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EDEXCEL INTERNATIONAL GCSE CHEMISTRY: QUESTIONS BY TOPIC

Organic Chemistry (4)

International GCSE Chemistry Topic 4

74 questions · 879 marks · Mark schemes included

Pearson Edexcel International GCSE (9–1) Chemistry 4CH1, Papers 1C, 1CR, 2C & 2CR, June 2019 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.
Click any row below to jump straight to that sub-topic or question.
On every question page, click ANSWER in the top-right corner to jump to its mark scheme.
Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

	QUESTION		SOURCE	MARKS	PAGE
4a	**INTRODUCTION TO ORGANIC CHEMISTRY**			6 Qs · 81 marks	**5**
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2.	**Q7**		Paper 1C January 2023	12	**9**
3.	**Q5**		Paper 1C January 2020	14	**11**
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5.	**Q8**		Paper 1CR January 2021	15	**16**
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24.	**Q7**		Paper 1CR June 2022	15	**57**
4c	**ALKANES**			11 Qs · 130 marks	**61**
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38.	**Q10**		Paper 1C November 2024	12	**90**
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43.	**Q5**		Paper 2C November 2020	15	**105**
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45.	**Q10**		Paper 1CR June 2023	15	**111**
46.	**Q8**		Paper 1C June 2024	15	**114**
4e	**ALCOHOLS**			15 Qs · 180 marks	**117**
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	QUESTION		SOURCE	MARKS	PAGE
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QUESTIONS

74 questions · 879 marks · 8 sub-topics

SUB-TOPIC 4a

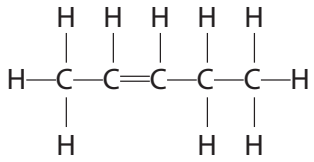
INTRODUCTION TO ORGANIC CHEMISTRY

Sub-topic 4a · 6 questions · 81 marks · lowest tariff first

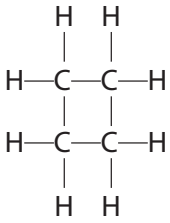
6 This question is about organic compounds.

(a) The diagram shows the displayed formulae of five compounds, U, V, W, X and Y.

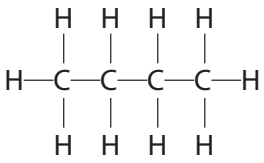
U



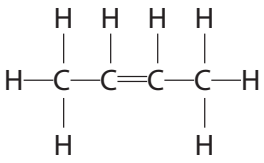
V



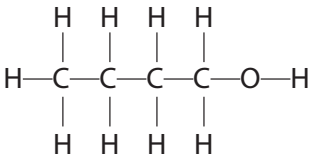
W



X



Y



(i) Give the letter of the compound that is not a hydrocarbon.

(1)

.....

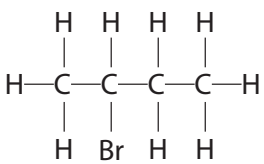
(ii) Give the letter of the compound that is a saturated hydrocarbon with the empirical formula CH_2

(1)

.....

(iii) Give the letter of the compound that reacts with bromine in the presence of ultraviolet radiation to form this structure.

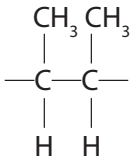
(1)



.....

(iv) Give the letter of the compound that forms an addition polymer with this repeat unit.

(1)



.....

(v) Give the displayed formula of an alkene that is an isomer of compound X.

(1)

(vi) Compounds U and X are members of the same homologous series.

Members of the same homologous series have the same functional group.

Give two other characteristics of compounds in the same homologous series.

(2)

1 .....

.....

2 .....

.....

(b) Compound Z contains 38.7% carbon, 9.7% hydrogen and 51.6% oxygen by mass.

(i) Show by calculation that the empirical formula of compound Z is CH_3O

(2)

(ii) The relative formula mass (M_r) of compound Z is 62

Deduce the molecular formula of compound Z.

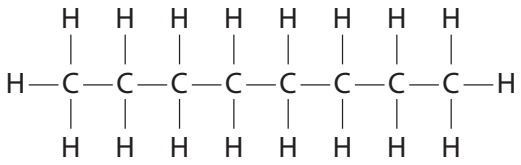
(2)

molecular formula = ...

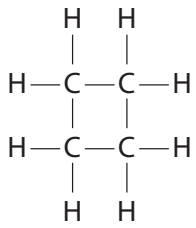
(Total for Question 6 = 11 marks)

7 The table shows the displayed formulae of some organic compounds.

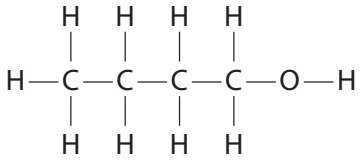
V



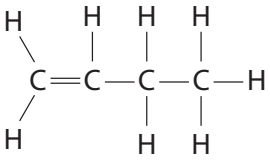
W



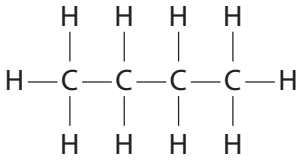
X



Y



Z



(a) Give a reason why compound **X** is **not** a hydrocarbon.

(1)

.....

.....

(b) Give the letter of the compound that is a saturated hydrocarbon with the empirical formula CH_2

(1)

.....

(c) Give the letter of the compound that produces nine moles of water when one mole undergoes complete combustion.

(1)

.....

(d) Give the structural formula of compound **Y**.

(1)

.....

(e) Explain why compounds **W** and **Y** are isomers.

(2)

(f) Compound **Z** reacts with bromine in the presence of ultraviolet radiation.

(i) Write a chemical equation for this reaction.

(2)

(ii) What is the name for this type of reaction?

(1)

☒ **A** addition

☒ **B** combustion

☒ **C** substitution

☒ **D** thermal decomposition

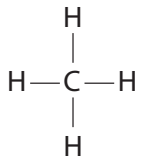
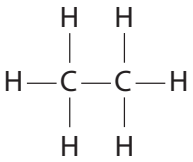
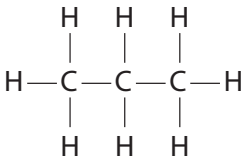
(g) Describe how the combustion of sulfur-free petrol in a car engine produces gases that can cause acid rain.

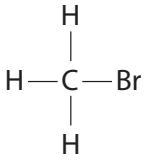
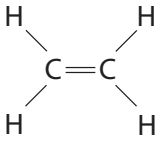
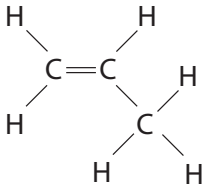
Do not refer to carbon dioxide in your answer.

(3)

(Total for Question 7 = 12 marks)

5 The boxes show the displayed formulae of six organic compounds, P, Q, R, S, T and U.

		
P	**Q**	**R**

		
S	**T**	**U**

(a) Use the letters P, Q, R, S, T and U to answer these questions.

Each letter may be used once, more than once or not at all.

(i) Give the letter of the compound that is **not** a hydrocarbon.

(1)

.....

(ii) Give the letters of the two compounds that have the same empirical formula.

(1)

.....

(iii) Give the letter of the compound that is used to manufacture poly(propene).

(1)

.....

(b) Describe a test that can be used to distinguish between compounds Q and T.

(3)

test .....

.....

result with compound Q .....

.....

result with compound T .....

.....

(c) Compounds P, Q and R are members of the same homologous series.

Give two characteristics of a homologous series.

(2)

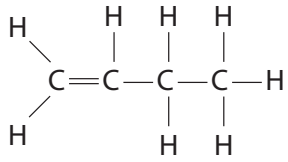
1 .....

.....

2 .....

.....

(d) This is the displayed formula of an alkene, V.



(i) Give the name of alkene V.

(1)

.....

(ii) Draw the displayed formula of another alkene that is an isomer of alkene V.

(1)

(e) An organic compound has the percentage composition by mass

C = 36.36% H = 6.06% F = 57.58%

(i) Show that the empirical formula of the compound is CH_2F

(2)

(ii) The relative molecular mass (M_r) of the compound is 66.

Determine the molecular formula of the compound.

(2)

molecular formula = ...

(Total for Question 5 = 14 marks)

6 The table shows the molecular formulae of six organic compounds, A, B, C, D, E and F.

A	B	C	D	E	F
C_2H_4	C_2H_6	C_3H_6	C_3H_8	C_4H_8	C_4H_{10}

(a) (i) Explain which homologous series compound B belongs to.

(2)

.....

.....

.....

(ii) Give the letter of the compound that has the same empirical formula as its molecular formula.

(1)

.....

(iii) Compound F exists as two isomers.

Explain what is meant by the term **isomers**.

Include the structures of the two isomers of compound F in your answer.

(3)

.....

.....

.....

.....

.....

.....

(b) Describe how compound D can be obtained from crude oil using the industrial process of fractional distillation.

(4)

(c) Compound C can be used to make a polymer.

(i) State the type of polymer formed from compound C.

(1)

(ii) Name the polymer formed from compound C.

(1)

(iii) Draw the structure of this polymer.

Include the displayed formula of the repeat unit.

(2)

(Total for Question 6 = 14 marks)

8 (a) (i) Organic compounds can exist as isomers.

Explain what is meant by the term **isomers**.

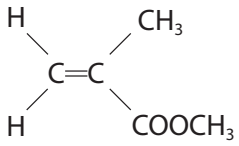
(2)

(ii) Organic compound Q reacts with bromine, without the presence of ultraviolet radiation, to form the compound $C_4H_8Br_2$

Draw the displayed formulae of two isomers of Q.

(2)

(b) An acrylic polymer can be formed from molecules with this structure.



(i) A student describes the molecule as an unsaturated hydrocarbon.

Explain whether this is a correct description.

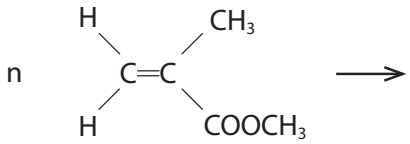
(2)

(ii) Name the type of polymerisation that occurs in the formation of the polymer.

(1)

(iii) Complete the equation for the polymerisation reaction.

(2)



(c) Octane is a compound in petrol.

The equation for the complete combustion of octane is

$$C_8H_{18} + 12.5\ O_2 \rightarrow 8\ CO_2 + 9\ H_2O$$

(i) The fuel tank of a car contains 50.0 dm^3 of octane.

Calculate the mass, in kg, of carbon dioxide formed if all the octane in the fuel tank undergoes complete combustion.

[mass of 1 dm^3 of octane = 700 g]

(5)

mass = ... kg

(ii) State an environmental problem caused by carbon dioxide.

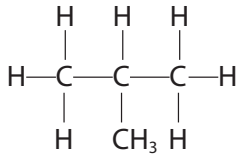
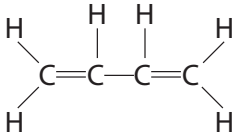
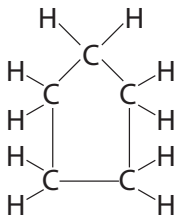
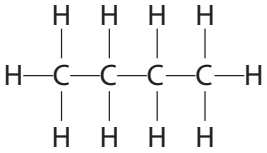
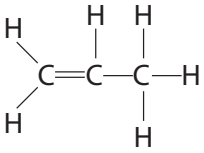
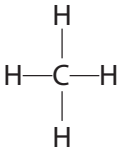
(1)

.....

.....

(Total for Question 8 = 15 marks)

8 The table shows the structures of six organic compounds.

A 	B 	C 
D 	E 	F 

(a) (i) Give the letter of a compound **not** shown as a displayed formula.

(1)

.....

(ii) Give the letter of a saturated compound with the general formula C_nH_{2n}

(1)

.....

(iii) Name compound E.

(1)

.....

(iv) Explain why compound A and compound D are isomers.

(2)

.....

.....

.....

.....

(b) Compound F reacts with bromine in the presence of ultraviolet radiation.

(i) Complete the equation for the reaction.

(1)

$CH_4 + Br_2 \rightarrow$

(ii) Give the name of this type of reaction.

(1)

.....

(c) (i) Another compound, G, has this percentage composition by mass.

C = 37.8 % H = 6.3 % Cl = 55.9 %

Show by calculation that the empirical formula of compound G is C_2H_4Cl

(3)

(ii) The relative formula mass (M_r) of G is 127

Determine the molecular formula of G.

(2)

molecular formula = ...

(d) Compound E is used to make an addition polymer.

(i) Complete the equation to show part of the polymer formed from two molecules of compound E.

(2)



(ii) Give one problem caused by the disposal of addition polymers.

(1)

.....

.....

(Total for Question 8 = 15 marks)

SUB-TOPIC 4b

CRUDE OIL

Sub-topic 4b · 18 questions · 201 marks · lowest tariff first

2 Crude oil is a mixture of hydrocarbons.

(a) Name the process used to separate crude oil into fractions.

(1)

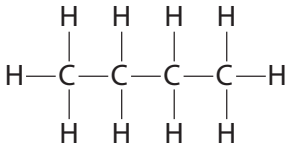
.....

(b) Give one use for the bitumen fraction.

(1)

.....

(c) The diagram shows the displayed formula of one of the alkanes in the refinery gases fraction.



(i) Determine the molecular formula of this alkane.

(1)

.....

(ii) Name this alkane.

(1)

.....

(iii) Give the general formula of the homologous series of alkanes.

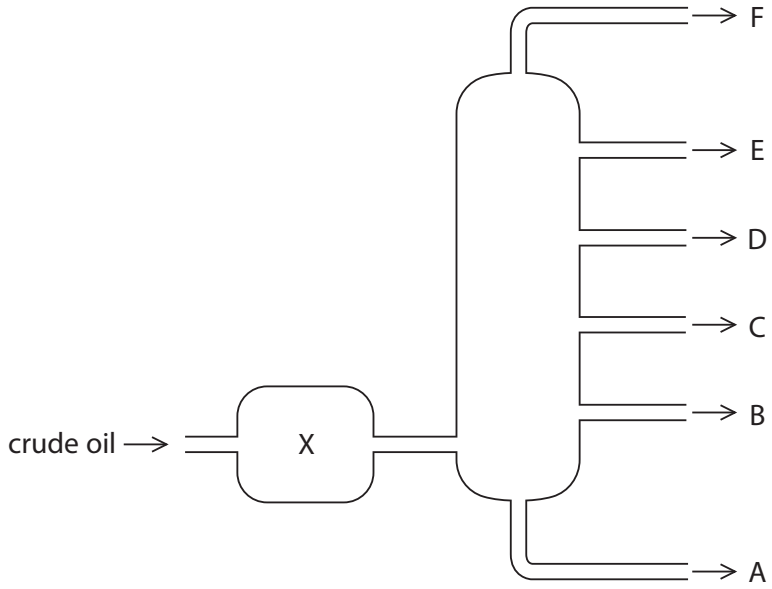
(1)

.....

(Total for Question 2 = 5 marks)

3 Crude oil is an important source of organic compounds.

(a) The diagram shows crude oil being separated into different fractions.



(i) Name the process used to separate crude oil into different fractions.

(1)

.....

(ii) State what happens to the crude oil at X.

(1)

.....

(iii) Describe the differences between fraction B and fraction E.

In your answer, refer to

- size of the molecules
- boiling point
- colour
- viscosity

(4)

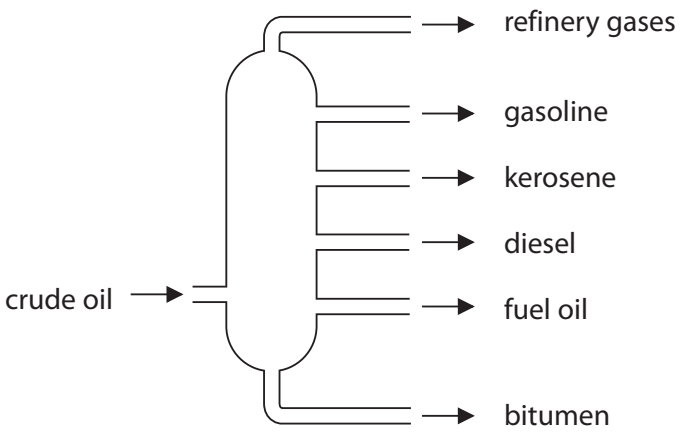
(b) Crude oil often contains sulfur as an impurity.

Explain why this is a problem when using crude oil fractions as fuels.

(2)

(Total for Question 3 = 8 marks)

3 (a) The diagram shows a fractionating column used to separate crude oil into fractions.



(i) Give a use for bitumen and a use for gasoline.

(2)

use for bitumen .....

use for gasoline .....

(ii) Explain why bitumen is collected at the bottom of the fractionating column and gasoline is collected near the top of the fractionating column.

(2)

.....

.....

.....

.....

(b) There is a low demand for some of the fractions obtained from crude oil.

Cracking can be used to convert these fractions into more useful substances.

(i) State the conditions needed for cracking.

(2)

.....

.....

(ii) Dodecane ($C_{12}H_{26}$) can be cracked to produce an alkane and two alkenes.

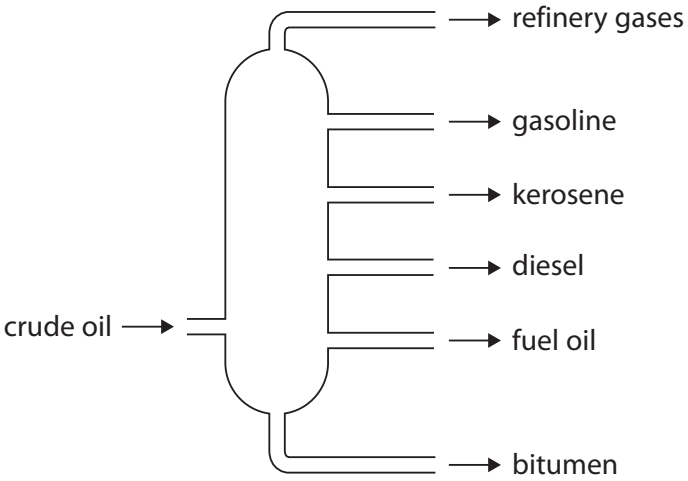
Complete the equation by giving the formulae of the two alkenes.

(2)

$C_{12}H_{26} \rightarrow C_7H_{16}$ + ... + ...

(Total for Question 3 = 8 marks)

4 (a) The diagram shows a fractionating column used to separate crude oil into fractions.



(i) Give one use for refinery gases and one use for bitumen.

(2)

refinery gases

.....

.....

bitumen

.....

.....

(ii) Give a reason why refinery gases rise to the top of the column.

(1)

.....

.....

(iii) State what must happen to the crude oil before it is pumped into the column.

(1)

.....

.....

(b) There is a low demand for some of the hydrocarbons obtained from crude oil.

Catalytic cracking can be used to convert low-demand hydrocarbons into more useful products.

(i) Give the conditions needed for cracking.

(2)

(ii) The cracking of tetradecane is shown in the equation.

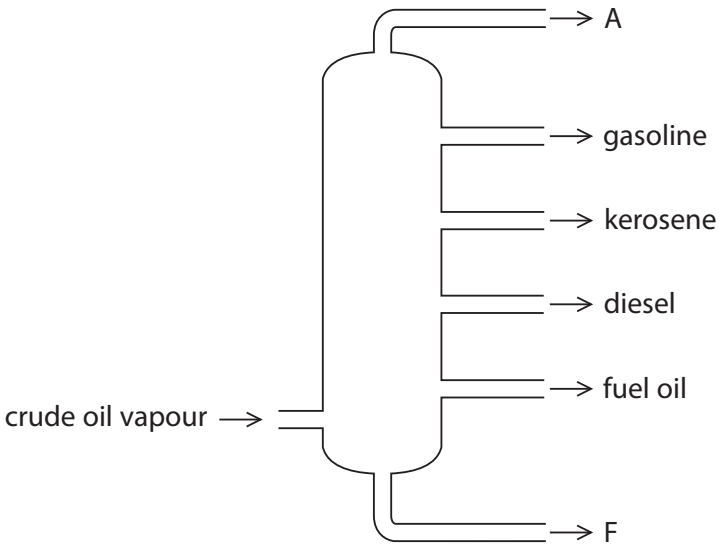
$$C_{14}H_{30} \rightarrow 2C_3H_6 + C_8H_{18}$$

Explain why there is a high demand for both of the products.

(3)

(Total for Question 4 = 9 marks)

3 The diagram shows the industrial equipment used to separate crude oil into fractions.



(a) (i) Give the name of the industrial equipment.

(1)

.....

(ii) Give one use of the fuel oil fraction.

(1)

.....

(iii) Give the names of fraction A and fraction F.

(2)

fraction A .....

fraction F .....

(b) One compound in the gasoline fraction is the alkane octane (C_8H_{18}) and one compound in the kerosene fraction is the alkane dodecane ($C_{12}H_{26}$)

These two alkanes are covalently bonded and have simple molecular structures.

(i) Give the general formula for the alkanes.

(1)

.....

(ii) Explain, in terms of their structures, why $C_{12}H_{26}$ has a higher boiling point than C_8H_{18}

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Catalytic cracking can be used to convert the alkane $C_{12}H_{26}$ into more useful products.

(i) Give the name of the catalyst used for catalytic cracking.

(1)

.....

(ii) Complete the equation for this cracking reaction.

(1)

$C_{12}H_{26} \rightarrow C_9H_{20} +$ .....

(Total for Question 3 = 10 marks)

2 Crude oil is a mixture of hydrocarbons.

(a) This passage is about the industrial separation of crude oil.

Complete the passage by adding the missing words.

(3)

Crude oil is ..... to form vapour.

The vapour is passed through a ..... column.

The refinery gases are collected at the top of the column because they have low

....

(b) Bitumen is collected at the bottom of the column.

Give one use of bitumen.

(1)

.....

(c) One of the hydrocarbons in crude oil is an alkane with this structural formula.

$CH_3CH_2CH_2CH_2CH_3$

(i) Give the name of this alkane.

(1)

.....

(ii) Calculate the relative molecular mass (M_r) of this alkane.

(1)

M_r = ...

(d) Catalytic cracking is used to convert long-chain alkanes into shorter-chain alkanes.

Give the name of the catalyst and the temperature used in catalytic cracking.

(2)

catalyst .....

temperature .....

(e) Catalytic cracking also produces alkenes.

Decane ($C_{10}H_{22}$) can undergo cracking to give C_4H_{10} and two different alkenes.

Complete the equation for this cracking process.

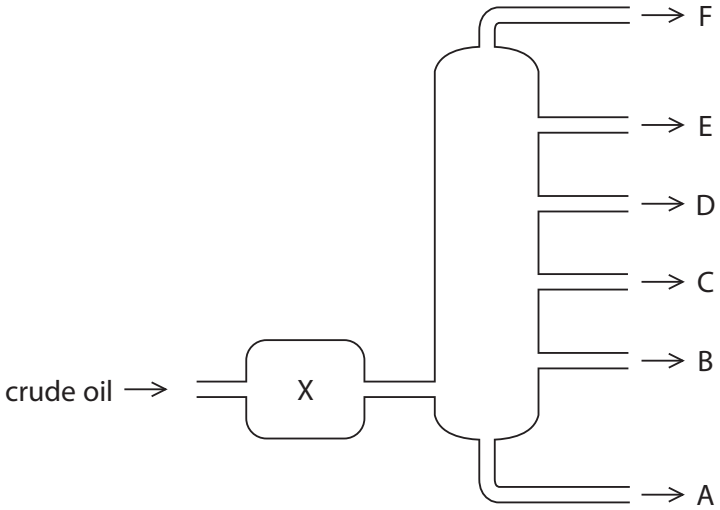
(2)

$C_{10}H_{22} \rightarrow C_4H_{10} +$ ..... $+$ .....

(Total for Question 2 = 10 marks)

3 Crude oil is an important source of organic compounds.

(a) The diagram shows how crude oil can be separated into fractions by fractional distillation.



(i) State what happens to the crude oil when it is in X.

(1)

.....

.....

(ii) Give the name of fraction E.

(1)

.....

(iii) Give a use for fraction A.

(1)

.....

(b) One of the compounds in fraction D is tridecane ($C_{13}H_{28}$) which can be cracked to form shorter-chain hydrocarbons.

(i) State the catalyst and temperature used in this cracking reaction.

(2)

catalyst

.....

temperature

.....

(ii) The equation shows an example of a catalytic cracking reaction.

$$C_{13}H_{28} \rightarrow C_8H_{18} + C_2H_4 + C_3H_6$$

Give two reasons why this reaction is important.

(2)

1 .....

.....

.....

2 .....

.....

.....

(c) Sulfur is an impurity in crude oil.
Explain why this is a problem for the environment.

(3)

.....

.....

.....

.....

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.....

.....

(Total for Question 3 = 10 marks)

2 Crude oil is a mixture of hydrocarbons.

(a) Name the process used to separate crude oil into fractions.

(1)

.....

(b) Give one use of the kerosene fraction.

(1)

.....

(c) One of the hydrocarbons in the refinery gas fraction is an alkane with the structural formula $CH_3CH_2CH_2CH_3$

(i) Give the name of this alkane.

(1)

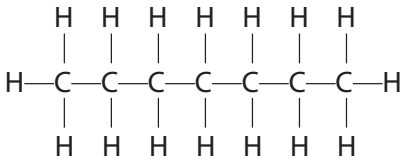
.....

(ii) Calculate the relative molecular mass (M_r) of this alkane.

(1)

M_r = ...

(d) One of the alkanes in the gasoline fraction has the displayed formula



(i) Determine the molecular formula of this alkane.

(1)

.....

(ii) Give the general formula for the alkanes.

(1)

.....

(e) Catalytic cracking is used to convert long-chain alkanes into shorter-chain alkanes.

(i) Name the catalyst used in catalytic cracking.

(1)

.....

(ii) Explain why it is necessary to convert long-chain alkanes into shorter-chain alkanes.

(2)

.....

.....

.....

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.....

.....

(f) Catalytic cracking also produces alkenes.

$C_{11}H_{24}$ can undergo cracking to give pentane (C_5H_{12}) and two different alkenes.

Complete the equation for this cracking reaction.

(2)

$C_{11}H_{24} \rightarrow C_5H_{12}$ + ... + ...

(Total for Question 2 = 11 marks)

8 This question is about crude oil.

(a) Describe how crude oil is separated into fractions by fractional distillation.

(4)

(b) Some of the products of fractional distillation are then cracked.

This equation represents a reaction that occurs during cracking.

$$C_{15}H_{32} \rightarrow C_8H_{18} + C_3H_6 + 2C_2H_4$$

Explain why cracking is an important process in the oil industry.

(4)

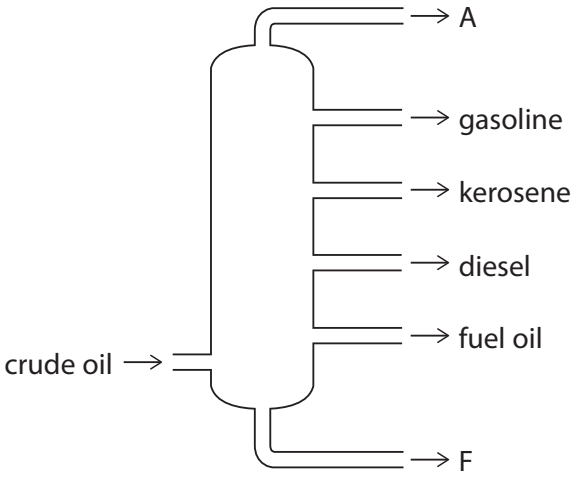
(c) Fuels obtained from crude oil may contain impurities.

Explain how an impurity found in fuels can cause an environmental problem.

(3)

(Total for Question 8 = 11 marks)

3 The diagram shows the separation of crude oil into fractions.



(a) Give the name of fraction A and the name of fraction F.

(2)

fraction A

.....

fraction F

.....

(b) One of the fractions is kerosene.

(i) Give one use of kerosene.

(1)

.....

(ii) Describe how kerosene can be obtained from crude oil.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

(c) Catalytic cracking is a process used to break down fractions containing long-chain molecules.

(i) Give the name of the catalyst and the temperature used for catalytic cracking.

(2)

catalyst

.....

temperature

.....

(ii) Explain why catalytic cracking is useful.

(3)

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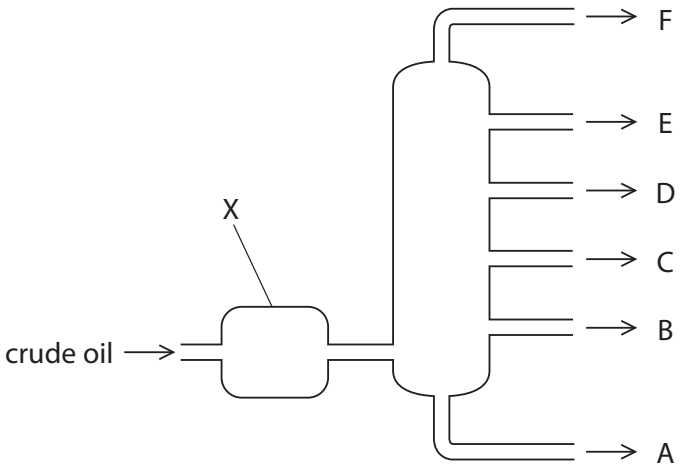
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(Total for Question 3 = 11 marks)

3 Crude oil is an important source of organic compounds.

(a) The diagram shows how crude oil can be separated into useful mixtures of hydrocarbons.



(i) Give the name of this method of separation.

(1)

.....

(ii) State what happens to the crude oil when it is in X.

(1)

.....

.....

(iii) Give the letter of the mixture that is most likely to contain a hydrocarbon with six carbon atoms.

(1)

.....

(iv) Give the name of mixture D.

(1)

.....

(v) Give a use for mixture B.

(1)

.....

.....

(b) Explain, in terms of intermolecular forces, why a hydrocarbon in mixture B has a higher boiling point than a hydrocarbon in mixture D.

(3)

(c) Catalytic cracking can be used to break down long-chain hydrocarbons to produce shorter-chain alkanes and alkenes.

(i) Give the name of a catalyst used in catalytic cracking.

(1)

(ii) Complete the equation to show two different alkenes that could be produced in this cracking reaction.

(2)

$C_{15}H_{32} \rightarrow C_8H_{18} +$ ..... + ...

(iii) Give one important use for short-chain alkenes.

(1)

(Total for Question 3 = 12 marks)

3 Crude oil is a mixture of organic compounds.

Most of these compounds are members of the same homologous series.

(a) State the name of this homologous series.

(1)

.....

(b) An industrial process is used to separate crude oil into fractions.

(i) The process depends on a difference in a property of the fractions.

What is this property?

(1)

- ☒ **A** boiling point
- ☒ **B** density
- ☒ **C** melting point
- ☒ **D** solubility

(ii) The boxes give some uses of fractions and some names of fractions.

Draw one straight line from each use to its correct fraction.

(3)

Use	**Fraction**
	bitumen
fuel for aeroplanes	diesel
fuel for ships	fuel oil
surfacing roads	gasoline
	kerosene

(c) Fuels obtained from the fractions may contain impurities.

Explain how the combustion of a common impurity in fuels may cause an environmental problem.

(3)

.....

.....

.....

.....

.....

.....

(d) Some of the fractions contain long-chain molecules which are not very useful.

(i) Give the name of the process used to convert long-chain molecules into more useful shorter-chain molecules.

(1)

.....

(ii) Give the catalyst and temperature used in the industrial process to convert long-chain molecules into shorter-chain molecules.

(2)

catalyst .....

temperature .....

(iii) When $C_{13}H_{28}$ is used in this process, three different molecules are formed.

Complete the equation for this reaction.

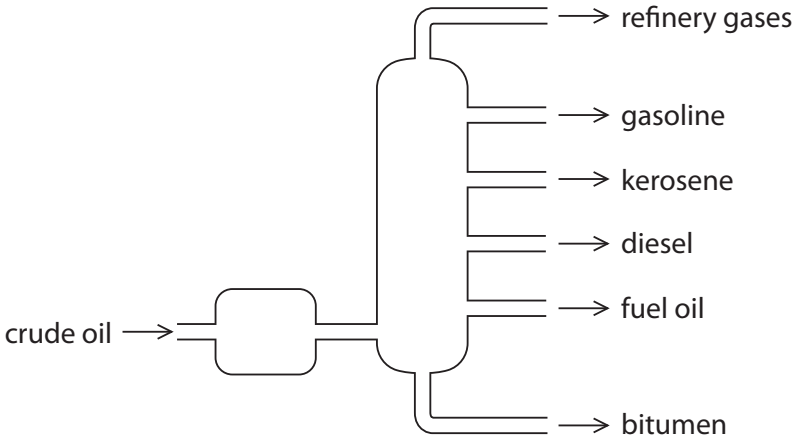
(2)

$$C_{13}H_{28} \rightarrow C_8H_{18} + \text{.....} + \text{.....}$$

(Total for Question 3 = 13 marks)

4 Fractional distillation is used to separate crude oil into fractions.

The diagram shows a fractionating column and the fractions obtained from crude oil.



(a) (i) Describe how crude oil is separated into fractions in the fractionating column.

(4)

(ii) Give a use for kerosene and a use for bitumen.

(2)

kerosene

bitumen

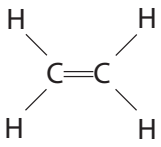
(b) Some fractions obtained from crude oil are cracked to form alkenes.

(i) Describe what is meant by cracking.

(2)

(ii) Ethene is obtained by cracking.

This is the displayed formula of ethene.



Explain why ethene is described as an unsaturated hydrocarbon.

(3)

(iii) Describe a test to show that ethene is unsaturated.

(2)

.....

.....

.....

.....

(Total for Question 4 = 13 marks)

6 This question is about crude oil.

(a) Describe how crude oil is separated into fractions by fractional distillation.

(4)

(b) Some of the long-chain alkanes obtained from fractional distillation are cracked, producing shorter-chain alkanes and ethene.

(i) Give the conditions necessary for cracking to occur.

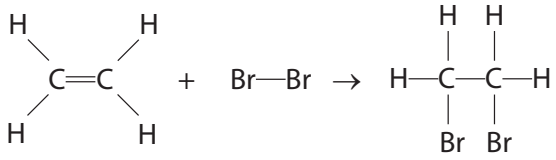
(2)

(ii) Explain why shorter-chain alkanes are more useful than longer-chain alkanes.

(2)

(iii) Ethene reacts with bromine.

The equation shows the displayed formulae of the reactants and product.



The table shows some bond energies.

Bond	Bond energy in kJ/mol
C=C	612
C—C	348
C—H	414
Br—Br	193
C—Br	276

Show that the molar enthalpy change, ΔH, for this reaction is about –100 kJ/mol.

(3)

ΔH = ... kJ/mol

(iv) Explain why the reaction between ethene and bromine is exothermic.

Refer to bond energies in your answer.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 6 = 13 marks)

9 This question is about products from crude oil.

(a) Most of the compounds in crude oil are from the same homologous series.

Give the name of this homologous series.

(1)

(b) Many fuels are obtained from the fractional distillation of crude oil.

Explain how the combustion of a common impurity in fuels causes acid rain.

(3)

(c) The equation shows the cracking of a hydrocarbon produced from the fractional distillation of crude oil.

$$C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$$

(i) Give the temperature and the catalyst used in catalytic cracking.

(2)

temperature

catalyst

(ii) Explain why cracking is a useful process in the oil industry.

(3)

(d) The formula C_5H_{12} represents three isomers.

(i) Explain what is meant by the term **isomers**.

(2)

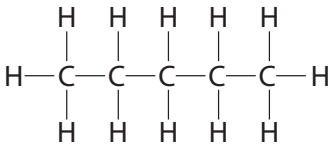
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.....

(ii) This is the displayed formula of one of the isomers.



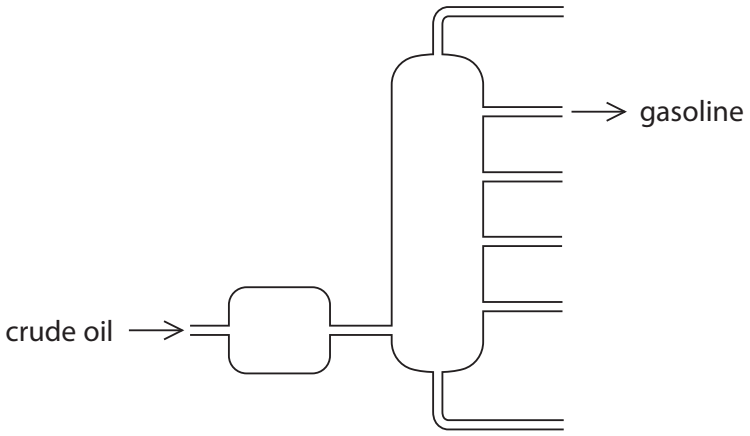
Draw the displayed formula of each of the other two isomers.

(2)

(Total for Question 9 = 13 marks)

7 This question is about octane (C_8H_{18}) which is produced in the gasoline fraction during fractional distillation of crude oil.

(a) The diagram shows a fractionating column.



Describe how crude oil is separated into fractions in the fractionating column.

(4)

(b) Octane can also be produced by the process of cracking.

Give the conditions for cracking.

(2)

(c) A car is driven at constant speed for 4.00 km.

The exhaust gases are collected and their volume at room temperature and pressure (rtp) is 5.02×10^5 cm^3.

The exhaust gases include carbon dioxide and oxides of nitrogen.

The carbon dioxide is removed from the exhaust gases. The volume of the remaining gases at rtp is 2.96×10^5 cm^3.

(i) Explain how oxides of nitrogen form in a car engine.

(2)

.....

.....

.....

.....

(ii) Give a reason why oxides of nitrogen should not be released into the atmosphere.

(1)

.....

.....

(iii) Show that the car produces less than 100 g of carbon dioxide per km.

[molar volume of carbon dioxide at rtp = 24 000 cm^3]

(5)

(Total for Question 7 = 14 marks)

6 This question is about ethane and ethene.

(a) Ethane can be obtained from crude oil.

Describe the industrial process used to separate crude oil into fractions.

(4)

(b) The equation for the reaction between ethene gas and hydrogen gas is

$$C_2H_4 + H_2 \rightarrow C_2H_6$$

The rate of this reaction can be increased by increasing the pressure.

(i) Explain why increasing the pressure increases the rate of this reaction.

(2)

(ii) The rate of this reaction can also be increased by using a catalyst.

Explain how using a catalyst increases the rate of a reaction.

(2)

.....

.....

.....

.....

(iii) Give one other way that the rate of reaction between ethene gas and hydrogen gas can be increased.

(1)

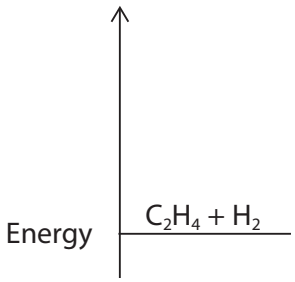
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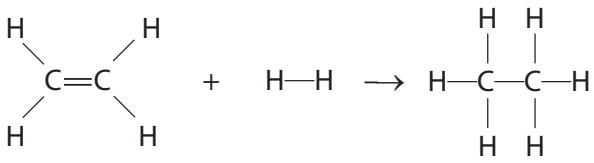
(iv) The reaction between ethene and hydrogen is exothermic.

Complete the reaction profile diagram, including labels for the activation energy and the enthalpy change, ΔH.

(3)



(c) The reaction between ethene and hydrogen can be represented using displayed formulae.



Bond	Bond energy in kJ/mol
C=C	612
C—H	412
H—H	436
C—C	348

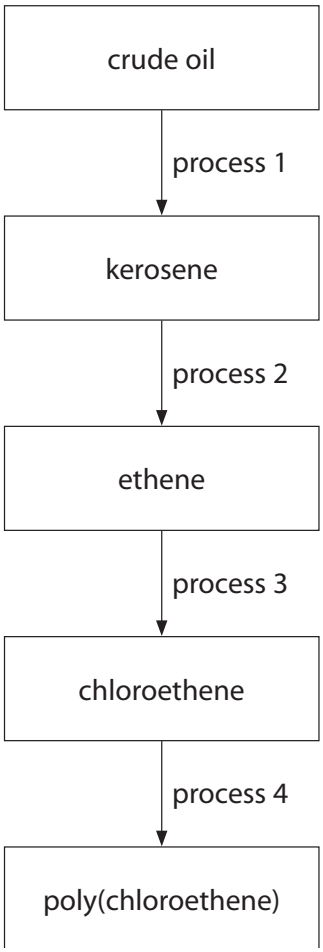
Use the bond energies in the table to calculate the enthalpy change, ΔH, in kJ/mol for this reaction.

(3)

$\Delta H =$ ..... kJ/mol

(Total for Question 6 = 15 marks)

7 The diagram shows some important conversion processes used in the oil industry.



(a) Describe how kerosene is produced from crude oil in process 1.

(5)

(b) $C_{12}H_{26}$ is present in kerosene.

In process 2, $C_{12}H_{26}$ is cracked to produce two molecules of ethene and one molecule of another hydrocarbon.

(i) Complete the equation for the cracking of $C_{12}H_{26}$

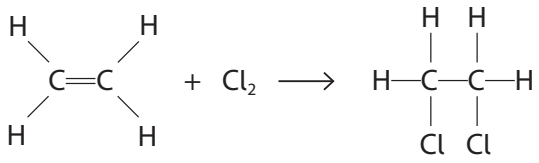
(1)

$$C_{12}H_{26} \rightarrow 2C_2H_4 + \text{.....}$$

(ii) Explain why cracking is a useful process in the oil industry.

(4)

(c) This is the equation for one of the reactions that may occur during process 3.



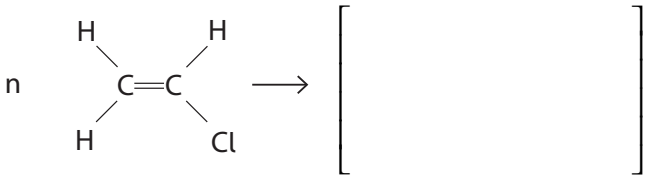
What is the name of this type of reaction?

(1)

- ☒ **A** addition
- ☒ **B** combustion
- ☒ **C** decomposition
- ☒ **D** substitution

(d) (i) Complete the equation for the polymerisation of chloroethene in process 4.

(2)



(ii) Explain why the disposal of polymers such as poly(chloroethene) is difficult.

(2)

(Total for Question 7 = 15 marks)

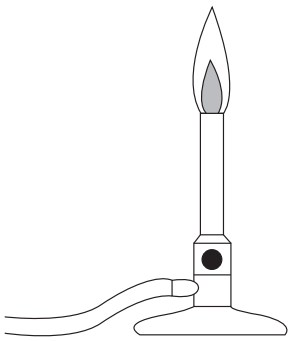
SUB-TOPIC 4c

ALKANES

Sub-topic 4c · 11 questions · 130 marks · lowest tariff first

2 This question is about methane, CH_4

The diagram shows a Bunsen burner that uses methane.



(a) During combustion, methane reacts with a gas in the air.

Give the name of this gas.

(1)

.....

(b) Give the two products of the complete combustion of methane.

(2)

.....

.....

(c) During the incomplete combustion of methane, carbon monoxide forms.

(i) Give a reason why carbon monoxide forms during incomplete combustion.

(1)

.....

.....

(ii) State why carbon monoxide is poisonous.

(1)

.....

.....

(d) The equation shows the reaction of methane with bromine.

$$CH_4 + Br_2 \rightarrow CH_3Br + HBr$$

Give the name of this type of chemical reaction.

(1)

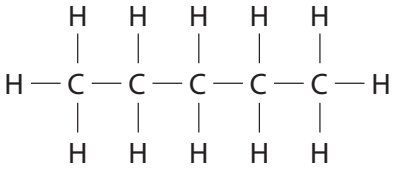
.....

(Total for Question 2 = 6 marks)

10 (a) There are three isomers with the molecular formula C_5H_{12}

One of these isomers is pentane.

The displayed formula for pentane is



(i) State what is meant by the term **isomers**.

(2)

(ii) Draw the displayed formula for another isomer of C_5H_{12}

(2)

(b) Pentane reacts with bromine in the presence of ultraviolet radiation.

(i) Complete the equation for this reaction.

(2)

$C_5H_{12} + Br_2 \rightarrow$ ..... + ...

(ii) Give the name of this type of reaction.

(1)

.....

(Total for Question 10 = 7 marks)

3 This question is about alkanes.

(a) (i) Which of these is the **molecular** formula of an alkane?

(1)

- ☒ **A** C_2H_5
- ☒ **B** C_4H_{10}
- ☒ **C** CH_2CH_2
- ☒ **D** $CH_3CH_2CH_3$

(ii) Which of these has the same empirical formula and molecular formula?

(1)

- ☒ **A** CH_2
- ☒ **B** C_2H_6
- ☒ **C** C_3H_8
- ☒ **D** C_4H_{10}

(b) In the presence of ultraviolet radiation, methane reacts with bromine to form bromomethane and hydrogen bromide.

(i) State the name of this type of reaction.

(1)

.....

(ii) Give a chemical equation for this reaction.

(1)

.....

(c) One mole of an alkane burns completely in oxygen.

The equation represents the reaction.

$$\text{alkane} + xO_2 \rightarrow yCO_2 + zH_2O$$

The numbers *x*, *y* and *z* are used to balance the equation.

(i) The complete combustion of one mole of the alkane produces 220 g of carbon dioxide and 108 g of water.

Calculate the values of *y* and *z*.

[M_r of $CO_2 = 44$ M_r of $H_2O = 18$]

(2)

y = ...

z = ...

(ii) Determine the molecular formula of the alkane and the value of *x*.

(2)

molecular formula = ...

x = ...

(d) When an alkane burns in a limited supply of air, incomplete combustion occurs.

Explain why incomplete combustion of an alkane could be harmful to humans.

(2)

.....

.....

.....

.....

(Total for Question 3 = 10 marks)

5 This question is about alkanes and alkenes.

(a) The alkane C_5H_{12} has three isomers.

(i) State what is meant by the term **isomers**.

(2)

.....

.....

.....

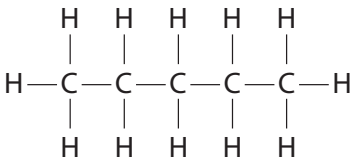
.....

(ii) Calculate the relative formula mass (M_r) of C_5H_{12}

(1)

M_r of C_5H_{12} = ...

(iii) This is the displayed formula of one of the isomers.



Give the name of this isomer.

(1)

.....

(iv) Draw the displayed formulae of the other two isomers.

(2)

Isomer 1	Isomer 2

(b) Ethane (C_2H_6) and ethene (C_2H_4) both react with bromine.

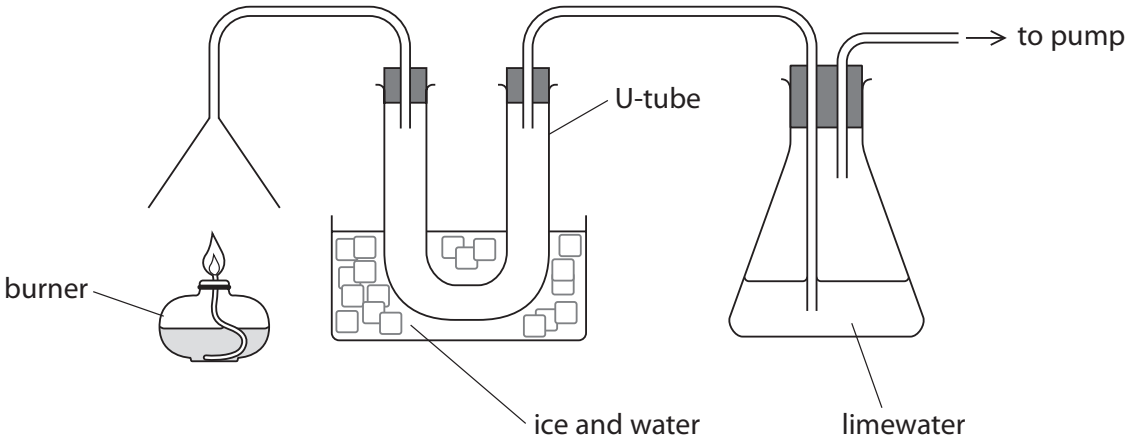
Describe the differences in the reactions of ethane and ethene with bromine.

Refer to the conditions, the products and the types of reaction involved.

(5)

(Total for Question 5 = 11 marks)

7 A teacher uses this apparatus to test the products of the combustion of liquid hydrocarbons.



(a) Explain the change in appearance that occurs in the limewater.

(2)

.....

.....

.....

.....

(b) The equation represents the complete combustion of an alkene.

$$C_nH_{2n} + \text{oxygen} \rightarrow \text{carbon dioxide} + nH_2O$$

Complete combustion of 0.0100 mol of the alkene produces 2.16 g of water.

(i) Determine the molecular formula of this alkene.

[for H_2O, $M_r = 18$]

(3)

molecular formula = ...

(ii) Give a reason why the mass of pure water that collects in the U-tube is less than 2.16 g.

(1)

.....

.....

(iii) Give a physical test to show that the water that collects in the U-tube is pure.

(2)

.....

.....

.....

.....

(c) The teacher burns 30.0 g of heptane.

This is the equation for the complete combustion of heptane.

$$C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$$

Calculate the minimum mass of oxygen needed for the complete combustion of 30.0 g of heptane.

[for C_7H_{16}, $M_r = 100$ for O_2, $M_r = 32$]

(3)

minimum mass of oxygen = ... g

(Total for Question 7 = 11 marks)

9 Propane is a hydrocarbon with the formula C_3H_8

(a) State why propane is a hydrocarbon.

(2)

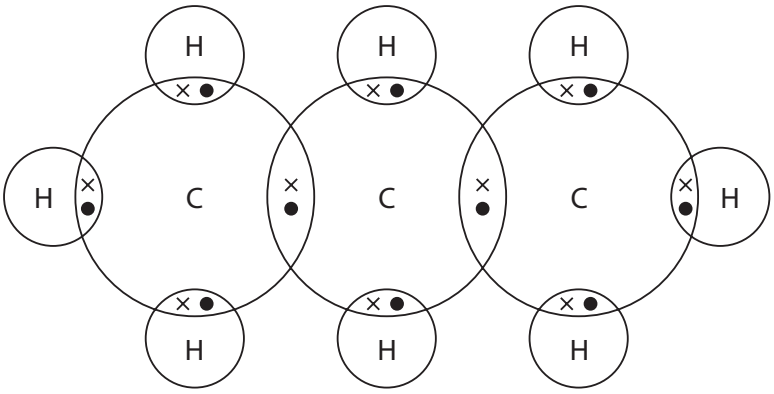
(b) (i) Name the poisonous gas that forms when propane is burned in a limited supply of air.

(1)

(ii) State why this gas is poisonous to humans.

(1)

(c) The diagram represents a molecule of propane.



Describe the forces of attraction between the atoms in a molecule of propane.

(2)

(d) Propane can be produced by cracking.

An equation for cracking is

$$C_{13}H_{28} \rightarrow C_3H_8 + 2C_3H_6 + 2C_2H_4$$

Explain why cracking is an important process in the oil industry.

(3)

(e) Propane reacts with bromine in the presence of ultraviolet radiation.

(i) Complete the equation for this reaction.

(2)

$C_3H_8 + Br_2 \rightarrow$ ..... + ...

(ii) Give the name of this type of reaction.

(1)

.....

.....

(Total for Question 9 = 12 marks)

4 This question is about hydrocarbons.

(a) State the meaning of the term **hydrocarbon**.

(2)

.....

.....

.....

.....

(b) One homologous series of hydrocarbons is the alkanes.

Pentane (C_5H_{12}) is an alkane.

(i) When pentane burns completely in oxygen, carbon dioxide and water are produced.

Give a chemical equation for this combustion reaction.

(2)

.....

(ii) Incomplete combustion can occur when the oxygen supply is limited.

Give the names of two products of the incomplete combustion of pentane.

(2)

1 .....

2 .....

(iii) One of the products of incomplete combustion is a poisonous gas.

State why this gas is poisonous to humans.

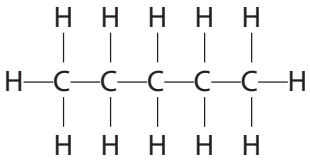
(1)

.....

.....

(iv) C_5H_{12} has three isomers.

The displayed formula for one of these isomers is



Draw the displayed formulae of the other two isomers.

(2)

(c) Another homologous series of hydrocarbons is the alkenes.

Alkenes are unsaturated hydrocarbons.

(i) Give the general formula for the alkenes.

(1)

(ii) State the meaning of the term **unsaturated**.

(1)

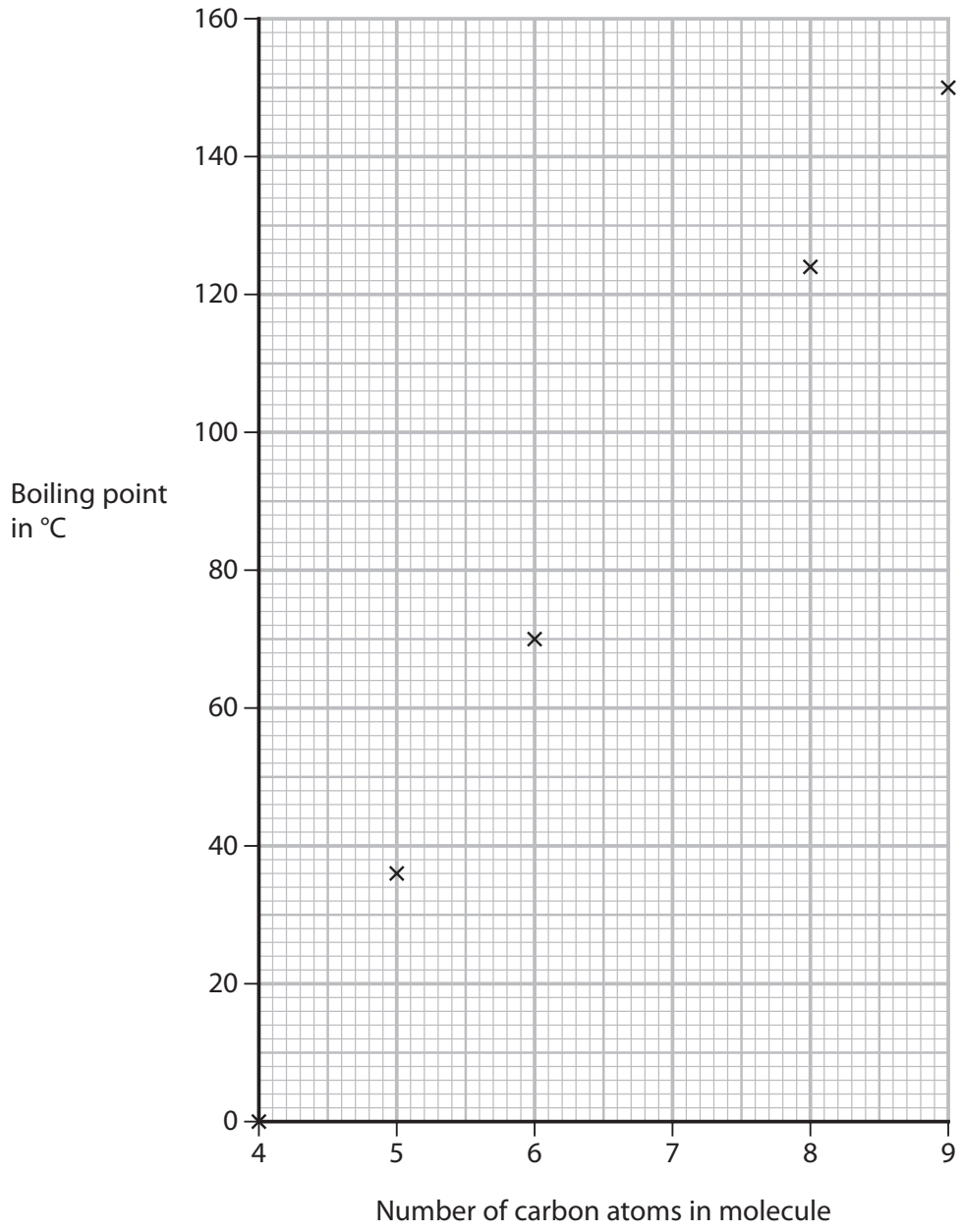
(iii) Describe a test to show that a hydrocarbon is unsaturated.

(2)

(Total for Question 4 = 13 marks)

10 This question is about alkanes.

(a) The graph shows the boiling points of several unbranched alkanes.



(i) Draw a curve of best fit.

(1)

(ii) Use the graph to find the boiling point of the alkane with 7 carbon atoms in its molecule.

Show on the graph how you obtain your answer.

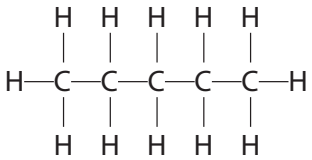
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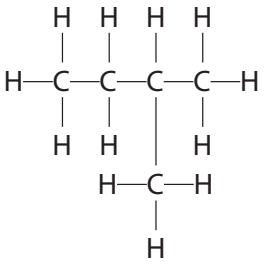
boiling point = ... °C

(iii) Explain the trend shown by the graph.

(3)

(b) The diagram represents two isomers with the formula C_5H_{12}





Explain why these compounds are isomers.

(2)

(c) (i) An alkane contains 82.8% carbon and 17.2% hydrogen by mass.

Show by calculation that the empirical formula of this alkane is C_2H_5

(2)

(ii) Deduce the molecular formula of this alkane.

(1)

.....

.....

(d) The equation for the complete combustion of one mole of an alkane can be represented by

$$\text{alkane} + ZO_2 \rightarrow XCO_2 + YH_2O$$

Complete combustion of one mole of the alkane produces 308 g of carbon dioxide and 144 g of water.

X, Y and Z are the numbers used to balance the equation.

Calculate the values of X, Y and Z.

[M_r of CO_2 = 44, M_r of H_2O = 18]

(3)

X = ...

Y = ...

Z = ...

(Total for Question 10 = 14 marks)

5 Butane (C_4H_{10}) is an alkane.

(a) Explain why butane is a saturated hydrocarbon.

(3)

(b) (i) When butane burns completely in oxygen, carbon dioxide and water are produced.

Give a chemical equation for this combustion reaction.

(2)

(ii) Incomplete combustion can occur when the oxygen supply is limited.

One product of the incomplete combustion of butane is carbon monoxide.

Give the name of another product of this incomplete combustion.

(1)

(iii) State why carbon monoxide is poisonous to humans.

(1)

(c) C_4H_{10} exists as two isomers.

(i) State what is meant by the term **isomers**.

(2)

.....

.....

.....

.....

(ii) Draw the displayed formula of each isomer.

(2)

(d) Explain why hexane (C_6H_{14}) has a higher boiling point than butane (C_4H_{10}).

(3)

.....

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.....

(Total for Question 5 = 14 marks)

3 This question is about alkanes.

(a) An alkane has the structural formula $CH_3CH_2CH_2CH_3$

Give the missing information for this alkane.

(4)

structural formula	$CH_3CH_2CH_2CH_3$
name	
	C_4H_{10}
empirical formula	
	C_nH_{2n+2}

(b) There are two isomers of C_4H_{10}

(i) State what is meant by the term **isomers**.

(2)

.....

.....

.....

.....

(ii) Draw the displayed formula of each isomer of C_4H_{10}

(2)

Isomer 1	Isomer 2

(c) Methane reacts with bromine to form bromomethane and one other product.

(i) Give the formula of the other product.

(1)

.....

(ii) What is the name of this type of reaction?

(1)

☒ **A** addition

☒ **B** decomposition

☒ **C** neutralisation

☒ **D** substitution

(iii) State the condition needed for this reaction to occur.

(1)

.....

(d) When ethane (C_2H_6) burns in a plentiful supply of air, carbon dioxide and water are formed.

(i) Give a chemical equation for this reaction.

(2)

.....

(ii) When the air supply is limited, incomplete combustion occurs.

Explain why a gas formed by incomplete combustion can cause a problem for humans.

(2)

.....

.....

.....

.....

(Total for Question 3 = 15 marks)

5 This question is about alkanes and alkenes.

(a) The alkane C_4H_{10} exists as two isomers.

(i) State what is meant by the term **isomers**.

(2)

.....

.....

.....

.....

(ii) Draw the displayed formulae for the two isomers of C_4H_{10}

(2)

Isomer 1	Isomer 2

(b) Ethane (C_2H_6) can react with bromine.

(i) State the condition needed for ethane to react with bromine.

(1)

.....

(ii) Complete the equation for this reaction.

(1)

$C_2H_6 + Br_2 \rightarrow$ ..... + ...

(iii) Give the name for this type of reaction.

(1)

.....

(c) Explain why ethane is described as a saturated compound.

(2)

(d) State what you would observe when ethane and ethene are added separately to two samples of bromine water.

(2)

ethane

ethene

(e) Explain why straight-chain alkenes always have the same empirical formula, but straight-chain alkanes have different empirical formulae.

Refer to the molecular formulae of the alkanes C_2H_6 and C_4H_{10} in your answer.

(3)

(f) An organic compound has this percentage composition by mass.

C = 19.2% H = 4.0% O = 12.8% Br = 64.0%

Calculate the empirical formula of this compound.

(3)

empirical formula = ...

(Total for Question 5 = 17 marks)

SUB-TOPIC 4d

ALKENES

Sub-topic 4d · 11 questions · 139 marks · lowest tariff first

8 Ethene (C_2H_4) can be converted into chloroethene (C_2H_3Cl) in a two-stage process.

(a) The first stage is to convert ethene into 1,2-dichloroethane, $C_2H_4Cl_2$

Ethene is reacted with hydrogen chloride and oxygen.

Complete the chemical equation for this reaction.

(1)

..... C_2H_4 + ... HCl + ... O_2 → ..... $C_2H_4Cl_2$ + ... H_2O

(b) In the second stage, 1,2-dichloroethane is converted into chloroethene.

$$C_2H_4Cl_2 \rightarrow C_2H_3Cl + HCl$$

This is a thermal decomposition reaction.

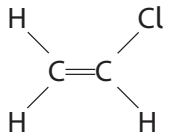
State what is meant by the term **thermal decomposition**.

(1)

.....

.....

(c) The diagram shows the displayed formula of chloroethene.



(i) State why chloroethene is described as an unsaturated compound.

(1)

.....

.....

(ii) Describe a test to show that chloroethene is unsaturated.

(2)

.....

.....

.....

.....

(d) Name the polymer formed from chloroethene.

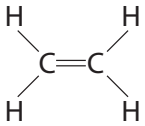
(1)

.....

(Total for Question 8 = 6 marks)

1 This question is about the unsaturated hydrocarbon, ethene.

The displayed formula of ethene is



(a) (i) State the meaning of the term **hydrocarbon**.

(2)

.....

.....

.....

.....

(ii) Give the reason why ethene is described as unsaturated.

(1)

.....

.....

(b) Ethene is bubbled through bromine water until there is no further colour change.

Which of these is the appearance of the solution formed?

(1)

- ☒ **A** colourless
- ☒ **B** orange
- ☒ **C** purple
- ☒ **D** red

(c) Ethanol is produced industrially by the reaction between ethene and steam.

The equation for the reaction is

$$CH_2CH_2(g) + H_2O(g) \rightarrow CH_3CH_2OH(l)$$

(i) State the temperature and pressure used in this reaction.

(2)

temperature

.....

pressure

.....

(ii) Give the **molecular** formula of ethanol.

(1)

.....

(Total for Question 1 = 7 marks)

10 This question is about alkanes and alkenes.

(a) Ethane and ethene each react with bromine, but under different conditions.

(i) Give a reason why **ethane** does not undergo an addition reaction with bromine.

(1)

.....

.....

(ii) Complete the equation for the substitution reaction between **ethane** and bromine, including an essential condition for the reaction.

(2)

$C_2H_6 + Br_2 \rightarrow$ ..... + ...

condition

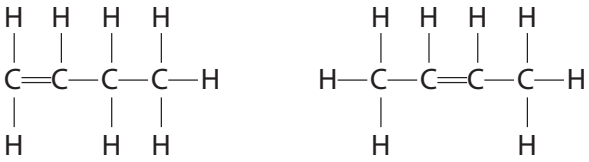
.....

(iii) Give the colour change that occurs when **ethene** reacts with bromine water.

(1)

.....

(b) The diagram shows the displayed formulae of two compounds in the homologous series of alkenes.



(i) Compounds in the same homologous series have the same general formula.

Give two other characteristics of compounds in the same homologous series.

(2)

1 .....

.....

2 .....

.....

(ii) Explain why the alkenes in the diagram are isomers.

(2)

.....

.....

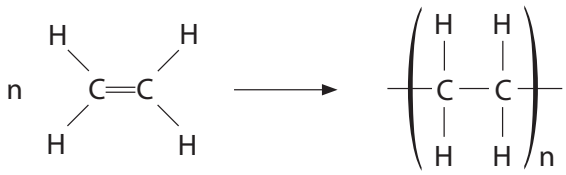
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(iii) Draw the displayed formula of another alkene that is an isomer of these two alkenes.

(1)

(c) The reaction used to make poly(ethene) can be represented by this equation.



Describe the differences between the reactant and the product in this reaction.

Refer to carbon chain length, type of bond and state of matter in your answer.

(3)

(Total for Question 10 = 12 marks)

9 This question is about alkenes and polymers.

(a) (i) Ethene (C_2H_4) can be represented by different types of formula.

Complete the table by giving the missing information.

(2)

Molecular formula	C_2H_4
Empirical formula	
General formula	

(ii) Ethene is a member of the homologous series of alkenes.

All members of the same homologous series have the same general formula.

Give two other characteristics of a homologous series.

(2)

1 .....

.....

2 .....

.....

(b) Ethene is used to make poly(ethene).

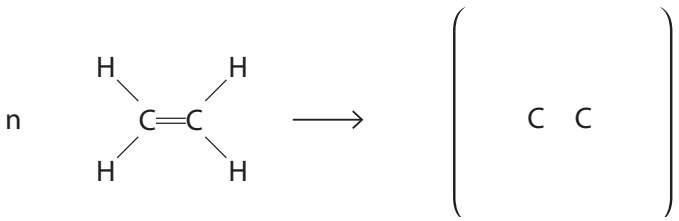
(i) State the type of polymerisation used to form poly(ethene).

(1)

.....

(ii) Complete the equation for the polymerisation of ethene.

(2)



(iii) Poly(ethene) is used to make plastic bags.

Corn starch from plants can also be used to make polymers for plastic bags.

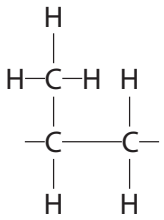
The table gives some information about poly(ethene) and polymers made from corn starch.

	Poly(ethene)	Polymers from corn starch
Cost per tonne	£1500	£3700
Relative strength	100	50
Time to decompose	estimated 450 years	3–6 months

Use the information in the table and your knowledge to discuss the advantages and disadvantages of using poly(ethene) to make plastic bags.

(5)

(c) The diagram shows the repeat unit of another polymer.



Draw the displayed formula of the monomer used to make this polymer.

(1)

(Total for Question 9 = 13 marks)

6 Ocimene is an organic compound that gives some plants their particular smell.

The molecular formula of ocimene is $C_{10}H_{16}$

(a) Calculate the relative formula mass (M_r) of ocimene.

(1)

M_r = ...

(b) Using ocimene as an example, explain what is meant by the term **empirical formula**.

(2)

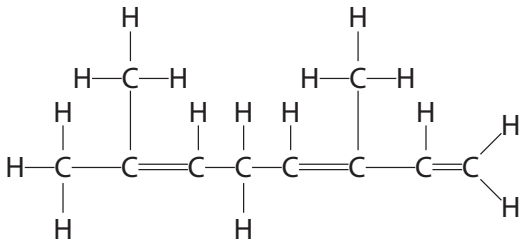
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(c) The displayed formula of ocimene is



Explain why ocimene is described as an unsaturated hydrocarbon.

(3)

.....

.....

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.....

(d) Ocimene is an alkene.

(i) Which of these types of reaction occurs between ocimene and bromine?

(1)

- ☒ **A** addition
- ☒ **B** polymerisation
- ☒ **C** precipitation
- ☒ **D** substitution

(ii) Many alkenes have the general formula C_nH_{2n}

Suggest why ocimene does not have this general formula.

(1)

.....

.....

.....

(e) Ocimene can take part in combustion reactions.

Complete the equation for the complete combustion of ocimene.

(2)

$C_{10}H_{16}$ + ... O_2 → ..... + ...

(f) Two different products can form during the incomplete combustion of ocimene.
One product is a solid and the other is a poisonous gas.

(i) Identify these two products.

(2)

.....

.....

(ii) State why the gas produced is poisonous.

(1)

.....

.....

.....

.....

(Total for Question 6 = 13 marks)

3 This question is about alkenes and alkanes.

(a) Complete the table by giving the missing information about the alkene with the molecular formula C_3H_6

(4)

Molecular formula	C_3H_6
Name	
Empirical formula	
General formula	
Displayed formula	

(b) Alkenes are unsaturated compounds.

(i) State what is meant by the term **unsaturated**.

(1)

.....

.....

(ii) Describe a test to show that a compound is unsaturated.

(2)

.....

.....

.....

.....

(c) When the alkane methane reacts with chlorine, the products are chloromethane (CH_3Cl) and hydrogen chloride gas.

(i) Give a chemical equation for this reaction.

(1)

.....

(ii) What is the name of this type of reaction?

(1)

- ☒ **A** addition
- ☒ **B** decomposition
- ☒ **C** neutralisation
- ☒ **D** substitution

(iii) State the condition needed for this reaction to occur.

(1)

.....

(d) When ethane reacts with chlorine, one of the products of the reaction has the formula $C_2H_4Cl_2$

There are two isomers with this formula.

(i) State what is meant by the term **isomers**.

(2)

.....

.....

.....

.....

(ii) Draw the displayed formulae of the two isomers with the formula $C_2H_4Cl_2$

(2)

isomer 1	isomer 2

(Total for Question 3 = 14 marks)

4 This question is about unsaturated hydrocarbons.

(a) Ethene (C_2H_4) is a member of the homologous series of alkenes.

(i) Give two characteristics of a homologous series.

(2)

1 .....

.....

2 .....

.....

(ii) Draw a dot-and-cross diagram to show the bonding in a molecule of ethene.

Show outer electrons only.

(2)

(b) Propene (C_3H_6) is another member of the homologous series of alkenes.

(i) State why the empirical formula of all alkenes in this homologous series is CH_2

(1)

.....

.....

(ii) Propene can be polymerised to form poly(propene).

Draw the displayed formula of propene and the repeat unit of poly(propene).

(2)

propene	repeat unit of poly(propene)

(c) This is the structural formula of another hydrocarbon compound.

$CH_2{=}CH{-}CH{=}CH_2$

(i) Give the molecular formula and the empirical formula of this compound.

(2)

molecular formula

empirical formula

(ii) Explain why this compound is an unsaturated hydrocarbon.

(3)

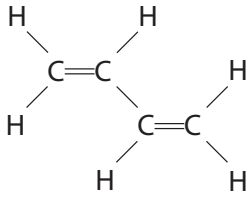
(iii) Describe a test to show that this hydrocarbon is unsaturated.

(2)

(Total for Question 4 = 14 marks)

5 The organic compound butadiene is a colourless gas used in the manufacture of synthetic rubber for tyres.

The displayed formula of butadiene is



(a) Explain why butadiene is described as an unsaturated hydrocarbon.

(3)

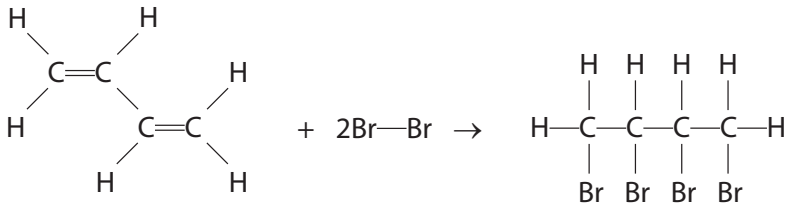
(b) (i) Butadiene reacts with bromine water.

State the colour change that occurs during this reaction.

(1)

from ..... to .....

(ii) The equation for the reaction between butadiene and bromine can be shown using displayed formulae.



The table gives some bond energies.

Bond	C—H	C═C	Br—Br	C—C	C—Br
Bond energy in kJ/mol	412	612	193	348	276

Use this information to calculate the enthalpy change, ΔH, for the reaction.

Include a sign in your answer.

(4)

ΔH = ... kJ/mol

(c) A scientist does an investigation to find out if butadiene would be a good fuel.

He burns a sample of butadiene gas and observes that carbon forms as black soot.

(i) Complete the equation to explain the scientist's observation.

(1)

$2C_4H_6 + 7O_2 \rightarrow$ .....C + 4CO + $2CO_2$ + ...H_2O

(ii) Explain how one of the products, other than carbon, may cause a problem.

(2)

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(iii) The equation for the combustion of butadiene in excess oxygen is

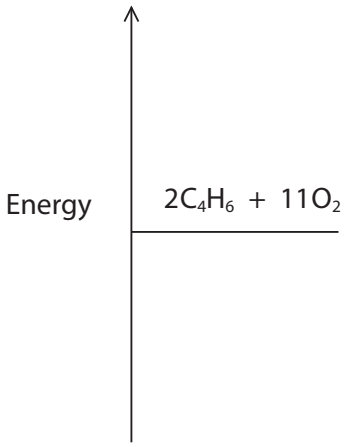
$$2C_4H_6 + 11O_2 \rightarrow 8CO_2 + 6H_2O$$

The enthalpy change for this reaction, ΔH, is – 3446 kJ/mol.

Complete the energy profile diagram for the reaction.

Label the enthalpy change for this reaction, ΔH, and the activation energy.

(4)



(Total for Question 5 = 15 marks)

5 This question is about alkanes and alkenes.

(a) (i) Complete the boxes by giving the missing information about the alkane with the molecular formula C_2H_6

(3)

molecular formula	C_2H_6
name	
empirical formula	
displayed formula	

(ii) Complete the chemical equation for the complete combustion of the alkane C_2H_6

(1)

.....C_2H_6 + ...O_2 → .....CO_2 + ...H_2O

(iii) Incomplete combustion occurs when the air supply is limited.

Give the names of two products of incomplete combustion.

(2)

1 .....

2 .....

(b) An alkene with molecular formula C_4H_8 reacts with bromine to form a compound with molecular formula $C_4H_8Br_2$

(i) What is the name of this type of reaction?

(1)

- ☒ **A** addition
- ☒ **B** decomposition
- ☒ **C** precipitation
- ☒ **D** substitution

(ii) Draw displayed formulae for two different alkenes with the molecular formula C_4H_8

(2)

alkene 1	alkene 2

(iii) State the term used for compounds with the same molecular formula but different structural formulae.

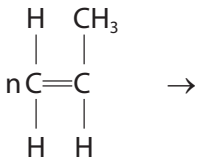
(1)

.....

(c) The alkene C_3H_6 can be polymerised to form the polymer poly(propene).

(i) Complete the equation for this polymerisation reaction.

(2)



(ii) Two ways of disposing of polymers such as poly(propene) are

- burying them in landfill sites
- burning them to release heat energy

Discuss the environmental problems caused by these two methods of disposal.

(3)

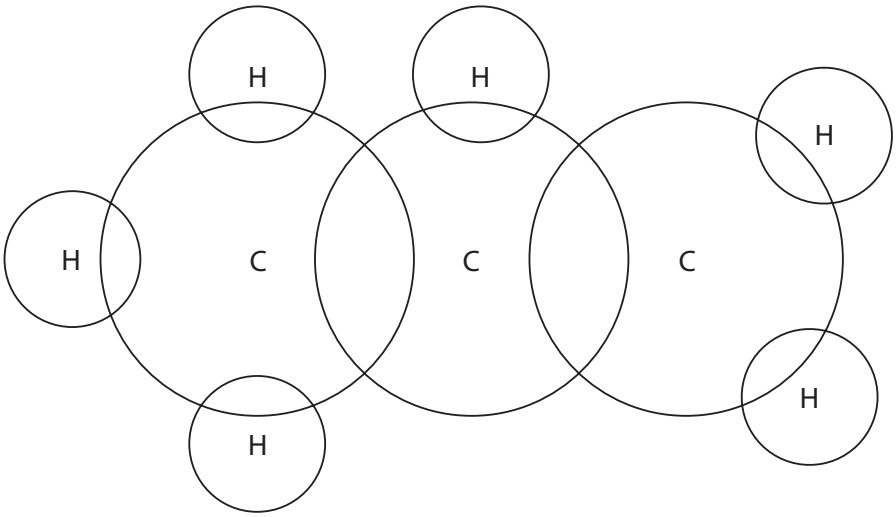
(Total for Question 5 = 15 marks)

10 This question is about propene.

(a) (i) The structural formula of propene is $CH_3CH{=}CH_2$

Complete the dot-and-cross diagram for a molecule of propene.

(2)



(ii) Describe the forces of attraction that hold the atoms together in a molecule of propene.

(2)

.....

.....

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.....

(b) The alkane pentadecane has the formula $C_{15}H_{32}$

Describe how propene can be produced from pentadecane.

(2)

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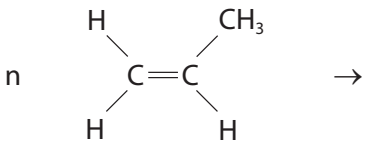
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(c) Propene is used to make poly(propene).

(i) Complete the equation for the formation of poly(propene).

(2)



(ii) Explain why the disposal of poly(propene) in landfill sites is a problem.

(2)

.....

.....

.....

.....

(d) Propene can be converted into compound X.

(i) Compound X contains these percentages by mass.

- carbon 60%
- hydrogen 13.3%
- oxygen 26.7%

Compound X has an M_r of 60

Determine the molecular formula of compound X.

(3)

molecular formula = ...

(ii) Propene and compound X both have simple molecular structures.

Explain why compound X has a higher boiling point than propene.

(2)

.....

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(Total for Question 10 = 15 marks)

8 This question is about hydrocarbons.

(a) The molecular formula C_4H_8 represents all the isomers of an alkene.

(i) Explain what is meant by the term **isomers**.

(2)

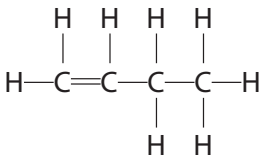
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(ii) The displayed formula of one of the isomers of the alkene is shown.



Draw displayed formulae for two other alkene isomers with the molecular formula C_4H_8

(2)

alkene isomer 1	alkene isomer 2

(b) But-1-ene reacts with bromine to form a compound with molecular formula $C_4H_8Br_2$

What is the name given to this type of reaction?

(1)

☒ **A** addition

☒ **B** combustion

☒ **C** decomposition

☒ **D** substitution

(c) The alkene C_3H_6 can be polymerised to form the polymer poly(propene).

(i) Draw the repeat unit of poly(propene).

(1)

(ii) These are two methods for disposing of polymers such as poly(propene).

method 1 burying them in landfill sites

method 2 burning them to release heat energy

State one environmental problem linked to each of these methods of disposal.

(2)

method 1

.....

.....

method 2

.....

.....

(d) Complete combustion of one mole of an alkane produces 396 g of carbon dioxide and 180 g of water.

This is the equation for the reaction.

$$\text{alkane} + xO_2 \rightarrow yCO_2 + zH_2O$$

Calculate the values of x, y and z.

[for CO_2, $M_r = 44$ for H_2O, $M_r = 18$]

(3)

x = ...

y = ...

z = ...

(e) In a petrol engine, incomplete combustion occurs because there is a limited supply of oxygen.

(i) Petrol contains octane, C_8H_{18}

Complete the equation for this reaction, including state symbols.

(2)

$C_8H_{18}(l)$ + ...O_2(.....) → .....CO(.....) + 3C(.....) + ...H_2O(.....)

(ii) Explain one problem for humans caused by a product of this incomplete combustion.

(2)

.....

.....

.....

.....

(Total for Question 8 = 15 marks)

SUB-TOPIC 4e

ALCOHOLS

Sub-topic 4e · 15 questions · 180 marks · lowest tariff first

4 This question is about alcohols, carboxylic acids and esters.

(a) The table gives information about some alcohols.

Alcohol	Structural formula	Relative formula mass
methanol	CH_3OH	32
ethanol	C_2H_5OH	
	C_4H_9OH	74

Complete the table by giving the missing information.

(2)

(b) Ethanol can be oxidised to ethanoic acid by heating with potassium dichromate(VI) and another reagent.

(i) Name the other reagent.

(1)

.....

(ii) State the colour change that occurs during this reaction.

(1)

from ..... to .....

(c) Alcohols react with carboxylic acids to form esters.

(i) Name the ester that forms when ethanol reacts with ethanoic acid.

(1)

.....

(ii) Complete the equation for the reaction between methanol and ethanoic acid.

(2)

CH_3OH + ... → ..... + H_2O

(Total for Question 4 = 7 marks)

4 This question is about the manufacture of ethanol by the fermentation of glucose.

(a) Fermentation needs to be done in the absence of air.

Give **two** other conditions needed for fermentation.

(2)

1 .....

2 .....

(b) Explain why fermentation needs to be done in the absence of air.

(2)

.....

.....

.....

.....

(c) (i) Complete the equation for fermentation.

(1)

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2\ldots\ldots$$

(ii) A mixture containing 500 mol of glucose is fermented.

A mass of 5750 g of ethanol is obtained.

Calculate the percentage yield.

[for ethanol, $M_r = 46$]

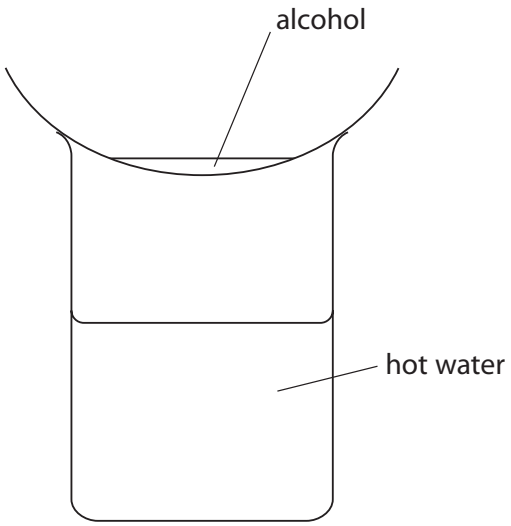
(3)

percentage yield = ... %

(Total for Question 4 = 8 marks)

3 Methanol, ethanol, propanol and butanol are alcohols. They are all liquids that evaporate easily when warmed.

A student uses this apparatus to compare the time taken for the four liquids to evaporate.



She uses this method.

- pour some methanol into an evaporating basin
- place the evaporating basin on top of a beaker containing hot water
- measure the time taken for the methanol to evaporate completely
- repeat the experiment with each of the other alcohols, using the same apparatus

(a) State two variables the student should control to make sure her results are valid.

(2)

1 .....

.....

2 .....

.....

(b) State why it is not safe to heat the evaporating basin directly with a Bunsen flame.

(1)

.....

.....

(c) The table shows the results of experiments done by four students, A, B, C and D.

Alcohol	Formula of alcohol	Time taken for liquid to evaporate in s				
		Student A	Student B	Student C	Student D	Mean time in s
methanol	CH_3OH	20	24	22	26	23
ethanol	C_2H_5OH	32	34	35	30	33
propanol	C_3H_7OH	45	47	50	48	48
butanol	C_4H_9OH	64	63	90	60	

(i) Calculate the mean (average) time for butanol to evaporate.

(2)

mean time = ... s

(ii) Explain how the results show which alcohol evaporates most easily.

(2)

.....

.....

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.....

(iii) State the relationship between the number of carbon atoms in the molecule and how easily the alcohol evaporates.

(2)

.....

.....

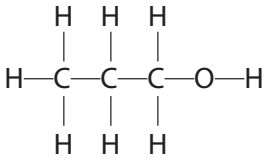
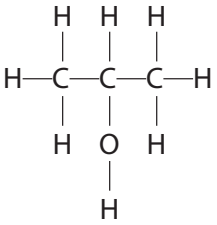
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(Total for Question 3 = 9 marks)

4 (a) Hand sanitiser liquids are used regularly to reduce the spread of infections.

Three compounds P, Q and R are often present in these liquids.

P	Q	R
CH_3CH_2OH		

(i) What type of formula is shown for P?

(1)

- ☒ **A** a displayed formula
- ☒ **B** an empirical formula
- ☒ **C** a molecular formula
- ☒ **D** a structural formula

(ii) Compounds P, Q and R are members of the same homologous series.

Give two properties of a homologous series.

(2)

1 .....

.....

2 .....

.....

(iii) Name the homologous series that contains compounds P, Q and R.

(1)

.....

(iv) Give the name of compound Q.

(1)

.....

(b) Diols and dicarboxylic acids react together in polymerisation reactions to form polyesters.

(i) Explain the name given to the type of polymerisation that occurs in these reactions.

(2)

.....

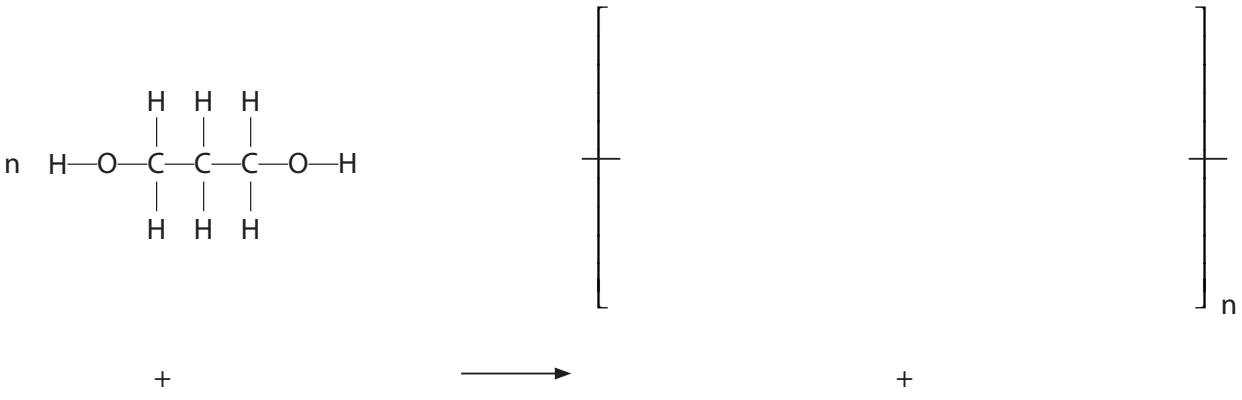
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(ii) Complete the equation for the polymerisation reaction by giving the displayed formula of the repeat unit of the polymer.

(2)



(Total for Question 4 = 9 marks)

5 Methanol, CH_3OH, is the first member of the homologous series of alcohols.

(a) Give two characteristics of a homologous series.

(2)

1 .....

.....

2 .....

.....

(b) Methanol is heated with potassium dichromate(VI) and one other reagent.

The methanol is oxidised to methanoic acid, HCOOH

(i) Give the formula of the other reagent.

(1)

.....

(ii) Give the colour change that occurs during the reaction.

(2)

from ..... to .....

(iii) Draw the displayed formula for methanol and for methanoic acid in the boxes.

(2)

methanol	methanoic acid

(c) Methanol reacts with methanoic acid to form an ester.

Complete the equation for this reaction.

(1)

$CH_3OH + HCOOH \rightarrow$ ..... + ...

(d) The structural formula of an ester is $CH_3COOCH_2CH_2CH_2CH_3$

(i) What is the name of this ester?

(1)

☒ **A** butyl ethanoate

☒ **B** butyl methanoate

☒ **C** ethyl butanoate

☒ **D** methyl butanoate

(ii) Deduce the molecular formula of this ester.

(1)

.....

(Total for Question 5 = 10 marks)

6 Ethanol, C_2H_5OH, can be manufactured from ethene and steam using a phosphoric acid catalyst.

(a) (i) State the temperature and pressure used in this manufacturing process.

(2)

temperature .....

pressure .....

(ii) Draw the displayed formula of ethanol.

(1)

(b) Ethanol burns in a plentiful supply of air to form carbon dioxide and water.

(i) Give the chemical equation for this reaction.

(2)

.....

(ii) When the air supply is limited, incomplete combustion occurs and carbon monoxide forms.

State why carbon monoxide is poisonous to humans.

(1)

.....

.....

(c) When ethanol reacts with ethanoic acid, an ester forms.

Give the name of this ester.

(1)

.....

(d) Butanedioic acid and ethanediol react together to form a polyester and water.

(i) Give the name of this type of polymerisation.

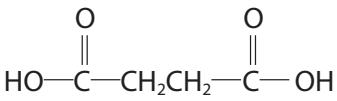
(1)

.....

(ii) Complete the equation.

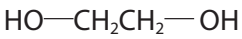
Show only one repeat unit of the polyester.

(3)



.....

\+ → +



.....

(Total for Question 6 = 11 marks)

6 This question is about alcohols, carboxylic acids and esters.

(a) Ethanol can be manufactured by reacting ethene with steam in the presence of a phosphoric acid catalyst.

Which row gives the correct conditions of temperature and pressure for this reaction?

	Temperature in °C	Pressure in atmospheres
☒ **A**	35	300
☒ **B**	65	300
☒ **C**	300	65
☒ **D**	300	35

(1)

(b) Give the displayed formula of butanol.

(1)

(c) Ethanoic acid (CH_3COOH) is a carboxylic acid present in vinegar.

(i) The concentration of CH_3COOH in vinegar can be found by titration with aqueous potassium hydroxide (KOH).

The equation for the reaction is

$$CH_3COOH + KOH \rightarrow CH_3COOK + H_2O$$

In a titration, a 25.0 cm^3 sample of vinegar is neutralised by 45.00 cm^3 of KOH solution of concentration 0.400 mol/dm^3.

Calculate the concentration, in mol/dm^3, of CH_3COOH in this sample of vinegar.

(2)

concentration = ... mol/dm^3

(ii) A sample of vinegar containing 0.0030 mol of CH_3COOH is poured into a flask.

Calculate the maximum volume, in cm^3, of carbon dioxide gas formed at rtp when excess sodium carbonate is added to the flask.

The equation for the reaction is

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$$

[Assume that the molar volume of carbon dioxide at rtp is 24 000 cm^3]

(2)

volume = ... cm^3

(d) Alcohols react with carboxylic acids to form esters.

Which alcohol could react to form the ester ethyl propanoate?

(1)

☒ **A** CH_3OH

☒ **B** C_2H_5OH

☒ **C** C_3H_7OH

☒ **D** C_4H_9OH

(e) Polyesters are formed in condensation polymerisation reactions between dicarboxylic acids and diols.

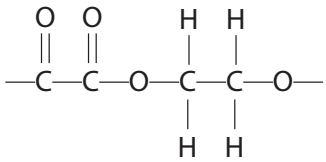
(i) State one difference between condensation polymerisation and addition polymerisation.

(1)

.....

.....

(ii) The repeat unit of a polyester is



Give the displayed formula of each of the two monomers needed to form this polyester.

(2)

(iii) Give one advantage of biopolyesters.

(1)

.....

.....

(Total for Question 6 = 11 marks)

5 This question is about alcohols, carboxylic acids and esters.

(a) Ethanol can be manufactured by the fermentation of a solution of glucose.

(i) Write a word equation for this reaction.

(1)

.....

(ii) State the substance that needs to be added for the reaction to occur.

(1)

.....

(iii) State two conditions needed for this reaction.

(2)

1 .....

2 .....

(b) In the presence of an acid catalyst, ethanoic acid is heated with butanol to form an ester.

(i) Which of these is the formula of the ester?

(1)

☒ **A** $CH_3COOC_3H_7$

☒ **B** $CH_3COOC_4H_9$

☒ **C** $C_2H_5COOC_4H_9$

☒ **D** $C_3H_7COOC_2H_5$

(ii) State how you would know that an ester has formed.

(1)

.....

.....

(iii) Give one use of an ester.

(1)

.....

.....

(c) Aspirin is a compound used to reduce pain.

Aspirin contains a carboxylic acid functional group and an ester functional group.

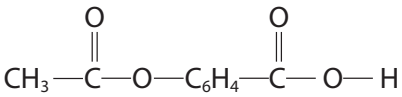
(i) State what is meant by the term **functional group**.

(1)

.....

.....

(ii) This is the structural formula of aspirin.



Draw a circle around the carboxylic acid functional group.

(1)

(iii) Aspirin has this percentage composition by mass.

C = 60.00 % H = 4.44 % O = 35.56 %

Show by calculation that the empirical formula of aspirin is $C_9H_8O_4$

(3)

(Total for Question 5 = 12 marks)

6 Some cars in Brazil use ethanol, C_2H_5OH, as a fuel instead of petrol.

The ethanol is made by the fermentation of glucose which is obtained from sugar cane.

The sugar is extracted from the sugar cane and then dissolved in water to make a sugar solution.

(a) (i) Name the substance that is added to the sugar solution that causes glucose to ferment.

(1)

.....

(ii) Which temperature is the most suitable for fermentation?

(1)

☒ **A** 0 °C

☒ **B** 10 °C

☒ **C** 30 °C

☒ **D** 80 °C

(iii) Explain why fermentation is done in the absence of air.

(2)

.....

.....

.....

.....

(b) (i) State what is meant by the term **fuel**.

(1)

.....

.....

(ii) Write a chemical equation for the complete combustion of ethanol in air.

(2)

.....

(c) Ethanol is also manufactured by reacting steam with ethene, C_2H_4

The equation for this reaction is

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

State the conditions of temperature and pressure used in this process.

(2)

temperature .....

pressure .....

(d) When ethanol is heated with acidified potassium dichromate(VI), it is oxidised to ethanoic acid.

(i) State the colour change that occurs in the potassium dichromate(VI) during this reaction.

(1)

from ..... to .....

(ii) The structural formula of ethanoic acid is CH_3COOH

Draw the displayed formula of ethanoic acid.

(2)

(iii) Complete the equation for the reaction of ethanoic acid with sodium.

(2)

.....$CH_3COOH(aq)$ + ...$Na(s)$ → .....(aq) + ...(g)

(Total for Question 6 = 14 marks)

7 (a) Ethanol, C_2H_5OH, can be produced by the fermentation of glucose, $C_6H_{12}O_6$

(i) Complete the equation for the fermentation of glucose.

(1)

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2 \text{ .....}$$

(ii) State why it is necessary for fermentation to be done in the absence of air.

(1)

.....

.....

(iii) Explain why the temperature should not be higher than 40 °C.

(2)

.....

.....

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.....

(iv) When 4 mol of glucose is fermented, a mass of 55.2 g of ethanol is produced.

Show that the percentage yield of ethanol is 15%.

[M_r of C_2H_5OH = 46]

(2)

(b) Ethanol can also be produced by the reaction between ethene and steam.

The equation for the reaction is

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

(i) This reaction is in dynamic equilibrium.

Give two features of a reaction in dynamic equilibrium.

(2)

1 .....

.....

2 .....

.....

(ii) When the equilibrium mixture is heated, the yield of ethanol decreases.

Explain whether the forward reaction is exothermic or endothermic.

(2)

.....

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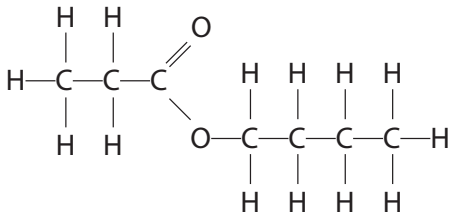
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(c) Carboxylic acids react with alcohols to form esters.

The displayed formula of an ester is



(i) Carboxylic acid A and alcohol B react to produce this ester.

Give the displayed formula of carboxylic acid A and of alcohol B.

(2)

Carboxylic acid A	Alcohol B

(ii) Indicators can be used to test for carboxylic acids.

Describe a different chemical test for a carboxylic acid.

(2)

.....

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.....

(Total for Question 7 = 14 marks)

5 Ethanol, C_2H_5OH, is a member of the homologous series of alcohols.

(a) Give two characteristics of a homologous series.

(2)

1 .....

.....

2 .....

.....

(b) When ethanol is heated with potassium dichromate(VI) and one other reagent, the ethanol is oxidised to ethanoic acid, CH_3COOH

(i) Give the formula of the other reagent.

(1)

.....

(ii) State the colour change that occurs during this oxidation reaction.

(2)

from ..... to .....

(iii) Draw the displayed formulae for ethanol and ethanoic acid in the boxes.

(2)

ethanol	ethanoic acid

(c) Ethanol can be manufactured by two different methods.
The table gives some information about the two methods.

	Hydration of ethene	Fermentation of glucose
raw material	crude oil	sugar cane
rate of reaction	fast	slow
purity of ethanol	pure	impure
operating temperature	300 °C	30 °C
operating pressure	60 – 70 atmospheres	1 atmosphere
catalyst	phosphoric acid	enzymes in yeast

(i) Discuss the advantages and disadvantages of these two methods, using information from the table.

(6)

(ii) The word equation for the fermentation process is

glucose → ethanol + carbon dioxide

Complete the chemical equation for this reaction.

(1)

$C_6H_{12}O_6 \rightarrow$ ..... + ...

(Total for Question 5 = 14 marks)

4 Alcohols contain the functional group —OH

(a) Give the structural formula of the alcohol that contains one carbon atom.

(1)

(b) Ethanol (C_2H_5OH) is an alcohol that can be obtained from glucose ($C_6H_{12}O_6$).

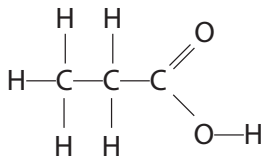
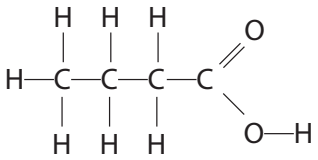
(i) Name the process that converts glucose into ethanol.

(1)

(ii) Explain why this process is carried out in the absence of air and at a temperature below 40 °C.

(4)

(c) The table gives information about some organic compounds in the same homologous series.

Compound	Molecular formula	Displayed formula
ethanoic acid	$C_2H_4O_2$	
propanoic acid		
	$C_4H_8O_2$	

(i) Complete the table by giving the missing information.

(3)

(ii) Name the homologous series that contains these compounds.

(1)

.....

(d) The compounds in the table can react with alcohols to form esters.

When preparing esters, a small amount of concentrated sulfuric acid is also used.

(i) State the purpose of the acid.

(1)

.....

(ii) Draw the displayed formula of the ester that forms when propanoic acid reacts with ethanol.

(2)

(iii) Esters have particular uses that depend on their properties.

Give an example of a property and use of esters.

(2)

property.....

use.....

.....

(Total for Question 4 = 15 marks)

3 This question is about alcohols.

Ethanol can be manufactured using two different methods.

- hydration of ethene
- fermentation of glucose

This is the equation for hydration.

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

(a) Complete the equation for fermentation.

(2)

$C_6H_{12}O_6 \rightarrow$ ..... + ...

(b) The table gives some information about the two methods.

	Hydration	Fermentation
Reagents	ethene and steam	aqueous glucose
Catalyst		enzymes in yeast
Temperature in °C	300	
Pressure in atmospheres		1
Rate of process	fast	slow
Purity of product	pure	impure

(i) Complete the table by giving the missing information.

(3)

(ii) Explain one advantage and one disadvantage of using fermentation rather than hydration to produce ethanol.

You should use information from the table to help your answer.

(4)

advantage

disadvantage

(c) Explain why fermentation needs to occur in the absence of air.

(2)

(d) Propanol has this percentage composition by mass.

C = 60.0% H = 13.3% O = 26.7%

(i) Show by calculation that the empirical formula of propanol is C_3H_8O.

(3)

(ii) Draw the displayed formula of propanol.

(1)

(Total for Question 3 = 15 marks)

7 This question is about ethanol, C_2H_5OH, which can be used as a fuel.

Ethanol can be produced by the fermentation of glucose solution.

(a) (i) Name the substance that is added that causes the fermentation of glucose solution.

(1)

.....

(ii) Which temperature is most suitable for fermentation?

(1)

- ☒ **A** 0 °C
- ☒ **B** 10 °C
- ☒ **C** 30 °C
- ☒ **D** 100 °C

(iii) Explain why fermentation is done in the absence of air.

(2)

.....

.....

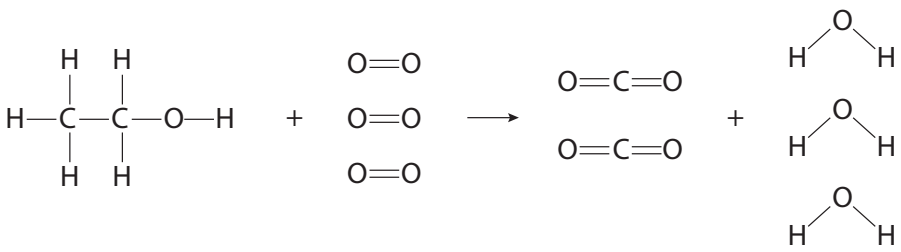
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(b) This is the equation for the combustion of ethanol.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

The equation shows the displayed formulae of the reactants and products.



The table shows some bond energies.

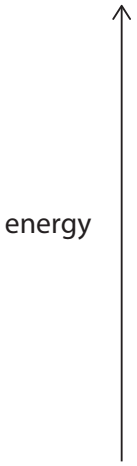
Bond	Bond energy in kJ / mol
C—H	414
C—C	346
C—O	358
O—H	463
O=O	498
C=O	804

(i) Use the bond energies to show that the molar enthalpy change, ΔH, is about −1300 kJ / mol.

(3)

(ii) Complete the energy level diagram for the reaction between C_2H_5OH and O_2

(3)



(iii) Explain, in terms of bonds broken and bonds made, why this reaction is exothermic.

(2)

.....

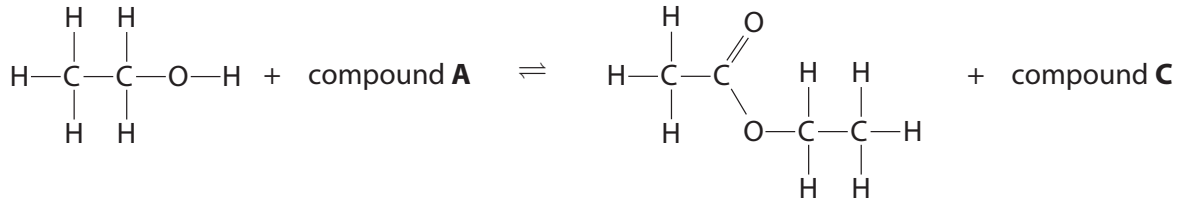
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.....

(c) Ethanol reacts with compound **A** to produce ester **B** and compound **C**.

This is the equation for the reaction.



ester **B**

(i) Draw the displayed formula for compound **A** and for compound **C**.

(2)

compound **A**	compound **C**

(ii) Name ester **B**.

(1)

.....

(Total for Question 7 = 15 marks)

7 (a) Ethanol, C_2H_5OH, can be oxidised to produce ethanoic acid, CH_3COOH, by heating it with potassium dichromate(VI).

(i) Name one other reactant needed for this reaction to occur.

(1)

.....

(ii) Which colour change occurs during this reaction?

(1)

☒ **A** colourless to green

☒ **B** green to orange

☒ **C** orange to colourless

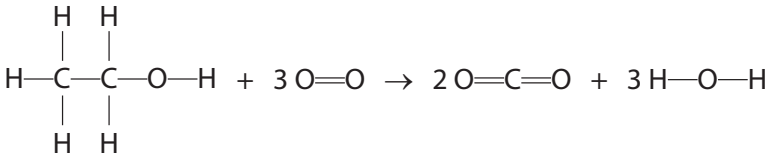
☒ **D** orange to green

(b) When ethanol is burned in air, complete combustion can occur.

The equation for this reaction is

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

This equation can also be written using displayed formulae to show all the covalent bonds in the molecules.



The table gives the bond energies for these bonds.

Bond	C—C	C—H	C—O	O—H	O═O	C═O
Bond energy in kJ/mol	346	412	358	463	496	743

(i) Use values from the table to calculate the energy needed to break all the bonds in the reactants.

(2)

energy needed ..... kJ

(ii) Use values from the table to calculate the energy released when all the bonds in the products are formed.

(2)

energy released ..... kJ

(iii) Calculate the molar enthalpy change (ΔH) in kJ/mol, for the complete combustion of ethanol.

Include a sign in your answer.

(1)

ΔH = ... kJ/mol

(c) Ethanol reacts with methanoic acid, HCOOH, in the presence of an acid catalyst to form an ester.

The equation for the reaction is

$$C_2H_5OH + HCOOH \rightleftharpoons HCOOC_2H_5 + H_2O$$

(i) Give the name of the ester that forms.

(1)

.....

(ii) Draw the displayed formula for this ester.

(2)

(iii) When this reaction takes place in a sealed container, the reaction can reach dynamic equilibrium.

Give two characteristics of a reaction at dynamic equilibrium.

(2)

1 .....

.....

2 .....

.....

(d) Methanoic acid reacts with sodium carbonate to form sodium methanoate, carbon dioxide and water.

The equation for the reaction is

$$2HCOOH + Na_2CO_3 \rightarrow 2HCOONa + CO_2 + H_2O$$

Calculate the volume, in cm^3, of carbon dioxide gas produced when 2.3 g of methanoic acid reacts completely with sodium carbonate.

[M_r of HCOOH = 46]

[molar volume of carbon dioxide at rtp = 24 dm^3]

(4)

volume of carbon dioxide = ... cm^3

(Total for Question 7 = 16 marks)

SUB-TOPIC 4f

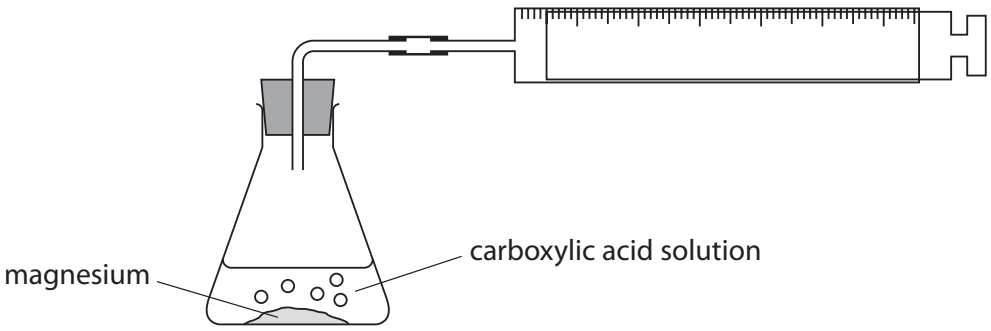
CARBOXYLIC ACIDS

Sub-topic 4f · 6 questions · 62 marks · lowest tariff first

3 This question is about carboxylic acids.

Solutions of carboxylic acids react with magnesium metal to form hydrogen gas.

A student uses this apparatus to investigate the time taken to produce 10 cm^3 of hydrogen gas from different carboxylic acids.



This is the student's method.

- pour some carboxylic acid solution into a conical flask
- add some magnesium powder
- quickly connect the gas syringe and start a timer
- record the time taken to collect 10 cm^3 of hydrogen gas

The student repeats the method with three other carboxylic acids.

(a) (i) All the carboxylic acids are of the same concentration.

Give two other variables the student should control in his investigation.

(2)

1 .....

.....

2 .....

.....

(ii) Give a reason why it is important to connect the gas syringe quickly.

(1)

.....

.....

(b) The table shows the student's results.

Carboxylic acid	Formula of carboxylic acid	Time taken to produce 10 cm^3 of hydrogen in s				
		Experiment 1	Experiment 2	Experiment 3	Experiment 4	Mean time in s
Methanoic acid	HCOOH	48	50	47	49	49
Ethanoic acid	CH_3COOH	61	63	60	61	61
Propanoic acid	CH_3CH_2COOH	69	93	70	71	
Butanoic acid	$CH_3CH_2CH_2COOH$	83	85	82	81	83

(i) Calculate the mean (average) time for propanoic acid to produce 10 cm^3 of hydrogen gas.

(2)

mean time = ... s

(ii) Deduce the relationship between the number of carbon atoms in the molecule and the time taken to produce 10 cm^3 of hydrogen gas.

(1)

.....

.....

.....

(c) An ester is formed by adding ethanoic acid to ethanol in the presence of sulfuric acid.

Give the displayed formula of the ester produced when ethanoic acid reacts with ethanol.

(2)

(Total for Question 3 = 8 marks)

4 This question is about alcohols, carboxylic acids and their reactions.

(a) The boxes give some information about a carboxylic acid.

Complete the boxes by giving the missing information.

(3)

structural formula	CH_3COOH
name	
	CH_2O
displayed formula	

(b) Ethanol can be oxidised to produce a carboxylic acid.

(i) Give the names of the two reagents used in this oxidation reaction.

(2)

1 .....

2 .....

(ii) Which of these colour changes occurs during the reaction?

(1)

- ☒ **A** green to orange
- ☒ **B** orange to green
- ☒ **C** red to yellow
- ☒ **D** yellow to red

(c) Alcohols and carboxylic acids can be heated together to form esters.

(i) State why it is better to heat the mixture using a water bath rather than directly with a Bunsen burner flame.

(1)

.....

.....

(ii) An ester has the structural formula $CH_3CH_2COOCH_3$

Which of these is the name of this ester?

(1)

☒ **A** ethyl methanoate

☒ **B** methyl ethanoate

☒ **C** methyl propanoate

☒ **D** propyl methanoate

(Total for Question 4 = 8 marks)

5 This question is about the reactions of carboxylic acids.

(a) Carboxylic acids react with solutions of metal carbonates.

(i) Complete the chemical equation for the reaction of ethanoic acid, CH_3COOH, with potassium carbonate solution.

(2)

$2CH_3COOH + K_2CO_3 \rightarrow$ ..... + ... + ...

(ii) State what you would see in this reaction.

(1)

.....

(b) The ester, ethyl ethanoate, can be prepared by reacting ethanol with ethanoic acid.

This is the method for the preparation.

- mix equal amounts of ethanoic acid and ethanol in a boiling tube
- add a few drops of concentrated sulfuric acid
- place the boiling tube in a hot water bath for several minutes

(i) State the role of concentrated sulfuric acid in this reaction.

(1)

.....

.....

(ii) Suggest why the mixture is heated in a water bath rather than directly with a Bunsen burner flame.

(1)

.....

.....

(iii) State how you would know that ethyl ethanoate has formed.

(1)

.....

.....

(c) Another ester, methyl propanoate, can be prepared by reacting methanol with propanoic acid.

(i) Draw the displayed formulae of methanol, propanoic acid and the ester, methyl propanoate.

(3)

methanol	propanoic acid

methyl propanoate

(ii) Give the name of the other product of this reaction.

(1)

.....

(d) Give one use of esters.

(1)

.....

(Total for Question 5 = 11 marks)

5 This question is about carboxylic acids and esters.

(a) Ethanoic acid reacts with magnesium to form two products.

(i) Complete the equation for this reaction.

(2)

..... + ... → $(CH_3COO)_2Mg$ + ...

(ii) Give two observations that could be made during this reaction.

(2)

1 .....

2 .....

(b) Propanoic acid reacts with methanol to form an ester.

(i) Give the name of a suitable catalyst for this reaction.

(1)

.....

(ii) What is the structural formula of the ester that forms?

(1)

☒ **A** $HCOOCH_2CH_2CH_3$

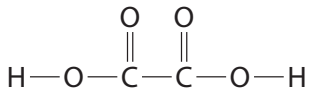
☒ **B** $CH_3COOCH_2CH_2CH_3$

☒ **C** $CH_3CH_2COOCH_3$

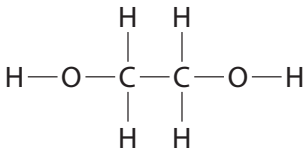
☒ **D** $CH_3CH_2CH_2COOCH_3$

(c) A polyester can be made by reacting ethanedioic acid with ethanediol.

These are the displayed formulae of the two reactants.



ethanedioic acid



ethanediol

(i) Give the name for this type of polymerisation.

(1)

.....

(ii) Give the name of the other product of this reaction.

(1)

.....

(iii) Draw the displayed formula for the repeat unit of the polyester that forms.

(2)

(d) State what is meant by the term **biopolyester**.

(1)

.....

.....

(Total for Question 5 = 11 marks)

7 This question is about alcohols and carboxylic acids.

(a) These are the structural formulae of alcohol A and carboxylic acid B.

Alcohol A $CH_3CH_2CH_2OH$

Carboxylic acid B $CH_3(CH_2)_nCOOH$

(i) Name alcohol A.

(1)

.....

(ii) Draw the displayed formula of alcohol A.

(1)

(iii) Carboxylic acid B has a chain of carbon atoms with no branches.

The number of CH_2 units is represented by the letter n.

Calculate the value of n.

[for carboxylic acid B, $M_r = 242$]

(3)

n = ...

(iv) Alcohol A and carboxylic acid B react together to form an ester.

Give the other product of the reaction.

(1)

.....

(b) These are the structural formulae of dicarboxylic acid C and diol D.

Dicarboxylic acid C $HOOCCH_2CH_2COOH$

Diol D $HOCH_2CH_2OH$

(i) This is the equation for the reaction between dicarboxylic acid C and sodium hydroxide solution.

$$HOOCCH_2CH_2COOH + 2NaOH \rightarrow NaOOCH_2CH_2COONa + 2H_2O$$

25.0 cm^3 of 0.150 mol/dm^3 sodium hydroxide solution is completely neutralised by 17.5 cm^3 of a solution of dicarboxylic acid C.

Calculate the concentration, in mol/dm^3, of the solution of dicarboxylic acid C.

Give your answer to three significant figures.

(4)

concentration = ... mol/dm^3

(ii) Dicarboxylic acid C and diol D react to form a polyester.

Draw the displayed formula of the repeat unit of this polyester.

(2)

(Total for Question 7 = 12 marks)

4 This question is about the reactions of ethanol and ethanoic acid.

(a) (i) Ethanol reacts with potassium dichromate(VI) to form ethanoic acid.

Name the other reagent needed in this reaction.

(1)

.....

(ii) State the colour change that occurs when ethanol reacts with potassium dichromate(VI).

(2)

from ..... to .....

(b) Ethanoic acid reacts with solid sodium carbonate.

(i) Complete the chemical equation for this reaction.

(2)

$2CH_3COOH + Na_2CO_3 \rightarrow$ ..... + ... + ...

(ii) State two observations seen in this reaction.

(2)

1 .....

.....

2 .....

.....

(c) A student prepares the ester, ethyl ethanoate, by reacting ethanol with ethanoic acid.

This is the student's method.

- mix equal amounts of ethanol and ethanoic acid in a boiling tube
- add a few drops of concentrated sulfuric acid
- place the boiling tube in a hot water bath for several minutes

(i) State the role of sulfuric acid in this reaction.

(1)

.....

.....

(ii) State why the student heats the mixture in a water bath instead of directly with a Bunsen burner flame.

(1)

.....

.....

(iii) State how the student would know that ethyl ethanoate has formed.

(1)

.....

.....

(iv) Draw the displayed formula of ethyl ethanoate.

(2)

(Total for Question 4 = 12 marks)

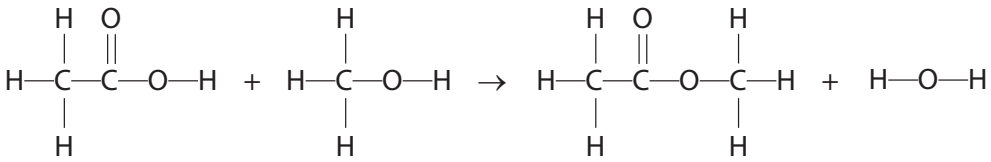
SUB-TOPIC 4g

ESTERS

Sub-topic 4g · 4 questions · 46 marks · lowest tariff first

6 Ethanoic acid reacts with methanol to form an ester.

The equation shows the displayed formulae for the reactants and products.



(a) (i) Give the name of a suitable catalyst to increase the rate of this reaction.

(1)

.....

(ii) State how you would know that an ester has formed.

(1)

.....

.....

(iii) Give the name of this ester.

(1)

.....

(b) The table shows the number of bonds in the reactants and the number of bonds in the products.

Bond	C—H	C—C	C—O	C═O	O—H
Number of bonds in reactants	6	1	2	1	2
Number of bonds in products	6	1	2	1	2

(i) State which two bonds need to be broken in the reactants.

(1)

.....

(ii) Explain why the enthalpy change in this reaction is approximately 0 kJ / mol.

(2)

.....

.....

.....

.....

(Total for Question 6 = 6 marks)

5 (a) An organic compound has this percentage composition by mass.

C = 40 % H = 6.7 % O = 53.3 %

(i) Show that the empirical formula of the compound is CH_2O

(2)

(ii) Draw the structural formula of a compound with the molecular formula $C_2H_4O_2$

(1)

(b) Methanoic acid (HCOOH) reacts with sodium carbonate solution to give three products.

(i) Complete the equation for this reaction.

(2)

$2HCOOH + Na_2CO_3 \rightarrow$ ..... + ... + ...

(ii) State what you would observe in this reaction.

(1)

.....

.....

(c) Methanoic acid also reacts with propanol to form an ester.

The equation for the reaction is

$$HCOOH + C_3H_7OH \rightleftharpoons HCOOC_3H_7 + H_2O$$

(i) Give the name of the ester that forms.

(1)

.....

(ii) State what is meant by the $\rightleftharpoons$ symbol.

(1)

.....

(iii) When this reaction occurs in a sealed container, the reaction can reach dynamic equilibrium.

Give one characteristic of a reaction at dynamic equilibrium.

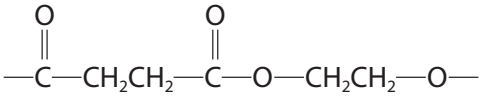
(1)

.....

.....

(d) A polyester forms when butanedioic acid reacts with ethanediol.

The diagram shows the repeat unit of the polyester that forms.



(i) Give the name of this type of polymerisation.

(1)

.....

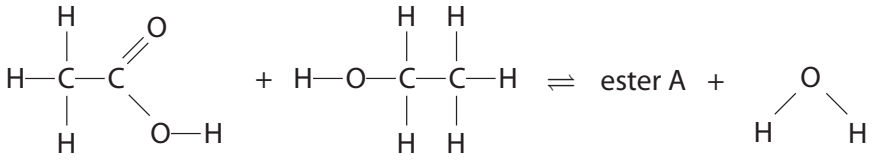
(ii) Draw the structural formulae of the two monomers used to make this polyester.

(2)

(Total for Question 5 = 12 marks)

6 When ethanoic acid reacts with ethanol in the presence of concentrated sulfuric acid, one of the products is ester A.

This is the equation for the reaction.



ethanoic acid ethanol water

(a) (i) Draw a circle around the functional group in ethanoic acid.

(1)

(ii) Give the displayed formula of ester A.

(2)

(iii) Name ester A.

(1)

(b) The reaction mixture is kept in a sealed container until dynamic equilibrium is reached.

State what is meant by the term **dynamic equilibrium**.

(2)

(c) During the reaction, the number of moles of ethanoic acid in the reaction mixture decreases, but the number of moles of concentrated sulfuric acid does not change.

(i) Give a reason why the number of moles of concentrated sulfuric acid does not change.

(1)

(ii) A student does a titration to find the accurate volume of sodium hydroxide solution needed for complete neutralisation.

The student starts by using a pipette to transfer 25.0 cm^3 of the reaction mixture to a conical flask.

Describe how the student should complete the titration.

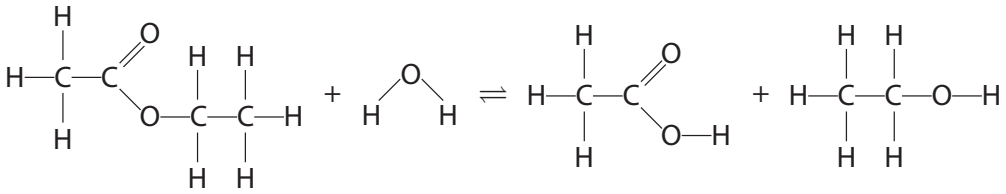
(6)

(Total for Question 6 = 13 marks)

7 This question is about esters.

Ester A reacts with water to form ethanoic acid and ethanol.

The displayed formulae of the reactants and products are shown in this equation



ester A

The molar enthalpy change (ΔH) for the reaction is 0 kJ/mol.

(a) (i) Draw a ring around the functional group in ester A.

(1)

(ii) Give the name of ester A.

(1)

.....

(iii) Describe a chemical test, other than using an indicator, to show that the reaction mixture contains ethanoic acid.

(2)

.....

.....

.....

.....

(b) Explain why the molar enthalpy change (ΔH) for the reaction between ester A and water is 0 kJ/mol.

In your answer, refer to the bonds broken and the bonds formed.

(2)

.....

.....

.....

.....

(c) A mixture of ester A and water is left in a sealed container until the reaction mixture reaches dynamic equilibrium.

(i) Describe what is meant by dynamic equilibrium.

(2)

.....

.....

.....

.....

(ii) Explain why adding a catalyst does not change the position of equilibrium.

(2)

.....

.....

.....

.....

(d) The ethanoic acid produced in the reaction is completely neutralised by 22.75 cm^3 of 0.150 mol/dm^3 barium hydroxide solution.

The equation for the neutralisation reaction is

$$2CH_3COOH + Ba(OH)_2 \rightarrow Ba(CH_3COO)_2 + 2H_2O$$

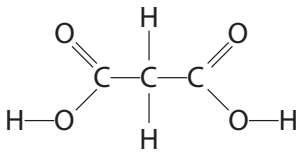
Calculate the amount, in moles, of ethanoic acid neutralised.

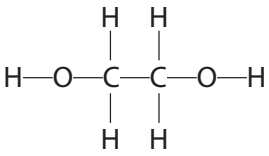
Give your answer to 3 significant figures.

(3)

amount = ... mol

(e) The structures of two organic compounds are shown.





These compounds react together to form a polymer.

Give the repeat unit of the polymer formed.

(2)

(Total for Question 7 = 15 marks)

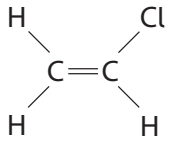
SUB-TOPIC 4h

SYNTHETIC POLYMERS

Sub-topic 4h · 3 questions · 40 marks · lowest tariff first

6 This question is about polymers.

(a) This is the structure of a monomer.



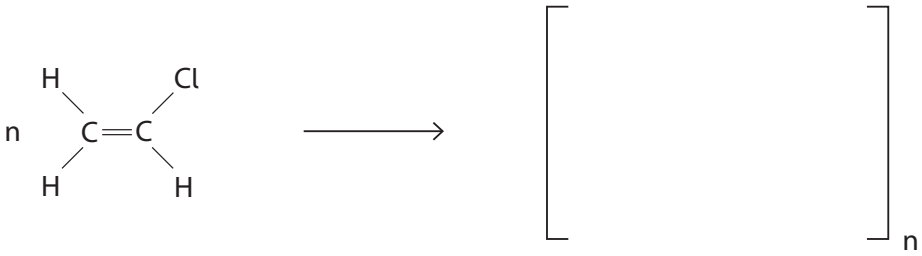
What is the name of this monomer?

(1)

- ☒ **A** chloroethane
- ☒ **B** chloroethene
- ☒ **C** chloropropane
- ☒ **D** chloropropene

(b) Complete the equation to show the repeat unit of the polymer that forms from this monomer.

(1)



(c) A typical molecule of the polymer has a relative molecular mass (M_r) of 2 490 000

Show that the number of monomer molecules needed to make this typical molecule is about 40 000

[for C, $A_r = 12$ for Cl, $A_r = 35.5$]

(2)

(d) These are two methods used to dispose of the polymer.

- burying in landfill sites
- burning

Discuss the environmental problems caused by these two methods of disposal.

(4)

(e) A different polymer molecule contains 10 600 atoms of carbon, 10 600 atoms of hydrogen and 31 800 atoms of chlorine.

Determine the empirical formula of this polymer.

(2)

empirical formula = ...

(Total for Question 6 = 10 marks)

6 Poly(chloroethene) is a polymer.

It is made from its monomer, chloroethene.

(a) Chloroethene has the percentage composition by mass

C = 38.4% H = 4.8% Cl = 56.8%

Show, by calculation, that the empirical formula of chloroethene is C_2H_3Cl

(3)

(b) The molecular formula of chloroethene is also C_2H_3Cl

Chloroethene can be prepared by a two-stage process.

In stage 1, ethene reacts with chlorine in the presence of an iron(III) chloride catalyst to form dichloroethane.

The reaction is exothermic.

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$$

(i) Give the formula of iron(III) chloride.

(1)

.....

(ii) State the purpose of using a catalyst.

(1)

.....

.....

(iii) State the meaning of the term **exothermic**.

(1)

.....

.....

(iv) What type of reaction occurs in stage 1 between ethene and chlorine?

(1)

- ☒ **A** addition
- ☒ **B** displacement
- ☒ **C** neutralisation
- ☒ **D** substitution

(v) In stage 2, dichloroethane decomposes into chloroethene and hydrogen chloride.

Give a chemical equation for this reaction.

(1)

(c) (i) Draw the displayed formula of

- chloroethene
- the repeat unit of poly(chloroethene)

(3)

chloroethene	repeat unit of poly(chloroethene)

(ii) Draw a dot-and-cross diagram to represent a molecule of chloroethene.

Show only the outer electrons of each atom.

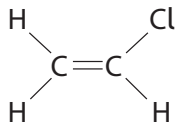
(2)

(Total for Question 6 = 13 marks)

9 This question is about organic compounds.

(a) Chloroethene (C_2H_3Cl) is a covalent molecule that is used to make poly(chloroethene).

This is the displayed formula of chloroethene.



(i) Draw a dot-and-cross diagram of chloroethene.

Show only the outer shell electrons.

(2)

(ii) Describe, in terms of electrostatic attraction, what is meant by a covalent bond.

(2)

(iii) Chloroethene is a monomer.

Draw the displayed formula of the repeat unit of poly(chloroethene).

(1)

(iv) Poly(chloroethene) is non-biodegradable.

There are two main methods used to dispose of poly(chloroethene).

Describe one problem caused by each method.

(4)

1 .....

.....

.....

.....

2 .....

.....

.....

.....

(b) An organic compound contains this percentage composition by mass.

C = 22.0% H = 4.6% Br = 73.4%

Calculate the empirical formula of this compound.

(3)

empirical formula = ...

(c) Ethane and ethene undergo different types of reaction with bromine.

Describe the differences between these two reactions.

(5)

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(Total for Question 9 = 17 marks)

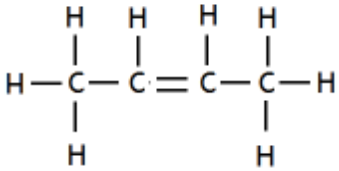
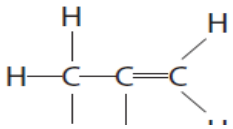
MARK SCHEMES

official Pearson Edexcel mark schemes

Question number	Answer	Notes	Marks
6 (a) (i)	Y		1
(ii)	V		1
(iii)	W		1
(iv)	X		1
(v)	displayed formula of but-1-ene or methylpropene		1
(vi)	Any two from **M1** same general formula **M2** similar chemical properties **M3** trend in physical properties **M4** each consecutive member differs by a CH_2 group	 **ALLOW** same empirical formula **ALLOW** they react in a similar way/same chemical properties **ACCEPT** named physical property e.g. trend in boiling points	2
(b) (i)	**M1** $\frac{38.7}{12}$ $\frac{9.7}{1}$ $\frac{51.6}{16}$ **OR** 3.225 9.7 3.225 **M2** (divide by smallest) 1 3 1	0 marks if upside down calculation or use of atomic numbers	2
(ii)	**M1** Mr of CH_3O = 31 **M2** (62 ÷ 31 = 2 so molecular formula is) $C_2H_6O_2$	$C_2H_6O_2$ without working scores 2	2
			11

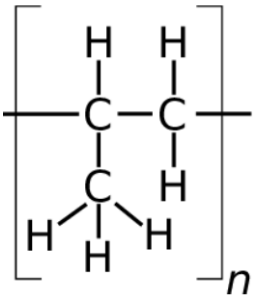
Question number	Answer	Notes	Marks
7 (a)	X contains oxygen /OH	ALLOW hydrocarbons only contain hydrogen and carbon (atoms) REJECT oxygen molecules or hydrogen and carbon molecules	1
(b)	W		1
(c)	V		1
(d)	$CH_2=CHCH_2CH_3$	ALLOW $CH_2CHCH_2CH_3$	1
(e)	M1 same molecular formula M2 different displayed / structural formulae	ALLOW same numbers of C and H atoms ALLOW different arrangement of atoms	2
(f) (i)	$C_4H_{10} + Br_2 \rightarrow C_4H_9Br + HBr$ M1 C_4H_9Br as product M2 rest of the equation correct	 ALLOW polysubstitution M2 dep on M1	2
(ii)	**C** (substitution) A is not the correct answer because alkanes do not undergo addition reactions B is not the correct answer as this is not a combustion reaction D is not the correct answer as this reaction is not thermal decomposition		1
(g)	A description that refers to any 3 from M1 nitrogen and oxygen (from air) M2 react at the high temperatures (in a car engine) M3 forming oxides of nitrogen M4 which react with/dissolve in water forming nitric acid /HNO_3 /acid rain	 REJECT mention of petrol contains nitrogen for M1 only M2 dep on mention of nitrogen and oxygen ALLOW NO_x or named oxides of nitrogen M4 dep on M3	3
			Total for question = 12

Question number	Answer	Notes	Marks
5 (a) (i)	S		1
(ii)	T and U		1
(iii)	U		1
(b)	A description that makes reference to the following three points **M1** (add) bromine water **M2** no change / stays orange **M3** (bromine water) decolourised / changes (from orange) to colourless	 **ACCEPT** Br_2 (aq) **ALLOW** no reaction If initial colour of bromine water is given in M2 or M3 it must be correct -ALLOW any combination of orange/yellow/brown – but penalise once only If bromine given for M1 then in M2 and M3 allow any combination of red/orange/brown/yellow **M2** and **M3** dep on bromine water/bromine in **M1** If no reagent and correct M2 and M3 – score 1 if incorrect reagent and correct M2 and M3 score 0 **IGNORE** clear **REJECT** discoloured **ALLOW M1** acidified potassium manganate(VII) **M2** no change/stays purple **M3** decolourised / goes colourless	3

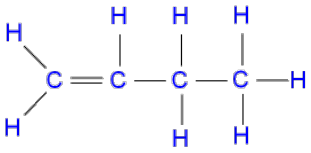
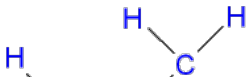
Question number	Answer	Notes	Marks
5 (c)	Any **two** of the following points **M1** (can be represented by a) general formula **M2** each member differs from the next by a CH_2 group OWTTE **M3** (each member has) same functional group **M4** (each member has) similar/same chemical properties / similar/same (chemical) reactions **M5** trend in physical properties (between successive members)	**ACCEPT** react in similar/same way **ACCEPT** named physical property, e.g. boiling point **REJECT** similar/same physical properties	2
(d) (i)	but-1-ene	**ALLOW** 1-butene	1
(ii)	**Either**  **Or** 	**ACCEPT** cis or trans isomer **REJECT** displayed formulae of cyclic alkanes	1

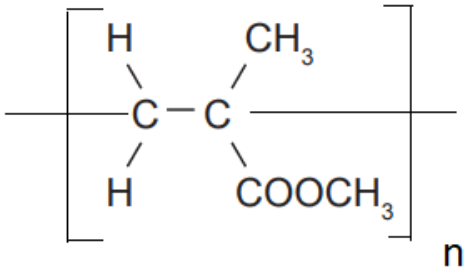
Question number	Answer	Notes	Marks
5 (e) (i)	• Divide percentages by relative atomic masses • Divide results by smallest value to obtain ratio Example calculation **M1** C: $\frac{36.36}{12}$ H: $\frac{6.06}{1}$ F: $\frac{57.58}{19}$ **M2** $\frac{3.03}{3.03}$ $\frac{6.06}{3.03}$ $\frac{3.03}{3.03}$ **OR** 1 2 1	0 marks if division by atomic numbers or upside down calculation	2
(ii)	• divide relative molecular mass by empirical formula mass • correct molecular formula Example calculation **M1** $\frac{66}{12 + 2 + 19}$ **OR** $\frac{66}{33}$ OR 2 **M2** $C_2H_4F_2$	**ACCEPT** symbols in any order correct answer without working scores 2 marks. $2CH_2F$ scores 1	2
			Total 14

Question number	Answer	Notes	Marks
6 (a) (i)	M1 alkanes M2 because fits general formula C_nH_{2n+2}	 M2 not dep on M1	2 Grad
(ii)	D	ALLOW C_3H_8	1 cler
(iii)	M1 (compounds of F with same molecular formula /C_4H_{10}) but different structural/displayed formulae M2 structural/displayed formula of butane M3 structural/displayed formulae of methylpropane		3 Exp
(b)	a description including the following points M1 heat/vapourise crude oil M2 pass into (fractionating) column/tower M3 fractions/compounds/molecules/hydrocarbons separate because of different boiling points M4 compound D collected at top of column/in refinery gas fraction	 ALLOW boil ALLOW idea of temperature gradient All marks could be scored from a suitably labelled diagram MAX 3 if description of lab process If confusion with cracking only M1 can be awarded	4 Exp

Question number	Answer	Notes	Marks
6 (c) (i)	addition (polymer)	REJECT additional	1 Cler
(ii)	poly(propene) / polypropene	ALLOW polypropylene	1 grad
(iii)	 M1 correct repeat unit M2 brackets and n and extension bonds	Ignore bond angles ALLOW use of CH_3 M2 DEP M1	2 Exp

Total for Q6 = 14

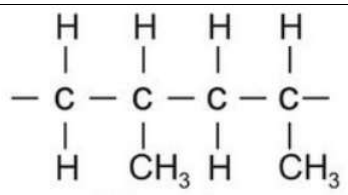
Question number	Answer	Notes	Marks
8 (a) (i)	explanation linking M1 (molecules/compounds) having same molecular formulae M2 but different structural/displayed formulae	 ALLOW different structures ALLOW different arrangement of atoms	2
(ii)	M1 displayed formula of but-1-ene  M2 displayed formula of but-2-ene 	IGNORE bond angles ALLOW displayed formula of methylpropene	2

Question number	Answer	Notes	Marks
8 (b) (i)	explanation linking M1 molecule is unsaturated as contains (carbon to carbon) double bond M2 molecule not a hydrocarbon as contains oxygen	 ACCEPT does not contain hydrogen and carbon only	 2
(ii)	addition		1
(iii)	 M1 correct repeat unit structure M2 extension bonds, brackets and n	 n can be anywhere after bracket extension bonds do not have to go through brackets M2 DEP M1 or near miss	2

Question number	Answer	Notes	Marks
8 (c) (i)	M1 calculation of mass of octane M2 calculation of Mr of C_8H_{18} and CO_2 M3 link between mass/mol C_8H_{18} and mass/mol CO_2 M4 calculation of mass CO_2 in g M5 calculation of mass CO_2 in kg Example calculation: M1 50 x 700 = 35000 (g) M2 M_r of C_8H_{18} = 114 and M_r CO_2 = 44 M3 114g C_8H_{18} produces (8 x 44 =) 352 (g) CO_2 M4 35000 g C_8H_{18} produces $\frac{35000 \times 352}{114}$ = 108070.2 (g) CO_2 M5 = 108 (kg) Alternative method using mol: M1 50 x 700 = 35000 (g) M2 M_r of C_8H_{18} = 114 and Mr CO_2 = 44 M3 n (C_8H_{18}) = $\frac{35000}{114}$ = 307.0175 mol so n (CO_2) = 8 x 307.0175 = 2456.14 mol M4 mass CO_2 = 2456.14 x 44 = 108070.2 (g) M5 = 108 (kg)	ALLOW 2 sig fig or more in M4 and M5 ALLOW 2 sig fig or more in M3 M4 and M5 MARK CSQ in both methods correct answer without working scores 5	5

(ii)	global warming/climate change	IGNORE greenhouse effect	1

(Total for Question 8 = 15)

Question number	Answer	Notes	Marks
8 (a) (i)	A		1
(ii)	C		1
(iii)	propene		1
(iv)	M1 same molecular formula M2 different structural / displayed formulae		2
(b) (i)	$CH_3Br + HBr$	ALLOW balanced equations for multiple substitutions	1
(ii)	substitution		1
(c) (i)	M1 37.8÷12, 6.3÷1, 55.9÷35.5 M2 3.15, 6.3, 1.57 M3 divide by smallest to get 2:4:1 **OR** M1 M_r of C_2H_4Cl = 63.5 M2 24/63.5 x 100 and 4/63.5 x 100 and 35.5/63.5 x100 M3 37.8% and 6.3% and 55.9%	M2 subsumes M1 M3 must be calculated	3
(ii)	M1 127÷63.5=2 M2 Molecular formula = $C_4H_8Cl_2$	Answer of $C_4H_8Cl_2$ without working scores 2	2
(d) (i)	 M1 two carbon atoms both with 2 H atoms M2 two carbon atoms both with 1 H atom and 1 CH_3 group and nothing attached to the joining bonds	Marks are independent	2
(ii)	Any one from:		1

	landfill sites are getting full toxic / greenhouse gases are produced when burned		
			Total for question = 15 marks

Question number	Answer	Notes	Marks
2 (a)	(fractional) distillation		1
(b)	(surfacing) roads / road tar / tarmac/ roofs	ALLOW ‘making roads’	1
(c) (i)	C_4H_{10}		1
(ii)	butane		1
(iii)	C_nH_{2n+2}		1
			Total = 5

Question number	Answer	Notes	Marks
3 (a) (i)	fractional distillation	**ALLOW** fractionating /fractionation	1
(ii)	crude oil/it is heated/vapourised	**ALLOW** boiled **IGNORE** evaporates	1
(iii)	A description which refers to the following four points **M1** B contains larg**er**/long**er** molecules **M2** B has a high**er** boiling point **M3** B has a dark**er** colour **M4** B is **more** viscous/ has great**er** viscosity	**ACCEPT** reverse arguments for E **ALLOW** E is more volatile **IGNORE** melting point **ALLOW** arison giving specific colours e.g B is orange and E is pale yellow **ALLOW** E is more runny MAX 2 marks if no reference to fractions E or B in the answer?	4
(b)	An planation which links the following two points **M1** (when sulfur burns) sulfur dioxide /SO_2 is formed **M2** causes acid rain	**ALLOW** sulfur trioxide/SO_3 **IGNORE** sulfur oxides **ALLOW** a specified harmful effect of acid rain **ACCEPT** references to causing/ acerbating respiratory problems **ALLOW** greenhouse gas/ causes global warming/ imate change	2 **Total 8**

Question number	Answer	Notes	Marks
3 (a) (i)	**M1** (bitumen) (surfacing) roads/(surfacing) roofs **M2** (gasoline) petrol / fuel for cars/vehicles	**ALLOW** other suitable uses **ALLOW** other suitable uses e.g. fuel for cooking	2 Exp
(ii)	An explanation that links the following two points **M1** column is cooler near the top than at the bottom ORA **M2** gasoline has a lower boiling point than bitumen (so is collected nearer the top) ORA	**ACCEPT** column cool near the top and hot at the bottom **ACCEPT** temperature decreases up the column ORA **ACCEPT** gasoline has a low boiling point (so is collected near the top) and bitumen has a high boiling point (so is collected near the bottom)	2 Exp
(b) (i)	**M1** alumina/silica (catalyst) **M2** 600 – 700 (°C)	**ACCEPT** Al_2O_3 / SiO_2 /aluminium oxide /silicon dioxide /aluminosilicate(s) /zeolite(s) **ACCEPT** range or any value within the range **ACCEPT** correct temperatures in other units	2 Exp
(ii)	$C_{12}H_{26}$ --> C_7H_{16} + C_2H_4 + C_3H_6 **M1** C_2H_4 **M2** C_3H_6	**ACCEPT** answers in either order	2 Exp
			Total 8

Question number	Answer	Notes	Marks
4 (a) (i)	refinery gases: (fuel for) heating / cooking bitumen: tar / road surfacing / road building / roofing	ALLOW bottled gas ALLOW roads	2
(ii)	any one from: refinery gases have the low(est) boiling point **OR** refinery gases do not condense in the column	 ALLOW they are the most volatile REJECT refs to melting point	1
(iii)	it is heated / vaporised	IGNORE any temperatures given ALLOW boiled	1
(b) (i)	**M1** temperature 600 – 700°C **M2** catalyst alumina / silica / zeolites / aluminium oxide / silicon dioxide	ALLOW any temperature in the range IGNORE pressures	2
(ii)	an explanation containing any three of the following points: **M1** alkenes / propene / C_3H_6 can be used to make (addition) polymers / plastics **M2** (because) they have double bonds / are unsaturated **M3** shorter alkanes / octane / C_8H_{18} are used as fuels / petrol **M4** (because) they have lower boiling points / are more flammable	 ALLOW used to make poly(propene) ALLOW to make alcohols / propanol IGNORE used as fuels	3
			Total 9

Question number	Answer	Notes	Marks
3 (a) (i)	fractionating column/ fractionating tower	**ALLOW** fraction(al) column /fraction(al) tower **IGNORE** fractional distillation	1
(ii)	fuel for ships/fuel for power stations		1
(iii)	**M1** fraction A refinery gases **M2** fraction F bitumen		2
(b) (i)	C_nH_{2n+2}	**ALLOW** x or N in place of n	1
(ii)	An explanation that links the following 3 points **M1** $C_{12}H_{26}$ has larger molecules/longer chain/ORA **M2** $C_{12}H_{26}$ has stronger intermolecular forces/ORA **M3** more energy is needed to separate the molecules/ overcome the forces in $C_{12}H_{26}$ /ORA	**ACCEPT** forces between molecules for intermolecular forces **ALLOW** intermolecular bonds /bonds between molecules no **M2** or **M3** if implied that covalent bonds break	3
(c) (i)	silica/alumina	**ACCEPT** silicon dioxide /aluminium oxide /SiO_2/Al_2O_3 /aluminosilicates /zeolite	1
(ii)	$C_{12}H_{26} \rightarrow C_9H_{20} + C_3H_6$		1
			Total 10

Question number	Answer	Notes	Marks
2 (a)	**M1** heated	**ALLOW** boiled **IGNORE** vapourised/evaporated	3
	M2 fractionating	**ACCEPT** fractional distillation	
	M3 boiling point(s)	**ACCEPT** boiling temperature(s) **IGNORE** melting point(s)/low density	
(b)	road surfacing / roofing	**ALLOW** roads	1
(c) (i)	pentane		1
(ii)	(M_r = 5 x 12 + 12 x 1 =) 72		1

Question number	Answer	Notes	Marks
2 (d)	**M1** alumina / silica **M2** any temperature in the range 600 – 700 °C inclusive	**ACCEPT** aluminium oxide / silicon dioxide / Al_2O_3 / SiO_2 / zeolite(s) / aluminosilicate(s)	2
(e)	($C_{10}H_{22}$ → C_4H_{10}) + C_2H_4 + C_4H_8 **M1** C_2H_4 **M2** C_4H_8	alkenes can be in either order **ALLOW** 1 mark for C_6H_{12} / $2C_3H_6$ / $C_3H_6 + C_3H_6$ **ALLOW** correct displayed formulae	2
			Total 10

Question number			Answer	Notes	Marks
3	(a)	(i)	(crude oil/it is) heated / vapourised	**ALLOW** evaporated / boiled **REJECT** melted	1
		(ii)	gasoline	**ALLOW** petrol	1
		(iii)	road (surfacing) / roofs / tarmac		1
	(b)	(i)	**M1** silica / alumina (catalyst) **M2** 600 to 700 °C	**ACCEPT** SiO_2/Al_2O_3 / silicon dioxide / aluminium oxide /aluminosilicates / zeolites	2
		(ii)	Any two from: **M1** shorter-chain alkanes are in high(er) demand / more useful / used for petrol / more flammable **M2** alkenes are needed / used to make polymers	**ALLOW** C_8H_{18} is in high(er) demand (than $C_{13}H_{28}$) / more useful / used for petrol / more flammable **IGNORE** shorter-chain alkanes are used as fuels **ALLOW** C_2H_4 / C_3H_6 are needed / used to make polymers / plastics shorter chain hydrocarbons **/** the products are in high(er) demand / more useful / more flammable scores 1 **if no other mark awarded** to create shorter alkanes and alkenes scores 1 **if no other mark awarded**	2

(c)	An explanation that links the following three points: **M1** sulfur dioxide produced when fuel is burned **M2** (sulfur dioxide) dissolves in / reacts with rain / water **M3** (causing) acid rain	 **ALLOW** sulfur / fuel reacts with oxygen / oxidises forming sulfur dioxide **IGNORE** sulfur trioxide and sulfur oxide **ACCEPT** (sulfur oxide / sulfur trioxide) dissolves in / reacts with rain / water **IGNORE** mixes	3
			Total 10

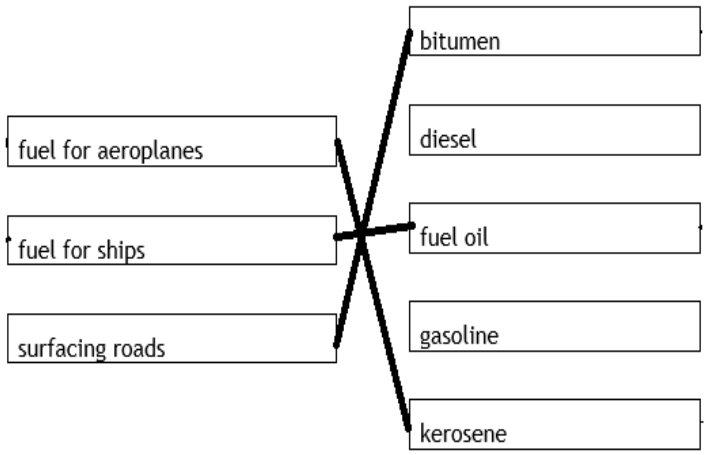
Question number	Answer	Notes	Marks
2 (a)	fractional distillation	**ACCEPT** fractionation/fractionating **IGNORE** distillation alone	1 1
(b)	aircraft fuel/jet fuel/paraffin or fuel for lamps/ heaters	**ALLOW** heating oil **ALLOW** cooking fuel	
(c) (i)	butane	Spelling must be correct	1
(ii)	(M_r = 4 x 12 + 10 x 1 =) 58		1
(d) (i)	C_7H_{16}		1
(ii)	C_nH_{2n+2}	**ACCEPT** different letters to n / uppercase	1

Question number	Answer	Notes	Marks
2 (e) (i)	alumina / silica	**ACCEPT** aluminium oxide / silicon dioxide / Al_2O_3 / SiO_2 / zeolite(s) / aluminosilicate(s)	1
(ii)	An explanation that links the following two points **M1** greater demand for short chain alkanes (than long chain alkanes) **M2** more long-chain alkanes than are needed / too great a supply of /surplus of long-chain alkanes **OR** not enough short chain alkanes to meet demands	**ALLOW** short chain alkanes are more useful (than long chain alkanes) **ALLOW** short chain alkanes needed for specific uses e.g. petrol	2
(f)	($C_{11}H_{24}$ → C_5H_{12}) + C_2H_4 + C_4H_8 **M1** C_2H_4 **M2** C_4H_8	alkenes can be in either order **ALLOW** 1 mark for C_6H_{12} / $2C_3H_6$ / $C_3H_6 + C_3H_6$ **ALLOW** correct displayed formulae	2
			Total 11

Question number	Answer	Notes	Marks
8 (a)	a description that links any 4 of the following points M1 crude oil is heated / vapourised M2 the vapour enters the lower part / bottom of the column M3 there is a temperature gradient in the column M4 the vapours rise up the column until they condense M5 at a height where the boiling point of the vapour is lower than the temperature in the column	 ALLOW boiled ACCEPT cooler at the top and hotter at the bottom ALLOW the fractions are separated according to their boiling point	4
(b)	an explanation that links any 4 of the following points M1 fractional distillation of crude oil produces more long chain hydrocarbons than can be used directly M2 (cracking) produces shorter (chain) alkanes M3 which are more flammable/ more useful as fuels M4 (cracking) produces alkenes M5 which are used to make polymers/plastics	 ALLOW is a lower demand for long chain hydrocarbons / a higher demand for short chain hydrocarbons ALLOW petrol / gasoline M3 dep on M2 M5 dep on M4	4
(c)	M1 fuels contain sulfur M2 which burns producing sulfur dioxide M3 causing acid rain	IGNORE C / CO / CO_2 and any reference to global warming etc. REJECT nitrogen for M1 ALLOW effects of acid rain M3 dep on M1 or M2 or NO_2 or SO_3	3
			total for question = 11

Question number	Answer	Notes	Marks
3 (a)	**M1** (A) refinery gases **M2** (F) bitumen		2
(b) (i)	aircraft fuel		1
(ii)	A description that refers to three of the following points		3
	M1 crude oil is heated/vaporised	**IGNORE** evaporated	
	M2 (the vapour) passes into/rises up the (fractionating) column / chamber OWTTE		
	M3 the kerosene /the fraction is tapped off/removed at its boiling point range /condenses and removed	**ALLOW** kerosene/the fraction is removed at the 3rd or 4th level	
(c) (i)	**M1** silica/alumina	**ALLOW** silicon dioxide/SiO_2 /aluminium oxide /Al_2O_3 /zeolites /aluminosilicates	2
	M2 any value or range between 600 and 700 (°C) inclusive		
(ii)	An explanation that links three of the following points		3
	M1 there is a surplus supply of / less demand for larger fractions /molecules/hydrocarbons **OR** there is not enough supply / greater demand for smaller fractions/molecules /hydrocarbons		
	M2 alkenes are produced which are needed to make polymers	**ALLOW** plastics / to make ethanol	
	M3 smaller fractions /alkanes /molecules /hydrocarbons are needed for petrol	**ALLOW** gasoline / fuel for cars	
			Total 11

Question number			Answer	Notes	Marks
3	(a)	(i)	fractional distillation	**ALLOW** fractionating	1
		(ii)	(crude oil/it is) heated / vapourised/ boiled	Ignore evaporated	1
		(iii)	E	**ALLOW** gasoline/petrol	1
		(iv)	kerosene	**ALLOW** paraffin	1
		(v)	(Fuel) for ships	**ALLOW** any acceptable use of fuel oil eg home heating, industrial heating, electricity generation, power station, furnaces for metal smelting, feedstock for plastics/fertilisers	1
	(b)		An explanation that links the following three points **M1** B has long**er** chain/molecules ORA **M2** B has strong**er** intermolecular forces/bonds Forces/bonds between molecules ORA **M3** more energy is needed to overcome the (intermolecular) forces/intermolecular bonds separate the molecules ORA	 **ALLOW** B has larg**er/bigger/longer chain/** molecule/hydrocarbon ALLOW molecule/hydrocarbon with greater mass ALLOW more intermolecular forces/ bonds REJECT IMF between atoms No **M2** or **M3** if any reference to breaking of covalent bonds	3
	(c)	(i)	silica / alumina (catalyst)	**ACCEPT** SiO_2/Al_2O_3 /silicon dioxide /aluminium oxide /aluminosilicates /zeolites	1
		(ii)	Any one of the following two pairs **M1** C_2H_4 and **M2** C_5H_{10} **OR** **M1** C_3H_6 and **M2** C_4H_8	 If the equation does not balance allow 1 mark for a correct formula of an alkene	2
		(iii)	(to make) polymers /polymerisation	**ACCEPT** the name of a correct addition polymer eg polyethene, polypropene etc. **ACCEPT** to make alcohol(s) Reject fuels	1
					Total 12

Question number	Answer	Notes	Marks
3 (a)	alkanes		1
(b) (i)	**A** boiling point is the correct answer because fractional distillation depends on differences in boiling point **B** is not correct because fractional distillation does not depend on differences in density **C** is not correct because fractional distillation does not depend on differences in melting point **D** is not correct because fractional distillation does not depend on differences in solubility		1
(b) (ii)	 1 mark for each correct line from boxes on left	If more than one line from a box on left do not award mark for that box	3
(c)	explanation including the following points: M1 (common impurity in fuels is) sulfur M2 sulfur burns/combusts/reacts (in air/oxygen) to form sulfur dioxide/SO_2 M3 sulfur dioxide/SO_2 dissolves in/reacts with rain/water to form acid rain	If M2 M3 not scored ALLOW 1 mark for reference to sulphur dioxide/SO_2 and acid rain	3

Question number	Answer	Notes	Marks
3 (d) (i)	cracking		1
(ii)	M1 (catalyst) silica/alumina M2 (temperature) 600-700 (°C)	ALLOW silicon dioxide/aluminium oxide ALLOW formulae ALLOW zeolite	2
(iii)	$C_{13}H_{28} \rightarrow C_8H_{18}$ + M1 C_3H_6 + M2 C_2H_4	in either order ALLOW structural formulae ALLOW 1 mark for single product C_5H_{10}	2

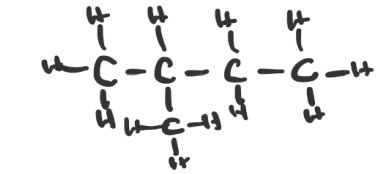
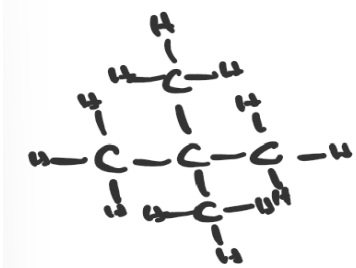
(Total for Question 3 = 13)

Question number	Answer	Notes	Marks
4 (a) (i)	M1 crude oil is heated / vapourised M2 vapours / gases / compounds / hydrocarbons rise up the column M3 the column is hotter at the bottom than the top M4 vapours / compounds / hydrocarbons condense at their **boiling** point	ALLOW boiled REJECT burned ALLOW temperature gradient of the column ALLOW different temperatures at each level ALLOW fractions with lowest boiling point rise to the top IGNORE refs to gradient in density of molecules ALLOW vapours / compounds / hydrocarbons / condense at different heights ALLOW the vapours / compounds / hydrocarbons / fractions have different boiling points IGNORE melting point	4
(ii)	kerosene = aeroplane <u>fuel</u> / <u>fuel</u> for heating bitumen = road tar / tarmac / (waterproofing) roofs	ALLOW <u>fuel</u> for lamps / <u>fuel</u> for cooking ALLOW road surfacing / road making	2
(b) (i)	M1 breaking down long-chain <u>hydrocarbons</u> / long-chain <u>molecules</u> / long-chain <u>alkanes</u> M2 to form shorter chains (of alkanes / alkenes / hydrocarbons)	REJECT polymers IGNORE refs to separation ALLOW to break (C-C) bonds	2
(ii)	M1 (ethene is unsaturated because it has a) double (C=C) bond M2 (ethene is a hydrocarbon as it contains) hydrogen and carbon (atoms) M3 only	 REJECT carbon and hydrogen molecules M3 dep on mention of carbon and hydrogen in M2	3

(iii)	M1 add bromine water M2 which decolourises / turns colourless	ALLOW bromine solution NOT just 'bromine' M2 dep on mention of bromine in M1 IGNORE starting colour of bromine IGNORE clear NOT just 'changes colour' If reaction takes place in presence of uv, then score M1 only	2
			Total for question = 13

Question number	Answer	Notes	Marks
6 (a)	M1 crude oil / it is heated M2 the vapours / gases rise up the column M3 the column is hotter at the bottom than the top OWTTE M4 the vapours condense at their boiling points	ALLOW boiled/vaporised ALLOW the vapours cool as they rise up the column/temperature gradient	4
(b) (i)	M1 600-700°C M2 catalyst of silica/alumina	ALLOW any number or range between 600-700 ALLOW aluminosilicates/ zeolites / SiO_2 / Al_2O_3	2
(ii)	M1 (shorter chain alkanes) are more flammable / are easier to burn M2 therefore are more useful as fuels /petrol /gasoline	 ALLOW used as fuels /petrol/gasoline	2
(iii)	M1 (bonds broken) = 612+193 OR 805 (kJ/mol) M2 (bonds formed) = 348+(2×276) OR 900 (kJ/mol) M3 -95 (kJ/mol) OR M1 (bonds broken) = (4×414)+612+193 OR 2461 (kJ/mol) M2 (bonds formed) = (4×414)+348+(2×276) OR 2556 (kJ/mol) M3 -95 (kJ/mol)	working must be shown for a show that question ALLOW M1-M2 as long as answer is between -80 and -120 (kJ/mol) ALLOW M1-M2 as long as answer is between -80 and -120 (kJ/mol)	3
(iv)	M1 more energy / heat was given out /released when the bonds (in the products) were formed M2 than was taken in / needed to break the bonds (in the reactants)	ALLOW sum of bond energies to break the bonds (in the reactants) ALLOW is less than the sum of the bond energies for making the bonds (in the products) no marks for energy taken in /needed to make the bonds OR for energy given out /released to break the bonds	2
		Total = 13	

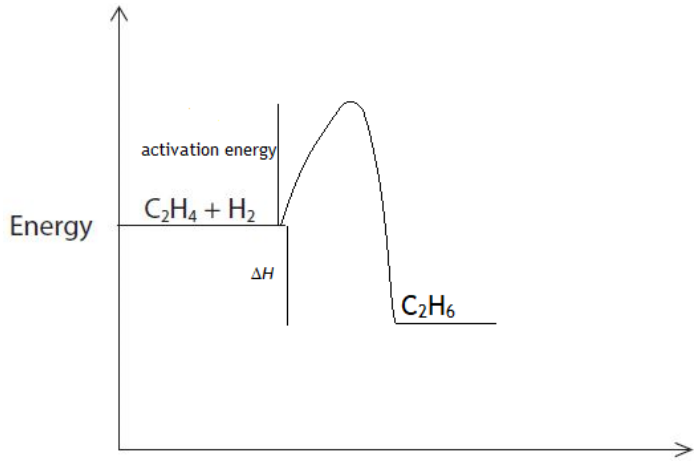
Question number	Answer	Notes	Marks
9 (a)	alkane(s)	not alkene(s)	1
(b)	M1 when sulfur (impurity in fuels) burns /combusts M2 sulfur dioxide / SO_2 forms M3 which dissolves / reacts with (rain) water	ALLOW sulfur reacts with oxygen do not allow acid rain alone as this is in the question IGNORE mention of nitrogen and NO_2 and carbon dioxide M3 dep on M1 or M2	3
(c) (i)	temperature 600-700°C catalyst alumina/silica/aluminosilicates/zeolites /Al_2O_3 /SiO_2		2
(ii)	M1 long-chain alkanes/hydrocarbons have lower demand or are less useful M2 (cracking produces) shorter alkanes that are more flammable / more useful as fuels or petrol or gasoline	ALLOW short chain hydrocarbons/alkanes are more useful/higher demand	3

		M3 (cracking produces) alkenes that can be used to make polymers /alcohols		
(d)	(i)	M1 same molecular formula M2 different structural/displayed formulae	ALLOW same number of carbons and hydrogens ALLOW different of arrangement of atoms	2 2
	(ii)	 		
				Total = 13

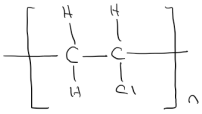
Question number	Answer	Notes	Marks
7 (a)	M1 crude oil is heated / vapourised M2 vapours / gases / compounds / hydrocarbons rise up the column M3 the column is hotter at the bottom than the top M4 vapours / compounds / hydrocarbons condense at their boiling point	**ALLOW** boiled **ALLOW** temperature gradient of the column **ALLOW** vapours / compounds / hydrocarbons / condense at different heights **ALLOW** the vapours / compounds / hydrocarbons / fractions have different boiling points.	4
(b)	M1 temperature of 600°C - 700°C M2 catalyst of silica / alumina	 **ALLOW** aluminosilicates / zeolites / silicon dioxide / aluminium oxide **IGNORE** references to pressure	2

Question number	Answer	Notes	Marks
(c) (i)	M1 nitrogen (from the air) reacts / combines with oxygen (from the air) M2 at high temperatures (in the car engine)	**REJECT** any implication that oxygen or nitrogen come from the fuel.	2
(ii)	Any one from: acid rain respiratory problems		1
(iii)	Example calculation M1 volume of carbon dioxide = 206 000 cm^3 / 2.06×10^5 cm^3 / 206 dm^3 M2 volume of carbon dioxide per km = 51 500 cm^3/ 5.15×10^4 cm^3 / 51.5 dm^3 M3 (51 500 ÷ 24 000) = 2.15 moles M4 M_r of carbon dioxide is 44 M5 mass of carbon dioxide per Km = 94.4 g	Division by 4 can happen in M1, M2, M3 or M5 **ALLOW** M1 ÷ 4 **ALLOW** M2 or M1 ÷ 24 000 **ALLOW** 94 – 95 g **ALLOW** ecf from incorrect M_r Correct answer of 94 – 95 g scores 5 marks.	5
			14 marks

Question number	Answer	Notes	Marks
6 (a)	A description including the following points: **M1** (use) fractional distillation / fractionating column / fractionating tower **M2** (crude oil) heated / vaporised **M3** column is cooler at top / hotter at the bottom / idea of temperature gradient **M4** fractions condense/collected at different heights OWTTE **OR** fractions have different boiling point (ranges)	 **ALLOW** boiled **ALLOW** fractions with high(er) boiling points/large(r) molecules condense/collected near bottom ORA	4
6 (b) (i)	**M1** particles/molecules are closer together **M2** therefore more (successful) collisions per unit time	**ALLOW** more particles/molecules per unit volume **ALLOW** more frequent (successful) collisions If reference to particles have more energy/move faster, then 0/2	2
(ii)	**M1** (a catalyst provides) an alternative pathway **M2** of lower activation energy	**ALLOW** a catalyst provides a surface for the reaction to take place on **ALLOW** so more collisions/particles have energy greater than the activation energy.	2
(iii)	increase the temperature	**ALLOW** heat it up **IGNORE** references to concentration **REJECT** increase the surface area	1

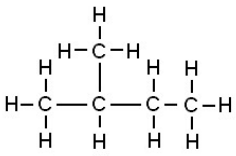
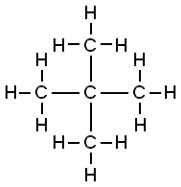
6	(b) (iv)	 **M1** C_2H_6 on horizontal line below the reactants **M2** activation energy correctly shown and labelled **M3** ΔH correctly shown and labelled	**ACCEPT** arrow pointing upwards or double headed arrow **ACCEPT** arrow pointing from reactants level to product level or double headed arrow ALLOW max 2 for a correctly labelled endothermic reaction	3
	(c)	• find energy needed to break bonds • find energy released when bonds form • correct evaluation of ΔH Example calculation **M1** (4 x 412) + 612 + 436 OR 2696 **M2** (6 x 412) + 348 OR 2820 **M3** -124 if M1 M2 correct	**IGNORE sign** **ALLOW** 1048 **IGNORE sign** **ALLOW** 1172 -124 without working scores 3 (+)124 scores 2 **ALLOW M3** ECF **M1 M2**	3

Question number	Answer	Notes	Marks
7 (a)	Any five from		5
	M1 fractional distillation		
	M2 crude oil heated/vapourised	**ALLOW** boiled	
	M3 reference to (fractionating) column/tower		
	M4 which is hotter at the bottom than at the top	**ALLOW** reference to temperature gradient **ALLOW** the hydrocarbons/gases/vapours cool as they rise up the column	
	M5 shorter hydrocarbons/chains/molecules have lower boiling point (and rise higher/towards the top)	**ACCEPT** reverse argument	
	M6 fractions/hydrocarbons/gases/vapours/kerosene condense(s) at (levels depending on) their boiling points OWTTE	**ALLOW** correct reference to position of kerosene fraction below refinery gases and gasoline fractions or above diesel and fuel oil fractions	
(b) (i)	C_8H_{18}		1
(ii)	Any four from		4
	M1 fractional distillation/crude oil produces more long-chain hydrocarbons than can be used (directly)	**ALLOW** short(er) chain hydrocarbons are in higher demand/more useful than long(er) chain hydrocarbons ORA	
	M2 cracking produces short chain alkanes	**ALLOW** cracking changes long(er) chain hydrocarbons into short(er) chain hydrocarbons	
	M3 short chain alkanes/hydrocarbons are more flammable/can be used as fuels		
	M4 cracking produces alkene(s)	**IGNORE** named alkene	
	M5 alkenes can be used to make polymers	**ALLOW** named alkene forming (named) polymer e.g. ethene can be used to make poly(ethene)/polymer	

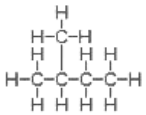
(c)	A Addition The only correct answer is A because the reaction between an alkene and a halogen forming a halogenoalkane is addition. B is not the correct answer since this reaction is not combustion. C is not the correct answer since this reaction is not decomposition. D is not the correct answer since this reaction is not substitution.		1
(d) (i)	 M1 single bond between the two carbons **and** single bonds to three hydrogens and one chlorine M2 two extension bonds and n	n can be anywhere after brackets extension bonds do not have to go through brackets M2 dep on M1	2
(ii)	M1 they are inert/unreactive M2 (so) they are non-biodegradable/ do not (naturally) break down/decompose (in landfill sites) OR M1 when burned M2 they produce toxic fumes	**ALLOW** take long time to break down (so landfill sites may fill up)	2

Total for question 7 = 15 marks

Question number	Answer	Notes	Marks
2 (a)	oxygen	ALLOW O_2	1
(b)	M1 carbon dioxide / CO_2 M2 water / H_2O	answers can be in either order ACCEPT water vapour ALLOW steam	2
(c) (i)	there is a limited supply of air / oxygen OWTTE	ALLOW not enough air/oxygen	1
(ii)	carbon monoxide reduces the capacity of blood to transport oxygen OWTTE	ACCEPT correct references to haemoglobin ALLOW produces carboxyhaemoglobin	1
(d)	substitution	ALLOW redox (reaction)	1
			total for question = 6

Question number	Answer	Notes	Marks
10ai	**M1** (compounds/molecules) with the same molecular formula **M2** but with different structural/displayed formula	**ACCEPT** same number **and** same type of atoms **REJECT** elements for compounds/molecules once only **ACCEPT** different structures **ACCEPT** atoms arranged differently **REJECT** contradicting statements, e.g. same displayed formula but different structures scores 0 out of 2	**2**
ii	 **OR**  **M1** correct carbon skeleton **M2** all hydrogen atoms and all bonds shown	**M2** dep on **M1**	**2**
bi	$(C_5H_{12} + Br_2) \rightarrow$ **$C_5H_{11}Br$ + HBr** **M1** correct formula of organic product **M2** HBr as a product **and** correctly balanced	deduct 1 mark if cases or subscripts incorrect **ACCEPT** multiple substitutions of bromine $C_5H_{10}Br_2 + H_2$ scores **M1**	**2**
ii	substitution		**1**
		Total	**7**

Question number	Answer	Notes	Marks
3 (a) (i)	**B** C_4H_{10} A is incorrect as C_2H_5 is not the molecular formula of an alkane C is incorrect as CH_2CH_2 is the structural formula of an alkene D is incorrect as $CH_3CH_2CH_3$ is the structural formula of an alkane		1
(ii)	**C** C_3H_8 A is incorrect as CH_2 is not a molecular formula but is an empirical formula of an alkene B is incorrect as the empirical formula of C_2H_6 is CH_3 D is incorrect as the empirical formula of C_4H_{10} is C_2H_5		1
(b) (i)	substitution		1
(ii)	$CH_4 + Br_2 \rightarrow CH_3Br + HBr$	ALLOW multiples IGNORE state symbols even if incorrect	1
(c) (i)	**M1** y (= 220 ÷ 44) = 5 **M2** **z** (= 108 ÷ 18) = 6		2
(ii)	**M1** C_5H_{12} **M2** **x** = 8	ALLOW ECF in (ii) from incorrect values of y and z in (i) to score M1 the answer must be the formula of an alkane	2
(d)	An explanation including one of the following pairs **M1** carbon monoxide/CO is produced **M2** (carbon monoxide) is toxic/poisonous /reduces the capacity of the blood to carry oxygen OWTTE **OR** **M1** carbon/soot **M2** causes asthma/bronchitis/respiratory problems OWTTE	**M2** dep on **M1** ACCEPT prevents blood from carrying oxygen ALLOW correct explanation in terms of haemoglobin e.g. prevents haemoglobin from carrying oxygen	2 **Total 10**

Question number	Answer	Notes	Marks
5 (a) (i)	**M1** (compounds with) same molecular formula	**ALLOW** same number of carbons and hydrogens / atoms of each element	2
	M2 different structural / displayed formulae	**ALLOW** different structures / arrangement of atoms	1
(ii)	(5 x 12 + 12 x1 =) 72		1
(iii)	pentane	spelling must be correct	1
(iv)	**M1** 	either order	2
	M2 H		

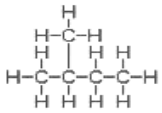
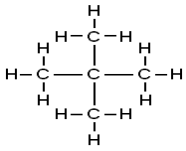
(b)	A description that refers to any five of the following points: **M1** ethane needs UV (radiation) to react **M2** ethane produces bromoethane **M3** ethane produces hydrogen bromide / HBr **M4** reaction with ethane involves breaking C-H bond / reaction with ethene involves breaking C=C bond **M5** ethane reaction is substitution **M6** ethene produces dibromoethane **M7** ethene reaction is addition	**IGNORE** any colour changes given **IGNORE** UV for ethene **IGNORE** any references to temperature and pressure **ALLOW** formulae **ALLOW** formula **M1, M2, M3** and **M6** can be scored from word or chemical equations	5 **Total 11**

Question number	Answer	Notes	Marks
7 (a)	M1 limewater turns cloudy /milky AND any one from: M2 because carbon dioxide / CO_2 is / produced /one of the products M3 which reacts with limewater forming calcium carbonate	ALLOW chalky / white precipitate ALLOW carbon dioxide / CO_2 is present ALLOW forming an insoluble product	2
(b) (i)	M1 amount of water = 2.16÷18 **OR** 0.12 mol M2 number of hydrogen atoms (0.12÷0.01)×2 OR 24 M3 formula of alkene = $C_{12}H_{24}$	 ALLOW $12H_2O$ Correct answer of $C_{12}H_{24}$ scores 3 C_6H_{12} scores 2	3
(ii)	some steam / water vapour is lost (to the atmosphere)	ALLOW some steam /water vapour does not condense IGNORE references to incomplete combustion	1
(iii)	M1 heat (the water) / measure the boiling point M2 (if it) boils at 100 °C (it is pure water) / boiling point is 100 °C	ALLOW find the freezing point /melting point REJECT evaporate ALLOW freezes/ melts at 0°C	2
(c)	M1 (moles of heptane) = 30 ÷ 100 **OR** 0.3(0) M2 (moles of oxygen) = 0.3(0) × 11 **OR** 3.3 M3 (mass of oxygen) = (3.3 × 32) = 106 (g) OR M1 11 x 32 **OR** 352 (g) of oxygen M2 so mass of oxygen = 352 x 30 ÷ 100 M3 106 (g)	Answer of 106 g OR 105.6 g scores 3 ALLOW M1 × 11 ALLOW ecf from M2 ALLOW 2 or more significant figures for M3 Answer of 9.6 (g) scores 2	3
			Total for question = 11

Question number	Answer	Notes	Marks
9 (a)	M1 (propane/it) contains hydrogen and carbon (atoms) M2 only	**REJECT** carbon and hydrogen molecules M2 is dependent on mention of just carbon and hydrogen in M1	2
(b) (i)	carbon monoxide	**ALLOW** CO	1
(ii)	it decreases the capacity of the blood to transport oxygen OWTTE	**ALLOW** carbon monoxide binds to haemoglobin	1
(c)	M1 (strong electrostatic) attraction between (bonding) pair of electrons M2 (and) nuclei (of both atoms) **OR** M1 (bonding) pair of electrons M2 attracted to nuclei	 **REJECT** nucleus **REJECT** nucleus 0 marks if reference to intermolecular forces between atoms	2
(d)	An explanation that links the following three points M1 (crude oil) produces more long chain hydrocarbons than can be used directly OWTTE M2 shorter chain alkanes are more flammable /more useful as fuels M3 alkenes are used to make polymers / plastics	 **ALLOW** less demand for long chain hydrocarbons **ALLOW** shorter chain alkanes/hydrocarbons are more useful	3
(e) (i)	M1 C_3H_7Br M2 HBr	 **ALLOW** polysubstituted product if correct balancing number in front of Br_2 and HBr	2
(ii)	substitution		1

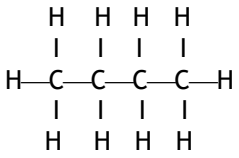
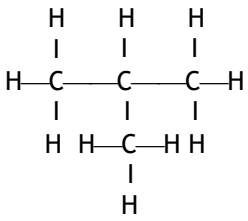
12 marks

Question number	Answer	Notes	Marks
4 a	**M1** (a compound containing the elements/atoms) hydrogen and carbon **M2** only	**ALLOW** molecule/substance for compound **REJECT** element/atom/ mixture for compound **REJECT** ions/molecules for elements/atoms **ACCEPT** other equivalent words eg solely **M2 DEP** on mention of hydrogen and carbon in **M1**	2
b (i)	$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ **M1** all formulae correct **M2** balancing of correct formulae	**ALLOW** fractions/multiples **IGNORE** state symbols	2
(ii)	Any two from **M1** carbon monoxide **M2** carbon **M3** water	**ACCEPT** correct formulae/symbol **ALLOW** soot for carbon	2
(iii)	reduces/limits capacity of blood to transport oxygen OWTTE M1	**ACCEPT** prevents blood from carrying oxygen OWTTE **ACCEPT** correct references to haemoglobin eg prevents haemoglobin from carrying oxygen	1 2

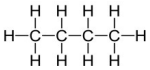
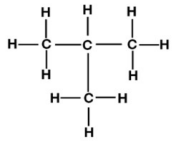
b(iv)			
	M2 	in either order	
c (i)	C_nH_{2n}		1
(ii)	(contains a carbon to carbon) double bond	**ALLOW** (contains a carbon to carbon) multiple bond	1
(iii)	A description linking the following two points **M1** add bromine water/solution **M2** (bromine water/solution) is decolourised / turns (from orange to) colourless	 **ALLOW** $Br_2(aq)$ **IGNORE** clear **REJECT** discoloured If initial colour of bromine water given it must be correct- **ALLOW** any combination of orange/yellow/brown **M2** dep on **M1** or near miss **ALLOW** **M1** add acidified potassium manganate(VII) **M2** (potassium manganate(VII)) is decolourised/turns (from purple to) colourless **REJECT** any other initial colour	2 Total 13

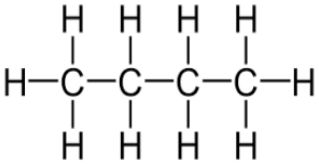
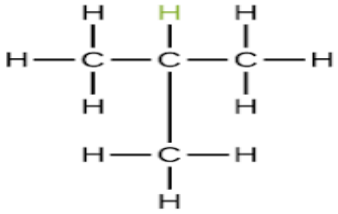
Question number	Answer	Notes	Marks
10 (a) (i)	curve of best fit	**REJECT** dot to dot line	1
(ii)	M1 lines shown on graph M2 value correctly read from graph (expected value between 97 and 103°C)	**ALLOW** extra point on curve at 7 carbon atoms **ACCEPT** value to ± 1°C	2
(iii)	An explanation that links the following three points M1 the boiling point increases as the number of carbons / the chain length increases M2 because the intermolecular forces (of attraction) get stronger M3 and therefore take more energy to overcome / break	 **ALLOW** boiling point increases as the M_r increases **REJECT** directly proportional M3 dep on M2 Any mention of breaking covalent bonds does not score M2 or M3	3
(b)	M1 same **molecular** formula M2 different **displayed** / **structural** formulae	 **ALLOW** different structures/ different arrangement of atoms	2
(c) (i)	M1 82.8 ÷ 12 **or** 6.9 17.2 ÷ 1 **or** 17.2 M2 (divide by smallest to give) 1:2.5 which is 2:5	0 marks if upside down calculation or use of atomic numbers **ACCEPT** alternative methods	2
(ii)	C_4H_{10}		1

(d)	M1 moles of CO_2 = 7 **or** X = 7 M2 moles of H_2O = 8 **or** Y = 8 M3 balancing number = 11 **or** Z = 11	**ALLOW** ecf from incorrect values of X and Y	3
			14 marks

		Answer	Notes	Marks
5 (a)		**M1** butane contains hydrogen/H and carbon/C (atoms) **M2** only **M3** and contains only single bonds	**REJECT** hydrogen and carbon molecules for **M1** **M2** dep on hydrogen and carbon **ACCEPT** does not contain double bonds/multiple bonds	3
(b)	(i)	$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ **M1** all formulae correct **M2** balancing of correct formulae	 **ALLOW** multiples and fractions	2
	(ii)	carbon	**ALLOW** soot / C **ALLOW** water / water vapour / steam	1
	(iii)	carbon monoxide reduces the capacity of blood to transport oxygen OWTTE	**ACCEPT** correct references to haemoglobin **ALLOW** produces carboxyhaemoglobin	1
(c)	(i)	**M1** isomers have the same molecular formula **M2** but different structural/displayed formulae	**ALLOW** same number of carbons and hydrogens **ALLOW** different arrangement of atoms	2 2
	(ii)	**M1**  **M2** 	Must show all bonds for both M1 and M2	

(d)	An explanation that links the following three points **M1** hexane is a larger molecule/longer chain ORA **M2** stronger intermolecular forces between the molecules ORA **M3** so more energy to overcome the forces ORA	 **ALLOW** contains more carbon (and hydrogen) atoms no **M2** or **M3** if any mention of breaking covalent bonds	3 **Total 14**

Question number	Answer	Notes	Marks
3 (a)	<table><tr><td>structural formula</td><td>$CH_3CH_2CH_2CH_3$</td></tr><tr><td>name</td><td>butane</td></tr><tr><td>molecular formula</td><td>C_4H_{10}</td></tr><tr><td>empirical formula</td><td>C_2H_5</td></tr><tr><td>general formula</td><td>C_nH_{2n+2}</td></tr></table> 1 mark for each correct answer		4
(b) (i)	**M1** (compounds with the) same molecular formula **M2** (but with) different structural/displayed formulae	**ALLOW same numbers of each atom** **ALLOW** different arrangement of atoms	2
(ii)	**M1** displayed formula of butane  **M2** displayed formula of methylpropane 		2
(c) (i)	HBr	REJECT incorrect case letters Ignore name	1
(ii)	**D** substitution A is incorrect as it is not an addition reaction B is incorrect as it is not a decomposition reaction C is incorrect as it is not a neutralisation reaction		1
(iii)	ultraviolet (radiation)	**ACCEPT** UV (radiation) **ALLOW** ultraviolet/UV light/sunlight	1
(d) (i)	$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$ **M1** all formulae correct **M2** balancing of correct formulae	**ALLOW** multiples and fractions **M2** dep **on M1**	2
(ii)	An explanation that links the following points **M1** carbon monoxide/CO (is the gas produced) **M2** (carbon monoxide) limits the capacity of the blood/haemoglobin to carry oxygen OWTTE	 **M2** dep **on M1**	2 **Total 15**

Question number	Answer	Notes	Marks
5 (a) (i)	**M1** (compounds with) same molecular formula **M2** different structural/displayed formulae	IGNORE general formula/chemical formula **ALLOW** different structures/arrangement of atoms	2
(ii)	**M1** displayed formula of butane  **M2** displayed formula of methylpropane 	REJECT molecular formula in structure Accept either order	2
(b) (i)	ultraviolet/UV (radiation)	**ALLOW** ultraviolet/UV light/rays	1
(ii)	$C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$	**ALLOW** multiple substitutions as long as the equation is balanced	1
(iii)	Substitution		1
(c)	An explanation that links the following two points **M1** (has) **all** single bonds/**only** single bonds/ (has) no double/multiple bonds **M2** (so) no other atoms can be added (to ethane)/no addition reactions	 **ALLOW** contains the maximum number of hydrogen atoms /each carbon bonded to four hydrogen atoms ALLOW only undergoes substitution reactions	2
(d)	**M1** with ethane bromine water stays orange/yellow **M2** with ethene bromine water changes (from orange/yellow) to colourless/ is decolourised	**ALLOW** no (colour) change /not decolourised IGNORE no reaction ,no observation IGNORE brown REJECT any other colour **IGNORE** brown REJECT any other colour	2

(e)	An explanation that links the following three points **M1** there are twice as many H atoms as C atoms in alkenes **OR** general formula of alkenes is C_nH_{2n} **M2** (so alkenes) empirical formula is always CH_2 **M3 (alkanes)**empirical formula of C_2H_6 is CH_3 and empirical formula of C_4H_{10} is C_2H_5 (shows they are different) Alkanes general formula is C_nH_{2n+2} so can't divide by n	**ALLOW** examples of any two from C_2H_4 C_3H_6 C_4H_8	3

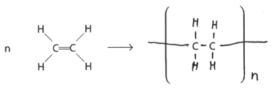
(f)	**M1** $\frac{19.2}{12}$ $\frac{4.0}{1}$ $\frac{12.8}{16}$ $\frac{64.0}{80}$ **M2** $\frac{1.6}{0.8}$ $\frac{4.0}{0.8}$ $\frac{0.8}{0.8}$ $\frac{0.8}{0.8}$ **OR** 2 5 1 1 **M3** C_2H_5OBr	0 marks for upside down calculation or use of atomic numbers Ecf on incorrect atomic mass but can't be an atomic number 6,8 or 35 Symbols can be in any order correct answer without working scores 3	3
			Total 17

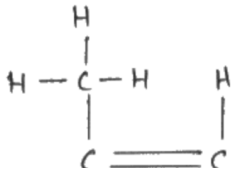
Question number	Answer	Notes	Marks
8 a	**2** C_2H_4 + **4** HCl + **(1)** O_2 → **2** $C_2H_4Cl_2$ + **2** H_2O	**ACCEPT** multiples and fractions	**1**
b	breaking down by heating OWTTE		**1**
c i	(it) contains a (carbon to carbon) double bond		**1**
ii	**M1** add bromine water/solution **M2** (bromine water/solution) is decolourised/ turns (from orange to) colourless	**ACCEPT** Br_2(aq) as long as the state symbol is present **IGNORE** clear **REJECT** discoloured If initial colour of bromine water given it must be correct- **ALLOW** any combination of orange/yellow/brown **M2** dep on **M1** or near miss **ALLOW** **M1** add acidified potassium manganate(VII) **M2** potassium manganate(VII) is decolourised/turns (from purple) to colourless **REJECT** any other initial colour	**2**
d	poly(chloroethene) /polychloroethene	**ACCEPT** polyvinyl chloride **ALLOW** PVC	**1**
		Total	**6**

Question number	Answer	Notes	Marks
1 (a) (i)	M1 a compound/substance/molecule containing hydrogen/H and carbon/C (atoms) M2 only	no M1 if reference to element containing C and H OR C and H molecules M2 dep on M1 or near miss	2
(ii)	ethene has a double bond		1
(b)	A colourless A is the only correct answer because alkenes such as ethene react with bromine water forming a colourless solution B is not correct as bromine water is orange before it reacts with ethene C is not correct as the solution produced is not purple D is not correct as the solution produced is not red		1
(c) (i)	temperature = 300°C pressure = 60-70 atmospheres	ACCEPT any value or range of values between 250 and 350°C If no unit given assume it is Celsius ACCEPT equivalent temperatures in other units provided the unit is given ACCEPT any value or range of values between 60 and 70 atm If no unit given assume it is atm ACCEPT equivalent pressures in other units provided the unit is given	2
(ii)	C_2H_6O	IGNORE size of numbers REJECT C_2H_5OH	1
			Total for question = 7

Question number	Answer	Notes	Marks
10 (a) (i)	any **one** from: M1 ethane is saturated M2 ethane has no double bonds M3 ethane has single bonds only		1
(ii)	M1 products C_2H_5Br and HBr M2 condition ultra violet radiation / ultra violet light/UV	In either order ALLOW balanced equations with a polysubstituted halogenoalkane	2
(iii)	orange/yellow/brown to colourless/decolourises	NOT red/red-brown	1
(b) (i)	any **two** from: M1 same functional group M2 the same/similar chemical properties OR undergo same/similar chemical reactions M3 trend in physical properties M4 differ by CH_2	 NOT similar reactivity ALLOW a named physical property e.g. boiling point NOT similar physical properties	2
(ii)	M1 same molecular formula M2 different displayed/structural formulae	NOT same empirical/general formula ALLOW different structures/arrangements	2
(iii)		ALLOW E/trans isomer 	1

(c)	M1 chain length longer in poly(ethene) M2 polymer contains only single (covalent) bonds /no double bond M3 ethene is a gas and poly(ethene) is a solid	ALLOW monomer contains double C=C bonds ALLOW reactant/ethene unsaturated ALLOW product/polyethene saturated	3
		Total = 12	

Question number			Answer	Notes	Marks
9	(a)	(i)	**M1** (Empirical formula) CH_2 **M2** (General formula) C_nH_{2n}	**ALLOW** sub and super script numbers for M1 and M2 **ALLOW** letters other than n **ALLOW** capital letters	2
		(ii)	Any two from: **M1** each member differs from the next by a CH_2 group OWTTE **M2** (each member has) same functional group **M3** (each member has) similar/same chemical properties / similar/same (chemical) reactions **M4** trend in physical properties (between successive members)	 **ACCEPT** react in similar/same way **ACCEPT** named physical property, e.g. boiling point **REJECT** similar/same physical properties	2
	(b)	(i)	addition	**ALLOW** additional **REJECT** condensation	1
		(ii)	(ii) Complete the equation for the polymerisation of ethene. (2)  **M1** Single bond between the two carbons, 4 hydrogens joined by single bonds **M2** trailing bonds through the brackets and the n to the right	 **ALLOW** n in any position outside the bracket to the right of the structure. **ALLOW** capital N	2
		(iii)	Any 5 points from: **M1** Poly(ethene) is cheaper than polymers from corn starch **M2** Poly(ethene) is stronger than polymers from corn starch **M3** Poly(ethene) frees up land to grow food crops	If only advantages or disadvantages given, max 3 marks **IGNORE** durable	5

	M4 Poly(ethene) comes from (cracking of certain fractions from) crude oil **M5** Poly(ethene) is non-renewable **OR** ethene is a finite source **M6** Poly(ethene) is inert **M7** poly(ethene) is non-biodegradable **M8** poly(ethene) takes longer to decompose **M9** Disposal of poly(ethene) is a problem (in landfill) **M10** Poly(ethene) causes problems with litter **M11** Burning poly(ethene) (could) create toxic fumes / greenhouse gases		
(c)		Must show every bond. **IGNORE** bond angles **IGNORE** n **IGNORE** brackets **REJECT** trailing bonds	1

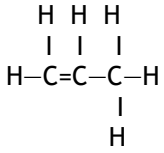
Question number	Answer	Notes	Marks
6 (a)	136		1
6 (b)	**M1** simplest (whole number) ratio of atoms present (in a compound) **M2** empirical formula (of ocimene/$C_{10}H_{16}$) is C_5H_8	**ALLOW** elements for atoms **ALLOW** C : H ratio 5:8	2

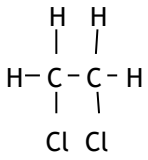
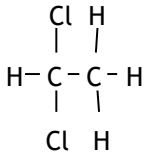
Question number	Answer	Notes	Marks
6 (c)	unsaturated hydrocarbon because **M1** contains (carbon to carbon) double bond(s) **M2** contains carbon and hydrogen (atoms) **M3** only	 **REJECT** molecules **M3** DEP on mention of carbon and hydrogen	3
6 (d) (i)	**A** addition B is incorrect because the type of reaction between an alkene and bromine is addition not polymerisation C is incorrect because the type of reaction between an alkene and bromine is addition not precipitation D is incorrect because the type of reaction between an alkene and bromine is addition not substitution		1

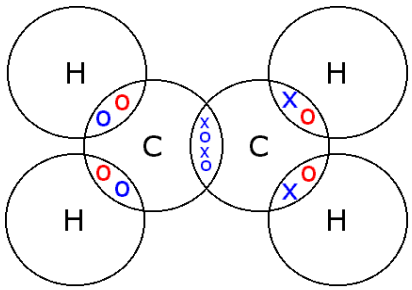
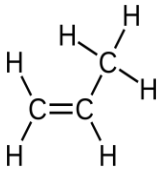
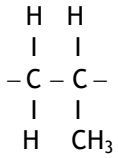
Question number	Answer	Notes	Marks
6 (d) (ii)	ocimene contains more than one double bond /three double bonds		1

Question number	Answer	Notes	Marks
6 (e)	$C_{10}H_{16} + 14\,O_2 \rightarrow 10\,CO_2 + 8\,H_2O$ **M1** $CO_2 + H_2O$ **M2** correctly balanced	 **ACCEPT** in either order **M2 DEP M1** **ACCEPT** multiples or fractions	2
6 (f) (i)	**M1** carbon/C/soot **M2** carbon monoxide/CO	**ACCEPT M1 M2** in either order	2
(ii)	(carbon monoxide/CO) reduces capacity of blood to carry oxygen OWTTE	**ACCEPT** correct references to haemoglobin / carboxyhaemoglobin	1

Total for Question 6 = 13 marks

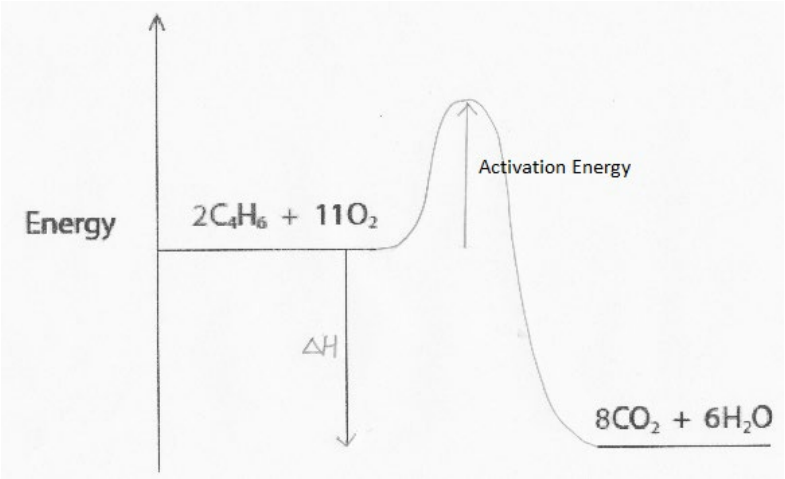
Question number	Answer	Notes	Marks
3 (a)	<table><tr><td>molecular formula</td><td>C_3H_6</td></tr><tr><td>name of this alkene</td><td>propene</td></tr><tr><td>empirical formula</td><td>CH_2</td></tr><tr><td>general formula</td><td>C_nH_{2n}</td></tr><tr><td>displayed formula</td><td>  </td></tr></table> 1 mark for each correct answer	**ACCEPT** propylene **ACCEPT** N or other letters e.g. x	4
b) i)	(contains a carbon carbon) double bond	**ACCEPT multiple bond**	1
ii)	M1 add bromine water M2 decolourises/changes to colourless	**REJECT bromine** **REJECT bromide** **ALLOW** turns colourless **IGNORE** clear **M2** dep **M1** or near miss	2
(c) (i)	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$	**ACCEPT** multiples	1
(ii)	**D** Substitution A is incorrect as it is not an addition reaction B is incorrect as it is not a decomposition reaction C is incorrect as it is not a neutralisation reaction		1
(iii)	Ultraviolet radiation/light	**ACCEPT** UV/ultraviolet rays	1
(d) (i)	**M1** (isomers have) the same molecular formula **M2** (but) different structural/displayed formulae	 **ALLOW** different structures **ALLOW** different arrangement of atoms	2

(ii)	**M1**			2
	M2			
				Total 14

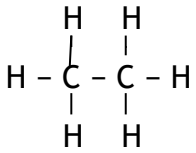
Question number	Answer	Notes	Marks
4 (a) (i)	Any two from **M1** same general formula **M2** same functional group **M3** each member differs from the next by CH_2 **M4** similar chemical properties / (chemical) reactions **M5** trend/change/increase in physical properties	**IGNORE** references to a specific homologous series **ALLOW** same chemical properties / (chemical) reactions **ACCEPT** named physical property e.g. trend in boiling points **REJECT** same / similar physical properties	2
(ii)	 **M1** two shared pairs of electrons between two carbon atoms **M2** shared pair of electrons between each hydrogen and the carbon it is bonded to	**ACCEPT** any combination of dots and crosses **ACCEPT** with or without shells drawn **IGNORE** inner shells on carbon atoms **REJECT** if non-bonding electrons shown on carbon **REJECT** if non-bonding electrons shown on hydrogen	2
(b) (i)	There are twice as many hydrogen atoms as carbon atoms (in every alkene) OWTTE	**ACCEPT** general formula is C_nH_{2n} **ACCEPT** it is the lowest whole number ratio of atoms in alkenes	1
(ii)	**M1**  **M2** 	**ALLOW** methyl group to be shown as $-CH_3$ rather than fully displayed **IGNORE** brackets and n **REJECT** structure without extension bonds	2

Question number	Answer	Notes	Marks
4 (c) (i)	**M1** (molecular formula) C_4H_6		2
	M2 (empirical formula) C_2H_3		
(ii)	An explanation that links the following three points		3
	M1 made up of carbon/C and hydrogen/H (atoms)	**REJECT** carbon and hydrogen molecules in **M1**	
	M2 only	**M2** dep on mention of just carbon and hydrogen in **M1**	
	M3 contains (two) C=C / (carbon-carbon) double bonds	**ALLOW** contains a (carbon-carbon) double bond	
(iii)	A description that refers to the following two points		2
	M1 add bromine water	**REJECT** add bromine for **M1**	
	M2 (bromine water) decolourised / turns (from orange/yellow to) colourless	**M2** dep on reference to bromine in **M1** **IGNORE** incorrect initial colour **REJECT** if reference to uv being needed for reaction to take place	
			Total 14

Question number	Answer	Notes	Marks
5 (a)	Explanation including following points M1 (unsaturated because) contains (carbon to carbon) double bond(s) M2 (hydrocarbon because) contains (the elements/atoms) carbon and hydrogen M3 only	 ALLOW contains C=C REJECT molecules M3 DEP on carbon and hydrogen	3 grad
(b) (i)	from orange to colourless	ALLOW yellow for orange or any combination of orange/yellow IGNORE clear	1 grad
(ii)	calculation including following steps M1 calculation of energy involved in bond breaking in reactants M2 calculation of energy involved in bond making in products M3 evaluation of difference M4 correct answer and sign Example calculation M1 2(612) + 1(348) + 6(412) + 2(193) OR 4430 M2 3(348) + 6(412) + 4(276) OR 4620 M3 (4620 - 4430 =) 190 M4 -190	 ECF from M1 and M2 IGNORE signs in M1 and M2 ACCEPT 2(612) + 2(193) OR 1610 for M1 and 2(348) + 4(276) OR 1800 for M2 IGNORE sign ACCEPT (1800 – 1610 =) 190 M3 M4 ECF from M1 and M2 If M1 > M2 answer for M4 must be positive If M1 < M2 answer for M4 must be negative -190 with or without working scores 4 (+) 190 with or without working scores 3	4 Exp

(c)	(i)	$2C_4H_6 + 7O_2 \rightarrow 2C + 4CO + 2CO_2 + 6H_2O$		1 Exp
	(ii)	Explanation including M1 CO/carbon monoxide M2 is poisonous/toxic/reduces capacity of blood to carry oxygen OWTTE **OR** M1 CO_2/carbon dioxide M2 is a greenhouse gas/contributes to global warming/ contributes to climate change OWTTE	M2 DEP M1 correct or missing **ACCEPT** prevents blood from carrying oxygen OWTTE ALLOW correct explanation in terms of haemoglobin eg prevents haemoglobin from carrying oxygen / forms carboxyhaemoglobin	2 Exp
	(iii)	 M1 horizontal line below level of reactants with $8CO_2 + 6H_2O$ M2 profile curve rising from reactants level to form "hump" and then falling down to products level M3 activation energy correctly shown and labelled M4 $\triangle H$ correctly shown and labelled	ALLOW double headed arrow REJECT arrow pointing downwards ALLOW double headed arrow REJECT arrow pointing upwards ALLOW -3446 for $\triangle H$ label an endothermic reaction profile can score M2 M3 M4 ECF	4 Exp

Total for Q5 = 15

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>5 (a) (i)</td><td>
<table>
<tr><td>molecular formula</td><td>C_2H_6</td></tr>
<tr><td>name</td><td>ethane</td></tr>
<tr><td>empirical formula</td><td>CH_3</td></tr>
<tr><td>displayed formula</td><td>  </td></tr>
</table>
</td><td>Penalise incorrect use of case, superscripts</td><td>3</td></tr>
<tr><td>(ii)</td><td>$\mathbf{2}C_2H_6 + \mathbf{7}O_2 \rightarrow \mathbf{4}CO_2 + \mathbf{6}H_2O$</td><td>ACCEPT multiples and fractions</td><td>1</td></tr>
<tr><td>(iii)</td><td>Any two from

M1 carbon monoxide/CO

M2 carbon/C

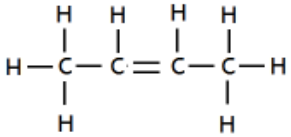
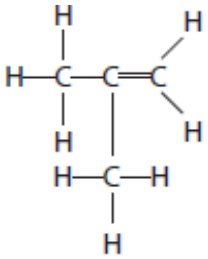
M3 water (vapour)/steam/H_2O</td><td>

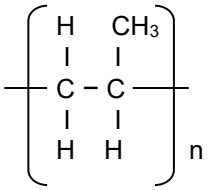
ALLOW soot

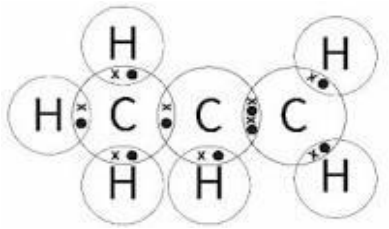
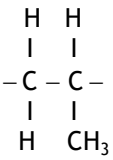
IGNORE carbon dioxide</td><td>2</td></tr>
<tr><td>(b) (i)</td><td>A addition

B is incorrect as it is not a decomposition reaction
C is incorrect as no solid precipitate is produced
D is incorrect as it is not a substitution reaction</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>Any two from

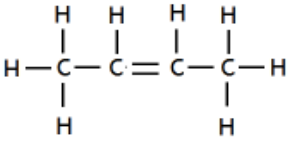
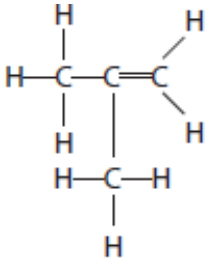
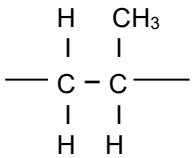
M1</td><td>Do not accept displayed formulae of cyclic alkanes</td><td>2</td></tr>
</table>

	M2  **M3** 	**ALLOW** cis-trans (E/Z) isomers of but-2-ene for both marks	
(iii)	isomers	**ALLOW** isomerism	1

Question number	Answer	Notes	Marks
5 (c) (i)		If double bond between carbon atoms scores 0	2
	M1 correct repeat unit **M2** extension bonds, brackets and n after brackets		
(ii)	A discussion which refers to the following points		3
	M1 polymers/poly(propene) will remain in landfill indefinitely OWTTE **M2** (as they) are inert /unreactive/do not biodegrade		
	M3 burning produces toxic gases	**ALLOW** burning produces greenhouse gases	
			Total 15

Question number	Answer	Notes	Marks
10 (a) (i)	M1 four electrons between carbon 2 and carbon 3 and two electrons between carbon 1 and carbon 2 M2 two electrons between each carbon and hydrogen 	ACCEPT any combination of dots and crosses Max 1 if any extra non-bonding electrons added	2
(ii)	M1 shared pair(s) of electrons M2 attracted to (two) nuclei OR M1 (two) nuclei M2 attracted to shared pair(s) of electrons	REJECT nucleus. Must be plural for M2 REJECT nucleus. Must be plural for M1	2
(b)	Any two from: M1 cracking M2 heat to / at a temperature of 600-700°C M3 with a catalyst of silica/alumina	 ALLOW a correct cracking equation including propene ALLOW aluminosilicates / aluminium oxide / silicon oxide/Al_2O_3/SiO_2 /zeolites	2
(c) (i)	M1  M2 extension bonds, brackets and n to the right	ALLOW correct repeat unit with or without extension bonds M2 dep on M1	2
(ii)	M1 (poly(propene)) remains for a long time (in landfill) M2 because it is inert/unreactive/non-biodegradable	ALLOW takes up a lot of space ALLOW does not decompose	2

(d)	(i)	M1 $\frac{60}{12}$ $\frac{13.3}{1}$ $\frac{26.7}{16}$ M2 $\frac{5}{1.67}$ $\frac{13.3}{1.67}$ $\frac{1.67}{1.67}$ OR 3:8:1 M3 (36 + 8 + 16 = 60 / 60 ÷ 60 = 1 so molecular formula is) C_3H_8O	C_3H_8O scores 3 atoms can be in any order no marks for upside down calculation or use of atomic numbers ACCEPT alternative methods	3
	(ii)	M1 intermolecular forces in compound X are stronger AND any one from M2 so require more energy to overcome M3 because the M_r / the surface area of the molecule is higher M4 because the molecule has more electrons	M2, M3, and M4 dep on M1	2
				Total for question = 15

Question number	Answer	Notes	Marks
8 (a) (i)	An explanation that links the following two points **M1** (compounds with) the same molecular formula	**ALLOW** same number of carbons and hydrogens/atoms of each element **REJECT** elements with the same molecular formula **REJECT** chemical formula for M1	2
	M2 but different structural/displayed formulae	**ALLOW** different structures/arrangements of atoms **M2** independent of **M1**	
(ii)	**M1** 	Must show all bonds **ALLOW** cis and trans isomers for both marks	2
	M2 	**REJECT** cycloalkanes	
(b)	**A** (addition) B is incorrect as this is not a combustion reaction C is incorrect as this is not a decomposition reaction D is incorrect as this is not a substitution reaction		1
(c) (i)		**IGNORE** brackets and n	1

	(ii)	**M1** they are inert/unreactive/do not biodegrade/decomposes (very) slowly/running out space **M2** they produce toxic fumes/greenhouse gases (when burned)	**IGNORE** global warming	2
(d)		**M1** y (= 396 ÷ 44) = 9 **M2** z (= 180 ÷ 18) = 10 **M3** x = 14	**ALLOW** ecf for **M3** on incorrect values for **M1** and/or **M2**	3
(e)	(i)	$C_8H_{18}(l) + 7O_2(g) \rightarrow 5CO(g) + 3C(s) + 9H_2O(l)$ **M1** correct balancing **M2** correct state symbols	**ACCEPT** (g) for H_2O	2
	(ii)	**M1** carbon monoxide/CO **M2** is poisonous/toxic/limits the capacity to carry oxygen in the blood	**ALLOW** carbon/C **ALLOW** soot causes respiratory problems **ACCEPT** correct references to haemoglobin **M2** dep on **M1** **IGNORE** harmful	2
				Total 15

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>4 (a)</td><td>
<table>
<tr><td>Name</td><td>Structural formula</td><td>Relative formula mass</td></tr>
<tr><td>methanol</td><td>CH_3OH</td><td>32</td></tr>
<tr><td>ethanol</td><td>C_2H_5OH</td><td>46 (1)</td></tr>
<tr><td>butanol (1)</td><td>C_4H_9OH</td><td>74</td></tr>
</table>
</td><td>ALLOW correct names of isomers</td><td>2</td></tr>
<tr><td>(b) (i)</td><td>sulfuric acid</td><td>If oxidation number given must be correct
ALLOW H_2SO_4
IGNORE reference to concentration</td><td>1</td></tr>
<tr><td>(ii)</td><td>from orange to green</td><td></td><td>1</td></tr>
<tr><td>(c) (i)</td><td>ethyl ethanoate</td><td>ALLOW as one word</td><td>1</td></tr>
<tr><td>(ii)</td><td>$CH_3OH + CH_3COOH \rightarrow CH_3COOCH_3 + H_2O$
M1 CH_3COOH
M2 CH_3COOCH_3</td><td>ALLOW displayed formula</td><td>2</td></tr>
</table>

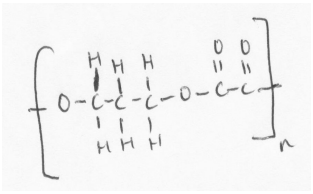
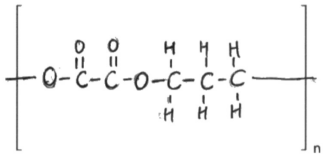
(Total for Question 4 = 7)

Question number	Answer	Notes	Marks
4 (a)	M1 30°C M2 (enzymes from) yeast	ALLOW values within the range of 30°C- 40°C ALLOW zymase IGNORE glucose/anaerobic/pressure	2
(b)	M1 oxygen in the air would react with ethanol M2 to form ethanoic acid OR M1 ethanol would not be formed M2 CO_2 and H_2O would form	ACCEPT ethanol would be oxidised ALLOW to form carboxylic acid ALLOW to form vinegar	2
(c) (i)	CO_2		1
(ii)	12.5% M1 (theoretical moles of ethanol from glucose) = 500 x 2 = 1000 M2 (100% yield) = 46 000 g M3 (percentage yield) = (5750 ÷ 46 000) × 100 = 12.5% OR M1 moles of ethanol from mass = 5750/46 = 125 M2 theoretical moles of ethanol = 500 x 2 = 1000 M3 (percentage yield) = 125/1000 × 100 = 12.5%	Answer of 12.5% without working scores 3 marks ALLOW ecf from M1 ALLOW ecf from M2 Allow ecf for M3	3
			Total marks for question 4 = 8

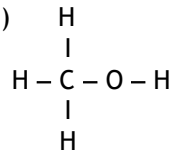
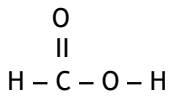
Question number	Answer	Additional guidance	Marks
3 (a)	**M1** the volume of liquid/alcohol **M2** the temperature of the water	**ALLOW** amount of liquid/alcohol **IGNORE** mass **IGNORE** volume of water **ALLOW** temperature of surroundings **IGNORE** references to temperature of the alcohol	2
(b)	alcohols/the liquids are flammable/catch fire easily	**ALLOW** alcohols/the liquids can be easily ignited **ALLOW** any named alcohol from the table	1
(c) (i)	**M1** (64 + 63 + 60) ÷3 **M2 =** 62	 **ALLOW** 62.3 62/62.3 with no working scores 2 **ALLOW** 69/69.25/69.3 for 1 mark	2
(ii)	An explanation including the following two points: **M1** methanol/CH_3OH (evaporates most easily) **M2** because the time taken is the shortest	 **ACCEPT** because has lowest (mean) time	2

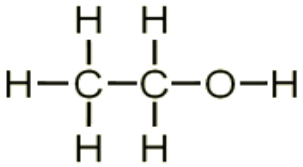
Question Number	Answer	Additional Guidance	Marks
(iii)	**M1** as the number of carbon atoms increases **M2** the ease of evaporation decreases/the less easily the alcohol evaporates	**ALLOW** the less volatile the alcohol **IGNORE** the slower the alcohol evaporates **IGNORE** references to time taken **ALLOW** correct reverse argument	2
		Total	**9**

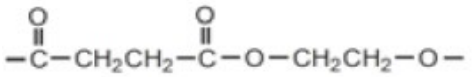
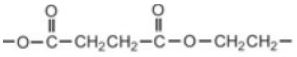
Question number	Answer	Notes	Marks
4 (a) (i)	The correct answer is **D** a structural formula **A** is incorrect because CH_3CH_2OH is not a displayed formula **B** is incorrect because CH_3CH_2OH is not an empirical formula **C** is incorrect because CH_3CH_2OH is not a molecular formula		1
(ii)	Any two from the following: **M1** same general formula **M2** each member differs from the next by CH_2 **M3** same functional group **M4** similar chemical properties/reactions **M5** trend/gradation in physical properties OWTTE	ACCEPT named physical property eg boiling point	2
(iii)	alcohol(s)		1
(iv)	propan-1-ol	ALLOW 1-propanol ALLOW propanol	1
(b) (i)	explanation including **M1** condensation (polymerisation) **M2** because water also produced/eliminated/removed/lost	ALLOW small molecule also produced/ eliminated/removed/ lost	2

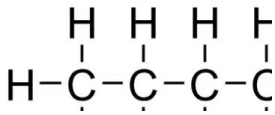
(ii)	 OR  **M1** correct ester linkage shown **M2** rest of repeat unit fully correct	 M2 DEP M1	2

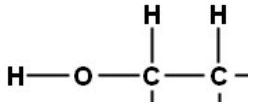
(Total for Question 4 = 9 marks)

Question number	Answer	Notes	Marks
5 (a)	Any two from **M1** same general formula **M2** same functional group **M3** similar chemical properties /characteristics **M4** trend in physical properties /characteristics **M5** consecutive members differ by a CH_2 group	 **IGNORE** same chemical properties accept any trend in specified physical property	2
(b) (i)	H_2SO_4		1
(ii)	**M1** (from) orange **M2** (to) green	must be in the correct order	2
(iii)	**M1** (methanol)  **M2** (methanoic acid) 	Penalise once only if O – H bond not shown and both structures correct	2
(c)	$CH_3OH + HCOOH \rightarrow HCOOCH_3 + H_2O$	**ALLOW** multiples **ALLOW** CH_3OOCH **IGNORE** state symbols even if incorrect **REJECT** CH_3COOH and $C_2H_4O_2$	1
(d) (i)	**A** (butyl ethanoate) B butyl methanoate is not the correct name of the ester $CH_3COOCH_2CH_2CH_2CH_3$ C ethyl butanoate is not the correct name of the ester $CH_3COOCH_2CH_2CH_2CH_3$ D methyl butanoate is not the correct name of the ester $CH_3COOCH_2CH_2CH_2CH_3$		1
(ii)	$C_6H_{12}O_2$	**ALLOW** symbols in any order	1
			Total 10

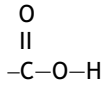
Question number	Answer	Notes	Marks
6 (a) (i)	**M1** 300 (°C)	**ACCEPT** any temperature or range 250 to 350 inclusive. **ACCEPT** any correct alternative unit and quantity	2
	M2 60 to 70 (atm)	**ACCEPT** any pressure or range 60 to 70 inclusive **ACCEPT** any correct alternative unit and quantity	
(ii)		All bonds including bond between O and H must be shown.	1
(b) (i)	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$		2
	M1 all formulae correct	**ALLOW** C_2H_6O for ethanol	
	M2 balancing of correct formulae	**ACCEPT** multiples and fractions **IGNORE** state symbols even if incorrect **M2** dep on **M1**	
(ii)	prevents blood from carrying oxygen/ reduces the capacity of blood to carry oxygen OWTTE	**ALLOW** references to combining with haemoglobin in red blood cells or forming carboxyhaemoglobin	1

Question number	Answer	Notes	Marks
6 (c)	ethyl ethanoate	**ALLOW** ethyl acetate	1
(d) (i)	condensation (polymerisation)		1
(ii)	 + $2H_2O$ **M1** correct ester link **M2** rest of polymer structure correct with extension bonds **M3** $2H_2O$	**ACCEPT**  for **M1** and **M2** If brackets and n present equation must be fully balanced with n in front of each reactant and $2nH_2O$ for full marks, otherwise max 2 If dimer is drawn with OH at one end and COOH at the other a mark can be awarded for H_2O without the 2 as this equation is then balanced, so **M1** and **M3** can be awarded.	3
			Total 11

Question number	Answer	Notes	Marks
6 (a)	C is the only correct answer as temperature used is 300°C and pressure is 65 atm (60-70 atm) A is incorrect because 35°C and 300 atm are not the correct conditions B is incorrect because 65°C and 300 atm are not the correct conditions D is incorrect because 300°C and 35 atm are not the correct conditions		1
(b)		formula must be fully displayed ALLOW fully displayed formula for butan-2-ol	1
(c)(i)	M1 mol(KOH) = $\frac{45.00 \times 0.40}{1000}$ = 0.018		2
	M2 conc(CH_3COOH) = $\frac{0.018 \times 1000}{25}$ = 0.72 (mol/dm^3)	ALLOW ecf from M1 0.72 (mol/dm^3) without working scores 2	
(ii)	M1 mol(CO_2) = (0.0030÷2) = 0.0015 M2 vol(CO_2) = 0.0015 x 24000 = 36 (cm^3)	ALLOW ecf from M1 36 (cm^3) without working scores 2 72 (cm^3) without working scores 1	2
(d)	**B** C_2H_5OH is the only correct answer A is not correct because CH_3OH could not form the ester ethyl propanoate C is not correct because C_3H_7OH could not form the ester ethyl propanoate D is not correct because C_4H_9OH could not form the ester ethyl propanoate		1

(e)	(i)	(in condensation polymerisation) two different monomers used / water is produced	ALLOW small molecule is produced	1
	(ii)	M1 	ALLOW -OH	2
		M2 	ACCEPT in either order ALLOW -OH	
	(iii)	biodegradable	ACCEPT description	1

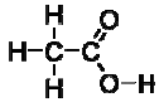
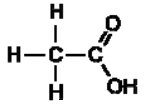
Total marks for Question 6 = 11

Question number	Answer	Notes	Marks
5 (a) (i)	glucose → ethanol + carbon dioxide	ACCEPT fully correct chemical equation IGNORE yeast	1
(ii)	yeast	IGNORE zymase/enzymes	1
(iii)	**M1** 30 °C	ACCEPT any value between 20 and 40 inclusive IGNORE yeast IGNORE room temperature	2
	M2 anaerobic conditions / absence of air/oxygen	Answers can be in any order	
(b) (i)	**B** $CH_3COOC_4H_9$ A is incorrect as this is propyl ethanoate C is incorrect as this is butyl propanoate D is incorrect as this is ethyl butanoate		1
(ii)	sweet/fruity/distinctive smell OWTTE		1
(iii)	perfumes/(food) flavourings/solvents	IGNORE (food) colourings ACCEPT any other appropriate use eg emulsifiers	1
(c) (i)	(atom/group of atoms in a compound that) determines its chemical properties/reactions OWTTE	ALLOW (atom/group of atoms that) determines which homologous series a compound is in OWTTE	1
(ii)	circle around 		1

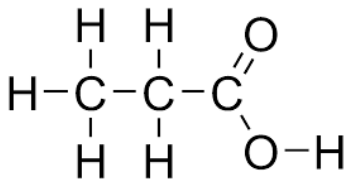
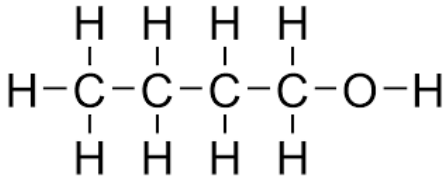
(iii)	**M1** $\frac{60.00}{12}$ $\frac{4.44}{1}$ $\frac{35.56}{16}$ **M2** $\frac{5.(00)}{2.2225}$ $\frac{4.44}{2.2225}$ $\frac{2.2225}{2.2225}$ **OR** 2.25 2 1 **M3** 2.25 x 4 2 x 4 1 x 4 = 9:8:4	If upside down/use atomic numbers scores 0 ALLOW rounding of 2.2225 but should show at least 2 dp ALLOW other correct methods eg **M1** Mr (of aspirin) = 180 **M2** 9x12 or 108 8x1 or 8 4x16 or 64 ALL 3 needed for M2 **M3** $\frac{108}{180}$ x 100 = 60 (%) $\frac{8}{180}$ x 100 = 4.44 (%) $\frac{108}{180}$ x 100 = 35.56 (%) ALL 3 needed for M3	3 **Total 12**

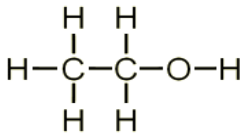
Question number	Answer	Additional guidance	Marks
6 (a) (i)	yeast	**IGNORE** zymase	1
(ii)	**C** (30 °C) is correct as it is the most suitable temperature for fermentation A is incorrect as at 0°C the enzymes would not be active so not the most suitable temperature for fermentation B is incorrect as at 10°C the enzymes would not be very active so not the most suitable temperature for fermentation D is incorrect as at 80°C the enzymes would be denatured so not the most suitable temperature for fermentation		1
(iii)	An explanation using either of the following linked pairs: **M1** oxygen in the air would react with ethanol **M2** to form ethanoic acid **OR** **M1** the fermentation/reaction/respiration needs to be anaerobic **M2** ethanol would not be formed /CO_2 and H_2O would form	**ACCEPT** ethanol would be oxidised **ALLOW** to form carboxylic acid **ALLOW** to form vinegar	2

(b)	(i)	a substance that releases thermal energy/heat (energy) when burned/combusted	**IGNORE** energy on its own	1
	(ii)	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ **M1** all formulae correct **M2** correctly balanced	**ACCEPT** multiples **M2** DEP **M1**	2

Question number	Answer	Additional guidance	Marks
6 (c)	**M1** (temperature) 300 °C **M2** 60 – 70 atm	**ACCEPT** any value or range of values between 250 and 350 °C If no unit given assume it is Celsius **ACCEPT** equivalent temperatures in other units provided the unit is given **ACCEPT** any value or range of values between 60 and 70 atm If no unit given assume it is atm **ACCEPT** equivalent pressures in other units provided the unit is given	2
(d) (i)	(from) orange (to) green		1
(ii)		**IGNORE** bond angles  scores 1 mark	2
(iii)	$CH_3COONa + \frac{1}{2}H_2$ **M1** for both products correct **M2** for correctly balanced	**ALLOW** $NaCH_3COO$ **ACCEPT** multiples **M2** DEP **M1**	2
		Total	**14**

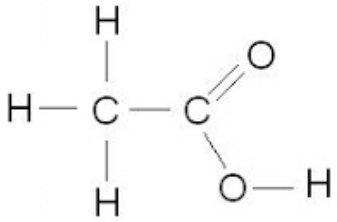
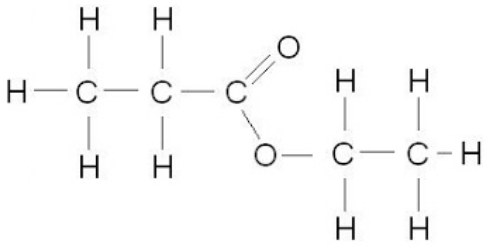
Question number	Answer	Notes	Marks
7 (a) (i)	CO_2		1
(ii)	(otherwise) ethanoic acid will form	**ALLOW** (otherwise) ethanol will be oxidised or react with oxygen **ALLOW** fermentation/reaction/respiration needs to be anaerobic **ALLOW** (otherwise) ethanol would not be formed / CO_2 and H_2O would be formed	1
(iii)	**M1** (reaction is catalysed by) enzymes (in yeast) **M2** which will denature (above 40°C)	**IGNORE** yeast unqualified **ALLOW** enzymes do not work above 40°C	2
(iv)	**M1** maximum mass of ethanol = 8 x 46 = 368 (g) **M2** $\frac{55.2}{368}$ x 100 (=15%) **Alternative method:** **M1** actual yield of ethanol in mol = $\frac{55.2}{46}$ = 1.2 **M2** $\frac{1.2}{8}$ x 100 (=15%)		2
(b) (i)	**M1** rate of the forwards reaction = the rate of the backwards reaction **M2** the concentrations of reactants and products remain constant	**IGNORE** it is reversible reaction **REJECT** concentrations of reactants and products are equal or are the same	2
(b) (ii)	**M1** an increase in temperature shifts the (position of) equilibrium in the endothermic direction (so backwards reaction is endothermic) **M2** so forward reaction is exothermic	**IGNORE** references to Le Chatelier's Principle **ALLOW** heating for increase in temperature **M2 DEP M1** or near miss	2

7 (c) (i)	**M1** (displayed formula of A - propanoic acid)  **M2** (displayed formula of B - butan-1-ol) 	**ALLOW** 1 mark if both OH but otherwise correct	2
(c) (ii)	**M1** add a named carbonate or hydrogencarbonate **M2** effervescence/bubbles/fizzing **OR** **M1** add a suitable named metal e.g. magnesium, aluminium, zinc, iron **M2** effervescence/bubbles/fizzing **OR** **M1** add a named alcohol (and some concentrated sulfuric acid and warm) **M2** sweet smell (of an ester)	**ALLOW** correct formula **M2 DEP M1** or near miss **ALLOW** carbon dioxide/CO_2 produced **REJECT** incorrect gas **ALLOW** correct symbol **REJECT** a metal that is too reactive e.g. potassium or too unreactive e.g. copper **M2 DEP M1** or near miss **ALLOW** hydrogen/H_2 produced **REJECT** incorrect gas **ALLOW** correct formula **M2 DEP M1** or near miss	2

Question number	Answer	Notes	Marks
5 (a)	Any two from: **M1** same general formula **M2** each member differs from the next by CH_2 **M3** same functional group **M4** similar chemical properties/reactions **M5** trend/steady increase in physical properties	 **ALLOW** same chemical properties/reactions **ACCEPT** named physical properties e.g. trend in boiling points	2
(b) (i)	H_2SO_4	If name and formula given, name must be correct.	1
(ii)	**M1** from orange **M2** to green	colours must be in the correct order	2
(iii)	**M1**  **M2**	Penalise no bond between O and H once only	2

Question number	Answer	Notes	Marks
5 (c) (i)	A discussion which refers to any six of the following points: Advantages of fermentation/disadvantages of hydration **M1** sugar cane can be re-grown/is renewable **M2** crude oil is finite/cannot be replaced/is non-renewable **M3** fermentation uses lower temperatures so energy costs are lower/ hydration uses higher temperatures, so energy costs are higher **M4** fermentation uses lower pressure so energy costs are lower/ hydration uses higher pressure, so energy costs are higher **M5** yeast is a natural substance and not harmful/ phosphoric acid is corrosive Advantages of hydration/disadvantages of fermentation **M6** hydration is a faster process/ fermentation is a slower process **M7** hydration gives pure ethanol/ fermentation gives impure ethanol **M8** growing sugar cane takes up land which could be used for growing food/rearing livestock **M9** hydration is a continuous process/fermentation is a batch process		6
(ii)	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$	**ALLOW** $2C_2H_6O$ for ethanol **ALLOW** multiples and fractions	1
			Total 14

Question number	Answer	Notes	Marks
4 (a)	CH_3OH	IGNORE displayed formula	1 grad
(b) (i)	fermentation		1 cler
(ii)	Explanation including four from		4 exp
	M1 fermentation/reaction/respiration needs to be anaerobic	ALLOW M1 in air ethanol would react with oxygen / be oxidised	
	M2 because in air / aerobic conditions ethanol not produced	M2 in air ethanol would form ethanoic acid /carboxylic acid/vinegar	
	M3 because in air / aerobic conditions CO_2 and H_2O are produced		
	M4 (if temperature above 40 °C/too high) enzymes (in yeast) become denatured/lose their structure OWTTE		
	M5 causing fermentation/reaction to slow down /stop	ALLOW reference to optimum temperature (between 30 °C and 40 °C)	

Question number	Answer	Notes	Marks
4 (c) (i)	 M1 M2 $C_3H_6O_2$ M3 butanoic acid		3 grad
(ii)	carboxylic (acids)		1 grad
(d) (i)	(acid acts as) a catalyst/to speed up reaction	IGNORE references to activation energy	1 grad
(ii)	 M1 ester linkage M2 rest of molecule fully correct	M2 DEP M1	2 exp
(iii)	M1 (Property:) distinctive/sweet/fruity smell M2 used in perfumes/flavourings	ALLOW volatile ALLOW any correct use eg in making soaps/ in solvents (for paints/varnishes)	2 exp

Total for Q4 = 15

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>3 (a)</td><td>$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

M1 both formulae correct

M2 balancing of correct formulae</td><td>ACCEPT CH_3CH_2OH

M2 dep on M1 but if C_2H_6O given no M1 but allow M2 for correct balancing

IGNORE state symbols even if incorrect

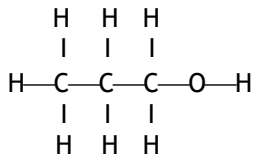
ALLOW multiples and fractions</td><td>2</td></tr>
<tr><td>(b) (i)</td><td><table><tr><th></th><th>Hydration</th><th>Fermentation</th></tr><tr><td>Reagents</td><td>ethene and steam</td><td>aqueous glucose</td></tr><tr><td>Catalyst</td><td>phosphoric acid</td><td>enzymes in yeast</td></tr><tr><td>Temperature in °C</td><td>300</td><td>30</td></tr><tr><td>Pressure in atmospheres</td><td>60 – 70</td><td>1</td></tr></table></td><td>ACCEPT H_3PO_4
If formula alone must be correct, but if name given and formula incorrect ignore formula

ALLOW sulphuric acid / H_2SO_4

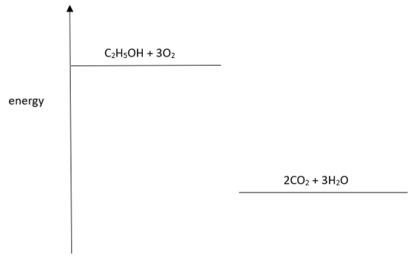
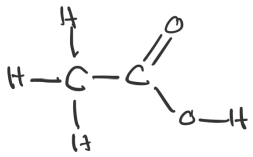
ACCEPT any temperature between 20 and 40 inclusive

ACCEPT any pressure between 60 and 70 inclusive</td><td>3</td></tr>
</table>

	(ii)	An explanation that links one advantage and one disadvantage advantage: **M1** uses low(er) pressure / atmospheric pressure / 1 atm **M2** so less energy needed / less costly equipment / safer **OR** **M1** uses low(er) temperature **M2** so less energy / heat needed **OR** **M1** glucose /sugar cane is a natural resource /is renewable **M2** whereas ethene obtained from crude oil /ethene is non-renewable / ethene is a finite resource **OR** **M1** yeast is a natural resource **M2** whereas phosphoric acid is a manufactured catalyst disadvantage: **M3** fermentation is slow(er) **M4** fermentation is less efficient /so hydration is more efficient **OR** **M3** ethanol is impure **M4** so ethanol needs to be purified ORA **OR** **M3** growing sugar cane takes up land **M4** that can be used to grow food crops	**IGNORE** cheaper /less costly alone **IGNORE** cheaper /less costly **ALLOW** **M3** fermentation is a batch process **M4** whereas hydration is a continuous process (so more efficient) **IGNORE** reference to yield	4

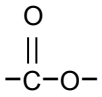
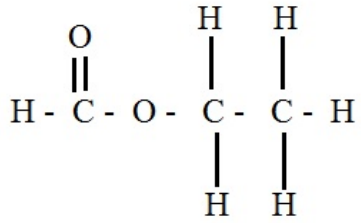
(c)		An explanation that links the following two points **M1** oxygen would oxidise / react with ethanol / alcohol **M2** which would produce ethanoic acid / CH_3COOH **OR** **M1** fermentation needs to be anaerobic **M2** so ethanol / alcohol will be formed / otherwise only carbon dioxide and water would form	 **ALLOW** acetic acid / vinegar **IGNORE** carboxylic acid	2
(d)	(i)	**M1** $\frac{60.0}{12}$ $\frac{13.3}{1}$ $\frac{26.7}{16}$ **M2** 5.0 13.3 1.67 **M3** $\frac{5.0}{1.67}$ $\frac{13.3}{1.67}$ $\frac{1.67}{1.67}$ **OR** 2.99 7.96 1	0 marks for division by atomic numbers or upside-down calculation **ALLOW** any number of sig figs except 1 apart from 5 in **M2** and **M3** **ACCEPT** alternative methods	3
	(ii)		Bond between O and H must be shown **ACCEPT** structure of propan-2-ol	1
				Total 15

Question number			Answer	Notes	Marks
7	(a)	(i)	yeast	ALLOW zymase/enzymes from yeast	1
		(ii)	C 30°C A is not the correct answer because 0°C is too low for fermentation B is not the correct answer because 10°C is too low for fermentation D is not the correct answer because 100°C is too high for fermentation		1
		(iii)	An explanation using either of the following linked pairs: M1 oxygen (in the air) would react with ethanol/ alcohol M2 to form ethanoic acid **OR** M1 (in the presence of air) the glucose would react with the oxygen M2 so ethanol does not form	 ALLOW ethanol would be oxidised ALLOW to form carboxylic acid ALLOW to form vinegar/acetic acid ALLOW correct reference to aerobic respiration ALLOW forms CO_2 and H_2O	2
	(b)	(i)	M1 346 + (5 × 414) + 358 + 463 + (3 × 498) **OR** 4731 M2 (4 × 804) + (6 × 463) **OR** 5994 M3 −1263 (kJ/mol) OR M1 346 + (5 × 414) + 358 + (3 × 498) **OR** 4268 M2 (4 × 804) + (5 × 463) **OR** 5531 M3 −1263 (kJ/mol)	 −1263 kJ/mol scores 3 ALLOW ecf for M3	3

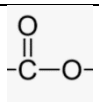
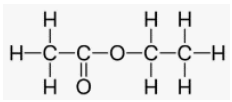
	(ii)	 M1 right-hand line below left-hand line M2 correct names/balanced formulae of both reactants M3 correct names/balanced formulae of both products	IGNORE any activation energy hump IGNORE enthalpy change arrow If only use words reactants (on left) and products (on right) award 1 mark from M2 and M3 If no/incorrect coefficients then 1 mark from M2 and M3	3
	(iii)	An explanation that links together the following two points: M1 more energy is given out when the bonds are made M2 than is taken in when the bonds are broken ACCEPT correct reverse argument **OR** M1 breaking bonds is endothermic/takes in energy AND making bonds is exothermic/releases energy M2 the energy released is more than the energy taken in	If state/imply that energy required to make bonds OR If state/imply that energy released when bonds are broken scores 0/2 M2 dep on M1	2
(c)	(i)	M1 displayed formula for ethanoic acid  M2 displayed formula for water/H_2O	ACCEPT any shape	2

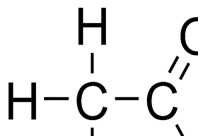
(ii)	ethyl ethanoate	IGNORE hyphens	1
			Total = 15

Question number	Answer	Notes	Marks
7 (a) (i)	sulfuric acid	**IGNORE** references to concentration **ALLOW** H_2SO_4 **REJECT** sulfurous acid	1 Grad
(ii)	**D** orange to green A is incorrect as the solution is not colourless at the start of the reaction B is incorrect as the solution is not green at the start or orange at the end of the reaction C is incorrect as the solution is not colourless at the end of the reaction		1 Comp
(b) (i)	• show the expression for the sum of the bond energies for the breaking of bonds • evaluation to give answer in kJ Example calculation **M1** ∑ C-C + 5C-H + C-O + O-H + 3O=O **OR** ∑ 346 + (5 x 412) + 358 + 463 + (3 x 496) **M2** 4715 (kJ)	correct answer without working scores 2 - 1 mark for each error	2 Exp
(ii)	• show the expression for the sum of the bond energies for the forming of bonds • evaluation to give answer in kJ Example calculation **M1** ∑ 4C=O + 6O-H **OR** ∑ (4 x 743) + (6 x 463) **M2** 5750 (kJ)	correct answer without working scores 2 - 1 mark for each error **IGNORE** any signs in (i) and (ii)	2 Exp
(iii)	(4715 – 5750 =) – 1035 (kJ/mol)	minus sign must be included **ACCEPT** – 1040 (kJ/mol) **ALLOW** ecf on answers to (i) and (ii) If answers to (i) and (ii) are reversed allow max 3 and ecf on (iii)	1 Exp

Question number	Answer	Notes	Marks
7 (c) (i)	ethyl methanoate	**ALLOW** ethyl formate **ALLOW** words written without gap	1 Grad
(ii)	**M1** ester linkage  **M2** rest of molecule correct  Structural formula of ethyl formate or ethyl methanoate	**M2** dep on **M1**	2 Exp
(iii)	**M1** forward and reverse reactions occur at the same rate OWTTE **M2** concentrations of reactants and products remain constant		2 Exp
(d)	• calculate amount in moles of HCOOH • use equation to find amount in moles of CO_2 • multiply amount in moles of CO_2 by molar volume • evaluation of answer in cm^3 Example calculation **M1** n(HCOOH) = 2.3 ÷ 46 **or** 0.05(0) **M2** $n(CO_2)$ = 0.05(0) ÷ 2 **or** 0.025 **M3** (volume of CO_2) = 0.025 x 24 **or** 0.025 x 24000 **M4** 600 (cm^3)	correct answer without working scores 4 No ecf from **M1** and **M2** if mass or M_r multiplied by 24 /24000 **ALLOW** ecf from **M3** 0.6, 1200 and 2400 score 3 1.2 and 2.4 score 2	4 Exp

			Total 16

Question number	Answer	Notes	Marks
3 (a) (i)	Any **two** from: M1 volume of acid M2 temperature M3 mass / moles of magnesium M4 surface area / size of pieces of magnesium		2
(ii)	so as little gas as possible escapes	**ALLOW** so no gas escapes **IGNORE** references to accuracy **REJECT** references to gas getting in	1
(b) (i)	M1 (69 + 70 + 71) ÷ 3 M2 70s	Answer of 70 with or without working scores 2 Answer of 76 or 75.8 or 75.75 with or without working scores 1	2
(ii)	as the (number of) carbons increases the time (to produce 10 cm^3 of hydrogen) increases ORA		1
(c)	M1 ester linkage as a displayed structure  M2 rest of molecule correct as a fully displayed structure 		2
			8 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>4 (a)</td><td>
<table>
<tr><td>structural formula</td><td>CH_3COOH</td></tr>
<tr><td>name</td><td>ethanoic acid</td></tr>
<tr><td>empirical formula</td><td>CH_2O</td></tr>
<tr><td>displayed formula</td><td>  </td></tr>
</table>
</td><td>1 mark for each correct answer

ALLOW acetic acid

Must show O-H bond</td><td>3</td></tr>
<tr><td>(b) (i)</td><td>M1 potassium dichromate(VI)

M2 (dilute) sulfuric acid</td><td>VI not essential for the mark
ACCEPT sodium dichromate(VI)
ALLOW $K_2Cr_2O_7$

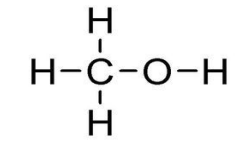
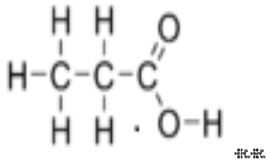
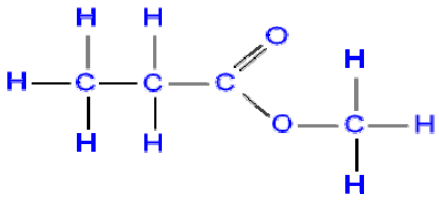
ALLOW concentrated sulfuric acid
ALLOW H_2SO_4

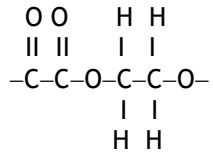
ACCEPT reagents in either order</td><td>2</td></tr>
<tr><td>(ii)</td><td>B orange to green

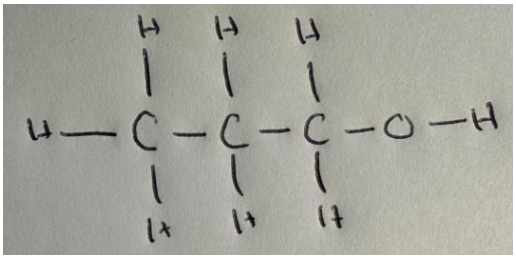
A is incorrect as the colour does not change from green to orange
C is incorrect as the colour does not change from red to yellow
D is incorrect as the colour does not change from yellow to red</td><td></td><td>1</td></tr>
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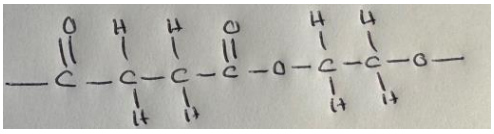
Question number	Answer	Notes	Marks
4 (c) (i)	alcohols are flammable/might catch fire/might ignite	**ACCEPT** esters/mixture are/is flammable/might catch fire/might ignite **ALLOW** alcohol/ester/ carboxylic acid might evaporate	1
(ii)	**C** methyl propanoate A ethyl methanoate is not the correct name of the compound B methyl ethanoate is not the correct name of the compound D propyl methanoate is not the correct name of the compound		1
			Total 8

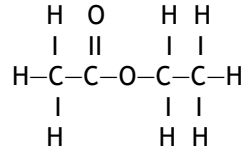
Question number			Answer	Notes	Marks
5	(a)	(i)	$2CH_3COOH + K_2CO_3 \rightarrow 2CH_3COOK + CO_2 + H_2O$ **M1** $2CH_3COOK$ **M2** $CO_2 + H_2O$	**ALLOW** multiples **ACCEPT** $2CH_3COO^-K^+$ **ALLOW** $2KCH_3COO$ If **M1** not awarded any numbers before $CO_2 + H_2O$ can be ignored and **M2** can be awarded. For both marks to be awarded the equation must be correctly balanced	2
		(ii)	effervescence / fizzing / bubbles	**IGNORE** carbon dioxide/gas given off/evolved/ formed /produced **IGNORE** mention of incorrect gas	1
	(b)	(i)	(acts as a) catalyst	**ACCEPT** increases the rate of the reaction/speeds up the reaction	1
		(ii)	ethanol is flammable / might catch fire / might ignite	**ACCEPT** ethyl ethanoate /the mixture /it is flammable /might catch fire /might ignite	1
		(iii)	(ester has) sweet / fruity / distinctive smell	**ALLOW** liquid (ester) floats on top of mixture OWTTE	

Question number	Answer	Notes	Marks
5 (c) (i)	  	Penalise missing bond between O and H once only If incorrect number of carbon atoms in alcohol and or acid allow ECF for structure of ester formed from their alcohol and acid	3
(ii)	water	**ACCEPT** H_2O	1
(d)	food flavourings / perfumes	**ACCEPT** any correct use e.g. in cosmetics / making soaps / making detergents /solvents (for paints / varnishes)	1 **Total 11**

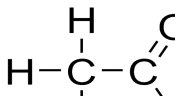
Question number	Answer	Notes	Marks
5 (a) (i)	$2CH_3COOH + Mg \rightarrow (CH_3COO)_2Mg + H_2$ **M1** $2CH_3COOH + Mg$ **M2** H_2	**ALLOW** multiples and fractions **ALLOW** $2C_2H_4O_2$ **REJECT** $2CH_4COO$ **IGNORE** state symbols even if incorrect	2
(ii)	**M1** effervescence/fizzing/bubbles **M2** magnesium becomes smaller/disappears	**IGNORE** gas evolved **ALLOW** dissolves	2
(b) (i)	(concentrated) sulfuric acid	**ALLOW** any suitable inorganic acid e.g. hydrochloric or nitric or phosphoric **IGNORE** dilute	1
(ii)	**C ($CH_3CH_2COOCH_3$)** A is incorrect as it is propyl methanoate B is incorrect as it is propyl ethanoate D is incorrect as it is methyl butanoate		1
(c) (i)	condensation (polymerisation)		1
(ii)	water	**ALLOW** H_2O	1
(iii)	 **M1** correct displayed ester functional group **M2** rest of structure correct	**ALLOW** structure without extension bonds O can be on LHS instead of on RHS **IGNORE** brackets and n	2
(d)	(a polyester that) is biodegradable	**ACCEPT** can be degraded by bacteria **ALLOW** can be decomposed	1
			Total 11

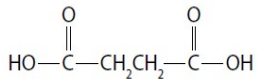
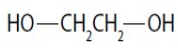
Question number	Answer	Notes	Marks
7 (a) (i)	propan-1-ol	ALLOW propanol REJECT propan-2-ol	1
(ii)		REJECT -OH must be -O-H	1
(iii)	M1 242-(15+45) = 182 M2 182÷14 M3 13	13 without working scores 3 ALLOW M1÷14 M3 must be an integer 17 scores 2	3
(iv)	H_2O / water		1

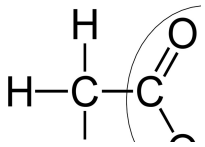
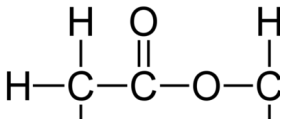
(b) (i)	M1 (moles of NaOH) 0.150×0.025 **OR** 0.00375(mol) M2 (moles of C) 0.00375÷2 **OR** 0.001875(mol) M3 0.001875÷0.0175 **OR** 0.10714(mol/dm^3) M4 0.107(mol/dm^3)	correct answer without working scores all 4 marks ALLOW M1÷2 ALLOW M2÷0.0175 ALLOW M3 to 3 sig figs M4 must be to 3 sig figs 0.214 scores 3 marks	4
(ii)	 M1 for the ester linkage M2 rest of the molecule correct	ALLOW without the extension bonds M2 dep on M1	2
		Total = 12	

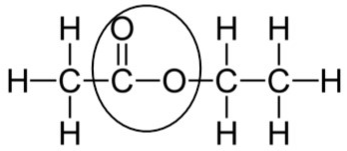
Question number	Answer	Notes	Marks
4 (a) (i)	sulfuric acid / phosphoric acid	**ACCEPT** dilute or concentrated **ALLOW** H_2SO_4 /H_3PO_4	1
(ii)	**M1** (from) orange **M2** (to) green	must be in the correct order	2
(b) (i)	$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + CO_2 + H_2O$ **M1** $2CH_3COONa$ **M2** $CO_2 + H_2O$	 **ALLOW** $2NaCH_3COO$ /$2NaOOCCH_3$	2
(ii)	Any two from:- **M1** bubbles/ fizzing/effervescence **M2** sodium carbonate/solid disappears /gets smaller **M3** loss of vinegar smell	 **IGNORE** gas produced even if incorrect **ALLOW** dissolves	2
(c) (i)	catalyst / to speed up the reaction		1
(ii)	ethanol is (in)flammable /can ignite	**ACCEPT** ethyl ethanoate is (in)flammable /can ignite **ALLOW** mixture or it is (in)flammable /can ignite	1
(iii)	distinctive/fruity/sweet smell	**ACCEPT** oily liquid **IGNORE** nice smell	1
(iv)	**M1** correct ester functional group **M2** rest of molecule correct 	 **M2** dep on **M1**	2
			Total 12

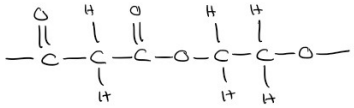
Question number	Answer	Notes	Marks
6 (a) (i)	sulfuric acid / H_2SO_4	**ACCEPT** hydrochloric acid / HCl and nitric acid / HNO_3 / phosphoric acid / H_3PO_4	1
(ii)	distinctive / sweet / fruity smell	**ACCEPT** an oily layer forms (on the surface)	1
(iii)	methyl ethanoate	spelling must be correct	1
(b) (i)	C—O and O—H		1
(ii)	An explanation that links the following two points **M1** the same (two) bonds / C—O and O—H are broken and formed **M2** energy needed to break bonds equals energy released when bonds form (so overall enthalpy change is 0)	**ALLOW** ecf if wrong bonds in (i) **IGNORE** the same number of bonds are broken and formed	2
			Total 6

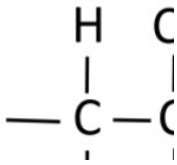
Question number	Answer	Notes	Marks
5 (a) (i)	**M1** $\frac{40.0}{12}$ $\frac{6.7}{1}$ $\frac{53.3}{16}$	0 marks for division by atomic numbers or upside-down calculation	2
	M2 3.33 6.7 3.33 **AND** 1 2 1	**ALLOW** any number of sig figs except 1 **ACCEPT** alternative methods	
(ii)	CH_3COOH **OR** 	**ACCEPT** $HCOOCH_3$ **OR** 	1
(b) (i)	$2HCOOH + Na_2CO_3 \rightarrow 2HCOONa + CO_2 + H_2O$		2
	M1 $CO_2 + H_2O$	**IGNORE** numbers in front of CO_2 and/or H_2O if only **M1** scored	
	M2 HCOONa **and** equation correctly balanced	**REJECT** NaCOOH **ALLOW** NaHCOO	
(ii)	bubbles/ fizzing/ effervescence	**IGNORE** gas given off **ALLOW** sodium carbonate disappears/dissolves	1
(c) (i)	propyl methanoate	spelling must be correct **ALLOW** propyl formate	1
(ii)	reversible reaction	**ALLOW** reaction which goes both ways **IGNORE** equilibrium	1

	(iii)	forward and backward reactions occur at the same rate OWTTE **OR** concentrations of reactants and products remain constant/stay the same/do not change	**ALLOW** amounts/moles/ratios of reactants and products remain constant **REJECT** concentrations of reactants and products are equal/the same	1
(d)	(i)	condensation (polymerisation)		1
	(ii)	**M1**  **M2** 	**ALLOW** $HOOCCH_2CH_2COOH$ for **M1** **ALLOW** $HOCH_2CH_2OH$ for **M2** **REJECT** OH—C once only	2
				Total 12

Question number	Answer	Notes	Marks
6 (a) (i)		REJECT more than one molecule or group circled	1
(ii)			2
	M1 ester linkage (COO) correctly displayed		
	M2 rest of the molecule correct	M2 dep on M1	
(iii)	ethyl ethanoate		1
(b)	M1 the forwards and the reverse reactions occur at the same rate		2
	M2 the concentrations of reactants and products remain constant	REJECT concentrations of reactants and products are the same ALLOW amounts	
(c) (i)	(concentrated) sulfuric acid /it is a catalyst		1
(ii)	Any 6 of the following:		6
	M1 rinse the burette <u>with sodium hydroxide</u>		
	M2 fill the burette <u>with sodium hydroxide</u>		
	M3 make sure that the jet / space between tap and tip contains liquid	ALLOW no bubbles in the burette	
	M4 add (a few drops) of indicator (to the conical flask)	ALLOW any named indicator except universal indicator	
	M5 add (sodium hydroxide) from the burette until the indicator changes colour (permanently)	ACCEPT <u>any</u> stated colour change	
	M6 swirl the conical flask	ACCEPT shake	
	M7 add (sodium hydroxide) dropwise close to the endpoint		
	M8 record initial and final volume on burette	ALLOW record volume of solution added	
	M9 repeat until concordant results	ALLOW repeat until two results are ± 0.2 cm^3	
			Total for question = 13

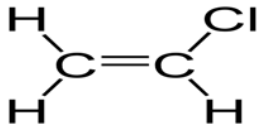
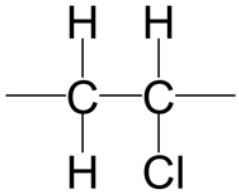
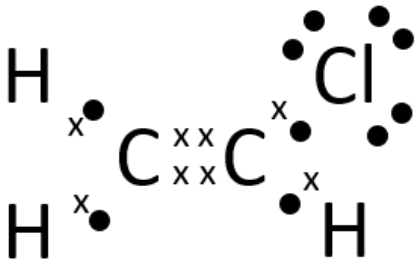
Question number	Answer	Notes	Marks
7 (a) (i)		REJECT any other atoms in the ring.	1
(ii)	ethyl ethanoate	ALLOW ethylethanoate ALLOW ethyl acetate	1
(iii)	M1 add a metal such as magnesium, aluminium, zinc or iron M2 effervescence/bubbles/fizzing **OR** M1 add a carbonate M2 effervescence/bubbles/fizzing	must be a named metal REJECT Group 1 metals ACCEPT test gas with lighted splint which pops M2 dep on reference to adding a metal ACCEPT any named carbonate ACCEPT test gas with limewater which goes cloudy/milky M2 dep on M1	2
(b)	M1 C-O and one / two O-H bonds are broken and formed M2 so the same amount of energy is needed to break the bonds in the reactants as is given off when the bonds in the products are formed	ALLOW the same bonds are broken and formed ALLOW energy of bonds formed equals energy of bonds broken	2
(c) (i)	M1 the rate of the forward reaction equals the rate of the backward reaction M2 the concentrations of reactants and products remain constant	 REJECT concentration of the reactants and products are the same	2
(ii)	M1 a catalyst increases the rate of forward and backward reactions M2 equally	 M2 dep on M1	2

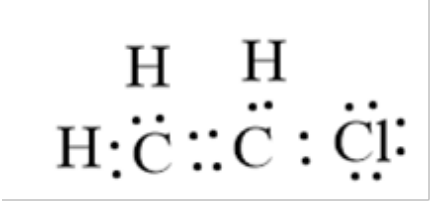
Question number	Answer	Notes	Marks
7 (d)	example calculation M1 moles barium hydroxide = (0.150 × 22.75)÷ 1000 **OR** 0.0034125 M2 moles ethanoic acid = 0.006825 M3 moles ethanoic acid to 3 significant figures = 0.00683	M1 needs to be given to at least 3 sig figs ALLOW M1 × 2 ALLOW answer to M2 to 3 significant figures. correct answer of 0.00683 moles with or without working scores 3 marks ACCEPT answer in standard form ACCEPT 0.00682 if M1 given to 3 sig figs 6.83 with or without working scores 2 marks	3
(e)	correct answer scores 2 marks  M1 three carbons from the dicarboxylic acid and two from the diol and the ester linkage M2 -OH lost from the dicarboxylic acid and -H lost from the diol	ALLOW structure without extension bonds IGNORE brackets and n and + H_2O ALLOW -OH lost from diol and -H lost from dicarboxylic acid	2
			Total for question = 15

Question number	Answer	Notes	Marks
6 (a)	**B** (chloroethene) A is not correct as the monomer has a double bond C is not correct as the monomer has two carbons D is not correct as the monomer has two carbons		1
(b)		Extension bonds do not need to go through the brackets	1
(c)	M1 (M_r of chloroethene) = 62.5 M2 2490000 ÷ 62.5 = 39 840		2
(d)	A discussion which refers to any 4 of the following points M1 polymers/poly(propene) will remain in landfill indefinitely OWTTE M2 (as they) are inert /unreactive/do not biodegrade/do not decompose M3 burning produces greenhouse gases / CO_2 M4 reference to climate change /global warming M5 burning produces toxic gases	 ALLOW reference to running out of landfill sites OWTTE ALLOW carbon monoxide /CO /hydrogen chloride/HCl Max 3 if any reference to the ozone layer	4
(e)	M1 1:1:3 / 31 800 ÷ 10 600 M2 $CHCl_3$	ALLOW other evidence of working ALLOW the atoms in any order Answer of $CHCl_3$ without working scores 2	2
			Total for question = 10

Question number	Answer	Notes	Marks
6 (a)	• Dividing percentages by atomic masses • Correct results of divisions • Obtaining ratio by dividing results by smallest value **M1** C H Cl 38.4/12 4.8/1 56.8/35.5 **M2** 3.2 4.8 1.6 **M3** 3.2/1.6 4.8/1.6 1.6/1.6 (= 2 3 1) Alternative method • Calculating Mr of C_2H_3Cl • Working for finding ratio of each element • Evaluation of correct percentages **M1** C_2H_3Cl (= 24 + 3 + 35.5) = 62.5 **M2** C H Cl 24/62.5 3/62.5 35.5/62.5 **M3** all x 100 = 38.4(%) 4.8(%) 56.8(%)	0 marks if division by atomic numbers or calculation upside down	3

Question Number		Answer	Notes	Marks
(b)	(i)	$FeCl_3$	**REJECT** incorrect use of upper and lower case letters, and superscript **ACCEPT** correct formula as ions $Fe^{3+}(Cl^-)_3$	1
	(ii)	to increase the rate of the reaction/ to speed up the reaction	**ALLOW** references to (providing reaction pathway of) lower activation energy	1
	(iii)	gives out heat (energy)	**ACCEPT** thermal energy **NOT** energy alone **IGNORE** reference to negative △H	1
	(iv)	A addition B is incorrect as this is not a displacement reaction C is incorrect as this is not a neutralisation reaction D is incorrect as this is not a substitution reaction		1
	(v)	$C_2H_4Cl_2 \rightarrow C_2H_3Cl + HCl$	**IGNORE** incorrect use of lower/upper case and superscripts	1

Question number	Answer	Notes	Marks
6 (c) (i)	**M1** displayed formula of chloroethene 	**IGNORE** bond angles **IGNORE** brackets/n	3
	M2 correct displayed formula with single bond between C atoms 	If double bond in repeat unit no **M2** or **M3** **IGNORE** brackets/n	
	M3 extension bonds shown on C atoms	more than one correct repeat unit with extension bonds scores 1 mark out of M2/M3	
(ii)	**M1** 2 shared pairs between C atoms **M2** rest of structure fully correct 	**ACCEPT** any combination of dots and crosses. **IGNORE** inner shells even if incorrect **M2 DEP on M1**	2
			Total 13

Question number			Answer	Notes	Marks
9	(a)	(i)	**M1** two shared pairs between carbon atoms **M2** rest of molecule fully correct 	**ALLOW** any combination of dots and crosses **M2** dep on **M1**	2
		(ii)	a description that refers to the following points **M1** attraction between a shared pair of electrons **M2** and two nuclei **OR** **M1** attraction between nuclei **M2** and a shared pair of electrons	 Do not allow nucleus Do not allow nucleus	2
		(iii)	H H | | — C — C — | | H Cl	**ALLOW** with or without extension bonds **IGNORE** brackets and n	1
		(iv)	A description that refers to the following two pairs of points **M1** disposal of poly(chloroethene) in landfill **M2** takes up space / takes a very long time to decompose/ they are inert OWTTE **M3** burning poly(chloroethene) **M4** hydrogen chloride / toxic gases produced	 **IGNORE** non-biodegradable M2 dependent on M1 M4 dependent on M3 ALLOW produces greenhouse gases	4
	(b)		**M1** $\frac{22.0}{12}$ $\frac{4.6}{1}$ $\frac{73.4}{80}$ **M2** $\frac{1.83}{0.92}$ $\frac{4.6}{0.92}$ $\frac{0.92}{0.92}$	0 marks if division by atomic numbers or upside down calculation correct answer without	3

	OR 2 5 1 **M3** C_2H_5Br	working scores 3 **ALLOW** symbols in any order	
(c)	A description that refers to any five of the following points with a <u>maximum of three marks from each section/reactant:</u> **ethane** **M1** a substitution reaction **M2** does not decolourise/stays orange/decolourises very slowly **M3** ultraviolet radiation/light needed **M4** produces bromoethane/C_2H_5Br **M5** produces hydrogen bromide/HBr **ethene** **M6** an addition reaction **M7** decolourises (immediately) / turns colourless **M8** produces dibromoethane/$C_2H_4Br_2$	**ALLOW** UV	5 **Total 17**