All questions are for separate science students only

Q1.

This question is about organic compounds.

(a) Butane is an alkane with small molecules.

Complete the sentence.

Choose the answer from the box.

fertiliser	formulation	fuel

Butane can be used as a fuel.

(1)

(b) Poly(propene) is a polymer.

What is the name of the monomer used to produce poly(propene)?

Tick (✓) **one** box.

Propane	☐
Propanoic acid	☐
Propanol	☐
Propene	✓

(1)

Ethene and steam react to produce ethanol.

The equation for the reversible reaction is:

ethene + steam ⇌ ethanol

(c) The reaction produces a maximum theoretical mass of 400 kg of ethanol from 243 kg of ethene and 157 kg of steam.

A company produces 380 kg of ethanol from 243 kg of ethene and 157 kg of steam.

The percentage yield of ethanol is less than 100%

Calculate the percentage yield of ethanol.

Use the equation:

$$\text{percentage yield of ethanol} = \frac{\text{mass of ethanol actually made}}{\text{maximum theoretical mass of ethanol}} \times 100$$

$= \frac{380}{400} \times 100 = 95\%$

Percentage yield = 95 %

(2)

(d) What are **two** possible reasons why the percentage yield of ethanol is less than 100%?

Tick (✓) **two** boxes.

Ethanol is the only product of the reaction.	☐
Ethanol is very unreactive.	☐
Some ethanol changes back into ethene and steam.	✓
Some ethanol escapes from the apparatus.	✓
Some ethanol reacts with steam.	☐

(2)

(e) Ethanol burns in oxygen.

Balance the equation for the reaction.

$$C_2H_5OH + \underline{3}\ O_2 \rightarrow 3\ H_2O + 2\ CO_2$$

(1)

(f) Two processes for producing ethanol are:

- fermentation
- hydration (reacting ethene with steam).

The table below shows information about the processes.

Feature	**Process**	
	Fermentation	**Hydration**
Raw material	sugar	crude oil
Energy usage	low	high

Rate of reaction	slow	fast
Purity of ethanol	15%	98%

Give **two** advantages and **two** disadvantages of using fermentation to produce ethanol.

Advantage of fermentation 1 Low energy usage

Advantage of fermentation 2 Uses renewable raw materials

Disadvantage of fermentation 1 Produces impure ethanol

Disadvantage of fermentation 2 Slow rate of reaction

(4)

(Total 11 marks)

Q2.

This question is about cycloalkenes.

Cycloalkenes are ring-shaped hydrocarbon molecules containing a double carbon-carbon bond.

Cycloalkenes react in a similar way to alkenes.

(a) Describe a test for the double carbon-carbon bond in cycloalkene molecules.

Give the result of the test.

Test Add bromine water

Result Changes from brown/orange to colourless

(2)

(b) The table below shows the name and formula of three cycloalkenes.

Name	Formula

C H
4 6
5 8
6 10

Cyclobutene	C_4H_6
Cyclopentene	C_5H_8
Cyclohexene	C_6H_{10}

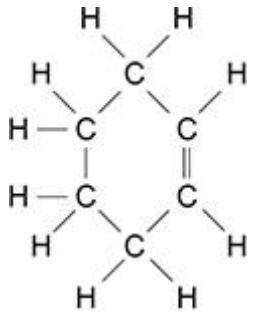
Determine the general formula for cycloalkenes.

General formula = C_nH_{2n-2}

(1)

Figure 1 shows the displayed structural formula of cyclohexene, C_6H_{10}

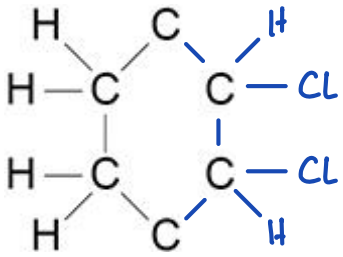
Figure 1



Chlorine reacts with cyclohexene to produce a compound with the formula $C_6H_{10}Cl_2$

(c) Complete **Figure 2** to show the displayed structural formula of $C_6H_{10}Cl_2$

Figure 2



(2)

(d) Calculate the percentage by mass of chlorine in a molecule of $C_6H_{10}Cl_2$

Relative atomic masses (A_r): H = 1 C = 12 Cl = 35.5

$M_r\ C_6H_{10}Cl_2 = (6\times12)+(10\times1)+(2\times35.5)$

$= 153$

$\%\ \text{Mass}\ Cl_2 = \frac{(2\times35.5)}{153} \times 100 = 46.4\%$

Percentage by mass = 46.4 %

(3)

(Total 8 marks)

Q3.

This question is about alkenes and alcohols.

Ethene is an alkene produced from large hydrocarbon molecules.

Large hydrocarbon molecules are obtained from crude oil by fractional distillation.

(a) Name the process used to produce ethene from large hydrocarbon molecules.

Steam / catalytic cracking

(1)

(b) Describe the conditions used to produce ethene from large hydrocarbon molecules.

High temperature
Steam / catalyst

(2)

(c) Ethanol can be produced from ethene and steam.

The equation for the reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

The forward reaction is exothermic.

Explain how the conditions for this reaction should be chosen to produce ethanol as economically as possible.

Rate: ↑T ↑Rate (more frequent collisions)
↑P ↑Rate "
Catalyst ↑Rate as activation energy ↓

Yield: ↑T ↓Yield (exothermic reaction)
↑P ↑Yield (more molecules on LHS)

Other Factors: ↑T - uses more energy - ↑costs
↑P "
↑P needs stronger reaction vessels ↑cost
Compromise
T & P compromise between Rate, Yield & Cost.

(6)

(d) Ethanol can also be produced from sugar solution by adding yeast.

Name this process.

Fermentation

(1)

(e) Butanol can be produced from sugar solution by adding bacteria.

Sugar solution is broken down in similar ways by bacteria and by yeast.

Suggest the reaction conditions needed to produce butanol from sugar solution by adding bacteria.

Warm temperature ~ 37°C
Anaerobic conditions

(2)

Ethanol and butanol can be used as fuels for cars.

(f) A car needs an average of 1.95 kJ of energy to travel 1 m

Ethanol has an energy content of 1300 kilojoules per mole (kJ/mol).

Calculate the number of moles of ethanol needed by the car to travel 200 km

Energy to travel 200km = 200×10^3 m × 1.95 kJ m^{-1}
= 3.9×10^5 kJ
N° moles ethanol = $\frac{3.9 \times 10^5 \text{ kJ}}{1300 \text{ kJ mol}^{-1}}$
= 300 mol

Number of moles = 300 mol

(3)

(g) When butanol is burned in a car engine, complete combustion takes place.

Write a balanced equation for the complete combustion of butanol.

You do **not** need to include state symbols.

$C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O$

(2)

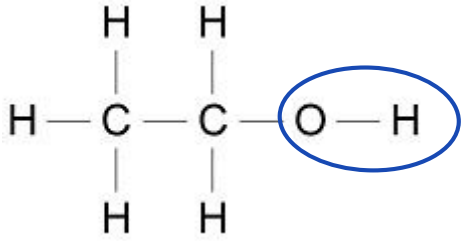
(Total 17 marks)

Q4.

This question is about ethanol and ethanoic acid.

Ethanol is an alcohol.

(a) The diagram below shows the displayed structural formula of ethanol.



Draw a circle on the diagram above around the alcohol functional group.

(1)

(b) An ethanol molecule contains atoms of three different elements.

Complete the table below to show:

- the name of each element
- the symbol for each element
- the number of atoms of each element in one molecule of ethanol.

Use the diagram above.

Name of element	**Symbol for element**	**Number of atoms in one molecule of ethanol**
Carbon	C	2
Hydrogen	H	6
Oxygen	O	1

(3)

(c) Ethanol removes grass stains from clothes.

What type of substance is ethanol when used to remove grass stains?

Tick (✓) **one** box.

A solute ☐

A solution ☐

A solvent ☑

Wine contains ethanol.

Wine is produced from grape juice by fermentation.

(1)

(d) Complete the sentence.

Grape juice can be fermented to produce wine because

grape juice contains sugar.

(1)

(e) What is added to grape juice to cause fermentation?

yeast

(1)

(f) Ethanol reacts with ethanoic acid to produce an ester.

What is the name of the ester produced when ethanol reacts with ethanoic acid?

Tick (✓) **one** box.

Ethane ☐

Ethene ☐

Ethyl ethanoate ☑

(1)

(g) Ethanoic acid reacts with sodium carbonate.

The equation for the reaction is:

$2\ CH_3COOH(aq) + Na_2CO_3(s) \rightarrow 2\ CH_3COONa(aq) + H_2O(l) + CO_2(g)$

What is the name of the liquid produced by this reaction?

water

(1)

(h) Vinegar is a solution that contains ethanoic acid.

400 cm^3 of vinegar contains 20 g of ethanoic acid.

Calculate the mass of ethanoic acid in 1.0 dm^3 of vinegar.

$400\ cm^3 = \frac{400}{1000} = 0.4\ dm^3$

Mass in 1 dm^3 $= \frac{1.00\ dm^3}{0.4\ dm^3} \times 20g$

$= 50g$

Mass = 50 g

(3)

(Total 12 marks)

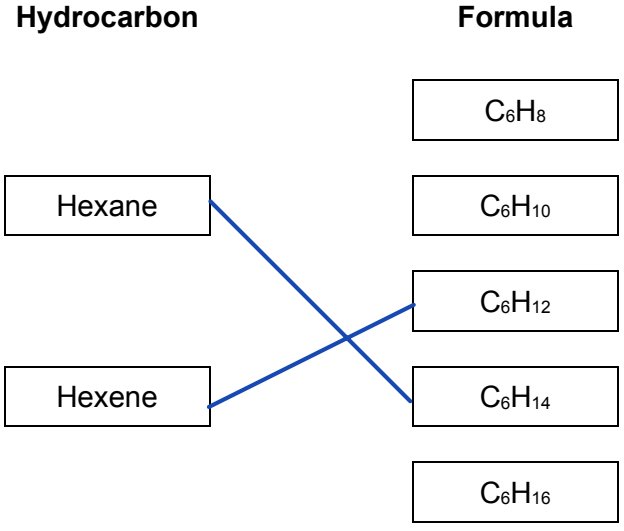
Q5.

This question is about hydrocarbons.

Hexane and hexene are hydrocarbons containing six carbon atoms in each molecule.

Hexane is an alkane and hexene is an alkene.

(a) Draw **one** line from each hydrocarbon to the formula of that hydrocarbon.



(2)

(b) Bromine water is added to hexane and to hexene.

What would be observed when bromine water is added to hexane and to hexene?

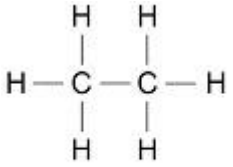
Hexane Remains orange

Hexene Becomes colourless

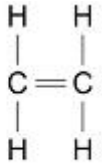
(2)

(c) Ethane is an alkane and ethene is an alkene.

The diagram below shows the displayed structural formulae of ethane and of ethene.



Ethane



Ethene

Compare ethane with ethene.

You should refer to:

- their structure and bonding
- their reactions.

Structure and Bonding:

Both are hydrocarbons with 2 C per molecule. (small)
Both have covalent bonds, ethene has C–C, both have C–H
ethene contains a double bond C=C.

Reactions:

Both react with O_2 in complete oxidation reactions to produce $CO_2 + H_2O$. Incomplete $O_2 \Rightarrow CO + C + H_2O$
Ethene decolorises bromine water (ethane does not)
Ethene is more reactive than ethane.
Ethene can react with $H_2 \Rightarrow$ ethane C_2H_6
$H_2O \Rightarrow$ ethanol CH_3CH_2OH
halogens $\Rightarrow$ halogenoalkanes
can undergo addition reactions
can polymerise $\Rightarrow$ poly(ethene)

(6)

(Total 10 marks)

Q6.

This question is about carboxylic acids.

Carboxylic acids belong to a homologous series.

The table below shows information about the first three carboxylic acids in this homologous series.

Name	Formula	pH of a 0.01 mol/dm^3 solution
Methanoic acid	HCOOH	2.91
Ethanoic acid	CH_3COOH	3.39
Propanoic acid	CH_3CH_2COOH	3.44

(a) Complete the table above.

(2)

(b) Ethanoic acid ionises in water.

The equation for the reaction is:

$$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

Explain how the equation shows that ethanoic acid is a weak acid.

⇌ Incomplete ionisation. because reaction is reversible.

(2)

(c) A student adds a solution of ethanoic acid to zinc carbonate in an open flask on a balance.

Explain what happens to the mass of the flask and its contents during the reaction.

Mass of flask and contents decreases because carbon dioxide is produced and escapes from the flask

(3)

(d) The student compares the rates of the reaction of zinc carbonate with:

- 0.01 mol/dm^3 methanoic acid
- 0.01 mol/dm^3 ethanoic acid.

The rate of the reaction with methanoic acid is greater than the rate of the reaction with ethanoic acid.

Explain why.

You should refer to ions in your answer.

Use the table above.

0·01 mol/dm^3 methanoic acid has a lower pH
∴ higher concentration of H^+ ions
∴ more collisions per unit time

(3)

Ethanoic acid reacts with ethanol to produce an ester.

(e) Give the name of the ester produced when ethanoic acid reacts with ethanol.

ethyl ethanoate

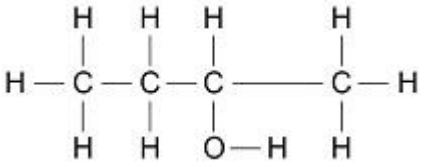
(1)

(f) Hexanedioic acid and ethanediol join together to produce a polyester.

Ethanoic acid and ethanol join together in the same way to produce an ester.

Which is the displayed structural formula of the ester produced when ethanoic acid reacts with ethanol?

Tick (✓) **one** box.



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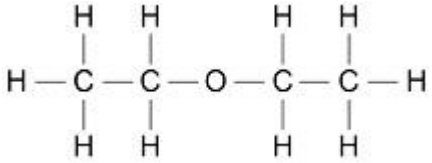

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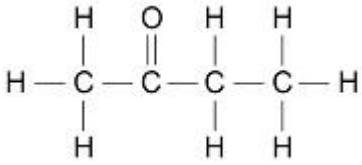

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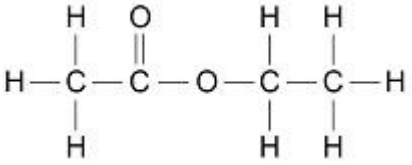


☑

(1)

(Total 12 marks)

Q7.

Methylated spirit is a useful product made from a mixture of substances.

The table below shows the mass of the substances in a sample of methylated spirit.

Substance	Mass in grams
Ethanol	265.5
Methanol	23.3
Pyridine	3.0
Methyl violet	1.5

(a) What name is given to a useful product such as methylated spirit?

Formulation

(1)

(b) Calculate the percentage by mass of methanol in methylated spirit.

Use the table above.

$$\frac{23.3}{265.5 + 23.3 + 3.0 + 1.5} \times 100$$

= 7.9%

Percentage = 7.9 %

(2)

Methylated spirit contains ethanol and is available cheaply.

Methylated spirit also contains:

- pyridine which has a very unpleasant smell
- methyl violet which makes the mixture purple.

(c) Suggest why pyridine and methyl violet are added to ethanol to make methylated spirit.

To deter drinking by people

(1)

(d) Suggest **one** use of methylated spirit.

Fuel

(1)

(e) Describe how ethanol is produced from sugar solution.

Give the name of this process.

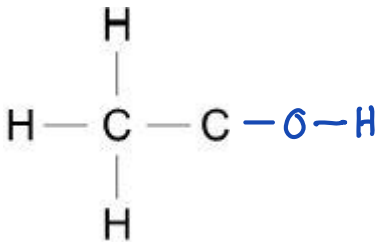
Fermentation

Add yeast to solution and warm.

(3)

(f) The diagram below shows part of the displayed formula for ethanol.

Complete the diagram.



(1)

(g) Name the gas produced when sodium is added to ethanol.

Hydrogen

(1)

(h) Methanol is used to produce methanoic acid.

What type of substance reacts with methanol to produce methanoic acid?

Oxidising agent

(1)

(Total 11 marks)

Q8.

The table below gives information about four alcohols.

Alcohol	Formula	Melting point in °C	Boiling point in °C
Methanol	CH_3OH	−94	65
Ethanol	CH_3CH_2OH	−118	78
Propanol	$CH_3CH_2CH_2OH$	−129	97
Butanol	$CH_3CH_2CH_2CH_2OH$	−89	118

(a) Which alcohol in the table is liquid over the greatest temperature range?

Propanol

(1)

(b) Which statement is correct?

Tick **one** box.

A molecule of ethanol has 5 hydrogen atoms	☐
Butanol has the highest boiling point	☑
Methanol has the largest molecules	☐
Propanol has the highest melting point	☐

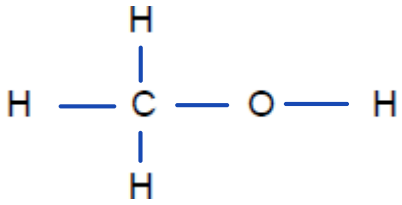
(1)

(c) A molecule of methanol has five single covalent bonds.

Draw the missing bonds in **Figure 1** to complete the displayed formula for

methanol.

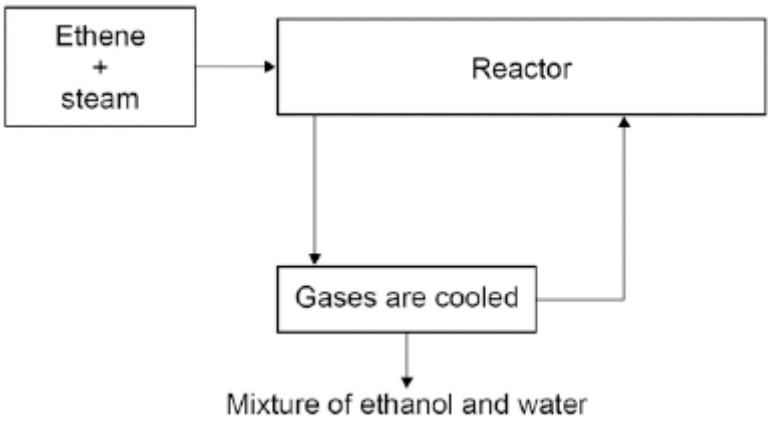
Figure 1



(1)

(d) **Figure 2** shows a flow diagram of the process to produce ethanol.

Figure 2



Complete the word equation for the reaction to produce ethanol.

ethene + water → ethanol

(1)

(e) What happens to the unreacted ethene?

Recycled back to reactor

(1)

(f) Wine contains ethanol.
A bottle of wine was left open in air.
After a few days, the wine tasted of vinegar.
Vinegar is a solution of ethanoic acid in water.

Explain how oxidation causes the wine to taste of vinegar after a few days.

Air contains oxygen, which oxidises ethanol to produce ethanoic acid.

(3)

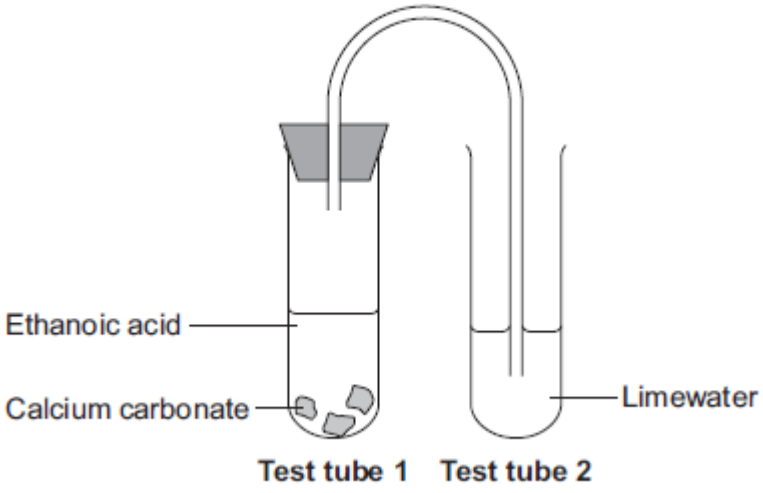
(Total 8 marks)

Q9.

This question is about reactions of ethanoic acid and the analysis of salts.

(a) **Figure 1** shows the apparatus used to investigate the reaction of ethanoic acid with calcium carbonate.

Figure 1



(i) Describe a change that would be seen in each test tube.

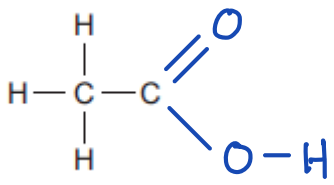
Give a reason for each change.

Test tube 1 Fizzing - bubbles of gas given off because carbon dioxide is produced.

Test tube 2 Limewater turns milky because a precipitate of calcium carbonate forms - caused by the carbon dioxide

(4)

(ii) Complete the displayed structure of ethanoic acid.



(1)

(iii) Ethanoic acid is a carboxylic acid.
Complete the sentence.

Carboxylic acids react with alcohols in the presence of an

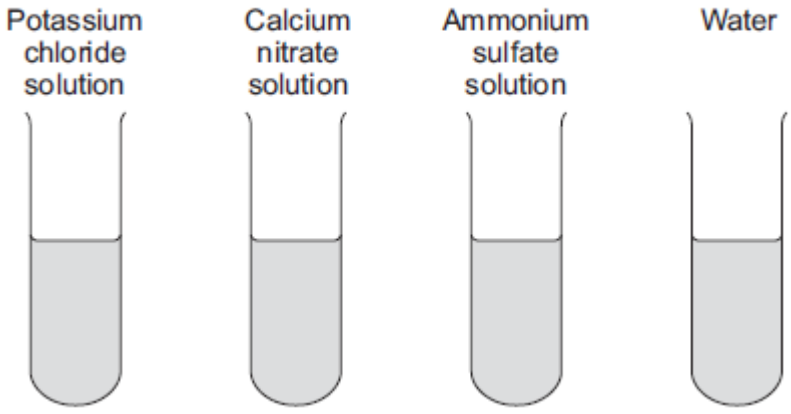
acid catalyst to produce pleasant-smelling compounds

called esters .

(2)

(b) **Figure 2** shows four test tubes containing three different salt solutions and water.

Figure 2



Each solution and the water was tested with:

- silver nitrate in the presence of dilute nitric acid
- barium chloride in the presence of dilute hydrochloric acid.

Complete the table of results.

	Potassium chloride solution	**Calcium nitrate solution**	**Ammonium sulfate solution**	**Water**
Test with silver nitrate in the	White precipitate	no change	no change	no change

presence of dilute nitric acid				
Test with barium chloride in the presence of dilute hydrochloric acid	no change	no change	white precipitate	no change

(2)

(c) Flame tests can be used to identify metal ions.

(i) Complete the following sentences.

The flame colour for potassium ions is lilac .

The flame colour for calcium ions is red .

(2)

(ii) Give **one** reason why a flame test would **not** show the presence of both potassium ions and calcium ions in a mixture.

With a mixture, the colours are masked or changed by each flame colour

(1)

(Total 12 marks)

Q10.

This question is about organic compounds.

Hydrocarbons can be cracked to produce smaller molecules.

The equation shows the reaction for a hydrocarbon, $C_{18}H_{38}$

$C_{18}H_{38} \rightarrow C_6H_{14} + C_4H_8 + 2\,C_3H_6 + C_2H_4$

(a) Which product of the reaction shown is an alkane?

C_nH_{2n+2}

Tick **one** box.

C_2H_4 ☐

C_3H_6 ☐

C_4H_8 ☐

C_6H_{14} ✓

(1)

(b) The table below shows the boiling point, flammability and viscosity of $C_{18}H_{38}$ compared with the other hydrocarbons shown in the equation.

	Boiling point	Flammability	Viscosity
A	highest	lowest	highest
B	highest	lowest	lowest
C	lowest	highest	highest
D	lowest	highest	lowest

Which letter, **A**, **B**, **C** or **D**, shows how the properties of $C_{18}H_{38}$ compare with the properties of C_2H_4, C_3H_6, C_4H_8 and C_6H_{14}?

Tick **one** box.

A ✓

B

C

D

(1)

(c) The hydrocarbon C_4H_8 was burnt in air.

Incomplete combustion occurred.

Which equation, **A**, **B**, **C** or **D**, correctly represents the incomplete combustion reaction?

A $C_4H_8 + 4O \rightarrow 4CO + 4H_2$ ×

B $C_4H_8 + 4O_2 \rightarrow 4CO + 4H_2O$ ✓

C $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$ × Complete Combustion

D $C_4H_8 + 8O \rightarrow 4CO_2 + 4H_2$ ×

Tick **one** box.

A

B ☑

C ☐

D ☐

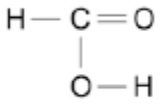
(1)

(d) Propanoic acid is a carboxylic acid.

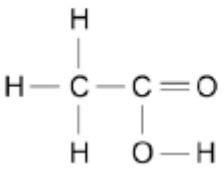
3 C

Which structure, **A**, **B**, **C** or **D**, shows propanoic acid?

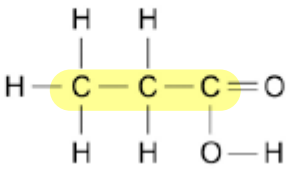
A



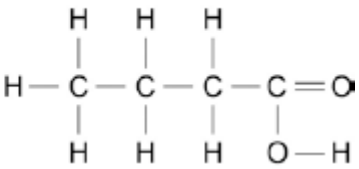
B



C



D



Tick **one** box.

A ☐

B ☐

C ☑

D ☐

(1)

(e) Propanoic acid is formed by the oxidation of which organic compound?

Tick **one** box.

Propane ☐

Propene ☐

Propanol ☑

Polyester ☐

(1)

(Total 5 marks)