

GRANDE PRAIRIE REGIONAL COLLEGE
DEPARTMENT OF SCIENCE: CHEMISTRY

FORTY-THIRD SESSION 2008 – 2009

COURSE OUTLINE: ORGANIC CHEMISTRY

CH2630 A3

CHEMISTRY 2630 A3: Organic Chemistry II

PREREQUISITE: CH1610 or CH2610

INSTRUCTOR: Dr. John P. Sloan

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LECTURE: CH2630 A2 M,W 8:30 – 9:50 in J229

ALBERTA TRANSFER CREDIT

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

GPRC:	CH 2610 (3)	CH 2630 (3)
U of Alberta:	CHEM 261 (3)	CHEM 263 (3) or AUCHE 252 3
U of Calgary:	CHEM 351 (3)	CHEM 353 (3)
U of Lethbridge:	CHEM 2500 (3)	CHEM 2600 (3)
Athabasca U:	CHEM 350 (3)	CHEM 360 (3)
Canadian UC:	CHEM 241 (4)	CHEM 242 (4)
Concordia UC:	CHEM 261 (3)	CHEM 263 (3)
King's UC:		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 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 pharmaceutical 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 A3 M,W 8:30 – 9:50 in J229
2. Laboratory Component: Day, Time and Place
CH2630 L1 T 14:30 - 17:20 in J119
3. Tutorial Component: Day, Time and Place
CH2630 S1 F 11:30 - 12:20 in J229

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, 9th Edition, Wiley, 2008

2. 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:

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

Study Guides and Solutions Manuals are supplementary items, namely:

- 4.1 Fernandez, J.E., and Solomons, T.W.G., Study Guide and Solutions Manual to Organic Chemistry, 8th Edition, 2004;
- 4.2 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 -----	30%
3.	Laboratory -----	25%
4.	Tutorial Grading Component -----	<u>10%</u>
		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

* 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. 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 2008 - 2009: Course Description (page 178).

CH 2630 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 A3 READING, STUDYING, AND PRACTICE PROBLEMS

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

WINTER SEMESTER

Weeks of Jan 5 & 12: SPECTROSCOPIC METHODS OF STRUCTURE DETERMINATION.
 NUCLEAR MAGNETIC RESONANCE (NMR) and MASS SPECTROSCOPY (MS):
 Tools for Structure Determination

Sect # Page # Read and Study Chapter 9.

9.1	364	Introduction;
9.2	364	Nuclear Magnetic Resonance (NMR) Spectroscopy;
9.2A	365	Chemical Shift (δ in parts per million, ppm);
	366	Table 9.1: Approximate proton Chemical Shifts;
9.2B	367	Integration of Signal Areas: Integral Step Heights;
9.2C	368	Coupling (Signal Splitting);
9.3	369	Interpreting Proton, ^1H , NMR Spectra;
9.4	371	Nuclear Spin: The Origin of the Signal;
9.5	373	Detecting the Signal: Fourier Transform NMR Spectrometers;
9.6	374	Shielding and Deshielding of Protons;
	375	Deshielding by Electronegative Groups;
	376	Shielding and Deshielding by Circulation of π Electrons;
9.7	376	The Chemical Shift;
9.7A	377	PPM and the δ Scale;
9.8	377	Chemical Shift Equivalent and Nonequivalent Protons;
9.8A	377	Homotopic Hydrogen Atoms;
9.8B	378	Enantiotopic and Diastereotopic Hydrogen Atoms;
9.9	379	Signal Splitting: Spin-Spin Coupling;
9.9A	380	Vicinal Coupling
9.9B	380	Splitting Tree Diagrams and the Origin of Signal Splitting;
	381	Splitting Analysis for the Doublet
	381	Splitting Analysis for the Triplet;
	382	Splitting Analysis for the Quartet;
9.9C	385	Coupling Constants – Recognizing Splitting Patterns;
9.9D	385	The Dependence of Coupling Constants on Dihedral Angle;
9.9E	386	Complicating Features;
9.9F	387	Analysis of Complex Interactions;
9.10	388	Proton NMR Spectra and Rate processes
	388	Conformational Changes;
	389	Chemical Exchange Causes Spin Decoupling;
9.11	390	Carbon-13, ^{13}C , NMR Spectroscopy;
9.11A	390	Interpretation of ^{13}C NMR Spectra;
9.11B	391	One Peak for each Unique carbon Atom;
9.11C	391	^{13}C Chemical Shifts;
	391	Figure 9.19: Approximate ^{13}C Chemical Shifts;
	392	Table 9.2: Approximate ^{13}C Chemical Shifts;
9.11D	393	Off-Resonance Decoupled Spectra;

9.11E	394	DEPT ^{13}C Spectra;
9.12	396	Two-Dimensional (2D) NMR Techniques;
9.12A	396	COSY Cross-Peak Correlations;
9.12B	398	HETCOR Cross-Peak Correlations;
	399	The Chemistry of Magnetic Resonance Imaging in Medicine;
9.13	399	An Introduction to Mass Spectroscopy;
9.14	400	Formation of Ions: Electron Impact Ionization;
9.15	400	Depicting a Molecular Ion;
9.16	401	Fragmentation;
9.16A	402	Fragmentation by Cleavage at a Single Bond;
9.16B	403	Fragmentation of Longer Chain and Branched Alkanes;
9.16C	404	Fragmentation to Form Resonance-Stabilized Cations;
9.16D	406	Fragmentation by Cleavage of Two Bonds;
9.17	407	Determination of Molecular Formulas and Molecular Weights;
9.17A	407	Isotopic Peaks and the Molecular Ion;
	408	Table 9.4: Principal Stable Isotopes of Common Elements;
9.17B	411	High-Resolution Mass Spectroscopy;
	412	Table 9.6: Exact Masses of Nuclides;
9.18	412	Mass Spectrometer Instrument Designs;
9.18A	412	Ionization Techniques: Electron Impact, Electrospray, and MALDI;
	412	Electron Impact Ionization;
	413	Electrospray Ionization- A Technique Especially Useful for Biomolecules;
	414	MALDI- A Technique Useful for Both Biomolecules and Synthetic Polymers;
9.18B	414	Mass Analysis: Ion Sorting and Detection;
	414	Magnetic Focusing;
	414	Quadrupole, Ion Trap, and Time-of-Flight (TOF) Mass Analyzers;
9.19	415	GC/MS (Gas Chromatography/Mass Spectrometry) Analysis;
9.20	416	Mass Spectrometry of Biomolecules;
	416	Key Terms and Concepts.
	417	Concept Map ^1H NMR Spectroscopy
	418	Concept Map ^{13}C NMR Spectroscopy
	419	Concept Map Mass Spectroscopy
Problems:		In-Chapter 9.1 to 9.23
	420	End of Chapter 9.24 to 9.44
	425	Learning Group Problems.

Week of Jan 19: AROMATIC COMPOUNDS.

Read and Study Chapter 14:

14.1	596	Aromatic Compounds: Why the Name?
14.2	597	Nomenclature of Benzene Derivatives;
14.3	599	Reactions of Benzene;
14.4	600	The Kekulé Structure for Benzene;
14.5	601	The Stability of Benzene;
14.6	602	Modern Theories of the Structure of Benzene;
14.6A	603	The Resonance Explanation of the Structure of Benzene;
14.6B	604	The Molecular Orbital Explanation of the Structure of Benzene;
14.7	605	Hückel's Rule, the $4n + 2 \pi$ Electron Rule;
14.7A	606	The Annulenes;

14.7B	608	NMR Spectroscopy: Evidence of Electron Delocalization in Aromatic Compounds;
14.7C	609	Aromatic Ions;
14.7D	611	Aromatic, Antiaromatic, and Nonaromatic Compounds;
14.8	613	Other Aromatic Compounds;
14.8A	613	Benzenoid Aromatic Compounds;
14.8B	615	Nonbenzenoid Aromatic Compounds;
14.8C	615	Fullerenes;
	616	The Chemistry of Nanotubes;
14.9	617	Heterocyclic Aromatic Compounds;
14.10	618	Aromatic Compounds in Biochemistry;
14.11	620	Spectroscopy of Aromatic Compounds;
14.11A	620	¹ H NMR Spectra;
14.11B	621	¹³ C NMR Spectra;
14.11C	623	Infrared Spectra of Substituted Benzenes;
	623	Table 14.1; Infrared Absorptions in the 680-860 cm ⁻¹ Regions;
14.11D	624	Visible-Ultraviolet Spectra of Aromatic Compounds;
	624	The Chemistry of Sunscreens (Catching the Sun's Rays and What Happens to Them);
14.11E	625	Mass Spectra of Aromatic Compounds;
	625	Key Terms and Concepts;
	626	Concept Map Aromatic Compounds
Problems:		In-Chapter 14.1 to 14.16
	627	End of Chapter 14.17 to 14.39
	634	Learning Group Problems.

Weeks of Jan 26: REACTIONS OF AROMATIC COMPOUNDS.

Read and Study Chapter 15.

15.1	637	Electrophilic Aromatic Substitution Reactions;
15.2	637	E+ Ar Subn., a General Mechanism, Arenium Ions;
15.3	640	Halogenation of Benzene;
	640	A Mechanism for the Reaction of Electrophilic Aromatic Bromination;
15.4	641	Nitration of Benzene;
	641	A Mechanism for the Reaction of Nitration of Benzene;
15.5	642	Sulfonation of Benzene;
	642	A Mechanism for the Sulfonation of Benzene;
15.6	643	Friedel-Crafts Alkylation;
	644	A mechanism for the Reaction of Friedel-Crafts Alkylation;
15.7	645	Friedel-Crafts Acylation;
	646	A Mechanism for the Reaction of Friedel-Crafts Acylation;
15.8	647	Limitations of Friedel-Crafts Reactions;
15.9	649	Synthetic Applications of Friedel-Crafts Acylations, the Clemmensen Reduction;
15.10	650	Effect of Substituents on Reactivity and Orientation;
15.10A	651	Activating Groups: Ortho-Para Directors;
15.10B	652	Deactivating Groups: Meta Directors;
15.10C	653	Halo Substituents: Deactivating Ortho-Para Directors;
	653	Table 15.1: Electrophilic Substitutions of Chlorobenzene
15.10D	653	Classification of Substituents;
	653	Table 15.2: Effect of Substituents on Electrophilic Aromatic Substitution;
15.11	653	Theory of Substituent Effects on Electrophilic Aromatic Substitution;

15.11A	653	Reactivity: The Effect of Electron-Releasing and Electron-Withdrawing Groups;
15.11B	655	Inductive and Resonance Effects: Theory of Orientation;
15.11C	656	Meta-Directing Groups;
15.11D	658	Ortho-Para-Directing Groups;
15.11E	661	Ortho-Para Directing and Reactivity of Alkylbenzenes;
	662	The Chemistry of Iodine Incorporation in Thyroxine Biosynthesis
15.11F	663	Summary of Substituent Effects on Orientation and Reactivity;
15.12	664	Reactionss of the Side Chain of Alkyl Benzenes;
15.12A	664	Benzylic Radicals and Cations;
	665	The Chemistry of Industrial Styrene Synthesis;
15.12B	665	Halogenation of the Side Chain - Benzylic Radicals;
	666	A mechanism for the Reaction of Benzylic Halogenation;
15.13	668	Alkenyl Benzenes;
15.13A	668	Stability of Conjugated Alkenylbenzenes;
15.13B	669	Additions to the Double Bond of Alkenylbenzenes;
15.13C	669	Oxidation of the Side Chain;
15.13D	670	Oxidation of the Benzene Ring;
15.14	670	Synthetic Applications;
15.14A	672	Use of Protecting and Blocking Groups;
15.14B	673	Orientation in Disubstituted Benzenes;
15.15	674	Allylic and Benzylic Halides in Nucleophilic Substitution Reactions;
	674	Table 15.3: A Summary of Alkyl, Allylic, and Benzylic Halides in S_N2 and S_N1 Reactions,
15.16	676	Reduction of Aromatic Compounds;
	676	A mechanism for the Reaction of Birch Reduction;
	677	Key Terms and Concepts;
	678	Concept Map: Summary of Mechanisms;
	679	Concept Map: Some Synthetic Connections of Benzene and Aryl Derivatives.
Problems		In-Chapter 15.1 to 15.25
	680	End of Chapter 15.26 to 15.56
	685	Learning Group Problems.

Week of Feb 2: ALDEHYDES AND KETONES I: NUCLEOPHILIC ADDITION TO THE CARBONYL GROUP.

Read and Study Chapter 16.

16.1	687	Introduction;
16.2	687	Nomenclature of Aldehydes and Ketones;
16.3	689	Physical Properties;
	689	Table 16.1: Physical Properties of Aldehydes and Ketones;
	690	The Chemistry of Aldehydes and Ketones in Perfumes;
16.4	690	Synthesis of Aldehydes;
16.4A	690	Aldehydes by Oxidation of Primary Alcohols;
16.4B	691	Aldehydes by reduction of Acyl Chlorides, Esters and Nitriles;
	692	A Mechanism for the Reaction of Reduction of an Acyl Chloride to an Aldehyde;
	693	A Mechanism for the Reaction of Reduction of an Ester to an Aldehyde;
	693	A mechanism for the Reaction off Reduction of a Nitrile to an Aldehyde
16.5	694	Synthesis of Ketones;
16.5A	694	Ketones from Alkenes, Arenes, and Secondary Alcohols;
16.5B	694	Ketones from Nitriles;

- 16.6 696 Nucleophilic Addition to the Carbon-Oxygen Double Bond;
 697 A Mechanism for the Reaction of Addition of a Strong Nucleophile to an Aldehyde or Ketone;
 697 A Mechanism for the Reaction of Acid-Catalyzed Nucleophilic Addition to an Aldehyde or Ketone;
- 16.6A 698 Reversibility of Nucleophilic Additions to Carbon-Oxygen Double Bond;
- 16.6B 698 Relative Reactivity: Aldehydes versus Ketones;
- 16.6C 698 Subsequent Reactions of Addition Products;
- 16.7 699 Addition of Alcohols: Hemiacetals and Acetals;
- 16.7A 699 Hemiacetals;
 699 A Mechanism for the Reaction of Hemiacetal Formation;
 700 A Mechanism for the Reaction of Acid-Catalyzed Hemiacetal Formation;
 700 A Mechanism for the Reaction of Base-Catalyzed Hemiacetal Formation;
 701 Aldehyde Hydrates: gem-Diols;
 701 A mechanism for the Reaction of Hydrate Formation;
- 16.7B 702 Acetals;
 702 A mechanism for the Reaction of Acid-Catalyzed Acetal Formation;
- 16.7C 704 Acetals as Protecting Groups;
- 16.7D 705 Thioacetals;
- 16.8 706 The Addition of Derivatives of Ammonia, Primary and Secondary Amines;
- 16.8A 706 Imines;
 706 A Mechanism for the Reaction of Imine Formation;
- 16.8B 707 Oximes, Hydrazones and Semicarbazones;
 707 Table 16.2: Reactions of Aldehydes and Ketones with Derivatives of Ammonia;
 708 The Chemistry of Pyridoxal Phosphate;
- 16.8C 709 Enamines;
 709 A mechanism for the Reaction of Enamine Formation;
- 16.9 710 The Addition of Hydrogen Cyanide;
 710 A mechanism for the Reaction of Cyanohydrin Formation;
- 16.10 711 The Addition of Ylides: the Wittig Reaction;
 712 A mechanism for the Reaction of The Wittig Reaction;
- 16.11 715 Oxidation of Aldehydes;
- 16.12 717 Chemical Analyses of Aldehydes and Ketones;
- 16.12A 715 Derivatives of Aldehydes and ketones;
- 16.12B 715 Tollen's Test (Silver Mirror Test);
- 16.13 716 Spectroscopic Properties of Aldehydes and Ketones;
- 16.13A 716 IR Spectra of Aldehydes and Ketones;
 716 Table 16.3: IR Carbonyl Stretching Bands of Aldehydes and Ketones
- 16.13B 717 NMR Spectra of Aldehydes and Ketones
 717 ¹³C NMR Spectra;
 717 ¹H NMR Spectra;
- 16.13C 718 Mass Spectra of Aldehydes and Ketones;
- 16.13D 718 UV Spectra;
- 16.14 719 Summary of Aldehyde and Ketone Addition Reactions;
 719 Nucleophilic Addition Reactions of Aldehydes and ketones;
 720 Key Terms and Concepts;
 721 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;
 722 Summary of Mechanisms: Nucleophilic Addition to Aldehydes and Ketones under Basic Conditions;

- 723 Summary of Mechanisms: Nucleophilic Addition to Aldehydes and Ketones under Basic Conditions;
 724 Synthetic Connections: Some Synthetic Connections of Aldehydes, Ketones, and Other Functional Groups;

Problems:	In-Chapter	16.1 to 16.18
725	End of Chapter	16.19 to 16.46
730	Learning Group Problems.	

Weeks of Feb 9 & 23: ALDEHYDES AND KETONES II: ENOLS AND ENOLATES.

Read and Study Chapter 17.

- 17.1 733 The Acidity of the α Hydrogens of Carbonyl Compounds, Enolate Anions;
 17.2 735 Keto and Enol Tautomers;
 17.3 736 Reactions via Enols and Enolate Ions;
 17.3A 736 Racemization;
 737 A Mechanism for the Reaction of Base-Catalyzed Enolization
 737 A Mechanism for the Reaction of Acid-Catalyzed Enolization
 17.3B 738 Halogenation of Aldehydes and Ketones;
 738 A Mechanism for the Reaction of Base-Promoted Halogenation of Aldehydes and Ketones;
 739 A Mechanism for the Acid-Catalyzed Halogenation of Aldehydes and Ketones;
 17.3C 739 The Haloform reaction;
 740 A Mechanism for the Reaction of Halogenation Steps of the Haloform Reaction;
 741 A Mechanism for the Reaction of Cleavage Step of the Haloform Reaction;
 17.3D 741 Environmental Concerns;
 17.4 742 The Aldol Reaction, the Addition of Enolate Anions to Aldehydes and Ketones;
 742 A Mechanism for the Reaction of The Aldol Reaction;
 17.4A 743 Dehydration of the Aldol Addition Product;
 743 A Mechanism for the Reaction of Dehydration of the Aldol Addition Product;
 17.4B 743 Synthetic Applications of the Aldol Reaction;
 745 The Chemistry of A Retro-Aldol Reaction in Glycolysis – Dividing Assets to Double the ATP Yield;
 17.4C 746 The Reversibility of Aldol Additions;
 17.4D 746 Acid-Catalyzed Aldol Condensations;
 A Mechanism for the Reaction of The Acid-Catalyzed Aldol Reaction;
 17.5 747 Crossed Aldol Reactions;
 17.5A 748 Practical Crossed Aldol Reactions;
 749 Table 17.1: Crossed Aldol Reactions;
 17.5B 749 Claisen-Schmidt Reactions;
 750 A mechanism for the Reaction of The Claisen-Schmidt Reaction;
 17.5C 751 Condensations with Nitroalkanes;
 17.5D 752 Condensations with Nitriles;
 17.6 752 Cyclization via Aldol Condensations;
 753 A Mechanism for the Reaction of The Aldol Cyclization;
 17.7 754 Lithium Enolates;
 17.7A 754 Regioselective Formation of Enolates;
 17.7B 755 Lithium Enolates in Directed Aldol Reactions;
 17.7C 757 Direct Alkylation of Ketones via Lithium Enolates;
 758 The Chemistry of Silyl Enol Ethers;

- 17.8 759 α -Selenation: A Synthesis of α,β -Unsaturated Carbonyl Compounds;
 17.9 760 Additions to α,β -unsaturated Aldehydes and Ketones;
 761 A mechanism for the Reaction of The Conjugate Addition to HCN;
 762 A Mechanism for the Reaction of The Conjugate Addition of an Amine;
 17.9A 762 Michael Additions;
 763 The Chemistry of Calicheamicin γ_1^I Activation for Cleavage of DNA;
 17.10 764 Summary of Enolate Chemistry;
 766 Key Terms and Concepts.
 767 Summary of Mechanisms: Enolates: Formation and Reaction with Electrophiles by
 Substitution or Addition;
 768 Synthetic Connections: Some Synthetic Connections Involving Enolates;
 Problems: In-Chapter 17.1 to 17.27
 769 End of Chapter 17.28 to 17.44
 774 Learning Group Problems.

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

Week of March 2: CARBOXYLIC ACIDS AND THEIR DERIVATIVES:
 NUCLEOPHILIC ADDITION-ELIMINATION AT THE ACYL CARBON.

Read and Study Chapter 18, and Special Topic B.

- 18.1 779 Introduction;
 779 Table 18.1: Carboxylic Acid Derivatives
 18.2 779 Nomenclature and Physical Properties;
 18.2A 779 Carboxylic Acids;
 780 Table 18.2: Carboxylic Acids;
 18.2B 781 Carboxylic Salts;
 18.2C 781 Acidity of Carboxylic Acids;
 18.2D 783 Dicarboxylic Acids;
 783 Table 18.3: Dicarboxylic Acids;
 18.2E 784 Esters;
 784 Table 18.4: Carboxylic Esters
 18.2F 785 Carboxylic Anhydrides;
 18.2G 785 Acyl Chlorides;
 18.2H 785 Amides;
 18.2I 786 Nitriles;
 18.2J 786 Spectroscopic Properties of Acyl Compounds;
 786 IR Spectra;
 788 ^1H NMR Spectra;
 788 ^{13}C NMR Spectra;
 18.3 823 Preparation of Carboxylic Acids;
 789 1. By Oxidation of Alkenes;
 789 2. By Oxidation of Aldehydes and Primary Alcohols;
 789 3. By Oxidation of Alkyl Benzenes;
 789 4. By Oxidation of the Benzene Ring;
 789 5. By Oxidation of Methyl Ketones;
 790 6. By Hydrolysis of Cyanohydrins and Other Nitriles;
 790 7. By Carbonation of Grignard Reagents;
 18.4 791 Nucleophilic Addition-Elimination at the Acyl Carbon;

- 792 A Mechanism for the Reaction of Acyl Transfer by Nucleophilic Addition-Elimination;
- 18.4A 793 Relative Reactivity of Acyl Compounds;
- 18.4B 793 Synthesis of Acid Derivatives;
- 18.5 794 Acyl Chlorides;
- 18.5A 794 Synthesis of Acyl Chlorides;
- 794 A Mechanism for the Reaction of Synthesis of Acyl Chlorides Using Thionyl Chloride.
- 18.5B 795 Reactions of Acyl Chlorides;
- 18.6 795 Carboxylic Acid Anhydrides;
- 18.6A 795 Synthesis of Carboxylic Acid Anhydrides;
- 18.6B 796 Reactions of Carboxylic Acid Anhydrides;
- 18.7 797 Esters;
- 18.7A 797 Synthesis of Esters: Esterification;
- 798 A Mechanism for the Reaction of Acid-Catalyzed Esterification;
- 798 Esters from Acyl Chlorides
- 799 Esters from Carboxylic Acid Anhydrides;
- 18.7B 800 Base-Promoted Hydrolysis of Esters: Saponification;
- 800 A Mechanism for the Reaction of Base-Promoted Hydrolysis of an Ester;
- 18.7C 801 Lactones;
- 18.8 802 Amides;
- 18.8A 802 Synthesis of Amides;
- 18.8B 803 Amides from Acyl Chlorides;
- 18.8C 803 Amides from Carboxylic Anhydrides;
- 18.8D 804 Amides from Esters;
- 18.8E 804 Amides from Carboxylic Acids and Ammonium Carboxylates;
- 805 A Mechanism for the Reaction of DCC-Promoted Amide Synthesis
- 18.8F 805 Hydrolysis of Amides;
- 806 A Mechanism for the Reaction of Acidic Hydrolysis of an Amide;
- 806 A Mechanism for the Reaction of Basic Hydrolysis of an Amide;
- 18.8G 807 Nitriles from Dehydration of Amides;
- 18.8H 807 Hydrolysis of Nitriles;
- 808 A Mechanism for the Reaction of Acidic Hydrolysis of a Nitrile;
- 808 A Mechanism for the Reaction of Basic Hydrolysis of a Nitrile;
- 18.8I 809 Lactams;
- 809 The Chemistry of Penicillins;
- 18.9 810 Derivatives of Carbonic Acid ;
- 18.9A 810 Alkyl Chloroformates and Carbamates (Urethanes);
- 18.10 812 Decarboxylation of Carboxylic Acids;
- 813 The Chemistry of Thiamine;
- 18.10A 814 Decarboxylation of Carboxyl Radicals;
- 18.11 815 Chemical Tests for Acyl Compounds;
- 815 Summary of the Reactions of Carboxylic Acids and Their Derivatives;
- 815 Reactions of Carboxylic Acids:
1. As Acids;
 2. Reduction;
 3. Conversion to Acyl Chlorides;
 4. Conversion to Esters;
 5. Conversion to Amides;
 6. Decarboxylation;
- 816 Reactions of Acyl Chlorides;
1. Conversion to Acids;

- 2. Conversion to Anhydrides;
- 3. Conversion to Esters;
- 4. Conversion to Amides;
- 5. Conversion to Ketones;
- 6. Conversion to Aldehydes;
- 817 Reactions of Acid Anhydrides;
 - 1. Conversion to Acids;
 - 2. Conversion to Esters;
 - 3. Conversion to Amides;
 - 4. Conversion to Aryl Ketones;
- 817 Reactions of Esters;
 - 1. Hydrolysis;
 - 2. Conversion to Other Esters: Transesterification;
 - 3. Conversion to Amides;
 - 4. Reaction with Grignard Reagents;
 - 5. Reduction;
- 818 Reactions of Amides;
 - 1. Hydrolysis;
 - 2. Conversion to Nitriles;
- 808 Reactions of Nitriles;
 - 1. Hydrolysis to Carboxylic Acid or Carboxylate Anion;
 - 2. Reduction to an Aldehyde with (*i*-Bu)₂AlH (DIBAL-H);
 - 3. Conversion to a Ketone by a Grignard or Organolithium Reagent;
- 819 Summary and Review Tools: Synthetic Connections of Carboxylic Acids and Related Functional Groups: A 3-D Array of Linked Functional Groups.
- 821 Key Terms and Concepts.
- Problems: In-Chapter 18.1 to 18.18
- 821 End of Chapter 18.19 to 18.55
- 829 Learning Group Problems.
- 830 Special Topic B: Step Growth Polymers;
- B.1 830 Polyamides;
- 832 The Chemistry of a Green Feedstock for Nylon;
- B.2 833 Polyesters;
- 835 The Chemistry of a PET Green Recycling Method
- B.3 835 Polyurethanes;
- B.4 836 Phenol-Formaldehyde Polymers;
- B.5 837 Cascade Polymers.

Week of March 9: SYNTHESIS AND REACTIONS OF β -DICARBONYL COMPOUNDS:
MORE CHEMISTRY OF ENOLATE IONS.

Read and Study Chapter 19, and Special Topics C and D.

- 19.1 841 Introduction;
- 19.2 842 The Claisen Condensation: The Synthesis of β -Keto Esters;
- 843 A Mechanism for the Reaction of The Claisen Condensation;
- 845 The Dieckmann Condensation;
- 845 A Mechanism for the Reaction of The Dieckmann Condensation;
- 19.2A 846 Crossed Claisen Condensation;

19.2B	847	Acylation of Other Carbanions;
19.3	847	The Acetoacetic Ester Synthesis: Synthesis of Methyl Ketones (Substituted Acetones);
19.3A	847	Alkylation;
19.3B	851	Acylation;
19.3C	852	Acetoacetic Ester Dianion: Alkylation at the Terminal Carbon;
19.4	853	The Malonic Ester Synthesis: Synthesis of Substituted Acetic Acids;
	853	A Mechanism for the Reaction of The Malonic Ester Synthesis of Substituted Acetic Acids;
19.5	857	Further Reactions of Active Hydrogen Compounds;
19.6	858	Direct Alkylation of Esters and Nitriles;
19.7	858	Alkylation of 1,3- Dithianes;
19.8	860	The Knoevenagel Condensation;
19.9	860	Michael Additions;
	861	A Mechanism for the Reaction of Michael Addition of an Active Hydrogen Compound;
19.10	862	The Mannich Reaction;
	862	A Mechanism for the Reaction of The Mannich Reaction;
	863	The Chemistry of A Suicide Enzyme Substrate;
19.11	864	Synthesis of Enamines: Stork Enamine Reactions;
	866	The Chemistry of Antibody-Catalyzed Aldol Condensations;
19.12	867	Barbiturates;
19.13	869	Summary of Important Reactions;
	1.	Claisen Condensation;
	2.	Crossed Claisen Condensation;
	3.	Acetoacetic Ester Synthesis;
	4.	Malonic ester Synthesis;
	5.	Direct Alkylation of Esters;
	6.	Alkylation of Dithianes;
	7.	Knoevenagel Condensation;
	8.	Michael Addition;
	9.	Mannich Reaction;
	10.	Stork Enamine Reaction;
	871	Summary of Mechanisms: Some Synthetic Connections Involving β -Dicarbonyl Compounds;
	872	Key Terms and Concepts;
Problems:		In-Chapter 19.1 to 19.24;
	872	End of Chapter 19.25 to 19.51
	878	Learning Group Problems.
	881	Special Topic C: Thiols, Sulfur Ylides and Disulfides.
C.1	882	Preparation of Thiols;
C.2	883	Physical Properties of Thiols;
C.3	884	The Addition of Sulfur Ylides to Aldehydes and Ketones;
C.4	884	Thiols and Disulfides in Biochemistry;
	886	Special Topic D: Thiol Esters and Lipid Biosynthesis;
D.1	886	Thiol Esters;
D.2	888	Biosynthesis of Fatty Acids;
D.3	892	Biosynthesis of Isoprenoid Compounds;
D.4	894	Biosynthesis of Steroids;
D.5	898	Cholesterol and Heart Disease.

Week of March 16: AMINES.

- Read and Study Chapter 2., and Special Topic E.
- 20.1 900 Nomenclature;
- 20.1A 901 Arylamines;
- 20.1B 901 Heterocyclic Amines;
- 20.2 902 Physical Properties and Structure of Amines;
- 20.2A 902 Physical Properties;
- 902 Table 20.1: Physical Properties of Amines;
- 20.2B 902 Structure of Amines;
- 20.3 903 Basicity of Amines, Amine Salts;
- 20.3A 904 Basicity of Aryl Amines;
- 20.3B 906 Basicity of Heterocyclic Amines;
- 20.3C 906 Amines versus Amides;
- 20.3D 907 Aminium Salts and Quaternary Ammonium Salts;
- 20.3E 908 Solubility of Amines in Aqueous Acids;
- 20.3F 908 Amines as Resolving Agents;
- 910 The Chemistry of HPLC Resolution of Enantiomers;
- 910 The Chemistry of Biologically Important Amines;
1. 2-Phenylethylamines;
 2. Vitamins and Antihistamines;
- 912
3. Tranquilizers;
 4. Neurotransmitters;
- 20.4 912 Preparation of Amines;
- 20.4A 912 Through Nucleophilic Substitution Reactions;
1. Alkylation of Ammonia;
- 913 A Mechanism for the Reaction of Alkylation of NH_3 ;
- 913
2. Alkylation of Azide Ion and Reduction;
 3. The Gabriel Synthesis;
- 914 Alkylation of Tertiary Amines
- 20.4B 914 Preparation of Aromatic Amines through Reduction of Nitro Compounds;
- 20.4C 914 Preparation of Primary, Secondary, or Tertiary Amines through Reductive Amination;
- 915 A Mechanism for the Reaction of Reductive Amination;
- 20.4D 916 Preparation of Primary, Secondary, or Tertiary Amines through Reduction of Nitriles, Oximes and Amides;
- 20.4E 917 Preparation of Primary Amines through the Hofmann and Curtius Rearrangements;
- 918 A Mechanism for the Reaction of The Hofmann Rearrangement;
- 20.5 919 Reactions of Amines;
- 919
1. Acid-Base Reactions;
 2. Alkylation;
 3. Acylation;
 4. Electrophilic Aromatic Substitution;
- 20.5A 920 Oxidation of Amines;
- 20.6 921 Reactions of Amines with Nitrous Acid;
- 20.6A 921 Reactions of Primary Aliphatic Amines with Nitrous Acid;
- 20.6B 921 Reactions of Primary Arylamines with Nitrous Acid;
- 922 A mechanism for the Reaction of Diazotization;
- 922 The Chemistry of N-Nitrosoamines;
- 20.6C 923 Reactions of Secondary Amines with Nitrous Acid;
- 20.6D 923 Reactions of Tertiary Amines with Nitrous Acid;

- 20.7 923 Replacement Reactions of Arenediazonium Salts;
 20.7A 924 Synthesis Using Diazonium Salts;
 20.7B 924 The Sandmeyer Reaction: Replacement of the Diazonium Group by -Cl, -Br, -CN;
 20.7C 925 Replacement by -I;
 20.7D 925 Replacement by -F;
 20.7E 925 Replacement by -OH;
 20.7F 925 Replacement by Hydrogen: Deamination by Diazotization;
 20.8 926 Arene Diazonium Salts, Coupling Reactions;
 20.9 929 Reactions of Amines with Sulfonyl Chlorides;
 20.9A 929 The Hinsberg Test;
 930 The Chemistry of Chemotherapy and Sulfa Drugs;
 931 1. Chemotherapy;
 931 2. Sulfa Drugs;
 932 3. Essential Nutrients and Antimetabolites;
 20.10 933 Synthesis of Sulfa Drugs;
 20.11 934 Analysis of Amines;
 20.11A 934 Chemical Analysis;
 20.11B 934 Spectroscopic Analysis;
 1. Infrared Spectra;
 935 2. ¹H NMR Spectra;
 3. ¹³C NMR Spectra;
 4. Mass Spectra of Amines;
 20.12 935 Eliminations Involving Ammonium Compounds;
 20.12A 935 The Hofmann Elimination;
 20.12B 936 The Cope Elimination;
 937 Summary of Preparations and Reactions of Amines;
 937 Preparation of Amines;
 1. Gabriel Synthesis;
 2. By Reduction of Alkyl Azides;
 3. By Amination of Alkyl Halides;
 4. By Reduction of Nitroarenes;
 5. By Reductive Amination;
 938 6. By Reduction of Nitriles, Oximes, and Amides;
 7. Through the Hofmann and Curtius Rearrangements;
 938 Reactions of Amines;
 1. As bases;
 939 2. Diazotization of Primary Aryl Amines and Replacement of, or Coupling with, the
 Diazonium Group;
 3. Conversion to Sulfonamides;
 4. Conversion to Amides;
 5. Hofmann and Cope Eliminations;
 940 Key Terms and Concepts;
 Problems: In-Chapter 20.1 to 20.20;
 940 End of Chapter 20.21 to 20.53;
 947 Learning Group Problems;
 949 Special Topic E: Alkaloids;
 E.1 949 Alkaloids Containing a Pyridine or Reduced Pyridine Ring;
 E.2 952 Alkaloids Containing an Isoquinoline or Reduced Isoquinoline Ring;
 E.3 953 Alkaloids Containing Indole or Reduced Indole Rings.

Week of March 23: PHENOLS AND ARYL HALIDES: NUCLEOPHILIC AROMATIC SUBSTITUTION.

Read and Study Chapter 21.

Read Special Topics F, G, and H, pages 992-1019.

- 21.1 955 Structure and Nomenclature of Phenols;
 21.A 955 Nomenclature of Phenols;
 21.2 956 Naturally Occurring Phenols;
 21.3 957 Physical Properties of Phenols;
 957 Table 21.1: Physical Properties of Phenols;
 21.4 957 Synthesis of Phenols;
 21.4A 957 Laboratory Synthesis;
 958 The Chemistry of Polyketide Anticancer Antibiotic Biosynthesis;
 21.4B 959 Industrial Synthesis;
 1. Hydrolysis of Chlorobenzene (Dow Process).
 2. Alkali Fusion of Sodium Benzenesulfonate.
 3. From Cumene Hydroperoxide.
 21.5 961 Reactions of Phenols as Acids;
 21.5A 961 Strengths of Phenols as Acids;
 961 Table 21.2: Acidity Constants of Phenols;
 21.5B 962 Distinguishing and Separating Phenols from Alcohols and Carboxylic Acids;
 21.6 963 Other Reactions of the O-H Group of Phenols;
 21.6A 963 Phenols in the Williamson Synthesis;
 21.7 964 Cleavage of Alkyl Aryl Ethers;
 21.8 964 Reactions of the Benzene Ring of Phenols;
 964 1. Bromination;
 965 2. Nitration;
 3. Sulfonation;
 4. Kolbe Reaction;
 966 A Mechanism for the Kolbe Reaction;
 21.9 967 The Claisen Rearrangement;
 21.10 968 Quinones;
 21.11 969 Aryl Halides and Nucleophilic Aromatic Substitution;
 970 The Chemistry of The Bombardier Beetle's Noxious Spray;
 21.11A 971 Nucleophilic Aromatic Substitution by Addition-Elimination: The S_NAr Mechanism;
 971 A Mechanism for the Reaction of The S_NAr Mechanism;
 972 The Chemistry of Bacterial Dehalogenation of a PCB Derivative;
 21.11B 973 Nucleophilic Aromatic Substitution through an Elimination-Addition Mechanism,
 The Benzyne Mechanism;
 974 A Mechanism for the Reaction of The Benzyne Elimination-Addition Mechanism;
 21.11C 976 Phenylation;
 21.12 977 Spectroscopic Analysis of Phenols and Aryl Halides;
 1. Infrared Spectra;
 2. 1H NMR Spectra;
 3. ^{13}C NMR Spectra;
 4. Mass spectra;
 978 Concept Map: Some Synthetic Connections of Phenols and Related Aromatic Compounds;
 979 Key Terms and Concepts.

Problems:	In-Chapter	21.1 to 21.12
	979	End of Chapter 21.13 to 21.38
	984	Learning Group Problems
	986	Second Review Problem Set 1 to 24.
	992	Special Topic F: Aryl Halides: Their Uses;
F.1	992	Aryl Halides as Insecticides;
F.2	993	Organic halides as Heerbicides;
F.3	994	Polychlorinated Biphenyls (PBCBs);
	995	Special Topic G: Electrocyclic and Cycloaddition Reactions.
G.1	995	Introduction;
G.2	995	Electrocyclic Reactions;
G.2A	997	Electrocyclic Reactions of $4n$ π -Electron Systems;
G.2B	1001	Electrocyclic Reactions of $(4n + 2)$ π -Electron Systems;
	1001	Table G.1: Woodward-Hoffmann Rules for Electrocyclic Reactions;
G.3	1004	Cycloaddition Reactions;
G.3A	1005	[2 + 2] Cycloadditions;
G.3B	1007	[4 + 2] Cycloadditions.
	1008	Special Topic H: Transition Metal Organometallic Compounds;
H.1	1008	Introduction
H.2	1009	Electron Counting in Metal Complexes;
	1010	Table H.1: Common Ligands in Transition Metal Complexes;
H.3	1011	Metallocenes: Organometallic Sandwich Compounds;
H.4	1012	Reactions of Transition Metal Complexes;
H.5	1014	Homogeneous Hydrogenation;
H.6	1015	Carbon-Carbon Bond-Forming Reactions;
H.6A	1016	Coupling Reactions;
		1. The Heck Reaction;
		2. The Suzuki Reaction;
		3. The Stille Coupling;
		4. The Sonogashira Reaction;
H.6B	1017	Ruthenium Alkylidene (Ruthenium Carbene) Complexes: Olefin Metathesis and Grubbs' Catalysts;
H.7	1019	Vitamin B ₁₂ : A Transition Metal Biomolecule;

Week of March 30: CARBOHYDRATES AND LIPIDS (OPTIONAL).

Read Chapters 22 & 23.

	1020	Carbohydrate Recognition in Healing and Disease;
22.1	1021	Introduction to Carbohydrates;
22.1A	1021	Classification of Carbohydrates;
22.1B	1022	Photosynthesis and Carbohydrate Metabolism;
22.2	1023	Monosaccharides;
22.2A	1023	Classification of Monosaccharides;
22.2B	1024	D and L Designation of Monosaccharides;
22.2C	1025	Structural Formulas of Monosaccharides;
22.3	1028	Mutarotation;

- 22.4 1029 Glycoside Formation;
 1030 A Mechanism for the Reaction of Formation of a Glycoside;
 1031 A Mechanism for the Reaction of Hydrolysis of a Glycoside;
- 22.5 1032 Other Reactions of Monosaccharides;
- 22.5A 1032 Enolization, Tautomerization, and Isomerization;
- 22.5B 1032 Use of Protecting Groups in Carbohydrate Synthesis;
- 22.5C 1033 Formation of Ethers;
- 22.5D 1034 Conversion to Esters;
- 22.5E 1035 Conversion to Cyclic Acetals
- 22.6 1035 Oxidation Reactions of Monosaccharides;
- 22.6A 1035 Benedict's or Tollens' Reagents: Reducing Sugars;
- 22.6B 1036 Bromine Water: The Synthesis of Aldonic Acids;
- 22.6C 1037 Nitric Acid Oxidation: Aldaric Acids;
- 22.6D 1038 Periodate Oxidations: Oxidative Cleavage of Polyhydroxy Compounds;
- 22.7 1040 Reduction of Monosaccharides: Alditols;
- 22.8 1041 Reactions of Monosaccharides with Phenylhydrazine: Osazones;
 1041 A Mechanism for the Reaction of Phenyllosazone Formation;
- 22.9 1042 Synthesis and Degradation of Monosaccharides;
- 22.9A 1042 Kiliani-Fischer Synthesis;
- 22.9B 1043 The Ruff Degradation;
- 22.10 1044 The D family of Aldoses;
- 22.11 1044 Fischer's Proof of the Configuration of D-(+)-Glucose;
 1045 Fig 22.7: The D Family of Aldohexoses;
 1047 The Chemistry of Stereoselective Synthesis of All the L-Aldohexoses;
- 22.12 1049 Disaccharides;
- 22.12A 1049 Sucrose;
- 22.12B 1050 Maltose;
- 22.12C 1050 Cellobiose;
 1052 The Chemistry of Artificial Sweeteners (How Sweet It Is);
- 22.12D 1053 Lactose;
- 22.13 1053 Polysaccharides;
- 22.13A 1053 Starch;
- 22.13B 1054 Glycogen;
- 22.13C 1055 Cellulose;
- 22.13D 1056 Cellulose Derivatives;
 1057 The Chemistry of the Oligosaccharide Synthesis on a Solid Support
 – The Glycal Assembly Approach;
- 22.14 1059 Other Biologically Important Sugars;
- 22.15 1059 Sugars That Contain Nitrogen;
- 22.15A 1059 Glycosylamines;
- 22.15B 1060 Amino Sugars;
- 22.16 1061 Glycolipids and Glycoproteins of the Cell Surface: Cell Recognition and the Immune System;
 1063 The Chemistry of Vaccines Against Cancer;
- 22.17 1064 Carbohydrate Antibiotics.
 1065 Summary of Reactions of Carbohydrates;
 1066 Summary and Review Tools: A Summary of Reactions Involving Monosaccharides;
 1067 Key Terms and Concepts.
- Problems: In-Chapter 22.1 to 22.19
 1067 End of Chapter 22.20 to 21.45
 1071 Learning Group Problems

1073 LIPIDS (Chapter 23)

- 1073 Insulation for Nerves;
- 23.1 1074 Introduction to Lipids;
- 23.2 1075 Fatty Acids and Triacylglycerols;
- 1076 Table 23.1: Common Fatty Acids;
- 1077 Table 23.2: Fatty Acid Composition Obtained by Hydrolysis of Common Fats and Oils;
- 23.2A 1077 Hydrogenation of Triacylglycerols;
- 23.2B 1077 Biological Functions of Triacylglycerols;
- 1078 The Chemistry of Olestra and Other Fat Substitutes;
- 23.2C 1079 Saponification of Triacylglycerols;
- 23.2D 1081 Reactions of Carboxyl Groups of Fatty Acids;
- 23.2E 1081 Reactions of the Alkenyl Chain of Unsaturated Fatty Acids;
- 1082 The Chemistry of Self-Assembled Monolayers
– Lipids in Materials Science and Bioengineering;
- 23.3 1083 Terpenes and Terpenoids;
- 23.3A 1086 Natural Rubber;
- 23.4 1087 Steroids;
- 23.4A 1087 Structure and Systematic Nomenclature of Steroids;
- 23.4B 1089 Cholesterol;
- 23.4C 1090 Sex Hormones;
- 23.4D 1092 Adrenocortical Hormones;
- 23.4E 1092 D Vitamins
- 23.4F 1093 Other Steroids;
- 23.4G 1094 Reactions of Steroids;
- 23.5 1095 Prostaglandins;
- 23.6 1097 Phospholipids and Cell Membranes;
- 23.6A 1097 Phosphatides;
- 1099 The Chemistry of STEALTH Liposomes for Drug Delivery;
- 23.6B 1100 Derivatives of Sphingosine;
- 23.7 1100 Waxes;
- 1101 Summary of the Reactions of Lipids;
- 1101 Key Terms and Concepts.
- Problems: In-Chapter 23.1 to 23.11
- 1101 End of Chapter 23.12 to 23.26
- 1107 Learning Group Problems.

Week of March 31: AMINO ACIDS AND PROTEINS (OPTIONAL).

Read Chapter 24.

- 1107 Catalytic Antibodies: Designer Catalysts
- 24.1 1108 Introduction;
- 24.2 1109 Amino Acids;
- 24.2A 1109 Structures and Names;
- 24.2B 1109 Essential Amino Acids;
- 1110 Table 24.1: L-Amino Acids Found in Proteins;
- 24.2C 1112 Amino Acids as Dipolar Ions;
- 24.3 1115 Synthesis of α -Amino Acids;

- 24.3A 1115 From Potassium Phthalimide;
 24.3B 1116 The Strecker Synthesis;
 1116 A Mechanism for the Reaction of Formation of:
 an α -Aminonitrile During the Strecker Synthesis;
 24.3C 1116 Resolution of DL-Amino Acids;
 24.3D 1117 Asymmetric Syntheses of Amino Acids;
 24.4 1119 Polypeptides and Proteins;
 24.4A 1120 Hydrolysis;
 24.5 1122 Primary Structure of Polypeptides and Proteins;
 24.5A 1122 Edman Degradation;
 24.5B 1123 Sanger N-Terminal Analysis;
 24.5C 1124 C-Terminal Analysis;
 24.5D 1124 Complete Sequence Analysis;
 24.5E 1125 Peptide Sequencing Using Mass Spectroscopy and Sequence Databases;
 24.6 1126 Examples of Polypeptides and Proteins Primary Structure;
 24.6A 1126 Oxytocin and Vasopressin;
 24.6B 1127 Insulin;
 1128 The Chemistry of Sickle-Cell Anemia
 24.6C 1128 Other Polypeptides and Proteins
 24.7 1129 Polypeptide and Protein Synthesis;
 24.7A 1130 Protecting Groups;
 24.7B 1131 Activation of Carboxyl Group;
 24.7C 1132 Peptide Synthesis;
 24.7D 1133 Automated Peptide Synthesis;
 24.8 1135 Secondary, Tertiary, and Quaternary Structures of Proteins;
 24.8A 1135 Secondary Structure;
 24.8B 1139 Tertiary Structure;
 24.8C 1140 Quaternary Structure;
 24.9 1140 Introduction to Enzymes;
 24.10 1141 Lysozyme: Mode of Action of an Enzyme;
 24.11 1145 Serine Proteases;
 24.12 1148 Haemoglobin, a Conjugated Protein;
 1148 The Chemistry of Some Catalytic Antibodies;
 24.13 1150 Purification and Analysis of Polypeptides and Proteins
 24.13A 1150 Purification;
 24.13B 1150 Analysis;
 24.14 1152 Proteomics;
 1154 Key Terms and Concepts.
 Problems: In-Chapter 24.1 to 24.16
 1154 End of Chapter 24.17 to 24.27
 1157 Learning Group Problems

Week of April 6: NUCLEIC ACIDS AND PROTEIN SYNTHESIS

- 1158 Read Chapter 25
 1158 Tools for Finding Families;
 25.1 1159 Introduction;
 25.2 1160 Nucleotides and Nucleosides;
 25.3 1163 Laboratory Synthesis of Nucleosides and Nucleotides;

- 25.3A 1166 Medical Applications;
- 25.4A 1166 Primary Structure;
- 25.4B 1167 Secondary Structure;
- 25.4C 1171 Replication of DNA;
- 25.5 1173 RNA and Protein Synthesis;
- 25.5A 1173 Messenger RNA Synthesis;
- 25.5A 1173 Messenger RNA Synthesis-Transcription;
- 25.5B 1174 Ribosomes-rRNA
- 25.5C 1176 Transfer RNA;
- 25.5D 1177 The Genetic Code;
- 25.5E 1178 Translation;
- 25.6 1180 Determining the Base Sequence of DNA:
The Chain-Terminating (Dideoxynucleotide) Method;
- 25.6A 1181 DNA Sequencing by the Chain-Terminating (Dideoxynucleotide) Method;

CHEMISTRY 2630 A3: 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 5 & 12: SPECTROSCOPIC METHODS OF STRUCTURE DETERMINATION,
Chapters 12/13.

Chapter 12: INFRARED SPECTROSCOPY AND MASS SPECTROSCOPY

Sect # Page # Read and Study Chapter 12.

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;
13.5	565	The Chemical Shift;
13.5A	565	Measurement of Chemical Shifts;
	567	Table 13.1: Variation of Chemical Shift with Electronegativity;
	567	Table 13.2: Chemical Shifts of the Chloromethanes;
13.5B	567	Characteristic Values of Chemical Shifts;
	568	Table 13.3: Typical values of Chemical Shifts;
	568	Vinyl and Aromatic Protons;
	570	Acetylenic Hydrogens;
	570	Aldehyde Protons;
	571	Hydrogen-Bonded protons;
	571	Carboxylic Acid protons;
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;
	578	Relative peak Intensities of Symmetric Multiplets - Pascal's Triangle;
13.8C	578	The Range of Magnetic Coupling;
	581	Problem-Solving Strategy; Drawing an NMR Spectrum;
13.8D	582	Coupling Constants;
13.9	585	Complex Splitting;
13.10	588	Stereochemical Nonequivalence of protons;
13.11	591	Time Dependence of NMR Spectroscopy;
13.11A	591	Conformational Changes;
13.11B	591	Fast Proton Transfers: Hydroxyl Protons and N-H Protons;
	594	Problem Solving Strategy; Interpreting Proton NMR Spectra;
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 ^1H and ^{13}C Techniques; Operating Frequency and Peak Areas;
13.12E	603	Spin-Spin Splitting;
	603	Proton Spin Decoupling: Each Carbon Atom Appears as a Singlet;
	603	Off-Resonance Decoupling: Splits the ^{13}C Nuclei According to the N + 1 Rule;
13.12F	604	DEPT ^{13}C NMR: Distortionless Enhanced Polarization Transfer;
	605	Table 13.4: Summary of DEPT Spectra;
13.13	607	Interpreting Carbon NMR Spectra;
13.14	609	Nuclear Magnetic Resonance Imaging;
	610	Problem-Solving Strategy: Spectroscopy Problems;
	614	Chapter 13 Glossary;
	615	Essential Problem-Solving Skills in Chapter 13;

616 Study Problems: In Chapter 13.1 – 13.32; End of Chapter 13.33 – 13.52.

Week of Jan 19: 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 $(4n+2)$ π 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
- 655 Study Problems: In-Chapter 14.1 - 14.15; End of Chapter 14.16 - 14.38
- 662 Learning Group Problems.

Weeks of Jan 26: 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;

- 15.10A679 Activating Groups: Ortho-Para Directors;
 15.10B680 Deactivating Groups: Meta Directors;
 15.10C681 Halo Substituents: Deactivating Ortho-Para Directors;
 15.10D681 Classification of Substituents;
 15.11 681 Theory of Substituent Effects on Electrophilic Aromatic Substitution;
 15.11A681 Reactivity: The Effect of Electron-Releasing and Electron-Withdrawing Groups;
 15.11B684 Inductive and Resonance Effects: Theory of Orientation;
 15.11C685 Meta-Directing Groups;
 15.11D686 Ortho-Para-Directing Groups;
 15.11E690 Ortho-Para Directing and Reactivity of Alkylbenzenes;
 15.11F692 Summary of Substituent Effects on Orientation and Reactivity;
 15.12 693 Alkyl Benzenes, Side Chain Reactions;
 15.12A693 Benzylic Radicals and Cations;
 15.12B694 Halogenation of the Side Chain - Benzylic Radicals;
 15.13 697 Alkenyl Benzenes;
 15.13A697 Stability of Conjugated Alkenylbenzenes;
 15.13B698 Additions to the Double Bond of Alkenylbenzenes;
 15.13C699 Oxidation of the Side Chain;
 15.13D698 Oxidation of the Benzene Ring;
 15.14 699 Synthetic Applications;
 15.14A701 Use of Protecting and Blocking Groups;
 15.14B702 Orientation in Disubstituted Benzenes;
 15.15 703 Allylic and Benzylic Halides in Nucleophilic Substitution Reactions;
 15.16 705 Reduction of Aromatic Compounds;
 15.16A706 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.
 710 Study Problems: In-Chapter 15.1 - 15.25; End of Chapter 15.26 - 15.56
 715 Learning Group Problems.

Week of Feb 2: 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.
	761	Study Problems: In-Chapter; 16.1 - 16.22; End of Chapter 16.23 - 16.53
	767	Learning Group Problems.

Weeks of Feb 9 & 23: ALDEHYDES AND KETONES II: ALDOL REACTIONS.

Read and Study Chapter 17.

17.1	770	The Acidity of the α -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	α -Selenation: A Synthesis of α , β Unsaturated Carbonyl Compounds;
17.9	797	Additions to α , β 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.
	804	Study Problems: In-Chapter 17.1 - 17.27; End of Chapter 17.28 - 17.45
	809	Learning Group Problems.

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

Week of March 2: 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.
	858	Study Problems: In-Chapter 18.1 - 18.18; End of Chapter 18.19 - 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 9: SYNTHESIS AND REACTIONS OF β -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 β -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 β -Dicarbonyl Compounds;
 912 Key Terms and Concepts.
 912 Study Problems: In-Chapter 19.1 - 19.24; End of Chapter 19.25 - 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 16: AMINES.

Read and Study Chapter 20.

- 20.1 941 Nomenclature;
 20.1A 942 Arylamines;
 20.1B 942 Heterocyclic Amines;
 20.2 943 Physical Properties and Structure of Amines;
 20.2A 943 Physical Properties;
 20.2B 944 Structure of Amines;
 20.3 945 Basicity of Amines, Amine Salts;
 20.3A 946 Basicity of Aryl Amines;
 20.3B 947 Basicity of Heterocyclic Amines;
 20.3C 947 Amines versus Amides;
 20.3D 948 Aminium Salts and Quaternary Ammonium Salts;
 20.3E 949 Solubility of Amines in Aqueous Acids;
 20.3F 950 Amines as Resolving Agents;
 20.4 952 Some Biologically Important Amines;
 20.5 954 Preparation of Amines;
 20.5A 954 Through Nucleophilic Substitution Reactions;
 20.5B 956 Preparation of Aromatic Amines through Reduction of Nitro Compounds;
 20.5C 957 Preparation of Primary, Secondary, or Tertiary Amines through Reductive Amination;
 20.5D 958 Preparation of Primary, Secondary, or Tertiary Amines through Reduction of Nitriles, Oximes and Amides;
 20.5E 960 Preparation of Primary Amines through the Hofmann and Curtius Rearrangements;
 20.6 962 Reactions of Amines;
 20.6A 963 Oxidation of Amines;
 20.7 963 Reactions of Amines with Nitrous Acid;
 20.7A 963 Reactions of Primary Aliphatic Amines with Nitrous Acid;

- 20.7B 964 Reactions of Primary Arylamines with Nitrous Acid;
 20.7C 965 Reactions of Secondary Amines with Nitrous Acid;
 20.7D 966 Reactions of Tertiary Amines with Nitrous Acid;
 20.8 966 Arene Diazonium Salts, Replacement Reactions;
 20.8A 966 Synthesis Using Diazonium Salts;
 20.8B 967 The Sandmeyer Reaction: Replacement of the Diazonium Group by -Cl, -Br, -CN;
 20.8C 968 Replacement by -I;
 20.8D 968 Replacement by -F;
 20.8E 968 Replacement by -OH;
 20.8F 968 Replacement by Hydrogen: Deamination by Diazotization;
 20.9 969 Arene Diazonium Salts, Coupling Reactions;
 20.10 972 Reactions of Amines with Sulfonyl Chlorides;
 20.10A972 The Hinsberg Test;
 20.11 974 The Sulfa Drugs, Sulfanilamide;
 20.11A974 Chemotherapy;
 20.11B974 Sulfa Drugs;
 20.11C975 Essential Nutrients and Antimetabolites;
 20.11D976 Synthesis of Sulfa Drugs;
 20.12 977 Analysis of Amines;
 20.12A977 Chemical Analysis;
 20.12B978 Spectroscopic Analysis;
 20.13 979 Eliminations Involving Ammonium Compounds;
 20.13A979 The Hofmann Elimination;
 20.13B980 The Cope Elimination;
 981 Summary of Preparations and Reactions of Amines;
 984 Key Terms and Concepts;
 895 Study Problems: In-Chapter 20.1 - 20.20; End of Chapter 20.21 - 20.53
 992 Learning Group Problems.
 994 Special Topic E: Alkaloids;
 E.1 994 Alkaloids Containing a Pyridine or Reduced Pyridine Ring;
 E.2 997 Alkaloids Containing an Isoquinoline or Reduced Isoquinoline Ring;
 E.3 998 Alkaloids Containing Indole or Reduced Indole Rings.

Week of Mar 23: 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.
 1027 Study Problems: In-Chapter 21.1 - 21.12; End of Chapter 21.13 - 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 Complexes;
 G.5 1061 Homogeneous Hydrogenation;
 G.6 1062 Carbon-Carbon Bond-Formation Using Rhodium Complexes
 G.7 1064 Vitamin B12: 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 30: 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 Cellulose 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.
- 1122 Study Problems: In-Chapter 22.1 - 22.19; End of Chapter 22.20 - 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 Adrenocortical 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.
	1160 Study Problems: In-Chapter 23.1 - 23.11; End of Chapter 23.12 - 23.26;
	1164 Learning Group Problems.

Week of April 6: 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 α -Amino Acids;
24.3A	1173 Direct Ammonolysis of an α -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 Asymmetric 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;

- 24.5A 1181 Edman Degradation;
- 24.5B 1182 Sanger N-Terminal Analysis;
- 24.5C 1183 C-Terminal Analysis;
- 24.5D 1183 Complete Sequence Analysis;
- 24.5E 1184 Peptide Sequencing Using Mass Spectroscopy and Sequence Databases;
- 24.6 1185 Examples of Polypeptides and Proteins Primary Structure;
- 24.6A 1187 Oxytocin and Vasopressin;
- 24.6B 1187 Insulin;
- 24.6C 1188 Other Polypeptides and Proteins
- 24.7 1189 Polypeptide and Protein Synthesis;
- 24.7A 1190 Protecting Groups;
- 24.7B 1191 Activation of Carboxyl Group;
- 24.7C 1192 Peptide Synthesis;
- 24.7D 1193 Automated Peptide Synthesis;
- 24.8 1195 Secondary, Tertiary, and Quaternary Structures of Proteins;
- 24.8A 1195 Secondary Structure;
- 24.8B 1199 Tertiary Structure;
- 24.8C 1199 Quaternary Structure;
- 24.9 1200 Introduction to Enzymes;
- 24.10 1202 Lysozyme: Mode of Action of an Enzyme;
- 24.11 1203 Serine Proteases;
- 24.12 1210 Haemoglobin, a Conjugated Protein;
- 24.13 1211 Purification and Analysis of Polypeptides and Proteins
- 24.13A 1211 Purification;
- 24.13B 1211 Analysis;
- 24.14 1213 Proteomics;
- 1216 Key Terms and Concepts.
- 1217 Study Problems: In-Chapter 24.1 - 24.16; End of Chapter 24.17 - 24.27.
- 1219 Learning Group Problems

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