

# UNIT 10 & 20 Organic

Content Area: **Science**  
 Course(s): **IB Chemistry, HL**  
 Time Period: **Third Marking Period**  
 Length: **5 Weeks**  
 Status: **Published**

## Unit Overview

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Serendipity and scientific discoveries—PTFE and superglue.

Ethical implications—drugs, additives and pesticides can have harmful effects on both people and the environment. Much of the progress that has been made to date in the developments and applications of scientific research can be mapped back to key organic chemical reactions involving functional group interconversions.

## STAGE 1- DESIRED RESULTS

### 2020 New Jersey Student Learning Standards- Science

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SCI.9-12.HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
SCI.9-12.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
SCI.9-12.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

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SCI.6-8.MS-PS4-1	Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
SCI.6-8.MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

## Science and Engineering Practices

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- Analyzing and Interpreting Data
- Asking Questions and Defining Problems
- Constructing Explanations and Designing Solutions
- Developing and Using Models

- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information
- Planning and Carrying Out Information
- Using Mathematics and Computational Thinking

## **Cross Cutting Concepts**

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- Cause and Effect
- Energy and Matter
- Influence of Engineering, Technology, and Science on Society and the Natural World
- Interdependence of Science, Engineering, and Technology
- Patterns
- Scale, Proportion, and Quantity
- Stability and Change
- Structure and Functions
- Systems and System Models

## **Disciplinary Core Ideas**

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Organic Chemistry focuses on the chemistry of compounds containing carbon.

Structure, bonding and chemical reactions involving functional group interconversions are key strands in organic chemistry.

## **Physical Sciences**

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- PS1A: Structure and Properties of Matter
- PS1B: Chemical Reactions
- PS1C: Nuclear Processes
- PS2A: Forces and Motion
- PS2B: Types of Interaction
- PS3A: Definitions of Energy
- PS3B: Conservation of Energy and Energy Transfer
- PS3C: Relationship Between Energy and Forces
- PS3D: Energy in Chemical Processes and Everyday Life
- PS4A: Wave Properties

- PS4B: Electromagnetic Radiation
- PS4C: Information Technologies and Instrumentation

## **Life Sciences**

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- LS1A: Structure and Functions
- LS1B: Growth and Development of Organisms
- LS1C: Organization for Matter and Energy Flow in Organisms
- LS1D: Information Processing
- LS2A: Interdependent Relationships in Ecosystems
- LS2B: Cycles of Matter and Energy Transfer in Ecosystems
- LS2C: Ecosystems Dynamics, Functioning, and Resilience
- LS2D: Social Interactions and Group Behavior
- LS3A: Inheritance of Traits
- LS3B: Variation of traits
- LS4A: Evidence of Common Ancestry and Diversity
- LS4B: Natural Selection
- LS4C: Adaptation
- LS4D: Biodiversity and Humans

## **Earth and Space Sciences**

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- ESS1A: The Universe and its Stars
- ESS1B: Earth and the Solar System
- ESS1C: The History of Planet Earth
- ESS2A: Earth Materials and Systems
- ESS2B: Plate Tectonics and Large-Scale Systems
- ESS2C: The Role of Water in Earth's Surface Processes
- ESS2D: Weather and Climate
- ESS2E: Biogeology
- ESS3A: Natural Resources
- ESS3B: Natural Hazards
- ESS3C: Human Impacts on Earth Systems
- ESS3D: Global Climate Change

## Engineering. Technology. and Applications of Science

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- ETS1A: Defining and Delimiting an Engineering Problem
- ETS1B: Developing Possible Solutions
- ETS1C: Optimizing the Design Solution

### Essential Questions

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What is the focus of Organic Chemistry ?

How does structure, bonding and chemical reactions involving functional group interconversions contribute to the nature of Organic Chemistry?

### Enduring Understanding

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- A homologous series is a series of compounds of the same family, with the same general formula, which differ from each other by a common structural unit.
- Structural formulas can be represented in full and condensed format.
- Structural isomers are compounds with the same molecular formula but different arrangements of atoms.
- Functional groups are the reactive parts of molecules.
- Saturated compounds contain single bonds only and unsaturated compounds contain double or triple bonds.



- Benzene is an aromatic, unsaturated hydrocarbon.
- Alkanes have low reactivity and undergo free-radical substitution reactions.
- Alkenes are more reactive than alkanes and undergo addition reactions. Bromine water can be used to distinguish between alkenes and alkanes.
- Alcohols undergo nucleophilic substitution reactions with acids (also called esterification or condensation) and some undergo oxidation reactions.
- Halogenoalkanes are more reactive than alkanes. They can undergo (nucleophilic) substitution reactions. A nucleophile is an electron-rich species containing a lone pair that it donates to an electron-deficient carbon.
- Addition polymers consist of a wide range of monomers and form the basis of the plastics industry.
- Benzene does not readily undergo addition reactions but does undergo electrophilic substitution reactions.

## Students will know...

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- *Halogenoalkanes are more reactive than alkanes. They can undergo (nucleophilic) substitution reactions. A nucleophile is an electron-rich species containing a lone pair that it donates to an electron-deficient carbon.*
- Polymers:*
  - *Addition polymers consist of a wide range of monomers and form the basis of the plastics industry.*
- Benzene:*
  - Benzene does not readily undergo addition reactions but does undergo electrophilic substitution reactions.

**Nucleophilic Substitution Reactions:** SN1 represents a nucleophilic unimolecular substitution reaction and SN2 represents a nucleophilic bimolecular substitution reaction. SN1 involves a carbocation intermediate. SN2 involves a concerted reaction with a transition state.

For tertiary halogenoalkanes the predominant mechanism is SN1 and for primary halogenoalkanes it is SN2. Both mechanisms occur for secondary halogenoalkanes.

The rate determining step (slow step) in an SN1 reaction depends only on the concentration of the halogenoalkane, rate =  $k[\text{halogenoalkane}]$ . For SN2, rate =  $k[\text{halogenoalkane}][\text{nucleophile}]$ . SN2 is stereospecific with an inversion of configuration at the carbon.

SN2 reactions are best conducted using aprotic, polar solvents and SN1 reactions are best conducted using protic, polar solvents.

- *Electrophilic Addition Reactions:*

An electrophile is an electron-deficient species that can accept electron pairs from a nucleophile. Electrophiles are Lewis acids. Markovnikov's rule can be applied to predict the major product in electrophilic addition reactions of unsymmetrical alkenes with hydrogen halides and interhalogens. The formation of the major product can be explained in terms of the relative stability of possible carbocations in the reaction mechanism.

- *Electrophilic Substitution Reactions:*

Benzene is the simplest aromatic hydrocarbon compound (or arene) and has a delocalized structure of  $\pi$  bonds around its ring. Each carbon to carbon bond has a bond order of 1.5. Benzene is susceptible to attack by electrophiles.

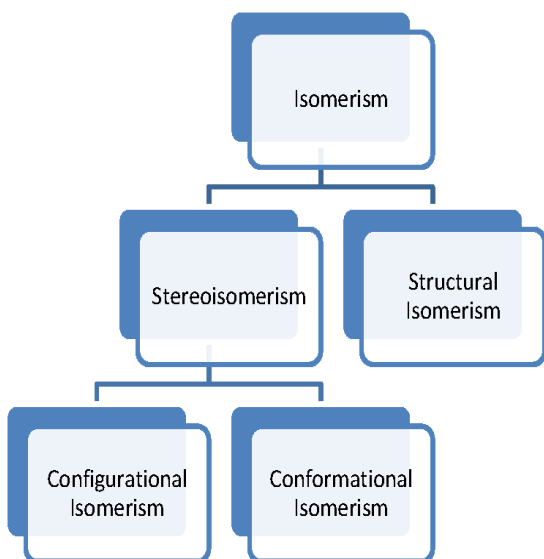
- *Reduction Reactions:*

Carboxylic acids can be reduced to primary alcohols (via the aldehyde). Ketones can be reduced to secondary alcohols. Typical reducing agents are lithium aluminium hydride (used to reduce carboxylic acids) and sodium borohydride.

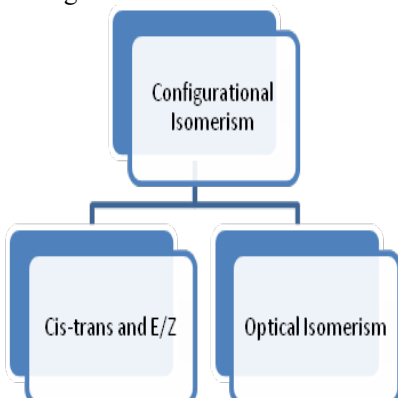
The synthesis of an organic compound stems from a readily available starting material via a series of discrete steps. Functional group interconversions are the basis of such synthetic routes.

Retro-synthesis of organic compounds.

- Stereoisomers are subdivided into two classes—conformational isomers, which interconvert by rotation about a  $\sigma$  bond and configurational isomers that interconvert only by breaking and reforming a bond.



Configurational isomers are further subdivided into *cis*-*trans* and E/Z isomers and optical isomers.



- *Cis*-*trans* isomers can occur in alkenes or cycloalkanes (or heteroanalogues) and differ in the positions of atoms (or groups) relative to a reference plane. According to IUPAC, E/Z isomers refer to alkenes of the form  $R_1R_2C=CR_3R_4$  ( $R_1 \neq R_2$ ,  $R_3 \neq R_4$ ) where neither  $R_1$  nor  $R_2$  need be different from  $R_3$  or  $R_4$ .
- A chiral carbon is a carbon joined to four different atoms or groups.
- An optically active compound can rotate the plane of polarized light as it passes through a solution of the compound. Optical isomers are enantiomers. Enantiomers are non-superimposable mirror images of each other. Diastereomers are not mirror images of each other.
- A racemic mixture (or racemate) is a mixture of two enantiomers in equal amounts and is optically inactive.

### Misconceptions:

Organic Chemistry is the study of biological molecules.

Aromatic molecules are cyclical.

## Students will be able to...

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- Explain the trends in boiling points of members of a homologous series.
- Distinguish between empirical, molecular and structural formulas.
- Identify different classes: alkanes, alkenes, alkynes, halogenoalkanes, alcohols, ethers, aldehydes, ketones, esters, carboxylic acids, amines, amides, nitriles and arenes.
- Identify typical functional groups in molecules eg phenyl, hydroxyl, carbonyl, carboxyl, carboxamide, aldehyde, ester, ether, amine, nitrile, alkyl, alkenyl and alkynyl.
- Construct 3-D models (real or virtual) of organic molecules.
- Apply IUPAC rules in the nomenclature of straight-chain and branched-chain isomers.
- Identify primary, secondary and tertiary carbon atoms in halogenoalkanes and alcohols and primary, secondary and tertiary nitrogen atoms in amines.
- Discuss the structure of benzene using physical and chemical evidence.

- *Alkanes:*

- Write equations for the complete and incomplete combustion of hydrocarbons.
- Explain the reaction of methane and ethane with halogens in terms of a free-radical substitution mechanism involving photochemical homolytic fission.

- *Alkenes:*

- Write equations for the reactions of alkenes with hydrogen and halogens and of symmetrical alkenes with hydrogen halides and water.
- Outline of the addition polymerization of alkenes.
- Relate between the structure of the monomer to the polymer and repeating unit.

- *Alcohols:*

- Write equations for the complete combustion of alcohols.
- Write equations for the oxidation reactions of primary and secondary alcohols (using acidified potassium dichromate(VI) or potassium manganate(VII) as oxidizing agents). Explanation of distillation and reflux in the isolation of the aldehyde and carboxylic acid products.
- Write the equation for the condensation reaction of an alcohol with a carboxylic acid, in the presence of a catalyst (eg concentrated sulfuric acid) to form an ester.

- *Halogenoalkanes:*

- Write the equation for the substitution reactions of halogenoalkanes with aqueous sodium hydroxide.
- *Nucleophilic Substitution Reactions:* Explanation of why hydroxide is a better nucleophile than water.
- Deduce the mechanism of the nucleophilic substitution reactions of halogenoalkanes with aqueous sodium hydroxide in terms of SN1 and SN2 mechanisms. Explanation of how the rate depends on the identity of the halogen (ie the leaving group), whether the halogenoalkane is primary, secondary or tertiary and the choice of solvent.
- Outline of the difference between protic and aprotic solvents.

### *Electrophilic Addition Reactions:*

Deduce the mechanism of the electrophilic addition reactions of alkenes with halogens/interhalogens and hydrogen halides.

- *Electrophilic Substitution Reactions:*

Deduce the mechanism of the nitration (electrophilic substitution) reaction of benzene (using a mixture of concentrated nitric acid and sulfuric acid).

- *Reduction Reactions:*

Write reduction reactions of carbonyl containing compounds: aldehydes and ketones to primary and secondary alcohols and carboxylic acids to aldehydes, using suitable reducing agents.

Convert nitrobenzene to phenylamine via a two-stage reaction.

Deduce multi-step synthetic routes given starting reagents and the product(s).

Construct 3-D models (real or virtual) of a wide range of stereoisomers.

Explain stereoisomerism in non-cyclic alkenes and C3 and C4 cycloalkanes.  
Compare between the physical and chemical properties of enantiomers.  
Describe and explain optical isomers in simple organic molecules.  
Distinguish between optical isomers using a polarimeter.

## **STAGE 2- EVIDENCE OF LEARNING**

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### **Formative Assessment**

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- 3- Minute Pause
- A-B-C Summaries
- Analogy Prompt
- Choral Response
- Debriefing
- Exit Card / Ticket
- Hand Signals
- Idea Spinner
- Index Card Summaries
- Inside-Outside Circle Discussion (Fishbowl)
- Journal Entry
- Misconception Check
- Observation
- One Minute Essay
- One Word Summary
- Portfolio Check
- Questions & Answers
- Quiz
- Self-Assessment
- Student Conference
- Think-Pair-Share
- Web or Concept Map



## Authentic Assessments

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### Experiments could include:

Distinguishing between alkanes and alkenes, preparing soap and the use of gravity filtration, filtration under vacuum (using a Buchner flask), purification including recrystallization, reflux and distillation, melting point determination and extraction

Either use model kits or suitable computer-generated molecular graphics programmes to construct three-dimensional models of a wide range of organic molecules.

Distillation to separate liquids or the use of a rotary evaporator to remove a solvent from a mixture.

## Benchmark Assessments

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IB HL Chemistry A Topic 10 Test

## STAGE 3- LEARNING PLAN

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### Instructional Map

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- Skeletal formulas should be discussed in the course.
- The general formulas (eg  $C_nH_{2n+2}$ ) of alkanes, alkenes, alkynes, ketones, alcohols, aldehydes and carboxylic acids should be known.
- The distinction between class names and functional group names needs to be made. Eg for OH, hydroxyl is the functional group whereas alcohol is the class name.
- The following nomenclature should be covered:
- Non-cyclic alkanes and halogenoalkanes up to haloheptanes.
- Alkenes up to hexene and alkynes up to hexyne.
- Compounds up to six carbon atoms (in the basic chain for nomenclature purposes) containing only one of the classes of functional groups: alcohols, ethers, aldehydes, halogenoalkanes, ketones, esters and carboxylic acids.
- Reference should be made to initiation, propagation and termination steps in free-radical substitution reactions. Free radicals should be represented by a single dot.
- The mechanisms of  $SN1$  and  $SN2$  and electrophilic substitution reactions are not required.

### Modification/Differentiation of Instruction

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#### Differentiation Strategies for Special Education Students

- Remove unnecessary material, words, etc., that can distract from the content

- Use of off-grade level materials
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Time allowed
- Level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials
- Use technology, if available and appropriate
- Varied homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Ability to work at their own pace
- Present ideas using auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment
- Differentiated checklists and rubrics, if available and appropriate

### Differentiation Strategies for Gifted and Talented Students

- Increase the level of complexity
- Decrease scaffolding
- Variety of finished products
- Allow for greater independence
- Learning stations, interest groups
- Varied texts and supplementary materials
- Use of technology
- Flexibility in assignments
- Varied questioning strategies
- Encourage research
- Strategy and flexible groups based on formative assessment or student choice
- Acceleration within a unit of study
- Exposure to more advanced or complex concepts, abstractions, and materials
- Encourage students to move through content areas at their own pace
- After mastery of a unit, provide students with more advanced learning activities, not more of the same activity
- Present information using a thematic, broad-based, and integrative content, rather than just single-

subject areas

### Differentiated Strategies for ELL Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials, including visuals
- Use technology, if available and appropriate
- Differentiate homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Allow students to work at their own pace
- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Role play
- Provide graphic organizers, highlighted materials
- Strategy and flexible groups based on formative assessment

### Differentiation Strategies for At Risk Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials
- Use technology, if available and appropriate
- Differentiate homework and products
- Varied questioning strategies
- Provide background knowledge

- Define key vocabulary, multiple-meaning words, and figurative language
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment

## **504 Plans**

Students can qualify for 504 plans if they have physical or mental impairments that affect or limit any of their abilities to:

- walk, breathe, eat, or sleep
- communicate, see, hear, or speak
- read, concentrate, think, or learn
- stand, bend, lift, or work

Examples of accommodations in 504 plans include:

- preferential seating
- extended time on tests and assignments
- reduced homework or classwork
- verbal, visual, or technology aids
- modified textbooks or audio-video materials
- behavior management support
- adjusted class schedules or grading
- verbal testing
- excused lateness, absence, or missed classwork
- pre-approved nurse's office visits and accompaniment to visits
- occupational or physical therapy

## **Modification Strategies**

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- Cooperative Grouping
- Extended Time

- Frequent Breaks
- Highlighted Text
- Interactive Notebook
- Modified Test
- Oral Directions
- Peer Tutoring
- Preferential Seating
- Re-direct
- Repeated Drill and Practice
- Shortened Assignment
- Teacher Notes
- Tutorials
- Use of Additional Reference Materials
- Use of Audio Resources

## **Differentiation Strategies**

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### **High Preparation**

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- Alternative Assessments
- Choice Boards
- Games and Tournaments
- Group Investigations
- Guided Reading
- Independent Research / Project
- Interest Groups
- Learning Contracts
- Leveled Rubrics
- Literature Circles
- Multiple Intelligence Options
- Multiple Texts
- Personal Agendas
- Project Based Learning (PBL)
- Stations / Centers
- Think-Tac-Toe
- Tiered Activities / Assignments

- Varying Graphic Organizers

## **Low Preparation**

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- Choice of Book / Activity
- Cubing Activities
- Exploration by Interest (using interest inventories)
- Flexible Grouping
- Goal Setting With Student
- Homework Options
- Jigsaw
- Mini Workshops to Re-teach or Extend Skills
- Open-ended Activities
- Think-Pair-Share by Readiness, Interest, or Learning Style
- Use of Collaboration
- Use of Reading Buddies
- Varied Journal Prompts
- Varied Product Choice
- Varied Supplemental Materials
- Work Alone / Together

## **Horizontal Intergration- Interdisciplinary Connections**

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See Appendix

## **Vertical Integration- Discipline Mapping**

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Eighth grade Chemical Interactions

Tenth grade Honors Chemistry

**Additional Materials**

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Pearson IB chemistry, Catrin Brown & Mike Ford

Richard Thornley Video Lessons

[www.IBChem.com](http://www.IBChem.com)