GRANDE PRAIRIE REGIONAL COLLEGE

DEPARTMENT OF SCIENCE: CHEMISTRY

FORTY-THIRD SESSION 2008 – 2009

COURSE OUTLINE: ORGANIC CHEMISTRY

CH2610 A3 & B3

CH2610 A3 & B3: Organic Chemistry I; Prerequisite, CH1010 or CH1030

INSTRUCTOR: Dr. John P. Sloan
Office # J207
Phone # 539-2004
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LECTURE: CH2610 T, R 13:00 – 14:20 in D308

ALBERTA TRANSFER CREDIT
(Ref: 2008-2009 Guide to Transfer Credit at Alberta Post-Secondary Institutions)

GPRC:	CH2610 (3)
U of Alberta:	CHEM 261 (3) or AUCHE 250 (3)
U of Calgary:	CHEM 351 (3)
U of Lethbridge:	CHEM 2500 (3)
Athabasca U:	CHEM 350 (3)
Canadian UC:	CHEM 241 (4)
Concordia UC:	CHEM 261 (3)

COURSE OUTLINE:

LECTURE COMPONENT:

A study of the fundamental principles of the chemistry of carbon compounds. The study is based on a reaction mechanism approach to the functional group chemistry of alkanes, alkenes, alkynes, cycloalkanes, alkyl halides, alcohols and ethers. Topics include: structure and bonding; physical properties; acidity and basicity; conformations of molecules; stereochemistry; addition, elimination and substitution reactions; structure-reactivity relationships; and introduction to methods for structure determination.

A representative selection of molecules found in agricultural, biological, environmental, industrial, medical, and pharmatheutical applications of organic chemistry will be discussed, e.g., molecules found in agrochemicals, fibres, food additives, perfumes, polymers, and prescription drugs.

LABORATORY COMPONENT:

Laboratory Techniques in organic chemistry; preparation of some organic compounds, and; methods of qualitative organic analysis.

TUTORIAL COMPONENT:

Problem solving and discussion sessions with short problem sets for completing and marking during the tutorial. In addition, weekly assignments consisting of 10 questions per assignment will be given. These assignments will consist of exam type questions and do not need to be submitted for marking. Detailed solutions to the assignments will be posted on Blackboard about 1 week after distribution.

NOTES:

1. Lectures, Time and Place
   CH2610 A2 T, R 13:00 - 14:20 in D308

2. Laboratory Component, Time and Place
   CH2610 L1 M 14:30 - 17:20 in J116
   CH2610 L2 T 14:30 - 17:20 in J116

3. Tutorial Component, Time and Place
   CH2610 S1 F 8:30 - 9:20 in J229
   CH2610 S2 F 10:00 - 10:50 in J229

4. Office Hours: Individual and group assistance will normally be available in office J207 during regular college business hours outside of formal class lecture, laboratory and tutorial hours.

TEXT BOOKS AND LABORATORY ITEMS:

<u>The following text books are required:</u>

CH2610

Either,
Solomons, T.W.G., and C.B. Fryhle, *Organic Chemistry,* 9th Edition, Wiley, 2008

Or,
Wade, L.G.(Jr), *Organic Chemistry,* 6th Edition, Pearson Prentice-Hall, 2006.

And
A Three Ring Binder to Hold: Sloan, J.P., *Organic Chemistry Experiments, Chemistry 2610/2630,* Grande Prairie Regional College, 2008/2009.

Molecular Models are highly recommended, namely:

Molecular Model Set for Organic Chemistry, Prentice Hall.

Study Guides and Solutions Manuals are supplementary items, namely:

1. Fernandez, J.E., and Solomons, T.W.G., *Study Guide and Solutions Manual to Organic Chemistry*, 9th Edition, 2008;
2. Simek, J.W., Wade L.G.(Jr), Solutions Manual to Organic Chemistry, 6th Edition.

Note:

1. All required and supplementary books, molecular structure model sets, safety glasses, and lab coats are available at the College Bookstore. *Organic Chemistry Experiments*, by J.P. Sloan, will be given as handouts in advance of each lab period. These are to be inserted in a three ring binder.

EVALUATION:

Examination Schedule and Composition of the Final Grade:

1. Midterm Exam # 1, Friday February 13 ---------- 15%
2. Midterm Exam # 2, Friday March 20 ---------- 20%
2. Final Exam to be scheduled between April 16 – 27 ---------- 35%
3. Laboratory ---------- 25%
4. Tutorial Grading Component ---------- 5%

100%

The Grades are based on the alpha grading system. The Registrar's Office will convert alpha grades to four-point equivalence for the calculation of grade point averages. Alpha grades, 4-point equivalence, and grade descriptors are as follows:

Alpha Grade	4-Point Equivalence	Descriptor
A^+	4.0	Excellent
A	4.0	
A-	3.7	Very Good First Class Standing
B+	3.3	
B	3.0	Good
B-	2.7	
C+	2.3	Satisfactory
C	2.0	
C-	1.7	
D+	1.3	Poor*
D	1.0	Minimal Pass*
F	0.0	Failure

* Other post secondary institutions may not award transfer credit for grades of D and D+.

Notes:

1. The Mid-Term Exams will be of 1.5 hours duration and the Final Exam will be of 3 hours duration.

2. Between 5 and 15% of exam content will be taken from a combination of weekly assignments and questions in the organic chemistry textbooks by Solomons and Fryhle, and by Wade.

3. A pass grade is essential for the Laboratory Component.

4. The Tutorial Grading Component consists of short tests at the end of each seminar and will contribute towards 5% of the final grade. A 10 question assignment will normally be given each week. To encourage general discussion and active student participation, assignment questions may be answered within, "paired teams/study groups". The assignments do not need to be submitted for grading, however, students are encouraged to complete all assignments. Detailed solutions to the assignments will be posted on Blackboard. Assistance with assignments will be given upon request.

5. Regular attendance in Lecture, Laboratory, and Tutorial Components is a Course Requirement.

Grande Prairie Regional College Calendar 2008 - 2009: Course Description (p 178).

CH2610 3(3-1-3)UT, 105 Hours, Organic Chemistry I

The correlation of structure and bonding in carbon compounds with the physical properties and chemical reactivity of organic molecules. Discussion will be based on functional groups with emphasis on hydrocarbons and derivatives that contain halogens, oxygen, sulphur and the hydroxyl group. Introduction to stereochemistry, three dimensional structure, reaction mechanisms, especially addition to double bonds, nucleophilic substitution and elimination reactions, and methods of structure determination. The study covers the functional group chemistry of alkanes, alkenes, alkynes, alcohols, ethers and sulfides.
Prerequisites: CH1010 or CH1030
Notes: Credit will be granted for only one of CH1610 or CH2610
Transfer: UA, UC, UL, AU, AF, CU, CUC, KUC

CHEMISTRY 2610: READING, STUDYING, AND PRACTICE PROBLEMS

All references are to T.W.G. Solomons and C.B. Fryhle, *Organic Chemistry*, 9th Edition, Wiley, 2008.

FALL SEMESTER

Weeks of
Jan 5 & 12: THE BASICS: Bonding and Molecular Structure
Molecular Graphic: Glycine, an organic molecule found in space

Sect #	**Page #**	Read and Study Chapter 1 "We are Star Dust"
1.1	2	Organic Chemistry and Life
1.2	3	The Structural Theory of Organic Chemistry
1.3	4	Isomers: The Importance of Structural Formulas
1.4	5	Chemical Bonds: The Octet Rule
1.5	7	Writing Lewis Structures
1.6	9	Exceptions to the Octet Rule
1.7	10	Formal Charge
1.8	13	Resonance Theory
1.8A	15	Summary of Rules for Resonance
1.9	18	Quantum Mechanics and Atomic Structure
1.10	20	Atomic Orbitals and Electron Configuration:
1.10A	21	Aufbau Principle; the Pauli Exclusion Principle; Hund's Rule
1.11	21	Molecular Orbitals: Bonding and Antibonding
1.12	24	The Structure of Methane and Ethane: sp^3 Hybridization;
1.12A	24	The Structure of Methane
1.12B	27	The Structure of Ethane
1.13	28	The Structure of Ethene (Ethylene): sp^2 Hybridization
1.13A	31	Restricted Rotation and the Double Bond
1.13B	32	Cis-Trans Isomers
1.14	33	The Structure of Ethyne (Acetylene): sp Hybridization
1.14A	34	Bond Lengths of Ethyne, Ethene, and Ethane
1.15	35	A Summary of Important Concepts that Come from Quantum Mechanics
1.16	36	Molecular Geometry: The Valence Shell Electron-Pair Repulsion (VSEPR) Model.
1.16A-F	37	Molecular Geometry: VSEPR Models for Methane, Ammonia, Water, Boron Trifluoride, Berylium Hydride and Carbon Dioxide
1.17	39	Representation of Structural Formulas: Dash; Condensed; Bond Line; and the Three Dimensional Wedge, Dash, Line Representation
1.18	44	Applications of Basic Principles: Opposite Charges Attract; Like Charges repel; Nature Tends Towards States of Lower Potential Energy; Orbital Overlap Stabilizes Molecules
	45	Key Terms and Concepts
	46	Concept Map

Practice Problems: You are encouraged to work all of the in-chapter problems, and you are required to complete the short in-class weekly assignments. Routinely doing problems in organic chemistry leads to understanding of the theory, and good grades in organic chemistry.

In the words of Solomons and Fryhle:

"*One way to check your progress is to work each of the in-chapter problems when you come to it. These problems have been written just for this purpose and are designed to help you decide whether or not you understand the material that has just been explained.*"

And, in the words of Wade:

"*It's easy to fool yourself into thinking you understand organic chemistry when you actually do not. As you read through this book, all the facts and ideas may make sense, yet you have not learned to combine and use those facts and ideas. An examination is a painful time to learn that you do not really understand the material.*

The best way to understand organic chemistry is to use it. You will certainly need to read and reread all the material in the chapter, but this level of understanding is just the beginning. Problems are provided so you can work with the ideas, applying them to new compounds and new reactions that you have never seen before. By working problems, you force yourself to use the material and fill in the gaps in your understanding. You also increase your level of self-confidence and your ability to do well on exams".

Problems:	In-Chapter	1.1 to 1.15
47	End of Chapter	1.16 to 1.38
50	Learning Group Problem	

Week of Jan 19: REPRESENTATIVE CARBON COMPOUNDS: Functional Groups, Intermolecular Forces, and Infrared (IR) Spectroscopy

		Read and Study Chapter 2
	51	Structure and Function: Organic Chemistry, Nanotechnology, and Bioengineering
2.1	52	Carbon-Carbon Covalent Bonds
2.2	52	Hydrocarbons: Representative, Alkanes, Alkenes, Alkynes, and Aromatic Compounds
2.3	55	Polar Covalent Bonds
2.4	56	Polar and Nonpolar Molecules
2.4A	58	Dipole Moments in Alkenes
2.5	59	Functional Groups
2.5A	59	Alkyl Groups and the Symbol R
2.5B	60	Phenyl and Benzyl Groups
2.6	60	Alkyl Halides or Haloalkanes
2.7	61	Alcohols, including Classification as Primary, Secondary and Tertiary (1E, 2E, 3E)
2.8	63	Ethers
2.9	63	Amines, including Classification as Primary, Secondary and Tertiary
2.10	65	Aldehydes and Ketones
2.11	65	Carboxylic Acids, Esters, and Amides
2.12	67	Nitriles
2.13	68	Summary of Important Families of Organic Compounds
2.14	68	Physical Properties and Molecular Structure with emphasis on Intermolecular Interactions, namely:
2.14A	69	Ion-Ion Forces in ionic compounds, e.g. sodium acetate, sodium chloride
2.14B	70	Dipole-Dipole Forces resulting from permanent dipoles, e.g. acetone, chloromethane

Week of Jan 26: AN INTRODUCTION TO ORGANIC REACTIONS: ACIDS AND BASES IN ORGANIC CHEMISTRY

1. Size Effect, acidity increases upon descending a column in the Periodic Table, H-I is a stronger acid than H-F; the acidity order is: H-I > H-Br > H-Cl > H-F
2. Electronegativity Effect, acidity increases from left to right in the Periodic Table, H-F is a stronger acid than CH_4; the acidity order is: HF > H_20 > NH_3 > CH_4

3.7A 107 3. The Effect of Hybridization, more s-character means the anion has lower energy, is more stable, and is a weaker base

3.7B 108 4. Inductive Effects, from polarization by electron attracting and electron withdrawing groups

3.8 108 Energy Changes; higher potential and kinetic energy implies less stable, lower energy implies more stable

3.8A 109 Potential Energy and Covalent Bonds, exothermic reactions give out heat, endothermic reactions absorb heat

3.9 110 The Relationship Between the Equilibrium Constant and the Standard Free-Energy Change, ΔG^o; a negative value favours products at equilibrium

3.10 111 The Acidity of Carboxylic Acids, with explanations arising from Resonance Effects and Inductive Effects

3.10A 112 The Effect of Delocalization: An Explanation based on Resonance Effects, due to resonance stabilization of the carboxylate anion

3.10B 113 An Explanation based on Inductive Effects, due to inductive withdrawal of electronic charge by –O and -C=O in carboxylate anions

3.10C 114 Summary of a Comparison of Conjugate Acid-Base Strengths

3.10D 114 Inductive Effects of Other Groups

3.11 115 The Effect of Solvent on Acidity - Protic Solvents

3.12 116 Organic Compounds as Bases

3.13 117 A Mechanism for an Organic Reaction

118 The Chemistry of carbonic Anhydrase

3.14 119 Acid and Base in Nonaqueous Solutions

3.15 120 Acid-Base Reactions, and Synthesis of Deuterium- and Tritium-Labelled Compounds

3.16 121 Applications of Basic Principles: Electronegativity Differences Polarize Bonds; Polarized Bonds Underlie Inductive Effects; Opposite Charges Attract; Nature Prefers States of Lower Potential Energy; Resonance Effects Can Stabilize Molecules and Ions

122 Key Terms and Concepts

123 Concept Map

Problems: In-Chapter 3.1 to 3.14

124 End of Chapter 3.15 to 3.42

127 Learning Group Problem

Week of Feb 2: NOMENCLATURE AND CONFORMATIONS OF ALKANES AND CYCLOALKANES

Read and Study Chapter 4

129 To be Flexible or Inflexible - Molecular Structure Makes the Difference

4.1 130 Introduction to Alkanes and Cycloalkanes

4.1A 130 Sources of Alkanes: Petroleum

130 The Chemistry of Petroleum Refining

131 Typical Fractions Obtained by Distillation of Petroleum

Problems: In-Chapter 4.1 to 4.21
178 End of Chapter 4.22 to 4.54
180 Learning Group Problems

Week of Feb 9: STEREOCHEMISTRY: CHIRAL MOLECULES

Read and Study Chapter 5

	181	The Handedness of Life
5.1	182	The Biological Significance of Chirality
5.2	183	Isomerism, Constitutional Isomers and Stereoisomers
5.3	184	Enantiomers and Chiral Molecules
5.4	187	More about the Biological Importance of Chirality
5.5	188	The Historical Origin of Stereochemistry
5.6	189	Tests for Chirality, Planes of Symmetry and Points of Symmetry
5.7	190	Nomenclature of Enantiomers: The R-S System
5.8	194	Properties of Enantiomers, Optical Activity
5.8A	195	Plane-Polarized Light
5.8B	195	The Polarimeter
5.8C	195	Specific Rotation
5.9	198	The Origin of Optical Activity
5.9A	199	Racemic Forms
5.9B	199	Racemic Forms and Enantiomeric Excess
5.10	200	The Synthesis of Chiral Molecules
5.10A	200	Racemic Forms
5.10B	201	Stereoselective Synthesis
5.11	202	Chiral Drugs
	203	The Chemistry of: Selective Binding of Drug Enantiomers to Left- and Right-Hand Coiled DNA
5.12	203	Molecules with More Than One Chirality Centree
5.12A	205	Meso Compounds
5.12B	206	Naming Compounds with More than One Chirality Centre
5.13	207	Fischer Projection Formulas
5.14	209	Stereoisomerism of Cyclic Compounds
5.14A	209	Cyclohexane Derivatives
5.15	211	Relating Configurations Through Reactions in Which No Bonds to the Chirality Centre are Broken
5.15A	212	Relative and Absolute Configurations
5.16	213	Separation of Enantiomers: Resolution
5.16A	214	Pasteur's Method for Separating Enantiomers
5.16B	214	Current Methods for Resolution of Enantiomers
5.17	214	Compounds with Chirality Centres Other than Carbon
5.18	215	Chiral Molecules that do not Possess a Chirality Centre (a Tetrahedral Atom with Four Different Groups Attached)
	216	Key Terms and Concepts
	217	Concept Map

Problems: In-Chapter 5.1 to 5.29

	218	End of Chapter 5.30 to 5.44
	220	Learning Group Problems
		Additional Problems - The CD accompanying the text book includes a set of computer molecular model stereochemistry exercises that are keyed to the text

Week of Feb 16: Family Day & Winter Semester Break: No Classes

Weeks of Feb 23 & March 2: IONIC REACTIONS: Nucleophilic Substitution and Elimination Reactions of Alkyl Halides

Read and Study Chapter 6

	221	Breaking Bacteria Cell Walls With Organic Chemistry
6.1	222	Organic Halides
	222	Table 6.1: Carbon-Halogen Bond lengths and Bond Strengths
6.1A	223	Physical Properties of Organic Halides
	223	Table 6.2: Organic Halides
6.2	224	Nucleophilic Substitution Reactions
6.3	224	Nucleophiles
6.4	225	Leaving Groups
6.5	226	Kinetics of a Nucleophilic Substitution Reaction - a Substitution Nucleophilic Bimolecular (S_N2) Reaction
6.6	227	A Mechanism for the S_N2 Reaction
6.7	228	Transition State Theory: Free-Energy Diagrams
6.8	229	The Stereochemistry of S_N2 Reactions
6.9	235	The Reaction of Tert-Butyl Chloride with Hydroxide Ion: An S_N1 Reaction
6.9A	235	Multistep Reactions and the Rate-Determining Step
6.10	236	A Mechanism for the S_N1 Reaction
6.11	237	Carbocations
6.11A	237	The Structure of Carbocations
6.11B	238	The Relative Stabilities of Carbocations
6.12	239	The Stereochemistry of S_N1 Reactions
6.12A	239	Reactions That Involve Racemization
6.12B	240	Solvolysis – Cleavage of the Solvent by the Nucleophile
6.13	241	Factor's Affecting the Rates of S_N1 and S_N2 Reactions
6.13A	241	The Effect of the Structure of the Substrate
	241	Table 6.4: Relative Rates of Reactions of Alkyl Halides in S_N2 Reactions
	243	S_N1 Reactions and the Hammond-Leffler Postulate
6.13B	244	The Effect of the Concentration and the Strength of the Nucleophile
	244	Nucleophilicity versus Basicity
6.13C	245	Solvent Effects on S_N2 Reactions: Polar Protic and Aprotic Solvents
6.13D	247	Solvent Effects on S_N1 Reactions: The Ionizing Ability of the Solvent
	247	Table 6.5: Dielectric Constants of Common Solvents
6.13E	247	The Nature of the Leaving Group
	249	Summary of S_N1 versus S_N2
	249	Table 6.6: Factors Favouring S_N1 versus S_N2 Reactions
6.14	250	Organic Synthesis - Functional Group Transformations Using S_N 2 Reactions
	251	The Chemistry of ... Biological Methylation: A Biological Nucleophilic Substitution Reaction
6.14A	252	The Unreactivity of Vinylic and Phenyl Halides

Week of March 9: ALKENES AND ALKYNES I: Properties and Synthesis. Elimination Reactions of Alkyl Halides

Read and Study Chapter 7

7.12 292 Alkylation of Alkynide Anions: Some General Principles of Structure and Reactivity Illustrated
7.13 292 Hydrogenation of Alkenes
293 The Chemistry of Hydrogenation in the Food Industry
7.14 294 Hydrogenation: The Function of the Catalyst
7.14A 295 Syn and Anti Additions
295 The Chemistry of Homogeneous Asymmetric Catalytic Hydrogenation: Examples Involving L-DOPA, (S)-Naproxen, and Aspartame
7.15 297 Hydrogenation of Alkynes
7.15A 297 Syn Addition of Hydrogen: Synthesis of cis-Alkenes
7.15B 297 Anti Addition of Hydrogen: Synthesis of trans-Alkenes
7.16 298 An Introduction to organic Synthesis
7.16A 298 Why do Organic Synthesis?
7.16B 299 Retrosynthetic Analysis – Planning an Organic Synthesis
7.16C 300 Identifying Precursors
302 The Chemistry of – From the Inorganic to the Organic
7.16D 302 Raison d'Etre
303 Summary and Review Tools
304 Summary of Methods for the Preparation of Alkenes and Alkynes ;
1. Dehydrohalogenation of Alkyl Halides (Section 7.6, p 275)
2. Dehydration of Alcohols (Sections 7.7 & 7.8, p 280)
3. Hydrogenation of Alkynes (Section 7.15, p 297)
(4. Dehydrohalogenation of vic-Dihalides x 2 (Section 7.9, p 288))
305 Summary and Review Tools
306 Key Terms and Concepts

Problems: In-Chapter 7.1 to 7.17
306 End of Chapter 7.18 to 7.46
310 Learning Group Problems

Week of March 16: ALKENES AND ALKYNES II: Addition Reactions.

Read and Study Chapter 8.

311 The Sea: A Treasure of Biologically Active Natural Products
8.1 312 Introduction: Addition to Alkenes
8.1A 313 Understanding Additions to Alkenes
8.2 314 Electrophilic Addition of Hydrogen Halides to Alkenes: Mechanism and Markovnikov's Rule
8.2A 316 Theoretical Explanation of Markovnikov's Rule
8.2B 318 Modern Statement of Markovnokov's Rule
8.2C 319 Regioselective Reactions
8.2D 319 An Exception to Markovnikov's Rule
8.3 319 Stereochemistry of the Ionic Addition to an Alkene
8.4 320 Addition of Sulfuric Acid to Alkenes
8.4A 320 Alcohols from Alkyl Hydrogen Sulfates
8.5 321 Addition of Water to Alkenes: Acid Catalyzed Hydration
8.5A 321 Mechanism for Acid-Catalyzed Hydration
8.5B 322 Rearrangements

Week of March 23: RADICAL REACTIONS

Read and Study Chapter 10

Problems: In-Chapter 10.1 to 10.22
461 End of Chapter 10.23 to 10.34
463 Learning Group Problems.

Week of March 30: ALCOHOLS AND ETHERS.

Read and Study Chapter 11.

	469	Molecular Hosts
11.1	470	Structure and Nomenclature
11.1A	471	Nomenclature of Alcohols
11.1B	472	Nomenclature of Ethers
11.2	472	Physical Properties of Alcohols and Ethers
	473	Tables 11.1 and 11.2: Physical Properties of Ethers and Alcohols
11.3	474	Important Alcohols and Ethers
11.3A-D	474	Methanol, Ethanol, Ethylene Glycol, Diethyl Ether
11.4	476	Synthesis of Alcohols from Alkenes
	476	1. Acid-Catalyzed Hydration of Alkenes
	477	2. Oxymercuration-Demercuration
	477	3. Hydroboration-Oxidation
11.5	478	Reactions of Alcohols
11.6	479	Alcohols as Acids
11.7	480	Conversion of Alcohols into Alkyl Halides
11.8	480	Alkyl Halides from the Reactions of Alcohols with Hydrogen Halides
11.8A	481	Mechanisms of the Reactions of Alcohols with HX
11.9	483	Alkyl Halides from the Reactions of Alcohols with PBr_3 or $SOCl_2$
11.10	484	Tosylates, Mesylates and Triflates: Leaving Group Derivatives of Alcohols
	487	The Chemistry of Alkyl Phosphates
11.11	487	Synthesis of Ethers
11.11A	487	Ethers by Intermolecular Dehydration of Alcohols
11.11B	489	The Williamson Synthesis of Ethers
11.11C	490	Synthesis of Ethers by Alkoxymercuration-Demercuration
11.11D	490	tert-Butyl Ethers by Alkylation of Alcohols: Protecting Groups
11.11E	491	Silyl Ether Protecting Groups
11.12	482	Reactions of Ethers: Ether Cleavage by Strong Acids
11.13	493	Epoxides
11.13A	493	Synthesis of Epoxides: Epoxidation of Alkenes
11.13B	495	Stereochemistry of Epoxidation
	494	The Chemistry of The Sharpless Asymmetric Epoxidation
11.14	496	Reactions of Epoxides: 1. Acid Catalyzed Ring Opening 2. Base Catalyzed Ring Opening
	498	The Chemistry of Epoxides, Carcinogens, and Biological Oxidation
11.14A	499	Polyethers from Epoxides
11.15	500	Anti 1,2-Dihydroxylation of Alkenes via Epoxides
	502	The Chemistry of Environmentally Friendly Alkene Oxidation Methods
11.16	503	Crown Ethers: Nucleophilic Substitution Reactions in Relatively Nonpolar Aprotic Solvents by Phase-Transfer Catalysis
11.16A	504	Crown Ethers
11.16B	506	Transport Antibiotics and Crown Ethers
11.17	506	Summary of Reactions of Alkenes, Alcohols and Ethers

11.17A 506 Alkenes in Synthesis
507 Key Terms and Concepts.
508 Summary and Review Tool: Some Synthetic Connections of Alkynes, Alcohols, Alkyl Halides and Ethers
Problems: In-Chapter 11.1 to 11.24
509 End of Chapter 11.25 to 11.51
512 Learning Group Problems.

Week of April 6: ALCOHOLS FROM CARBONYL COMPOUNDS: OXIDATION-REDUCTION AND ORGANOMETALLIC COMPOUNDS.

Read and Study Chapter 12
513 The Two Aspects of the Coenzyme NADH
12.1 514 Introduction
12.1A 514 Structure of the Carbonyl Group
12.1B 515 Reactions of Carbonyl Compounds with Nucleophiles
12.2 515 Oxidation-Reduction Reactions in Organic Chemistry
12.2A 516 Oxidation States of Organic Chemistry
12.3 517 Alcohols by Reduction of Carbonyl Compounds
12.3A 517 Lithium Aluminum Hydride Reductions of Carbonyl Compounds
12.3B 518 Sodium Borohydride Reductions of Carbonyl Compounds
12.3C 519 Overall Summary of $LiAlH_4$ and $NaBH_4$ Reactivity
519 The Chemistry of Alcohol Dehydrogenase
520 The Chemistry of Stereoselective Reductions of Carbonyl Groups
12.4 521 Oxidation of Alcohols
12.4A 521 Oxidation of Primary Alcohols to Aldehydes: RCH_2OH to RCHO
12.4B 522 Oxidation of Primary Alcohols to Carboxylic Acids: RCH_2OH to RCO_2H
12.4C 522 Oxidation of Secondary Alcohols to Ketones: RCH(OH)R' to RCOR'
12.4D 523 Mechanism of Chromate Oxidations
12.4E 525 A Chemical Test for Primary and Secondary Alcohols
12.4F 525 Spectroscopic Evidence for Alcohols
12.5 526 Organometallic Compounds
12.6 526 Preparation of Organo Lithium and Organo Magnesium Compounds
12.6A 526 Organolithium Compounds
12.6B 527 Grignard Reagents
12.7 528 Reactions of Organolithium and Organomagnesium Compounds
12.7A 528 Reactions with Compounds Containing Acidic Hydrogen Atoms
12.7B 529 Reactions of Grignard Reagents with Oxiranes (Epoxides)
12.7C 530 Reactions of Grignard Reagents with Carbonyl Compounds
12.8 531 Alcohols from Grignard Reagents: Reaction of Grignard Reagents with:
1. Formaldehyde to Give Primary Alcohols
2. Other Aldehydes to Give Secondary Alcohols
3. Ketones to Give Tertiary Alcohols
4. Esters with 2 x RMgX to Give Tertiary Alcohols
12.8A 532 Planning a Grignard Synthesis
12.8B 536 Restrictions on the Use of Grignard Reagents
12.8C 537 The Use of Lithium Reagents
12.8D 537 The Use of Sodium Alkynides
12.9 539 Protecting Groups

	540	Summary of Reactions
	541	Synthetic Connections of Alcohols and Carbonyl Compounds
	541	Key Terms and Concepts

Problems: In-Chapter 12.1 to 12.10
542 End of Chapter 12.11 to 12.29
545 Learning Group Problems.
546 First Review Problem Set 1 to 25.

Week of April 13: CONJUGATED UNSATURATED SYSTEMS.

Read and Study Chapter 13.

	550	Molecules With the Nobel Prize in Their Synthetic Lineage
13.1	551	Introduction
13.2	551	Allylic Substitution and the Allyl Radical
13.2A	552	Allylic Chlorination (High Temperature)
13.2B	554	Allylic Bromination with N-Bromosuccinimide (Low Conc. of Br_2)
13.3	555	The Stability of the Allyl Radical
13.3A	555	Molecular Orbital Description of the Allyl Radical
13.3B	557	Resonance Description of the Allyl radical
13.4	558	The Allyl Carbocation
13.5	559	Summary of Rules for Resonance
13.5A	560	Rules for Writing Resonance Structures
13.5B	561	Estimating the Relative Stability of Resonance Structures
13.6	563	Alkadienes and Polyunsaturated Hydrocarbons
13.7	564	1,3-Butadiene: Electron Delocalization
13.7A	564	Bond Lengths of 1,3-Bitadiene
13.7B	565	Conformations of 1,3-Butadiene, s-cis and s-trans
13.7C	565	Molecular Orbitals of 1,3-Butadiene
13.8	566	The Stability of Conjugated Dienes
13.9	568	Ultraviolet-Visible Spectroscopy
13.9A	568	The Electromagnetic Spectrum
13.9B	569	UV-Vis Spectrophotometers
13.9C	571	Absorption Maxima for Nonconjugated and Conjugated Dienes
	573	The Chemistry of The Photochemistry of Vision
13.9D	576	Analytical Uses of UV-Vis Spectroscopy
13.10	576	Electrophilic Attack on Conjugated Dienes: 1,4-Electrophilic Addition
13.10A	578	Kinetic Control versus Thermodynamic Control of a Chemical Reaction
13.11	580	The Diels-Alder Reaction: 1,4-Cycloaddition of Dienes
13.11A	581	Factors Favoring the Diels-Alder Reaction
13.11B	582	Stereochemistry of the Diels-Alder Reaction
13.11C	584	Molecular Orbital Considerations That Favor an Endo Transition State
	586	The Chemistry of Asymmetric and Intramolecular Diels-Alder Reactions
	588	Concept Map
	589	Key Terms and Concepts.

Problems: In-Chapter 13.1 to 13.15

589 End of Chapter 13.16 to 13.46
594 Learning Group Problems.

CHEMISTRY 2610: READING, STUDYING, AND PRACTICE PROBLEMS

All references are to Wade, L.G.(Jr), *Organic Chemistry,* 6th Edition, Pearson Prentice-Hall, 2006.

FALL SEMESTER

Weeks of
Jan 5, 12, 19 & 26: INTRODUCTION AND REVIEW, Chapter 1;
STRUCTURE AND PROPERTIES OF ORGANIC MOLECULES, Chap. 2;
INFRARED SPECTROSCOPY, Chap. 12, Sect 12-1 to 12-12;

Chapter 1, INTRODUCTION AND REVIEW

Sect #	**Page #**	Read and Study Chapter 1
1-1	1	The origin of Organic Chemistry
1-2	3	Principles of Atomic Structure
1-3	6	Bond Formation: The Octet
1-4	7	Lewis Structures
1-5	8	Multiple Bonding
1-6	9	Electronegativity and Bond Polarity
	9	Summary: Common Bonding Patterns (uncharged)
1-7	12	Formal Charge
1-8	12	Ionic Structures
	13	Summary: Common Bonding Patterns in Organic Compounds and Ions
1-9	13	Resonance
1-10	17	Structural Formulas
1-11	20	Molecular Formulas and Empirical Formulas
1-12	21	Arrhenius Acids and Bases
1-13	22	Bronsted-Lowry Acids and Bases
1-14	29	Lewis Acids and Bases
	32	Chapter 1 Glossary
	34	Essential Problem Solving Skills in Chapter 1
	34	Study Problems:
		In-Chapter, 1-1 to 1-19
	34	End of Chapter 1-20 to 1-48

Practice Problems: You are encouraged to work all of the in-chapter problems, and you are required to complete the short in-class weekly assignments. Routinely doing problems in organic chemistry leads to understanding of the theory, and good grades in organic chemistry.

In the words of Solomons and Fryhle:

"*One way to check your progress is to work each of the in-chapter problems when you come to it. These problems have been written just for this purpose and are designed to help you decide whether or not you understand the material that has just been explained.*"

And, in the words of Wade:

"It's easy to fool yourself into thinking you understand organic chemistry when you actually do not. As you read through this book, all the facts and ideas may make sense, yet you have not learned to combine and use those facts and ideas. An examination is a painful time to learn that you do not really understand the material.

The best way to understand organic chemistry is to use it. You will certainly need to read and reread all the material in the chapter, but this level of understanding is just the beginning. Problems are provided so you can work with the ideas, applying them to new compounds and new reactions that you have never seen before. By working problems, you force yourself to use the material and fill in the gaps in your understanding. You also increase your level of self-confidence and your ability to do well on exams".

Chapter 2, STRUCTURE AND PROPERTIES OF ORGANIC MOLECULES;

Read and Study Chapter 2

Chapter 12, Sections 12-1 to 12-12; INFRARED SPECTROSCOPY

Read and Study Chapter 12, Sections 12-1 to 12-12

12-9	523	Characteristic Absorptions of Carbonyl Compounds
12-10	529	Characteristic Absorptions of C-N Bonds
12-11	530	Simplified Summary of IR Stretching Frequencies
12-12	532	Reading and Interpreting IR Spectra (Solved Problems)
	552	Study Problems
		In-Chapter 12-1 to 12-6
	552	End of Chapter 12-12 to 12-28

Week of Feb 2: STRUCTURE AND STEREOCHEMISTRY OF ALKANES

Read and Study Chapter 3

3-1	81	Classification of Hydrocarbons (Review)
3-2	82	Molecular Formulas of Alkanes
3-3	83	Nomenclature of Alkanes
	83	Summary: Rules of Naming Alkanes
3-4	89	Physical Properties of Alkanes
3-5	91	Uses and Sources of Alkanes
3-6	93	Reactions of Alkanes
3-7	94	Structure and Conformations of Alkanes
3-8	98	Conformations of Butane
3-9	100	Conformations of Higher Alkanes
3-10	100	Cycloalkanes
3-11	103	cis-trans Isomerism in Cycloalkanes
3-12	103	Stabilities of Cycloalkanes: Ring Strain
3-13	107	Cyclohexane Conformations
	110	Problem-Solving Strategy: Drawing Chair Conformations
3-14	111	Conformations of Monosubstituted Cyclohexanes
3-15	114	Conformations of Disubstituted Cyclohexanes
	116	problem-Solving Strategy: Recognizing cis and trans isomers
3-16	117	Bicyclic Molecules
	119	Chapter 3 Glossary
	122	Essential Problem Solving Skills in Chapter 3
	122	Study Problems
		In-Chapter, 3-1 to 3-31
	34	End of Chapter 3-32 to 3-46

Week of Feb 9: STEREOCHEMISTRY: CHIRAL MOLECULES

Read and Study Chapter 5

5-1	167	Introduction
5-2	168	Chirality
5-3	174	(R) and (S) Nomenclature of Asymmetric Carbon Atoms
5-4	179	Optical Activity
5-5	184	Biological Discrimination of Enantiomers
5-6	185	Racemic Mixtures
5-7	186	Enantiomeric Excess and Optical Purity

Week of Feb 16: Family Day & Winter Semester Break: No Classes

Weeks of Feb 23 & March 2: ALKYL HALIDES: NUCLEOPHILIC SUBSTITUTION AND ELIMINATION REACTIONS

Read and Study Chapter 6

Week of March 9 & 16: ALKENES, AND ALKYNES: STRUCTURE, SYNTHESES AND REACTIONS (Chapters 7, 8 and 9)

Chapter 7: STRUCTURE AND SYNTHESIS OF ALKENES

Read and Study Chapter 7

Chapter 8: REACTIONS OF ALKENES

Read and Study Chapter 8

Week of March 23: THE STUDY OF CHEMICAL REACTIONS: RADICAL REACTIONS

Read and Study Chapter 4

Week of March 30 & April 6: ALCOHOLS, ETHERS, EPOXIDES AND SULFIDES (Chapters 10, 11 and 14)

Chapter 10: STRUCTURE AND SYNTHESIS OF ALCOHOLS

Read and Study Chapter 10

Chapter 11: REACTIONS OF ALCOHOLS

Read and Study Chapter 11

Chapter 14: ETHERS, EPOXIDES AND SULFIDES

Read and Study Chapter 14

14-7	636	Industrial Synthesis: Bimolecular Dehydration of Alcohols
	636	Summary: Synthesis of Ethers
14-8	636	Cleavage of Ethers by HBr and HI
14-9	639	Autoxidation of Ethers
	639	Summary: Reactions of Ethers
14-10	640	Sulfides (Thioethers)
14-11	642	Synthesis of Epoxides
	645	Summary: Epoxide Syntheses
14-12	645	Acid-Catalyzed Ring Opening of Epoxides
14-13	649	Base-Catalyzed Ring Opening of Epoxides
14-14	650	Orientation of Epoxide ring opening
14-15	652	Reactions of Epoxides with Grignard and Organolithium Reagents
14-46	653	Epoxy Resins: The Advent of Modern Glues
	655	Summary: Reactions of Epoxides
	656	Chapter 14 Glossary
	658	Essential Problem Solving Skills in Chapter 14
	658	Study Problems
		In-Chapter Problems 14-1 to 14-28
		End of Chapter Problems 14-29 to 14-48

Week of April 13: CONJUGATED SYSTEMS, ORBITAL SYMMETRY, AND ULTRAVIOLET SPECTROSCOPY

Read and Study Chapter 15.

15-1	663	Introduction
15-2	663	Stabilities of Dienes
15-3	665	Molecular orbital Picture of a Conjugated System
15-4	669	Allylic Cations
15-5	670	1,2- and 1,4- addition to Conjugated Dienes
15-6	672	Kinetic Versus Thermodynamic Control in addition of HBR to 1,3-Butadiene
15-7	674	Allylic Radicals
15-8	676	Molecular Orbitals of the Allylic System
15-9	678	Electronic Configurations of the Allylic Radical, Cation, and Anion
15-10	679	S_N2 Displacement Reactions of Allylic Halides and Tosylates
15-11	680	The Diels-Alder Reaction
	680	Key Mechanism: The Diels-Alder Reaction
15-12	689	The Diels-Alder as an Example of a Pericyclic Reaction
15-13	692	Ultraviolet Absorption Spectroscopy
	699	Chapter 15 Glossary
	701	Essential Problem Solving Skills in Chapter 15
	701	Study Problems
		In-Chapter Problems 15-1 to 15-22
	701	End of Chapter Problems 15-23 to 15-38

REFERENCES TO ORGANIC LECTURE AND LABORATORY TEXTS

1. Solomons, T.W.G., and Fryhle, C.B., *Organic Chemistry*, 9th Edition, Wiley, 2008. ISBN-13: 978-0-471-68496-1, QD253.2.S65 2006

2. Solomons, T.W.G., *Organic Chemistry,* 5th/6th/7th/8th Editions, Wiley, 1992/95/2000/02/04. QD253.2.S65 2003

3. Solomons, T.W.G., *Study Guide and Solutions Manual to Organic Chemistry,* 5th/6th/7th Editions, Wiley, 1992/95/2000/02. ISBN 0-471-83661-3.

4. Wade, L.G.(Jr), *Organic Chemistry*, 1st/2nd/3rd/4th/5th/6th Editions, Prentice-Hall, 1987/91/95/99/2003/05 ISBN 0-13-033832-X, QD 251.2.W 33 2003.

5. Simek, J.W., *Solutions Manual to Organic Chemistry by Wade*, Prentice-Hall, 1991/95.

6. Morrison, R.T., and Boyd, R.N., *Organic Chemistry,* Allyn and Bacon, 1973, 1983, and 1987 Editions, QD 251.2.M 67.

7. Bailey, P.S., Jr, Bailey, C.A., *Organic Chemistry: A brief Survey of Concepts and Applications,* 6th Edition, Prentice Hall, 2000, ISBN 0-13-924119-1, QD251.2.B34 2000 547-dc21

8. Baker, A.D., Engel, R., *Organic Chemistry*, West, 1992, QD251.2.B345.

9. Boxer, R., *Essential of Organic Chemistry,* Wm. C. Brown, 1997, ISBN 0-697-14060-1.

10. Brown, W.H., *Introduction to Organic Chemistry,* Saunders College Publishing/Harcourt Brace College Publishers, 1997, ISBN 0-03-016914-3.

11. Brown, W.H., Foote, C.S., Organic Chemistry, 2nd Edition, Saunders College Publishing/Harcourt Brace College Publishers, 1998, ISBN 0-03-020458-5.

12. Bruice, P.Y., *Organic Chemistry,* 1st/2nd/3rd/4th/5th Editions, 1995/98/2001/04/07, Prentice Hall, ISBN 0-13-196316-3, QD251.3.B78 2007.

13. Carey, F.A., *Organic Chemistry*, 1st/2nd/3rd/4th/5th Editions, 1987/92/96/2000/03 McGraw-Hill, ISBN 0-07-242458-3, QD 251.3.C37 2003.

14. Carroll, F.A., *Perspectives on Structure and Mechanism in Organic Chemistry,* Brooks/Cole, 1998, ISBN 0-534-24948-5, QD476.C375 1998 547-dc20.

15. Clayden, J., Greeves, N., Warren, S., Wothers, P., Organic Chemistry, Oxford University Press, 2001, ISBN 0 19 850346 6

16. Ege, S.N., *Organic Chemistry*, 2nd Edition, D.C. Heath, 1989, ISBN 0-669-18178-1.

17. Fessenden, R.J., and Fessenden, J.S., *Organic Chemistry,* 3rd/4th/5th/6th Editions, 1986/90/94/98, Brooks/Cole, QD 251.2.F 49.

18. Fox, M.A., Whitesell, J.K., *Organic Chemistry*, 2nd & 3rd Editions, Jones and Barlett, 1997, 2004 ISBN 0-7637-0178-5, QD251.2.F69 1997.

19. Hornback, J.M., *Organic Chemistry*, 1998, Brooks/Cole, QD 253.H66 1998. ISBN 0-534-35254-5

20. Loudon, G.M., *Organic Chemistry*, 4th Edition, Oxford University Press, 2002, ISBN 0-19-511999-1, QD 252.3.L68 2001.

21. Lowry, T.H., and Richardson, K.S., *Mechanism and Theory in Organic Chemistry*, 3rd Edition, Harper & Row, 1987, QD471.L68, ISBN 0-06-044084-8.

22. March, J., *Advanced Organic Chemistry*, 4th Edition, Wiley, 1992, QD251.2.M37, ISBN 0-471-60180-2

23. Miller, B., *Advanced Organic Chemistry: Reactions and Mechanisms*, Prentice Hall, 1998, ISBN O-13-373275-4

24. Millam, M.J., *Reaction Guide for the Brief Organic Chemistry Course*, Heath, 1988, ISBN 0-669-13247-0

25. Mackie, R.K., Smith, D.M., and Aitken, R.A., *Guide Book to Organic Synthesis*, 2nd Edition, Longman Scientific and Technical, 1990, ISBN 0-582-03375-6.

26. McMurray, J., *Organic Chemistry*, 1984/88/92/96 & 2004 (6th) Editions, Thomson Brooks/Cole, QD 251.2.M 43.

27. McMurray, J., *Fundamentals of Organic Chemistry*, 1990, 1998 (4th Edition), 2000 (5th Edition), Brooks/Cole, ISBN 0-534-37366-6, QD 251.2.M4.

28. McMurray, J., Castellion, M.E., *Fundamentals of General, Organic and Biological Chemistry*, 3rd Edition., ISBN 0-13-918517-3.

29. Ouellette, R.J., and Rawn, J.D., *Organic Chemistry*, Prentice Hall, 1996, QD 251.2.094.

30. Raber, D.J., and Raber, N.K., *Organic Chemistry*, West, 1988, QD251.2.R33.

31. Streitwieser, A.(Jr), and Heathcock, C.H., *Introduction to Organic Chemistry*, 3rd Edition, MacMillan, 1985, QD 251.2S 76.

32. Pine, S.H., *Organic Chemistry*, McGraw-Hill, 5th ed., 1987.

33. Vollhardt, K.P.C., Shore, N.E., *Organic Chemistry*, 2nd Edn. Freeman, 1994. QD 251.2.V 65.

34. Vollhardt, K.P.C., *Organic Chemistry*, Freeman, 1987. QD 251.2.V 65.

35. Sykes, *A Guidebook to Mechanisms in Organic Chemistry*, Longmans, 6th ed., 1987.

36. Pavia, D.L., Lampman, G.M., Kriz, G.S., and Engel, R.G. *Introduction to Organic Laboratory Techniques: a Microscale Approach*, 1st/2nd Editions, Saunders, 1990/95, ISBN 0-03-025418-3/0-03-006232-2.

37. Pavia, D.L., Lampman, G.M., and Kriz, G.S., *Introduction to Organic Laboratory Techniques*, Saunders, 3rd ed., 1988, QD 261.

38. Fessenden, R.J., and Fessenden, J.S., *Organic Laboratory Techniques,* 2nd Edition, 1993, Brooks/Cole, QD 261.F466 1993.

39. Mayo, D.W., Pike R.M., and Trumper, P.K., *Microscale Organic Laboratory: with Multistep and Multistep Syntheses,* 3rd Edition, Wiley, 1994, QD 261.M38.

40. Mayo, D.W., Pike R.M., and Butcher, S.S., *Microscale Organic Laboratory,* Wiley, 1986, QD 261.M38.

41. Mayo, D.W., Pike R.M., Butcher, S.S., and Trumper, P.K., *Microscale Techniques for the Organic Laboratory,* Wiley, 1991, ISBN 0471-62192-7 (pbk).

42. Most, C.F.(Jr), *Experimental Organic Chemistry,* Wiley, 1988, QD261.M78.

43. Wilcox, C.F.(Jr), *Experimental Organic Chemistry: a Small-Scale Approach,* 1st/2nd Editions, MacMillan, 1988/95, QD261.W497./QD261.W497, ISBN 0-02-427691-X.

44. Fieser, L.F., and Williamson, K.L., *Organic Experiments*, 7th edition, Heath, 1992, ISBN 0-669-24344-2.

45. Rappoport, Z., *CRC Handbook of Tables for Organic Compound Identification,* 3rd edition, CRC Press Inc, 1973, ISBN 0-8493-0303-6.

46. Svoronos, P., and Sarlo, E., *Organic Chemistry Laboratory Manual*, Wm. C. Brown, 1994, ISBN 0-697-14799-1.

47. Williamson, K.L., *Microscale Organic Experiments*, Heath, 1987.

48. Williamson, K.L., *Macroscale and Microscale Organic Experiments*, Houghton and Mifflin, 2003, ISBN 0-618-19702 -8.

49. Zanger, M., and McKee, J.R., *Small Scale Synthesis: A Laboratory Textbook of Organic Chemistry*, Wm. C. Brown, 1995, ISBN 0-697-20957-1.

50. Zubrick, J.W., *The Organic Chem Lab Survival Manual: A Student's Guide to Techniques,* 4th Edition, Wiley, 1997, ISBN 0-471-12948-8.

51. Rappoport, Z., *CRC Handbook of Tables for Organic Compound Identification*, 3rd Edition, CRC Press, 1964, ISBN 0-8493-0303-6.

52. Weast, R.C. (Editor), *CRC Handbook of Chemistry and Physics*, Annual Editions, CRC Press.

53. *The Aldrich Catalog/Handbook of Fine Chemicals,* Aldrich Chemical Company.

Note: These books are located in Room J207. Some of the texts are also located in the College Library. Additional items are located in J207, J211, the Chemistry Laboratories and the College Library.

54. Encyclopaedia's on Chemistry, Science and Technology;

55. Pouchert, C.J., *The Aldrich Library of Infrared Spectra*, 3rd Edition, Aldrich Chemical Co, 1981;

56. Pouchert, C.J., *The Aldrich Library of FT-IR Spectra*, Aldrich Chemical Co, 1985;

57. Pouchert, C.J., *The Aldrich Library of NMR Spectra*, Aldrich Chemical Co, 1983;

58. Pouchert, C.J., *The Aldrich Library C-13 and H-1 FT- NMR Spectra*, Aldrich Chemical Co, 1992;

59. *Chemical and Engineering News,* Rudy Baum (Editor), Published Weekly by the American Chemical Society (available in J.P. Sloan's office);

60. *Journal of Agricultural and Food Chemistry,* Seiber, J.N., (Editor), Published Monthly by the American Chemical Society (available in J.P. Sloan's office).

Document Reference: D\CH2610\CH2610A2-08-09out