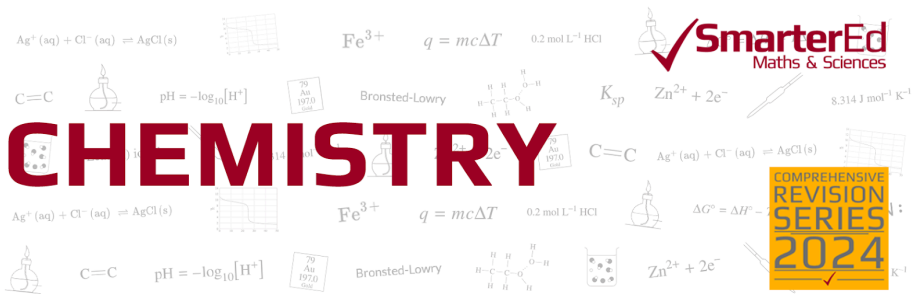


Thank you for subscribing to SmarterScience Teacher Edition in 2024.

Key features of the Chemistry "2024 HSC Comprehensive Revision Series" for include:

- ~15 hours of cherry picked HSC revision questions by topic
- Targeted at motivated students aiming for a Band 5 or 6 result
- Weighting toward more difficult examples
- Mark allocations given to each topic generally reflect its historical (new syllabus) HSC exam allocation.
- ***Attempt, carefully review and annotate*** this revision set in Term 3
- This question set provides the foundation of a concise and high quality revision resource for the run into the HSC exam.
- This resource should be used to complement (not replace) the critical final stretch preparation for every student - timed full exam practice papers.

Our analysis on each topic, the common question types, past areas of difficulty and recent HSC trends all combine to create this revision set that ensures students cover a wide cross-section of the key areas.

IMPORTANT: If students have been exposed to questions in these worksheets during the year, we say great. Many top performing students attest to the benefits of doing quality questions 2-3 times before the HSC. This type of revision set is aimed at creating confidence and *speed through the exam*, with cherry picked questions that cover all important elements of revision while avoiding low percentage rabbit hole excursions.

M7 Organic Chemistry – Alcohols (~11.3% historical contribution)

Key Areas addressed by this worksheet

- Alcohols is the blue whale of the Organic Chemistry Module 7 ocean, accounting for almost half the total allocated exam marks for this module!
- *Reactions of Alcohols* is the largest sub-topic, appearing in the longer-answer section of each new syllabus exam between 2019-22 as well as multiple-choice in 2022 and 2021.
- Students require a deep understanding of multistep synthesis and reaction pathways to score highly and must be able to both predict and draw the structural formulae of chemical reactions. Multiple examples cover this critical area.
- *Combustion* is a very consistent contributor, attracting long response questions in 4 of the last 5 new syllabus exams (only absent in 2021). The enthalpy of combustion is a key concept that is covered in multiple examples.
- Oxidation of Alcohols was examined in numerous questions in 2022 and 2021. Revision questions require a solid knowledge of the products formed when primary and secondary alcohols are oxidised.
- *Biofuels* have been examined in two new syllabus exams, most recently in 2023, and are covered.
- *Production* of alcohol was last examined in 2023 HSC 27 with a 4-mark allocation. This sub-topic is given deserved revision attention because when it appears, mark allocations are high and mean marks are low.

Study secret - pomodoros

Technique:

- *Phone on airplane mode, face-down (not to be touched)*
- *25-minute full focus clip of study on a timer*
- *5 minutes rest*
- *Repeat 4 times.*
- *If your 25-minute focus is compromised in any way, start the timer again*

CHEMISTRY
Stage 6

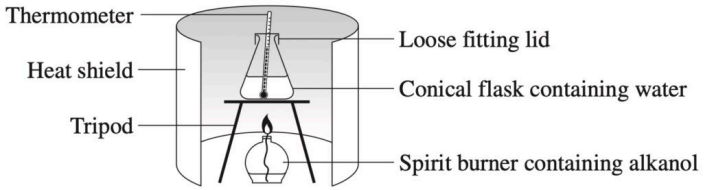
2024 Comprehensive Revision Series
M7 Organic Chemistry
- Alcohols

Exam Equivalent Time: 105 minutes *(based on allocation of 1.5 minutes per mark)*

Questions

1. CHEMISTRY, M7 2017 HSC 9 MC

The following equipment was set up to measure the heat of combustion of an alkanol.



Black deposits were observed on the bottom of the conical flask and the heat of combustion measured was lower than the theoretical value.

Which of the following equations could account for these observations?

A. $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$

B. $C_3H_8O(g) + 4O_2(g) \rightarrow CO_2(g) + CO(g) + 4H_2O(g)$

C. $2C_4H_{10}O(g) + 3O_2(g) \rightarrow 8C(s) + 2H_2(g) + 8H_2O(g)$

D. $2C_2H_6O(g) + 4O_2(g) \rightarrow 2CO_2(g) + 2C(s) + 6H_2O(g)$

2. CHEMISTRY, M7 2018 HSC 10 MC

Which row of the table correctly matches the reaction type with the reactant(s), catalyst and product(s)?

	Reaction type	*Reactant(s)*	*Catalyst*	*Product(s)*
A.	Hydration	$C_2H_4 + H_2O$	Dilute acid	C_2H_6
B.	Hydration	C_2H_4	Concentrated acid	C_2H_5OH
C.	Dehydration	C_2H_5OH	Dilute acid	C_2H_4
D.	Dehydration	C_2H_5OH	Concentrated acid	$C_2H_4 + H_2O$

3. CHEMISTRY, M7 2015 HSC 17 MC

What volume of carbon dioxide will be produced if 10.3 g of glucose is fermented at 25°C and 100 kPa?

A. 1.30 L

B. 1.42 L

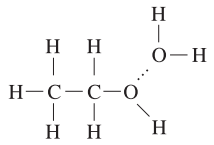
C. 2.57 L

D. 2.83 L

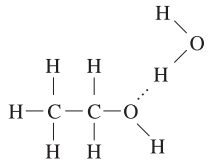
4. CHEMISTRY, M7 2016 HSC 5 MC

Which of the following diagrams best represents the bonding between molecules of water and ethanol?

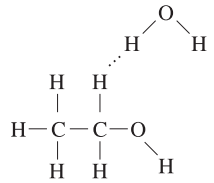
(A)



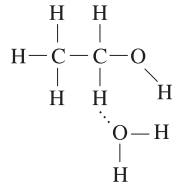
(B)



(C)



(D)



5. 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

6. CHEMISTRY, M7 2021 HSC 13 MC

A chemist synthesises a substance using the following pathway.

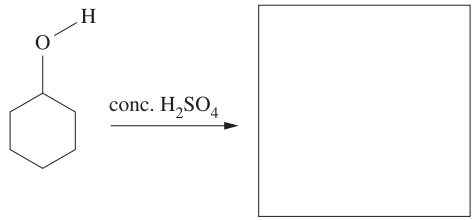
$$\mathbf{X} \xrightarrow{\text{hydration}} \mathbf{Y} \xrightarrow{\text{oxidation}} \mathbf{Z}$$

What are compounds $\mathbf{X, Y, Z}$?

	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

7. CHEMISTRY, M7 2022 HSC 11 MC

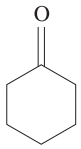
Cyclohexanol is an alcohol and undergoes a dehydration reaction with sulfuric acid as shown.

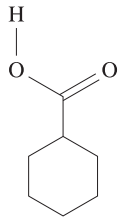


What is the major organic product of this reaction?

A. 

B. 

C. 

D. 

8. CHEMISTRY, M7 2023 HSC 15 MC

The table gives the heat of combustion of three different alcohols at 25°C.

Alcohol	*Heat of combustion* (Kj g^{-1})
Methanol	22.68
Ethanol	29.67
Butan-1-ol	36.11

Which of the following gives the best approximation for the molar heat of combustion of propan-1-ol, expressed in kJ g^{-1}?

A. $\left(\frac{22.68 + 29.67 + 36.11}{3}\right)$

B. $\left(\frac{29.67 + 36.11}{2}\right)$

C. $\left(\frac{22.68 + 29.67}{2}\right)$

D. $\left(\frac{3 \times 36.11}{4}\right)$

9. CHEMISTRY, M7 2015 HSC 10 MC

Which of the equations correctly describes incomplete combustion?

A. $C_2H_5OH(l) + 2O_2(g) \rightarrow 2CO(g) + 3H_2O(l)$

B. $C_2H_5OH(l) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

C. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

D. $C_2H_5OH(l) + 2O_2(g) \rightarrow C(s) + CO(g) + 3H_2O(l)$

10. CHEMISTRY, M7 2016 VCE 24 MC

Methanol is a liquid fuel that is often used in racing cars. The thermochemical equation for its complete combustion is

$$2\,CH_3OH\,(l) + 3\,O_2\,(g) \rightarrow 2\,CO_2\,(g) + 4\,H_2O\,(l) \qquad \Delta H = -1450\,kJ\,mol^{-1}$$

Octane is a principal constituent of petrol, which is used in many motor vehicles. The thermochemical equation for
the complete combustion of octane is

$$2\,C_8H_{18}\,(l) + 25\,O_2\,(g) \rightarrow 16\,CO_2\,(g) + 18\,H_2O\,(l) \qquad \Delta H = -10\,900\,kJ\,mol^{-1}$$

The molar mass of methanol is 32 g mol^{-1} and the molar mass of octane is 114 g mol^{-1}. Which one of the following statements is the most correct?

A. Burning just 1.0 g of octane releases almost 96 kJ of heat energy.

B. Burning just 1.0 g of methanol releases almost 23 kJ of heat energy.

C. Octane releases almost eight times more energy per kilogram than methanol.

D. The heat energy released by methanol will not be affected if the oxygen supply is limited.

---

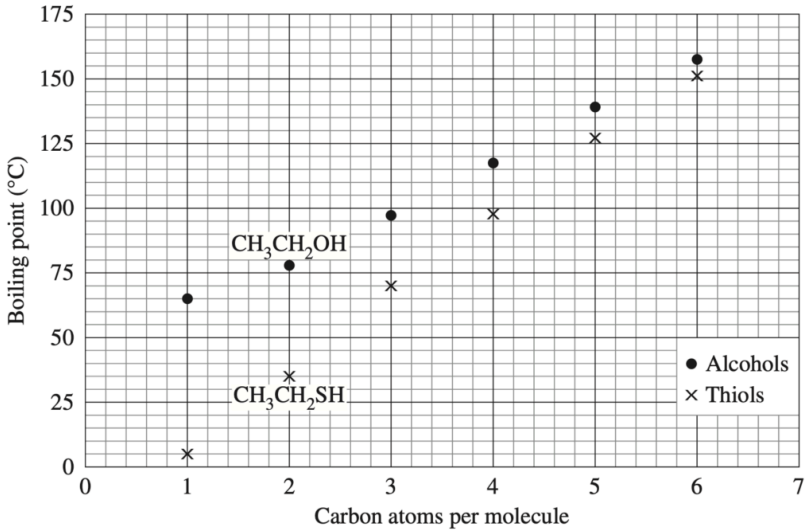
11. CHEMISTRY, M7 2015 VCE 5b

Draw the full structural formula of an isomer of butan-2-ol. *(1 mark)*

---

12. CHEMISTRY, M7 2019 HSC 32

Thiols are the sulfur analogues of alcohols in that the oxygen atom of the alcohol is replaced by a sulfur atom. For example, methanethiol (CH_3SH) is the analogue of methanol (CH_3OH). The boiling points of some straight chain alcohols and thiols are given in the following graph.



Explain the patterns of the boiling points shown in the graph. *(4 marks)*

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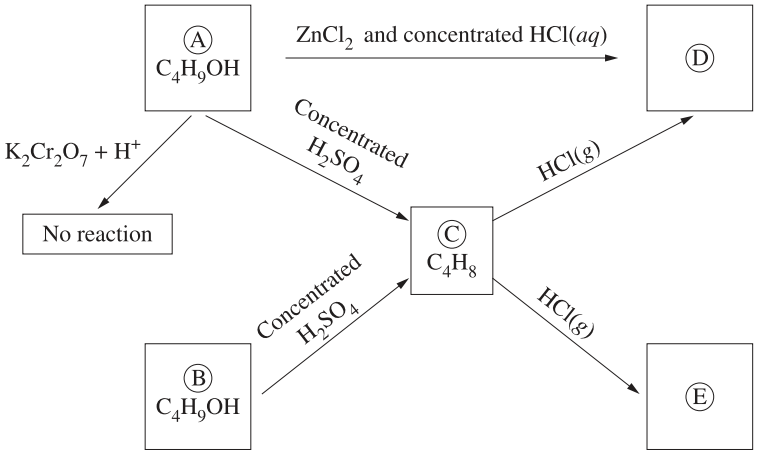
13. CHEMISTRY, M7 2020 HSC 29

The flow chart shows reactions involving five different organic compounds, Ⓐ to Ⓔ



Draw the structure of each compound Ⓐ to Ⓔ in the corresponding space provided. ***(5 marks)***

Ⓐ

Ⓑ

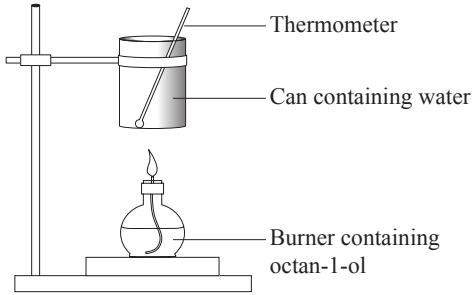
Ⓒ

Ⓓ

Ⓔ

14. CHEMISTRY, M7 2023 HSC 25

A student used the apparatus shown to investigate the combustion of octan-1-ol.



The following results were obtained by the student.

Mass of water heated	= 205 g
Initial temperature of water	= 23.7°C
Final temperature of water	= 60.4°C

The following data are given.

Molar enthalpy of combustion of octan-1-ol	= – 5294 kJ mol^{-1}
Molar mass of octan-1-ol	= 130.23 g kJ mol^{-1}

a. Assuming that no energy released by this combustion is lost to the surroundings, calculate the mass of octan-1-ol burnt. ***(3 marks)***

b. Explain ONE advantage of using a biofuel compared to fossil fuels. ***(2 marks)***

15. CHEMISTRY, M7 2023 HSC 27

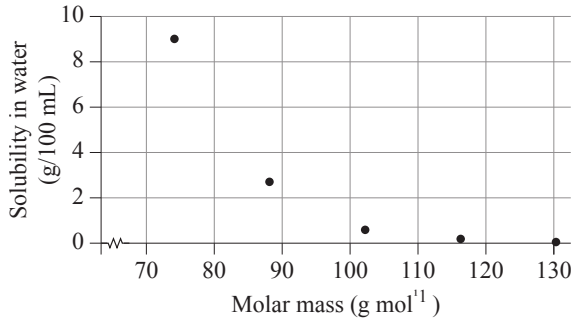
A student has been asked to produce 185 mL of ethanol (MM = 46.068 g mol^{-1}) by fermenting glucose using yeast, as shown in the equation.

$$C_6H_{12}O_6\,(aq) \rightarrow 2\,C_2H_5OH\,(aq) + 2\,CO_2\,(g)$$

Given that the density of ethanol is 0.789 g mL^{-1}, calculate the volume of carbon dioxide gas produced at 310 K and 100 kPa. *(4 marks)*

16. CHEMISTRY, M7 2023 HSC 29

The following graph shows the solubility of some alkan-1-ols in water at 20°C.



Explain the relationship between the trend shown in the graph and the relevant intermolecular forces. *(3 marks)*

17. CHEMISTRY, M7 EQ-Bank 22

Calculate the mass of methanol that must be burnt to increase the temperature of 325 g of water by 65°C, if exactly half of the heat released by this combustion is lost to the surroundings.

The heat of combustion of methanol is 726 kJ mol^{-1}. *(3 marks)*

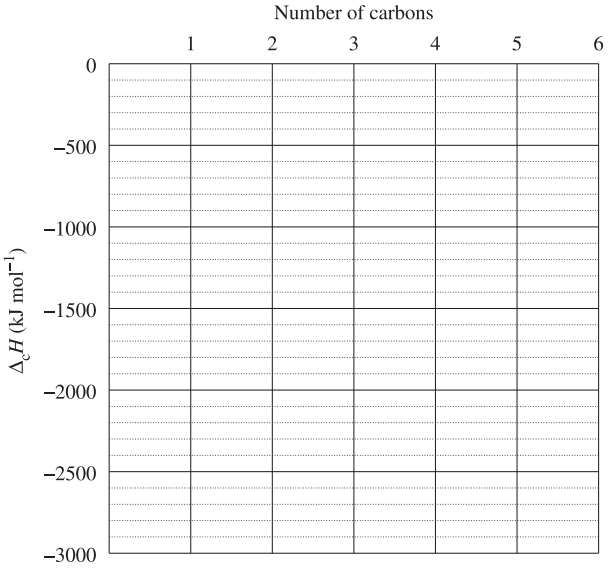
18. CHEMISTRY, M7 2022 HSC 29

The enthalpies of combustion of four alcohols were determined in a school laboratory.

The results are shown in the table.

Alcohol	$\Delta_c H$ (kJ mol^{-1})
Methanol	–596
Ethanol	–978
Propan-1-ol	–1507
Pentan-1-ol	–2910

a. Plot the results, including a curved line of best fit, to estimate the enthalpy of combustion of butan-1-ol. *(3 marks)*



Enthalpy of combustion of butan-1-ol

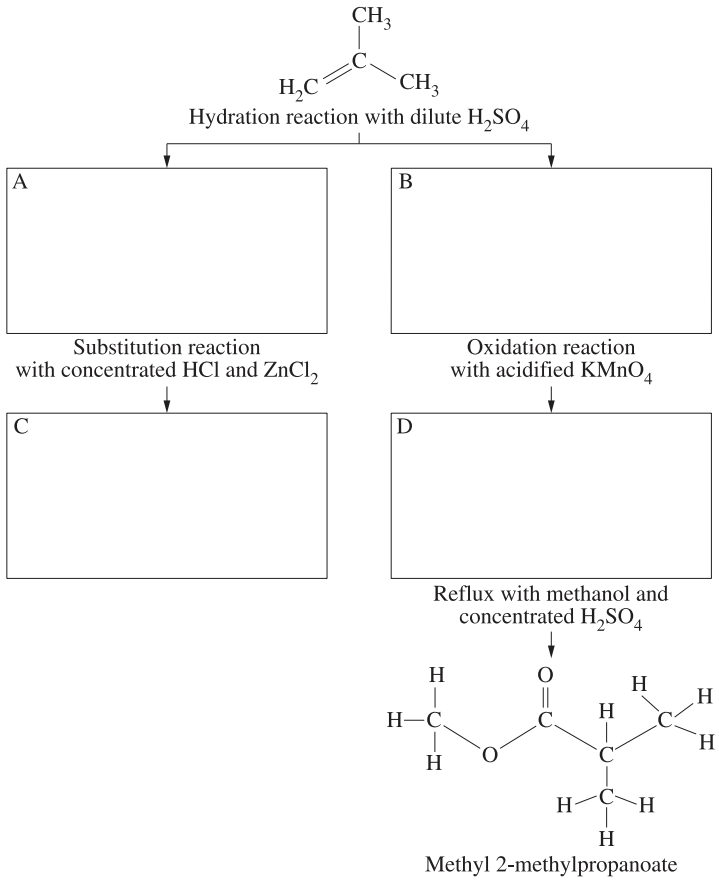
b. The published value for the enthalpy of combustion of pentan-1-ol is closer to -3331 kJ mol^{-1}.

Justify ONE possible reason for the difference between the school's results and published values. *(2 marks)*

19. CHEMISTRY, M7 2021 HSC 26

A sequence of chemical reactions, starting with 2-methylprop-1-ene, is shown in the flow chart.

a. Complete the flow chart by drawing structural formulae for compounds **A**, **B**, **C**, and **D**. *(4 marks)*

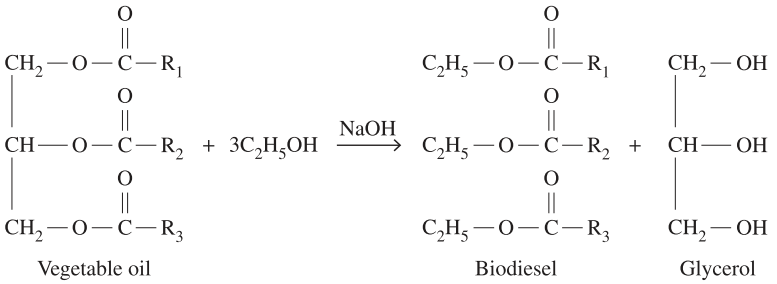


b. Reflux is used in the synthesis of methyl 2-methylpropanoate.

Provide TWO reasons for using this technique. *(2 marks)*

20. CHEMISTRY, M7 2020 HSC 24

Biodiesel, an alternative fuel to diesel, may be produced from vegetable oil. The chemical reaction which converts oils from biomass into biodiesel is shown. $\mathbf{R_1}$, $\mathbf{R_2}$ and $\mathbf{R_3}$ are alkyl chains which may vary from 10 to 22 carbons in length.



a. Which functional group is present in both the oil and the biodiesel? *(1 mark)*

b. Explain why biodiesel $(\mathbf{C_{14}H_{30}O_2})$ produces less soot than diesel $(\mathbf{C_{18}H_{38}})$ when combusted under the same conditions. Support your answer with balanced chemical equations. *(3 marks)*

c. The energy densities of biodiesel and diesel are 38 MJ kg^{-1} and 43 MJ kg^{-1} respectively. The densities of biodiesel and diesel are 0.90 kg L^{-1} and 0.83 kg L^{-1} respectively.

When 60.0 L of diesel is combusted in a typical engine, 2141 MJ of energy is released.

What volume of biodiesel would be required to produce the same amount of energy? *(2 marks)*

d. Explain TWO advantages and TWO disadvantages of using bioethanol (ethanol produced from biomass) as an alternative to a fossil fuel. *(4 marks)*

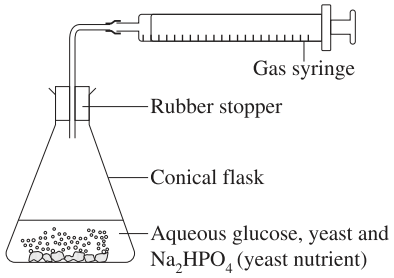
21. CHEMISTRY, M7 2017 HSC 28b

The molar heat of combustion (ΔH_c) for ethanol is 1360 kJ mol^{-1}.

Calculate the energy generated per kg of $\mathbf{CO_2}$ released by the combustion of ethanol. *(3 marks)*

22. CHEMISTRY, M7 2021 HSC 25

A student conducted an experiment in the school laboratory under standard laboratory conditions (25°C, 100 kPa) to determine the volume of carbon dioxide gas produced during the fermentation of glucose. The following apparatus was set up.



The following data were collected.

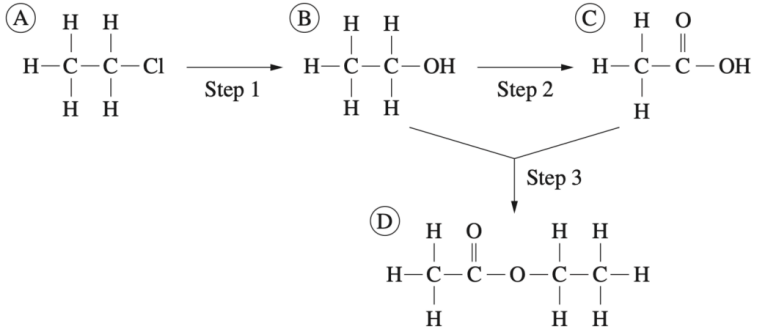
Day	*Total volume of gas* (mL)
1	489
2	677
3	899
4	1006
5	1006

Assume the total volume of gas produced was due to the production of carbon dioxide.

Calculate the mass of ethanol produced by the fermentation reaction. Include a relevant chemical equation in your answer. ***(4 marks)***

23. CHEMISTRY, M7 2019 HSC 34

The following reaction scheme can be used to synthesise ethyl ethanoate.



Outline the reagents and conditions required for each step and how the product of each step could be identified. ***(7 marks)***

Worked Solutions

1. CHEMISTRY, M7 2017 HSC 9 MC

The black deposit is carbon (soot).

By Elimination:

A: Ethane is not an alkanol (eliminate A).

B: No soot is formed in this reaction (eliminate B).

C: This reaction is incorrect as no hydrogen gas is produced (eliminate C).

$\Rightarrow D$

---

2. CHEMISTRY, M7 2018 HSC 10 MC

→ The dehydration of an alkanol $(\mathrm{C_2H_5OH})$ uses a concentrated acid catalyst to produce an alkene $(\mathrm{C_2H_4})$ and water.

$\Rightarrow D$

---

3. CHEMISTRY, M7 2015 HSC 17 MC

$$\mathrm{C_6H_{12}O_6 \longrightarrow 2\,CO_2 + 2\,C_2H_5OH}$$

$$\mathrm{n(C_6H_{12}O_6)} = \frac{10.3}{6 \times 12.01 + 12 \times 1.008 + 6 \times 16} = \frac{10.3}{180.156} = 0.057\,\mathrm{mol}$$

$$\mathrm{n(CO_2)} = 2 \times \mathrm{n(C_6H_{12}O_6)} = 0.114\,\mathrm{mol}$$

$$\mathrm{Volume\ (CO_2)} = 0.114 \times 24.79 = 2.83\,\mathrm{L}$$

$\Rightarrow D$

---

4. CHEMISTRY, M7 2016 HSC 5 MC

→ In a solution of ethanol and water, hydrogen bonding (strongest intermolecular force) occurs between the partially negative oxygen end of the ethanol molecule and the partially positive hydrogen end of a water molecule.

$\Rightarrow B$

---

5. 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.

$\Rightarrow B$

---

6. 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

$\Rightarrow C$

---

7. CHEMISTRY, M7 2022 HSC 11 MC

When alcohols are dehydrated using concentrated $\mathrm{H_2SO_4}$, an OH group and a H atom from the adjacent carbon is eliminated to form an alkene.

$\Rightarrow B$

---

8. CHEMISTRY, M7 2023 HSC 15 MC

→ The boiling point of straight-chained alcohols increases with their chain length.

→ Therefore the boiling point of Propan-1-ol will exist between Ethanol and Butan-1-ol

$\Rightarrow B$

---

9. CHEMISTRY, M7 2015 HSC 10 MC

→ Incomplete combustion produces carbon and/or carbon monoxide (eliminate B and C).

♦ Mean mark 44%.

→ Option D is not balanced (oxygen atoms do not equate)

$\Rightarrow \boldsymbol{A}$

10. CHEMISTRY, M7 2016 VCE 24 MC

Consider option B:

♦ Mean mark 40%.

→ 1 mole of $\mathbf{CH_3OH}$ produces 725 kJ of heat energy

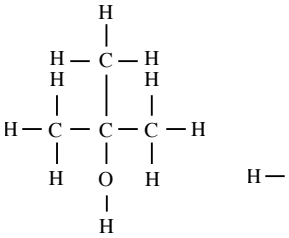
→ $\mathbf{MM\ (CH_3OH) = 32.0\ grams}$

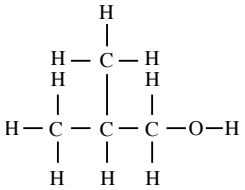
→ Heat energy of 1 gram $\mathbf{CH_3OH} = \dfrac{\mathbf{725}}{\mathbf{32.0}} = \mathbf{22.7}$ kJ

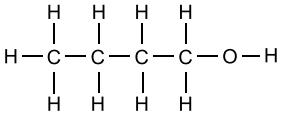
$\Rightarrow \boldsymbol{B}$

11. CHEMISTRY, M7 2015 VCE 5b

Possible images include:







12. CHEMISTRY, M7 2019 HSC 32

→ The boiling point of a compound increases with an increase in the number of carbon atoms due to the increase in dispersion forces.

→ Alcohols have higher boiling points than thiols with the same number of carbon atoms due to the stronger hydrogen bonding in alcohols compared to the weaker dispersion forces in thiols.

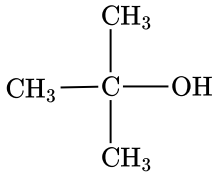
→ As the chain length increases, the difference in boiling point between alcohols and thiols decreases because hydrogen bonding becomes a smaller contributor to the total intermolecular forces and the increasing strength of dispersion forces becomes more significant.

→ Methanol has hydrogen bonding as the dominant intermolecular force, while methanethiol has dipole-dipole forces as the dominant intermolecular force, resulting in a lower boiling point for methanethiol.

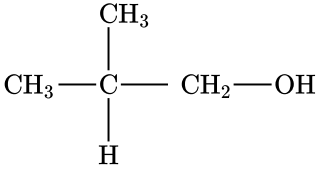
→ As the chain length increases, the thiols have a greater increase in boiling point due to their higher molecular mass and stronger dispersion forces compared to the alcohols.

13. CHEMISTRY, M7 2020 HSC 29

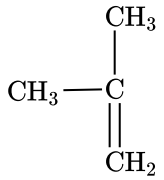
(A)



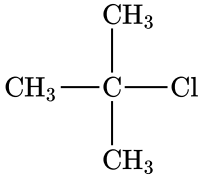
(B)



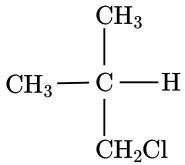
(C)



(D)



(E)



14. CHEMISTRY, M7 2023 HSC 25

a. Find the heat absorbed by the water ((\q\)):

$$
\begin{aligned}
q &= mc\Delta T \\
&= 205 \times 4.18 \times 36.7 \\
&= 31\,488.23 \text{ J} \\
&= 31.448 \text{ kJ}
\end{aligned}
$$

$$\text{octan-1-ol} \Rightarrow C_8H_{18}O$$

$$\text{MM}(C_8H_{18}O) = 12.01 \times 8 + 1.008 \times 18 + 16 = 130.224$$

$$
\begin{aligned}
\text{n(octan-1-ol)} &= \frac{-31.448 \text{ kJ}}{-5294 \text{ kJ mol}^{-1}} \\
&= 5.94 \times 10^{-3} \text{ mol}
\end{aligned}
$$

$$
\begin{aligned}
\text{m(octan-1-ol)} &= 5.94 \times 10^{-3} \times 130.224 \\
&= 0.774 \text{ g}
\end{aligned}
$$

b. Advantage of biofuel vs fossil fuel

→ Combustion of biofuels derived from plants will have a lower greenhouse impact as the carbon dioxide released during combustion will replace that used in photosynthesis, unlike fossil fuels.

Other answers could include:

→ Biofuels are biodegradable and therefore pose a much reduced environmental threat than fossil fuels which are not.

→ Biofuels are more sustainable than fossil fuels as they are produced from renewable resources.

15. CHEMISTRY, M7 2023 HSC 27

$$\text{Density}(\rho) = \frac{\text{m}}{\text{V}} \Rightarrow \text{m} = \rho \times \text{V}$$

$$\text{m(ethanol)} = 0.789 \times 185 = 146\ \text{g}$$

$$\text{n(ethanol)} = \frac{\text{m}}{\text{MM}} = \frac{146}{46.068} = 3.17\ \text{mol}$$

$$\text{V} = \frac{\text{n}RT}{P}$$

$$= \frac{3.17 \times 8.314 \times 310}{100}$$

$$= 81.7\ \text{L}$$

---

16. CHEMISTRY, M7 2023 HSC 29

→ The graph shows a non-linear relationship with the following clear trend, as the molar mass increases, solubility decreases.

→ When molar mass increases, the chain length of a molecule increases. Hence, as the chain length of alkan-1-ols increase, their solubility in water decreases.

→ Shorter chain alcohols dissolve more readily in water. This is due to the formation of hydrogen bonds between the hydroxyl group of the alcohol and water molecules.

→ However, as the chain length of alkan-1-ols increase, the dispersion forces between the alkyl groups become stronger, decreasing their solubility.

my solution

→ The graph shows a non-linear relationship with the following clear trend, as the molar mass increases, solubility decreases.

→ When molar mass increases, the chain length of a molecule increases. In alkan-1-ols this increases the length of their carbon backbone, increasing their non-polar nature (increased dispersion forces), thus solubility in polar solvents (eg: water) decreases

→ Shorter chain alcohols dissolve more readily in water. This is due to the formation of hydrogen bonds between the hydroxyl group of the alcohol and water molecules and the comparatively polar nature of the molecule compared top long-chained alkan-1-ols

→ However, as the chain length of alkan-1-ols increase, the dispersion forces between the alkyl groups become stronger and mitigate the polarity of the hydroxyl group, decreasing their solubility.

---

17. CHEMISTRY, M7 EQ-Bank 22

Using $q = mc\Delta T$:

$$q = 325\ \times 10^{-3}\ \times 4.18\ \times 10^{3}\ \times 65 = 88\,302.5\ \text{J} = 88.3025\ \text{kJ}$$

$$\text{Methanol heat combustion} = 726\ \text{kJ mol}^{-1}\ \text{(given)}$$

$$\text{n}(CH_3(OH)) = \frac{88.3025}{726}$$

$$\text{MM}(CH_3(OH)) = 12.01 + 3\ \times 1.008 + 16 + 1.008 = 32.042$$

$$\text{m}(CH_3(OH)) = \frac{88.3025}{726}\ \times 32.042$$

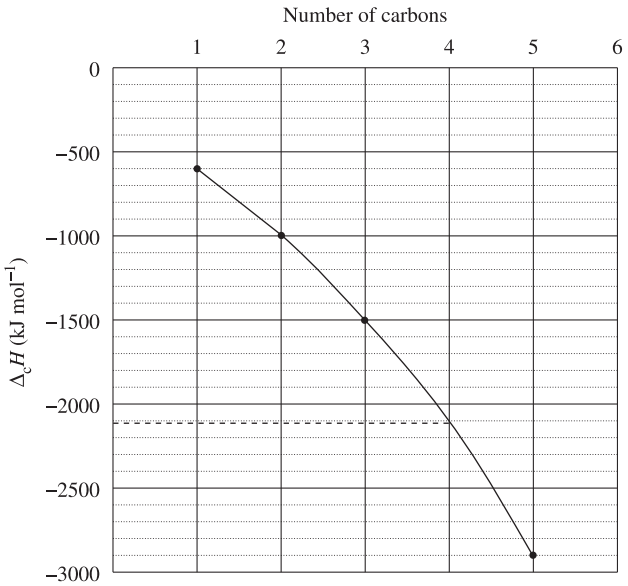
Since 50% of heat is lost → twice as much methanol is needed

$$\text{m}(CH_3(OH))\ \text{initial} = 2\ \times \frac{88.3025}{726}\ \times 32.042 = 7.79\ \text{g}$$

---

18. CHEMISTRY, M7 2022 HSC 29

a.



From interpolating the graph, the enthalpy of combustion of butan-1-ol is −2120 kJ mol^{-1}.

b. Heat loss to the surroundings.

→ The school's results are lower in magnitude than the published values because heat is lost to the surroundings, making the measured change in temperature smaller.

♦ Mean mark (b) 48%.

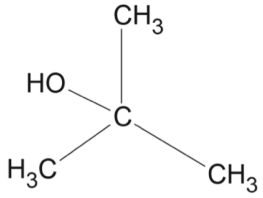
Other possible answers:

→ Incomplete combustion

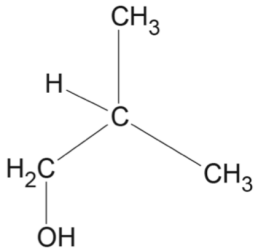
→ Temperature change will be reduced if combustion is incomplete as less heat is released. Enthalpy of combustion will be lower as a result.

19. CHEMISTRY, M7 2021 HSC 26

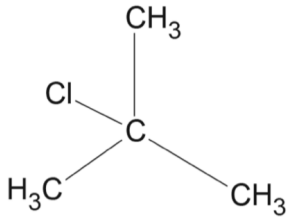
a. Compound A:



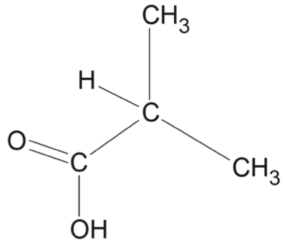
Compound B:



Compound C:



Compound D:



b. Reasons for reflux technique:

♦ Mean mark (b) 46%.

→ Reflux heats the reaction mixture which increases the average kinetic energy, and thus increases the reaction rate.

→ Heating causes the volatile substances to form vapour molecules. Refluxing uses a condenser to cool the vapour molecules into liquids, and thus retains the substances.

20. CHEMISTRY, M7 2020 HSC 24

a. Ester functional group.

♦♦ Mean mark (a) 39%, (b) 49%.

b. $\mathrm{C_{14}H_{30}O_2\,(l) + \frac{41}{2}\,O_2\,(g) \longrightarrow 14\,CO_2\,(g) + 15\,H_2O\,(l)}$

$\mathrm{C_{18}H_{38}\,(l) + \frac{55}{2}\,O_2\,(g) \longrightarrow 18\,CO_2\,(g) + 19\,H_2O\,(l)}$

→ Soot is produced when a fuel source undergoes incomplete combustion due to insufficient oxygen.

→ Since biodiesel already contains oxygen atoms within its structure, it would require less oxygen to undergo complete combustion compared to diesel, and is therefore less likely to produce soot.

c. $\mathrm{m(biodiesel) = \frac{2141}{38} = 56.3\ kg}$

$\mathrm{V(biodiesel) = \frac{56.3}{0.90} = 63\ L\ \ (nearest\ L)}$

d. Advantages of bioethanol (two examples needed only):

♦ Mean mark (d) 55%.

→ Bioethanol is sustainable because it is produced from renewable resources, whereas petrol is produced from nonrenewable crude oil reserves.

→ Additionally, bioethanol is biodegradable whereas petrol isn't. As a result, bioethanol would pose less of an environmental threat in comparison to petrol.

→ Ethanol produces less airborne particulates that are associated with lung cancer.

Disadvantages of bioethanol (two examples needed only):

→ Bioethanol requires a large amount of arable land in order to grow crops to produce bioethanol. Thus, it would lead to soil erosion and environmental pollution.

→ More energy is also required to produce bioethanol because of the requirement for labour, fertilisation, and distillation of ethanol from fermentation.

→ If fossil fuels are used as the energy source within the manufacturing process of biofuel, it will not achieve carbon neutrality and will contribute to global warming.

21. CHEMISTRY, M7 2017 HSC 28b

♦ Mean mark 48%.

$$C_2H_5OH\,(l) + 3\,O_2\,(g) \longrightarrow 2\,CO_2\,(g) + 3\,H_2O\,(g)$$

$$m(CO_2) = 12.01 + 2 \times 16.00 = 44.01\ g\ mol^{-1}$$

$$n(CO_2) = \frac{1000}{44.01} = 22.72\ mol$$

$$n(C_2H_5OH) = \frac{22.72}{2} = 11.36\ mol$$

$$\therefore \text{ Energy per kg } CO_2 = 11.36 \times 1360$$
$$= 15\ 450\ kJ$$

22. CHEMISTRY, M7 2021 HSC 25

♦ Mean mark 55%.

The fermentation reaction:

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

$$v_{(CO_2)} = 1006\ mL = 1.006\ L$$

$$n_{(CO_2)} = \frac{v}{V_m} = \frac{1.006}{24.79} = 0.04058087939\ mol$$

$$n_{(C_2H_5OH)} = n_{(CO_2)} = 0.04058087939\ mol$$

$$m_{(C_2H_5OH)} = n \times MM$$
$$= 0.04058087939 \times 46.068$$
$$= 1.869\ g$$

23. CHEMISTRY, M7 2019 HSC 34

♦♦ Mean mark 38%.

Step 1:

→ To synthesise chloroethane (A) into ethanol (B), $NaOH$ is added and heated. $KMnO_4 / H^+$ is then added and heated.

→ The mixture is then treated with concentrated sulfuric acid and refluxed.

→ Ethanol (B) can be identified using infrared spectroscopy by looking for a broad absorption between 3230 cm^{-1} and 3550 cm^{-1}, which indicates the presence of an $O-H$ bond. This absorption would not be present in chloroethane (A).

→ Alternative ways to identify ethanol include: mass spectrum analysis (single ion peak at m/z = 46), reactivity tests, and ^1H NMR spectrum analysis (3 signals vs 2 for chloroethane).

Step 2:

→ Ethanol (B) can be converted into ethanoic acid (C) by combining it with a strong oxidant like sodium carbonate, which produces carbon dioxide bubbles, confirming the presence of a carboxylic acid.

→ Ethanol will not react as above and the compounds can be distinguished.

→ Alternative ways to identify ethanoic acid include: IR or ^{13}C NMR spectrum analysis, litmus indicators, mass spectrum analysis (ion peak at m/z = 60 vs m/z = 46)

Step 3

→ Ethyl ethanoate (D) can be synthesised by heating a mixture of ethanol, ethanoic acid and concentrated sulfuric acid under reflux.

→ A ^1H NMR spectrum can be used to identify ethyl ethanoate as it will have 3 signals versus ethanol and ethanoic acid that will only have 2 each.

→ Alternative ways to identify ethyl ethanoate include: a distinct smell, no $O-H$ peaks in the IR spectrum or mass spectrum analysis (ion peak at m/z = 102).