



# Department of Chemistry

## Sophomore Organic Chemistry for non-Chemistry Majors

### CHEMISTRY 331 $\diamond$ ORGANIC CHEMISTRY I

#### GENERAL INFORMATION

Chemistry 331, Chemistry 332 and Chemistry 337 constitute the course sequence for pre-professional students (medicine, dentistry, optometry, pharmacy and other health professions), chemical engineering students and other students, not majoring in chemistry, who require a year of organic chemistry.

#### PREREQUISITES

One full year of general chemistry with lab  
CH 121, CH 122, CH 123; or  
CH 231, CH 232, CH 233; or  
CH 201, CH 202, CH 205 and CH 123  
Or equivalent set of courses taken at a different university

#### ACID-BASE CHEMISTRY IN ORGANIC CHEMISTRY

Bronsted-Lowry acids and bases  
 $K_a$  values,  $pK_a$  values, equilibrium constants  
Predicting the positions of acid-base equilibria  
Predicting approximate  $pK_a$  values  
Ranking acids in order of acid strength; ranking bases in order of base strength  
Acids and bases in organic chemistry  
Lewis acids and bases  
Nucleophiles and electrophiles  
Mechanism of an acid-base reaction  
-two-electron processes; the use of curved arrow notation

#### ALKANES

Nomenclature, structure and bonding, physical properties  
Stereochemistry  
-structural isomerism, stereoisomerism, conformational isomerism  
Conformations of acyclic alkanes, cyclic alkanes including cyclohexane, monosubstituted cyclohexanes and disubstituted cyclohexanes  
-torsional strain, steric strain, angle strain, ring strain  
Conformational equilibria  
-equilibrium constants, composition at equilibrium

#### ALKENES

Nomenclature, structure, bonding, physical properties  
Stereochemistry  
-configurational isomerism, chirality, optical activity  
Conversion to Markovnikov alkyl halides  
-hydrohalogenation, protonation, carbocations, carbocation rearrangements, regiochemistry/stereochemistry, mechanistic aspects  
Conversion to Markovnikov alcohols  
-hydration via the aqueous acid pathway, protonation, carbocations, carbocation rearrangements, regiochemistry/stereochemistry, mechanistic aspects  
-hydration via the oxymercuration-demercuration pathway, mercurinium ions, organomercurial alcohols, regiochemistry/stereochemistry, mechanistic aspects  
Conversion to anti-Markovnikov alcohols

-hydration via the hydroboration-oxidation pathway, alkylboranes, regiochemistry/stereochemistry, mechanistic aspects  
Conversion to vicinal-dihalides and halohydrins  
-cyclic halonium ions, anti-addition, regiochemistry/stereochemistry, mechanistic aspects  
Conversion to alkanes  
-catalytic hydrogenation, syn-addition, stereochemistry, mechanistic aspects  
Conversion to epoxides  
-syn-addition, stereochemistry, mechanistic aspects  
Conversion to vicinal-diols  
-using osmium tetroxide, using permanganate, stereochemistry, mechanistic aspects  
Conversion to aldehydes, ketones &/or carboxylic acids  
-oxidative cleavage using permanganate, ozonolysis

#### ALKYL HALIDES

Nomenclature, structure, bonding, physical properties  
 $S_N1$  and  $E1$  reactions  
-rate laws, substituent effects, leaving group effects, solvent effects, rearrangements, stereochemistry, mechanistic aspects, competition  
-applications to synthesis  
 $S_N2$  and  $E2$  reactions  
-rate laws, nucleophilicity, steric effects, solvent effects, leaving group effects, stereochemistry, mechanistic aspects, competition  
-applications to synthesis

#### ALKYNES

Nomenclature, structure and bonding, physical properties  
Preparations of alkynes  
-via the double dehydrohalogenation of alkyl dihalides, mechanistic aspects  
Conversion to Markovnikov vinyl halides, dihalides  
-protonation, vinyl cations, regiochemistry/stereochemistry, mechanistic aspects  
Conversion to ketones  
-hydration via the mercuric ion catalyzed pathway, regiochemistry/stereochemistry, keto-enol tautomerism, mechanistic aspects  
Conversion to alkanes and cis alkenes  
-via catalytic hydrogenation, stereochemistry  
Conversion to trans alkenes  
-via metal-ammonia reduction to trans alkenes, stereochemistry, mechanistic aspects  
Conversion to geminal dihalides, tetrahalides  
-stereochemistry, mechanistic aspects  
Chemistry acetylide ions  
-preparations/properties, applications to synthesis



# Department of Chemistry

## Sophomore Organic Chemistry for non-Chemistry Majors

### CHEMISTRY 332 ◊ ORGANIC CHEMISTRY II

#### GENERAL INFORMATION

Chemistry 331, Chemistry 332 and Chemistry 337 constitute the course sequence for pre-professional students (medicine, dentistry, optometry, pharmacy and other health professions), chemical engineering students and other students, not majoring in chemistry, who require a year of organic chemistry.

#### PREREQUISITES

One year of freshman chemistry  
CH 121, CH 122, CH 123; or  
CH 221, CH 222, CH 223  
and CH 331

#### ALCOHOLS AND ETHERS

Nomenclature, structure, bonding, physical properties  
Conversion to alkyl halides and sulfonate esters  
-mechanistic aspects, applications to synthesis  
Conversion to alkenes  
-via the acid-catalyzed dehydration of alcohols, E1 and E2 pathways, mechanistic aspects  
Conversion to aldehydes and ketones  
-oxidizing agents (Jones reagent, PCC)  
-oxidation of primary alcohols to aldehydes and carboxylic acids, mechanistic aspects  
-oxidation of secondary alcohols to ketones, mechanistic aspects  
Chemistry of ethers  
-epoxide ring opening, mechanistic aspects  
-Williamson ether synthesis, mechanistic aspects  
-acid-catalyzed cleavage of ethers, mechanistic aspects

#### ALDEHYDES AND KETONES

Nomenclature, structure, bonding, physical properties  
Relative reactivities of aldehydes and ketones  
Conversion to alcohols  
-via the addition of hydride and organometallic reagents (preparations/properties of sodium borohydride, lithium aluminum hydride, Grignard reagents, acetylide ions, organolithium compounds), mechanistic aspects  
Conversion to hydrates, hemiacetals, acetals  
-via the addition of water and alcohols, acetals as protecting groups in synthesis, mechanistic aspects  
Conversion to imines  
-via the addition of ammonia and its derivatives, mechanistic aspects

#### AROMATICITY AND CHEMISTRY OF BENZENE

Nomenclature, structure, bonding, physical properties  
Aromaticity  
Electrophilic aromatic substitutions  
-halogenation, nitration, sulfonation, Friedel-Crafts alkylation, Friedel-Crafts acylation, mechanistic aspects  
Clemmensen reduction  
Wolff-Kishner reduction

#### CARBOHYDRATES

Nomenclature, structure, bonding, physical properties  
Aldoses, ketoses  
D sugars, L sugars  
Furanoses, furanosides, pyranoses, pyranosides  
Alpha and beta anomers  
Oxidations  
-conversion to aldaric acids  
-conversion to aldonic acids  
Reductions  
-conversion to alditols  
Reducing sugars, nonreducing sugars  
Alpha-glycosidic linkages, beta-glycosidic linkage  
the constituent sugar(s) of a disaccharide; a trisaccharide; a polysaccharide

#### CARBOXYLIC ACIDS AND ESTERS

Nomenclature, structure, bonding, physical properties  
Chemistry of carboxylic acids  
-esterification, metal hydride reduction, mechanistic aspects  
Chemistry of esters  
-acid-catalyzed hydrolysis, saponification, metal hydride reduction, conversion to alcohols, mechanistic aspects  
Fatty acids  
Waxes, triglycerides, fats, oils  
Soaps

#### STRUCTURE DETERMINATION

Degrees of unsaturation  
Energy, wavelength, frequency  
Infrared spectroscopy  
-typical vibrational modes  
-predicting/interpreting spectral features  
-compound identification  
Proton NMR spectroscopy  
-shielding, deshielding  
-chemically equivalent protons, non-chemically equivalent protons  
-splitting, pitchfork diagrams  
-predicting/interpreting spectral features  
-compound identification



## Department of Chemistry

### Sophomore Organic Chemistry for non-Chemistry Majors

#### CHEMISTRY 337 ◊ ORGANIC CHEMISTRY LABORATORY

##### GENERAL INFORMATION

Chemistry 331, Chemistry 332 and Chemistry 337 constitute the course sequence for pre-professional students (medicine, dentistry, optometry, pharmacy and other health professions), chemical engineering students and other students, not majoring in chemistry, who require a year of organic chemistry.

##### PREREQUISITES

One year of freshman chemistry  
CH 121, CH 122, CH 123; or  
CH 221, CH 222, CH 223;

and

CH 331, CH 332 or  
CH 334, CH 335, CH 336

##### ENOLATE CHEMISTRY

Alkylation  
Aldol condensation  
Claisen condensation

##### RADICAL CHEMISTRY

Conversion of alkanes to alkyl halides  
-one-electron processes; chain reactions; reactive intermediates;  
energy diagrams; mechanistic aspects  
Addition of hydrogen halides to alkenes and alkynes  
Radical polymerization

##### AMINES AND AMIDES

Nomenclature, structure and bonding, physical properties  
Preparations and reactions

##### AMINO ACIDS

Classification, nomenclature  
Acid-base properties of amino acids  
Separation techniques  
Electrophoresis and thin-layer chromatography

##### PROTEINS

Classification, structure  
Peptide bonds; disulfide bonds  
Peptide synthesis

##### LABORATORY TECHNIQUES

Melting point determination  
Recrystallization  
Extraction (solid-liquid; liquid-liquid)  
Chromatography (TLC; GC)  
Distillation (simple; fractional; steam)  
Preparation/handling of moisture-sensitive reagents  
Spectroscopy (IR; NMR)

##### LABORATORY EXPERIMENTS

- > *Isolation/characterization of trimyristin from nutmeg*  
Techniques Solid-liquid extraction, simple distillation, melting point determination
  
- > *Synthesis of salicylic acid via saponification*  
Chemistry Ester saponification  
Techniques Heating under reflux, recrystallization, melting point determination, IR, NMR
  
- > *Separation of a methanol/water mixture*  
Techniques Simple distillation, fractional distillation
  
- > *Isolation/characterization of essential oils from spices*  
Techniques Steam distillation, liquid-liquid extraction, IR, NMR
  
- > *Synthesis of dibenzalacetone via an aldol condensation (not taught in summer courses)*  
Chemistry Aldol condensation  
Techniques Recrystallization, melting point determination, IR, NMR
  
- > *Synthesis of benzoic acid via a Grignard reaction*  
Chemistry Grignard chemistry  
Techniques Prep/handling of moisture-sensitive reagents, liquid-liquid extraction, recrystallization, melting point determination, IR, NMR
  
- > *Isolation/characterization of lactose (not taught in CH 337-020)*  
Chemistry Benedict's test
  
- > *Isolation/characterization of green-leaf pigments from spinach*  
Techniques Solid-liquid extraction, liquid-liquid extraction, column chromatography, TLC
  
- > *Synthesis of 1-butene, cis-2-butene and trans-2-butene via E1 dehydration of 2-butanol*  
Chemistry Dehydration alcohols  
Techniques GC
  
- > *Synthesis of 1-butene, cis-2-butene and trans-2-butene via E2 dehydrohalogenation of 2-bromobutane*  
Chemistry Dehydrohalogenation of alkyl halides  
Techniques GC