CHEM-1020: INTRODUCTION TO ORGANIC CHEMISTRY AND BIOCHEMISTRY

Cuyahoga Community College

Viewing: CHEM-1020 : Introduction to Organic Chemistry and Biochemistry

Board of Trustees:
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Academic Term:
Fall 2023

Subject Code
CHEM - Chemistry

Course Number:
1020

Title:
Introduction to Organic Chemistry and Biochemistry

Catalog Description:
Study of the structure, properties, and function of carbon-based compounds. Introduction to biochemistry including structure, properties, and metabolism of proteins, carbohydrates, and lipids. Roles and structures of enzymes, vitamins, chemical messengers, deoxyribonucleic acid (DNA), and ribonucleic acid (RNA) in cellular function. Principles of structure and function will be applied to medicine and nutrition.

Credit Hour(s):
4

Lecture Hour(s):
3

Lab Hour(s):
3

Other Hour(s):
0

Requisites

Prerequisite and Corequisite
CHEM-1010 Introduction to Inorganic Chemistry, or CHEM-101H Honors Introduction to Inorganic Chemistry, or sufficient score on Chemistry Assessment test.

Outcomes

Course Outcome(s):
Utilize the fundamental knowledge of organic chemistry to analyze chemical reactions and associated properties and develop critical thinking skills to predict and determine the causes of chemical change.

Essential Learning Outcome Mapping:
Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):
1. Identify the general characteristics of organic molecules and recognize the differences between organic and inorganic compounds.
2. Draw structural, condensed, and line formulas of organic compounds.
3. Assign IUPAC names for alkanes given structures and draw alkanes given their names.
4. Draw structural (constitutional) isomers of alkanes.
5. Draw structural formulas and assign IUPAC names for cis and trans isomers of cycloalkanes.

6. Describe the physical properties of alkanes.
7. Write alkane combustion reactions.
8. Predict the product of alkane halogenation reactions and draw isomeric products formed when possible.
9. Classify unsaturated hydrocarbons as alkenes, alkynes, or aromatics.
10. Write the IUPAC names of alkenes and alkynes, predict the existence of cis-trans isomers using the structural, condensed, or line formula of an alkene and assign the configuration as cis or trans if applicable.
11. Predict the product of addition reactions of alkenes including hydrogenation, hydration, halogenation and hydrohalogenation reactions.
12. Utilize Markovnikov's rule when addition reactions to unsymmetrically substituted alkenes occur.
13. Draw the structure of polymers formed from alkene monomers.
14. Assign IUPAC names and draw structural formulas for aromatic compounds including phenols.
15. Predict the products of substitution reactions of benzene including halogenation, sulfonation, and nitration.
16. Classify alcohols as primary, secondary, or tertiary on the basis of their structural features.
17. Predict the products obtained upon dehydration of an alcohol.
18. Predict the oxidation products of a primary. secondary and tertiary alcohol.
19. Name and draw structural formulas of ethers, and describe key physical properties.
20. Identify thiols and explain how they are converted into disulfides and vice versa.
21. Identify functional groups in polyfunctional compounds.
22. Recognize carbonyl group in compounds and classify the compounds as aldehydes and ketones.
23. Assign IUPAC names and draw simple aldehydes and ketones given a structure or a name.
24. Predict the product of reactions for aldehydes and ketones including oxidation of aldehydes, reduction of aldehydes and ketones, hemiacetal and acetal formations.
25. Assign IUPAC names and draw simple carboxylic acids.
26. Predict the product of reactions of carboxylic acids including reactions with bases, ester formation, and amide formation.
27. Predict the product of hydrolysis reactions of esters and amides.
28. Classify amines as primary, secondary, or tertiary given the formulas.
29. Predict the product of reactions of amines including reactions with acids to form ammonium salts and amide formation.
30. Draw the products of acidic and basic hydrolysis of amides.
31. Identify molecules possessing chiral centers including cyclic structures.
32. Draw enantiomers in three dimensions around the chirality center.
33. Draw Fischer projections formulas.
34. Identify relationship between molecules including constitutional isomers, enantiomers and diasteremers.
35. Compare the physical properties of enantiomers and diastereomers.

Course Outcome(s):

Develop interpretative skills to apply analytical methods to solve problems in health sciences and other scientific studies.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Recognize the molecular formulas and explain the general differences between organic and inorganic compounds.
2. Identify functional groups in polyfunctional compounds including complex natural products and medicinal agents.
3. Compare the key physical properties of organic compounds including hydrocarbons, alcohols and phenols, aldehydes and ketones, carboxylic acids, and amines.
4. Analyze polymers to identify the alkene monomeric units, and discuss recyclable polymers.
5. Explain the importance and function of resonance in aromatic compounds.
6. Identify the different type of organic reactions.
7. Predict the products of addition, elimination and substitution reactions.
8. Draw the structures and sources of important monosaccharides and disaccharides, and describe the structure and sources of important polysaccharides.
9. Write reactions for the hydrolysis of disaccharides and polymers.
10. Describe the structural similarities and differences between fats and oils.

11. Analyze structural formulas of triglycerides and identify the component parts.
12. Draw structural formulas to illustrate the various Ionic forms assumed by amino acids.
13. Analyze the primary structure of proteins and identify the component amino acids.
14. Describe interactions in the different structural stages of protein, including construction of primary structure, the role of hydrogen bonding in the secondary structure, and the role of side-chain interactions in the tertiary structure.
15. Determine the function and/or substrate of an enzyme on the basis of its name.
16. Use lock-and-key theory and the induced-fit model to describe enzyme activity.
17. Compare the mechanisms of enzyme inhibition.
18. Classify lipids as saponifiable or nonsaponifiable and describe the major functions of lipids.
19. Distinguish between and classify vitamins as water-soluble or fat-soluble on the basis of their structural formulas and behaviour in the body.
20. Analyze short segments of DNA and RNA to describe the component parts.
21. Explain the processes of replication, transcription, and translation.
22. Describe the basic elements of the genetic code.
23. Describe the basic features of recombinant DNA, the polymerase chain reaction, and DNA fingerprinting.
24. Differentiate between metabolism, anabolism, and catabolism.
25. Outline the three stages in the production of energy from food.
26. Explain the role of ATP in energy production and how coupled reactions drive energetically unfavorable reactions.
27. Explain the roles of coenzymes in the common catabolic pathway.
28. Describe the stages of citric acid cycle and it is regulated in response to cellular energy needs.
29. Calculate the amount of ATP produced in glucose metabolism.
30. Describe the main features of gluconeogenesis.
31. Summarize the process of β- oxidation of fatty aids.
32. Calculate the amount of ATP produced from fatty acid oxidation.
33. Identify the structure of ketone bodies and describe their role in metabolism.

Course Outcome(s):

Apply basic principles of organic chemistry to health careers and other scientific studies.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Explain the general differences between organic and inorganic compounds.
2. Distinguish between organic and inorganic compounds.
3. Predict the shape around atoms in organic molecules.
4. Relate physical and chemical properties to structure and bonding in various types of molecules.
5. Distinguish various structures by name and formulas (structural and line-bond).
6. Use knowledge of bond polarity to predict chemical reactivity.
7. Discuss how hydrogen bonding influences the physical properties of alcohols and carboxylic acids.
8. identify functional groups in polyfunctional compounds such as complex natural products and medicinal agents.
9. Identify the different types of organic reactions.
10. Predict the outcome of chemical reactions based on the characteristic features of functional groups.
11. Recognize the difference between constitutional isomers and stereoisomers, as well identify cis and trans isomers.
12. Explain the significance of chirality in drug design and development.
13. Explain the acid-base chemistry of carboxylic acids and amines and discuss the acid-base chemistry of aspirin.

Course Outcome(s):

Apply a fundamental knowledge of biochemistry when working in the health sciences or in other scientific studies.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.
Written Communication: Demonstrate effective written communication for an intended audience that follows genre/disciplinary conventions that reflect clarity, organization, and editing skills.

Objective(s):

1. Describe protein metabolism including the relationships to the citric acid cycle, the urea cycle, and gluconeogenesis.
2. Define the nature and properties of hormones and other chemical messengers.
3. List the nature and properties of lipids including simple and compound lipids and steroids along with the relationship to cell membranes.
4. Describe the nature of digestion including the related enzymes and the resultant blood sugar levels along with the processes of glycogenesis and glycogenolysis.
5. Interrelate carbohydrate, lipid, and protein metabolisms, the effects of fasting, and the causes of positive and negative protein balance.
6. Describe the nature and properties of amino acids and proteins including zwitterion structure, amphoteric nature, isoelectric point, optical activity of amino acids and the primary, secondary, tertiary, and quaternary structures of proteins.
7. Explain the nature and properties of enzymes including the composition, specificity, various functions, and inhibition.
8. Compare the composition and nature of DNA and RNA and explain the relationship of DNA and RNA to protein synthesis.
9. List the nature and properties of carbohydrates including monosaccharides, disaccharides and polysaccharides.
10. Examine carbohydrate metabolism including glycolysis, the citric acid cycle, and the electron transport chain with the resultant production of adenosine triphosphate (ATP) from adenosine diphosphate (ADP).
11. Relate lipid metabolism including the beta oxidation cycle of fatty acids with the citric acid cycle and the electron transport chain and the ATP calculation for a given fatty acid.

Course Outcome(s):

Develop preparative skills to safely and effectively use various experimental techniques to collect laboratory data. To use these skills in health careers and other scientific studies.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Demonstrate knowledge of rules of safety in the organic chemistry laboratory.
2. Demonstrate an understanding of chemical nomenclature.
3. Perform basic organic chemistry and biochemistry laboratory skills and techniques.
4. Use various types of laboratory equipment to acquire data.
5. Collect, organize, and interpret data.
5. Deduce the structures of organic molecules using representative chemical tests and simple spectroscopic techniques.
6. Distinguish between biomolecules such as amino acids, proteins, carbohydrates, lipids, and fatty acids using chemical tests.

Course Outcome(s):

Develop analytical skills to interpret, evaluate, and report experimental results.

Essential Learning Outcome Mapping:

Written Communication: Demonstrate effective written communication for an intended audience that follows genre/disciplinary conventions that reflect clarity, organization, and editing skills.

Objective(s):

1. Describe the purpose of the laboratory as a means of supporting theoretical phenomena.
2. Observe chemical reactions, identify the products, and summarize the change by a chemical equation.
3. Record accurate and detailed data in a laboratory notebook.

Course Outcome(s):

Apply fundamental knowledge of organic chemistry and biochemistry to evaluate experimental results, and communicate scientific information effectively in written formats.

Essential Learning Outcome Mapping:

Written Communication: Demonstrate effective written communication for an intended audience that follows genre/disciplinary conventions that reflect clarity, organization, and editing skills.

Objective(s):

1. Describe the purpose of the laboratory as a means of supporting theoretical phenomena.
2. Report experimental results and conclusions in a written form using scientific language.
3. Use information resources in chemistry, including the primary literature, and report in a written form.

Course Outcome(s):

Apply the scientific method to solve a problem, develop experimental procedures, and explain the design of scientific studies.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Describe the scientific methods including the basic steps of the process.
2. Apply the steps of the scientific method to solve a problem.
3. Describe the purpose of the laboratory as a means of supporting theoretical phenomena.
4. Explain the design of scientific studies to support a chemical concept or principle.

Methods of Evaluation:

a. Exams
b. Final examination
c. Laboratory exam(s)
d. Quizzes
e. Written Lab reports
f. Subjective evaluation of laboratory skills by the instructor
g. Participation
h. Homework assignments
i. Research paper/report

Course Content Outline:

a. Saturated hydrocarbons
    i. Classification of organic compounds according to functional groups
    ii. Alkanes and cycloalkanes
    iii. System of naming (nomenclature) devised by International Union of Pure and Applied Chemistry (IUPAC)
    iv. Properties and reactions of saturated hydrocarbons
    v. Safety in organic chemistry laboratory
    vi. Chemical model building
    vii. Experimental procedures for analysis of organic compounds
b. Unsaturated hydrocarbons
    i. Alkenes, alkynes and aromatic compounds
    ii. Nomenclature by IUPAC method
    iii. Cis-trans isomerism, addition polymers and benzene
    iv. Reactions of alkenes: addition of hydrogen, addition of halogen, addition of hydrogen halide, and addition of water.
    v. The Markovnikov's rule: addition of hydrogen halide and addition of water.
    vi. Experimental evaluation of the reactivity of different hydrocarbons
    vii. Synthesis of a polymer
    viii. study of polymer solubility

   ix. Nomenclature of benzene derivatives
   x. Substitution reactions of benzene: halogenation, nitration and suffocation
c. Alcohols, phenols, ethers
   i. Nomenclature by IUPAC method and some common names
   ii. Physical properties
   iii. Reactions of alcohols: dehydration and oxidation
d. The three-dimensional shapes of molecules
   i. Constitutional isomerism
   ii. Chirality centers
   iii. Drawing pairs of enantiomers
   iv. Fischer projections
   v. Compounds with two chirality centers (Diastereomers)

e. Organic halogen and sulfur compounds
   i. Nomenclature
   ii. Disulfides
   iii. Uses of halogenated compounds
f. Aldehydes and ketones
   i. Structure and bonding
   ii. Nomenclature by IUPAC method and some common names
   iii. Physical properties
   iv. Oxidation of aldehydes, and reduction of aldehydes and ketones
   v. Acetal formation
   vi. Observation of properties and reactivity
g. Carboxylic acids and their derivatives
   i. Structure and bonding
   ii. Nomenclature by IUPAC method and some common names
   iii. Physical properties
   iv. Observation of properties and reactivity
   v. Carboxylic acid derivatives: esters and amides
   vi. Acidity of carboxylic acids: reaction with bases.
   vii. Ester formation (Fischer esterification)
   viii. Amide formation
   ix. Ester and amide hydrolysis.
   x. Synthesis of aspirin
   xi. Polymers: Polyester and polyamide
   xii. Technique of thin layer chromatography
h. Amines
   i. Structure and bonding
   ii. Nomenclature by IUPAC method and some common names
   iii. Classification of amines
   iv. Physical properties
   v. Heterocyclic nitrogen compounds and alkaloids
   vi. Reactions of amines with acids
i. Amino acids and proteins
   i. Introduction to biochemistry
   ii. Amino acids classification
   iii. Physical and chemical properties of amino acids
   iv. Handedness in amino acids
   v. Peptide bond
   vi. Dipeptides, tripeptides, and polypeptides
   vii. Protein structure
      1. primary
      2. secondary
      3. tertiary
      4. quaternary
   viii. Protein hydrolysis and protein denaturation
   ix. Experimental tests on amino acids and proteins to determine properties and reactivity

j. Enzymes, vitamins, and chemical messengers
   i. Catalysis by enzymes
   ii. Enzymes structure
   iii. Models of enzyme action
   iv. Effects of concentration, temperature and pH on enzyme activity
   v. Enzyme regulation
   vi. Water soluble vitamins
   vii. Fat soluble vitamins
   viii. Antioxidants
   ix. Hormones
   x. Neurotransmitters and drugs
   xi. Laboratory study of several enzymes
k. Nucleic acids and protein synthesis
   i. Composition of nucleic acids and structure of the chains
   ii. The Watson-Crick model
   iii. Replication of DNA
   iv. Structure and function of RNA
   v. Transcription
   vi. The Genetic code
   vii. Translation
l. Carbohydrates
   i. Handedness
   ii. The D and L family of sugars
   iii. Monosaccharide, disaccharides and polysaccharides: structures and reactions
   iv. Experimental tests on carbohydrates
m. Lipids
   i. Structure and classification
   ii. Fatty acids
   iii. Esters of fatty acids
   iv. Fats and oils
   v. Hydrogenation reaction of oils
   vi. Hydrolysis of fats and oils
   vii. Cell membrane lipids
   viii. Structure of cell membranes
   ix. Transport across cell membranes
   x. Experimentation on the process of soap and detergent production
n. Metabolism of carbohydrates, lipids, and proteins
   i. Overview of metabolism and energy production
   ii. Metabolic pathways
   iii. Oxidized and reduced coenzymes
   iv. The citric acid cycle
   v. The Electron-transport chain and ATP production
   vi. Digestion of carbohydrates, triacylglycerols and proteins
   vii. Glycolysis, glycogenesis, glycogenolysis and gluconeogenesis
   viii. Glycerol catabolism
   ix. Oxidation of fatty acids
   x. The urea cycle
   xi. Catabolism of the carbon skeleton of amino acids
   xii. Catabolism of heme

Resources

McMurry, John, Mary Castellion, David S. Ballantine, Carl A. Hoeger, and Virginia E. Peterson. *Fundamentals of General, Organic and Biological Chemistry.* 8th ed. Upper Saddle River, NJ: Prentice-Hall, 2016.

Smith, Janice G. *General, Organic, and Biological Chemistry*. 5th ed. New York: McGraw-Hill, 2021.

Bettelheim, Frederick A., William H. Brown, Mary K. Campbell, and Shawn O. Farrell. *Introduction to General, Organic, and Biochemistry.* 11th ed. Belmont: Brooks/Cole, 2015.

Seager, S.; Slabaugh, M.; Hansen, M. *Chemistry for Today: General, Organic, and Biochemistry*. 10th ed. Brooks Cole, 2022.

Denniston, Katherine; Topping, Joseph; Quirk Forr, Danae. *General, Organic, and Biochemistry*. 11th ed. New York: McGraw Hill, 2022.

Henrickson, Charles H., Larry C. Byrd, and Norman W. Hunter. *A Laboratory Manual for General, Organic, and Biochemistry.*

Bettelheim, Frederick A., and Joseph M. Landesberg. *Laboratory Experiments for Introduction to General, Organic, and Biochemistry.*

Resources Other

a. Laboratory Experiments for General, Organic, and Biochemistry. Westshore Campus Health Careers and Sciences Department, (2017). (available for download on Westshore Laboratory Blackboard Site)"

Instructional Services

OAN Number:

Ohio Transfer 36 TMNS

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