MIAMI DADE COMMUNITY COLLEGE

CHM 2210-2211 – Organic Chemistry

Prerequisites for CHM 2210 CHM 1046 with a grade of C or better.	**Co-requisites for CHM 2210:** CHM 2210L
Prerequisites for CHM 2211 CHM 2210 with a grade of C or better.	**Co-requisites for CHM 2211:** CHM 2210L with a grade of C or better and taking CHM 2211L

These courses are not part of the 4,000-word requirement of the Gordon Rule.	*3 Credits Each*

Course Description:

Organic Chemistry, CHM 2210 is the first half of the CHM 2210-CHM 2211 sequence for professional chemistry, pharmacy, medicine, and other programs. It includes the study of nomenclature, preparations, reactions, mechanisms and the electronic and structural features of alkanes, alkenes, alkynes, alkyl halides, aromatic hydrocarbons, and other organic compounds.

Organic Chemistry, CHM 2211 is the second half of this sequence. It includes nomenclature, preparations, reactions, and electronic and structural features of alcohols, ethers, phenols, aldehydes, ketones, carboxylic acids and their derivatives, amines and other selected organic compounds.

Competency 1: The student will identify and compare the structure of atomic orbitals, hybrid orbitals, and molecules, and relate the structure to properties by:

a. identifying the types of bonds according to ionic, covalent, nonpolar or polar, SIGMA or PI.
b. determining the shape of specific molecules based on hybridization theory and VSEPR theory.
c. distinguishing between homolysis and heterolysis of covalent bonds and calculating energy changes involving these processes.
d. determining the polarity of a molecule based on the shape of the molecule and electronegativity of the bonding atoms.
e. relating physical properties such as melting point, boiling point, and solubility to intermolecular or interionic forces.
f. defining and giving examples of van der Waal's forces, dipolar forces, hydrogen bonds, and ionic forces of attraction.
g. identifying and giving examples of Bronsted-Lowry and Lewis acids and bases.
h. defining and giving examples of structural isomers.

Competency 2: The student will name, draw structures of, and write reactions for alkanes by

a. distinguishing the terms hydrocarbon, aliphatic, aromatic, methane, ethane, propane, butane, and alkane.

b. identifying the structure of alkanes in terms of hybridization, physical properties, conformational arrangements (including eclipsed, staggered, gauche,anti).

c. writing equations for the oxidation and halogenation of various alkanes.

d. comparing the reactivity of various halogens in alkylation and comparing the reactivity of different hydrogens on an alkane to a particular halogen.

e. describing the accepted mechanism of halogenation using appropriate terminology.

f. naming designated alkanes and alkyl halides using the IUPAC and the common nomenclature systems.

g. drawing and label potential energy vs. progress of reaction curves for simple collision reactions.

h. identifying the factors that affect reaction rate and indicating the relative importance of each.

i. calculating empirical and molecular formulae from appropriate data.

j. listing factors that affect the stability of various conformations.

k. identifying ways in which to prepare alkanes and applying this to the preparation of specific alkanes.

l. listing the relative stability of the various free radicals and explaining in terms of stabilization.

m. identifying the terms: conformational isomer, configurational isomer, energy of activation, transition state, pyrolysis, cracking.

n. drawing all structural isomers of a given formula.

o. determining the percentage of each structural isomer in the monochlorination of an alkane given the relative reactivity of the individual classes of hydrogen atoms (optional).

Competency 3: The student will identify specific stereoisomers and correlate, when applicable, the stereochemistry involved in a particular reaction by

a. defining stereoisomer, chiral, optically active, plane-polarized light, polarimeter, dextrorotatory, levorotatory, specific rotation, enantiomer, diastereomer, meso compound, R and S configurations, racemic modification.

b. applying the Cahn, Ingold, Prelog sequence rules for assignment of R,S configuration to chiral centers.

c. drawing Fisher formulae for compounds containing 1,2, 3, and more chiral centers.

d. labeling stereoisomers as enantiomers, diastereomers, meso compounds.

e. distinguishing between conformational and configurational isomers.

f. describing the stereochemistry involved when (1) a chiral center is generated from achiral reactants, (2) a chiral molecule reacts but no bonds to the chiral center are broken and the instance of this where (3)a new chiral center is formed, (4) a bond to the chiral center is broken, and (5) a chiral compound is reacted with a chiral reagent.

g. relating the configuration of product to that of reactant when possible.

h. calculating optical purity from appropriate data.

i. describing the stereochemistry involved in free-radical chlorination.

j. describing the stereochemistry of SN1, SN2, E1 and E2 reactions.

k. defining SYN and ANTI modes of addition and elimination and classifying appropriate reactions into these categories.

l. defining and contrasting stereospecific and stereoselective reactions.

m. identifying the terms sterospecific reaction, enantiotopic ligand, enantiotopic face, diastereotopic ligand, diastereotopic face, heterotopic, homotopic (optional).

n. indicating the stereochemistry of specific reactions using appropriate terminology (optional).

Competency 4: The student will identify S_N1 and S_N2 reactions and describe characteristics and intermediates of each by

a. naming alkyl halides and classifying each as primary, secondary, and tertiary.

b. characterizing selected physical properties of alkyl halides and describing specific methods of preparing these compounds.

c. defining and giving examples of nucleophile, substrate, nucleophilic substitution, leaving group.

d. listing appropriate nucleophiles and leaving groups.

e. describing the characteristics of S_N1 reactions in terms of mechanism, kinetics, stereochemistry, intermediate carbocations, relationship to branching of R-X .

f. describing the characteristics of S_N2 reactions in terms of mechanism, kinetics, stereochemistry, intermediate, relationship to branching of R-X.

g. comparing and contrasting the inductive and resonance effects and explaining the importance of these in S_N1 reactions.

h. identifying the relative stability of the various carbocations.

i. describing and giving examples of a 1,2-hydride shift and a 1,2-alkyl shift.

j. comparing and contrasting S_N1 and S_N2 reactions.

k. writing an accepting the mechanism for the reaction between ROH and HX to form RX and HOH.

l. identifying ion-ion, dipole-dipole, hydrogen bonds.

m. identifying van der Waal forces and ion-dipole bonds.

n. identifying protic and aprotic solvents and listing what types of compounds dissolve in each.

o. describing the importance of solvent in S_N1 reactions.

Competency 5: The student will name, draw structures, and use reactions involving alkenes by

a. describing the structure and bonding of alkenes.

b. identifying geometric isomers, cis and trans isomers, and Z and E isomers in terms of structure.

c. naming alkenes using the IUPAC system of nomenclature and the common name for selected compounds.

d. characterizing the physical properties of alkenes and explaining the differences between cis and trans isomers.

e. identifying methods of preparing alkenes and using these methods to prepare specific alkenes.

f. comparing and contrasting E1 and E2 reactions in terms of mechanism, kinetics, stereochemistry, relationship to branching of alkyl halide.

g. identifying "primary hydrogen isotope effect", element effect, and hydrogen exchange in terms of significance when establishing a mechanism.

h. defining Saytzeff's rule and using it to predict relative quantities of alkenes produced.

i. writing an accepted mechanism for the dehydration of an alcohol under acidic conditions.

j. defining "microscopic reversibility".

k. describing electrophilic addition.

l. identifying reactions of alkenes by reagents used, products formed, intermediates, and mechanisms to include addition of hydrogen, halogen, HX, sulfuric acid, water and other selected addition reactions.

m. identifying reactions of alkenes to include oxymercuration-demercuration, hydroboration oxidation and other selected reactions by reagents used, defining products and indicating mechanisms.

n. identifying free radical addition (peroxide effect) , allylic substitution, addition of carbenes by reagents used, products formed and mechanisms involved.

o. identifying methods of forming glycols from alkenes to include reagents needed and products formed.

p. predicting the products in ozonolysis of alkenes and vice versa.

q. explaining the importance of heats of hydrogenation in estimating the relative stability of structures.

r. stating Markovnikov's rule and applying it to appropriate reactions.

s. defining the term regioselective.

t. describing lab tests that can be used to identify the presence of an alkene.

u. using the knowledge of reactions and products to synthesize appropriate products from given starting materials.

v. using knowledge of accepted mechanisms to determine the mechanism of a related reaction.

Competency 6: The student will draw appropriate resonance structures and describe the importance of resonance to reactivity by

a. drawing appropriate resonance structures for the allylic free radical and the allylic carbocation.

b. listing the general principles applying to resonance theory including the terms hybrid, resonance energy, equivalency of resonance structures.

c. describing the orbital picture of the allylic carbocation and the allylic free radical.

d. explaining the terms "delocalization of electrons", hyperconjugation, complete vs. incomplete octet.

e. comparing isolated, cumulated, and conjugated dienes in terms of structure, stability, and relative reactivity to addition reagents.

f. identifying 1,2 and 1,4-addition products to 1,3-butadiene.

g. comparing and contrasting rate (or kinetically) controlled product formation and equilibrium (or stability) controlled product formation.

h. identifying the relative stability of the allylic free radical and the allylic carbocation.

i. naming selected α,β-unsaturated carbonyl compounds and showing the structure of the intermediate and of the product obtained by addition of electrophiles such as HA and by the addition of nucleophiles such as :B.

Competency 7: The student will name, draw structures of and reactions involving alkynes by

a. describing the structure of the triple bond in terms of bond angles, orbitals used, and relative strength.

b. naming alkynes using IUPAC nomenclature and common nomenclature based upon acetylene.

c. describing some of the physical properties of alkynes.

d. listing several methods of preparing alkynes and use these in the preparation of specific alkynes.

e. listing reactions of alkynes (to include addition of hydrogen, halogen, HX, and water; formation of metal acetylides and other acidic reactions) and using these in the preparation of specific products from specific alkynes.

f. defining and giving examples of keto-enol tautomerism.

Competency 8: The student will name, draw structures of, and write appropriate reactions for alicyclic hydrocarbons by

a. naming monocyclic aliphatic compounds using IUPAC nomenclature.

b. naming bicyclic and tricyclic compounds using IUPAC nomenclature.

c. identifying several methods to prepare cyclic compounds.

d. explaining the stability of conformations based upon angle strain, torsional strain, van der Waal's strain, and dipole-dipole interactions.

e. describing the appearance of cyclopropane, cyclobutane, cyclopentane in terms of conformational stability.

f. defining and explaining the Baeyer ring strain theory.

g. listing the ring-opening reactions that are found for cyclopropane and for cyclobutane and applying this knowledge to synthesis.

h. listing the conformations of cyclohexane and identifying axial, equatorial positions in the chair conformation.

i. identifying 1,3-diaxial interactions.

j. describing the stereochemistry associated with cis and trans substituents in 1,2, or 1,3, or 1,4 positions as applicable to the specific compound.

k. explaining what is meant by interconversion of the chair conformations.

l. identifying two reactions that involve carbenes in the formation of a cyclopropane ring structure.

Competency 9: The student will describe the characteristics of aromatic compounds by

a. distinguishing between aromatic and aliphatic compounds.
b. drawing the structure of benzene and listing characteristics of benzene.
c. explaining the stability of benzene in terms of resonance and delocalization of electrons.
d. listing various electrophilic substitution reactions that benzene undergoes.
e. identifying ortho, meta, and para positions.
f. listing necessary characteristics for aromaticity including Huckel's rule.

Competency 10: The student will explain electrophilic aromatic substitution in terms of mechanism, reactivity, and orientation by

a. classifying substituent groups in terms of reactivity toward electrophilic aromatic substitution and in terms of orientation.
b. writing and accepted mechanism for nitration, sulfonation, halogention, Friedel-Crafts alkylation and acylation, and desulfonation.
c. applying relative reactivity and directing properties to the synthesis of specific compounds.
d. listing limitations of Friedel-Crafts alkylation.
e. naming given arenes by IUPAC and common nomenclature.
f. comparing and contrasting conditions needed for reaction at the aromatic ring and at an alkyl side chain.
g. drawing resonance structures for the benzylic free radical and the benzylic carbocation.
h. identifying the products of the side chain oxidation of an alkylbenzene.
i. Applying the ideas of resonance and electrophilic substitution reactions to 5-member and 6-member heterocycles. (optional)

Competency 11: The student will identify various forms of spectroscopy and apply this knowledge to identify compounds by

a. identifying the type of measurement made and information obtained from: mass spectra, IR spectra, UV spectra, and NMR spectra.
b. applying information given in IR correlation charts to the identification of functional groups and partial structures present in selected organic molecules.
c. identifying the information supplied by the PMR spectrum including number of signals, location of signal, intensity, and splitting.
d. using information from the PMR spectrum of a compound to identify the compound.
e. identifying the information supplied by the CMR spectrum including number of signals, location of signal, intensity, and splitting.
f. using information from the CMR spectrum of a compound to identify the compound.
g. combining spectral data to identify an unknown compound's structure.

Competency 12: The student will name alcohols, identify their characteristics, methods of preparation, and reactions, and apply this to syntheses by

a. identifying the structure, classification, nomenclature, and physical properties of alcohols.
b. listing and apply different methods to synthesize alcohols including oxymercuration-demercuration, hydroboration-oxidation, Grignard synthesis and others.
c. detailing the accepted mechanism for each synthesis method.
d. listing and applying the reactions of the -OH group to include acid-base reactions, oxidation, ester and sulfonate formation, reaction with HX and PX_3, and dehydration.
e. using these reactions in the synthesis of specific compounds.
f. indicating the methods used to analyze alcohols including iodoform test, periodic acid oxidation of glycols, and spectral analysis.
g. identifying structure, classification, nomenclature, reactions of thiols (optional).
h. comparing thiols with alcohols (optional)..
i. applying reactions of thiols to specific syntheses (optional)..

Competency 13: The student will identify and name ethers and epoxides and their reactions, and apply this knowledge to specific syntheses by

a. giving the structure, name ethers and epoxides, and vice-versa.
b. identifying physical properties of ethers and methods of preparation, including dehydration of alcohols, the Williamson synthesis, and alkoxymercuration-demercuration.
c. writing the accepted mechanism for each synthesis.
d. applying reactions to the synthesis of a specific product.
e. listing and applying the various reactions of ethers including acidic cleavage and electrophilic substitution in aromatic ethers.
f. identifying methods of preparing epoxides.
g. identifying products of acidic cleavage and basic cleavage (include Grignard) of epoxides, including mechanism and stereochemistry where applicable.
h. listing characteristic absorbances of ethers in PMR, CMR, and IR spectra.
i. identifying selected sulfur analogs to ethers and epoxides and their reactions (optional).

Competency 14: The student will name, draw structures of, apply reactions of aldehydes and ketones in synthesis and analysis by

a. naming selected aldehydes and ketones by IUPAC and common nomenclature when given the structure and vice-versa.
b. listing methods to prepare aldehydes and ketones and applying these methods to specific compounds.
c. comparing and contrasting aldehydes with ketones.
d. identifying reactions of aldehydes and using these in synthesis of specific compounds.
e. identifying reactions of ketones and using these in synthesis of specific compounds.
f. indicating the mechanism for nucleophilic addition to aldehydes and ketones to include Grignard reagents, CN-, derivatives of ammonia, and alcohols.
g. describing lab tests to distinguish aldehydes from ketones.
h. describing lab tests and/or spectral data used to identify the presence of aldehydes and/or ketones.
i. identifying the Cannizzaro reaction as to reactants, products, and mechanism.

Competency 15: The student will prepare and name specific carboxylic acids and use the reactions of these acids in synthesis by

a. naming carboxylic acids containing between one and five carbons in the common and the IUPAC nomenclature from the given structure and vice-versa and selected other acids and dicarboxylic acids.

b. describing the structure and properties characteristic of carboxylic acids.

c. listing ways to prepare carboxylic acids and applying these methods to the synthesis of particular products.

d. discussing the relative acidity of carboxylic acids and relative solubility of the acid versus the salt.

e. identifying electronic factors that increase or decrease acidity and listing specific substituent groups that cause each effect.

f. writing appropriate reactions to form acid derivatives and using these reactions to synthesize specific compounds.

g. writing and using in synthesis other selected reactions of carboxylic acids.

h. identifying specific spectral characteristics of carboxylic acids in CMR, PMR, and IR.

i. calculating the neutralization equivalent of a carboxylic acid from appropriate data.

j. indicating the derivative formation reactions for carbonic acid.

Competency 16: The student will characterize, prepare, and use carboxylic acid derivatives in synthesis and/or analysis by

a. naming and listing in order of reactivity the acid chlorides, anhydrides, esters, and amides when given the structure.

b. listing the relative structure and physical characteristics of each derivative.

c. preparing each derivative from appropriate starting materials.

d. listing some reactions (to include hydrolysis, aminolysis, reduction as appropriate) of each acid derivative and applying this knowledge to the preparation of specific compounds.

e. identifying lactones, lactams, and imides by structure and preparation.

f. identifying by mechanism selected reactions of acid derivatives.

g. listing and using spectral data (PMR, CMR, IR) that identifies each derivative.

h. naming and drawing structures of carbonic acid derivatives in which one -OH group has been replaced and those in which both -OH groups have been replaced by similar or different nucleophiles (optional)..

i. identifying the decomposition products of several carbonic acid derivatives (optional)..

j. naming and drawing structures of the derivatives of cyanic acid (optional)..

k. writing selected reactions for these derivatives and use those reactions to synthesize a specific product (optional)..

Competency 17: The student will characterize carbanion reactions as to mechanism, products, and synthesis to include Claisen condensation, aldol condensation, Michael addition, malonic ester synthesis, acetoacetic ester synthesis and other related reactions by

a. identifying by mechanism and product the aldol, crossed aldol, and related aldol reactions and applying this knowledge to selected syntheses.

b. identifying by mechanism and product the Claisen, crossed Claisen, and related reactions and applying this knowledge to selected syntheses.

c. describing the Wittig reaction and applying to specific syntheses.

d. identifying by mechanism and product the malonic ester synthesis and applying this to specific syntheses.

e. identifying by mechanism and product the acetoacetic ester synthesis and applying this knowledge to specific syntheses.

f. explaining the process of decarboxylation in terms of electron pair motion and carbanion stability.

g. identifying by mechanism and product the Michael addition of a carbanion to an alpha-beta unsaturated carbonyl compound and applying this reaction to specific product formation.

h. selecting those carbanion reactions which may result in intramolecular condensation and using such reactions in synthesis.

i. characterizing and using the Stork enamine synthesis to prepare specific products. (optional)

j. characterizing and using the organoborane synthesis to prepare specific products. (optional)

k. characterizing and using the enamine synthesis to prepare specific products. (optional)

l. using lithium diisopropylamide in direct alkylation at alpha positions. (optional)

m. characterizing and using in synthesis the Dieckmann cyclization reaction. (Internal Claisen). (optional)

n. characterizing and using the Robinson annulation reaction in the synthesis of specific products. (optional)

Competency 18: The student will describe the properties, preparations, and reactions of amines using proper terminology and apply this knowledge to specific syntheses by

a. naming and classifying simple aliphatic and aromatic amines given the structure and vice-versa.

b. describing the physical properties of amines (including the stereochemistry of nitrogen) and amine salts and relating these to solubility.

c. identifying methods of preparing amines to include reduction of nitro compounds, reaction of alkyl halides with ammonia or amines, reductive amination of carbonyl compounds, reduction of nitriles, and/or reduction of azides, amides, or the Gabriel synthesis, Hofmann rearrangement, or Curtius rearrangement.

d. applying preparatory methods to the synthesis of specific amines.

e. describing the factors affecting the relative basicity of amines and write appropriate acid/base reactions of amines.

f. writing reactions for the formation of amides and sulfonamides from the various classes of amines.

g. describing the Hinsberg test for classification of amines in terms of reactions and observations.

h. identifying various electrophilic substitution reactions of aniline.

i. describing exhaustive methylation and Hofmann elimination by giving examples and applying each process to specific compounds.

j. describing by equation the reaction of HONO with the various classes of amines, especially the formation of diazonium salts.

k. writing equations for the reaction of diazonium salts with CuCl, CuBr, CuCN, I-, HBF_4, H_3O+, H_3PO_2, and the coupling with highly activated aromatic compounds.

l. applying amine reactions including diazonium salts to the synthesis of specific compounds.

m. listing the special spectral characteristics of amines in PMR, CMR, and IR and applying this information to the identification of selected amines.

n. describing the preparation of sulfanilic acid and its use in the preparation of sulfa drugs.

Competency 19: The student will describe the properties, preparations, and reactions of phenols using proper terminology and apply this knowledge to specific syntheses by

a. naming selected phenols given the structure and vice-versa.

b. describing the physical properties of phenols and salts of phenols and relating these to solubility.

c. explaining ways in which phenols may be synthesized including alkali fusion of sulfonates, hydrolysis of diazonium salts, and cumene hydroperoxide rearrangment.

d. applying preparatory methods to the synthesis of specific phenols.

e. describing the relative acidity of phenols and the effect of various substituents on that acidity.

f. writing equations for the formation of esters and ethers from phenolic compounds.

g. describing the reactivity of phenol toward electrophilic aromatic substitution and identifying various reactions in this category to include nitration, sulfonation, halogenation, diazocoupling, and carbonation and other selected reactions.

h. listing and applying to various spectra the specific absorbances associated with phenols in the PMR, CMR, and IR spectra.

i. describing industrial uses of phenols as resins, adhesives, antiseptics, and herbicides. (optional)

j. relating the formation of quinones to the ease of oxidation of phenols. (optional)

k. describing by electron flow the Claisen rearrangement of allyl phenyl ether to form ortho-allylphenol. (optional)

Competency 20: The student will describe the preparation, properties, and reactions of aryl halides and apply this information to specific syntheses by

a. writing the structure of an aryl halide given the name and vice versa.

b. describing the physical characteristics of aryl halides.

c. relating the bond strength of the C-X bond to the reactivity of these compounds.

d. preparing aryl halides using proper synthetic reactions.

e. writing equations for the reaction of aryl halides to form Grignard reagents, in bimolecular displacement reactions, and in elimination-addition reactions.

f. describing the mechanism of bimolecular displacement and apply this reaction to specific syntheses.

g. describing the mechanism of elimination-addition reactions including the structure of benzyne and using this reaction in specific syntheses.

h. comparing and contrasting alkyl and aryl halides in terms of bond strength, reactivity, and ease of analysis.

Competency 21: The student will identify specific heterocyclic compounds, write appropriate reactions for each and include such compounds in appropriate syntheses by (optional)

a. naming and drawing the structures of selected heterocycles.

b. indicating the source of specific 5-member and 6-member heterocycles.

c. writing resonance structures of 5-member and 6-member heterocycles.

d. writing electrophilic and nucleophilic reactions of 5-member and 6-member heterocycles.

e. writing appropriate reactions of selected heterocycles to include several from the Chichibabin reaction, the Skraup synthesis, the Bischler-Napieralski synthesis and others.

f. indicating spectral characteristics of selected heterocyclic compounds.

Competency 22: The student will identify, characterize, and define neighboring group effects in selected reactions by (optional)

a. indicating the type of evidence that indicates a neighboring group effect.

b. defining anchimeric assistance, neighboring group, leaving group, migrating group, migration source, migration terminus, intramolecular.

c. applying neighboring group effects in describing specific reactions such as hydrolysis of mustard gas or other appropriate examples.

Competency 23: The student will describe accepted mechanisms for specific rearrangements using appropriate terminology by (optional)

a. defining and using with selected examples the terms migrating group, migration source, migration terminus.

b. distinguishing between SN1-like and SN2-like migrations.

c. describing the mechanism of several selected rearrangements such as the Hofmann rearrangement of amides, the cumene hydroperoxide rearrangement, and/or the pinacol rearrangment.

d. defining the neighboring group effect and giving examples of this effect in selected reactions.

e. defining and giving examples of nonclassical ions.

Competency 24: The student will identify selected MOs and apply this knowledge to electrocyclic reactions by (optional)

a. describing what is meant by bonding, antibonding, molecular orbitals, LCAO, MO, HOMO, and LUMO.

b. describing the MOs for 1,3-butadiene, the allyl system, benzene, cyclopentadienyl system, and the cyclopropenyl system and in each case indicating the most stable number of electrons to occupy the MOs.

c. defining electrocyclic reactions applying the Woodward-Hoffman rules of orbital symmetry.

d. defining conrotatory and disrotatory motion and giving examples of each in cyclization.

e. distinguishing between thermal and photochemical induction of electrocyclic reactions.

f. describing the characteristics of the Diels-Alder cycloaddition reaction and apply this reaction to the synthesis of specific compounds.

g. defining sigmatropic reactions and apply them to selected examples.

Competency 25: The student will identify certain polynuclear aromatic compounds by name, characterize them by reactions and preparations and apply this information to specific syntheses by (optional)

a. naming and drawing the structure of napthalene, anthracene and phenanthrene.

b. describing reactions of these compounds such as oxidation, reduction, and electrophilic substitution and applying these reactions to predict products and to synthesize compounds in specific instances.

c. listing several carcinogenic hydrocarbons.

d. applying the reactions of polynuclear aromatic compounds to specific syntheses.

Competency 26: The student will identify several mechanisms for polymer formation, several important characteristics of selected polymers, and uses of polymers in appropriate terminology by (optional)

a. defining the terms macromolecule, polysaccharide, elastomer, plastic, and polymerization.

b. defining and giving examples of chain-reaction polymerization and step-reaction polymerization.

c. describing the mechanism for free radical polymerization and citing examples of common polymers formed in this way.

d. defining homopolymer and copolymer and citing examples of each.

e. defining cationic and anionic polymerization and citing examples of each.

f. describing the structure and properties of selected polymers.

Competency 27: The student will describe the structure, properties, and reactions of selected fats by (optional)

a. defining the terms lipid, fat, glyceride, hydrolysis, micelles, detergent, soap, saturated fat, unsaturated fat, phosphoglyceride, phospholipid.

b. describing the occurrence and importance of fats in living organisms.

c. identifying selected fatty acids by name, structure, and stereochemistry.

d. writing chemical equations for the hydrolysis of glycerides.

e. writing chemical equations for the preparation of specific soaps and detergents.

f. relating the structure of phospholipids to their importance in cell membranes.

Competency 28: The student will name, write structures and reactions of various carbohydrates by (optional)

a. defining glucose, cellulose, starch, glycogen, monosaccharide, disaccharide, polysaccharide, aldose, ketose, triose, tetrose, pentose, hexose and carbohydrate.

b. defining and giving examples of reducing sugars.

c. drawing the Fisher projection for (+)-glucose and (-)-fructose.

d. giving the specific names of selected monosaccharides.

e. writing equations for the reaction of aldoses with Fehling's or Tollens' reagent, with bromine water, with nitric acid, and with periodic acid.

f. defining "epimer" and explaining the reaction of epimers with phenylhydrazine to give osazones.

g. applying the Kiliani-Fischer synthesis to lengthen the carbon chain of a selected aldose.

h. applying the Ruff degradation reaction to shorten the carbon chain of a selected aldose.

i. listing the steps in the Fischer proof of the structure of (+)-glucose.

j. defining and giving examples of the optical families "D" and "L".

k. describing the cyclic structure of D-(+)-glucose .

l. defining anomer and explaining the difference between the ALPHA and BETA linkages in formation of ring structures.

m. identifying selected disaccharides (including lactose and maltose, sucrose) by structure, hydrolysis products, and biological importance.

n. identifying selected polysaccharides (to include starch, cellulose, glycogen) by structure, hydrolysis products, and biological importance.

Competency 29: The student will identify the structure and reactions of selected amino acids and relate these to the formation of proteins and indicate selected reactions of and biological importance of several proteins by (optional)

a. defining protein and listing the important functions of protein.

b. naming and giving the structure of selected amino acids.

c. describing selected amino acids in terms of zwitterion form, physical properties, and acidity and basicity constants, and isoelectric point.

d. applying previous reactions to the synthesis of specific amino acids and using previous reactions with amino acids to yield specific products.

e. describing the peptide linkage and identifying by N-terminal and C-terminal amino acid residues.

f. describing the analysis of amino acids by terminal residue analysis and partial hydrolysis.

g. describing the synthesis of peptides using amino acids.

h. classifying proteins as fibrous or globular.

i. defining "denaturation" and giving examples of this process.

j. explaining the process of electrophoresis and its application to analysis of peptides and proteins.

k. defining and giving examples of conjugated protein, prosthetic group, coenzyme, apoenzyme.

l. describing the secondary structure of protein including the ALPHA HELIX.

Competency 30: The student will apply the knowledge of organic chemistry to selected biological processes by (optional)

a. explaining the mechanism of the action of selected enzymes such as chymotrypsin.

b. describing the organic chemistry of vision.

c. explaining the role of ATP as the energy source for biological reactions and citing specific examples such as carbohydrate oxidation and/or other oxidation processes.

d. explaining the biosynthesis of fatty acids.

e. explaining the structure and importance of nucleoproteins in nucleic acids.

f. explaining the chemistry of heredity in terms of genetic codes.