GRANDE PRAIRIE REGIONAL COLLEGE

DEPARTMENT OF SCIENCE: CHEMISTRY

FORTY-FIRST SESSION 2006 – 2007

COURSE OUTLINES: ORGANIC CHEMISTRY

CH2630 B3

CHEMISTRY 2630 B3: Organic Chemistry II

PREREQUISITE: CH1610 or CH2610

INSTRUCTOR:
Dr. John P. Sloan
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LECTURE: CH2630 B3 T, R 10:00 - 11:20 in J201

ALBERTA TRANSFER CREDIT (Ref 2006-2007 Alberta Transfer Guide):

GPRC:	CH 2630	(3)	CH 2610	(3)	CH 2630	(3)
U of Alberta:	CHEM 161	(3)	CHEM 261	(3)	CHEM 363	(3)
U of Calgary:	CHEM 351	(3)	CHEM 351	(3)	CHEM 353	(3)
U of Lethbridge:	CHEM 2100	(3)	CHEM 2500	(3)	CHEM 2600	(3)
Athabasca U:	CHEM 2xx	(3)	CHEM 350	(3)	CHEM 360	(3)
Canadian UC:	CHEM 1xx	(4)	CHEM 241	(4)	CHEM 242	(4)
Concordia UC:	CH 161	(3)	CHEM 261	(3)	CHEM 263	(3)
King's UC:	CHEM 2xx	(3)	CHEM 350	(3)	CHEM 351	(3)

COURSE OUTLINE:

Lecture Component:

A continuation of the study of the fundamental principles of the chemistry of carbon compounds as commenced in Chemistry 1610 and Chemistry 2610. The study is based on a reaction mechanism approach to the functional group chemistry of arenes, aldehydes, ketones, carboxylic acids, esters, amides, amino acids and carbohydrates. Topics include: structure and bonding; physical properties; acidity and basicity; conformations of molecules; stereochemistry; addition, elimination and substitution reactions; structure-reactivity relationships; aromaticity and aromatic substitution; and spectroscopic 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:

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

Tutorial Component:

Problem solving and discussion sessions with weekly problem sets. Regular assignments will be given and marked.

Notes:

1. Lectures: Days, Time and Place
   CH2630 B3 M,W 8:30 – 9:50 in J201.

2. Laboratory Component: Day, Time and Place
   CH2630 BL1 T 14:30 - 17:20 in J119
   CH2630 BL2 M 14:30 - 17:20 in J116

3. Tutorial Component: Day, Time and Place
   CH2630 BS1 F 8:30 - 9:20 in J203
   CH2630 BS2 F 10:00 - 10:50 in J203

TEXT BOOKS AND LABORATORY ITEMS:

The following books are required:

Either,

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

Or,

1.2 Solomons, T.W.G., and C.B. Fryhle*, Organic Chemistry,* 8th Edition, Wiley, 2004

2. A Three Ring Binder to Hold: Sloan, J.P.*, Organic Chemistry Experiments Chemistry 1610/2610/2630,* Grande Prairie Regional College, 2006/2007.

The following is highly recommended:

3. Molecular Model Set for Organic Chemistry, Prentice Hall.

The following is a supplementary item:

1. Fernandez, J.E., and Solomons, T.W.G., *Study Guide and Solutions Manual to Organic Chemistry,* 8th Edition, 2004;
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 to be Scheduled for Friday Feb 16 --------	25%
2.	Final Exam to be scheduled between April 14 & 24 --------	40%
3.	Laboratory ----------	25%
4.	Tutorial Grading Component ----------	10%
		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	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

Notes:

1. The Mid-Term exam will be of 2 hours duration and the Final Exam will be of 3 hours duration.
2. Between 5 and 15% of exam content will be taken directly from weekly assignments.
3. A pass grade is essential for the Laboratory Component.
4. The Tutorial Grading Component consists of assignments and will contribute towards 10% of the final grade. A 10 question assignment will normally be given each week during the tutorial hour. To encourage general discussion and active student participation, assignment questions may be answered within "paired teams/study groups". Assignments not completed during the tutorial period are due within 24 hours without penalty, or later at the discretion of the Instructor.
   The marking scheme is:
   - 4.1 1 mark per correct answer with full details;
   - 4.2 ½ mark per correct answer with incomplete details;
   - 4.3 20% may be deducted from the mark for each college business day that an assignment is overdue.
5. Regular attendance in Lecture, Laboratory, and Tutorial Components is a Course Requirement.

Grande Prairie Regional College Calendar 2006 - 2007: Course Description (page 165).

CH2630 3(3-1-3)UT 105 Hours Organic Chemistry II

Continuation of the study of structural and chemical properties of the basic functional groups of organic compounds including aromatic compounds, aldehydes, ketones, carboxylic acids and their derivatives and amines. Illustration of these functional groups in natural products such as carbohydrates, amino acids and proteins, nucleic acids and lipids and discussion of the application of spectroscopic methods for structure determination in simple organic molecules.

Prerequisites: CH1610 or CH 2610

CHEMISTRY 2630 B3
READING, STUDYING, AND PRACTICE PROBLEMS

All references are to T.W.G. Solomons and C.B. Fryhle, *Organic Chemistry,* 8th Edition, Wiley, 2004.

WINTER SEMESTER

Weeks of Jan 1 & 8: SPECTROSCOPIC METHODS OF STRUCTURE DETERMINATION.

Sect #	**Page #**	Read and Study Chapter 9.
9.1	384	Introduction;
9.2	384	The Electromagnetic Spectrum;
9.3	386	Nuclear Magnetic Resonance (NMR) Spectroscopy;
9.3A	387	Sweep [Continuous Wave (CW)] NMR Spectrometers;
9.3B	387	Fourier Transform (FT) NMR Spectrometers;
9.3C	388	Chemical Shift - Peak Position in an NMR Spectrum;
9.3D	389	Integration of peak Areas - The Integral Curve;
9.3E	390	Signal Splitting;
9.4	390	Nuclear Spin: The Origin of the Signal;
9.5	392	Shielding and Deshielding of Protons;
9.6	394	The Chemical Shift;
9.7	395	Chemical Shift Equivalent and Non-equivalent Protons;
9.7A	395	Homotopic Hydrogen Atoms;
9.7B	396	Enantiotopic and Diastereotopic Hydrogen Atoms;
9.8	397	Signal Splitting, Spin-Spin Coupling;
9.9	406	Proton NMR Spectra and Rate Processes;
9.10	409	Carbon-13 NMR Spectroscopy;
9.10A	409	Interpretation of C-13 NMR Spectra;
9.10B	409	One Peak for Each Unique Carbon Atom;
9.10C	409	C-13 Chemical Shifts;
9.10D	411	Off-Resonance Decoupled Spectra;
9.10E	412	DEPT C-13 Spectra;
9.11	414	Two-Dimensional (2D) NMR Techniques;
9.11A	414	COSY Cross-Peak Correlations;
9.11B	416	HETCOR Cross-Peak Correlations;
9.12	412	An Introduction to Mass Spectrometry;
9.13	418	The Mass Spectrometer;
9.13A	418	Ionization
9.13B	419	Fragmentation;
9.13C	420	Ion Sorting;
9.14	421	The Mass Spectrum;
9.15	423	Determination of Molecular Formulas and Molecular Weights;
9.15A	423	The Molecular Ion and Isotopic Peaks;
9.15B	426	High-Resolution Mass Spectrometry;
9.16	428	Fragmentation;
9.16A	428	Fragmentation by Cleavage at a Single Bond;
9.16B	429	Fragmentation Equations;
9.16C	433	Fragmentation by Cleavage of two Bonds;
9.17	434	Gas Chromatography Coupled with Mass Spectroscopy (GC/MS) Analysis;
9.18	435	Mass Spectrometry of Biomolecules;
	436	Key Terms and Concepts.
	437	Concept Map ^{1}H NMR Spectroscopy
	438	Concept Map ^{13}C NMR Spectroscopy
	439	Concept Map Mass Spectroscopy

Problems: In-Chapter 9.1 to 9.24
440 End of Chapter 9.25 to 9.44
427 Learning Group Problems.

Week of Jan 15: AROMATIC COMPOUNDS.

Read and Study Chapter 14.

14.1 623 Introduction;
14.2 624 Nomenclature of Benzene Derivatives;
14.3 626 Reactions of Benzene;
14.4 627 The Kekulé Structure for Benzene;
14.5 628 The Stability of Benzene;
14.6 629 Modern Theories of the Structure of Benzene;
14.6A 630 The Resonance Explanation of the Structure of Benzene;
14.6B 631 The Molecular Orbital Explanation of the Structure of Benzene;
14.7 632 Hückel's Rule, the (4n+2) B Electron Rule;
14.7A 633 The Annulenes;
14.7B 635 NMR Spectroscopy - Evidence of Electron Delocalization in Aromatic Compounds;
14.7C 636 Aromatic Ions;
14.7D 638 Aromatic, Antiaromatic, and Nonaromatic Compounds;
14.8 640 Other Aromatic Compounds;
14.8A 640 Benzenoid Aromatic Compounds;
14.8B 642 Nonbenzenoid Aromatic Compounds;
14.8C 642 Fullerenes;
14.9 644 Heterocyclic Aromatic Compounds;
14.10 645 Aromatic Compounds in Biochemistry;
14.11 648 Spectroscopy of Aromatic Compounds;
14.11A 648 H-1 NMR Spectra;
14.11B 648 C-13 NMR Spectra;
14.11C 651 Infrared Spectra of Substituted Benzenes;
14.11D 652 Visible-Ultraviolet Spectra of Aromatic Compounds;
14.11E 653 Mass Spectra of Aromatic Compounds;
653 Key Terms and Concepts;
654 Concept Map Aromatic Compounds

Problems: In-Chapter 14.1 to 14.15
655 End of Chapter 14.16 to 14.38
662 Learning Group Problems.

Weeks of Jan 22: REACTIONS OF AROMATIC COMPOUNDS.

Read and Study Chapter 15.

15.1 665 Electrophilic Aromatic Substitution Reactions;
15.2 666 E^+ Ar Subn., a General Mechanism, Arenium Ions;
15.3 668 Halogenation of Benzene;
15.4 669 Nitration of Benzene;
15.5 670 Sulfonation of Benzene;
15.6 671 Friedel-Crafts Alkylation;
15.7 673 Friedel-Crafts Acylation;
15.8 675 Limitations of Friedel-Crafts Reactions;
15.9 677 Synthetic Applications of Friedel-Crafts Acylations, the Clemmensen Reduction;
15.10 679 Effect of Substituents on Reactivity and Orientation;
15.10A 679 Activating Groups: Ortho-Para Directors;
15.10B 680 Deactivating Groups: Meta Directors;
15.10C 681 Halo Substituents: Deactivating Ortho-Para Directors;
15.10D 681 Classification of Substituents;

15.11 681 Theory of Substituent Effects on Electrophilic Aromatic Substitution;
15.11A 681 Reactivity: The Effect of Electron-Releasing and Electron-Withdrawing Groups;
15.11B 684 Inductive and Resonance Effects: Theory of Orientation;
15.11C 685 Meta-Directing Groups;
15.11D 686 Ortho-Para-Directing Groups;
15.11E 690 Ortho-Para Directing and Reactivity of Alkylbenzenes;
15.11F 692 Summary of Substituent Effects on Orientation and Reactivity;
15.12 693 Alkyl Benzenes, Side Chain Reactions;
15.12A 693 Benzylic Radicals and Cations;
15.12B 694 Halogenation of the Side Chain - Benzylic Radicals;
15.13 697 Alkenyl Benzenes;
15.13A 697 Stability of Conjugated Alkenylbenzenes;
15.13B 698 Additions to the Double Bond of Alkenylbenzenes;
15.13C 699 Oxidation of the Side Chain;
15.13D 698 Oxidation of the Benzene Ring;
15.14 699 Synthetic Applications;
15.14A 701 Use of Protecting and Blocking Groups;
15.14B 702 Orientation in Disubstituted Benzenes;
15.15 703 Allylic and Benzylic Halides in Nucleophilic Substitution Reactions;
15.16 705 Reduction of Aromatic Compounds;
15.16A 706 The Birch Reduction;
707 Key Terms and Concepts;
708 Concept Map: Summary of Mechanisms;
709 Concept Map: Some Synthetic Connections of Benzene and Aryl Derivatives.
Problems In-Chapter 15.1 to 15.25
710 End of Chapter 15.26 to 15.56
715 Learning Group Problems.

Week of Jan 29: ALDEHYDES AND KETONES I: NUCLEOPHILIC ADDITION TO THE CARBONYL GROUP.

Read and Study Chapter 16.

16.1 717 Introduction;
16.2 717 Nomenclature of Aldehydes and Ketones;
16.3 719 Physical Properties;
16.4 720 Synthesis of Aldehydes;
16.4A 720 Aldehydes by Oxidation of Primary Alcohols;
16.4B 721 Aldehydes by reduction of Acyl Chlorides, Esters and Nitriles;
16.5 724 Synthesis of Ketones;
16.5A 724 Ketones from Alkenes, Arenes, and Secondary Alcohols;
16.5B 725 Ketones from Alkynes;
16.5C 726 Ketones from Lithium Dialkyl Cuprates;
16.5D 727 Ketones from Nitriles;
16.6 728 Nucleophilic Addition to the Carbon-Oxygen Double Bond;
16.6A 730 Reversibility of Nucleophilic Additions to Carbon-Oxygen Double Bond;
16.6B 730 Relative Reactivity: Aldehydes versus Ketones;
16.6C 731 Subsequent Reactions of Addition Products;
16.7 731 Addition of Water, Alcohols & Thiols: Hydrates, Hemiacetals, Acetals & Thioacetals;
16.7A 731 Hydrates and Hemiacetals;
16.7B 734 Acetals;
16.7C 736 Acetals as Protecting Groups;
16.7D 738 Thioacetals;
16.8 738 The Addition of Derivatives of Ammonia, Primary and Secondary Amines;
16.8A 739 Imines;
16.8B 740 Oximes, Hydrazones and Semicarbazones;

16.8C 740 Enamines;
743 Table 16.2: Reactions of Aldehydes and Ketones with Derivatives of Ammonia;
16.9 743 The Addition of Hydrogen Cyanide;
16.10 745 The Addition of Ylides: the Wittig Reaction;
16.11 749 The Addition of Organometallic Reagents, the Reformatsky Reaction;
16.12 751 Oxidation of Aldehydes and Ketones;
16.12A 751 The Baeyer-Villiger Oxidation of Aldehydes and Ketones;
16.13 753 Chemical Analyses of Aldehydes and Ketones;
16.13A 753 Derivatives of Aldehydes and Ketones;
16.13B 753 Tollen's Test (The Silver Mirror test);
16.14 754 Spectroscopic Properties of Aldehydes and Ketones;
16.14A 754 IR Spectra of Aldehydes and Ketones;
16.14B 754 NMR Spectra of Aldehydes and Ketones;
16.14C 756 Mass Spectra of Aldehydes and Ketones;
16.14D 756 Ultraviolet Spectra of Aldehydes and Ketones;
757 Summary of the Mechanisms – Acetals, Imines, and Enamines: Common Mechanistic Themes in their Acid-catalyzed Formation from Aldehydes and ketones for Addition Reactions to Aldehydes and Ketones;
758 Summary of Mechanisms: Nucleophilic Addition to Aldehydes and Ketones under Basic Conditions;
759 Summary of Mechanisms: Nucleophilic Addition to Aldehydes and Ketones under Basic Conditions;
761 Key Terms and Concepts.
Problems: In-Chapter 16.1 to 16.22
761 End of Chapter 16.23 to 16.53
767 Learning Group Problems.

Weeks of Feb 5 & 12: ALDEHYDES AND KETONES II: ALDOL REACTIONS.

Read and Study Chapter 17.

17.1 770 The Acidity of the ∀-Hydrogens of Carbonyl Compounds, Enolate Ions;
17.2 772 Keto and Enol Tautomers;
17.3 773 Reactions via Enols and Enolate Ions;
17.3A 773 Racemization;
17.3B 775 Halogenation of Ketones;
17.3C 776 The Haloform reaction;
17.4 779 The Aldol Reaction, the Addition of Enolate Ions to Aldehydes and Ketones;
17.4A 779 Dehydration of the Aldol Addition Product;
17.4B 780 Synthetic Applications;
17.4C 781 The Reversibility of Aldol Additions;
17.4D 783 Acid-Catalyzed Aldol Condensations;
17.5 784 Crossed Aldol Reactions;
17.5A 785 Practical Crossed Aldol Reactions;
17.5B 786 Claisen-Schmidt Reactions;
17.5C 788 Condensations with Nitroalkanes;
17.5D 789 Condensations with Nitriles;
17.6 789 Cyclization via Aldol Condensations;
17.7 791 Lithium Enolates;
17.7A 791 Regioselective Formation of Enolate Anions;
17.7B 792 Lithium Enolates in Directed Aldol Reactions;
17.7C 794 Direct Alkylation of Ketones via Lithium Enolates;
17.8 796 ∀-Selenation: A Synthesis of ∀,ß-Unsaturated Carbonyl Compounds;
17.9 797 Additions to ∀,ß-unsaturated Aldehydes and Ketones;
17.9A 799 Conjugate Addition of Organocopper Reagents;
17.9B 800 Michael Additions;
802 Summary of Mechanisms – Enolates: Formation and Reaction of Electrophiles by Substitution or Addition;
803 Synthetic Connections: Some Synthetic Connections Involving Enolates;

804 Key Terms and Concepts.
Problems: In-Chapter 17.1 to 17.27
804 End of Chapter 17.28 to 17.45
809 Learning Group Problems.

February 19 **Family Day, No Classes**

Week of Feb 19: **Winter Break, No Classes.**

Week of Feb 26: **CARBOXYLIC ACIDS AND THEIR DERIVATIVES: NUCLEOPHILIC ADDITION-ELIMINATION AT THE ACYL CARBON.**

Read and Study Chapter 18.

18.1 814 Introduction;
18.2 814 Nomenclature and Physical Properties;
18.2A 814 Carboxylic Acids;
18.2B 816 Carboxylic Salts;
18.2C 816 Acidity of Carboxylic Acids;
18.2D 818 Dicarboxylic Acids;
18.2E 819 Esters;
18.2F 820 Carboxylic Anhydrides;
18.2G 820 Acyl Chlorides;
18.2H 820 Amides;
18.2I 821 Nitriles;
18.2J 821 Spectroscopic Properties of Acyl Compounds;
18.3 823 Preparation of Carboxylic Acids;
18.4 826 Nucleophilic Addition-Elimination at the Acyl Carbon;
18.4A 828 Relative Reactivity of Acyl Compounds;
18.4B 828 Synthesis of Acid Derivatives;
18.5 828 Acyl Chlorides;
18.5A 828 Synthesis of Acyl Chlorides;
18.5B 829 Reactions of Acyl Chlorides;
18.6 830 Carboxylic Acid Anhydrides;
18.6A 830 Synthesis of Carboxylic Acid Anhydrides;
18.6B 831 Reactions of Carboxylic Acid Anhydrides;
18.7 832 Esters;
18.7A 832 Synthesis of Esters: Esterification;
18.7B 835 Base-Promoted Hydrolysis of esters: Saponification;
18.7C 837 Lactones;
18.8 838 Amides;
18.8A 838 Synthesis of Amides;
18.8B 838 Amides from Acyl Chlorides;
18.8C 839 Amides from Carboxylic Anhydrides;
18.8D 840 Amides from Esters;
18.8E 840 Amides from Carboxylic Acids and Ammonium Carboxylates;
18.8F 841 Hydrolysis of Amides;
18.8G 843 Nitriles from Dehydration of Amides;
18.8H 843 Hydrolysis of Nitriles;
18.8I 845 Lactams;
18.9 846 Derivatives of Carbonic Acid
18.9A 846 Alkyl Chloroformates and Carbamates (Urethanes);
18.10 848 Decarboxylation of Carboxylic Acids;
18.10A 850 Decarboxylation of Carboxyl Radicals;
18.11 851 Chemical Tests for Acyl Compounds;
851 Summary of the Reactions of Carboxylic Acids and Their Derivatives;
856 Summary and Review Tools: Synthetic Connections of Carboxylic Acids and Related Functional

Groups: A 3-D Array of Linked Functional Groups.
857 Key Terms and Concepts.
Problems: In-Chapter 18.1 to 18.18
858 End of Chapter 18.19 to 18.55
866 Learning Group Problems.
867 Special Topic B: Step Growth Polymers;
B.1 868 Polyamides;
B.2 870 Polyesters;
B.3 872 Polyurethanes;
B.4 873 Phenol-Formaldehyde Polymers;
B.5 874 Cascade Polymers.

Week of Mar 5: SYNTHESIS AND REACTIONS OF ß-DICARBONYL COMPOUNDS: MORE CHEMISTRY OF ENOLATE IONS.

Read and Study Chapter 19.

19.1 879 Introduction;
19.2 880 The Claisen Condensation: The Synthesis of ß-keto Esters;
19.2A 883 Crossed Claisen Condensation;
19.2B 885 Acylation of Other Carbanions;
19.3 885 The Acetoacetic Ester Synthesis: Synthesis of Methyl Ketones (Substituted Acetones);
19.3A 885 Alkylation;
19.3B 889 Acylation;
19.3C 890 Acetoacetic Ester Dianion: Alkylation at the Terminal Carbon
19.4 891 The Malonic Ester Synthesis: Synthesis of Substituted Acetic Acids;
19.5 895 Further Reactions of Active Hydrogen Compounds;
19.6 896 Direct Alkylation of Esters and Nitriles;
19.7 897 Alkylation of 1,3- Dithianes;
19.8 898 The Knoevenagel Condensation;
19.9 898 Michael Additions;
19.10 900 The Mannich Reaction;
19.11 902 Synthesis of Enamines: Stork Enamine Reactions;
19.12 907 Barbiturates;
19.13 908 Summary of Important Reactions;
911 Summary of Mechanisms: Some Synthetic Connections Involving ß-Dicarbonyl Compounds;
912 Key Terms and Concepts.
Problems : In-Chapter 19.1 to 19.24
912 End of Chapter 19.25 to 19.51
919 Learning Group Problems.
922 Special Topic C: Thiols, Sulfur Ylides and Disulfides.
C.1 923 Preparation of Thiols;
C.2 924 Physical Properties of Thiols;
C.3 925 The Addition of Sulfur Ylides to Aldehydes and Ketones;
C.4 925 Thiols and Disulfides in Biochemistry;
927 Thiol Esters and Lipid Biosynthesis;
D.1 927 Thiol Esters;
D.2 929 Biosynthesis of Fatty Acids;
D.3 933 Biosynthesis of Isoprenoid Compounds;
D.4 935 Biosynthesis of Steroids;
D.5 939 Cholesterol and heart Disease.

Week of Mar 12: AMINES.

Read and Study Chapter 20.

20.1 941 Nomenclature;

Week of Mar 19: PHENOLS AND ARYL HALIDES: NUCLEOPHILIC AROMATIC SUBSTITUTION. ORGANIC HALIDES AND ORGANOMETALLIC COMPOUNDS IN THE ENVIRONMENT.

Read and Study Chapter 21.
Read Special Topics F, G, and H, pages 1041-1071.

21.1 1001 Structure and Nomenclature of Phenols;
21.A 1001 Nomenclature of Phenols;
21.2 1002 Naturally Occurring Phenols;
21.3 1003 Physical Properties of Phenols;
21.4 1003 Synthesis of Phenols;
21.4A 1003 Laboratory Synthesis;
21.4B 1005 Industrial Synthesis;
1. Hydrolysis of Chlorobenzene (Dow Process).
2. Alkali Fusion of Sodium Benzenesulfonate.
3, From Cumene Hydroperoxide.

21.5 1008 Reactions of Phenols as Acids;
21.5A 1008 Strengths of Phenols as Acids;
21.5B 1010 Distinguishing and Separating Phenols from Alcohols and Carboxylic Acids;
21.6 1010 Other Reactions of the O-H Group of Phenols;
21.6A 1011 Phenols in the Williamson Synthesis;
21.7 1011 Cleavage of Alkyl Aryl Ethers;
21.8 1012 Reactions of the Benzene Ring of Phenols;
21.9 1014 The Claisen Rearrangement;
21.10 1015 Quinones;
21.11 1016 Aryl Halides and Nucleophilic Aromatic Substitution;
21.11A 1018 Nucleophilic Aromatic Substitution by Addition-Elimination: The S_NAr Mechanism;
21.11B 1019 Nucleophilic Aromatic Substitution through an Elimination-Addition Mechanism
The Benzyne Mechanism;
21.11C 1024 Phenylation;
21.12 1025 Spectroscopic Analysis of Phenols and Aryl Halides;
1026 Concept Map: Some Synthetic Connections of Phenols and Related Aromatic Compounds;
1027 Key Terms and Concepts.
Problems: In-Chapter 21.1 to 21.12
1027 End of Chapter 21.13 to 21.38
1032 Learning Group Problems

1035 Second Review Problem Set 1 to 24.

1041 Special Topic F: Electrocyclic and Cycloaddition Reactions.
F.1 1041 Introduction;
F.2 1041 Electrocyclic Reactions;
F.2A 1043 Electrocyclic Reactions of 4n pi-Electron Systems;
F.2B 1047 Electrocyclic Reactions of (4n + 2) pi-Electron Systems;
F.3 1050 Cycloaddition Reactions;
F.3A 1051 [2 + 2] Cycloadditions;
F.3B 1053 [4 + 2] Cycloadditions.
1055 Special Topic G: Transition Metal Organometallic Compounds;
G.1 1055 Introduction
G.2 1056 Electron Counting: the 18-Electron Rule;
G.3 1058 Metallocenes: Organometallic Sandwich Compounds;
G.4 1059 Reactions of Transition Metal Complexex;
G.5 1061 Homogeneous Hydrogenation;
G.6 1062 Carbon-Carbon Bond-Formation Using Rhodium Complexes

G.7 1064 Vitamin B_{12}: A Transition Metal Biomolecule;
1066 Special Topic H: Organic Halides and Organometallic Compounds in the Environment;
H.1 1066 Organic Halides as Insecticides;
H.2 1068 Organic Halides as Herbicides;
H.3 1069 Germicides;
H.4 1069 Polychlorinated Biphenyls (PCBs);
H.5 1070 Polybromobiphenyls (PBBs);
H.6 1070 Organometallic Compounds;

Week of Mar 26: CARBOHYDRATES AND LIPIDS (OPTIONAL).

Read Chapters 22 & 23.

1072 Carbohydrate recognition in Healing and Disease;
22.1 1073 Introduction to Carbohydrates;
22.1A 1073 Classification of Carbohydrates;
22.1B 1074 Photosynthesis and Carbohydrate Metabolism;
22.2 1076 Monosaccharides;
22.2A 1076 Classification of Monosaccharides;
22.2B 1076 D and L Designation of Monosaccharides;
22.2C 1077 Structural Formulas of Monosaccharides;
22.3 1081 Mutarotation;
22.4 1082 Glycoside Formation;
22.5 1085 Other Reactions of Monosaccharides;
22.5A 1085 Enolization, Tautomerization, and Isomerization;
22.5B 1085 Use of Protecting Groups in Carbohydrate Synthesis;
22.5C 1086 Formation of Ethers;
22.5D 1087 Conversion to Esters;
22.5E 1088 Conversion to Cyclic Acetals
22.6 1088 Oxidation Reactions of Monosaccharides;
22.6A 1088 Benedict's or Tollens' Reagents: Reducing Sugars;
22.6B 1089 Bromine water: The Synthesis of Aldonic Acids;
22.6C 1090 Nitric Acid Oxidation: Aldaric Acids;
22.6D 1091 Periodate Oxidations: Oxidative Cleavage of Polyhydroxy Compounds;
22.7 1093 Reduction of Monosaccharides: Alditols;
22.8 1094 Reactions of Monosaccharides with Phenylhydrazine: Osazones;
22.9 1095 Synthesis and Degradation of Monosaccharides;
22.9A 1095 Kiliani-Fischer Synthesis;
22.9B 1097 The Ruff Degradation;
22.10 1097 The D family of Aldoses;
22.11 1099 Fischer's Proof of the Configuration of D-(+)-Glucose;
22.12 1102 Disaccharides;
22.12A 1102 Sucrose;
22.12B 1103 Maltose;
22.12C 1104 Cellobiose;
22.12D 1107 Lactose;
22.13 1107 Polysaccharides;
22.13A 1107 Starch;
22.13B 1109 Glycogen;
22.13C 1110 Cellulose;
22.13D 1111 Celluose Derivatives;;
22.14 1113 Other Biologically Important Sugars;
22.15 1114 Sugars That Contain Nitrogen;
22.15A 1114 Glycosylamines;
22.15B 1115 Amino Sugars;
22.16 1116 Glycolipids and Glycoproteins of the Cell Surface: Cell Recognition and the Immune System;
22.17 1119 Carbohydrate Antibiotics.

1120 Summary of Reactions of Carbohydrates;
1121 Summary and Review Tools: A Summary of Reactions Involving Monosaccharides;
1122 Key Terms and Concepts.
Problems: In-Chapter 22.1 to 22.19
1122 End of Chapter 22.20 to 21.45
1127 Learning Group Problems

1142 LIPIDS (Chapter 23)

1129 Insulation for Nerves;
23.1 1130 Introduction to Lipids;
23.2 1131 Fatty Acids and Triacylglycerols;
23.2A 1133 Hydrogenation of Triacylglycerols;
23.2B 1134 Biological Functions of Triglycerols;
23.2C 1135 Saponification of Triglycerols;
23.2D 1138 Reactions of Carboxyl Groups of Fatty Acids;
23.2E 1139 Reactions of the Alkenyl Chain of Unsaturated Fatty Acids;
23.3 1139 Terpenes and Terpenoids;
23.3A 1143 Natural Rubber;
23.4 1143 Steroids;
23.4A 1143 Structure and Systematic Nomenclature of Steroids;
23.4B 1145 Cholesterol;
23.4C 1147 Sex Hormones;
23.4D 1149 Ardrenocortical Hormones;
23.4E 1150 D Vitamins
23.4F 1150 Other Steroids;
23.4G 1151 Reactions of Steroids;
23.5 1153 Prostaglandins;
23.6 1154 Phospholipids and Cell Membranes;
23.6A 1155 Phosphatides;
23.6B 1157 Derivatives of Sphingosine;
23.7 1158 Waxes;
1159 Summary of the Reactions of Lipids;
1159 Key Terms and Concepts.
Problems: In-Chapter 23.1 to 23.11
1160 End of Chapter 23.12 to 23.26
1164 Learning Group Problems.

Week of April 2: AMINO ACIDS AND PROTEINS (OPTIONAL).

Read Chapter 24.

1166 Catalytic Antibodies: Designer Catalysts
24.1 1167 Introduction;
24.2 1168 Amino Acids;
24.2A 1168 Structures and Names;
24.2B 1168 Essential Amino Acids;
24.2C 1170 Amino Acids as Dipolar Ions;
24.3 1173 Laboratory Synthesis of ∀-Amino Acids;
24.3A 1173 Direct Ammonolysis of an ∀-Halo Acid;
24.3B 1173 From Potassium Phthalimide;
24.3C 1174 The Strecker Synthesis;
24.3D 1175 Resolution of DL-Amino Acids;
24.3E 1175 Asymetric Syntheses of Amino Acids;
24.4 1177 Analysis of Polypeptides and Proteins;
24.4A 1179 Hydrolysis;
24.5 1181 Primary Structure of Polypeptides and Proteins;

Week of April 9: **REVIEW.**

CHEMISTRY 2630 B3
READING, STUDYING, AND PRACTICE PROBLEMS

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

WINTER SEMESTER

Weeks of Jan 1 & 8: SPECTROSCOPIC METHODS OF STRUCTURE DETERMINATION, Chapters 12 & 13.

Chapter 12: INFRARED SPECTROSCOPY AND MASS SPECTROSCOPY

Sect #	**Page #**	Read and Study Chapter12.
12-1	508	Introduction
12-2	509	The Electromagnetic Spectrum
12-3	510	The Infrared Region
12-4	511	Molecular Vibrations
12-5	513	IR-Active and IR-Inactive Vibrations
12-6	514	Measurement of the IR Spectrum
12-7	517	Infrared Spectroscopy of Hydrocarbons
12-7A	517	Carbon-Carbon Bond Stretching
12-7B	518	Carbon-Hydrogen Bond Stretching
12-7C	518	Interpretation of the IR Spectra of Hydrocarbons
12-8	522	Characteristic Absorptions of Alcohols and Amines
12-9	523	Characteristic Absorptions of Carbonyl Compounds
12-9A	523	Simple Ketones, Aldehydes and Acids
12-9B	527	Resonance Lowering of Carbonyl Frequencies
12-9C	528	Carbonyl Absorptions Above 1710 cm^{-1}
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)
12-13	537	Introduction to Mass Spectroscopy
12-13A	538	The Mass Spectrometer
12-13B	539	The Mass Spectrum
12-13C	539	Mass Spectrometry of Mixtures: The GC-MS
12-14	541	Determination of the Molecular Formula by Mass Spectrometry
12-14A	541	High Resolution Mass Spectrometry
12-14B	541	Use of Heavier Isotope Peaks
12-15	544	Fragmentation Patterns in Mass Spectroscopy
12-15A	544	Mass Spectra of Alkanes
12-15B	546	Fragmentation Giving Resonance Stabilized cations
12-15C	548	Fragmentation Splitting Out a Small Molecule; Mass Spectra of Alcohols
	549	Summary; Common Fragmentation Patterns
	551	Chapter 12 Glossary
	552	Essential Problem-Solving Skills in Chapter 12
	552	Study Problems: In Chapter, 12-1 to 12-11; End of Chapter, 12-12 to 12-28

Chapter 13: NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

Read and Study Chapter 13.

13-1	559	Introduction
13-2	559	Theory of Nuclear Magnetic Resonance
13-3	562	Magnetic Shielding by Electrons
13-4	564	The NMR Spectrometer
13-5A	565	Measurement of Chemical Shifts

13-5B	567	Characteristic Value of Chemical Shifts
13-6	572	The Number of Signals
13-7	573	Areas of the Peaks
13-8	576	Spin-Spin Splitting
13-8A	576	Theory of Spin-Spin Splitting
13-8B	578	The N + 1 Rule
13-8C	578	The Range of Magnetic Coupling
13-8D	582	Coupling Constants
13-9	585	Complex Splitting
13-10	588	Stereochemical Non-equivalence of Protons
13-11	591	Time Dependence of NMR Spectroscopy
13-11A	591	Conformational Changes
13-11B	591	Fast proton Transfers
13-12	599	Carbon-13 NMR Spectroscopy
13-12A	599	Sensitivity of Carbon NMR
13-12B	600	Fourier Transform NMR Spectroscopy
13-12C	601	Carbon Chemical Shifts
13-12D	602	Important Differences between Proton and Carbon Techniques
13-12E	603	Spin-Spin Splitting
13-12F	604	DEPT ^{13}C NMR
13-13	607	Interpreting Carbon NMR Spectra
13-14	609	Nuclear Magnetic Resonance Imaging
	614	Chapter 13 Glossary
	615	Essential Problem Solving Skills in Chapter 13
	616	Study Problems: In Chapter, 13-1 to 13-32; End of Chapter, 13-33 to 13-52

Week of Jan 15: AROMATIC COMPOUNDS.

Read and Study Chapter 16

16-1	705	Introduction: The Discovery of Benzene
16-2	705	The Structure and Properties of Benzene
16-3	709	The Molecular Orbitals of Benzene
16-4	712	The Molecular Orbital Picture of Cyclobutadiene
16-5	714	Aromatic, Antiaromatic, and Nonaromatic Compounds
16-6	714	Huckel's Rule
16-7	715	Molecular orbital Derivation of Huckel's Rule
16-8	717	Aromatic Ions
16-8A	718	The Cyclopentadienyl Ions (Anions & Cations)
16-8B	720	The Cycloheptatrienyl Ions (Anions & Cations)
16-8C	720	The Cyclooctatetraene Dianion
16-8D	722	Summary of Annulenes and Their Ions
16-9	723	Heterocyclic Aromatic Compounds
16-9A	723	Pyridine
169B	723	Pyrrole
16-9C	724	Pyrimidine and Imidazole
16-9D	725	Furan and Thiophene
16-10	727	Polynuclear Aromatic Hydrocarbons
16-11	729	Aromatic Allotropes of Carbon
16-11A	729	Allotropes of Carbon: Diamond
16-11B	730	Graphite
16-11C	730	Fullerenes
16-12	731	Fused Heterocyclic Compounds
16-13	732	Nomenclature of Benzene Derivatives
16-14	734	Physical properties of Benzene and its Derivatives
16-15	735	Spectroscopy of Aromatic Compounds

	738	Chapter 16 Glossary
	740	Essential Problem Solving Skills in Chapter 16
	740	Study Problems: In Chapter, 16-1 to 16-25; End of Chapter 16-26 to 16-50

Weeks of Jan 22: REACTIONS OF AROMATIC COMPOUNDS.

Read and Study Chapter 17

17-1	749	Electrophilic Aromatic Substitution
	750	Key Mechanism 17-1: Electrophilic Aromatic Substitution
17-2	751	Halogenation of Benzene
	751	Mechanism 17-2: Bromination of Benzene
17-3	753	Nitration of Benzene
	754	Mechanism 17-3: Nitration of Benzene
17-4	755	Sulfonation of Benzene
	755	Mechanism 17-4: Sulfonation of Benzene
17-5	757	Nitration of Toluene: The Effect of Alkyl Substitution
17-6	759	Activating, Ortho, Para-Directing Substituents
17-6A	759	Alkyl Groups
17-6B	760	Substituents with Nonbonding Electrons
	762	Summary: Activating, Ortho, Para-Directors
17-7	763	Deactivating Meta-Directing Substituents
	766	Summary: Deactivating Meta-Directors
17-8	766	Halogen Substituents: Deactivating, but Ortho, Para-Directing
	758	Summary: Directing Effects of Substituents
17-10	771	The Friedel-Crafts Alkylation
	772	Mechanism 17-5: Friedel Crafts Alkylation
17-11	775	The Friedel-Crafts Acylation
17-11A	776	Mechanism of Acylation
	776	Mechanism 17-6: Friedel Crafts Acylation
	778	Summary: Comparison of Friedel Crafts Alkylation and Acylation
17-11B	778	The Clemmensen Reduction Reaction: Synthesis of Alkyl Benzenes
17-11C	779	The Gatterman-Koch Formylation: Synthesis of Benzaldehydes

Note: The remainder of Chapter 17 is scheduled for covering after Chapter 19

See the Week of March19 for the remainder of Chapter 17: The remainder of Chapter 17 is:

17-12	780	Nucleophilic Aromatic Substitution
17-12A	781	The Addition-Elimination Mechanism
	781	Mechanism 17-7: Nucleophilic Aromatic Substitution (Addition-Elimination)
17-12B	781	The Benzyne Mechanism: Elimination-Addition
	784	Mechanism 17-8: Nucleophilic Aromatic Substitution (Benzyne Mechanism)
17-13	785	Addition Reactions of Benzene Derivatives
17-13A	785	Chlorination
17-13B	785	Catalytic Hydrogenation of Aromatic Rings
17-13C	785	Birch reduction
	786	Mechanism 17-9: The Birch Reduction
17-14	787	Side-Chain Reactions of Benzene
17-14A	787	Permanganate Oxidation
17-14B	788	Side-Chain Halogenation
17-14C	790	Nucleophilic Substitution at the Benzylic Position
17-15	791	Reactions of Phenols
17-15A	792	Oxidation of Phenols to Quinones
17-15B	793	Electrophilic Aromatic Substitution of Phenols
	794	Summary: Reactions of Aromatic Compounds

797 Chapter 17 Glossary
799 Essential Problem-Solving Skills in Chapter 17
800 Study Problems: In Chapter, 17-1 to 17-42; End of Chapter, 17-43 to 17-69

Week of Jan 29: ALDEHYDES AND KETONES I: Nucleophilic Addition to the Carbonyl Group.

Read and Study Chapter 18.

18-1 805 Carbonyl Compounds
805 Table 18-1: Some Common Classes of Carbonyl Compounds
18-2 806 Structure of the Carbonyl Group
18-3 806 Nomenclature of Ketones and Aldehydes
808 Table 18-2: Common Names of Aldehydes
18-4 809 Physical Properties of ketones and Aldehydes
810 Table 8-3: Physical Properties of Some ketones and Aldehydes
18-5 811 Spectroscopy of Ketones and Aldehydes
18-5A 811 Infrared Spectra of Ketones and Aldehydes
18-5B 811 Proton NMR Spectra of Ketones and Aldehydes
18-5C 812 Carbon NMR Spectra of Ketones and Aldehydes
18-5D 813 Mass Spectra of Ketones and Aldehydes
18-5E 816 Ultraviolet Spectra of Ketones and Aldehydes
18-6 818 Industrial Importance of Ketones and Aldehydes
818 Table 18-4: Ketones and Aldehydes Used in Household Products
18-7 818 Review of Synthesis of Ketones and Aldehydes
18-7A 818 Ketones and Aldehydes from Oxidation of Alcohols (Section 11-2)
18-7B 819 Ketones and Aldehydes from Ozonolysis of Alkenes (Section 18-15B)
18-7C 820 Phenyl Ketones and Aldehydes: Friedel Crafts Acylation (Section 17-11)
18-7D 820 Ketones and Aldehydes from Hydration of Alkynes (Section9-9F)
18-8 822 Synthesis of Ketones and Aldehydes Using 1,3-Dithianes
18-9 823 Synthesis of Ketones from Carboxylic Acids
18-10 824 Synthesis of Ketones from Nitriles
18-11 825 Synthesis of Aldehydes and Ketones from Acid Chlorides
826 Summary: Syntheses of Ketones and Aldehydes
18-12 829 Reactions of Ketones and Aldehydes: Nucleophilic Addition
831 Key mechanism 18-1: Nucleophilic Additions to Carbonyl Groups
18-13 832 The Wittig Reaction
834 Mechanism 18-2: The Wittig Reaction
18-14 836 Hydration of Ketones and Aldehydes
837 Mechanism 18-3: Hydration of Ketones and Aldehydes
18-15 838 Formation of Cyanohydrins
838 Mechanism 18-4: Formation of Cyanohydrins
18-16 840 Formation of Imines
840 Key Mechanisms 18-5: Formation of Imines
18-17 843 Condensations with Hydroxylamine and Hydrazines
844 Summary: Condensations of Amines with Ketones and Aldehydes
18-18 845 Formation of Acetals
846 Key Mechanisms 18-6: Formation of Acetals
848 Problem-Solving Strategy: Proposing Reaction Mechanisms
18-19 850 Use of Acetals as protecting Groups
18-20 852 Oxidation of Aldehydes
18-21 853 Reductions of Ketones and Aldehydes
18-21A 853 Hydride Reductions (Review)
18-21B 853 Catalytic Hydrogenation
18-21C 853 Deoxygenation of ketones and Aldehydes
855 Mechanism 18-7: Wolff-Kishner Reduction
855 Summary: Reactions of Ketones and Aldehydes

858 Chapter 18 Glossary
860 Essential Problem-Solving Skills in Chapter 18
861 Study Problems: In Chapter 18-1 to 18-37; End of Chapter 18-38 to 18-76

Weeks of Feb 5 & 12: CONDENSATIONS AND ALPHA SUBSTITUTIONS OF CARBONYL COMPOUNDS

Read and Study Chapter 12.

22-1 1041 Introduction
1041 Mechanism 22-1: Alpha Substitution
1042 Mechanism 22-2: Addition of an Enolate to Ketones and Aldehydes (a Condensation)
1042 Mechanism 22-3: Substitution of an Enolate on an Ester (a Condensation)
22-2 1042 Enols and Enolate Ions
22-2A 1042 Keto-Enol Tautomerism
1042 Mechanism 22-4: Base-Catalyzed Keto-Enol Tautomerism
1043 Mechanism 22-5: Acid-Catalyzed Keto-Enol Tautomerism
22-2B 1044 Formation and Stability of Enolate Ions
22-3 1046 Alpha Halogenation of Ketones
22-3A 1046 Base-Promoted α Halogenation
1046 Mechanism 22-6: Base-Promoted Halogenation
22-3B 1047 The Haloform Reaction
1048 Mechanism 22-7: Final Steps of the Haloform Reaction
22-3C 1049 Acid-Catalyzed Alpha Halogenation
1050 Mechanism 22-8: Acid-Catalyzed Halogenation
22-4 1051 α Bromination of Acids: The HVZ Reaction
22-5 1052 Alkylation of Enolate Ions
22-6 1053 Formation and Alkylation of Enamines
22-7 1056 The Aldol Condensation of Ketones and Aldehydes
1056 Key Mechanism 22-9: Base-Catalyzed Aldol Condensation
22-7B 1058 Acid-Catalyzed Aldol Condensation
1059 Mechanism 22-10: Acid-Catalyzed Aldol Condensation
22-8 1060 Dehydration of Aldol products
1060 Key mechanism 22-11: Base-Catalyzed hydration of an Aldol
22-9 1061 Crossed Aldol Condensation
1062 Problem-Solving Strategy: Proposing Reaction Mechanisms
22-10 1064 Aldol Cyclizations
22-11 1065 Planning Syntheses Using Aldol Condensations

Note: The remainder of Chapter 22 is scheduled for covering after Chapter 20

See the Week of March 5 for the remainder of Chapter 22: The remainder of Chapter 22 is:

22-12 1067 The Claisen Ester Condensation
1067 Key Mechanism 22-12: The Claisen Ester Condensation
22-13 1070 The Dieckmann Condensation: A Claisen Cyclization
22-14 1071 Crossed Claisen Condensations
22-15 1074 Syntheses Using β-Dicarbonyl Compounds
1075 Table 22-1: Typical Acidities of Carbonyl Compounds
22-16 1076 The Malonic Ester Synthesis
22-17 1079 The Acetoacetic Ester Synthesis
22-18 1081 Conjugate Additions: The Michael Reaction
1082 Mechanism 22-13: 1,2-Addition and 1,4-Addition (Conjugate Addition)
1082 Table 22-2: Some Common Michael Donors and Michael Acceptors
22-19 1085 The Robinson Annulation
1086 Problem-Solving Strategy: Proposing Reaction Mechanisms
1088 Summary: Enolate Additions and Condensations

1090 Chapter 22 Glossary
1091 Essential problem-Solving Skills in Chapter 22
1092 Study Problems: In Chapter, 22-1 to 22-59; End of Chapter, 22-60 to 22-81

February 19 **Family Day, No Classes**

Week of Feb 19: **Winter Break, No Classes.**

Week of Feb 26: **CARBOXYLIC ACIDS AND THEIR DERIVATIVES: NUCLEOPHILIC ADDITION-ELIMINATION AT THE ACYL CARBON.**

Read and Study Chapter 20.

20-1	935	Introduction
20-2	935	Nomenclature of Carboxylic Acids
20-2A	935	Common Names
	936	Table 20-1: Names and Physical Properties of Some Carboxylic Acids
20-2B	936	IUPAC Names
20-2C	937	Nomenclature of Dicarboxylic Acids
	938	Table 20-2: Names and Physical Properties of Dicarboxylic Acids
20-3	939	Structure and Physical properties of Carboxylic Acids
20-4	940	Acidity of Carboxylic Acids
20-4A	940	Measurement of Acidity
	941	Table 20-3: Values of K_a and pK_a for Carboxylic Acids and Dicarboxylic Acids
20-4B	942	Substituent Effects on Acidity
	943	Table 20-4: Values of K_a and pK_a for Substituted Carboxylic Acids
20-5	944	Salts of Carboxylic Acids
20-6	947	Commercial Sources of carboxylic Acids
20-7	948	Spectroscopy of Carboxylic Acids
20-7A	948	Infrared Spectroscopy
20-7B	949	NMR Spectroscopy
20-7C	951	Ultraviolet Spectroscopy
20-7D	951	Mass Spectroscopy
20-8	952	Synthesis of Carboxylic Acids
20-8A	952	Review of Previous Syntheses
20-8B	954	Carboxylation of Grignard Reagents
20-8C	954	Formation and Hydrolysis of Nitriles
	955	Summary: Syntheses of Carboxylic Acids
20-9	957	Reactions of Carboxylic Acids and Derivatives; Nucleophilic Acyl Substitution
	957	Mechanism 20-1: Nucleophilic Acyl Substitution in the Basic Hydrolysis of an Ester
20-10	958	Condensation of Acids with Alcohols: The Fischer Esterification
	959	Key Mechanism 20-2: Fischer Esterification
20-11	962	Esterification Using Diazomethane
	962	Mechanism 20-3: Esterification Using Diazomethane
20-12	963	Condensation of Acids with Amines: Direct Synthesis of Amides
20-13	963	Reduction of Carboxylic Acids
20-14	965	Alkylation of Carboxylic Acids to Form Ketones
20-15	966	Synthesis and Use of Acid Chlorides
	968	Summary: Reactions of Carboxylic Acids
	970	Chapter 20 Glossary
	971	Essential Problem-Solving Skills in Chapter 20
	971	Study Problems: In Chapter, 20-1 to 20-24; End of Chapter, 20-25 to 20-50

Week of Mar 5: SYNTHESIS AND REACTIONS OF ß-DICARBONYL COMPOUNDS: MORE CHEMISTRY OF ENOLATE IONS.

Review Chapter 22 Sections 22-1 to 22-11; and Read and Study Chapter 22, Sections 22-12 to 22-19

Week of Mar 12: AMINES.

Read and Study Chapter 19.

19-14 895 Formation of Sulfonamides
19-15 897 Amines as Leaving Groups: The Hofmann Elimination
897 Mechanism 19-4: Hofmann Elimination
19-16 900 Oxidation of Amines; The Cope Elimination
901 Mechanism 19-5: The Cope Elimination of an Amine Oxide
19-17 902 Reactions of Amines with Nitrous Acid
902 Mechanism 19-6: Diazotization of an Amine
19-18 904 Reactions of Arenediazonium Salts
908 Summary: Reactions of Amines
19-19 911 Synthesis of Amines by Reductive Amination
19-20 913 Synthesis of Amines by Acylation-Reduction
19-21 915 Syntheses Limited to Primary Amines
19-21A 915 Direct Alkylation and Gabriel Synthesis
19-21B 916 Reduction of Azides and Nitriles
19-21C 917 Reduction of Nitro Compounds
19-21D 919 The Hofmann Rearrangement of Amides
919 Mechanism 19-7: The Hofmann Rearrangement of Amides
921 Summary: Synthesis of Amines
923 Chapter 19 Glossary
925 Essential Problem-Solving Skills in Chapter 19
926 Study problems: In Chapter, 19-1 to 19-34; End of Chapter, 19-35 to 19-62

Week of Mar 19: PHENOLS AND ARYL HALIDES: NUCLEOPHILIC AROMATIC SUBSTITUTION. ORGANIC HALIDES AND ORGANOMETALLIC COMPOUNDS IN THE ENVIRONMENT.

Review Chapter 17 Sections 17-1 to 17-11; and Read and Study Chapter 17, Sections 17-12 to 17-15

17-12 780 Nucleophilic Aromatic Substitution
17-12A 781 The Addition-Elimination Mechanism
781 Mechanism 17-7: Nucleophilic Aromatic Substitution (Addition-Elimination)
17-12B 781 The Benzyne Mechanism: Elimination-Addition
784 Mechanism 17-8: Nucleophilic Aromatic Substitution (Benzyne Mechanism)
17-13 785 Addition Reactions of Benzene Derivatives
17-13A 785 Chlorination
17-13B 785 Catalytic Hydrogenation of Aromatic Rings
17-13C 785 Birch reduction
786 Mechanism 17-9: The Birch Reduction6
17-14 787 Side-Chain Reactions of Benzene
17-14A 787 Permanganate Oxidation
17-14B 788 Side-Chain Halogenation
17-14C 790 Nucleophilic Substitution at the Benzylic Position
17-15 791 Reactions of Phenols
17-15A 792 Oxidation of Phenols to Quinones
17-15B 793 Electrophilic Aromatic Substitution of Phenols
794 Summary: Reactions of Aromatic Compounds

Week of Mar 26: CARBOHYDRATES AND NUCLEIC ACIDS, AND LIPIDS (OPTIONAL).

Read Chapters 23 & 25.

23.1 1097 Introduction
23-2 1098 Classification of Carbohydrates
23-3 1099 Monosaccahrides
23-3A Classification of Monosaccharides

	23-3B	The D and L Configuration of Sugars
23-4	1102	Erythro and Threo Diastereomers
23-5	1103	Epimers
23-6	1104	Cyclic Structures of Monosaccharides
23-7	1108	Anomers of Monosaccharides; Mutarotation
23-8	1110	Reactions of Monosaccharides: Side Reactions in Base
	1111	Mechanism 22-3: Base Catalyzed Epimerization of Glucose
	1111	Mechanism 23-3: Base-Catalyzed Enediol Rearrangement
23-9	1112	Reduction of Monosaccharides
23-10	1113	Oxidation of Monosaccharides; Reducing Sugars
23-11	1115	Nonreducing Sugars: Formation of Glycosides
23-12	1117	Ether and Ester Formation
23-13	1119	Reactions with Phenylhydrazine: Osazone Formation
23-14	1120	Chain Shortening: The Ruff Degradation
23-15	1121	Chain lengthening: The Kiliani-Fischer Syntheses
	1122	Summary: Reactions of Sugars
23-16	1124	Fischer's Proof of the Conformation of Glucose
23-17	1127	Determination of Ring Size; periodic Acid Cleavage of Sugars
23-18	1129	Disaccharides
23-18A	1130	The 1,4' Linkage: Cellobiose, Maltose, and Lactose
23-18B	1132	The 1,6' Linkage: Gentiobiose
23-18C	1132	Linkage of Two Anomeric Carbons: Sucrose
23-19	1143	Polysaccharides
23-19A	1134	Cellulose
23-19B	1135	Starches: Amylopectin, and Glycogen
23-19C	1137	Chitin: A Polymer of N-Acetylglucosamine
23-20	1137	Nucleic Acids: Introduction
23-21	1139	Ribonucleosides and Ribonucleotides
23-22	1141	The Structure of Ribonucleic Acid
23-23	1141	Deoxyribose and the Structure of Deoxyribonucleic Acid
23-23A	1142	Base Pairing
23-23B	1143	The Double helix of DNA
23-24	1145	Additional Functions of Nucleotides
	1147	Chapter 23 Glossary
	1149	Essential Problem-Solving Skills in Chapter 23
	1149	Study Problems: In Chapter, 23-1 to 23-51; End of Chapter, 23-52 to 23-77

Read and Study Chapter 25

25-1	1200	Introduction
25-2	1200	Waxes
25-3	1201	Triglycerides
25-4	1204	Saponification of Fats and Oils; Soaps and Detergents
25-5	1208	Phospholipids
25-6	1209	Steroids
25-7	1212	Prostaglandins
25-8	1213	Terpenes
	1214	Table 25-3: Some Useful Essential Oils
25-8A	1214	Characteristics and Nomenclature of Terpenes
25-8B	1215	Classification of Terpenes
25-8C	1217	Terpenoids
	1217	Chapter 25 Glossary
	1218	Essential Problem-Solving Skills in Chapter 25
	1218	Study Problems; In Chapter, 25-1 to 25-13; End of Chapter, 25-14 to 25-33

Week of April 2: AMINO ACIDS AND PROTEINS (OPTIONAL).

Read and Study Chapter 24

Week of April 9: **REVIEW.**

REFERENCES TO ORGANIC LECTURE AND LABORATORY TEXTS

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14. 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.

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

18. 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.

19. Fox, M.A., Whitesell, J.K., *Organic Chemistry,* 2nd/3rd Editions, Jones and Barlett, 1997/2003, ISBN 0-7637-0178-5, QD251.2.F69 1997 & ISBN 0-7637-2197-2, QD251.3.F69 2003.

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

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

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Note: Many of 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, e.g.

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