CHEMISTRY

Stage 6

Module 7: Organic Chemistry

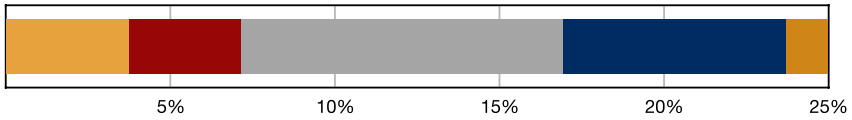
Hydrocarbons and Associated Reactions

Nomenclature

Teacher: Shane Sandot

Exam Equivalent Time: 159 minutes *(based on allocation of 1.5 minutes per mark)*

M7 Organic Chemistry



- Nomenclature
- Hydrocarbons and Associated Reactions
- Alcohols
- Reactions of Organic Acids and Bases
- Polymers

***SmarterScience analytics based on the average contribution of new syllabus content since 2019.**

HISTORICAL CONTRIBUTION

- *M7 Organic Chemistry* has contributed an average of 25.0% per HSC Chemistry exam since the new syllabus was introduced in 2019.
- This topic has been split into five sub-categories for analysis purposes which are: *1-Nomenclature (3.7%), 2-Hydrocarbons and Associated Reactions (3.4%), 3-Alcohols (9.8%), 4-Reactions of Organic Acids and Bases (6.8%) and 5-Polymers (1.3%).*
- This analysis looks at the sub-topic, *Hydrocarbons and Associated Reactions.*

HSC ANALYSIS - What to expect and common pitfalls

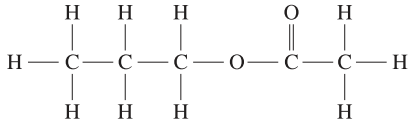
- *Hydrocarbons and Associated Reactions* has been examined predominantly within the multiple choice section of new syllabus exams, including twice each year between 2021-2023.
- Longer answer questions looking at this topic area are often within cross-topic contexts rather than dedicated examples, a number of which are included in the database.
- Questions looking at *Saturated and Unsaturated Hydrocarbons* represent the largest contributing sub-topic in this area, with longer answer questions appearing in both the 2021 and 2022 exams.
- *Solubility and Boiling Points* have been examined in 4 of the last 6 exams and deserve revision attention.
- *Formulae and molecular shape* are often presented in a multiple-choice format. Last examined in 2022, they represent fundamental concepts which have been poorly answered in the past.

Questions

1. CHEMISTRY, M7 2019 HSC 1 MC

Which structural formula represents pentan-2-one?

A.



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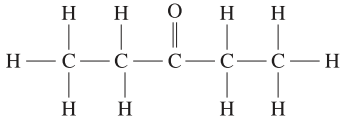

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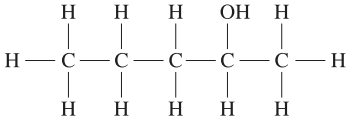

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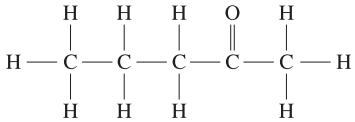

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2. CHEMISTRY, M7 2023 HSC 1 MC

What is the safest method for disposing of a liquid hydrocarbon after an experiment?

A. Pour it down the sink

B. Place it in a garbage bin

C. Burn it by igniting with a match

D. Place it in a separate waste container

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3. CHEMISTRY, M7 2015 VCE 13 MC

What is the name of the product formed when chlorine, Cl_2, reacts with but-1-ene?

A. 1,2-dichlorobutane

B. 1,4-dichlorobutane

C. 2,2-dichlorobutane

D. 2,3-dichlorobutane

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4. CHEMISTRY, M7 2015 VCE 5 MC

Which one of the following statements best defines a renewable energy resource?

A. an energy resource that will not be consumed within our lifetime

B. an energy resource that does not produce greenhouse gases when consumed

C. an energy resource derived from plants that are grown for the production of liquid biofuels

D. an energy resource that can be replaced by natural processes within a relatively short time

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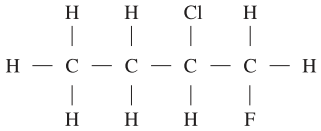
5. CHEMISTRY, M7 2017 HSC 3 MC

What is the name of this compound?



A. 2-chloro-1-fluorobutane

B. 3-chloro-4-fluorobutane

C. 1-fluoro-2-chlorobutane

D. 4-fluoro-3-chlorobutane

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6. CHEMISTRY, M7 2019 HSC 10 MC

Which class of organic compound must contain at least three carbon atoms?

A. Aldehydes

B. Alkenes

C. Carboxylic acids

D. Ketones

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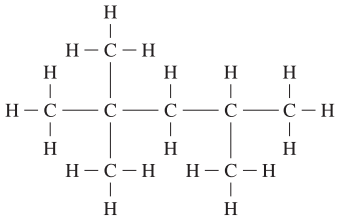
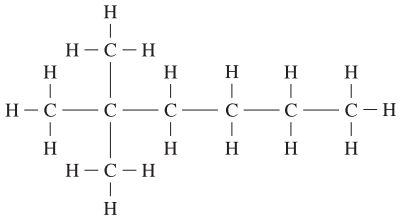
7. CHEMISTRY, M7 2022 HSC 9 MC

What is the structure of $CH_3C(CH_3)_2CH_2CH(CH_3)_2$?

A.



B.



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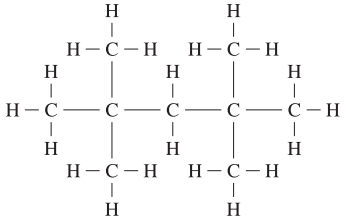
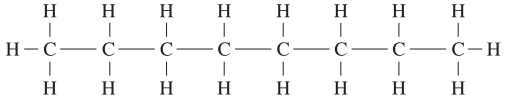


D.



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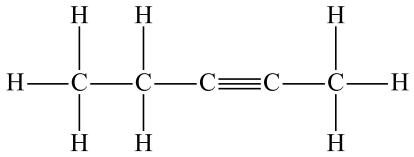
8. CHEMISTRY, M7 2023 HSC 3 MC

The structural formula of a compound is given.



What is the preferred IUPAC name of this compound?

A. Pent-2-ene

B. Pent-2-yne

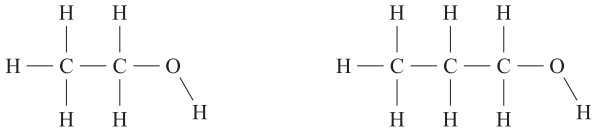
C. Pent-3-ene

D. Pent-3-yne

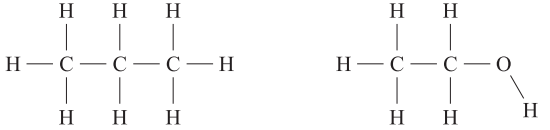
9. CHEMISTRY, M7 2024 HSC 1 MC

Which two substances are members of the same homologous series?

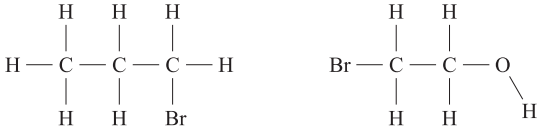
A.



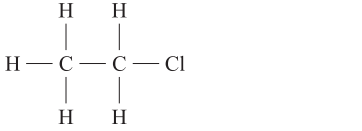
B.

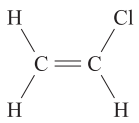


C.



D.





10. CHEMISTRY, M7 2016 HSC 15 MC

The table lists some properties of the straight-chained carbon compounds W, X, Y and Z.

Compound	*Reactivity in bromine water*	*Solubility in water*
W	Rapidly decolourises	Insoluble
X	Unreactive	Insoluble
Y	Unreactive	Soluble
Z	Unreactive	Partly soluble

Which row of the following table best identifies the compounds W, X, Y and Z?

	W	X	Y	Z
A.	C_3H_6	C_3H_8	CH_3OH	C_4H_9OH
B.	C_3H_8	C_3H_6	CH_3OH	C_4H_9OH
C.	C_3H_6	C_3H_8	C_4H_9OH	CH_3OH
D.	C_3H_8	C_3H_6	C_4H_9OH	CH_3OH

11. CHEMISTRY, M7 2019 HSC 9 MC

All of the following compounds have similar molar masses.

Which has the highest boiling point?

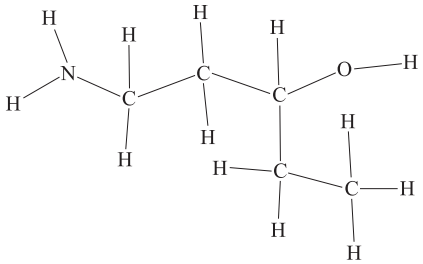
A. Butane

B. Ethanoic acid

C. Propan-1-ol

D. Propane

12. CHEMISTRY, M7 2020 VCE 4 MC



What is the IUPAC name of the molecule shown above?

A. 3-hydroxy-3-ethyl-propan-1-amine

B. 3-amino-1-methylpropan-1-ol

C. 3-hydroxypentan-1-amine

D. 1-aminopentan-3-ol

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13. CHEMISTRY, M7 2021 HSC 13 MC

A chemist synthesises a substance using the following pathway.

$$\mathrm{X} \xrightarrow{\text{hydration}} \mathrm{Y} \xrightarrow{\text{oxidation}} \mathrm{Z}$$

What are compounds X, Y, Z?

	X	Y	Z
A.	propane	propan-1-ol	propan-2-one
B.	propane	propan-1-ol	propanoic acid
C.	prop-1-ene	propan-2-ol	propan-2-one
D.	prop-1-ene	propan-2-ol	propanoic acid

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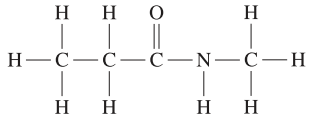
14. CHEMISTRY, M7 2021 HSC 3 MC

The structure of a compound is shown.



What is the preferred IUPAC name of this compound?

A. N-methylpropanamide

B. N-methylpropanamine

C. N-propanylamine

D. N-propylmethanamide

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15. CHEMISTRY, M7 2021 HSC 7 MC

Methanol undergoes a substitution reaction using hydrogen bromide.

Compared to methanol, the product of this reaction has a

A. lower boiling point.

B. lower molecular mass.

C. greater solubility in water.

D. different molecular geometry at the carbon atom.

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16. CHEMISTRY, M7 2023 HSC 10 MC

Which of the following correctly lists the compounds in order of increasing boiling point?

A. Heptane < heptan-2-one < heptan-1-o1 < heptanoic acid

B. Heptane < heptan-1-o1 < heptan-2-one < heptanoic acid

C. Heptanoic acid < heptan-2-one < heptan-1-o1 < heptane

D. Heptanoic acid < heptan-1-o1 < heptan-2-one < heptane

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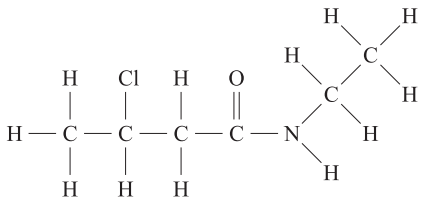
17. CHEMISTRY, M7 2024 HSC 12 MC

The structure of an organic substance is shown.



What is the preferred IUPAC name for this substance?

A. 2-chloro-1-ethylbutanamide

B. 2-chloro-N-ethylpropanamide

C. 3-chloro-N-ethylbutanamide

D. 3-chloro-1-ethylpropanamide

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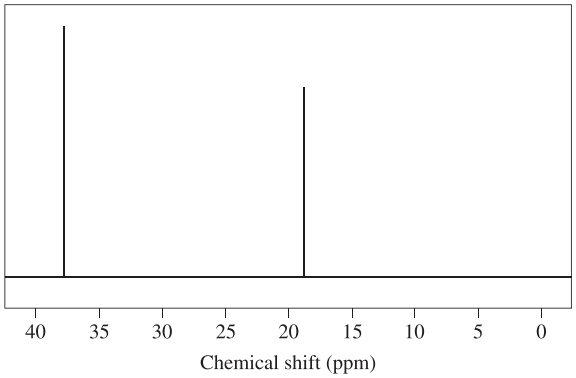
18. CHEMISTRY, M8 2020 HSC 5 MC

A $^{13}\mathrm{C}$ NMR spectrum is shown.



Which compound gives rise to this spectrum?

A. chloroethane

B. 1-chloropropane

C. 1, 2-dichloroethane

D. 1, 2-dichloropropane

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19. CHEMISTRY, M7 2016 VCE 22 MC

When ethene is mixed with chlorine in the presence of UV light, the following reaction takes place.

$$\mathrm{CH_2CH_2\,(g) + Cl_2\,(g) \xrightarrow{UV\ light} CH_2ClCH_2Cl\,(l)}$$

Reactions of organic compounds can be classified in a number of ways. The following list shows four possible classifications:

1. addition
2. substitution
3. redox
4. condensation

Which classification(s) applies to the reaction between ethene and chlorine?

A. 1

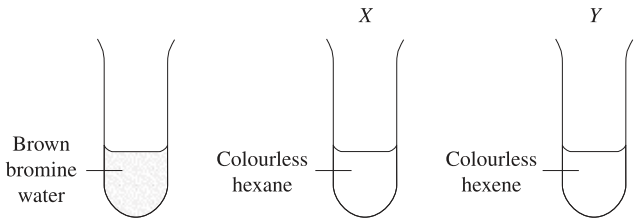
B. 1 and 2

C. 1 and 3

D. 4

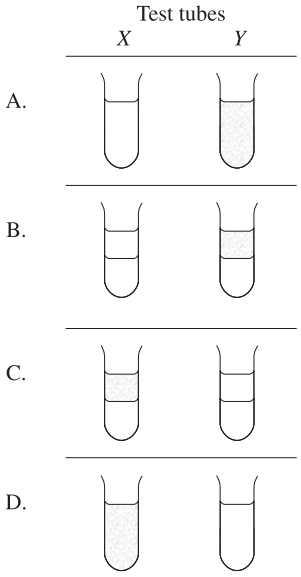
20. CHEMISTRY, M7 2017 HSC 7 MC

Three test tubes were set up as shown.



Bromine water was added to X and Y in the absence of UV light.

Which of the following best represents the changes in test tubes X and Y ?



21. CHEMISTRY, M7 2020 HSC 13 MC

Which of the following conversions results in the formation of a different shape around the carbon atom?

A. Methanoic acid to methanal

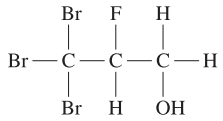
B. Methanoic acid to methanol

C. Methanoic acid to methanamide

D. Methanoic acid to sodium methanoate

22. CHEMISTRY, M7 2020 HSC 6 MC

The structure of a compound is shown.



What is the preferred IUPAC name of this compound?

A. 1,1,1-tribromo-2-fluoropropan-3-ol

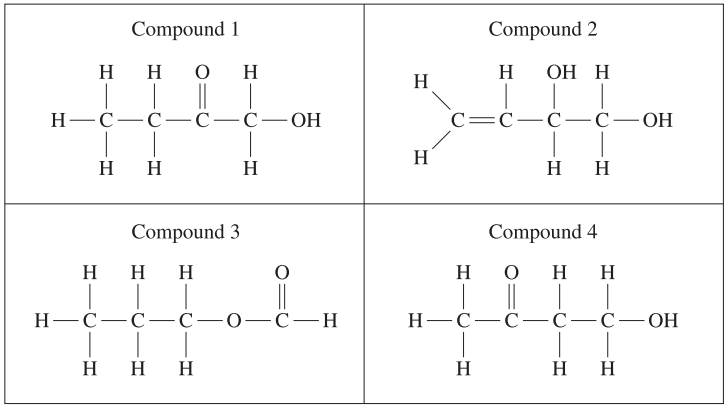
B. 2-fluoro-3,3,3-tribromopropan-1-ol

C. 2-fluoro-1,1,1-tribromopropan-3-ol

D. 3,3,3-tribromo-2-fluoropropan-1-ol

23. CHEMISTRY, M7 2020 HSC 7 MC

The structures of four isomers are shown.



Which statement is correct?

A. Compounds 1 and 2 are chain isomers.

B. Compounds 1 and 4 are chain isomers.

C. Compounds 2 and 3 are functional group isomers.

D. Compounds 2 and 4 are positional isomers.

24. CHEMISTRY, M7 2020 VCE 7 MC

How many structural isomers have the molecular formula C_3H_6BrCl?

A. 4

B. 5

C. 6

D. 7

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25. CHEMISTRY, M7 2022 HSC 7 MC

The name 2-ethyl-3-chlorohexane does not follow IUPAC conventions.

What is the systematic name of this organic compound?

A. 3-chloro-2-ethylhexane

B. 4-chloro-3-methylheptane

C. 4-chloro-5-ethylhexane

D. 5-methyl-4-chloroheptane

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26. CHEMISTRY, M7 2023 HSC 8 MC

How many structural isomers have the molecular formula $C_3H_6F_2$?

A. 2

B. 3

C. 4

D. 5

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27. CHEMISTRY, M7 2018 HSC 14 MC

How many isomers are there of C_3H_6ClF?

A. 3

B. 4

C. 5

D. 6

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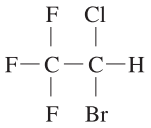
28. CHEMISTRY, M7 2016 HSC 11 MC

What is the IUPAC name of the following compound?



A. 1-bromo-1-chloro-2,2,2-trifluoroethane

B. 1-chloro-1-bromo-2,2,2-trifluoroethane

C. 2-chloro-2-bromo-1,1,1-trifluoroethane

D. 2-bromo-2-chloro-1,1,1-trifluoroethane

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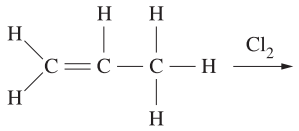
29. CHEMISTRY, M7 2022 HSC 21

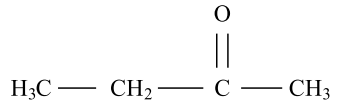
Prop-1-ene reacts with Cl_2 in an addition reaction. In the box given, draw the structural formula of the product of this reaction. ***(2 marks)***



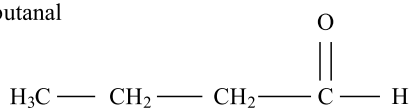
30. CHEMISTRY, M7 2023 HSC 21

Some isomers with the formula C_4H_8O are shown.

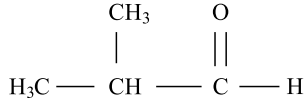
butan-2-one



butanal



2-methylpropanal



Name ONE pair of functional group isomers and ONE pair of chain isomers from the structures above. ***(2 marks)***

31. CHEMISTRY, M8 2021 HSC 21

Four organic liquids are used in an experiment. The four liquids are

- hexane
- hex-1-ene
- propan-1-ol
- propanoic acid

a. State ONE safety concern associated with organic liquids and suggest ONE way to address this safety concern. ***(2 marks)***

b. The organic liquids are held separately in four flasks but the flasks are not labelled. Tests were conducted to identify these liquids. The outcomes of the tests are summarised below. ***(2 marks)***

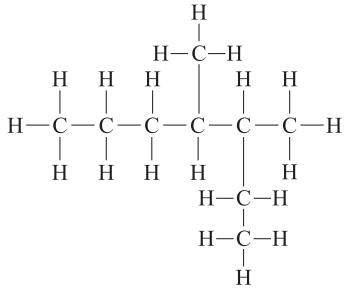
Flask	*Reaction with acidified oxidant* $\left(KMnO_4/H^+\right)$*?*	*Miscible with water?*
1	No	Yes
2	Yes	No
3	Yes	Yes
4	No	No

Identify the FOUR liquids.

Flask	*Liquid*
1	
2	
3	
4	

c. What chemical test, other than those used in part (b), could be used to confirm the identification of ONE of the liquids? Include the expected observation in your answer. ***(2 marks)***

32. CHEMISTRY, M7 2016 VCE 2*



What is the correct systematic name for the compound shown above? ***(2 marks)***

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33. CHEMISTRY, M7 2020 HSC 32

The table shows three compounds and their boiling points.

Compound	*Boiling point* (°C)
Methanol	64.7
Propanoic acid	141.2
Methyl propanoate	79.8

An ester does not always have a lower boiling point than both the alcohol and the alkanoic acid from which it is produced.

Using the information in the table, account for this observation. ***(4 marks)***

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34. CHEMISTRY, M7 2021 HSC 24

A straight-chained alkane has a molar mass of 72.146 g mol $^{-1}$.

Provide the structural formulae for this alkane and all of its isomers.

Name these molecules using IUPAC conventions. ***(4 marks)***

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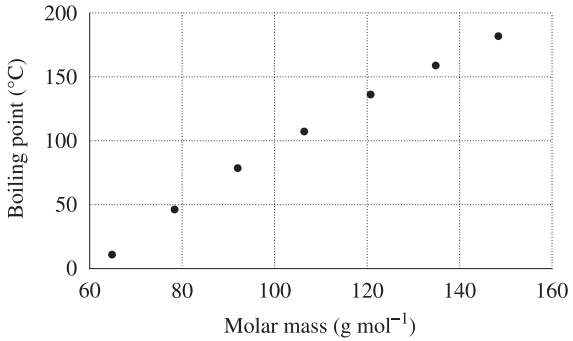
35. CHEMISTRY, M7 2022 HSC 24

The following graph shows the boiling points of some 1-chloroalkanes.



Explain the trend shown in the graph. ***(3 marks)***

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36. CHEMISTRY, M7 EQ-Bank 24

Primary, unbranched alcohols and alkanes of the same carbon length have quite different boiling points.

Explain the difference in boiling point of these organic compounds, showing all intermolecular forces. Support your answer with diagrams. ***(4 marks)***

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37. CHEMISTRY, M7 EQ-Bank 25

Draw the structural formulae and name all possible isomers of hexane. ***(3 marks)***

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38. CHEMISTRY, M8 2016 HSC 25

An unattended car is stationary with its engine running in a closed workshop. The workshop is 5.0 m × 5.0 m × 4.0 m and its volume is 1.0×10^5 L. The engine of the car is producing carbon monoxide in an incomplete combustion according to the following chemical equation:

$$\mathrm{C_8H_{18}\,(l)} + \frac{17}{2}\mathrm{O_2\,(g)} \longrightarrow 8\,\mathrm{CO\,(g)} + 9\,\mathrm{H_2O\,(l)}$$

Exposure to carbon monoxide at levels greater than 0.100 g L^{-1} of air can be dangerous to human health.

6.0 kg of octane was combusted by the car in this workshop.

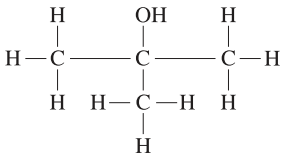
Using the equation provided, determine if the level of carbon monoxide produced in the workshop would be dangerous to human health. Support your answer with relevant calculations. ***(4 marks)***

---

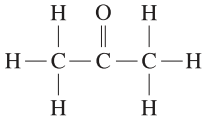
39. CHEMISTRY, M7 2019 HSC 21

a. The structural formula for 2-methylpropan-2-ol is shown in the table.

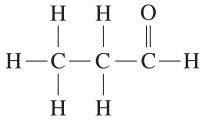
Draw one structural isomer of this alcohol and state its name. ***(2 marks)***

	Alcohol	*Isomer*
Structure		
Name	2-methylpropan-2-ol	

b. The structural formulae for two compounds are shown below.



Isomer A



Isomer B

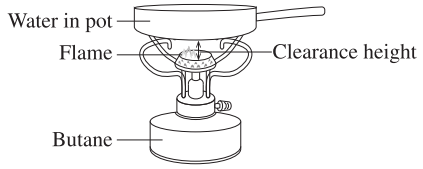
Why are these two compounds classed as functional group isomers? ***(2 marks)***

c. A chemical test is required to distinguish between the isomers in part (b).

Identify a suitable test and explain the expected observations. ***(3 marks)***

40. CHEMISTRY, M8 2018 HSC 28

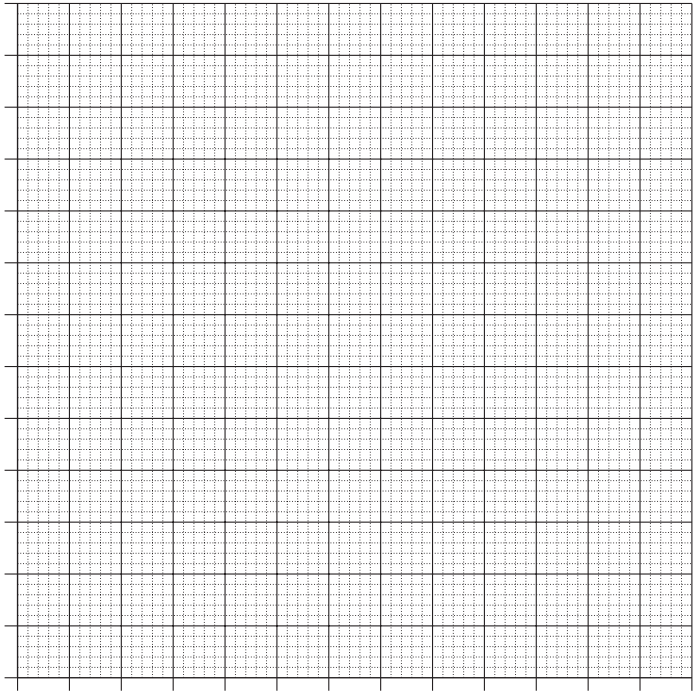
A camp stove using butane as a fuel was used to heat a pot of water inside a small tent. Poisonous carbon monoxide (CO) gas can be released from these stoves.



An investigation was carried out to determine the carbon monoxide concentration in the tent when the clearance height of the pot above the flame was altered. The results are shown in the table.

Clearance height (mm)	35	40	45	50
CO concentration (ppm)	120	87	50	18

a. Construct a graph of the data on the grid. ***(3 marks)***



b. Air containing a (CO) concentration above 30 ppm is considered unsafe to breathe.

What is the minimum clearance height at which the pot should be placed? ***(1 mark)***

c. Increasing the clearance height decreases the efficiency of the stove according to the following table.

Clearance height (mm)	35	40	45	50
Efficiency (%)	90	70	50	30

A bushwalker only has 15.0 g of butane with which to heat 1.0 L of water with a starting temperature of 20°C.

Calculate the highest temperature of the water that could safely be achieved in the tent. (Molar heat of combustion of butane: ΔH_c = 2877 kJ mol $^{-1}$) ***(4 marks)***

41. CHEMISTRY, M8 2022 HSC 27

A bottle labelled 'propanol' contains one of two isomers of propanol.

a. Draw the TWO isomers of propanol. ***(2 marks)***

b. Describe how $^{13}\mathrm{C\ NMR}$ spectroscopy might be used to identify which isomer is in the bottle. ***(2 marks)***

c. Each isomer produces a different product when oxidised.

Write equations to represent the oxidation reactions of the two isomers. Include reaction conditions. ***(3 marks)***

42. CHEMISTRY, M7 2024 HSC 35

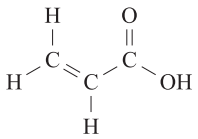
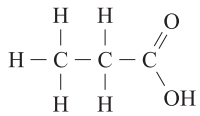
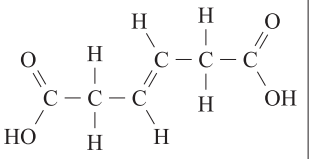
Unknown samples of three carboxylic acids, labelled X , Y and Z, are analysed to determine their identities.

- Both Y and Z react rapidly with bromine in the absence of UV light, but X does not. A 0.100 g sample of Y reacts with the same amount of bromine as a 0.200 g sample of Z.
- Separate 0.100 g samples of X , Y and Z are titrated with 0.0617 mol L^{-1} sodium hydroxide solution. The titre volumes are shown.

Acid	*X*	*Y*	*Z*
Volume of NaOH (mL)	21.88	22.49	22.49

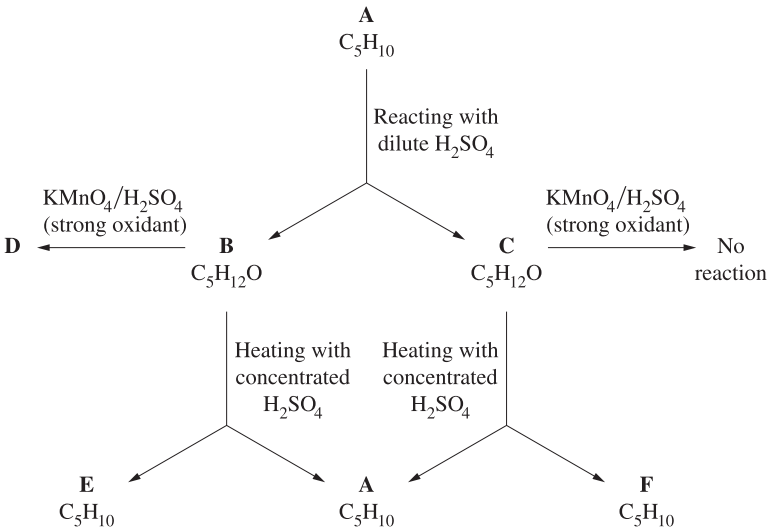
- Both Y and Z can undergo hydration reactions in the presence of a suitable catalyst. Two products are possible for the hydration of Y, but only one product is possible with Z.

Identify which structures 1, 2 and 3 in the table are acids X , Y and Z. Justify your answer with reference to the information provided. ***(7 marks)***

	Structure 1	*Structure 2*	*Structure 3*
			
Molar mass $\left(\mathrm{g\ mol^{-1}}\right)$	72.062 g mol^{-1}	74.078 g mol^{-1}	144.124 g mol^{-1}
Acid (X, Y or Z)			

43. CHEMISTRY, M7 EQ-Bank 26

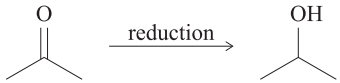
This flow chart shows reactions involving six different organic compounds (**A** to **F**).



Draw the structures of compounds **A** to **F**, justifying your diagrams with reference to the information provided. ***(7 marks)***

44. CHEMISTRY, M8 2024 HSC 33

Acetone can be reduced, as shown.



a. Identify the shape around the central carbon atom in each molecule. ***(2 marks)***

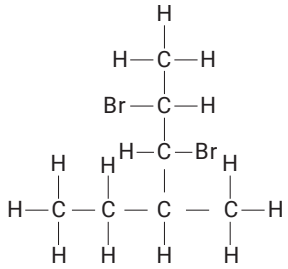
b. Explain how ^{13}C NMR spectroscopy could be used to monitor the progress of this reaction. ***(3 marks)***

45. CHEMISTRY, M7 2018 VCE 1a

Organic compounds are numerous and diverse due to the nature of the carbon atom. There are international conventions for the naming and representation of organic compounds.

i. Draw the structural formula of 2-methyl-propan-2-ol. ***(1 mark)***

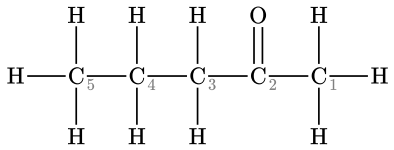
ii. Give the molecular formula of but-2-yne. ***(1 mark)***



iii. Give the IUPAC name of the compound that has the structural formula shown above. ***(1 mark)***

Worked Solutions

1. CHEMISTRY, M7 2019 HSC 1 MC



The ketone functional group is on the second carbon atom.

$\Rightarrow D$

2. CHEMISTRY, M7 2023 HSC 1 MC

→ Organic substances should be kept separate for safety (avoiding any possible other reactions).

$\Rightarrow D$

3. CHEMISTRY, M7 2015 VCE 13 MC

$\mathrm{CH_3CH_2CH=CH_2 + Cl_2 \rightarrow CH_3CH_2CHClCH_2Cl}$

→ Product is 1,2-dichlorobutane

$\Rightarrow A$

4. CHEMISTRY, M7 2015 VCE 5 MC

→ Renewable energy sources have the potential to be replenished at the same rate as their consumption.

$\Rightarrow D$

5. CHEMISTRY, M7 2017 HSC 3 MC

Compound: 2-chloro-1-fluorobutane

→ Functional groups are named alphabetically and hence -chloro precedes -fluoro.

$\Rightarrow A$

6. CHEMISTRY, M7 2019 HSC 10 MC

Consider each option

→ Aldehydes can form methanal (1 carbon atom – eliminate)

→ Alkenes can form ethene (2 carbon atoms – eliminate)

→ Carboxylic acids can form methanoic acid (1 carbon atom – eliminate)

→ Ketones can for propanone (3 carbon atoms)

$\Rightarrow D$

Worked Solutions

7. CHEMISTRY, M7 2022 HSC 9 MC

Drawing out the condensed structural formula matches the structure in A.

$\Rightarrow A$

8. CHEMISTRY, M7 2023 HSC 3 MC

→ The organic molecule has a 5-Carbon backbone, therefore the prefix will be “Pent”

→ The molecule contains no branches, so the rest of its name will be defined by the triple carbon bond “yne”

→ The rules of nomenclature state that the name must assign the triple carbon bond the lowest carbon number, this is achieved by numbering the carbons from right to left, placing the triple carbon bond at carbon 2

→ Hence the name of the compound is “Pent-2-yne”

$\Rightarrow B$

9. CHEMISTRY, M7 2024 HSC 1 MC

→ A homologous series refers to compounds with the same or similar functional group and same general formula.

→ Both substances in A contain a hydroxyl group.

$\Rightarrow A$

10. CHEMISTRY, M7 2016 HSC 15 MC

→ Compound W is unsaturated (C–C multiple bonds exist).

→ Compound X is saturated (all C–C bonds are single bonds).

→ Shorter alcohols, such as $\mathrm{CH_3OH}$ are more soluble.

$\Rightarrow A$

11. CHEMISTRY, M7 2019 HSC 9 MC

→ Carboxyllic acids have a high affinity for hydrogen bonding, the strongest molecular force.

→ They therefore require more heat to break the intermolecular forces to convert liquid to gas versus other substances.

$\Rightarrow B$

12. CHEMISTRY, M7 2020 VCE 4 MC

→ Molecule has a 5-carbon chain with single bonds (“pentan”)

→ Alcohol functional group attached to 3rd carbon (“-3-ol”)

$\Rightarrow D$

13. CHEMISTRY, M7 2021 HSC 13 MC

By elimination:

→ Hydration reaction is an addition reaction that can only occur on alkenes, thus X = prop-1-ene (eliminate A and B)

→ Y = propan-2-ol

→ The oxidation of secondary alcohol creates a ketone, thus Z = propanone

$\Rightarrow C$

14. CHEMISTRY, M7 2021 HSC 3 MC

Compound is a secondary amide.

→ Pre-fix (longest carbon chain) → -propan

→ Suffix (functional group) → -amide

→ Alkyl chain bound to the amide nitrogen is treated as a substituent and as it is bound to the nitrogen atom → N-methyl

∴ Compound name is N-methylpropanamide

$\Rightarrow A$

15. CHEMISTRY, M7 2021 HSC 7 MC

→ The product of the substitution reaction between methanol and hydrogen bromide is bromomethane.

→ Methanol contains an OH functional group and thus can form strong hydrogen bonds.

→ Bromomethane can only form dipole-dipole forces which are weaker than hydrogen bonds. As a result, bromomethane requires less energy to break these intermolecular forces, resulting in a lower boiling point than methanol.

$\Rightarrow A$

16. CHEMISTRY, M7 2023 HSC 10 MC

→ Compounds with functional groups capable of hydrogen bonding have higher boiling points (due to stronger bonds, more energy is required to break)

$\Rightarrow A$

17. CHEMISTRY, M7 2024 HSC 12 MC

Compound is a secondary amide.

→ Pre-fix (longest carbon chain) ⇒ -butan

→ Suffix (functional group) ⇒ -amide,

→ Alkyl chain bound to the amide nitrogen is treated as a substituent and as it is bound to the nitrogen atom ⇒ N-ethyl

→ As the amide group has the highest priority for the naming of the compound, carbon 1 is the carbon with the nitrogen and oxygen atom attached to it.

→ Hence, the chlorine atom is attached to carbon 3.

→ Compound name is 3-chloro-N-ethylbutanamide

$\Rightarrow C$

18. CHEMISTRY, M8 2020 HSC 5 MC

→ The $^{13}\mathrm{C}$ NMR spectrum shows two signals, indicating 2 unique carbon environments.

→ Chloroethane is the only compound with 2 unique carbon environments.

$\Rightarrow A$

19. CHEMISTRY, M7 2016 VCE 22 MC

♦♦ Mean mark 30%.

Addition reaction:

→ $\mathrm{Cl_2}$ has added across the $\mathrm{C=C}$ double bond (eliminate D).

Redox reaction:

→ The oxidation state of Cl decreases from zero in $\mathrm{Cl_2\,(g)}$ to −1 $\mathrm{CH_2ClCH_2Cl(l)}$.

→ In $\mathrm{CH_2=CH_2}$, the oxidation state of each H is +1, which means that the oxidation state of each C is −2 .

→ In $\mathrm{CH_2ClCH_2Cl}$, the oxidation states are $\mathrm{H:}$ +1, $\mathrm{Cl:}$ −1, $\mathrm{C:}$ −1

→ The oxidation state of C has increased (from −2 to −1) and the oxidation state of Cl has decreased from 0 to −1 , confirming it is a redox reaction.

$\Rightarrow C$

20. CHEMISTRY, M7 2017 HSC 7 MC

♦♦ Mean mark 33%.

By Elimination:

→ Liquids are immiscible (eliminate A and D).

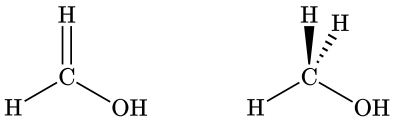
→ Bromine water does not decolourise with with alkanes, but does with alkenes (eliminate B).

$\Rightarrow C$

21. CHEMISTRY, M7 2020 HSC 13 MC

Methanoic acid is a trigonal planar shape around the carbon atom, whereas methanol is a tetrahedral shape.

♦ Mean mark 45%.



Methanoic acid

Methanol

$\Rightarrow B$

22. CHEMISTRY, M7 2020 HSC 6 MC

→ The hydroxyl functional group has the highest priority and therefore its associated C is given the lowest possible number.

♦ Mean mark 50%.

→ The substituents are named in alphabetical order.

$\Rightarrow D$

23. CHEMISTRY, M7 2020 HSC 7 MC

Consider each option:

→ Chain isomers have a different structure of the C chain. Compound 1, 2 and 4 have the same C chain structure (eliminate A and B).

♦ Mean mark 49%.

→ Positional isomers have the same C chain but with different allocations of the same functional group (eliminate D).

→ Functional group isomers occur when atoms form different functional groups. Compound 2 has a double bond and an OH group, whereas Compound 3 only contains an ester group (correct).

$\Rightarrow C$

24. CHEMISTRY, M7 2020 VCE 7 MC

Isomers are:

♦ Mean mark 46%.

$CH_3CH_2CHBrCl$: 1-bromo-1-chloropropane

$CH_3CHClCH_2Br$: 1-bromo-2-chloropropane

$CH_2ClCH_2CH_2Br$: 1-bromo-3-chlorooopropane

$CH_3CHBrCH_2Cl$: 2-bromo-1-chloropropane

$CH_3CBrClCH_3$: 2-bromo-2-chloropropane

$\Rightarrow B$

25. CHEMISTRY, M7 2022 HSC 7 MC

→ When drawn, the organic compound contains a carbon chain of 7 carbon atoms.

♦ Mean mark 43%.

→ The methyl group should be numbered with the lower carbon number. Thus, the correct name IUPAC name is 4-chloro-3-methylheptane.

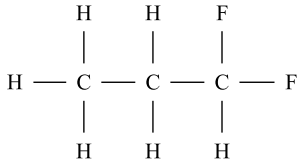
$\Rightarrow B$

26. CHEMISTRY, M7 2023 HSC 8 MC

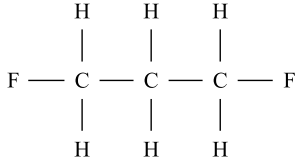
→ Structural Isomers will have the same molecular formula but different structures.

♦ Mean mark 53%.

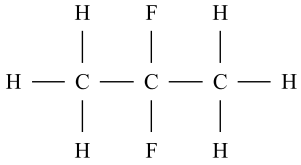
→ The fluoride Ions can exists at different points on the carbon chain, changing the name and structure of the compound without altering its molecular formula.



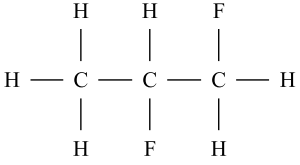
1,1-difluoropropane



1,3-difluoropropane



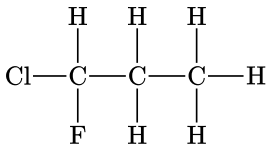
2,2-difluoropropane



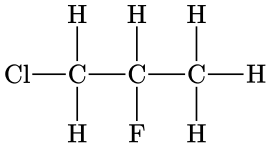
1,2-difluoropropane

$\Rightarrow C$

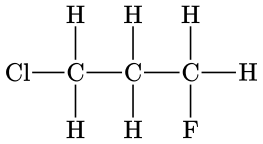
27. CHEMISTRY, M7 2018 HSC 14 MC



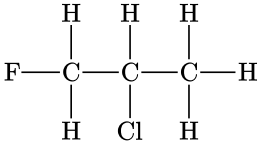
1-chloro-1-fluoropropane



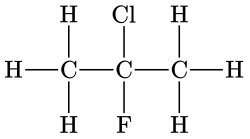
1-chloro-2-fluoropropane



1-chloro-3-fluoropropane



2-chloro-1-fluoroproprane



2-chloro-2-fluoropropane

♦♦ Mean mark 39%.

$\Rightarrow C$

28. CHEMISTRY, M7 2016 HSC 11 MC

By Elimination:

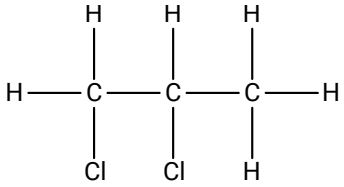
→ Halogen substituents must be in alphabetical order (eliminate B and C)

→ Numbers are allocated using the first point of difference rule (eliminate A)

$\Rightarrow D$

♦♦♦ Mean mark 28%.

29. CHEMISTRY, M7 2022 HSC 21



30. CHEMISTRY, M7 2023 HSC 21

Functional Group: Butan-2-one and butanal

Chain: Butanal and 2-methylpropanal

31. CHEMISTRY, M8 2021 HSC 21

a. A safety concern is that the organic liquids are flammable.

To address this, keep substance away from open flames and keep away from ignition sources.

b. Flask 1: propanoic acid (carboxylic acids can't be oxidised and are polar)

Flask 2: hex-1-ene (alkenes can be oxidised and are non-polar)

Flask 3: propan-1-ol (primary alcohols can be oxidised and are polar)

Flask 4: hexane (alkanes don't react with acidified oxidants and are non-polar)

c. Hex-1-ene

→ Could be identified using the bromine water test.

→ The addition of brown bromine water to an alkene causes an addition reaction where the solution changes colours from brown to colourless.

Propanoic acid

→ Could be identified through a neutralisation reaction using $\mathrm{Na_2CO_3}$.

→ Effervescent reaction will result.

Propan-1-ol

→ Could be identified through an oxidation reaction using acidified dichromate.

→ The reaction would cause the solution to change from green to orange.

32. CHEMISTRY, M7 2016 VCE 2*

→ 7 carbon string with single carbon and hydrogen bonds = heptane

→ Two methyl groups attached to carbon 3 and 4 (IUPAC convention)

→ Correct name is: 3,4-dimethylheptane

33. CHEMISTRY, M7 2020 HSC 32

→ The boiling points of all compounds are a function of the strength of their intermolecular forces.

→ All three compounds are polar and have dispersion forces between molecules and dipole-dipole interactions.

→ Methanol and propanoic acid can also form hydrogen bonds (strongest type of intermolecular force).

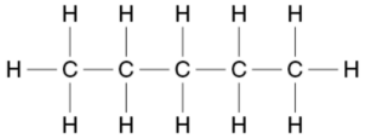
→ Methyl propanoate's larger size gives it stronger dispersion forces than methanol and propanoic acid, but it cannot form hydrogen bonds.

→ Despite having weaker dispersion forces, propanoic acid can form two hydrogen bonds per molecule, which makes up for its weaker dispersion forces and results in stronger overall intermolecular forces than methyl propanoate.

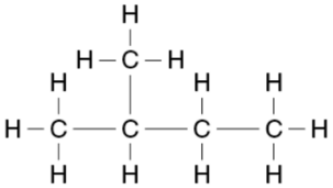
→ Methanol is a polar molecule that can form strong hydrogen bonds due to its hydroxyl group. However, it has the lowest boiling point due to its small molar mass, resulting in weaker dispersion forces.

34. CHEMISTRY, M7 2021 HSC 24

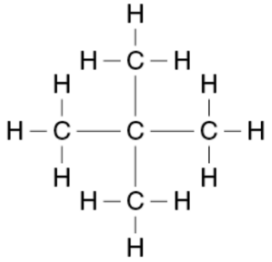
Straight chained alkane (Pentane):



2-methylbutane:



2,2-dimethylpropane:



35. CHEMISTRY, M7 2022 HSC 24

→ As the molar masses increase, the boiling point of 1-chloroalkanes increases.

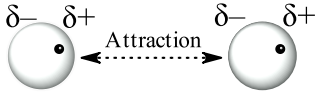
→ This is due to molecules with a larger molar mass containing more electrons. This allows for a higher likelihood of unequal electron distribution, thus, causing stronger dispersion forces.

→ Since more energy is required to break stronger dispersion forces, 1-chloroalkanes with higher molar masses have higher boiling points.

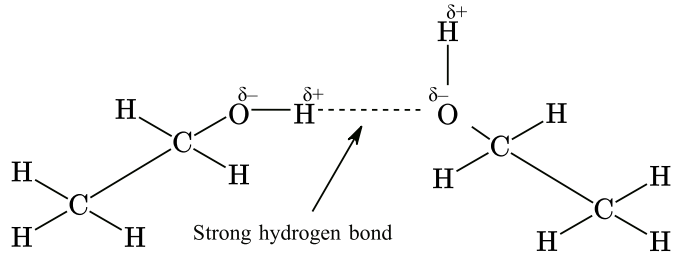
36. CHEMISTRY, M7 EQ-Bank 24

→ Alkanes are saturated hydrocarbons – i.e. they are made up of carbon and hydrogen atoms only and all atoms are joined together by single covalent bonds which are non-polar.

→ Weak intermolecular forces (Van der Waals) are therefore the only forces holding alkane molecules together and as a result, alkanes have low boiling points.



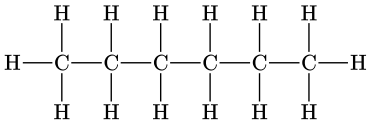
→ In contrast, alcohols have an OH functional group. The OH bond is polar with an oxygen "pole" that is slightly negatively charged and hydrogen "pole" that is slightly positively charged.



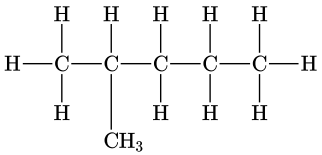
→ The hydrogen atom on one molecule will form an electrostatic bond with the oxygen atom on another atom creating a hydrogen bond.

→ Since hydrogen bonds are much stronger intermolecular forces than dispersion forces, the boiling points of alcohols are significantly higher than those of alkanes with the same carbon lengths.

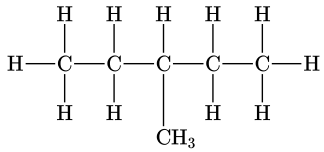
37. CHEMISTRY, M7 EQ-Bank 25



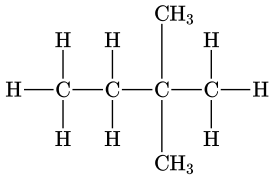
Hexane



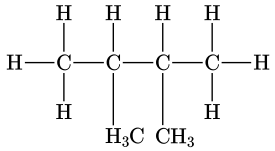
2-methylpentane



3-methylpentane



2,2-dimethylbutane



2,3-dimethylbutane

38. CHEMISTRY, M8 2016 HSC 25

$$n(C_8H_{18}) = \frac{m}{MM} = \frac{6000}{8 \times 12.01 + 18 \times 1.008} = \frac{6000}{114.224} = 52.53\,\text{mol}$$

$$n(CO) = 8 \times n(C_8H_{18}) = 420.24\,\text{mol}$$

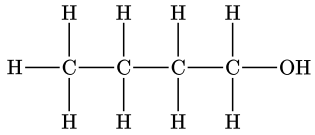
$$m(CO) = n \times MM = 420.24 \times (12.01 + 16.00) = 11\,771\,\text{g}$$

$$[CO] = \frac{11\,771}{1 \times 10^5} = 0.118\,\text{g L}^{-1}$$

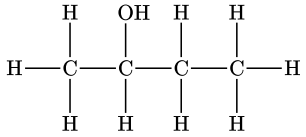
→ The carbon monoxide level is dangerous to human health as 0.118 g L^{-1} exceeds the safe limit of 0.100 g L^{-1} .

39. CHEMISTRY, M7 2019 HSC 21

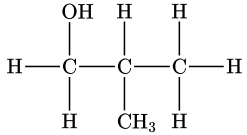
a. Successful answers should have one of the following:



butan-1-ol



butan-2-ol



2-methylpropan-1-ol

b. Functional Group isomers

→ Both isomers have the same number and type of atoms, but they have different arrangements of those atoms and therefore have different functional groups.

→ Isomer A has a ketone functional group, while isomer B has an aldehyde functional group.

c. Tollens' Test:

♦♦ Mean mark (c) 39%.

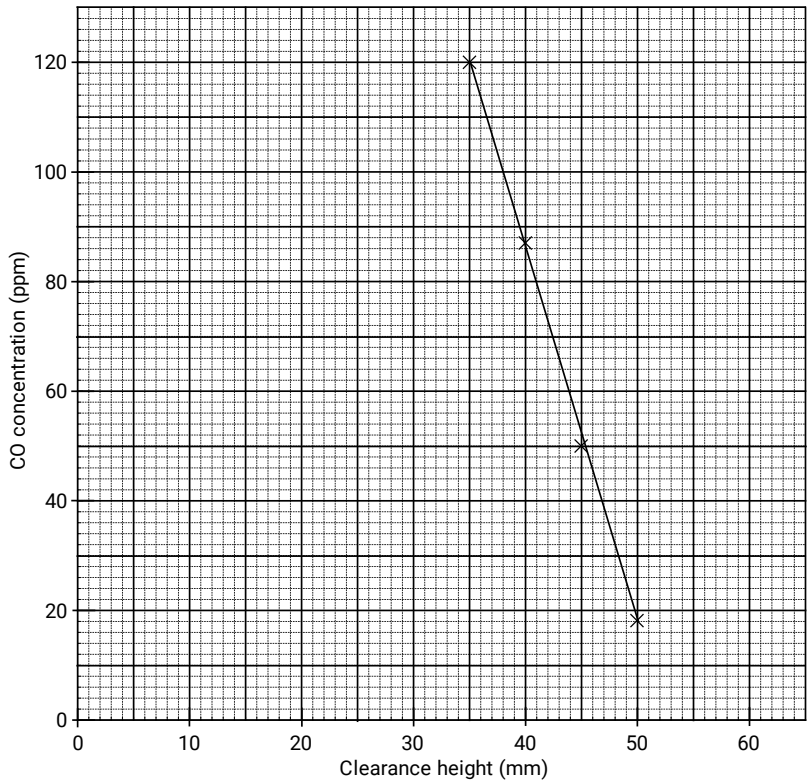
→ The Tollens' test can be used to differentiate between Isomer A (a ketone) and Isomer B (an aldehyde).

→ Isomer B will be readily oxidised to a carboxylic acid, whereas isomer A will not.

→ As a result, Isomer B will reduce the silver-ions in Tollens' reagent to form a silver mirror inside the test tube, while Isomer A will not react.

40. CHEMISTRY, M8 2018 HSC 28

a.



b. From the graph, the minimum height above the flame is 48 mm.

c. → The lowest safe distance = 48 mm (part (b)).

→ Fuel efficiency is 40% at 48 mm

Mean mark (c) 54%.

→ $\Delta H_c = 0.4 \times 2877 = 1151 \text{ kJ mol}^{-1}$

$$\text{n}(\text{C}_4\text{H}_{10}) = \frac{\text{m}}{\text{MM}} = \frac{15}{4 \times 12.01 + 10 \times 1.008} = \frac{15}{58.12} = 0.258 \text{ mol}$$

$$\text{Energy } (\text{C}_4\text{H}_{10}) = 0.258 \times 1151 = 297 \text{ kJ}$$

$$q = mC\Delta T$$

$$297\ 000 = 1.0 \times 4.18 \times 10^3 \times \Delta T$$

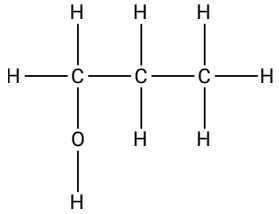
$$\Delta T = \frac{297\ 000}{4.18 \times 10^3}$$

$$= 71.1^\circ\text{C}$$

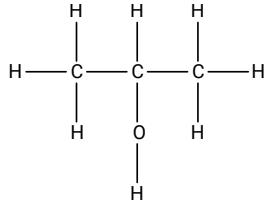
$\therefore$ Highest temperature of water = 20.0 + 71.1 = 91.1°C

41. CHEMISTRY, M8 2022 HSC 27

a. Isomer 1:



Isomer 2:

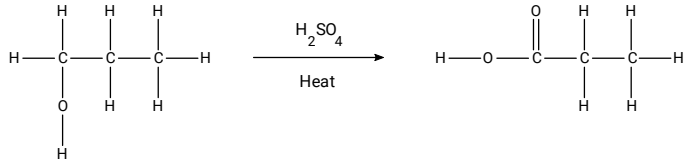


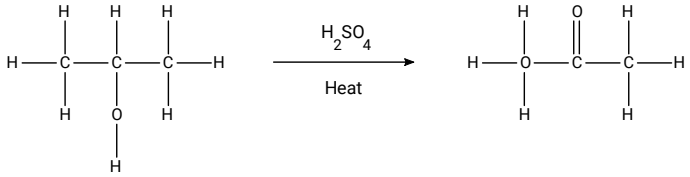
b. Identifying isomers with $^{13}\text{C NMR}$ spectroscopy:

→ this can be used to identify the isomers in the bottle because they show a different number of signals which helps deduce the carbon environment.

→ Propan-1-ol contains 3 C environments so it would have 3 peaks on a $^{13}\text{C NMR}$ spectrum whereas propan-2-ol only contains 2 C environments (due to symmetry), so it would only have 2 signals on a $^{13}\text{C NMR}$ spectrum.

c.





♦ Mean mark (c) 52%.

42. CHEMISTRY, M7 2024 HSC 35

♦ Mean mark 55%.

→ Both sample Y and Z undergo an addition reaction with bromine and a hydration reaction. Therefore these samples must contain a $\mathrm{C=C}$ bond.

→ As sample X, undergoes neither of these reactions, it must have no $\mathrm{C=C}$ bond, thus sample X is structure 2.

→ Both structure 1 and structure 3 contain 1 $\mathrm{C=C}$ each $\Rightarrow$ they will react in a $1:1$ with $\mathrm{Br_2}$. Hence the same number of moles of the carboxylic acid samples will react with the bromine.

→ Since the mass of sample Z that reacts with the bromine is double the mass of sample Y, the molar mass of sample Z must be double the molar mass of sample Y following the formula $m = n \times MM$.

→ Therefore, sample Y is structure 1 and sample Z is structure 3.

Other information provided that could support identification includes:

→ The two products formed for the hydration of Y is due to the asymmetry of structure 1 and the single product formed in the hydration of Z is due to the symmetrical nature of structure 3.

The titration values are consistent with the proposed samples and their corresponding structures.

→ $\mathrm{n(NaOH)}$ reacted with $\mathrm{X} = 0.0617 \times 0.02188 = 1.35 \times 10^{-3}\ \mathrm{mol}$

$\mathrm{n_X} = \dfrac{0.100}{74.078} = 0.00135\ \mathrm{mol}$. Therefore X reacts in a $1:1$ molar ratio as it is a monoprotic acid.

→ $\mathrm{n(NaOH)}$ reacted with Y and $\mathrm{Z} = 0.0617 \times 0.02249 = 1.39 \times 10^{-3}\ \mathrm{mol}$

$\mathrm{n_Y} = \dfrac{0.100}{72.062} = 0.00139\ \mathrm{mol}$. Therefore Y reacts in a $1:1$ molar ratio as it is a monoprotic acid.

$\mathrm{n_Z} = \dfrac{0.100}{144.124} = 0.0006938\ \mathrm{mol}$. Therefore Z reacts in a $2:1$ molar ratio with NaOH as it is a diprotic acid.

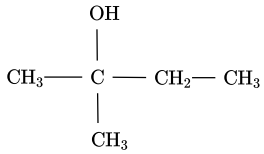
→ The equal volumes of Y and Z used in the titration can be attributed to Z having twice the molar mass of Y and being a diprotic acid.

43. CHEMISTRY, M7 EQ-Bank 26

→ **A** combines with dilute $\mathrm{H_2SO_4}$ to produce two alcohols.

→ **C** doesn't react with strong oxidant (i.e. it is a tertiary alcohol).

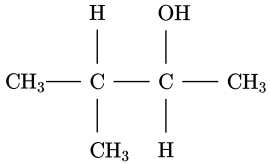
C:



→ **B** must therefore be 2-methylbutan-1-ol or 3-methylbutan-2-ol.

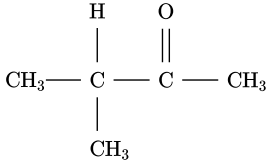
→ Since **B** gives two products when heated with concentrated $\mathrm{H_2SO_4}$, it must be 3-methylbutan-2-ol, as 2-methylbutan-1-ol will only produce one product.

B:



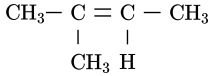
→ **D** is a ketone, produced by **B** reacting with a strong oxidant.

D:



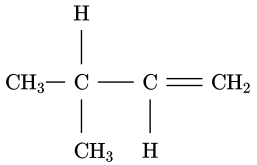
→ **A** can be dehydrated using concentrated $\mathrm{H_2SO_4}$ on either **B** or **C**.

A:



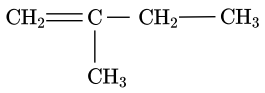
→ **B** dehydrates to **A** or **E**. Given **A**'s structure above,

E:



→ **C** dehydrates to **A** or **F**. Again, given A's structure above,

F:



44. CHEMISTRY, M8 2024 HSC 33

a. Acetone:

♦ Mean mark (a) 44%.

→ Double bond and 2 single bonds coming off the central carbon atom ⇒ trigonal planar.

Product:

→ Contains single bonds coming off the central carbon atom ⇒ tetrahedral. (Note: the hydrogen bonded to the central carbon atom in the product molecule is not shown due to the skeletal structure)

b. $^{13}\text{C NMR}$ Spectroscopy:

→ $^{13}\text{C NMR}$ will differentiate between molecules with different carbon environments. This produces different signals on the $^{13}\text{C NMR}$ spectrum.

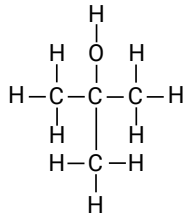
→ The acetone would produce two signals on the $^{13}\text{C NMR}$ spectrum. The first signal would be due to the CH_3 groups either side of the central carbon between 20-50 ppm. The second signal would be from the carbonyl group between 190-220 ppm.

→ The product of the reduction would also produce two signals on the $^{13}\text{C NMR}$ spectrum. The carbon with the hydroxyl group attached to it would produce a signal between 50-90 ppm and the CH_3 groups either side would produce a signal between 5-40 ppm.

→ The reaction can be monitored by observing the disappearance of the carbonyl signal (190-220 ppm) and appearance of the hydroxyl signal (50-90 ppm) as acetone is reduced to the product.

45. CHEMISTRY, M7 2018 VCE 1a

i.



ii. C_4H_6

→ Structural or semi-structural formulas are not appropriate.

iii. → Longest carbon chain is 6, hence hexane

♦♦♦ Mean mark (c) 27%.

→ Number carbons to give functional group lowest possible numbers: 2,3-dibromo, 4-methyl

→ Compound name: 2,3-dibromo-4-methylhexane