ILLINOIS VALLEY COMMUNITY COLLEGE

Course Syllabus

DIVISION: Natural Sciences Business

Course: CHM 2002

Date: December 2013

Semester Hours: 5

Prerequisite(s): CHM 1007 or consent of instructor

Delivery Method:
- ☒ **Lecture** **3 Credit Hours**
- ☒ **Seminar** **1 Credit Hours**
- ☒ **Lab** **1 Credit Hours**
- ☐ **Clinical** **0 Credit Hours**
- ☐ **Online**
- ☐ **Blended**

Offered: ☒ **Fall** ☐ **Spring** ☐ **Summer**

IAI Equivalent –***Only for Transfer Courses***-go to *http://www.itransfer.org*: CHM 913

CATALOG DESCRIPTION:
The course covers the fundamental principles of organic chemistry stressing the preparation, reactions, mechanisms and structure of organic compounds. Laboratory includes basic techniques in compound purification, synthesis and identification. Hands-on application of FT-infared spectroscopy and gas chromatography are utilized in qualitative and quantitative analysis of organic compounds.

GENERAL EDUCATION GOALS ADDRESSED

[See the last page of this form for more information.]

Upon completion of the course, the student will be able:

[Choose those goals that apply to this course.]

- ☒ To apply analytical and problem solving skills to personal, social and professional issues and situations.
- ☒ To communicate orally and in writing, socially and interpersonally.
- ☐ To develop an awareness of the contributions made to civilization by the diverse cultures of the world.
- ☒ To understand and use contemporary technology effectively and to understand its impact on the individual and society.
- ☒ To work and study effectively both individually and in collaboration with others.
- ☒ To understand what it means to act ethically and responsibly as an individual in one's career and as a member of society.
- ☐ To develop and maintain a healthy lifestyle physically, mentally, and spiritually.
- ☒ To appreciate the ongoing values of learning, self-improvement, and career planning.

EXPECTED LEARNING OUTCOMES AND RELATED COMPETENCIES:

[Outcomes related to course specific goals.]

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

1. demonstrate prior understanding of chemical concepts and be able to apply them to organic chemistry principles (Lewis structure, predict acidity orders of compounds based on structure and periodic properties, draw Newman projections of specific carbon-carbon bond conformations and relate these to potential energy diagrams.
2. demonstrate an understanding of IUPAC nomenclature for compounds containing the following functional groups (Alkane, Alkene, Alkyne, Alcohol, Ether, Alkyl Halide, Aldehyde, Ketone, and combinations thereof).
3. demonstrate an understanding of the 3-dimensional nature of organic molecules and how those molecules behave in 3-dimensional space (relate Fisher projections to chiral molecules and given chiral molecules and given chiral molecules draw a correct Fisher projection).
4. demonstrate an understanding of the various mechanistic pathways that organic chemicals use to react (SN1, SN2, E1 and E2, and free radical chain reaction mechanisms).
5. demonstrate an understanding of organic chemical reactions and synthesize a compound using multiple organic chemical reactions including but not limited to synthesis of and basic reactions of alcohols, alkenes, alkynes, alkyl halides, and ethers.
6. demonstrate an understanding of the various laboratory techniques including spectroscopic methods used in organic chemistry. Spectroscopy emphasis will be placed on interpretation of spectroscopic data (i.e. Fourier Transform Infra Red

(FTIR), Proton Nuclear Magnetic resonance, C-13 Nuclear Magnetic Resonance, Mass Spectroscopy) to determine basic functional groups present in a molecule and the arrangement of those groups in simple organic molecules.

COURSE TOPICS AND CONTENT REQUIREMENTS:

Outcome 1 - Students will be able to demonstrate prior understanding of chemical concepts and be able to apply them to organic chemistry principles. Determine Lewis structures, predict acidity orders of compounds based on structure and periodic properties, draw Newman projections of specific carbon-carbon bond conformations and relate these to potential energy diagrams.

Competency 1.1 Students will be able to predict from rules for Lewis Structures if one isomeric structure would be expected to be more stable than another.

Competency 1.2 Students will be able to write all equivalent resonance structures if any exist.

Competency 1.3 Students will be able to predict, giving rationale, which of two non-equivalent resonance structures would be more stable.

Competency 1.4 Students will be able to predict the shape or bond angles for simple molecules using knowledge of electronic hybridization theory.

Competency 1.5 Students will be able to state properties and structures which cause compounds to be acidic.

Competency 1.6 Students will be able to list types of organic compounds which are more acidic or less acidic based on their structure.

Competency 1.7 Students will be able to draw the Newman projection for the rotation about a specific carbon-carbon bond, showing both eclipsed and staggered conformations when given the structure of the alkane or cycloalkane.

Competency 1.8 Students will be able to relate these conformations to the potential energy diagram for the rotation about the carbon-carbon bond.

Competency 1.9 Students will be able to state how the stability of the cycloalkanes is related to the ring size in terms of angle strain and conformational interactions.

Competency 1.10 Students will be able to construct a perspective drawing of the chair conformation of cyclohexane which will indicate the axial and equatorial groups.

Competency 1.11 Students will be able to use conformational analysis of the different chair conformations of cyclohexane to determine relative stability of substituted cyclohexane.

Outcome 2 - Students will be able to demonstrate an understanding of IUPAC nomenclature for compounds containing the following functional groups (Alkane, Alkene, Alkyne, Alcohol, Ether, Alkyl Halide, Aldehyde, Ketone, and combinations thereof).

Competency 2.1 Students will be able to give the common name for any of the simple organic functional groups in the table of the text.

Competency 2.2 Students will be able to give the correct IUPAC name for any simple hydrocarbon or oxygen derivative of a hydrocarbon; or given the name, give the structure.

Competency 2.3 Students will be able to state the common names of the isomeric hydrocarbon groups containing two, three or four carbons.

Competency 2.4 Students will be able to work out the isomeric structures of hydrocarbons containing up to seven carbons.

Competency 2.5 Students will be able to give the name for an alkene or alkyne if given its structure or give its structure if given the name using both *cis*- and *trans*- as well as *E*- and *Z*- terminology as appropriate.

Competency 2.6 Students will be able to give the name for an alkyne if given its structure or give its structure given its name.

Competency 2.7 Students will be able to name alcohols and ethers given the structure or give the structure when given the name.

Competency 2.8 Students will be able to name ethers given the structure or give the structure when given the name.

Competency 2.9 Students will be able to name aldehydes given the structure or give the structure when given the name.

Competency 2.10 Students will be able to name ketones given the structure or give the structure when given the name.

Outcome 3 - demonstrate an understanding of the 3-dimensional nature of organic molecules and how those molecules behave in 3-dimensional space (relate Fisher projections to chiral molecules and given chiral molecules and given chiral molecules draw a correct Fisher projection).

Competency 3.1 Students given a model of a compound with one chiral center will be able to draw a correct Fisher projection and assign its (R-S) configuration.

Competency 3.2 Students given a model or formula of a compound with two chiral centers will be able to draw a correct Fisher projection and assign the (R-S) configuration for both centers.

Competency 3.3 Students will be able to determine whether a molecule could have optical activity, draw Fisher projections for all stereoisomers of the molecule correctly labeling them as enantiomers, diastereomers or meso compounds.

Competency 3.4 Students will be able to construct a model of a compound given its Fisher projection.

Competency 3.5 Students will be able to explain the geometry of free radicals.

Outcome 4 - Students will be able to demonstrate an understanding of the various mechanistic pathways that organic chemicals use to react (SN1, SN2, E1 and E2, and free radical chain reaction mechanisms).

Competency 4.1 Students will be able to describe the SN1, SN2, E1 and E2 mechanisms.

Competency 4.2 Students will be able to draw a reaction profile diagram given thermodynamic data or the relative order of rate constants for a simple reaction.

Competency 4.3 Students will be able to interpret a reaction profile diagram in terms of relative rates and equilibrium, and identify reactants, products, transition states, intermediates, AH, activation energy.

Competency 4.4 Students will be able to explain and/or predict the effect of changing any one of the following items on the mechanistic pathway (SN1, SN2, E1, E2):

A. Basicity or nucleophilicity of the attacking reagent
B. Substrate structure
C. Leaving group
D. Solvents

Competency 4.5 Students will be able to write the steps in a free radical chain reaction mechanism for halogenation of alkanes.

Competency 4.6 Students will be able to predict the products of monochlorination or monnobromination of an alkane and the expected approximate percentages of each product using the relative reactivities of C-H bonds toward chlorine or bromine.

Competency 4.7 Students will be able to explain the anti-Markovnikov addition of HBr to free radicals and give the mechanism.

Competency 4.8 Students will be able to explain how the ozone layer can be destroyed by free radical reactions and give the steps of the mechanism by which this might occur.

Competency 4.9 Students will be able to give the mechanisms for dehydrohalgenation and dehydration reactions.

Outcome 5 - Students will be able to demonstrate an understanding of organic chemical reactions and synthesize a compound using multiple organic chemical reactions including but not limited to synthesis of and basic reactions of alcohols, alkenes, alkynes, alkyl halides, and ethers.

Competency 5.1 Students will be able to predict the relative stability of alkenes given their structure.

Competency 5.2 Students will be able to recognize in a mechanism the transition state and intermediates, what bonds are being broken or formed, any conformational preference of the transition state.

Competency 5.3 Students will be able to give or complete the equations for the following reactions of alkenes along with any stereochemical preferences, ie, Markovnikov or anti-Markovnikov orientation, syn- or anti- addition.

A. Hydrocenation
B. Addition of HX (ionic); addition of Hbr (radical)
C. Addition of halogens X2
D. Addition of H2O
    1. By mercuric acetate and reduction (oxymercuration-demercuration)
    2. By hydroboration and oxidation
E. Oxidation by KMnO4 or O3 or peroxyacids

Competency 5.4 Students will be able to compare and explain the acidity of terminal alkynes with water, alcohol, ammonia, alkenes and alkanes.

Competency 5.5 Students will be able to give the reagents and the equations for the preparation of alkynes from alkyl halides via elimination reactions and displacement reactions for chain lengthening.

Competency 5.6 Students will be able to give the reaction products of alkynes when given the reactants and reaction conditions:

A. Reaction of terminal alkynes with Cu^{2+}, Ag+, NaNH2 or organic lithium compounds
B. Reduction with H2 on a catalyst Na in NH3
C. Electriphilic addition of HX, X2, H2O
D. Radical addition of HBr
E. Nucleophilic addition of alkoxides $R\text{-}O^-$
F. Hydroboration followed by:
   1. Protonolysis (cis addition of H_2 to form alkene)
   2. Oxidation (anti Markovnikor addition of H20 to yield aldehydes and ketones)
G. Oxidation reactions
   1. KmnO4 - formation of diketones
   2. KmnO4 - cleavage of carboxylic acids
   3. Coupling of terminal alkynes by Cu salts and

Competency 5.7 Students will be able to recognize, give or complete equations for the preparation of alcohols.

Competency 5.8 Students will be able to give the reaction equations for the conversion of alcohols to alkyl halides, alkyl ethers or alkenes and the mechanism for each conversion.

Competency 5.9 Students will be able to recognize, give or complete equations for the preparation of ethers and the reaction of ethers.

Outcome 6 - Students will be able to demonstrate an understanding of the various laboratory techniques including spectroscopic methods used in organic chemistry. Spectroscopy emphasis will be placed on interpretation of spectroscopic data (i.e. Fourier Transform Infra Red (FTIR), Proton Nuclear Magnetic resonance, C13 Nuclear Magnetic Resonance, Mass Spectroscopy) to determine basic functional groups present in a molecule and the arrangement of those groups in simple organic molecules.

Competency 6.1 Students will be able to identify the various parts of the FTIR.

Competency 6.2 Students will be able to generate a spectra from the FTIR spectrometer and interpret the resultant data.

Competency 6.3 Students will be able to interpret Proton Nuclear Magnetic Resonance (P-NMR) to assist in determining structural arrangments of functional groups in an organic compound.

Competency 6.4 Students will be able to interpret Carbon-13 Nuclear Magnetic Resonance (C13-NMR) to assist in determining structural arrangments of functional groups in an organic compound.

Competency 6.5 Students will be able to interpret Mass Spectroscopy to assist in determining structural arrangments of functional groups in an organic compound.

Competency 6.6 Students will be able to perform basic organic laboratory techniques of synthesis, extraction, purification, identification.

Competency 6.7 Students will be able to draw conclusions from experimental evidence and express those conclusions them in written form.

Competency 6.8 Students will be able to use data to support experimental findings.

Competntcy 6.9 Students will be able to demonstrate a practical knowledge of appropriate handling of chemicals and chemical disposal methods, including utilizing information found on an MSDS.

INSTRUCTIONAL METHODS:

1. Lecture
2. Discussion
3. Problem solving
4. Reading assignments
5. Written assignments
6. Individual instruction in the laboratory
7. Experiments
8. Peer tutoring
9. Report writing
10. Use of computers
11. Audio-visual aids
12. Cooperative learning exercises

INSTRUCTIONAL MATERIALS:

1. Brown & Foote, 2014, Organic Chemistry, 7th ed. Cengage Learning (required purchase)

2. Williamson, K. L. (2004) Organic Experiments 9th ed. Boston. Houghton Mifflin Company. (required purchase)

3. Laboratory notebook (required purchase)
4. Molecular model kits

5. Blackboard on-line course management system

6. Visorgog safety goggles (required purchase)

STUDENT REQUIREMENTS AND METHODS OF EVALUATION:

1. Lecture, seminar and laboratory attendance
2. Reading assignments
3. Written assignments, turned in, graded and discussed
4. Written quizzes and examinations
5. Participation in class/seminar discussion and learning exercises
6. Performance of laboratory experiments
7. Research projects including an in-class presentation
8. Evaluation will be done on the basis of quizzes, examinations, written work done outside of class, laboratory reports, presentations, and a comprehensive final examination

Grades are based on a standard scale of
90 - A
80 - B
70 - C
60 - D
below 60 - F

Specific grading policies are assigned by the instructor and are not defined by this document.

OTHER REFERENCES

CRC Handbook of Chemistry and Physics (Available in the Lab and the Library)

Aldrich Library of FTIR Spectra (Available in the Lab)

CRC Handbook of Organic Compounds (Available in the Lab)

Course Competency/Assessment Methods Matrix

Course Prefix, Number and Name	Assessment Options																															
For each competency/outcome place an “X” below the method of assessment to be used.	**Assessment of Student Learning**	Article Review	Case Studies	Group Projects	Lab Work	Oral Presentations	Pre-Post Tests	Quizzes	Written Exams	Artifact Self Reflection of Growth	Capstone Projects	Comprehensive Written Exit Exam	Course Embedded Questions	Multi-Media Projects	Observation	Writing Samples	Portfolio Evaluation	Real World Projects	Reflective Journals	Applied Application (skills) Test	Oral Exit Interviews	Accreditation Reviews/Reports	Advisory Council Feedback	Employer Surveys	Graduate Surveys	Internship/Practicum /Site Supervisor Evaluation	Licensing Exam	In Class Feedback	Simulation	Interview	Written Report	Assignment
Assessment Measures – Are direct or indirect as indicated. List competencies/outcomes below.	**Direct/ Indirect**	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	I	I	I	I	D	D						
1. Demonstrate prior understanding of chemical concepts and be able to apply them to organic chemistry principles (Lewis structure, predict acidity orders of compounds based on structure and periodic properties, draw Newman projections of specific carbon-carbon bond conformations and relate these to								X	X						X																	X

potential energy diagrams.																																
2. Demonstrate an understanding of IUPAC nomenclature for compounds containing the following functional groups (Alkane, Alkene, Alkyne, Alcohol, Ether, Alkyl Halide, Aldehyde, Ketone, and combinations thereof)								X	X																							
3. Demonstrate an understanding of the 3-dimensional nature of organic molecules and how those molecules behave in 3-dimensional space (relate Fisher projections to chiral molecules and given chiral molecules and given chiral molecules draw a correct Fisher projection).								X	X																							X
4. Demonstrate an understanding of the various mechanistic pathways that organic chemicals use to react (SN1, SN2, E1 and E2, and free radical chain reaction mechanisms).								X	X																							X
5. Demonstrate an understanding of organic chemical reactions and synthesize a compound using multiple organic chemical reactions including but not limited to synthesis of and basic reactions of alcohols, alkenes, alkynes, alkyl halides, and ethers					X	X		X	X																							X
6. Demonstrate an understanding of the various laboratory techniques including spectroscopic methods used in organic chemistry. Spectroscopy emphasis will be placed on interpretation of spectroscopic data (i.e. Fourier Transform Infra Red (FTIR), Proton Nuclear Magnetic resonance, C13 Nuclear Magnetic Resonance, Mass Spectroscopy) to determine basic functional groups present in a molecule					X			X	X						X																	X

and the arrangement of those groups in simple organic molecules.																																