John Abbott Science Program 200.BO

Organic Chemistry I

A. General information:

Program:	Science	Instructor:	
Course Number:	202-DCP-05	Office:	
Ponderation:	3-2-3	Telephone:	
Credits:	$2\,{}^{2}/_{3}$	E-mail:	
Competency code:	00XV, 00UU	Lab (3 hours):	
Prerequisite:	202-NYB-05 & 202-NYA-05	Lecture:	
Semester:	Fall 2019	Classroom:	
		Laboratory room:	
		Office Hours:	

B. Introduction:

Organic Chemistry I is a *science option* course. As such, it is specifically intended to meet all the requirements of objective **00XV** and to meet in part those of objective **00UU**. The skills and knowledge acquired are at the **university level** and students passing this course are often given an exemption from the one-semester university organic chemistry I course.

In the last unit of General Chemistry 202-NYA [atomic and molecular structure], the student is introduced to a few basic elements of organic chemistry, such as drawing organic structures, hybridization, isomerism and acid-base theory. This course will go much deeper into all these areas and will emphasize the three-key building blocks of organic chemistry: i) organic nomenclature; ii) the mechanism [arrow-pushing] of many important reactions in organic chemistry; iii) stereochemistry, particularly as applied to the stereochemical consequences and restrictions of a series of addition, elimination and substitution reactions.

The laboratory segment of the course will introduce the student to many of the standard techniques [synthesis, isolation, characterization] used in organic chemistry. This course lays the foundation for understanding and appreciating much of biochemistry, particularly much of the material covered in Biology II. The student will see that biochemical compounds are simply organic chemicals that happen to occur in living systems.

Comprehensive Assessment and Integration in the Science Program

The Ministry of Education requires every student to pass a program comprehensive assessment and a program integrating activity (Exit Profile Competency 14: "to apply what has been learned to new situations" and Ministry objective 00UU: "to apply acquired knowledge to one or more subjects in the sciences"). The Ministry introduced these requirements because it recognized the importance of connecting the various components within each program.

The various competencies to be addressed in the Science Program are outlined in the outcomes and standards of the Science Program Exit Profile and are listed below. They are divided into two groups: those competencies that are taught and assessed in virtually every course in the program, and those that will be the primary focus of the option courses

The following competencies are taught and assessed in most courses of the program:

3. To apply the scientific method.
4. To apply a systematic approach to problem solving.
5. To use appropriate data processing techniques.
6. To reason with rigour, i.e. with precision.
8. To learn in an autonomous manner.
13. To display attitudes and behaviour compatible with the scientific spirit and method.
14. To apply what has been learned to new situations.

The following competencies will be the special focus of the option courses of the program:

7. To communicate effectively.
9. To work as a member of a team.
10. To recognize the links between science, technology and the evolution of society.
11. To develop a personal system of values.
12. To put into context the emergence and development of scientific concepts.

Rather than impose a major exam or paper at the end of the Science Program, or requiring a single course to fulfill these requirements, John Abbott College has integrated the fulfillment of these requirements into the option courses taken late in the program. These courses have been designed so that by passing any three option courses a student will have met the above requirements of the program.
Note: By passing the comprehensive assessment in 202-DCP-Organic 1, the student will have fulfilled the requirement set by the program.

C. Course Objectives

Statement of the Competency

To solve simple problems in organic chemistry(00XV)**.**

Elements of the Competency

1. To apply the rules of nomenclature to simple organic compounds.
2. To represent the three-dimensional structure of organic compounds using their two-dimensional structural formula.
3. To distinguish the different types of isomerism: structural, geometric (cis-trans, E/Z) and optical (molecules containing an asymmetric carbon atom, chirality, enantiomers, R/S).
4. To recognize the different types of reagents: electrophiles, nucleophiles, free radicals, Lewis acids and bases.
5. To determine the reactivity of simple organic functional groups (alkanes, alkenes, alkynes, halogenated compounds, alcohols) using the main types of reaction mechanisms (S_N1, S_N2, E1, E2).
6. To theoretically conceive methods for synthesizing simple organic compounds on the basis of given products.
7. To describe the main functional groups that are useful in biology and biochemistry: amines, carboxylic acids and their derivatives, lipids, amino acids, proteins, carbohydrates.
8. To prepare, separate and identify simple organic compounds.

To apply acquired knowledge to one or more subjects in the sciences(00UU)**.**

Elements of the Competency

1. To apply the experimental method.
2. To reason logically.
3. To communicate effectively.
4. To show evidence of independent learning in the choice of documentation or laboratory instruments.
5. To work as members of team.

Standards

General Performance Criteria:

- Use of the systematic and traditional nomenclature of organic compounds
- Precision of the three-dimensional representation of organic molecules
- Explanation of the influence of the main electronic effects on the principal types of reaction mechanisms
- Analysis of addition, elimination and substitution reactions
- Justification of the mechanism proposed to explain a simple, newly encountered reaction
- Ability to organize logically the principal reactions of the simple functional groups
- Adherence to safety and environmental protection regulations
- Capacity to establish connections between an experimental procedure and chemical theory
- Quality of experimental design and practice
- Quality of the laboratory report: presentation using a word processor, working hypotheses, coherence of the presentation, analysis and discussion of results, clarity and quality of language, bibliography
- Use of an interdisciplinary approach
- Application of acquired knowledge to new situations(00UV)

Specific Performance Criteria:

Specific performance criteria for each of the elements of the competency are shown below, with the corresponding **Intermediate Learning Objectives**. *For the items in the list of learning objectives, it is understood that each is preceded by:*

'The student is expected to be able to….'

D. Evaluation Plan:

Assessment	**Ponderation***	**Competency**	**Date**	*Base ponderation. See following paragraphs for exceptions. The ponderation of individual laboratory experiments, quizzes and assignments are at the discretion of each teacher ** Please refer to teacher's appendix with tentative timetable.
Unit test 1	10%	(00XV)1,2,3	~ Week 5-6	
Unit test 2	10%	(00XV)4,5	~ Week 10-11	
Unit test 3	10%	(00XV)6,7	~ Week 14-15	
Final exam	30%	(00XV)1,2,3,4,5,6,7	TBA	
Laboratory	20%	(00XV)8 (00UU)1, 2	~Weekly	
Comprehensive assessment / Laboratory Project	10%	(00UU)1,2,3,4,5	TBA	
Quizzes, assignments	10%	(00XV)1,2,3,4,5,6,7	TBA	

Please Note:

a) The lowest unit test mark will be dropped if it is lower than the final exam mark, so that the remaining unit tests are worth 20% of the final grade, and the final exam is worth 40% of the final grade. Please note that this arrangement is not available for a student who is assigned a grade of zero on a unit test because of cheating.
b) To pass the laboratory portion of the course, a minimum of 60% of the total laboratory grade must be obtained. Failing this, a laboratory grade of **zero** will be given and a maximum grade of 55% will be allowed for the course.
c) Notwithstanding other class grades, if a student passes the laboratory portion of the course, a grade of 60% or more on the final exam will guarantee a pass in the course.
d) Every effort will be made to ensure **equivalence amongst the various sections** of the course. Laboratory experiments are common to all sections, common policies are used with respect to replacement of term grades with final exam marks, the requirements of lab projects are reviewed by the course committee, the standard required to pass the course is that of the common text used, and the final exam is both set and graded by all members of the course committee.
e) The final evaluation for this course is comprised of the Final Exam (30%) and the Laboratories (20%)

E. Course Content

Specific Performance Criteria / **Intermediate Learning Objectives**

1. 3-D Structures

1.1. Representation of the three-dimensional structure of organic compounds

- 1.1.1. For simple compounds, predict whether the bonds are mainly ionic or covalent.
- 1.1.2. Rationalize the 109.5° bond angle in methane by invoking sp^3 hybridization.
- 1.1.3. Show the orbital box diagram for the C of methane before and after hybridization.
- 1.1.4. Show an orbital overlap diagram for the bonding in methane and ethane.
- 1.1.5. Represent this three-dimensional structure of the sp^3 carbon with a 'line' diagram.
- 1.1.6. Depict Lewis Structures, condensed formula, Kekulé structures and bond-line structure.

2. Acid/Base Strength

2.1. Prediction of the relative strengths of common organic acids and bases

- 2.1.1. Understand the relationship between the acidity of an acid and the relative stability of that acid and its conjugate base.
- 2.1.2. Rationalize the relative acid strengths of a carboxylic acid, phenol, alcohol, H on a carbon α to a C=O, and H on a C=C. Analysis of conjugate base stability (introduce concept of resonance)
- 2.1.3. Rationalize substituent effects on p*K*a values.
- 2.1.4. Based on the p*K*a values of the various acids mentioned in 2.1.2., predict whether, in a particular acid-base reaction, the proton will be essentially totally removed [by examining the pK_as of the acids on the two sides of the equation].
- 2.1.5. Define a Lewis base and explain why amine bases are much stronger than oxygen bases.
- 2.1.6. Show how acid-base properties can be used to separate some mixtures.

3. Nomenclature, isomerism and stereochemistry

3.1. Nomenclature of alkanes, alkenes, alkynes, alkyl halides, alcohols, ethers, amines, carboxylic acids, ketones, esters, aldehydes, etc.

- 3.1.1. Nomenclature of various organic molecules containing common functional groups. Both systematic and common names.

3.2. Drawing of structural [constitutional] isomers, given a molecular formula

- 3.2.1. Represent butane and isobutane with both a structural formula and a stick diagram.
- 3.2.2. Draw structural formula and stick diagrams of the five C_6H_{14} structural isomers; use models to see the differences.
- 3.2.3. Draw wedge, Fisher and Newman projections of various alkanes.

3.3. Recognition of the bonding in, and shape of geometric (cis-trans) isomers

- 3.3.1. Rationalize the 120^0 bond angle in ethylene by invoking sp^2 hybridization.
- 3.3.2. Show the orbital box diagram for the carbons in ethylene before and after hybridization.
- 3.3.3. Show an orbital overlap diagram for the bonding in ethylene.
- 3.3.4. Represent the ethylene structure with both a structural formula and stick diagram, clearly indicating the 120^0 bond angle and the coplanarity of the six atoms.
- 3.3.5. Use models to confirm that cis and trans-2-pentene are different compounds.
- 3.3.6. Use models to show that geometric isomerism can also occur in rings.
- 3.3.7. Rationalize the 180^0 bond angle in acetylene by invoking *sp* hybridization.

Specific Performance Criteria	**Intermediate Learning Objectives**
3.4. Stereoisomers with *E*/*Z* and/or *R/S* configuration	3.4.1. Differentiate chiral and achiral compounds on the basis of superimposability of mirror images and the presence of a mirror plane in achiral compounds. 3.4.2. Flow chart analysis in order to differentiate between constitutional isomers, enantiomers and diastereomers. 3.4.3. Using models, verify that CHBrClF is chiral and use a 3-D diagram at the stereogenic carbon to represent the enantiomers. 3.4.4. For enantiomers, recognize the equivalency of the physical properties, except for optical rotation, and chemical reactions with achiral species. 3.4.5. For enantiomers, recognize the possibility of different biochemical reactions and relate this to enzyme action. 3.4.6. Stereoisomerism of cyclic compounds. Focus on di-substituted cyclohexanes. 3.4.7. Understand what a racemate is, why it is often produced in a chemical reaction, and its lack of optical rotation. 3.4.8. Given an organic compound, be able to identify if it is optically active and, if so, show a 3-D representation of the enantiomers. 3.4.9. Represent a 3-D structural diagram as a Fisher projection, and vice versa. 3.4.10. Assign the absolute configuration [R/S] to a stereogenic carbon. 3.4.11. Assign the E/Z stereochemistry to geometric isomers of alkenes. 3.4.12. Represent, with Fischer projections, enantiomers and diastereomers in a compound with at least two stereogenic carbons. 3.4.13. Determine the number of stereoisomers [2^n] and be able to draw all the stereoisomers of compounds containing multiple stereogenic carbons and as well as E/Z pi bonds. 3.4.14. Recognize the two conditions for a meso compound; understand that it is achiral and optically inactive. 3.4.15. Given a pair of compounds, determine whether they are identical, structural isomers or stereoisomers [and if they represent enantiomers or diastereomers].
3.5. Conformational Analysis of Cyclohexane and its Derivatives	3.5.1. Draw a chair conformation of cyclohexane and identify the equatorial and axial positions. 3.5.2. Show the most stable chair conformation of a substituted cyclohexane.
4. Reactivity and mechanisms	
4.1. Study of the mechanisms and products of a number of key organic reactions	4.1.1. Recognize the different types of reagents: electrophiles, nucleophiles, radical elements, Lewis acids and bases. 4.1.2. Acquire a working knowledge of 'arrow-pushing' to illustrate the mechanisms of common reactions. 4.1.3. Write mechanisms for a wide variety of important chemical reactions. The reactions studied include some or all of the following; the synthesis of alkenes via dehydration of alcohols and dehydrohalogenation of alkyl halides; the bromination of alkynes and their synthesis via a double dehyrohalogenation; esterification reactions; the bromination of an alcohol with HBr; the acid-base reaction of carboxylic acids; the Williamson synthesis of ethers; the hydrolysis of an ester in basic media; The addition, of HX, X_2, X_2/H_2O, X_2/ROH to alkenes/alkynes.

Specific Performance Criteria	**Intermediate Learning Objectives**
4.2. Substitution Reactions	4.2.1. Show the energy level diagram for an S_N1 and S_N2 reaction. 4.2.2. Show the Walden inversion in an S_N2 reaction at a stereogenic carbon. 4.2.3. Rationalize the relative reactivity via S_N2 of 1º, 2º and 3º alkyl halides. 4.2.4. Show the mechanism of an S_N1 reaction at a stereogenic carbon and the effect on optical rotation, and contrast with a S_N2 reaction. 4.2.5. Rationalize the relative reactivity of S_N1 of 1º, 2º and 3º alkyl halides. 4.2.6. Determine whether a reaction will occur via S_N1 or S_N2 by examining the nature of the alkyl halide, of the nucleophile and of the solvent. 4.2.7. Show the mechanism and product of the S_N2 reaction i) between hydroxide ion and an alkyl bromide; ii) in the Williamson ether synthesis; iii) between sodium cyanide and an alkyl halide [and then the mechanism of the acid-catalyzed hydrolysis of the nitrile]; iv) between an acetylide ion and an alkyl halide; v) between ammonia and an alkyl halide; vi) in the acid-catalyzed reaction of an epoxide with water; vii) between an alcohol and HBr. 4.2.8. Effects of leaving groups, nucleophiles, structure of alkyls halide and solvent effect on reaction rates. (Kinetics).
4.3. Elimination Reactions	4.3.1. Show and contrast the mechanisms of the E1 and E2 reaction. 4.3.2. Show the mechanism of the acid-catalyzed dehydration of a 3º alcohol. 4.3.3. Using sawhorse diagrams, show the stereochemistry of the E2 elimination of hydrogen halide from an alkyl halide. 4.3.4. Apply Zaitsev's rule to the direction of elimination in an E2 elimination on an alkyl halide, and in a dehydration of an alcohol. 4.3.5. Show the reagents and mechanism for a Hofmann elimination.
4.4. Addition Reactions	4.4.1. Show the mechanism of the addition of a halogen to an alkene and recognize the stereochemical consequences. 4.4.2. Apply Markovnikov's rule and show the mechanism of addition of acids to an alkene. 4.4.3. Show the mechanism of the acid-catalyzed addition of water/alcohol to an alkene. 4.4.4. Show the platinum or palladium catalyzed addition of hydrogen to an alkene. 4.4.5. Show the mechanism for anti-Markovnikov addition of HBr to an alkene in the presence of peroxide. 4.4.6. Show the mechanism for the stereospecific addition of bromine to an alkene. Compare the addition of bromine to a cis-alkene vs a trans-alkene. 4.4.7. Oxymercuration/demercuration, hydroboration/oxidation of alkenes/alkynes.
5. <u>Synthesis</u>	
5.1. Proposal of a synthesis of simple organic compounds	5.1.1. Introduction to retrosynthetic analysis. 5.1.2. Given the starting material and the product, using the reactions outlined, propose a reasonable synthetic route. 5.1.3. Synthesis of alkenes, alkynes, alcohols, alkyl halides, etc.

Specific Performance Criteria	**Intermediate Learning Objectives**
6. Aromatic compounds	
6.1. Understand the fundamental characteristics and chemistry of arenes	6.1.1. Describe the bonding in benzene using either M.O or V.B Theory 6.1.2. Understand the criteria (including Huckel's rule) and chemical consequences of aromaticity and antiaromaticity. 6.1.3. Explain the common characteristics of aromatic compounds; stability, diamagnetic anisotropy and similar chemical reactions 6.1.4. Nomenclature of substituted aromatic rings (use of o,m,p and numbering system) and certain heterocyclic compounds 6.1.5. Name common polynuclear aromatics; naphthalene, anthracene, phenanthrene. 6.1.6. Heterocyclic aromatic compounds: furan, thiophene, aniline, pyrrole, indole, etc.
6.2. Electrophilic aromatic substitution	6.2.1. Understand the general mechanism of electrophilic aromatic substitution. 6.2.2. Show the mechanism for the electrophilic aromatic substitution reactions: halogenation, nitration, sulfonation, Friedel-Crafts alkylation and acylation 6.2.3. Understand how substituted arenes can be synthesized from other substituted arenes. Reactions to be studied include Clemmensen reduction, Wolff-Kishner reduction, oxidation of alkyl substituents and the reduction of the nitro group. 6.2.4. Substitutions at the benzylic position.
6.3. Synthesis of benzene derivatives	6.3.1. Design synthetic sequences for the preparation of polysubstituted aromatics. 6.3.2. Focus on electron-donating/withdrawing substituents and the effect of aromatic substitution. 6.3.3. Employ electrophilic aromatic substitutions to synthesize a variety of substituted benzene derivatives. 6.3.4. Side-chain reactions.
7. Laboratory work 7.1. Synthesis, isolation, and identification of simple organic compounds	7.1.1. In a series of three-hour, 'wet labs', perform experiments analogous to the reactions learned in class 7.1.2. Use common organic preparative and separation [distillation, gas chromatography, recrystallization, vacuum filtration, etc.] techniques, most done on the microscale. 7.1.3. Identify products by physical means (melting point, boiling point, refractive index, etc.) 7.1.4. Identify products by physical means (melting point, boiling point, refractive index etc.)
8. Integration, comprehensive assessment, and exit profile goals 8.1. Recognition of links between science, technology and the evolution of society	8.1.1. Discuss the implications of science and technology for the evolution of society. 8.1.2. Develop an opinion on an issue and have the arguments to defend the position.
8.2. Development of a personal system of values	8.2.1. Display an awareness and understanding of the social and ethical implications of scientific work. 8.2.2. Display an understanding of the coherence within the discipline of chemistry. 8.2.3. Establish links among the various disciplines of the science program.
8.3. Application of what has been learned to new situations	8.3.1. Integrate what has been learned and apply it to solving problems in new situations.

F. Required Text and Material:

1. Organic Chemistry with Students Solutions Manual, 12^{th} edition, T.W. Graham Solomons, Graig B. Fryhle, Scott A. Snyder, Wiley. (~ $175).
2. A molecular model kit (~ $28).
3. Safety glasses must be worn at all times in the laboratory. Good quality safety glasses are available from the bookstore (about $8) or from most hardware stores. Normal prescription glasses may be worn.
4. Cotton lab coat (about $20 at the bookstore)
5. The major course costs are specified above. However, an instructor may require the student to purchase additional materials, such as a laboratory notebook or course notes.

G. Bibliography:

Other Materials and Readings: Determined by individual teacher.

H. Teaching Methods:

The course will be 75 hours, divided into Lecture and Laboratory periods; media, lectures/hand- outs posted on LEA:

Lectures: 45 hours
Two 1.5-hour lectures per week, consisting of the introduction of new material, usually accompanied by the working of sample problems. In addition, preparation for upcoming laboratory sessions will be discussed during lecture time.

Laboratory: 30 hours
In Organic Chemistry I, the laboratory periods are 3 hours in length. The student will be in the laboratory for at least 10 periods. There may be the occasional tutorial or workshop but most of the weeks the student will perform experiments utilizing some of the standard techniques [recrystallization, reflux, distillation, extraction] and instrumentation [for melting point, infra-red spectrometry, gas chromatography] of organic chemistry.

Laboratory Requirements:

* *Safety glasses and a sturdy cotton lab coat must be worn at all times in the laboratory*. Normal prescription glasses may be worn instead.

I. Departmental Policies:

a) Regular attendance is expected. If lectures are missed, it is the responsibility of the student to cover the material missed and to be aware of any announcements made concerning assignments, quizzes, tests or changes to the laboratory schedule.
b) Students must attend the laboratory session in which they are officially registered.
c) There is no guarantee that make-up tests, quizzes or laboratory periods will be available. If you miss an evaluation session or deadline due to illness, you must notify your instructor as soon as possible. A valid medical note is required to prove absence for a medical reason. If a test is missed for a valid reason, then the final exam mark may be used as a basis for a substitute for the missed test mark. Late homework policy will be determined by individual teacher.
d) Periodically there will be workshops held during the laboratory period. Attendance is required. Quizzes or assignments may be given during these workshops.
e) **A special note concerning the use of chemicals**: this course uses chemicals as part of its normal teaching practices. If a student has experienced allergic reactions in the past due to any particular chemical or chemicals he or she must inform the instructor. In the event that an allergic reaction is experienced at the college, the student should report to Campus Security immediately (6911 from any campus phone or 514-457-6911 from any other phone).
f) Cell phones and computers may only be used during class for pedagogical purposes.
g) Students are expected to behave respectfully towards their classmates and teachers. In case of inappropriate behavior a student will be asked to leave the class or the lab session. If an assessment is planned for this session, a mark of zero will be given in that case.

J. College Policies:

Policy No. 7- IPESA, Institutional Policy on the Evaluation of Student Achievement
http://departments.johnabbott.qc.ca/wp-content/uploads/2017/08/Policy-7-IPESA.pdf

- **Changes to Evaluation Plan in Course Outline** (Article 5.3)
  Changes require documented unanimous consent from regularly attending students and approval by the department and the program dean.
- **Evaluation** (Article 6)
  Teachers should evaluate and enter grades for a sufficient number of assessments in Gradebook in order that the College may advise DEC students of their progress by mid semester as per the ACADEMIC PROCEDURE: Academic Progress by Mid Semester.
- **Religious Holidays** (Article 3.2.13 and 4.1.6)
  Students who wish to miss classes in order to observe religious holidays must inform their teacher of their intent in writing within the first two weeks of the semester.
- **Student Rights and Responsibilities:** (Article 3.2.18)
  It is the responsibility of students to keep all assessed material returned to them and/or all digital work submitted to the teacher in the event of a grade review. (The deadline for a Grade Review is 4 weeks after the start of the next regular semester.)

- (Article 3.3.6)
  Student have the right to receive graded evaluations, for regular day division courses, within two weeks after the due date or exam/test date, except in extenuating circumstances. A maximum of three (3) weeks may apply in certain circumstances (ex. major essays) if approved by the department and stated on the course outline. For evaluations at the end of the semester/course, the results must be given to the student by the grade submission deadline (see current Academic Calendar). For intensive courses (i.e.: intersession, abridged courses) and AEC courses, timely feedback must be adjusted accordingly;

- **Academic Procedure: Academic Integrity, Cheating and Plagiarism** (Article 9.1 and 9.2)
  Cheating and plagiarism are unacceptable at John Abbott College. They represent infractions against academic integrity. Students are expected to conduct themselves accordingly and must be responsible for all of their actions.

  - **College definition of Cheating:**
    Cheating means any dishonest or deceptive practice relative to examinations, tests, quizzes, lab assignments, research papers or other forms of evaluation tasks. Cheating includes, but is not restricted to, making use of or being in possession of unauthorized material or devices and/or obtaining or providing unauthorized assistance in writing examinations, papers or any other evaluation task and submitting the same work in more than one course without the teacher's permission. It is incumbent upon the department through the teacher to ensure students are forewarned about unauthorized material, devices or practices that are not permitted.

  - **College definition of Plagiarism:**
    Plagiarism is a form of cheating. It includes copying or paraphrasing (expressing the ideas of someone else in one's own words), of another person's work or the use of another person's work or ideas without acknowledgement of its source. Plagiarism can be from any source including books, magazines, electronic or photographic media or another student's paper or work.