

## Second-Year HL Chemistry

### **Organic Chemistry**

**Read:**

#### **Concepts to be mastered:**

To master a concept, you must be able to do three things:

1. define the concept,
2. explain the concept, and
3. give an example of the concept.
  - hydrocarbon, saturated, unsaturated, homologous series,
  - Molecular formula, structural formula, condensed structural formula, straight-chain, branched-chain, (ring), structural isomer, substituent, alkyl group, cycloalkane,
  - primary carbon, secondary carbon, tertiary carbon, quaternary carbon,
  - Symmetrical alkene, addition reaction, substitution, combustion, complete combustion, incomplete combustion, bromination, hydrogenation, halogenation, hydration
  - monomer, polymer, polymerization, addition polymerization, free radical polymerization,
  - functional group, alkane, alkene, alkyne, alcohol, carbonyl, aldehyde, ketone, carboxylic acid, ether, ester, amine, amide, halogenoalkane
  - Primary alcohol, secondary alcohol, tertiary alcohol
  - isomerism, structural isomer, chain isomerism, positional isomerism, functional isomerism, geometric isomerism, optical isomerism (outdated term), plane-polarized light, polarimeter, polarizer, stereoisomerism, enantiomer, chiral molecule, chiral center (chiral carbon), chirality,
  - esterification, oxidation, polymerization, condensation polymerization, polyester, ester linkage, polyamide, amide linkage, amino acid, peptide, dipeptide, polypeptide, protein
  - Hybridization, substitution, geometry, free radical, homolytic fission, heterolytic fission, delocalized electrons,
  - Primary halogenoalkane, secondary halogenoalkane, tertiary halogenoalkane,
  - Mechanism, intermediate, nucleophilic substitution, leaving group, molecularity, rate, elementary step, rate determining step, dehydration, oxidation,
  - Mass spectrometry, mass spectrometer, ionization, fragmentation, parent (molecular) ion, fragmentation pattern, mass spectrum
  - electronic transition, emission, absorption, vibration, bending, stretching, wavelength, frequency, wavenumber
  - nuclear spin states, resonance, chemical Shifts, magnetic field,

#### **Skills to be mastered:**

To master a skill, you must be able to

1. recognize when the skill is needed,

2. recognize what information is needed to execute the skill,
3. execute the skill, and
4. assess whether the skill has been executed correctly.

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| <ul style="list-style-type: none"> <li>● Predict the trend in boiling point of members of a homologous series of alkanes</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>● Draw structural formulae for the isomers of the non-cyclic alkanes up to C<sub>6</sub>.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>● Name straight-chain alkanes up to C<sub>10</sub> using IUPAC rules.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>● Explain relative inertness of alkanes.</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>● Draw structural formula for straight-chain alkenes for up to C<sub>10</sub>.</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>● Describe complete and incomplete combustion of hydrocarbons and relate the environmental impact of the products</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>● State that combustion of hydrocarbons is an exothermic process.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>● Distinguish between functional group and substituent</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>● Describe the reaction of symmetrical alkenes with hydrogen, bromine, hydrogen halides and water.</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>● Outline use of reactions of alkenes (hydrogenation in the production of margarine, hydration of ethene in the manufacture of ethanol, bromination to distinguish between alkanes and alkenes)</li> </ul>        |  |  |
| <ul style="list-style-type: none"> <li>● Describe substitution reaction of alkane.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>● Describe the polymerization of alkenes</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>● Draw and state names of the compounds containing up to five carbon atoms with the following functional groups: : aldehyde, ketone, carboxylic acid, alcohol, amide, amine, ester and halogenoalkane.</li> </ul> |  |  |
| <ul style="list-style-type: none"> <li>● Predict relative volatility, solubility in water and acid-base behavior of the seven functional groups.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>● Explain that functional groups can exist as both positional as well as functional isomers.</li> </ul>   |  |  |

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| <ul style="list-style-type: none"> <li>Identify optical isomers.</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>Predict the trend in boiling point of members of a homologous series of a given functional group</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>Outline the condensation reaction of an alcohol with a carboxylic acid to form an ester, and state the uses of esters.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>Describe partial and complete oxidation of ethanol.</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>Compare and explain solubilities of alcohols in water as length of carbon chain increases</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>Describe the condensation of polymers formed by carboxylic acids and alcohols (polyesters), and carboxylic acids and amines (polyamides).</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>Describe the formation of peptides and proteins from 2-amino acids (another example of condensation polymerization).</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>Given the formula for an organic compound, draw and write condensed formulas for all isomers of that compound and determine their names</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>Explain poor reactivity of alkanes in terms of inertness of C-H and C-C bonds.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>State that alkanes can react with halogens and distinguish between homolytic and heterolytic fission.</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>Distinguish between primary, secondary and tertiary halogenoalkanes.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>Describe and explain the S<sub>N</sub>1 and S<sub>N</sub>2 mechanisms in nucleophilic substitution.</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>Describe and explain molecularity for the S<sub>N</sub>1 and S<sub>N</sub>2 mechanisms.</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>Describe how the rate of nucleophilic substitution in halogenoalkanes depends on both the identity of the halogen and whether the halogenoalkane is primary, secondary or tertiary.</li> </ul> |  |  |
| <ul style="list-style-type: none"> <li>Describe and explain the structure of benzene using chemical evidence.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>Describe the dehydration reactions of alcohol to form alkenes.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>Determine the products formed by the oxidation of primary, secondary and tertiary</li> </ul>   |  |  |

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| alcohols using acidified dichromate(VI) solution.   |  |  |
| <ul style="list-style-type: none"> <li>Describe and explain how information from a mass spectrum can be used to determine the structure of a compound</li> </ul>                      |  |  |
| <ul style="list-style-type: none"> <li>Identify the common fragments in the mass spectrum of an organic compound and determine the family of compound to which it belongs.</li> </ul> |  |  |
| <ul style="list-style-type: none"> <li>Identify functional groups present in an organic compound from its IR spectrum</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>Determine the number of different environments hydrogen is found in from proton NMR.</li> </ul>  |  |  |
| <ul style="list-style-type: none"> <li>Identify the number of hydrogen atoms in each environment</li> </ul>   |  |  |
| <ul style="list-style-type: none"> <li>Given an organic compound, predict the structural features in its proton nuclear magnetic spectrum</li> </ul>                                  |  |  |
| <ul style="list-style-type: none"> <li>Given a proton nuclear magnetic spectrum, describe the structural features present in the compound that generated the spectrum</li> </ul>      |  |  |

**End of chapter Problems:**

- Further Problems
- Draw the complete and the condensed structural formula and the carbon skeleton for the straight-chain compound with the formula  $C_5H_{12}$ .
  - Write the molecular formula for each of the following substances: (a)  $CH_3CH_2CH_2CH_3$  (b).  $CH_3CH=CHCH_2CH_3$
  - What is the difference between a saturated and an unsaturated compound?
  - Write the condensed structural formula for the next highest member of the homologous series for each of the following straight-chain compound: (a)  $C_4H_{10}$ , (b)  $C_2H_4$
  - Identify each of the following as an alkane or alkene: (a)  $C_5H_{12}$ , (b)  $C_4H_8$ .
  - Pentane,  $C_5H_{12}$ , can exist as structural isomers. Draw carbon skeletons and condensed structural formulae for each isomer.
  - Arrange the following compounds in order of increasing boiling point:  $C_{10}H_{22}$ ,  $C_3H_8$ ,  $C_5H_{12}$ .
  - Explain why hydrocarbons are insoluble in water.
  - What products are formed in the incomplete combustion of a hydrocarbon?
  - Write a balanced equation for the combustion of  $C_4H_{10}$ .
  - Write balanced equations for each of the following reactions. (Represent organic compounds by complete structural formulas.)
    - addition of bromine to but-1-ene
    - reaction of 1,2-dichloroethene with hydrogen iodide
    - acid-catalyzed addition of water to ethene.

15. Which of the following open-chain compounds would react with hydrogen? Explain your answer. (a) C<sub>6</sub>H<sub>14</sub> (b) C<sub>6</sub>H<sub>12</sub> (c) C<sub>4</sub>H<sub>8</sub>
16. Explain how a solution of bromine can be used to distinguish between hexane and hexene.
17. Write the structure of the monomer which would give the polymer  $-\text{[CH}_2\text{CHCl]}_n-$ ?
18. Write the structure of the polymerization of each of the following: (a) ethene, (b) propene.