CHEMISTRY

Stage 6

Module 7: Organic Chemistry

Reactions of Organic Acids and Bases

Teacher: Shane Sandot

Exam Equivalent Time: 154.5 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, *Reactions of Organic Acids and Bases.*

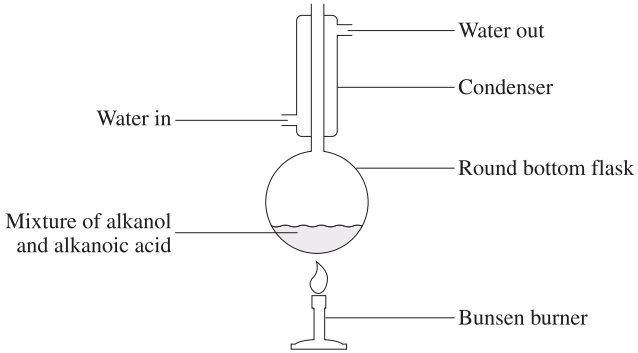
HSC ANALYSIS - What to expect and common pitfalls

- *Esters* is easily the most commonly assessed concept within this sub-topic (notably absent 2023-24). Questions deal mainly with the chemical reaction used to form an ester as well as the reflux process for esterification.
- *Reaction Pathways* which lead up to an ester synthesis were tested in 2021 and 2019. This area deserves revision attention due to high mark allocations and low mean marks (see *2021 HSC 26* and *2019 HSC 34*). An understanding of the reflux technique is important (see *2016 HSC 22c*).
- *Boiling Point* has been examined in 4 of the 6 new syllabus exams, including twice in longer answer questions (see *2024 HSC 24* and *2020 HSC 32*). Students must have a clear and concise explanation of intermolecular forces within this context.
- *Soaps and Detergents* has only appeared via multiple choice on one occasion since 2019. We see scope for a longer answer examination of this topic area and believe it warrants attention (review *M7 Q-Bank 21*).
- A review of *2019 HSC 21* is recommended as it proved challenging for a majority of students and is a reminder that reactions of ketones and aldehydes are explored in this sub-topic.

Questions

1. CHEMISTRY, M7 2017 HSC 4 MC

Esterification can be carried out in a school laboratory using the equipment shown.



How could the safety of the process shown be improved?

A. Place a stopper on top of the condenser.

B. Add concentrated sulfuric acid to the flask.

C. Change the direction of water flow through the condenser.

D. Replace the Bunsen burner with an electric heating mantle.

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2. 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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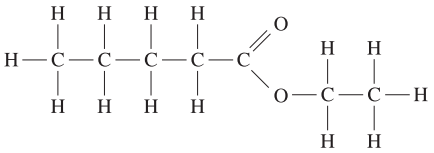
3. CHEMISTRY, M7 2021 HSC 4 MC

The structure of ethyl pentanoate is shown.



Which pair of chemicals would produce ethyl pentanoate by esterification?

A. Ethene and pentan-1-ol

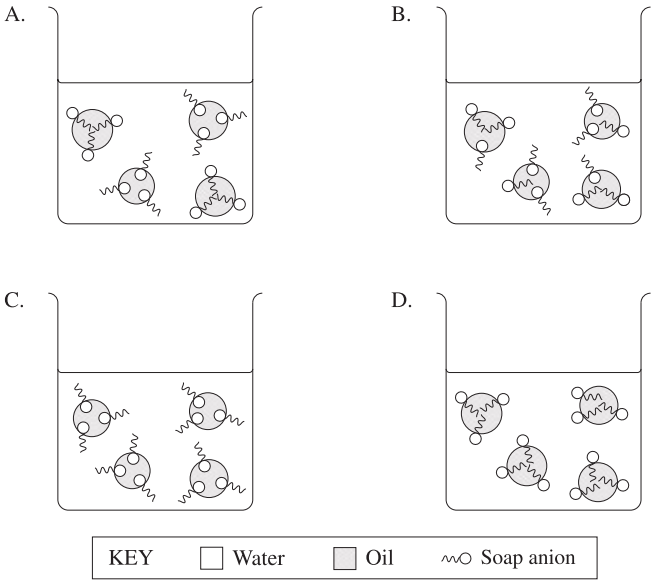
B. Ethane and pentanoic acid

C. Ethanol and pentanoic acid

D. Ethanoic acid and pentan-1-ol

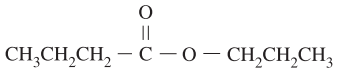
4. CHEMISTRY, M7 2021 HSC 8 MC

Which diagram shows the expected arrangement of soap anions in an emulsion?



5. CHEMISTRY, M7 2015 HSC 9 MC

What are the reactants used to make this compound?



A. Butan-1-ol and butanoic acid

B. Butan-1-ol and propanoic acid

C. Propan-1-ol and butanoic acid

D. Propan-1-ol and propanoic acid

6. CHEMISTRY, M7 2018 HSC 3 MC

An esterification reaction is to be performed.

Which of the following substances, when added, would increase the yield of the product?

A. Water

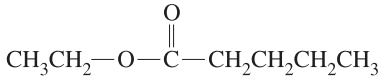
B. Boiling chips

C. More alkanol

D. Dilute sulfuric acid

7. CHEMISTRY, M7 2019 HSC 8 MC

The structure of an organic compound is shown.



Which row of the table correctly gives the name of the compound and one of the reactants used to produce it in a one-step reaction?

	Name	*Reactant*
A.	Ethyl pentanoate	Ethanol
B.	Ethyl pentanoate	Pentan-1-ol
C.	Pent-1-yl ethanoate	Ethanol
D.	Pent-1-yl ethanoate	Pentan-1-ol

8. 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

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9. CHEMISTRY, M7 2020 HSC 3 MC

Which of the following compounds is the most basic?

A. Ethane

B. Ethanol

C. Ethanamine

D. Ethyl ethanoate

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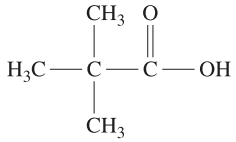
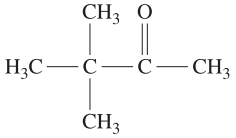
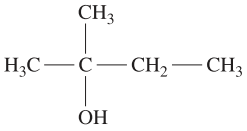
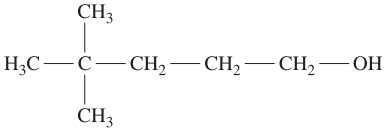
10. CHEMISTRY, M7 2020 HSC 9 MC

Which compound reacts readily with sodium hydrogen carbonate?

A. 

B. 

C. 

D. 

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11. 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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12. CHEMISTRY, M7 2016 HSC 3 MC

What is the molecular formula of pentanoic acid?

A. C_5H_9O

B. $C_5H_{10}O$

C. $C_5H_{10}O_2$

D. $C_5H_{11}O_2$

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13. CHEMISTRY, M7 2018 HSC 13 MC

Pentanol, propyl acetate, pentanoic acid and ethyl propanoate all contain five carbon atoms. These four compounds are mixed in a flask and then separated by fractional distillation.

Which compound would be most likely to remain in the flask?

A. Pentanol

B. Propyl acetate

C. Pentanoic acid

D. Ethyl propanoate

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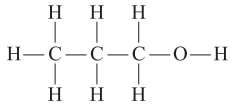
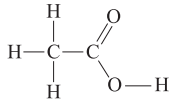
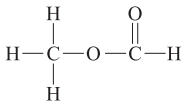
14. CHEMISTRY, M7 2020 VCE 16 MC

The following table provides information about three organic compounds, X, Y and Z.

Compound	Structural formula	Molar mass ($g\ mol^{-1}$)	Boiling point (°C)
X		60	97
Y		60	118
Z		60	?

Which one of the following is the best estimate for the boiling point of Compound Z?

A. 31 °C

B. 101 °C

C. 114 °C

D. 156 °C

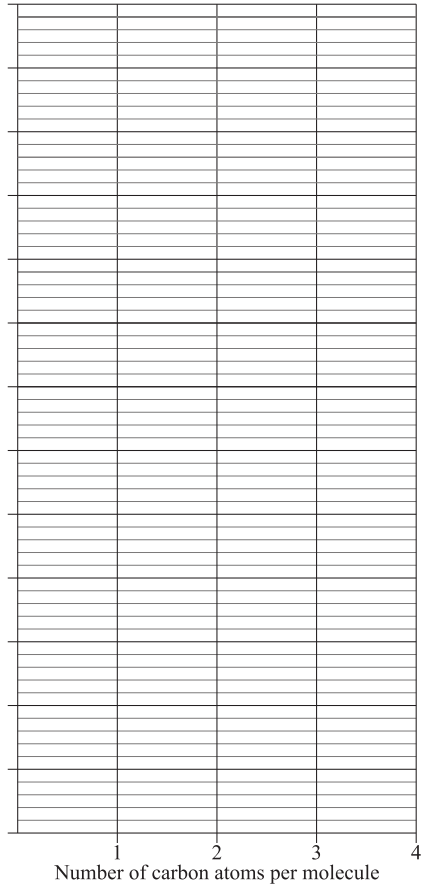
15. CHEMISTRY, M7 2024 HSC 24

The boiling points for two series of compounds are listed.

Amine	*Boiling point* (°C)
Methanamine	−6
Ethanamine	17
Propan-1-amine	48
Butan-1-amine	78

Alcohol	*Boiling point* (°C)
Methanol	65
Ethanol	78
Propan-1-ol	97
Butan-1-ol	118

a. Plot the boiling points for each series of compounds against the number of carbon atoms per molecule. ***(3 marks)***



b. With reference to hydrogen bonding and dispersion forces, explain the trends in the boiling point data of these compounds, within each series and between the series. ***(4 marks)***

16. CHEMISTRY, M7 EQ-Bank 23

a. Design a procedure that can be used to produce the ester, ethyl ethanoate, in a school laboratory. ***(4 marks)***

b. Describe a safety precaution in the production of an ester in a school laboratory. ***(2 marks)***

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17. 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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18. CHEMISTRY, M7 EQ-Bank 21

With the use of a labelled diagram, describe how grease can be removed from fabric using soap. ***(3 marks)***

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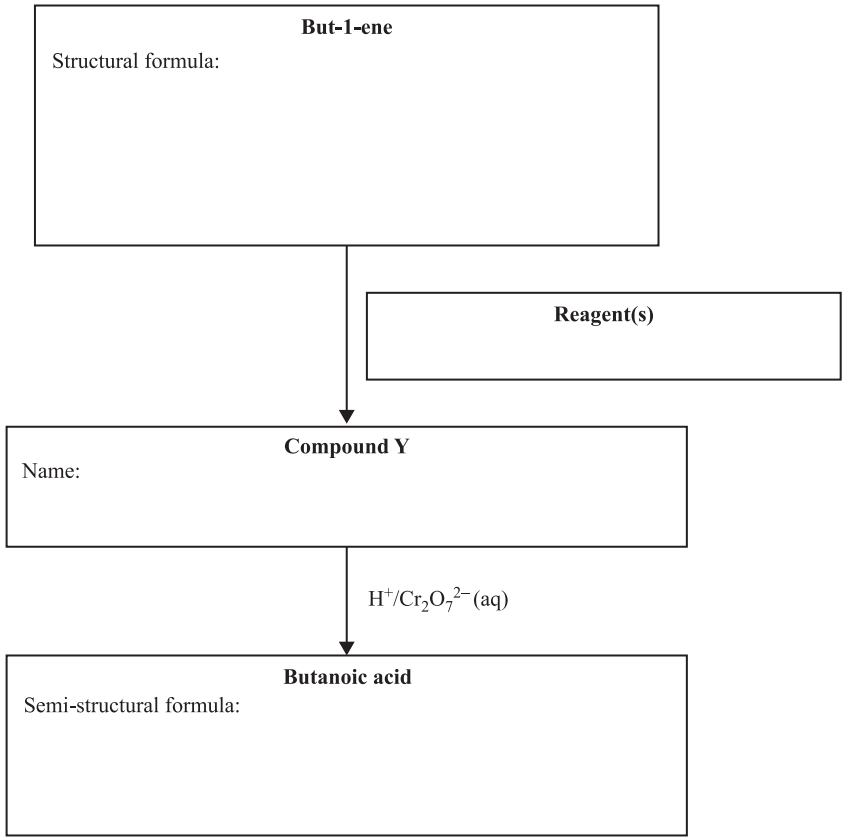
19. CHEMISTRY, M7 2016 VCE 7a

Butanoic acid is the simplest carboxylic acid that is also classified as a fatty acid. Butanoic acid may be synthesised as outlined in the following reaction flow chart.



i. Draw the structural formula of but-1-ene in the box provided. ***(1 mark)***

ii. State the reagent(s) needed to convert but-1-ene to Compound Y in the box provided. ***(1 mark)***

iii. Write the systematic name of Compound Y in the box provided. ***(1 mark)***

iv. Write the semi-structural formula of butanoic acid in the box provided. ***(1 mark)***

v. Write a balanced half-equation for the conversion of $Cr_2O_7^{2-}$ to Cr_3^+. ***(2 marks)***

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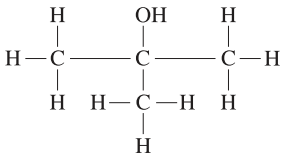
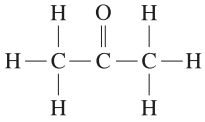
20. CHEMISTRY, M7 2019 HSC 21

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

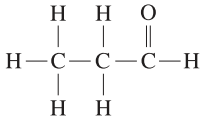
Draw one structural isomer of this alcohol and state its name. ***(2 marks)***

	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)***

21. CHEMISTRY, M6 2015 HSC 26

A sodium hydroxide solution was titrated against citric acid $(C_6H_8O_7)$ which is triprotic.

a. Draw the structural formula of citric acid (2-hydroxypropane-1,2,3-tricarboxylic acid). ***(1 mark)***

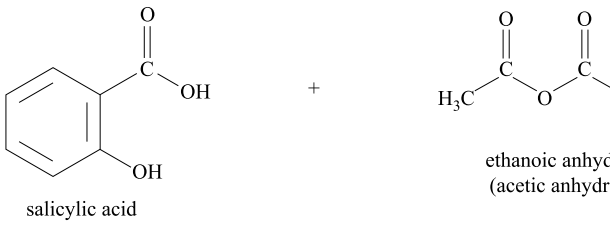
b. How could a computer-based technology be used to identify the equivalence point of this titration? ***(2 marks)***

c. The sodium hydroxide solution was titrated against 25.0 mL samples of 0.100 mol L^{-1} citric acid. The average volume of sodium hydroxide used was 41.50 mL.

Calculate the concentration of the sodium hydroxide solution. ***(4 marks)***

22. CHEMISTRY, M7 2015 VCE 5c

A student mixed salicylic acid with ethanoic anhydride (acetic anhydride) in the presence of concentrated sulfuric acid. The products of this reaction were the painkilling drug aspirin (acetyl salicylic acid) and ethanoic acid.

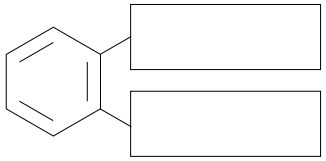


salicylic acid

+

ethanoic anhydride
(acetic anhydride)

concentrated
H_2SO_4



aspirin
(incomplete structure)

+ ethanoic acid

i. An incomplete structure of the aspirin molecule is shown above.

Complete the structure by filling in the two boxes provided in the diagram. ***(2 marks)***

ii. Sulfuric acid is used as a catalyst in this reaction.

Explain how a catalyst increases the rate of this reaction. ***(2 marks)***

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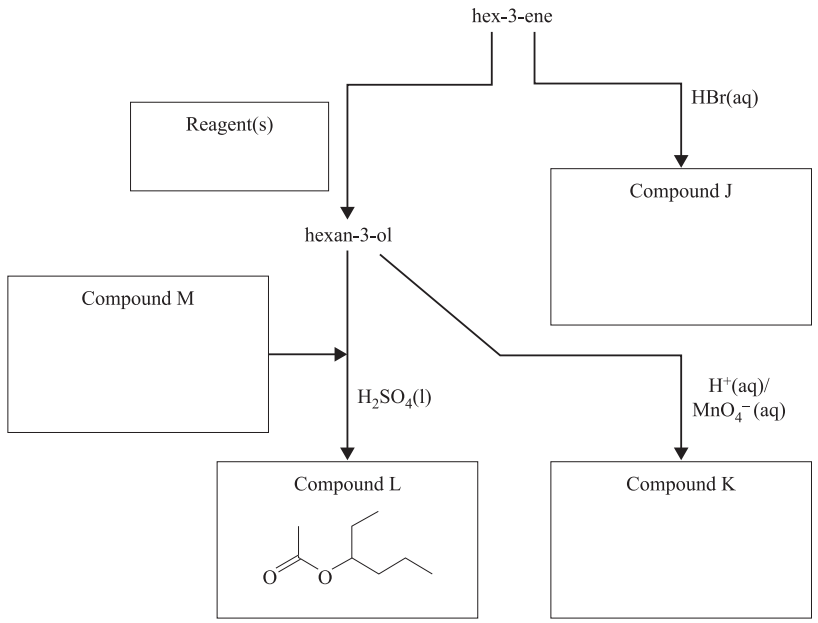
23. CHEMISTRY, M7 2020 VCE 3

Below is a reaction pathway beginning with hex-3-ene.



a. Write the IUPAC name of Compound J in the box provided. ***(1 mark)***

b. State the reagent(s) required to convert hex-3-ene to hexan-3-ol in the box provided. ***(1 mark)***

c. Draw the structural formula for a tertiary alcohol that is an isomer of hexan-3-ol. ***(1 mark)***

d. Hexan-3-ol is reacted with Compound M under acidic conditions to produce Compound L.

Draw the semi-structural formula for Compound M in the box provided on the image above. ***(1 mark)***

e. **i.** Draw the semi-structural formula for Compound K in the box provided on the image above. ***(1 mark)***

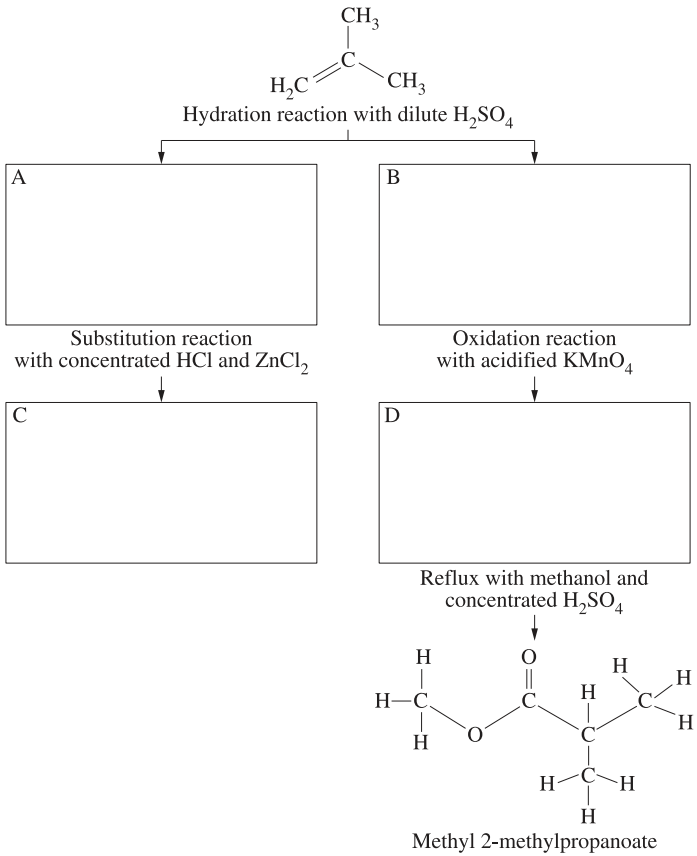
ii. Name the class of organic compound (homologous series) to which Compound K belongs. ***(1 mark)***

f. What type of reaction produces Compound K from hexan-3-ol? ***(1 mark)***

24. 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)***

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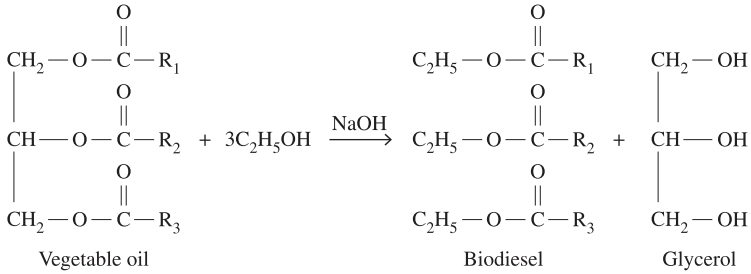
25. CHEMISTRY, M7 2020 HSC 24

Biodiesel, an alternative fuel to diesel, may be produced from vegetable oil. The chemical reaction which converts oils from biomass into biodiesel is shown. R_1, R_2 and 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 $(C_{14}H_{30}O_2)$ produces less soot than diesel $(C_{18}H_{38})$ 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)***

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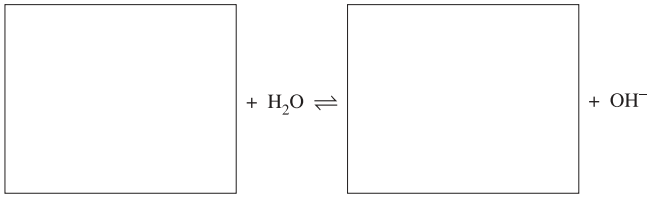
26. CHEMISTRY, M5 2020 HSC 27

A student makes up a solution of propan-2-amine in water with a concentration of 1.00 mol L $^{-1}$.

a. Using structural formulae, complete the equation for the reaction of propan-2-amine with water. ***(2 marks)***



b. The equilibrium constant for the reaction of propan-2-amine with water is 4.37×10^{-4}.

Calculate the concentration of hydroxide ions in this solution. ***(3 marks)***

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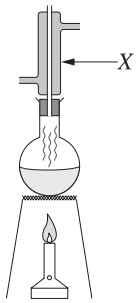
27. CHEMISTRY, M7 2016 HSC 22

This apparatus was set up to produce methyl butanoate.



a. Identify a safety issue in this experiment. ***(1 mark)***

b. Using structural formulae, write the equation for the production of methyl butanoate. ***(2 marks)***

c. Justify the use of apparatus X in this experiment. ***(2 marks)***

28. CHEMISTRY, M7 2017 HSC 27

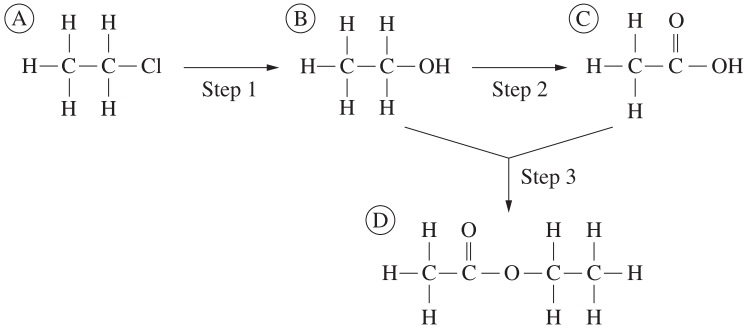
The boiling points and molar masses of three compounds are shown in the table.

Compound	*Boiling point* (°C)	*Molar mass* (g mol^{-1})
Acetic acid	118	60
Butan-1-ol	117	74
Butyl acetate	116	116

Acetic acid, butan-1-ol and butyl acetate have very different molar masses but similar boiling points. Explain why in terms of the structure and bonding of the three compounds. ***(5 marks)***

29. 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 4 MC

Consider each option

A: Resulting pressure build up is dangerous (incorrect)

B: Adds to the catalytic effect but not a safety reduction measure (incorrect)

C: Direction is optimal as water flow is coolest where vapours are hottest (incorrect)

D: Heating mantle reduces the chance of vapours igniting (correct)

$\Rightarrow D$

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2. 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)

$\Rightarrow D$

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3. CHEMISTRY, M7 2021 HSC 4 MC

→ Esterification involves a reaction between a carboxylic aciand an alcohol.

→ Creating ethyl pentanoate requires ethanol (which is an alcohol) and pentanoic acid (which is a carboxylic acid).

→ Ethanol + pentanoic acid ↔ ethyl pentanoate + water

$\Rightarrow C$

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4. CHEMISTRY, M7 2021 HSC 8 MC

→ Soap molecules contain a non-polar hydrophobic hydrocarbon tail and a polar hydrophilic head.

→ The non-polar tail forms dispersion forces with the oil molecule while the polar head forms ion-dipole forces with the polar water molecules.

→ The resulting orientation has the tail within the oil and the head group at the surface of the oil and water.

$\Rightarrow D$

Worked Solutions

5. CHEMISTRY, M7 2015 HSC 9 MC

→ Compound is an ester

→ Oxygen double bond comes from butanoic acid (eliminate B and D)

→ The other carbon chain comes from propan-1-ol

$\Rightarrow C$

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6. CHEMISTRY, M7 2018 HSC 3 MC

→ The addition of more alkanol increases one of the reactants in a reversible reaction.

→ By Le Chatelier's principle, this would shift the equilibrium to the right hand side (increase yield).

$\Rightarrow C$

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7. CHEMISTRY, M7 2019 HSC 8 MC

Compound: Ethyl pentanoate

Reactants: Ethanol and Pentanoic acid (only the former is listed in the table)

$\Rightarrow A$

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8. 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.

$\Rightarrow B$

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9. CHEMISTRY, M7 2020 HSC 3 MC

Amines are basic, whereas, alkanes, alcohols, and esters are neutral.

$\Rightarrow C$

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10. CHEMISTRY, M7 2020 HSC 9 MC

→ Compound A is a carboxylic acid, and thus readily reacts with $\mathrm{NaHCO_3}$, which is a base.

→ No other compounds are acidic.

$\Rightarrow A$

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11. 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)

$\Rightarrow A$

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12. CHEMISTRY, M7 2016 HSC 3 MC

$\Rightarrow C$

13. CHEMISTRY, M7 2018 HSC 13 MC

♦ Mean mark 46%.

→ Fractional distillation is the separating of a mixture into its component parts by heating.

→ The compound with the highest boiling point is pentanoic acid which will remain after all other compounds have vaporised.

→ Pentanoic acid has stronger hydrogen bonding than pentanol and hence stronger intermolecular forces.

$\Rightarrow C$

14. CHEMISTRY, M7 2020 VCE 16 MC

♦♦♦ Mean mark 20%.

→ Boiling points of molecular compounds are related to the strength of their intermolecular bonding.

→ All given molecules are polar molecules. Each intermolecular bonding will have contributions from both dispersion forces and dipole-dipole bonding.

→ Since the molar mass of each compound is the same, the contribution from dispersion forces will be similar for all.

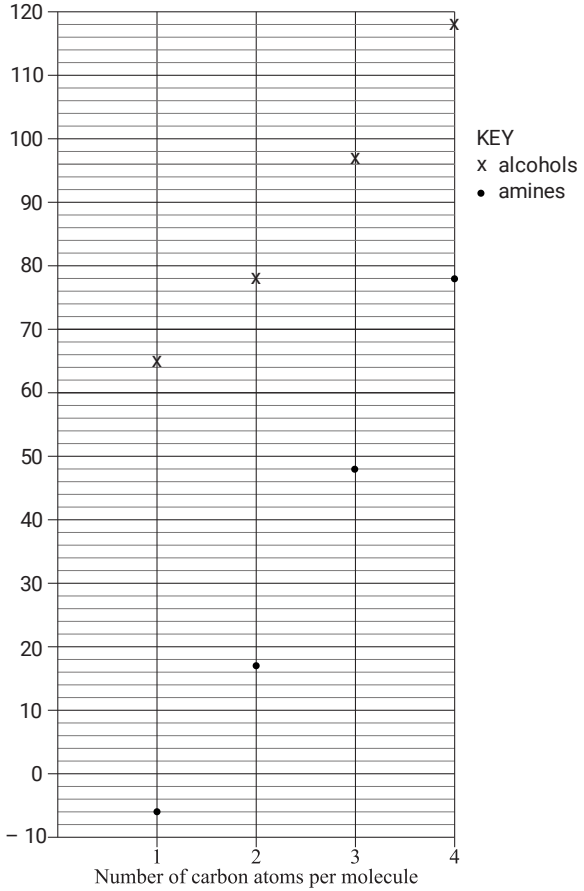
→ Compounds X and Y will both have hydrogen bonding, due to the presence of the $\mathrm{O}-\mathrm{H}$ functional group.

→ Compound Z does not have intermolecular hydrogen bonding and therefore would have the lowest boiling point.

$\Rightarrow A$

15. CHEMISTRY, M7 2024 HSC 24

a.



b. The alcohols have higher boiling points than amines of the same chain length.

→ Both alcohols and amines have polar hydrogen bonding as a result of the OH and $\mathrm{NH_2}$ functional groups respectively.

→ Oxygen molecules have higher electronegativity than nitrogen molecules making the hydrogen bonding in the alcohols significantly stronger than the hydrogen bonding in amines.

→ Since the dispersion forces in amines and alcohols of the same chain length are very similar, the difference in the strength of the intermolecular bonding is dependent on the strength of the hydrogen bonding.

→ Therefore, a larger amount of thermal energy is required to separate the alcohol molecules resulting in higher boiling points than amines.

As the chain length of the alcohols and amines increase, the boiling points also increase.

→ When the chain length increases, the number of electrons in the molecules also increase which corresponds to a larger number of dispersion forces between neighbouring molecules.

→ The stronger dispersion forces between the molecules increase the overall strength of the intermolecular forces in both the alcohols and amines therefore leading to higher boiling points as chain length increases.

16. CHEMISTRY, M7 EQ-Bank 23

a. Methodology:

STEP 1: Reflux equipment using a hot plate heating source.

STEP 2: Pour 10 mL of ethanol into a round bottom flask. Add 20 mL of glacial (water-free) acetic acid.

STEP 3: Add 1 mL of concentrated $\mathrm{H_2SO_4}$ (sulfuric acid) to the mixture. Boiling stones/chips can be added to smooth the boiling process before heating under reflux for 45 minutes.

STEP 4: Allow the solution to cool. The contents should then be transferred to a separating funnel.

STEP 5: Distilled water should be used to wash the contents which will remove excess alcohol and acetic acid. The ester layer has a density less than 1 g/mL and will therefore form a layer above the aqueous solution.

STEP 5: Remove the aqueous solution using the separating funnel.

STEP 6: By adding a solution of 1 mol $\mathrm{L^{-1}}$ $\mathrm{Na_2CO_3}$ (sodium carbonate), all remaining acid will be removed. Similarly to Step 4, the ester can be isolated by removing the lower layer of aqueous solution using the separating funnel.

b. → Ethanol presents a danger due to its combustibility.

→ A safety precaution that reduces the fire threat is through the use of a hot plate for heating rather than a naked flame.

17. 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.

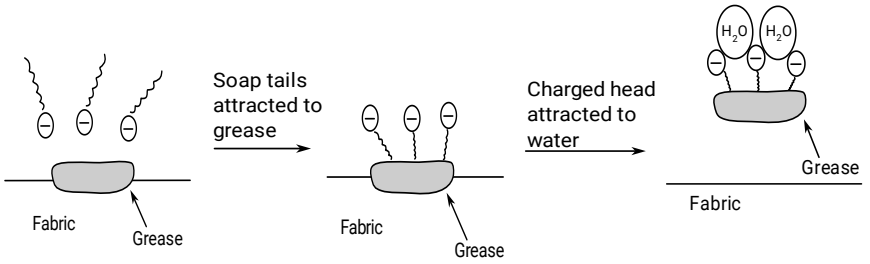
→ Methanol and propanoic acid can also form hydrogen bonds (strongest type of intermolecular force).

→ 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.

18. CHEMISTRY, M7 EQ-Bank 21



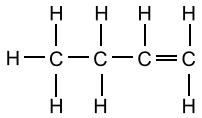
→ Soap molecules, as shown in the diagram, have a negatively charged (hydrophilic) "head" and a hydrophobic 'tail' consisting made up of fatty acids.

→ Hydrophobic tails are attracted to the grease particles and attach themselves.

→ The hydrophilic heads, at the same time, are attracted to water molecules. This chain of attractions will lift grease off the fabric and suspend it in the water.

19. CHEMISTRY, M7 2016 VCE 7a

i.



ii. $\mathrm{H_2O}$ and $\mathrm{H_3PO_4}$ (catalyst)

♦♦ Mean mark (ii) 29%.

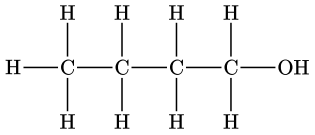
iii. butan-1-ol or 1-butanol

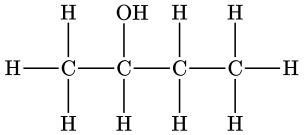
iv. $\mathrm{CH_3CH_2CH_2COOH}$

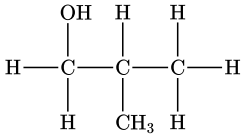
v. $\mathrm{Cr_2O_7^{2-}\,(aq) + 14\,H^+\,(aq) + 6\,e^- \rightarrow 2\,Cr^{3+}\,(aq) + 7\,H_2O\,(l)}$

20. 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.

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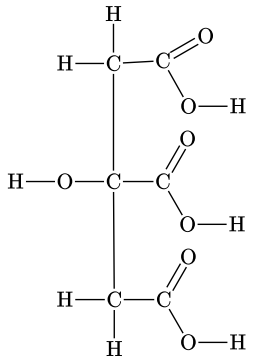
21. CHEMISTRY, M6 2015 HSC 26

a.



♦ Mean mark (a) 46%.

b. Technology solution

♦ Mean mark (b) 42%.

→ A digital pH probe could be placed in the flask and used to collect data that plots the pH of the solution against the volume of sodium hydroxide added.

→ The equivalence point would be identified by a steep rise in the pH on the graph.

c. $C_6H_8O_7 + 3\,NaOH \longrightarrow C_6H_5O_7Na_3 + 3\,H_2O$

Mean mark (c) 56%.

$n(C_6H_8O_7) = c \times V = 0.100 \times 0.0250 = 0.00250\,mol$

$n(NaOH) = 3 \times 0.00250 = 0.00750\,mol$

$$[NaOH] = \frac{n}{V} = \frac{0.00750}{0.04150} = 0.181\,mol\,L^{-1}\ (3\,sig\,fig)$$

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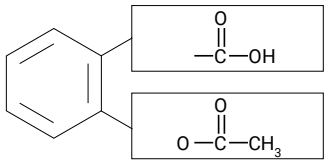
22. CHEMISTRY, M7 2015 VCE 5c

i.

♦ Mean mark (i) 48%.



ii. Sulphuric acid increases the rate of reaction by:

→ providing an alternative reaction pathway that involves a lower activation energy for the reagents.

→ this increases the likelihood of successful collisions.

23. CHEMISTRY, M7 2020 VCE 3

a. 3-bromohexane

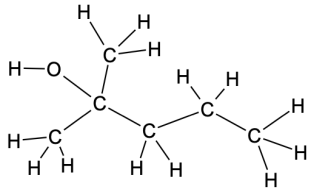
♦ Mean mark (b) 38%.

b. Steam and any specific inorganic strong acid (although not HCl) is correct.

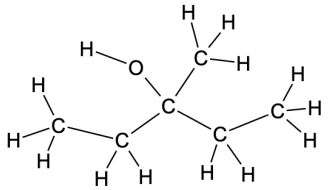
eg. $\mathrm{H_2O}$, $\mathrm{H^+}$

c.

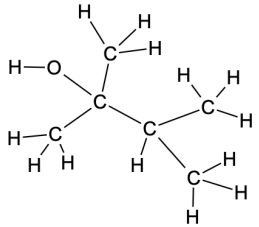
♦ Mean mark (c) 49%.



2-methylpentan-2-ol



3-methylpentan-3-ol



2,3-dimethylbutan-2-ol

d. Correct answers included one of:

$\mathrm{CH_3COOH}$ or $\mathrm{HOOCCH_3}$

e.i. Correct answers included one of the following:

♦ Mean mark e(i) 39%.

$\mathrm{CH_3CH_2COCH_2CH_2CH_3}$
$\mathrm{CH_3CH_2CH_2COCH_2CH_3}$
$\mathrm{CH_3CH_2CO(CH_2)_2CH_3}$

e.ii. Ketone

f. Oxidation

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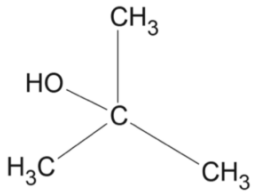
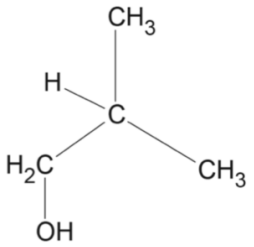
24. CHEMISTRY, M7 2021 HSC 26

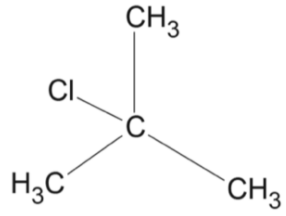
a. Compound A:



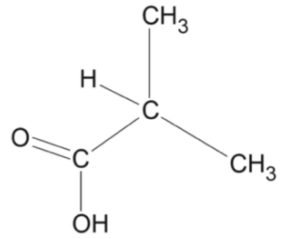
Compound B:



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.

---

25. CHEMISTRY, M7 2020 HSC 24

a. Ester functional group.

♦♦ Mean mark (a) 39%, (b) 49%.

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

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

→ 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. $\mathrm{m(biodiesel)} = \dfrac{2141}{38} = 56.3\ \mathrm{kg}$

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

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.

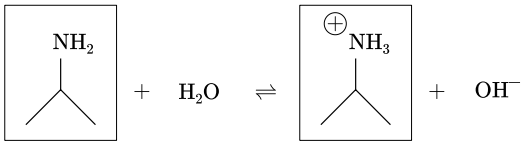
→ More energy is also required to produce bioethanol because of the requirement for labour, fertilisation, and distillation of ethanol from fermentation.

→ 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.

26. CHEMISTRY, M5 2020 HSC 27

a.

♦ Mean mark (a) 48%.



b.

Mean mark (b) 51%.

	$\mathrm{C_3H_7NH_2}$	$\mathrm{C_3H_7NH_3}$	$\mathrm{OH^-}$
Initial	1.00	0	0
Change	$-x$	$+x$	$+x$
Equilibrium	$1.00 - x$	x	x

$$K_b = \frac{[\mathrm{C_3H_7NH_3^+}][\mathrm{OH^-}]}{[\mathrm{C_3H_7NH_2}]} = \frac{x^2}{(1.00 - x)}$$

Assume $1.00 - x = 1.00$ because x is negligible:

$$4.37 \times 10^{-4} = \frac{x^2}{1.00}$$

$$x = \sqrt{4.37 \times 10^{-4}}$$

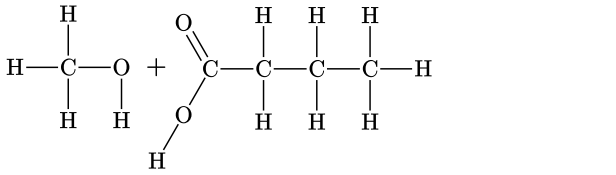
$$= 0.0209\ \mathrm{mol\,L^{-1}}$$

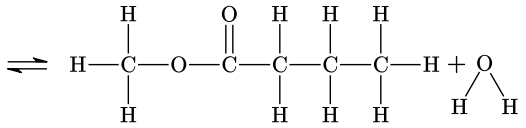
$$\Rightarrow [\mathrm{OH^-}] = 0.0209\ \mathrm{mol\,L^{-1}}$$

27. CHEMISTRY, M7 2016 HSC 22

a. Flame could ignite one of reagents which is flammable.

b.





♦ Mean mark (b) 52%.

c. → Esterification is a relatively slow reaction.

→ Heating the reaction makes it go faster. However, the low boiling points of the reactants make them volatile as they readily convert into gas.

→ The cooling condenser X prevents the gas reactants from escaping the experiment by condensing them back into the reaction mixture. This process allows the reaction to proceed at higher temperatures.

♦♦♦ Mean mark (c) 14%.

28. CHEMISTRY, M7 2017 HSC 27

→ Although the three listed compounds different molar masses, they have similar boiling points due to their different structures and resulting intermolecular forces.

→ Butyl acetate has the largest molar mass and therefore greatest dispersion forces but it is only slightly polar and has no hydrogen bonding.

→ Butan-1-ol has lower molar mass than butyl acetate and therefore smaller dispersion forces but it is polar and contains a hydrogen bound to an oxygen. Therefore, it exhibits hydrogen bonding resulting in strong intermolecular forces and a boiling point in the middle of the three compounds.

→ Acetic acid has the lowest molar mass and hence the weakest dispersion forces. It is however highly polar due to the presence of the carboxyl group (COOH) and contains a hydrogen bound to an oxygen allowing the formation of hydrogen bonds between molecules.

→ The presence of a second oxygen in acetic acid increases the hydrogen bonding compared with butan-1-ol.

→ These factors lead to acetic acid possessing the highest boiling point despite its molar mass being the lowest.

→ In summary, the totality of the intermolecular forces of all three molecules is similar and therefore similar boiling points.

♦♦ Mean mark 41%.

29. CHEMISTRY, M7 2019 HSC 34

♦♦ Mean mark 38%.

Step 1:

→ To synthesise chloroethane (A) into ethanol (B), NaOH is added and heated. $\mathrm{KMnO_4}$ / $\mathrm{H^+}$ 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 $\mathrm{O-H}$ 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 $^{1}\mathrm{H\ NMR}$ 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 $^{13}\mathrm{C\ NMR}$ 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 $^{1}\mathrm{H\ NMR}$ 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 $\mathrm{O-H}$ peaks in the IR spectrum or mass spectrum analysis (ion peak at m/z = 102).