

**ORGANIC CHEMISTRY II
CHMB42H3
LECTURE OUTLINE**

This document contains important course information and should be kept in a safe place where you can refer to it throughout the semester.

Welcome to CHMB42HS: Organic Chemistry II: CHMB42 provides an introduction to the spectroscopy of organic compounds, and studies the mechanisms of various chemical transformations, such as aromatic substitution, and the chemistry of carbonyl compounds. The chemistry of biologically important compounds, including heterocycles, carbohydrates, amino acids, and nucleic acids will also be discussed. This course includes a four hour laboratory every other week. It is a prerequisite for almost all other further chemistry and human biology and biochemistry courses at the University of Toronto at Scarborough campus. Students enrolled in CHMB42H must have previously successfully completed CHMB41H: Organic Chemistry I, or have received permission from the Course Coordinator.

Lectures: Tues 5-6pm AC 223
Wed 8-9am AC 223
Fri 2-3pm AC 223

Lecturer : Dr. Shadi Dalili

Lab Coordinator: Wanda Restivo (S-155A)

Email: sdalili@utsc.utoronto.ca

Office Hours (SW-651): Mon 3-5pm
Tues 1-3pm

Course Website: course site on Blackboard

Communication: via email and Blackboard

Blackboard Course Website: CHMB42HS will be using Blackboard for its course communication this semester. To access the CHMB42H website, or any other Blackboard-based course website, go to the UofT portal login page at <http://portal.utoronto.ca> and log in using your UTORid and password, which can be obtained by emailing help.desk@utoronto.ca or through the help desk in Robarts Library on the St. George campus. Once you have logged in to the portal, look for the **My Courses** module, where you will find the link to the CHMB42H course website along with the links to your other courses with active Blackboard sites. All course announcements, lecture notes, and test information will be posted on the CHMB42

website on Blackboard. Your lab, lab quiz, and midterm marks will be posted on the usual intranet site for CHMB42. The CHMB42 site on Blackboard also includes a chat and discussion board functionality which will be discussed further in the first class.

Textbook: Organic Chemistry (5th Edition), Paula Yurkanis Bruice

The text, a study guide, solutions manual, and the ACE access code, a chemistry tutorial and on-line testing access module, will be available, as a package.

If you already have a textbook and only need the ACE access material, you will need to buy it through the bookstore. If you previously purchased the ACE access code, it is good for 12 months from first activation.

The publisher's web site at: <http://www.prenhall.com/bruice/> includes media materials, which supplement the text.

Chapters: 12-19 and parts of 21, 22, and 27

Recommended: Study Guide and Solutions Manual (included in package with text)

Online Homework: ACE Organic by Pearson

ACE Organic Online Homework schedule: setup your account using instructions for setting up account in the textbook and ACE code package bought from bookstore. The course code you need is **1840** to register in this semester's course.

The problem sets will be released every Friday at 4:00 pm and they are due the following Friday at midnight.

The assignments will be equally weighted and recorded as a percentage. They will cover the material discussed in class.

The percentage of available marks on an assignment will fall linearly to 0% by 1 am on the Friday due date.

In the final calculation for the Homework grade, the lowest mark will be dropped.

Laboratory Schedule:

Odd numbered labs Sections **PRA0001, PRA0003** etc. (week 1 students) begin labs **January 11, 2008**. **Even numbered** labs Sections **PRA0002, PRA0004** etc. (week 2 students) begin labs **January 18, 2008**.

The laboratory component of CHMB42H is compulsory. In order to pass the CHMB42H course, students must pass the lab component of the course.

If you are absent: report it to your TA by phone or e-mail. You may also leave a message with the Lab Coordinator Wanda Restivo in SW155A or by phone 287-7220. Hand in medical note in your next class or ASAP.

The medical note should:

- verify that the student was examined on the day of the test
- if possible, state the illness and
- it **MUST** indicate the physician's professional opinion as to whether the student should receive special consideration on medical grounds.

Laboratory Rules

Lab Manual:

This must be purchased **from** the UTSC Bookstore (\$10).

Lab Coats: They are required. They may be purchased from most Hardware Stores or from the UTSC Bookstore.

Safety Glasses: Safety glasses must be worn at all times in the lab. Students who do wear glasses should purchase a pair of goggles which must be worn over their glasses at all times. **Contact lenses must not be worn in the laboratory. NO STUDENT WILL BE ALLOWED TO WORK IN THE LABORATORY UNLESS HE/SHE IS WEARING APPROVED EYE PROTECTION.**

Be punctual: The introductory explanations for the experiments and/or quizzes will begin at 10 minutes past the hour.

Be prepared: Each student will be expected to have a good knowledge of the assigned experiment **before** entering the laboratory. **It will be helpful to prepare a point-form pre-lab procedure before coming to the lab.**

Be there: Your term mark from the lab is worth a large percentage of your mark. It is based not only on the reports which you submit, but also on your ability to answer, with competence, the questions of the demonstrators and instructor.

- **PLEASE NOTE** that students will not be allowed to re-schedule or miss labs on the days of any first year term test or exam. This is a Chemistry Discipline Policy.

Tutorial Schedule:

Odd numbered Labs Sections PRA0001, PRA0003 etc. (week 1 students) begin tutorials Jan 18/07. Even numbered Labs Sections PRA0002, PRA0004 etc. (week 2 students) begin tutorials Jan 25/07.

There will be quizzes during tutorials which will be randomly administered. They will count for 5% of your overall grade. The lowest quiz grade will be dropped from your final grade calculation.

If you are absent: report it to your TA by phone or e-mail. You may also leave a message with the Lab Coordinator Wanda Restivo in SW155A or by phone 287-7220.

E-mail policy:

- Use UTSC account
- If Yahoo or Hotmail used follow instructions below to prevent email ending up in junk mail:
 - put CHMB42 in the subject line followed by the reason for the email
 - use a greeting of some kind - NOT "Hey"
 - sign your first and last name
 - please include your student number after your name
- Student emails will be replied to within 48 hours (M-F) provided that the above protocol is used.

Method of Evaluation: There are two different schemes for evaluation according to the table provided below. The scheme which gives you the higher grade at the end of the term will be used for your final grade calculation.

Term Test-NO MAKE UP	20%	First 5-6 weeks
Final Exam	45%	Entire course work
Online homework	5%	Lowest mark will be dropped from final grade
Tutorial Quizzes	5%	Lowest mark will be dropped from final grade
Laboratory	25%	See lab manual for dates/evaluation

No calculators, models, pagers, cell phones or other aids will be allowed during any quizzes, lecture test or exam, unless announced previously. Approved calculators (Texas Instruments TI30(TI32); TI34; Sharp EL-531; EL-509(EL-530); Casio fx-65, fx-250, fx-260 (fx-280) may be allowed during laboratory quizzes and tests. Models in (parenthesis) are no longer available, but may still be used.

Persons who miss a test or exam are expected to contact the S. Dalili immediately. Documentation, for approval, **must be given within one week** (e.g. Doctor's note - which

should say that you were seen on the day in question, and that in the Doctor's opinion you were unable to write a test that day). If the documentation is insufficient, you may be required to obtain further, signed, paperwork. Those presenting a valid, documented reason for absence, in writing, within this time frame, will be allowed to be excused OR to write a deferred exam (NO MAKEUP for midterm), AT THE INSTRUCTOR'S DISCRETION.

Marked Term Tests - an announcement will be made, in lecture and/or on the intranet and Blackboard, when tests are marked. You have one week to check your test with Shadi Dalili, during any office hours, or other announced times. Re-marking claims will only be considered for one week after the announcement has been made. Claims must be accompanied by a written statement, outlining the difficulty and presenting data (referenced, if necessary) to support your claim for extra marks.

CHAPTERS COVERED AND SUGGESTED PROBLEMS:

The assigned problems are the minimum number suggested for you to try. You should always attempt as many problems as possible, as Organic Chemistry is mainly learned by "doing". The best way to do this is to keep up with the lecture material as much as possible, getting help with any problems as soon as you can. Students will likely not be successful in the course if they put off doing problems until immediately before an exam. It is probably best to try these before you try the ACE online problems.

Chapters covered: The following outline is a rough guideline only and may change during the course. Always check course notes for updates.

Chapter 12. Mass Spectrometry, Infrared Spectroscopy and UV/Vis Spectroscopy

12.1 Mass Spectrometry

12.2 The Mass Spectrum - Fragmentation

12.3 Isotopes in Mass Spectrometry

12.4 High Resolution Mass Spectrometry

12.5 Fragmentation of Functional Groups - Section omitted

12.6 Spectroscopy and the Electromagnetic Spectrum - **review material**

12.7 Infrared Spectroscopy

12.8 Characteristic Infrared Absorption Bands

Students will be given Tables 12.4 on test/exam

12.9 The Intensity of Absorption Bands

12.10 The Position of Absorption Bands

Hooke's Law - Section omitted

12.11 The Position of Absorption Bands cont'd

12.12 The Shape of Absorption Bands

12.13 Absence of Absorption Bands

12.14 Infrared Inactive Vibrations

12.15 Interpreting Infrared Spectra

12.16 Ultraviolet and Visible Spectroscopy

12.17 Beer-Lambert Law - Section omitted

12.18 Effect of Conjugation on λ_{max}

12.19 Visible spectrum and Color

12.20 Applications of UV/Vis Spectroscopy - Section omitted

Recommended End of Chapter Problems for Chapter 12

41, 43, 46, 50, 52, 54, 57, 60, 63, 65, 69, 70

Chapter 13. NMR Spectroscopy

13.1 Introduction to NMR Spectroscopy

Note - Students are not required to memorize equations on page 571.

13.2 Fourier Transform NMR

13.3 Shielding

13.4 Number of Signals in ^1H NMR Spectrum

13.5 The Chemical Shift

13.6 The Relative Positions of ^1H NMR Signals

13.7 Characteristic Values of Chemical Shifts

Students will be given Table 13.1 on test/exam

13.8 Diamagnetic Anisotropy - Section omitted

13.9 Integration of NMR signals

13.10 Splitting of Signals

13.11 More Examples of ^1H NMR Spectra

13.12 Coupling Constants

13.13 Splitting Diagrams

13.14 Diastereotopic hydrogens - Section omitted

13.15 Time Dependence of NMR Spectroscopy

13.16 Protons Bonded to Oxygen and Nitrogen

13.17 Use of Deuterium in ^1H NMR Spectroscopy

13.18 Resolution of ^1H NMR Spectra

13.19 ^{13}C NMR Spectroscopy

Students will be given Table 13.4 on test/exam

13.20 Dept ^{13}C NMR Spectra

13.21 Two-Dimensional NMR Spectroscopy - Section omitted

13.22 Magnetic Resonance Imaging - Section omitted

Recommended End of Chapter Problems for Chapter 13

43, 45, 46, 50, 52, 54, 56, 58, 60, 62, 66, 69, 71, 72, 74

Chapter 14 Aromaticity • Reactions of Benzene

14.1 Aromatic compounds are unusually stable

14.2 Criteria for Aromaticity

14.3 Applying Criteria for Aromaticity

14.4 Aromatic Heterocyclic Compounds

14.5 Some Chemical Consequences of Aromaticity

14.6 Antiaromaticity

14.7 A Molecular Orbital Description

14.8 Nomenclature of Monosubstituted Benzenes

Students should memorize the structures of toluene, phenol, aniline, benzenesulfonic acid, anisole, styrene, benzaldehyde, benzoic acid, benzonitrile.

- 14.9 How Benzene Reacts
- 14.10 General Mechanism for Electrophilic Aromatic Substitution Reactions
- 14.11 Halogenation of Benzene
- 14.12 Nitration of Benzene
- 14.13 Sulfonation of Benzene
- 14.14 Friedel-Crafts Acylation of Benzene
- 14.15 Friedel-Crafts Alkylation of Benzene
- 14.16 Alkylation of Benzene by Acylation-Reduction
- 14.17 Coupling Reactions to Alkylate Benzene
- 14.18 More than one way to do reaction
- 14.19 Substituents on Benzene Chemically Changed

Recommended End of Chapter Problems for Chapter 14

31, 33, 36, 37, 40, 42, 45, 46, 48

Chapter 15 - Reactions of Substituted Benzenes

- 15.1 Nomenclature of Disubstituted and Polysubstituted Benzenes
- 15.2 The Effect of Substituents on Reactivity
- 15.3 The Effect of Substituents on Orientation
- 15.4 The Effect of Substituents on pK_a
- 15.5 The Ortho-Para Ratio
- 15.6 Additional Considerations Regarding Substituent Effects
- 15.7 Designing a Synthesis IV
- 15.8 Synthesis of Trisubstituted Benzenes
- 15.9 Synthesis of Substituted Benzenes Using Arenediazonium Salts
- 15.10 The Arenediazonium Ion as an Electrophile
- 15.11 Mechanism for the reaction of amines with nitrous acid - Section omitted
- 15.12 Nucleophilic Aromatic Substitution Reactions - Section omitted
- 15.13 Benzyne - Section omitted
- 15.14 Polycyclic Benzenoid Hydrocarbons - Section omitted

Recommended End of Chapter Problems for Chapter 15

35, 36, 38, 40, 42, 44, 46, 48, 52, 54, 57, 63

Chapter 16 - Carbonyl Compounds I - Nucleophilic Acyl Substitution

- 16.1 Nomenclature of Carboxylic Acids and Derivatives
- 16.2 Structures of Carboxylic Acids and Carboxylic Acid Derivatives
- 16.3 Physical Properties of Carbonyl Compounds - Section omitted
- 16.4 Naturally Occurring Carboxylic Acids - Section omitted
- 16.5 How Class I Carbonyl Compounds React
- 16.6 Relative Reactivities of Carboxylic Acids and Carboxylic Acid Derivatives
- 16.7 General Mechanism for Nucleophilic Acyl Substitution Reactions
- 16.8 Reactions of Acyl Halides

- 16.9 Reactions of Acid Anhydrides
- 16.10 Reactions of Esters
- 16.11 Acid-Catalyzed Ester Hydrolysis
- 16.12 Hydroxide-ion-Promoted Ester Hydrolysis
- 16.13 Mechanism Confirmation - Section omitted**
- 16.14 Soaps, Detergents and Micelles
- 16.15 Reactions of Carboxylic Acids
- 16.16 Reactions of Amides
- 16.17 Acid-Catalyzed Hydrolysis of Amides
- 16.18 Hydrolysis of an Imide: The Gabriel Synthesis
- 16.19 Hydrolysis of Nitriles
- 16.20 Designing a Synthesis V: The Synthesis of Cyclic Compounds
- 16.21 Activation of Carboxylic Acids
- 16.22 How Cells activate Carboxylic Acids - Section omitted**
- 16.23 Dicarboxylic Acids and Their Derivatives

Recommended End of Chapter Problems for Chapter 16

46, 48, 51, 53, 55, 56, 62, 64, 67, 70, 74, 78, 83, 87

Chapter 17 Carbonyl Compounds II

- 17.1 Nomenclature of Aldehydes and Ketones
- 17.2 Relative Reactivities of Carbonyl Compounds
- 17.3 How Aldehydes and Ketones React
- 17.4 Reactions of Carbonyl Compounds with Grignard Reagents
- 17.5 Reactions of Carbonyl Compounds with Acetylide Ions
- 17.6 Reactions of Carbonyl Compounds with Hydride Ion
- 17.7 Reactions of Aldehydes and Ketones with Hydrogen Cyanide - Section omitted**
- 17.8 Reactions of Aldehydes and Ketones with amines and derivatives of amines
- 17.9 Reactions of Aldehydes and Ketones with Water
- 17.10 Reactions of Aldehydes and Ketones with Alcohols
- 17.11 Protecting Groups
- 17.12 Addition of Sulfur Nucleophiles
- 17.13 The Wittig Reaction
- 17.14 Stereochemistry of Nucleophilic Addition Reaction - Section omitted**
- 17.15 Designing a Synthesis VI: Disconnections, Synthons and Synthetic Equivalents
- 17.16 Nucleophilic Addition to α , β -Unsaturated Aldehydes and Ketones
- 17.17 Nucleophilic Addition to α , β -Unsaturated Carboxylic Acid Derivatives
- 17.18 Enzyme-Catalyzed Additions to α , β -Unsaturated Compounds - Section omitted**

Recommended End of Chapter Problems for Chapter 17

45, 48, 52, 53, 56, 57, 60, 62, 64, 69, 72, 75, 77, 79, 82, 84

Chapter 18 Carbonyl Compounds III - Reactions at the α -Carbon

- 18.1 Acidity of α -Hydrogens
- 18.2 Keto-Enol Tautomerization
- 18.3 Enolization
- 18.4 How Enols and Enolate Ions React
- 18.5 Halogenation of the α -Carbon of Aldehydes and Ketones
- 18.6 Halogenation of the α -Carbon of Carboxylic Acids
- 18.7 α -Halogenated Carbonyl Compounds in Synthesis
- 18.8 Using LDA to Form an Enolate
- 18.9 Alkylation of the α -Carbon of Carbonyl Compounds
- 18.10 Alkylation and Acylation of the α -Carbon via an Enamine Intermediate
- 18.11 Alkylation of the β -Carbon: The Michael Reaction
- 18.12 The Aldol Reaction
- 18.13 Dehydration of Aldol Addition Products: Formation of α , β -Unsaturated
- 18.14 The Mixed Aldol Addition
- 18.15 The Claisen Condensation
- 18.16 The Mixed Claisen Condensation
- 18.17 Intramolecular Condensation and Addition Reactions
- 18.18 Decarboxylation of 3-Oxocarboxylic Acids
- 18.19 The Malonic Ester Synthesis: Synthesis of Carboxylic Acids
- 18.20 The Acetoacetic Ester Synthesis: Synthesis of Methyl Ketones
- 18.21 Designing a Synthesis VII: Making New Carbon-Carbon Bonds
- 18.22 Reactions at the α -Carbon in Biological Systems - Section omitted

Recommended End of Chapter Problems for Chapter 18

49, 52, 54, 55, 58, 60, 62, 64, 67, 69, 73, 76, 78, 81, 83

Chapter 19 More About Oxidation-Reduction Reactions

- 19.1 Reduction Reactions
- 19.2 Oxidation of Alcohols
- 19.3 Oxidation of Aldehydes and Ketones
- 19.4 Designing a Synthesis VIII: Controlling Stereochemistry
- 19.5 Hydroxylation of Alkenes
- 19.6 Oxidative Cleavage of 1,2-Diols
- 19.7 Oxidative Cleavage of Alkenes

Note - omitted Permanganate Cleavage (page 929)

19.8 Oxidative Cleavage of Alkynes - Section omitted

- 19.9 Designing a Synthesis IX: Functional Group Interconversion

Recommended End of Chapter Problems for Chapter 19

31 (excluding **b**), 33, 34, 37, 41, 44, 47, 53, 56, 60, 61

Chapter 21 Carbohydrates

Note - students will not need to memorize names and structures of ketoses/aldoses

- 21.1 Classification of Carbohydrates

- 21.2 The D and L Notation
- 21.3 Configuration of Aldoses
- 21.4 Configuration of Ketoses
- 21.5 Reactions of Monosaccharides in Basic Solutions - Section omitted**
- 21.6 Redox Reactions of Monosaccharides
- 21.7 Monosaccharides form Crystalline Osazones - Section omitted**
- 21.8 Chain Elongation: The Kiliani Fischer Synthesis
- 21.9 Shortening the Chain: The Wohl Degradation
- 21.10 Stereochemistry of Glucose: The Fischer Proof - Section omitted**
- 21.11 Monosaccharides form Cyclic Hemiacetals
- 21.12 Stability of Glucose - Section omitted**
- 21.13 Formation of Glycosides
- 21.14 The Anomeric Effect
- 21.15 Reducing and Nonreducing Sugars
- 21.16 Disaccharides
- 21.17 Polysaccharides
- 21.18-22.20 Sections are omitted**

Recommended End of Chapter Problems for Chapter 21
30, 34, 39, 44, 49

Chapter 22 Amino acids, Peptides and Proteins

Note - students will not need to memorize names structures of the 20 common amino acids

- 22.1 Classification and Nomenclature
- 22.2 Configuration of Amino acids
- 22.3 Acid-Base Properties of Amino Acids
- 22.4 The Isoelectric Point
- 22.5 Separation of Amino Acids - Section omitted**
- 22.6 Synthesis of Amino Acids
- 22.7-22.17 Sections are omitted**

Recommended End of Chapter Problems for Chapter 22
44, 47, 50, 53, 56, 60, 63,