

Structured Questions: Paper 2

10.1 Fundamentals of Organic Chemistry

10.1.1 Homologous Series / 10.1.2 Understanding Organic Molecules / 10.1.3 Nomenclature / 10.1.4 Organic Families - Hydrocarbons / 10.1.5 Organic Families - Halogenoalkanes / 10.1.6 Organic Families - Alcohols & Ethers / 10.1.7 Organic Families - Carbonyls / 10.1.8 Organic Families - Carboxylic Acids & Esters / 10.1.9 Organic Families - Organic Nitrogen Compounds / 10.1.10 3-D modelling / 10.1.11...

Easy (5 questions)	/31
Medium (5 questions)	/52
Hard (5 questions)	/35
Total Marks	/118

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Easy Questions

1 (a) Define the term hydrocarbon.

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(1 mark)

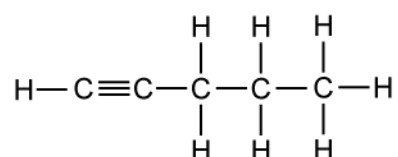
(b) State the general formula for the following hydrocarbon families.

Alkanes

Alkenes

.....
.....
(2 marks)

(c) State the IUPAC name of the following hydrocarbon.



.....
(1 mark)

(d) A student stated that as the number of carbon atoms increases in an alkane, the boiling point increases. State if the student is correct and justify your answer.

(3 marks)

2 (a) Propanal and propanone have the same molecular formula, C_3H_6O , but have different structures. Draw the displayed structures of propanal and propanone.

.....

.....
(2 marks)

(b) State the type of isomerism that is exhibited by propanal and propanone.

.....
(1 mark)

(c) Butanone can be reduced to a secondary alcohol by $LiAlH_4$. State the name of this alcohol.

.....
(1 mark)

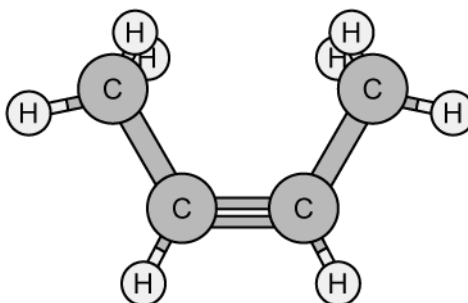
(d) State the general formula of an alcohol.

.....
(1 mark)

3 (a) Name the three possible isomers of C_5H_{12} .

(3 marks)

(b) Using IUPAC rules state the name of the molecule shown in the image below.



(1 mark)

(c) Draw the stereochemical drawing of methane.

(1 mark)

4 (a) State whether the following amines can be classed either primary, secondary or tertiary.

Ethylamine

2-aminopropane

.....
.....
(2 marks)

(b) 2-chloro-2-methylbutane is classed as a tertiary halogenoalkane.

- i) Draw the structure of 2-chloro-2-methylbutane.
- ii) Explain why this is classed as a tertiary haloalkane

.....
.....
(2 marks)

(c) The formulae of four organic compounds are given below. State the IUPAC names of the compounds.

$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$

$\text{CH}_3\text{CH}_2\text{COOH}$

$\text{CH}_3\text{CH}_2\text{OH}$

.....
.....
.....
(3 marks)

(d) State the two compounds from part (c) that will react to form an ester in the presence of concentrated sulfuric acid.

(1 mark)

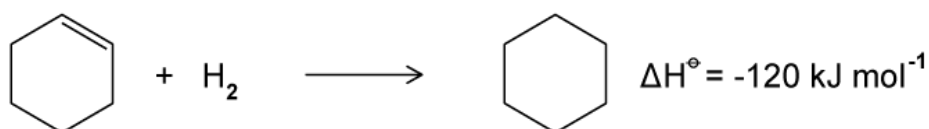
5 (a) State the formula for benzene and draw the displayed structure.

(2 marks)

(b) State the bond angle in the planar regular hexagon structure of benzene.

(1 mark)

(c) Cyclohexene is an unsaturated hydrocarbon and can undergo hydrogenation as shown below.



When benzene undergoes the same reaction with three hydrogen molecules the expected enthalpy change of the reaction is lower than expected.

State the expected value of the hydrogenation of benzene.

(1 mark)

(d) Explain why the enthalpy value for the hydrogenation of benzene is lower than expected.

(2 marks)

Medium Questions

1 (a) Organic compounds are classified into families called a *homologous series*.

State three features of members belonging to the same *homologous series*.

(3 marks)

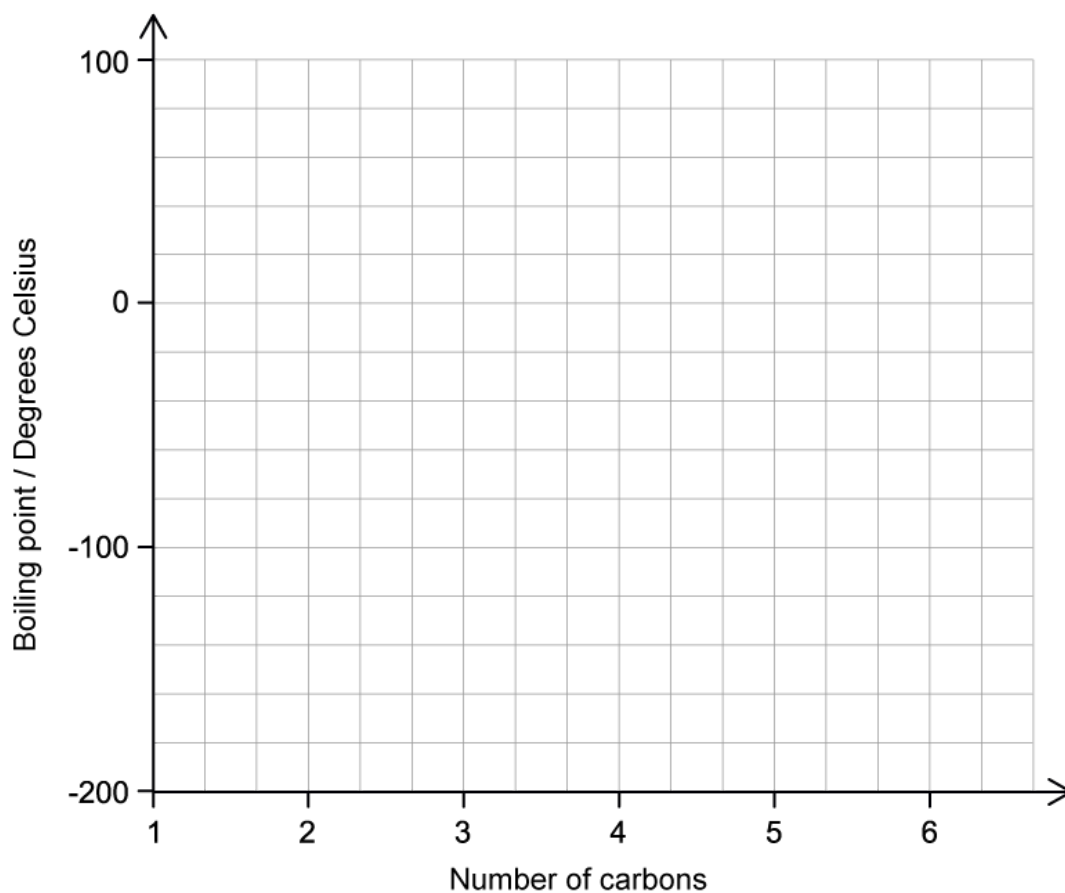
(b) **Table 1** shows the boiling points of the first five members of the alkane family.

Table 1

Alkane	Boiling point/ °C
methane	-162
ethane	-89
propane	-42
butane	-1
pentane	36

On the axes below in **Figure 1**, draw a graph of boiling point against the number of carbon atoms in the alkanes. Estimate the boiling point of the next member of the homologous series, hexane, C_6H_{14} , and show on your graph how you arrived at your estimated boiling point.

Figure 1



Estimated boiling point of hexane : _____ °C

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.....

.....

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(4 marks)

(c) State the general formula for an alkyne and give the molecular formula and name of the fifth member of the alkyne family.

.....

.....

(2 marks)

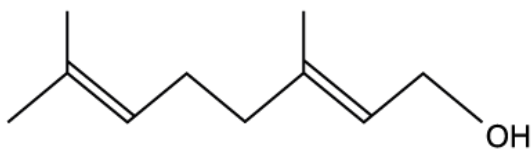
(d) The boiling point of ethyne, C_2H_2 , is $-84\text{ }^\circ\text{C}$.

State with, with a reason, whether the boiling point of ethyne would be expected to be higher or lower than the boiling point of ethane, C_2H_6 .

(2 marks)

2 (a) Geraniol is a colourless component of rose oil whose structure is shown in **Figure 1**.

Figure 1



- State the names of the two functional groups found in geraniol.
- Deduce the molecular formula of geraniol.
- Draw the displayed formula of geraniol.

.....

.....

.....

(3 marks)

(b) Butan-2-ol is an organic compound used industrially to make butanone.

- Draw the displayed structure of butan-2-ol.
- Draw the displayed structures of a positional isomer and a functional group isomer of butan-2-ol.

.....

.....

.....

(3 marks)

(c) Draw and name all the branched-chain isomers of butan-2-ol.

.....

.....

(2 marks)

(d) State, with a reason, the class of alcohols which butan-2-ol belongs to.

(1 mark)

- 3 (a) The formulae of four organic compounds are given in **Table 1**. Write the names of the compounds in the second column.

Table 1

compound	name
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$	
$\text{CH}_3\text{CH}_2\text{COCH}_3$	
$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$	

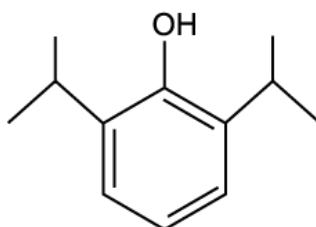
.....
.....
(2 marks)

- (b) Which of the compounds in part (a) are structural isomers of each other and what type of isomerism do they show?

.....
.....
(2 marks)

- (c) Propofol is a drug used to reduce consciousness during medical procedures. The skeletal structure of propofol is given in Figure 1.

Figure 1



- i) Determine the empirical formula of propofol.
- ii) Identify the number of positional isomers of propofol (not including propofol).
- iii) State the names of two functional groups found in propofol.

(3 marks)

(d) Valeric acid, $C_5H_{10}O_2$, is a straight chain carboxylic acid found in the plant *Valeriana officinalis*.

- i) State the general formula for a carboxylic acid.
- ii) Give the systematic name for valeric acid.
- iii) Draw a condensed structural formula for valeric acid.

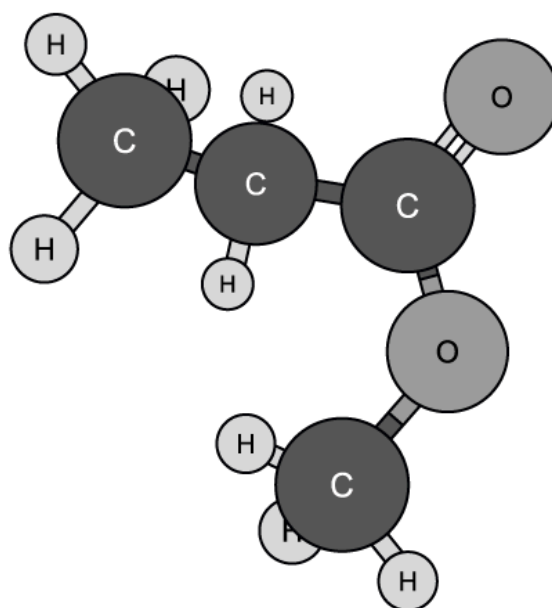
(3 marks)

4 (a) Draw and name all the possible isomers of C_6H_{14} .

(5 marks)

(b) **Figure 1** below shows a three-dimensional structure of a molecule.

Figure 1



- Using IUPAC rules state the name of this molecule.
- Draw and name a functional group isomer of this molecule.

(2 marks)

- (c) Explain the difference between a tertiary haloalkane and a tertiary amine, using suitable diagrams to illustrate your answer.

(2 marks)

- (d) Three important nitrogen containing functional groups used in chemical synthesis are carboxamides, nitriles and amines.

Draw the Lewis structure of each of these functional groups.

(3 marks)

5 (a) Benzene is an aromatic hydrocarbon which is often drawn as **Figure 1**.

Discuss the physical evidence that justifies this structure for benzene.

Figure 1



(2 marks)

(b) Benzene and cyclohexene are both *unsaturated* molecules, but cyclohexene reacts with bromine water and benzene does not.

- i) State the meaning of the terms *saturated* and *unsaturated* as applied to organic molecules.
- ii) Explain this difference in reactivity and write an equation for the reaction between cyclohexene and bromine.

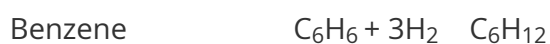
(3 marks)

(c) **Table 1** below shows the enthalpy changes for the hydrogenation of cyclohexene, benzene, and the theoretical molecule 1,3,5-cyclohexatriene.

Table 1

Compound	Enthalpy of hydrogenation
Cyclohexene, C ₆ H ₁₀	-120
Benzene, C ₆ H ₆	-208
1,3,5-cyclohexatriene, C ₆ H ₆	?

The equations for the hydrogenation reactions are:



- Use the data in **Table 1** to determine the enthalpy of hydrogenation of the theoretical molecule 1,3,5-cyclohexatriene.
- Discuss the difference between the enthalpy of hydrogenation of benzene and of 1,3,5-cyclohexatriene.

.....

.....

.....

(3 marks)

(d) An unknown aromatic compound has the molecular formula C₈H₈O₂.

Deduce the structural formula of **two** isomers of this compound which contain an ester group.

.....

.....

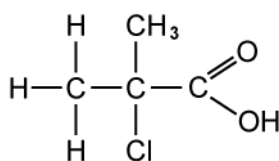
(2 marks)

Hard Questions

1 (a) State the general formula for carboxylic acids.

(1 mark)

(b) State the IUPAC name of the following compound.



(1 mark)

(c) Explain why the solubility of carboxylic acids decreases as chain length increases.

(2 marks)

(d) Propan-2-ol will form an ester when reacted with ethanoic acid in the presence of concentrated sulfuric acid.

Draw the displayed formula for the ester formed.

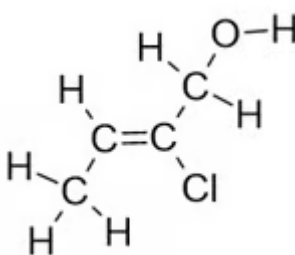
(1 mark)

2 (a) State the IUPAC names for the isomers of $C_5H_{12}O$ that are primary alcohols.

(4 marks)

(b) State the IUPAC name for the following primary alcohols.

i)



[1]

ii) $CH_2(Br)CH(CH_3)CH_2OH$

[1]

(2 marks)

(c) Draw the displayed formula for a straight chain isomer of $CH_2(Br)CH(CH_3)CH_2OH$.

(1 mark)

(d) The empirical formula of the compound in part b) i).

(1 mark)

3 (a) Draw a diagram to show the resonance structure in a molecule of benzene.

(2 marks)

(b) The energy change for hydrogenation of cyclohexene is -120 kJ mol^{-1} . However, when benzene undergoes hydrogenation, the energy change is 152 kJ mol^{-1} less than expected.

Use this data to explain the relative stabilities of benzene and the theoretical cyclohexa-1,3,5-triene molecule.

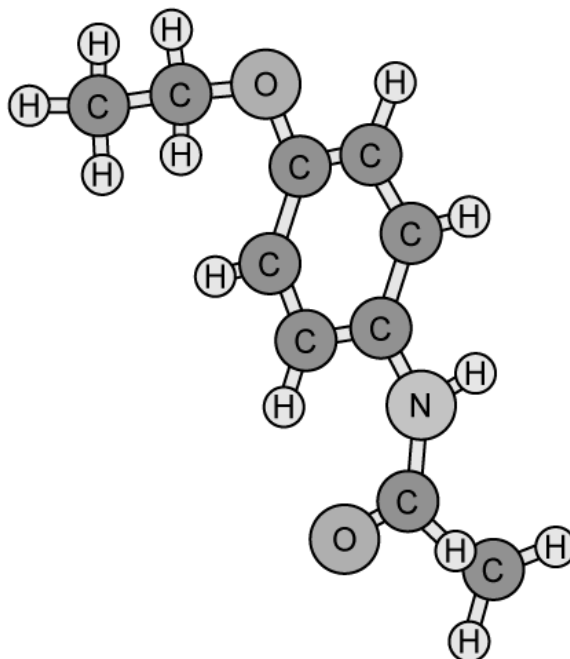
(3 marks)

With reference to bonding and hybridisation, describe the structure of benzene.

(c)

(4 marks)

- 4 (a) Phenacetin is a pain killer though the use of this was banned as it was found to cause harm to kidney function.



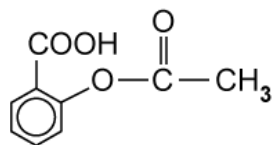
Deduce the molecular formula of phenacetin.

.....
(1 mark)

- (b) Identify the names of the three functional groups present in phenacetin.

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.....
.....
(3 marks)

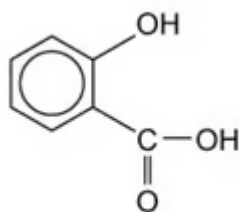
- (c) Aspirin is a common pain killer and has the following structure.



State the empirical formula of aspirin.

(1 mark)

- (d) Aspirin is formed from ethanoic anhydride and compound A. State the IUPAC name of compound A.



Compound A

(1 mark)

Deduce the number of isomers of C_6H_{14} .

5 (a)

(1 mark)

State the IUPAC name of **two** branched isomers of C_6H_{14} .

(b)

(2 marks)

Draw the displayed formula of a possible isomer of C_6H_{12} that does **not** contain a π bond.

(c)

(1 mark)

(d) State the IUPAC names of two branched isomers of C_5H_{10} that contain a π bond.

(3 marks)