El Camino College

COURSE OUTLINE OF RECORD - Official

I. GENERAL COURSE INFORMATION

Subject and Number: Chemistry 7A
Descriptive Title: Organic Chemistry I

Course Disciplines: Chemistry

Division: Natural Sciences

Catalog Description: This course involves a comprehensive study of the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers. This includes nomenclature, structure, properties, stereochemistry, reactions, synthetic methods, and spectroscopy. Emphasis is placed on a systematic approach to understanding the material through the use of bonding theories, energy concepts, kinetics, and reaction mechanisms. In the laboratory, emphasis is on techniques of separation and purification of organic compounds, common organic reactions, and spectroscopy.

Conditions of Enrollment: **Prerequisite**
Chemistry 1B with a minimum grade of C

Course Length: [X] Full Term [ ] Other (Specify number of weeks):
Hours Lecture: 3.00 hours per week [ ] TBA
Hours Laboratory: 6.00 hours per week [ ] TBA
Course Units: 5.00

Grading Method: Letter
Credit Status Associate Degree Credit

Transfer CSU: [X] Effective Date: Prior to July 1992
Transfer UC: [X] Effective Date: Prior to July 1992

General Education:

El Camino College: **1 – Natural Sciences**
Term: 1991 Other: Approved

CSU GE: **B1 - Physical Science**
Term: Fall 1991 Other:
B3 - Laboratory Sciences
Term: Fall 1991 Other:

IGETC: **5A - Physical Science with Lab**

Term: Fall 1991 Other:

5C - Science Laboratory

Term: Fall 1991 Other:

II. OUTCOMES AND OBJECTIVES

A. COURSE STUDENT LEARNING OUTCOMES (The course student learning outcomes are listed below, along with a representative assessment method for each. Student learning outcomes are not subject to review, revision or approval by the College Curriculum Committee)

1. Students will be able to create (via molecular models or drawings) accurate representations of compounds. The representations will dipict appropriate bonds, lone pairs, and geometry.
2. Given a compound name or formula, the student will create a correct representation of the compound.
3. Students will adhere to safety protocol in the laboratory regarding eye protection. Students will follow the proper procedure regarding wearing goggles in the laboratory, and keeping them on to protect their eyes.

The above SLOs were the most recent available SLOs at the time of course review. For the most current SLO statements, visit the El Camino College SLO webpage at http://www.elcamino.edu/academics/slo/.

B. Course Student Learning Objectives (The major learning objective for students enrolled in this course are listed below, along with a representative assessment method for each)

1. For all major classes of organic compounds (alkanes, alkenes, alkynes, alkyl halides, aromatic compounds, alcohols, phenols, ethers, carbonyl compounds, carboxylic acids, amines and their derivatives), the student will recognize the general formula and state the class name and vice-versa.

   Objective Exams
2. For all major classes of organic compounds, the student will identify the functional group(s) and class to which a specific compound belongs and formulate specific examples for a given class.

   Multiple Choice
3. For any given organic compound, the student will describe and illustrate the structure and bonding by constructing the Lewis structure.

   Essay exams
4. For any given organic compound, the student will describe and illustrate the structure and bonding by sketching and labeling the molecular geometries within the molecule.

   Other (specify)

   short answers
5. For any given organic compound, the student will describe and illustrate the structure and bonding by comparing and contrasting bond polarities.

   Multiple Choice
6. For any given organic compound, the student will describe and illustrate the structure and bonding by comparing and contrasting the conformations associated with the molecule.

   Objective Exams

7. For any given organic compound, the student will predict and explain properties in terms of structure and bonding.

    Essay exams

8. For any given organic compound, the student will evaluate the molecule for the existence of structural and stereoisomers and draw formulas for all structural and stereoisomers.

    Other (specify)

    short answers

9. For any given organic compound, the student will demonstrate knowledge of stereochemical concepts by locating all stereocenters in a stereoisomer.

    Objective Exams

10. For any given organic compound, the student will demonstrate knowledge of stereochemical concepts by deciding if a stereoisomer is chiral and if it is optically active.

    Objective Exams

11. For any given organic compound, the student will demonstrate knowledge of stereochemical concepts by classifying stereoisomers as enantiomers or diastereomers.

    Multiple Choice

12. For any given organic compound, the student will analyze IR and proton NMR spectra of the compound to determine its structural features and then predict its structure. MS, UV and carbon-13 NMR spectra are used to a lesser extent.

    Multiple Choice

13. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will draw a structure given a specific name and vice-versa.

    Essay exams

14. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will list the most common and/or important compounds.

    Other (specify)

    short answers

15. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will determine products given reactants and vice-versa for common and/or important reactions.

    Multiple Choice

16. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will demonstrate an extensive knowledge for many of the reactions studied by writing mechanisms, particularly those involving radical or carbocation intermediates.

    Essay exams

17. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will demonstrate an extensive knowledge for many of the reactions studied by explaining how kinetic studies and energy measurements are used to support or disprove a proposed mechanism.

    Essay exams

18. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will demonstrate an extensive knowledge for many of the reactions studied by comparing and contrasting competing reactions using factors such as mechanistic differences, structural effects, steric effects, solvent effects, temperature, electronic effects, and conjugation and resonance.

Multiple Choice

19. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will demonstrate an extensive knowledge for many of the reactions studied by predicting the structural and stereochemical outcome of reactions where isomeric products are possible.

    Essay exams

20. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will arrange a series of related compounds in order of a given physical or chemical property.

    Multiple Choice

21. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will plan and outline a synthesis of a given organic compound choosing from a limited variety of starting materials and utilizing the reactions studied.

    Essay exams

22. For the major classes of aliphatic hydrocarbons and of organic halides, alcohols and ethers, the student will describe how to distinguish between different compounds using simple tests.

    Multiple Choice

23. The student will be able to identify the major classes of bio-molecules (carbohydrates, lipids, amino acids, and nucleic acids) and discuss important functional groups in the context of simple biochemical reactions or macromolecule formation.

    No Assessment Selected

24. In the laboratory the student will learn and practice fundamental organic laboratory techniques by separating mixtures and/or purifying compounds using recrystallization, extraction, chromatography (including column, gas, paper, and thin layer chromatography), and distillation (including simple, fractional, and steam distillation).

    Laboratory reports

25. In the laboratory the student will set up and carry out several common multi-step synthesis reactions which illustrate a variety of laboratory techniques.

    Laboratory reports

26. In the laboratory the student will record IR spectra using an infrared spectrometer.

    Laboratory reports

III. OUTLINE OF SUBJECT MATTER (Topics are detailed enough to enable a qualified instructor to determine the major areas that should be covered as well as ensure consistency from instructor to instructor and semester to semester.)

Lecture or Lab	Approximate Hours	Topic Number	Major Topic
Lecture	3	I	Introduction to organic chemistry; structure and bonding in organic molecules
Lecture	2	II	Introduction to reaction mechanisms, energy concepts
Lecture	5	III	Alkanes A. Structure and nomenclature B. Physical properties and structural representation C. Reactions
Lecture	3	IV	Cycloalkanes

			A. Structure and nomenclature B. Physical properties and structural representation C. Reactions
Lecture	5	V	Stereoisomers A. Classification B. Chirality and optical activity C. Structural representations and R,S configuration D. Meso compounds
Lecture	6	VI	Haloalkanes A. Nomenclature B. Physical properties C. Substitution (S_N1 and S_N2) and elimination (E1 and E2) reactions.
Lecture	6	VII	Alcohols and Ethers A. Structure and nomenclature B. Physical properties C. Reactions D. Sulfur analogues of alcohols and ethers
Lecture	9	VIII	Spectroscopy A. Nuclear magnetic resonance spectroscopy B. Infrared spectroscopy C. Ultraviolet spectroscopy D. Mass spectrometry
Lecture	6	IX	Alkenes A. Structure, nomenclature, and spectroscopy B. Molecular orbital description of pi bonding C. Physical properties D. Reactions
Lecture	3	X	Alkynes A. Structure, nomenclature, and spectroscopy B. Physical properties C. Reactions
Lecture	4	XI	Delocalized Pi Systems (conjugation and resonance) A. Delocalization and conjugation B. Molecular orbital description of pi systems C. Spectroscopy D. Reactions
Lecture	2	XII	Introduction to bio-molecules A. Carbohydrates B. Lipids C. Nucleic Acids D. Amino Acids
Lab	108	XIII	Laboratory Experiments and Exercises such as: A. Introduction to the organic laboratory and laboratory safety B. Recrystallization of an impure organic solid C. Melting point:knowns, unknowns and mixtures D. Extraction of acidic, basic and/or neutral compounds E. Stereochemistry exercises using molecular models F. Paper exercises for NMR and FT-IR spectroscopy G. Spectral intrepretation computer lab H. Kinetic studies I. Several chromatography experiments including column, paper, thin layer and gas chromatography J. Several synthesis experiments utilizing common reactions such as substitution, elimination, Grignard, oxidation, etc.

			K. Several distillation experiments utilizing simple, fractional, and steam distillation L. Several liquid-liquid extraction experiments utilizing a separatory funnel. M. Isolation of several natural products such as essential oils from spices or caffeine from tea or coffee
Total Lecture Hours	54		
Total Laboratory Hours	108		
Total Hours	162		

IV. PRIMARY METHOD OF EVALUATION AND SAMPLE ASSIGNMENTS

A. **PRIMARY METHOD OF EVALUATION:**

Problem solving demonstrations (computational or non-computational)

B. **TYPICAL ASSIGNMENT USING PRIMARY METHOD OF EVALUATION:**

Draw the structures of the:

(a) three monochloro derivatives of n-pentane.

(b) four monochloro derivatives of isopentane.

C. **COLLEGE-LEVEL CRITICAL THINKING ASSIGNMENTS:**

1. Dehydrohalogenation of 2-bromopropane, which requires several hours of refluxing in alcoholic KOH, is brought about in less than a minute at room temperature by potassium tert-butoxide in DMSO. Suggest a possible mechanism for this observation.
2. Starting from alcohols of 4 carbons or fewer, and making use of any necessary solvents or reagents, outline a possible synthesis for the following compounds: (a) 3-methylhexane (b) 1-bromo-2-methyl-2-propanol.

D. **OTHER TYPICAL ASSESSMENT AND EVALUATION METHODS:**

Objective Exams

Other exams

Quizzes

Written homework

Laboratory reports

Homework Problems

Multiple Choice

Completion

Matching Items

True/False

V. INSTRUCTIONAL METHODS

Discussion
Laboratory
Lecture
Multimedia presentations

Note: In compliance with Board Policies 1600 and 3410, Title 5 California Code of Regulations, the Rehabilitation Act of 1973, and Sections 504 and 508 of the Americans with Disabilities Act, instruction delivery shall provide access, full inclusion, and effective communication for students with disabilities.

VI. WORK OUTSIDE OF CLASS

Study
Answer questions
Skill practice
Required reading
Problem solving activities
Written work

Estimated Independent Study Hours per Week: 6

VII. TEXTS AND MATERIALS

A. **UP-TO-DATE REPRESENTATIVE TEXTBOOKS**
Vollhardt and Shore. Organic Chemistry: Structure and Function. 7th ed. W. H. Freeman and Company, 2014.
Neil Shore. Study Guide and Solutions Manual for Organic Chemistry: Structure and Function. 7th ed. W. H. Freeman and Company, 2014.
Pavia, Lampman, Kriz and Engel. Introduction to Organic Laboratory Techniques: A Small Scale Approach. 2nd ed. Thompson/Brooks Cole, 2005.

B. **ALTERNATIVE TEXTBOOKS**

C. **REQUIRED SUPPLEMENTARY READINGS**

D. **OTHER REQUIRED MATERIALS**
Molecular Model Set for Organic Chemistry
Student Laboratory Notebook, Hayden-McNeil, spiral bound 100 carbonless duplicate sets
Department-Approved Goggles
Scientific Calculator

VIII. CONDITIONS OF ENROLLMENT

A. Requisites (Course and Non-Course Prerequisites and Corequisites)

Requisites	Category and Justification

Course Prerequisite Chemistry-1B	Sequential

B. Requisite Skills

Requisite Skills
describe the geometry about an atom using Valence Shell Electron Pair Repulsion Theory.
describe the orbital hybridization of atoms and bond types (sigma and pi) using Valence Bond Theory.
draw Lewis structures including all resonance forms.
relate structures to intermolecular forces of attraction and to physical properties, such as boiling point, vapor pressure, water solubility and polarity.
apply theories of acids and bases and pH to chemical reactions and solutions. CHEM 1B - Equilibrium. The student will I. describe what is meant by dynamic equilibrium in a chemical system. II. write the equilibrium constant expression terms of concentrations (K_c) for a reaction. III. given K_p or K_c determine the other. IV. given an equilibrium constant determine the equilibrium concentrations or vice-versa. V. calculate a reaction quotient, Q, and compare it to the equilibrium constant to predict the direction in which a reaction proceeds toward equilibrium. VI. use Le Chatelier's principle to make qualitative predictions concerning the direction equilibrium is shifted when the system is disturbed. VII. calculate pH, pOH, $[H_3O^+]$, $[OH^-]$ for strong and weak acids and bases. VIII. calculate the K_a, pK_a, K_b, and pK_b, of a weak acid or base given the concentration of the acid or base, and vice-versa. IX. describe the ionization of a polyprotic acid in aqueous solution and calculate the concentrations of the different species present in such a solution. X. predict which ions hydrolyze and whether salt solutions are acidic, basic, or neutral. XI. calculate values of K_a for cations, K_b for anions from ionization constants of their conjugates and from K_w for water. XII. calculate the pH values of salt solutions in which hydrolysis occurs. XIII. describe the effect of common ions on the ionization of weak acids and bases and calculate the concentrations of all species present in solutions of weak acids or bases. XIV. describe the conditions necessary for a buffer and carry out all calculations related to buffer systems. XV. explain how acid-base indicators work. XVI. construct a titration curve for any combination of strong and weak acids and bases. XVII. on titration curves be able to mark the equivalence point, pK_a or pK_b, and the buffer region. XVIII. write the solubility product expression, K_{sp}, and from the K_{sp} calculate the solubility and vice-versa. XIX. calculate the effect of common ions on the aqueous solubilities of sparingly soluble salts. XX. write equations showing the effect of complex ion formation on the other equilibrium processes such as solubility equilibria. XXI. use precipitation reactions in a qualitative analysis scheme and draw conclusions about the presence or absence of ions in an unknown from experimental observations.
describe the concept of acid dissociation and utilize acid dissociation constants, Ka. CHEM 1B - Equilibrium. The student will

I. describe what is meant by dynamic equilibrium in a chemical system.

II. write the equilibrium constant expression terms of concentrations (K_c) for a reaction.

III. given K_p or K_c determine the other.

IV. given an equilibrium constant determine the equilibrium concentrations or vice-versa.

V. calculate a reaction quotient, Q, and compare it to the equilibrium constant to predict the direction in which a reaction proceeds toward equilibrium.

VI. use Le Chatelier's principle to make qualitative predictions concerning the direction equilibrium is shifted when the system is disturbed.

VII. calculate pH, pOH, $[H_3O^+]$, $[OH^-]$ for strong and weak acids and bases.

VIII. calculate the K_a, pK_a, K_b, and pK_b, of a weak acid or base given the concentration of the acid or base, and vice-versa.

IX. describe the ionization of a polyprotic acid in aqueous solution and calculate the concentrations of the different species present in such a solution.

X. predict which ions hydrolyze and whether salt solutions are acidic, basic, or neutral.

XI. calculate values of K_a for cations, K_b for anions from ionization constants of their conjugates and from K_w for water.

XII. calculate the pH values of salt solutions in which hydrolysis occurs.

XIII. describe the effect of common ions on the ionization of weak acids and bases and calculate the concentrations of all species present in solutions of weak acids or bases.

XIV. describe the conditions necessary for a buffer and carry out all calculations related to buffer systems.

XV. explain how acid-base indicators work.

XVI. construct a titration curve for any combination of strong and weak acids and bases.

XVII. on titration curves be able to mark the equivalence point, pK_a or pK_b, and the buffer region.

XVIII. write the solubility product expression, K_{sp}, and from the K_{sp} calculate the solubility and vice-versa.

XIX. calculate the effect of common ions on the aqueous solubilities of sparingly soluble salts.

XX. write equations showing the effect of complex ion formation on the other equilibrium processes such as solubility equilibria.

XXI. use precipitation reactions in a qualitative analysis scheme and draw conclusions about the presence or absence of ions in an unknown from experimental observations.

determine dH values for reactions using bond dissociation energies.

state the Laws of Thermodynamics and relate dG, dH and Ea to chemical reactions. CHEM 1B - Chemical Thermodynamics. The student will

I. state the Laws of Thermodynamics.

II. relate `Delta` U to ΔH.

III. explain what is meant by entropy and predict whether entropy increases or decreases for certain processes.

IV. explain what is meant by the term spontaneous as related to chemical reactions, and predict whether a reaction will be spontaneous.

V. state the relationship between free energy, enthalpy and entropy and calculate any of these properties.

VI. use tables of standard free energy, enthalpy and entropy values to calculate the change in one of these values for a reaction under standard conditions.

VII. predict the signs of enthalpy, entropy and free energy of simple processes.

VIII. compute equilibrium constants from free energy values.

discuss factors controlling the rate of a reaction. CHEM 1B - Chemical Kinetics. The student will

I. discuss the factors that control the rate of a reaction and qualitatively predict the effect of a change on the overall rate.
II. derive the differential rate law of a reaction from a set of experimental data.
III. determine graphically or through calculation the value of the rate constant, k.
IV. graphically determine the order of a species in a reaction.
V. utilize the integrated rate law to determine the concentration of a species at any given time and vice-versa.
VI. determine if a proposed reaction mechanism is consistent with the observed rate law.
VII. identify reactants, intermediates, catalysts and products in a reaction mechanism.
VIII. discuss and apply the various theories of kinetics: collision, transition state.
IX. interpret a reaction coordinate diagram- identify rate determine step, intermediates, transition states, activation energies.
X. use the Arrhenius equation to calculate rate constants at other temperatures.
XI. discuss the effect of catalysis on rates of chemical reactions.

graphically determine the value of rate constants. CHEM 1B - Chemical Kinetics. The student will

I. discuss the factors that control the rate of a reaction and qualitatively predict the effect of a change on the overall rate.
II. derive the differential rate law of a reaction from a set of experimental data.
III. determine graphically or through calculation the value of the rate constant, k.
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IX. interpret a reaction coordinate diagram- identify rate determine step, intermediates, transition states, activation energies.
X. use the Arrhenius equation to calculate rate constants at other temperatures.
XI. discuss the effect of catalysis on rates of chemical reactions.

determine if a proposed reaction mechanism agrees with observed rate laws. CHEM 1B - Chemical Kinetics. The student will

I. discuss the factors that control the rate of a reaction and qualitatively predict the effect of a change on the overall rate.
II. derive the differential rate law of a reaction from a set of experimental data.
III. determine graphically or through calculation the value of the rate constant, k.
IV. graphically determine the order of a species in a reaction.

V. utilize the integrated rate law to determine the concentration of a species at any given time and vice-versa.

VI. determine if a proposed reaction mechanism is consistent with the observed rate law.

VII. identify reactants, intermediates, catalysts and products in a reaction mechanism.

VIII. discuss and apply the various theories of kinetics: collision, transition state.

IX. interpret a reaction coordinate diagram- identify rate determine step, intermediates, transition states, activation energies.

X. use the Arrhenius equation to calculate rate constants at other temperatures.

XI. discuss the effect of catalysis on rates of chemical reactions.

apply reaction coordinate diagrams to proposed mechanisms, including intermediates and transition states. CHEM 1B -

Chemical Kinetics. The student will

I. discuss the factors that control the rate of a reaction and qualitatively predict the effect of a change on the overall rate.

II. derive the differential rate law of a reaction from a set of experimental data.

III. determine graphically or through calculation the value of the rate constant, k.

IV. graphically determine the order of a species in a reaction.

V. utilize the integrated rate law to determine the concentration of a species at any given time and vice-versa.

VI. determine if a proposed reaction mechanism is consistent with the observed rate law.

VII. identify reactants, intermediates, catalysts and products in a reaction mechanism.

VIII. discuss and apply the various theories of kinetics: collision, transition state.

IX. interpret a reaction coordinate diagram- identify rate determine step, intermediates, transition states, activation energies.

X. use the Arrhenius equation to calculate rate constants at other temperatures.

XI. discuss the effect of catalysis on rates of chemical reactions.

For laboratory, the student should be: a. able to use common laboratory equipment including beakers, Erlenmeyer flasks, pipets, burets, burners and aspirators. b. familiar with common methods of dispensing and transferring liquids. c. able to measure the mass of a solid compound using a laboratory balance. CHEM 1B -

Laboratory. The student will

I. become more proficient in the use of volumetric glassware such as a buret, pipet, volumetric flask, pH meter, digital multimeter, spectrophotometer and a variable voltage/current DC power supply with experiments designed to reinforce lecture topics.

II. become more proficient in the use of computers for scientific data graphing and analysis.

III. perform the following experiments in a sequence that allows for covering the relevant lecture concepts before conducing the experiment:

i. Compute graphing and calculations using Microsoft Excel© or a comparable spreadsheet program that students have access to

ii. Chemical kinetics of a crystal violet/hydroxide reaction

iii. Chemical kinetics of an iodine/peroxydisulfate reaction

iv. Chemical equilibrium: Le Chatelier's principle

v. Hydrolysis of salts and pH of buffer solutions

vi. Determination of a solubility product constant

vii. pH titration of a weak unknown acid (student unknowns are issued)

viii. Introduction to qualitative analysis of some common cations and anions (student unknowns are issued)

ix. Electrochemical cells

x. Electrolysis, Faraday's constant and Avogadro's number

xi. Coordination compounds reactions and molecular models, or Synthesis of cobalt(III) coordination compound and molecular models.

C. Recommended Preparations (Course and Non-Course)

Recommended Preparation	Category and Justification

D. Recommended Skills

Recommended Skills

E. Enrollment Limitations

Enrollment Limitations and Category	Enrollment Limitations Impact

Course created by Robert W. Long on 02/01/1965.

BOARD APPROVAL DATE:

LAST BOARD APPROVAL DATE: 09/08/2015

Last Reviewed and/or Revised by Soshanna Potter on 03/07/2015

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