

GRANDE PRAIRIE REGIONAL COLLEGE*Department of Science**Discipline of Chemistry**Thirty-Eighth Session 2003 - 2004***CHEMISTRY 1630: Organic Chemistry II****PREREQUISITE:** Chemistry 1610**INSTRUCTOR:** Dr. John P. Sloan, Office # J207, Phone # 539-2004
E-mail SLOAN@GPRC.AB.CA**LECTURE:** CH1630 A3 MW, 8:30 - 9:50 in J201**ALBERTA TRANSFER CREDIT for CH1610 plus CH1630:**

U of Alberta:	CHEM 161/163	6 credits
U of Calgary:	CHEM 351/353	6 credits
U of Lethbridge:	CHEM 2100/2200	6 credits
Athabasca U:	CHEM 2xx/3xx	6 credits
Augustana U Col:	CHE 1xx/1xx	6 credits
Concordia Col:	CH 161/163	6 credits
The King's U Col:	CHEM 2xx/2xx	6 credits
Canadian Union C:	CHEM 1xx/1xx	8 credits

COURSE OUTLINE:**Lecture Component:**

A continuation of the study of the fundamental principles of the chemistry of carbon compounds as commenced in Chemistry 1610. 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 tests will be given and marked.

Notes:

1. Lectures: Days, Time and Place
CH1630 A3 MW, 8:30 - 9:50 in J201.
2. Laboratory Component: Day, Time and Place
CH1630 L1 M 14:30 - 17:20 in J116
CH1630 L2 T 14:30 - 17:20 in J119
3. Tutorial Component: Day, Time and Place

CH1630 S1 F 8:30 - 9:20 in J229
 CH1630 S2 F 10:00 - 10:50 in J228

TEXT BOOKS AND LABORATORY ITEMS:

The following books are required:

1. 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 1610/1630*, Grande Prairie Regional College, 2003/2004.

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;

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 week of Feb 23	-----	25%
2.	Final Exam to be scheduled between April 19 & 28	-----	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 Tests.
3. A pass grade is essential for the Laboratory Component.
4. The Tutorial Grading Component consists of tests and will contribute towards 15% of the final grade. A 10 question test will normally be given each week during the tutorial hour. To encourage general discussion and active student participation, test questions may be answered within "paired teams". Tests 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 a test is overdue.
5. Regular attendance in Lecture, Laboratory, and Tutorial Components is a Course Requirement.

Grande Prairie Regional College Calendar 2003 - 2004: Course Description (page 151-152).**CH1630 3(3-1-3)UT 105 Hours Organic Chemistry II**

Continuation is provided of the study of structure and reactivity of functional groups with special emphasis on molecules important to biology (e.g. fats, sugars, medicinal agents, antibiotics, amino acids, proteins, nucleic acids). Molecules found in everyday life (soaps, detergents, fibres, perfumes, and bio-polymers) will be discussed.

Prerequisite: CH1610

CHEMISTRY 1630
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 5 & 12: 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 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 $(4n+2)$ 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 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;
15.10A	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 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.
Problems:	In-Chapter	16.1 to 16.22
	761	End of Chapter 16.23 to 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.
Problems:	In-Chapter 17.1 to 17.27
804	End of Chapter 17.28 to 17.45
809	Learning Group Problems.

February 16 **Family Day, No Classes**

Week of Feb 16: **WINTER BREAK, NO CLASSES.**

Week of March 1: **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 8: 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.
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 15: AMINES.

Read and Study Chapter 20.

20.1	941	Nomenclature;
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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;
20.10A	972	The Hinsberg Test;
20.11	974	The Sulfa Drugs, Sulfanilamide;
20.11A	974	Chemotherapy;
20.11B	974	Sulfa Drugs;
20.11C	975	Essential Nutrients and Antimetabolites;
20.11D	976	Synthesis of Sulfa Drugs;
20.12	977	Analysis of Amines;
20.12A	977	Chemical Analysis;
20.12B	978	Spectroscopic Analysis;
20.13	979	Eliminations Involving Ammonium Compounds;
20.13A	979	The Hofmann Elimination;
20.13B	980	The Cope Elimination;
	981	Summary of Preparations and Reactions of Amines;
	984	Key Terms and Concepts;
Problems:		In-Chapter 20.1 to 20.20
	985	End of Chapter 20.21 to 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 22: 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 Complexes;
- 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 29: 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.
 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 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.
 Problems: In-Chapter 23.1 to 23.11
 1160 End of Chapter 23.12 to 23.26
 1164 Learning Group Problems.

Week of April 5: 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.
Problems:	In-Chapter	24.1 to 24.16
	1217	End of Chapter 24.17 to 24.27
	1219	Learning Group Problems

Week of April 12:

REVIEW.

REFERENCES TO ORGANIC LECTURE AND LABORATORY TEXTS

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

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