CHEM 144

I. **OVERVIEW**
The following information will appear in the 2009 - 2010 catalog

**CHEM-144 Fundamentals of Organic & Biochemistry** 4 Units

*Prerequisite: Satisfactory completion of CHEM 143.*

Basic principles of organic and biochemistry. Uses inductive and deductive problem solving methods. Field trips are not required. Course is applicable to the associate degree. General Education:

- CSU-GE - B1, B3
- IGETC Category: IGETC - 5A, 5A, 5A, 5B, 5B, 5B

II. **LEARNING CONTEXT**
Given the following learning context, the student who satisfactorily completes this course should be able to achieve the goals specified in Section III, Desired Learning:

A. **COURSE CONTENT**

1. **Required Content:**

   a. Properties and reactivity of the functional groups
      i. Alkanes
      ii. Alkenes, alkynes
      iii. Alkyl halides
      iv. Alcohols
      v. Carbonyls
      vi. Carboxylic acids and derivatives
      vii. Amines
      viii. Aromatics
      ix. Polyfunctional molecules

   b. Bonding and structure of organic molecules including
      i. Lewis structure
      ii. Hybrid orbitals
      iii. Isomers

   c. IUPAC Nomenclature of
      i. Alkanes
ii. Alkenes

iii. Alcohols and Ethers

iv. Aldehydes and Ketones

v. Carboxylic acids and Esters

vi. Amines and Amides

d. Steroisomerism

i. Chiral molecules

ii. Enantiomers

iii. Diastereomers

iv. Optical Activity

e. Acids and Bases

i. Properties of Acids and Bases

ii. Acid dissociation constants

iii. Buffers

f. Simple Organic Reactions involving or producing

i. Alkanes

ii. Alkenes

iii. Alcohols and Ethers

iv. Aldehydes and Ketones

v. Carboxylic acids and Esters

vi. Amines and Amides

g. Structure and metabolism of

i. Carbohydrates (sugars)

ii. Lipids

iii. Proteins

iv. Amino acids

v. Nucleic Acid
2. **Required Lab Content:**

   Lab Content (Typical Labs include):

   a. Molecular Models
   b. Distillation
   c. Extraction
   d. Hydrocarbons
   e. Chromatography
   f. Isolation of Cinnamaldehyde
   g. Preparation of Hand Cream
   h. Synthesis of Aspirin
   i. Carboxylic Acids and Titration of Vitamin C
   j. Polymers
   k. Carbohydrates
   l. Lipids: Triglycerides and Soaps
   m. Proteins
   n. Proteolytic enzymes

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B. **ENROLLMENT RESTRICTIONS**

1. **Prerequisites**

   Satisfactory completion of CHEM 143.

2. **Requisite Skills**

   *Before entering the course, the student will be able to:*

   a. Apply the principles of the scientific method to solve basic chemical concepts and use dimensional analysis for unit conversions.

   b. Differentiate between pure elements, pure compounds, homogenous and heterogeneous mixtures, chemical and physical properties and changes.

   c. Use the periodic table of elements to determine atomic number, mass number, protons, electrons, neutrons, molar mass, naming binary compounds. Classify elements as metals, nonmetals and metalloids.

   d. Balance chemical equations and use mole ratios to determine percent yield.
Differentiate between ionic and covalent compounds and use Lewis structures and VSEPR to predict shape of molecules.

Define normal boiling point, normal melting point and determine relative boiling points based on intermolecular forces.

Calculate molarity of a solution or use molarity to determine moles of an element or compound.

Differentiate between strong and weak acids; strong and weak bases, calculate pH and (H+), calculate the proper ratio of weak acid or base to conjugate cation or anion to prepare buffer solution of defined pH.

Use and identify standard chemical equipment including graduated cylinder, pipet, buret and Bunsen burner.

C. HOURS AND UNITS

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<th>INST METHOD</th>
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D. METHODS OF INSTRUCTION (TYPICAL)

Instructors of the course might conduct the course using the following method:

1. Relevant material is presented through class lectures and lecture/laboratory demonstrations.

2. Students perform laboratory experiments that reinforce and expand upon concepts discussed in lecture.

E. ASSIGNMENTS (TYPICAL)

1. **EVIDENCE OF APPROPRIATE WORKLOAD FOR COURSE UNITS**

   Time spent on coursework in addition to hours of instruction (lecture hours)

   a. Reading assignments from lecture text approximately

   b. Chapter Review homework and/or recommended problems

   c. Weekly preparation for laboratory including reading and pre-laboratory assignments

   d. A complete record of all experimental work performed, and analysis of results

2. **EVIDENCE OF CRITICAL THINKING**

   Assignments require the appropriate level of critical thinking

   Homework: For each pair below, describe the intermolecular force and choose the compound with the higher melting point.

   A) CH₃Cl and KCl
   B) NaOH and CH₃CH₂OH
   C) CH₃CH₂CH₂ and CH₃(CH₂)₅CH₃

   Draw the structure for each of the following compounds

   A) 2-methylpentanal
   B) formaldehyde
   C) acetic acid
Exam question:
Give the name or the structure for each of the following. If naming stereoisomers, be specific with D-, L-, alpha-, or beta-
A) Structure 1
B) beta-D-Galactose
C) Structure 2
D) any uronic acid
E) a triglyceride made from two palmitic acids and one oleic acid
F) the amino acid valine - as it is found at physiological pH

F. **TEXTS AND OTHER READINGS (TYPICAL)**


3. **Other:** Student must purchase goggles from MJC Bookstore (Fog Gard Plus, ANSI Z87.1-1989, SEI Certified)

III. **DESIRED LEARNING**

A. **COURSE GOAL**

As a result of satisfactory completion of this course, the student should be prepared to:

Recognize, name, and describe typical physical properties and reactions for the following classes of compounds: alkanes, alkenes, alkynes, benzene derivatives, alcohols, aldehydes, ketones, carboxylic acids, esters, and amides. The student should also be able to recognize structures and basic properties of carbohydrates, lipids, proteins, and nucleic acids.

B. **STUDENT LEARNING GOALS**

Mastery of the following learning goals will enable the student to achieve the overall course goal.

1. **Required Learning Goals**

   Upon satisfactory completion of this course, the student will be able to:

   a. Correctly draw number of covalent bonds and lone pairs required by hydrogen, carbon, oxygen, nitrogen, sulfur, or halogen atom.

   b. Predict bond angle and molecule geometry of molecules consisting of carbon, hydrogen, and oxygen atoms. Predict bond angles and geometries associated with single, double, or triple bonds.

   c. Name simple alkanes using IUPAC (systematic) nomenclature. Compare physical properties (such as boiling point) of two compounds from the same family. Distinguish between the terms "conformation", "constitutional isomer", and "different chemical formula". Understand and utilize the line angle method of drawing molecules.

   d. Name simple alkenes and alkynes using IUPAC nomenclature. Distinguish between cis and trans alkenes. Recognize alkenes that do not exist as cis-trans isomers. Predict correct product of addition to alkenes, utilizing Markovnikov's Rule if needed.

   e. Name simple benzene derivatives using IUPAC nomenclature. Recognize the difference between benzene rings and cyclohexane rings. Predict correct product of nucleophilic aromatic substitution onto benzene itself.

   f. Name simple alcohols using IUPAC (systematic) nomenclature. Compare physical properties (such as boiling point and water solubility) of two compounds from the same family or different families, including alcohols, ethers, or thiols. Predict correct product(s) of oxidation or
dehydration of alcohols.

g. Recognize tetrahedral stereocenters. Distinguish between chiral and achiral molecules. Tell the number of stereoisomers possible for a given chiral molecule. Distinguish between types of stereoisomers (cis-trans, enantiomer, diastereomer). Determine the R or S configuration of a stereocenter.

h. Define acid and base. Provide the conjugate acid of a given base or the conjugate base of a given acid. Determine relative strength of two acids given their Ka's or pKa's. Determine relative strength of two bases given their Kb's or pKb's. Given an acid-base reaction and strength of acids (or bases), determine the acid, base, conjugate acid, conjugate base, and tell which side is favored.

i. Name simple amines using IUPAC (systematic) nomenclature. Identify aromatic and aliphatic amine and determine which class is more basic.

j. Name simple aldehydes and ketones using IUPAC (systematic) nomenclature. Predict correct products of some reactions of aldehydes and ketones.

k. Name simple carboxylic acids, esters, and amides using IUPAC (systematic) nomenclature. Predict correct product(s) of some reactions of carboxylic acids, esters, and amides.

l. Compare physical properties (such as boiling point and water solubility) of two compounds from the same family or different families, including hydrocarbons, alcohols, ethers, thiols, amines, aldehydes, ketones, carboxylic acids, esters, and amides.

m. Recognize Fischer projections of simple carbohydrates, classify them as aldoses or ketoses, classify them as D or L sugars, determine the number of carbons, and determine the number of stereocenters. Provide the aldonic acid, alditol, or uronic acid of a simple carbohydrate in Fischer projection form. Recognize cyclic forms of sugars, classify them as aldoses or ketoses, classify them as pyranoses or furanoses, determine the number of carbons, identify the anomeric carbon, and classify them as alpha or beta. Understand the differences in structure between common disaccharides and polysaccharides.

n. Recognize the structures of common lipids such as triglycerides, glycerophospholipids, steroids, and eicosanoids. Identify the structural differences between saturated, unsaturated, and trans fatty acids and determine how the differences affect their physical properties and the properties of the triglycerides made with them. Predict the products of saponification or hydrogenation of a triglyceride.

o. Classify amino acids as non-polar, polar, acidic or basic. Predict the effect an acidic or basic amino acid will have on the pH of a peptide. Draw the correct protonation state of an amino acid or peptide at a given pH. Tell the charge an amino acid or peptide will have at a given pH. Given a chart of amino acids, draw a tri-peptide or tetra-peptide. Recognize the primary, secondary, tertiary, and quaternary structures of proteins. Identify the forces that hold together these structures. List agents that can disrupt these forces and denature the protein.

p. Classify enzymes based on the type of reactions they catalyze. Recognize the way an enzyme's rate of catalysis responds to changes in enzyme concentration, substrate concentration, pH, temperature, or inhibition. Define the following terms: active site, competitive inhibition, non-competitive inhibition, allosterism, feedback regulation, cofactor, coenzyme, apoenzyme, substrate.

q. Identify the structural parts of a nucleoside or nucleotide. Identify the differences between an RNA nucleotide and a DNA nucleotide. Identify the 3' and 5' ends of a nucleotide. Given a sample strand of DNA, provide the complementary strand of DNA or the translated strand of mRNA. Given a strand of mRNA and the genetic code, determine the protein produced by translation. Define the terms replication, transcription, translation, and reverse transcription.

2. **Lab Learning Goals**

   *Upon satisfactory completion of the lab portion of this course, the student will be able to:*

   a. Demonstrate safe practice in the chemistry laboratory, including measures to prevent/control
Demonstrate the ability to purify a mixture of chemicals by distillation. (The student shall demonstrate the ability to set up a distillation apparatus, use a pipet, and to use a density measurement to characterize a liquid).

c. Demonstrate the ability to purify a mixture of chemicals by extraction.

d. Demonstrate the ability to separate and identify components of a mixture by chromatography.

e. Investigate the solubilities and simple reactivities (eg. halogenation) of various hydrocarbons (alkanes, alkenes, arenes).

f. Investigate the solubilities and simple reactivities (eg. oxidation) of aldehydes.

g. Investigate the solubilities of carboxylic acids.

h. Perform a Fischer esterification reaction.

i. Perform chemical tests (eg. Benedict’s test) to investigate the properties of carbohydrates.

j. Investigate the solubilities and simple reactivities (eg. halogenation as saturation test) of various lipids.

k. Investigate the simple reactivities (eg. denaturation) of proteins.

3. **Recommended Learning Goals**
   
   Upon satisfactory completion of the course (when the related recommended content is covered) the student will be able to:
   
   a. Perform a saponification reaction to make soap.
   
   b. Perform a simple acetylation reaction to synthesize aspirin.
   
   c. Test the activity levels of proteolytic enzymes under various conditions.
   
   d. Perform a fermentation and purify the ethanol product.
   
   e. Perform a titration to detect vitamin C in juice.
   
   f. Investigate the properties of various polymers and perform synthesis and crosslinking reactions.

IV. **METHODS OF ASSESSMENT (TYPICAL)**

   A. **FORMATIVE ASSESSMENT**

   1. Assigned homework and/or quizzes given throughout the semester
   
   2. Examinations given at regular intervals throughout the semester
   
   3. Identification of laboratory unknowns
   
   4. Laboratory reports required after completion of each experiment
   
   5. Observation of laboratory technique and safety
B. SUMMATIVE ASSESSMENT

1. A comprehensive final examination