Organic Chemistry Chem-234 (Sec. 1)
Course Syllabus

3 Credits, Fall Semester, 2009

Lectures

Chem-234 (sec. 1) Tuesday and Thursday — 4:00 - 5:15 p.m. — 112 Clark Hall

Instructor

Professor George O'Doherty • 465 CRL• George.ODoherty@mail.wvu.edu
http://www.as.wvu.edu/~odoherty/site

Office hours: Tuesday and Thursday — 5:15 - 6:00 p.m.
or by appointment, which must be made by e-mail, one day in advance

Grading: Total Points = 1000 points

Web based Quizzes/Exams: 400 points

Best Four out of Five web based quiz total and/or exams (100 points each/400 points total)
Each exam is worth 100 points
Quiz total is the sum of your 10 best quiz scores out of 20 quizzes (maximum 100 points total)

For Web based exams, See: we-learn-horizon.com/ & www.welearnhorizon.com/
For technical support contact Prof. John Penn at http://www.as.wvu.edu/~jpenn

Midterm exam: 300 points

Midterm Exam (Thursday, October 22nd) 4:00 pm - 5:00 pm
in 112 Clark Hall

Final exam: 300 points

Chem-234 (sec. 1) **Final Exam (Tuesday, Dec. 15th)**
7:30 am - 10:30 am in 112 Clark Hall

Depending on room availability we will try to start at 7:30 and end at 10:30 am
times are subject to change (see: http://www.arc.wvu.edu/examschedule_fall.html)

Course Drop-Date

Friday, October 30, 2009 is the last day at which you can drop this class with a W!
(For more information call 304-293-2124)

Exam Dates

(See: http://www.as.wvu.edu/~odoherty/site/courses.html)

1st Exam (September 10th) 6:00 pm
2nd Exam (October 1st) 6:00 pm
Midterm Exam (Thursday Oct. 22nd) In Class
3rd Exam (November 16th) 6:00 pm
4th Exam (December 11th) 6:00 pm
Final Exam (Tuesday, Dec. 15th) In Class at 7:30 am.

Organic Chemistry Chem 234:

Section 1: Tuesday and Thursday — 4:00 - 5:15 p.m. — 112 Clark Hall

1) Stereochemistry of Organic Compounds (Chapter 5); Week 1
2) Stereochemistry of Organic Reactions (Chapter 6-12 & 15); Week 1/2
3) Alkene Chemistry review (Chapter 10); Week 2
4) Radical Reactions (Chapter 15); Week 2/3
5) Dienes: Conjugation and reactions (Chapter 16); Week 3
6) Arenes and Aromaticity (Chapter 17); Week 4
7) Electrophilic Aromatic Substitution Reactions (Chapter 18); Week 5
8) Carboxylic Acids and Relative Acidity (Chapter 19); Week 6
9) Carbonyl Chemistry, Organometallics/Oxidation/Reduction (Chapter 20); Week 7
10) Aldehydes and Ketones-Nucleophilic addition (Chapter 21); Week 8
11) Carboxylic Acids and Derivatives addition (Chapter 22); Week 9
12) Carbonyl Condensation Reactions (Chapter 23); Week 10
13) Enols and Enolates (Chapter 24): Week 11
14) Amines, Amino Acids and Peptides (Chapter 25/28); Week 12
15) Carbon-Carbon bond formation (Chapter 26); Week 13
16) Carbohydrates (Chapter 27); Week 14
17) Lipids (Chapter 29); Week 15

Chem-234 (sec. 1) **Final Exam (Tuesday, Dec. 15th)**
7:30 am - 10:30 am in 112 Clark Hall

This time is subject to change by WVU
(see: http://www.arc.wvu.edu/examschedule_spring.html)

Textbook:

Required Textbook: "Organic Chemistry" Smith 2nd Edition
(http://www.mhhe.com/sem/OrganicChem/smithorganic/index.html)
We-Learn account (we-learn-horizon.com/)

"Study Guide and Solution Manual"
Suggested Study Aids: "Darling Models" (Available from ACS Student Affiliates)

Laboratory: The laboratory **Check-in** will be held during the first week of classes. *If you do not show up for your laboratory during the first week you will be administratively dropped from the class and your place will be given to someone else* (e.g. someone who actually showed up).

Check-in policy for the laboratory will be rigidly enforced. Laboratory space will be assigned first to students who are pre-registered for the course. If no space is available for those who have not pre-registered for the course, a withdraw from the lecture course will have to be made, because the laboratory is a required co-requisite.

Policy on Web Quizzes and Exams: To take the web exams you will have to sign up at we-learn-horizon.com/ and to take the exams see: www.welearnhorizon.com/. This will require you to pay a $25 sign up fee. To sign up for the exams, point your browser to http:/www.welearnhorizon.com/ and then click on the "Purchase" button. This is a secure website and a credit card or debit card can be used to purchase the system. Your account name and password will be emailed to you within 24 hours of your purchase.

These online exams are offered to help those student who find it difficult to demonstrate their chemistry knowledge during the in class exams. You can, if you prefer, not take online exams and opt to have only the midterm and final count for your final grade. *You must indicate this preference to me in writing by Oct. 30th, which is also the last day to drop (**W**).*

All online exams will cover the material presented in lecture, the book and the first semester course (Chem 233), with emphasis on material covered during the latest lecture and chapter. It is possible that the material may not be covered before it is due (i.e., *you may have to read the book to answer all of the questions*!). I have found Google to be quite helpful). *All exams must be completed by the time indicated.*

Policy on Exams: Exams will cover all of the material from the beginning of the course, with emphasis on material since the previous exam. *All examinations must be taken at the times indicated above. Absolutely no make-up exams will be given.* Only university approved absence from the exam will be accepted. University approved absence missed exam will be made-up by applying the percentage received on the final exam for the missing exam.

Policy on Exam Re-grading: It is expected that some mistakes will be make in grading the exams. It is your responsibility to identify any errors in grading and make a written-request to me for a re-grade. If you would like your exam to be regarded, you must turn in your exam to me *within one week of the exam date* along with a written explanation as to why you think the exam needs to be regarded (this includes errors of addition). Exam submitted without written explanation will not be regarded. To insure against cheating in class exam will be photocopied and used for comparative purposes during regarding.

Policy on I Grades: An **I** grade will be assigned only when a prior arrangement has been made with the instructor. It will only be considered when the final exam is not taken and when work completed to that date is satisfactory. If the final exam is not taken and work completed prior to that date is unsatisfactory an F or N will be given, depending in the grading system the course was taken (**A**-**F** or **P**/**N**). *An "Agreement for Making-up an **I** Grade" form must be completed and signed by the instructor, student and turned in within 48 hours after the final exam.*

Issues of Disability: I stand ready to make reasonable accommodations, in accordance with the ADA (American Disability Act), for students with various kinds of disability, visible and invisible. I request that you see me during the ***first week of classes*** if this applies to you so that such accommodations may be made in a timely fashion. *You will need to present me with a letter from the Office of Disability Services.*

Classroom Diversity: You are expected to attend each lecture, be attentive during class and participate in class discussions (please feel free to ask questions if you do not understand something in lecture). You are also expected to listen respectfully to other students and me when we are speaking. *To show this respect, I recommend that you turn off your cell phone. Racism, sexism, homophobia, classism, ageism, and other forms of bigotry are inappropriate to express in lecture.*

Policy on Scholastic Dishonesty: Academic dishonesty of any kind will not be accepted in this course and will result in a grade of F on the exam or possibly harsher penalties. Academic dishonesty is defined as: submission of false records of academic achievement; cheating on assignments or examinations; plagiarizing; altering, forging, or misusing a University academic record; taking, acquiring, or using test materials without my permission; acting alone or in cooperation with another to falsify records or to obtain dishonest grades, honors awards or professional endorsement. All students must have ID cards readily available during the examination. Failure to follow these rules can result in a grade of F on the exam or possibly harsher penalties. It is worth noting that random in class exam will be photocopied and used for comparative purposes during regarding. Altered exams that are presented as original work fall under academic dishonesty.

Course Outline
Organic Chemistry II 234

Review (Chapter 1-12)

1) Stereochemistry (Chapter 5)
    a) Chirality
    b) Optical activity
    c) Assignment of configuration, *R, S* Convention
    d) Chiral molecules without chiral atoms
    e) Diastereomers
    f) Meso compounds
    g) Resolution of enantiomers
    h) Stereochemistry of chemical reaction

2) Stereochemistry of Organic Reactions (Chapter 6-12 & 15)
    a) Alkene chemistry
        i. electrophilic addition to alkenes
            a) addition of HX (Markovnikov addition and anti-Markovnikov addition)
            b) addition of Br_2 (with and without participating solvents)
            c) addition of $Hg(OAc)_2$ in participating solvents
            d) hydroboration/oxidation (anti-Markovnikov addition)
        ii. radical addition to alkenes
            a) radical addition of HX (anti-Markovnikov addition)
            b) allylic halogenation
        iii. hydrogenation of alkenes
    b) Alkyl halide chemistry
        i. S_N1 Substitution
        ii. S_N2 Substitution
        iii.E1 Elimination
        iv. E2 Elimination
        v. Grignard additions

3) Structure and Synthesis/Reaction of alkenes (Chapter 10)
    a) Electronic structure of the double bond
        i. π-electrons (π-bonds π*-bonds)
        ii. planer atoms (no bond rotation)
    b) Alkene stability
        i. more substituted double bond is more stable
        ii. trans(*E*) more stable than cis(*Z*) for acyclic alkenes
        iii. cis(*Z*) more stable than trans(*E*) for cyclic alkenes
    c) Preparation of alkenes by elimination reactions
        i. elimination of HX
        ii. elimination of X_2
        iii. Lindlar reduction of alkynes (cis selective, chapter 11)
        iv. dissolving metal reduction of alkynes (trans selective, chapter 11)
    d) Reactions of alkenes (Chapter 10)

i. electrophilic addition to alkenes
a) addition of HX (Markovnikov addition and anti-Markovnikov addition)
b) addition of Br_2 (with and without participating solvents)
c) addition of $Hg(OAc)_2$ in participating solvents
d) hydroboration/oxidation (anti-Markovnikov addition)
ii. radical addition to alkenes
a) radical addition of HX (anti-Markovnikov addition)
b) allylic halogenation
iii. hydrogenation of alkenes

4) Radical Reactions (Chapter 15)
a) Radical Halogenations
i. More stable radical/bond strength
ii. No stereocontrol
b) Preparation of alkyl halides
i. addition of HX across C=C
a) Markovnikov addition (prepares 2° and 3° alkyl halides)
b) anti-Markovnikov addition (prepares 1° alkyl halides)
ii. radical halogenation of alkanes
a) alkanes to alkylhalides
iii. radical halogenation of alkenes and arenes
a) alkenes to allylic halides and benzylic halides
iv. bromination vs chlorination
a) C-H abstraction from weakest C-H bond (allylic and benzylic bond)
b) Cl• more reactive than Br• so Br• is more selective than Cl•

5) Dienes (Chapter 16)
a) Resonance structures
i. movement of π-electrons not σ-electrons
ii. make and break π-bonds but not σ-bonds
iii. 1,3-dienes (conjugated dienes)
b) Stability
i. more substituted, more stable
a) alkenes
b) carbocations
c) carbon radicals
ii. more resonance structures, the more stable
a) alkenes
b) carbocations
i. allylic and benzylic carbocation a little more stable than secondary
c) carbon radicals
i. allylic and benzylic carbon radical more stable than tertiary
iii. benzylic and allylic bonds are weakened
c) Aromaticity is special case of stability
i. benzene gains 36 kcal/mol stabilization energy due to resonance
ii. anti-aromatic structures (4n)π electrons
d) Alkene reactivity
i. More substituted alkene is a more nucleophilic alkene
e) Diene formation

i. Alkene bromination/elimination

f) Kinetic vs Thermodynamic product formation

i. 1,2 vs 1,4 addition of HX and Br_2

g) Diels-Alder Reactions

i. Dienes

a) HOMO

b) Electron Rich

ii. Dienophiles

a) LUMO

b) Electron deficient

ii. Endo vs Exo

6) Arenes and Aromaticity (Chapter 17)

a) Resonance structures

i. movement of π-electrons not σ-electrons

ii. make and break π-bonds but not σ-bonds

iii. 1,3-dienes (conjugated dienes)

b) Aromaticity is special case of stability

i. benzene gains 36 kcal/mol stabilization energy due to resonance

ii. anti-aromatic structures (4n)π electrons

iii. Huckel's Rule

c) Substitution patterns

i. Ortho (1,2)

ii. Meta (1,3)

iii. Para (1,4)

7) Electrophilic Aromatic Substitution (Chapter 18)

a) Arene reactivity

i. Electron Donating groups (EDG)

a) activating (better nucleophile)

b) ortho/para directing

ii. Electron Withdrawing groups (EWG)

a) deactivating (better electrophile)

b) meta directing

c) the bromobenzene exception!

i) ortho/para directing yet deactivating!

iii. electrophilic bromination

a) requires a Lewis acid promoter

iv. nitration

a) fuming nitric acid

v. amination

a) via nitration/reduction

vi. Friedel-Crafts Reaction

a) Friedel-Crafts alkylation

i. no primary carbocation (carbocation rearrangement)

b) Friedel-Crafts acylation

i. via acyl carbocation

vii. sulfonation

a) sulfonic acid to phenol

b) Nucleophilic aromatic substitution
    i. ipso-substitution
    ii. benzyne intermediates
c) Benzylic oxidations
d) Benzylic reductions
    i) hydrogenolysis
e) Aromatic ring hydrogenation

8) Carboxylic Acids and Relative Acidity (Chapter 19)
a) Nomenclature
b) Acidity
c) Carboxylate preparation
    i. Alcohol oxidation
    ii. Aldehyde oxidation
    iii. Alkene oxidation
    iv. Ester, Amide, Nitrile hydrolysis
d) Nitrile preparation
    i. amide dehydration
    ii. cyanide displacement
e) Carboxylate/Nitrile Reductions
    i. $LiAlH_4$
    ii. BH_3
f) Additions to Carboxylates and Nitriles
    i. hydrides
    ii. organometallics
        a) Grignards
        b) organolithium compounds
        c) enolates

9) Carbonyl Chemistry, Organometallics/Oxidation/Reduction (Chapter 20)
a) Nomenclature
b) Relative reactivity
c) Preparation
    i. oxidations
        a) PCC/PDC
        b) Swern oxidation
        c) Alkene oxidation
    ii. carbon nucleophilic addition to carboxylate type functionality
        a) Acid
        b) Acid chlorides
        c) nitriles
        d) NOT ESTERS
        e) Wittig Reactions
    iii. Alkyne hydration
d) Wittig Reactions
e) Nucleophilic additions to ketones and aldehydes
    i. hydrides
    ii. organometallics
    iii. cyanides

iv. imines/hydrozones

f) Acid catalyzed acetal/ketal formation

i. hemiacetal

ii. acetal

iii. hemiketal

iv. ketal

g) Wolff-Kishner Reduction

h) Cuprate chemistry

i. enone/enal

a) 1,2- vs 1,4-addition

10) Aldehydes and Ketones-Nucleophilic addition (Chapter 21/22)

a) Nomenclature

b) Relative Reactivity

i. Acid Chloride, Anhydride, Aldehyde, Ketone, Ester, Amide, Carboxylic Acid

c) Ketones/Aldehydes from

i. Acid Chloride, Anhydride, Aldehyde, Ketone, Ester, Amide, Carboxylic Acid

a) Keto/Enol Tautomerization

b) tautomer stability

i. C=O > C=C

c) Carbonyl alpha proton acidity

d) Enolate formation

e) Enolate alkylation

f) Stablized enolate

i. Malonic Ester Synthesis

ii. Acetoacetic Ester Synthesis

12) Enols and Enolates (Chapter 23)

a) Keto/Enol Tautomerization

b) tautomer stability

i. C=O > C=C

c) Carbonyl alpha proton acidity

d) Enolate formation

e) Enolate alkylation

f) Stablized enolate

i. Malonic Ester Synthesis

ii. Acetoacetic Ester Synthesis

13) Carbonyl Condensation reactions (Chapter 24)

a) Enolate aldol reaction

i. dimerization vs mixed aldol

ii. intramolecular aldol reaction

iii. aldol dehydration

b) Claisen Condensation Reactions

i. formation of stabilized anion

c) Dieckmann Cyclization

i. formation of stabilized anion

d) Michael Reaction

i. kinetic vs. thermodynamic products

e) Enamine Chemistry
f) Robinson Annulation

13) Amines, Amino Acids and Peptides (Chapter 25/28)
- a) Nomeclature
- b) amine basicity
- c) Amine preparation
  - i. Nitrile reduction
  - ii. imine reduction
  - iii. amide reduction
  - iv. nitro group reduction
  - v. azide reduction
  - vi. amine/azide alkylation
- d) Amides
  - i. stability
  - ii. amide conformation/peptide structure
- e) peptide synthesis

15) Carbon-Carbon bond formation (Chapter 26)
- a) Cuprate Reaction
  - i. SP^2 coupling
  - ii. 1,4-addition reaction
- b) Palladium Rxn.
  - i. Suzuki
  - ii. Heck
  - iii. Stille
- c) Cyclopropanation
  - i. Diazocompounds
  - ii. Simmons-Smith
- d) Metathesis

16) Carbohydrates (Chapter 27)
- a) Nomenclature
  - i. enantiomer
    - a) D- vs L- sugars
  - ii. diastereomers
    - a) glucose
    - b) mannose (2-epi-glucose)
    - c) galactose (4-epi-glucose)
- b) alpha vs. beta sugars
  - i. hemiacetal chemistry
  - ii. acetal chemistry
- c) Pyranose vs. Furanose
  - i. chair
  - ii. axial vs. equatorial
- d) di-, tri- and oligosaccharides

17) Lipids (Chapter 29)
- a) long chain fatty acids

b) soap
    i. saponification
    ii. detergents
    iii. micelles
c) Phospholipids
    i. bilayers
    ii. cell membranes
d) Terpenes
e) Prostaglandins
f) Steroids