate what diagnostic or synthetic value such diazonium salts might have [Core Comp #1].
14. Write a general equation for the preparation of a diazonium salt. [Core Comp #1,2,3]
15. Write an equation showing the replacement of a diazonium group by -OH, -OR, -halide, -cyanide, -H, and -NO2 noting any particular conditions required to plan the indicated reaction. (Sandmeyer reaction) [Core Comp #1,2,3]
16. Write an equation for the preparation of an azo dye by a diazonium salt coupling reaction. [Core Comp #1,2,3]
17. Write an equation for the preparation of a sulfonamide from the reaction of an amine with sulfonyl chlorides (Hinsberg test). [Core Comp #1,2,3]
18. Use chemical tests, IR, 1H NMR, 13C NMR for structure assignment of amines. Justify the structure by relating it to all of the data. [Core Comp #1,2,3,6]
19. Write equations for the Hofman elimination reaction and the Cope elimination reaction. [Core Comp #1,2,3]
20. Illustrate the amine reactions that we have studied using heterocyclic amines. [Core Comp #1,2,3]

UNIT 27  Carbohydrates

1. Define the term carbohydrate and give an example. [Core Comp #1]
2. Define the terms monosaccharide, disaccharide, and polysaccharide and name at least one specific example of each. [Core Comp #1]
3. Classify a given sugar as an aldotriose, aldotetrose, aldo-pentose, aldohexose, ketotriose, ketotetrose, ketopentose, or ketohexose. [Core Comp #1]
4. Draw the Fisher projection formula and the Haworth formula for glucose. [Core Comp #1]
5. Define and illustrate the terms anomer, diastereomer, enantiomer, meso form, and racemic mixture. [Core Comp #1]
6. Given the Fisher projection formula of a sugar, classify the configuration of the sugar as D or L. [Core Comp #1]
7. Describe what is meant by MUTAROTATION. [Core Comp #1]
8. Describe, with the aid of suitable equations, the chemical basis of the Benedict's or Fehling's test for reducing sugars. [Core Comp #1]
9. Indicate what structural feature must be present or capable of being formed in aqueous solution for a sugar to act as a reducing sugar. [Core Comp #1]
10. Draw Fisher and Haworth formulas for the alpha and beta anomic forms of glucose. [Core Comp #1]
11. Define the term glycoside, draw the structure of an example, and name the structure you have drawn. [Core Comp #1]
12. Define what is meant by glycosidic linkage and illustrate it by drawing the structure of a disaccharide. [Core Comp #1]
13. Given a list of structures and names, be able to match the name to the structure for the monosaccharides fructose, galactose, glucose, 2-deoxyribose, and ribose; the disaccharides cellobiose, lactose, maltose, and sucrose; and polysaccharide segments of amyllopectin, amylose, cellulose and glycogen. [Core Comp #1]

LABORATORY


All procedures and reading assignments are in the lab text and/or handouts. Refer to course outline for details.

*The student will be able to:*

1. Prepare and organize laboratory notebook prior to coming to class. [Core Comp #1, 6, 8, 9 ]
2. Maintain a laboratory notebook that is accurate and up to date [Core Comp #1, 6, 7, 8, ]
3. Demonstrate safety in the laboratory [Core Comp #1, 6, 7]
4. Prepare organic compounds using safe and proper lab techniques [Core Comp #1, 2, 3, 9, 10, 11, 12]
5. Complete syntheses using separation, purification and assessment methods [Core Comp #1, 8, 11, 12]
6. Use IR spectrophotometer, chromatography and Meltemp and NMR spectrometer for data acquisition then analyze the data compound identification and purity [Core Comp #1, 10, 11, 12]
<table>
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<tr>
<th>Week</th>
<th>Experiment</th>
<th>Reading Assignment</th>
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| 1    | **EXP. 1:** Reduction of 9-Fluorenone  
Experimental Procedure – p652-653 **miniscale** | 621-624  
651-652 |
| 2    | **EXP. 2:** Oxidation of Cyclododecanol to Cyclododecanone  
Experimental Procedure – p593-595 **miniscale** | 585-591 |
| 3    | **EXP. 3:** Preparation of Grignard Reagent  
Experimental Procedure – Handout  
Preparation of Triphenylmethanol  
Experimental Procedure **Handout** | 715-719  
725-727 |
| 4    | Triphenylmethanol Handout (Continued)  
p728-729  
IR and NMR sample preparation | http://www-usr.rider.edu/~grushow/nmr/ |
| 5    | **EXP. 4:** NMR Tutorial and Acorn Nuts (Unknowns)  
Spectroscopy (**Handout**) | 235-254  
258-278  
284-288 |
| 6    | **EXP. 5:** The Diels-Alder Reaction  
Experimental Procedure A - p426 **miniscale**  
Experimental Procedure C - p430-431 **miniscale** | 421-425 |
| 7    | **EXP. 6:** Identification of Organic Compounds  
(SQUALOR **Handout**) | 759-765 |
| 8    | **EXP. 7:** Fisher Esterification of Carboxylic Acids  
Preparation of benzocaine  
Experimental Procedure A – p764 **miniscale** | |
| 9    | Fisher Esterification Continued  
Purification and Analysis | |
| 10   | **EXP. 8:** Preparation of Aspirin (**handout**) | |
| 11   | **EXP. 9:** ALDOL Reaction  
Preparation of trans-p-Anisalacetophenone  
Experimental Procedure p691-692 **miniscale** | 689-691  
869 |
| 12   | **EXP. 10:** Preparation of Diazonium Salt  
Preparation of Para Red (**Handout**) | Solomon’s12e, Ch. 20,  
890-898; 913-919 |
| 13   | **EXP. 11:** Carbohydrates – Models (**Handout**) | 875-878 |
| 14   | Checkout | |

**Evaluation of student learning:**

Grading: Letter grades will be assigned based on the total number of points earned in the course as compared to the total number of possible points. The percentage breakdown for letter grades is shown below.

Hour examinations, quizzes, and laboratory work will contribute to the total points as shown in the point composition column. Letter Grades

<table>
<thead>
<tr>
<th>% of maximum points</th>
<th>Grade</th>
<th>Point Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>93 - 100%</td>
<td>A</td>
<td>Hour Examinations 37.5%</td>
</tr>
<tr>
<td>90 - 92%</td>
<td>A-</td>
<td>Quizzes 12.5%</td>
</tr>
<tr>
<td>87 - 89%</td>
<td>B+</td>
<td>Final Examination 20%</td>
</tr>
<tr>
<td>83 - 86%</td>
<td>B</td>
<td>Laboratory Work* 30%</td>
</tr>
<tr>
<td>80 - 82%</td>
<td>B-</td>
<td></td>
</tr>
<tr>
<td>77 - 79%</td>
<td>C+</td>
<td></td>
</tr>
<tr>
<td>70 - 76%</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>60 - 69%</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>0 - 59%</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

*Acceptable laboratory participation and performance is required to pass the course.
**Academic Integrity Statement:** See [http://mlink.mccc.edu/omb/OMB210.pdf](http://mlink.mccc.edu/omb/OMB210.pdf)

The following statement of **ACADEMIC INTEGRITY** applies to the taking of quizzes, examinations and lab reports. Your examinations should reflect your work and knowledge alone. You may not use any outside help, written, oral or electronic. You may not use notes of any sort; nor exchange papers, comments or gestures with classmates. Such an exchange of information constitutes cheating. Any observed instance of cheating is punishable by confiscation of the examination papers and being assigned a grade of zero for the examination and a grade of “F” in the course. Any additional penalties are at the discretion of the instructor. This applies equally to the giver and receiver of information. You are just as guilty of cheating giving information to a person as is the person receiving it. All academic integrity violations will be reported to the Academic Integrity Committee as a record of academic misconduct. Be careful not to give the appearance of cheating. Keep your eyes on your paper. Keep your papers right in front of you so they cannot be seen by the people to either side of you or the person behind you. If you have a question, raise your hand and consult with the instructor. Your lab reports should reflect your work and knowledge alone. Plagiarism will result in a zero grade on the lab report and will be reported to the Academic Integrity Committee as an integrity violation.