GRANDE PRAIRIE REGIONAL COLLEGE

Department of Science

Discipline of Chemistry

Thirty-Ninth Session 2004 – 2005

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 J228

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 pharmatheutical applications of organic chemistry will be discussed, e.g., molecules found in agrochemicals, fibres, food additives, perfumes, polymers, and prescription drugs.

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

Tutorial Component:
Problem solving and discussion sessions with weekly problem sets. Regular tests will be given and marked.

Notes:

1. Lectures: Days, Time and Place
   CH1630 A3 MW, 8:30 - 9:50 in J228.

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 L123
CH1630 S2 F 10:00 - 10:50 in L123

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 Friday Feb 18 -------- 25%
2. Final Exam to be scheduled between April 16 & 26 -------- 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 10% 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 2004 - 2005: Course Description (page 165).

CH1630 3(3-1-3)UT 105 Hours Organic Chemistry II
A continuation of the study of carbon compounds based on a reaction mechanism approach to the functional group chemistry of arenes, aldehydes, ketones, carboxylic acids, esters, amides, amino acids, carbohydrates and lipids. Topics include: physical properties; acidity and basicity; stereochemistry; addition, elimination and substitution reactions; structure-reactivity relationships; aromaticity and aromatic substitution; and spectroscopic methods of structure determination. Examples of organic molecules found in agricultural, biological, environmental, industrial, medicinal, and pharmatheutical applications of organic chemistry will be discussed, e.g., molecules found in agrochemicals, fibres, food, perfumes, polymers, and prescription drugs. 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 3 & 10: 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 17: 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 24: REACTIONS OF AROMATIC COMPOUNDS.

Read and Study Chapter 15.

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

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

Week of Jan 31: 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 7 & 14: ALDEHYDES AND KETONES II: ALDOL REACTIONS.

Read and Study Chapter 17.

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

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

February 21 Family Day, No Classes

Week of Feb 21: WINTER BREAK, NO CLASSES.

Week of Feb 28: 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 7: SYNTHESIS AND REACTIONS OF ß-DICARBONYL COMPOUNDS: MORE CHEMISTRY OF ENOLATE IONS.

Read and Study Chapter 19.

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

Week of Mar 14: 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;
20.10A 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 21: PHENOLS AND ARYL HALIDES: NUCLEOPHILIC AROMATIC SUBSTITUTION. ORGANIC HALIDES AND ORGANOMETALLIC COMPOUNDS IN THE ENVIRONMENT.

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

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

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

Problems: In-Chapter 21.1 to 21.12
1027 End of Chapter 21.13 to 21.38
1032 Learning Group Problems

1035 Second Review Problem Set 1 to 24.

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

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

Week of Mar 28: CARBOHYDRATES AND LIPIDS (OPTIONAL).

Read Chapters 22 & 23.

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

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

1142 LIPIDS (Chapter 23)

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

Week of April 4: AMINO ACIDS AND PROTEINS (OPTIONAL).

Read Chapter 24.

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

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 11: **REVIEW.**

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