PEARSON EDEXCEL IAL CHEMISTRY · YCH11

CHEMISTRY



EXAM QUESTION PACK

UNIT 2: ALCOHOLS

SCORE	PERCENTAGE
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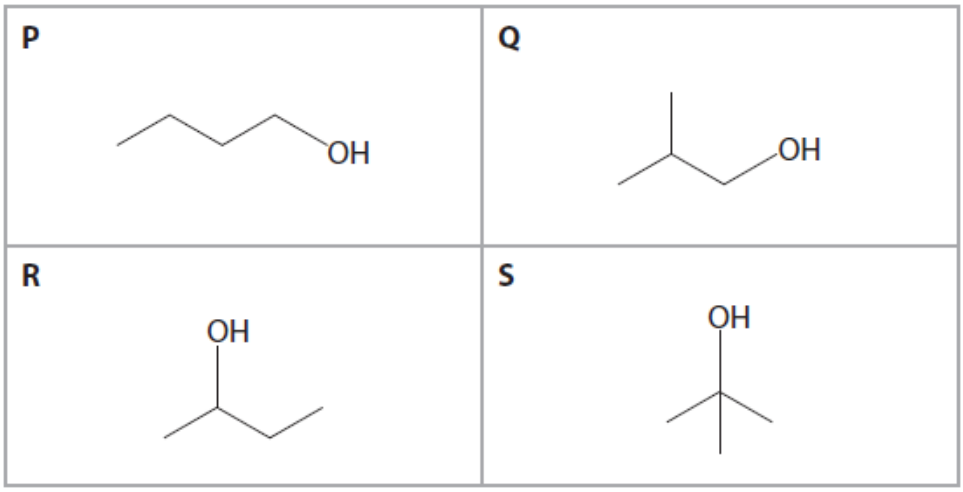
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Q1.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of these alcohols will produce a carboxylic acid when heated under reflux with acidified potassium dichromate(VI)?



☒ **A** **P** only

☒ **B** **P** and **Q** only

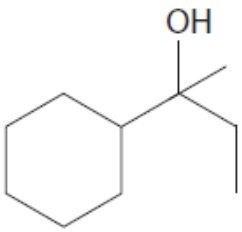
☒ **C** **P**, **Q** and **R** only

☒ **D** **P**, **Q**, **R** and **S**

(Total for question = 1 mark)

Q2.

An alcohol **Y** has the structure shown.



(a) Describe a **chemical** test and its positive result for the alcohol

functional group in **Y**.

(2)

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(b) **Y** reacts with concentrated phosphoric(V) acid, H_3PO_4, to form four isomers with the molecular formula $C_{10}H_{18}$.

(i) Draw the skeletal formulae of the **four** isomers formed in this reaction.

(4)

(ii) Describe, by referring to wavenumbers and bonds, how the infrared spectra of the isomers differ from the infrared spectrum of alcohol **Y**.

(2)

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(c) An isomer of **Y**, citronellol, has the systematic name 3,7-dimethyloct-6-en-1-ol.

Draw the structure of citronellol.

(2)

(Total for question = 10 marks)

Q3.

1-bromopropane is used for spot removal when 'dry cleaning' clothes.

(a) 1-bromopropane does not occur naturally but can be made from propan-1-ol.

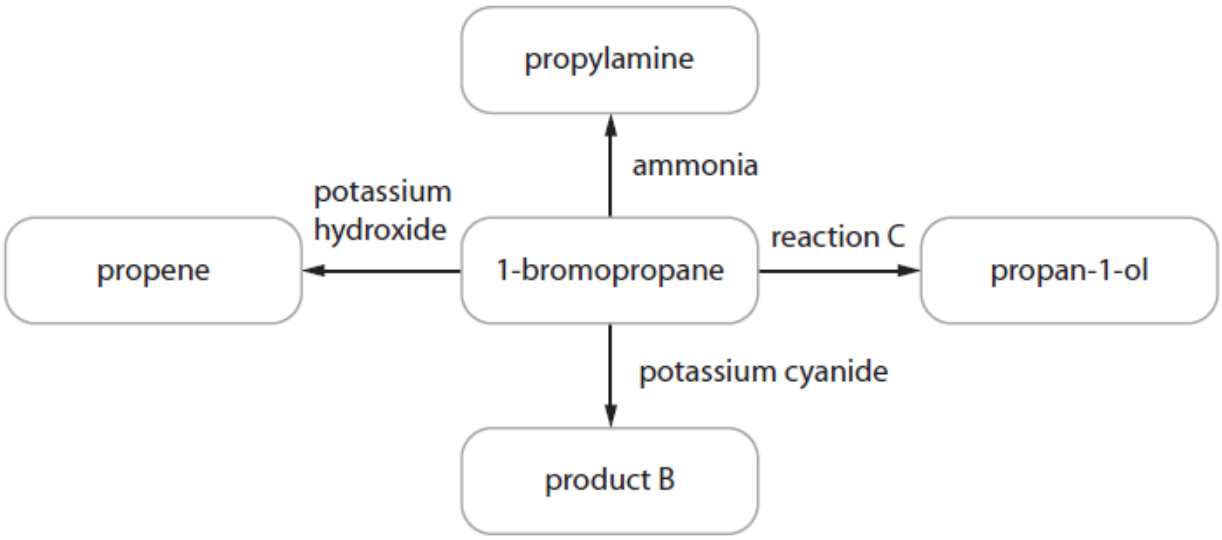
Identify the reagent or reagents you would use to make 1-bromopropane from propan-1-ol.

(1)

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(b) Some reactions of 1-bromopropane are shown.



(i) Give the conditions for the formation of propene.

(1)

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(ii) Give the **molecular** formula of product B.

(1)

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(iii) Name the type and mechanism of the reaction taking place in reaction C.

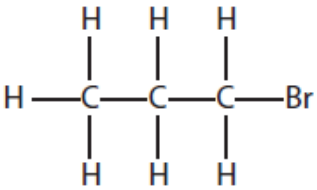
(2)

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(iv) Complete the mechanism for the reaction that occurs between ammonia and 1-bromopropane to form propylamine,
$CH_3CH_2CH_2NH_2$.

Include curly arrows, and relevant lone pairs and dipoles.

(4)



(Total for question = 9 marks)

Q4.

This question is about bicycles.

Bicycle frames have been made from steel and aluminium for many years but more recently titanium has been used.

Titanium is a metal that is extracted from its ore, impure titanium oxide (TiO_2), in a two-step process.

Step **1**

The titanium oxide reacts with chlorine in the presence of carbon to form titanium(IV) chloride ($TiCl_4$) and carbon monoxide.

Step **2**

The titanium(IV) chloride reacts with magnesium.

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

(a) (i) Write the equation for Step **1**.

State symbols are not required.

(1)

(ii) Explain why Step **2** is a redox reaction.

Refer to relevant oxidation numbers in your answer.

(2)

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(b) Titanium(IV) chloride is a liquid that reacts violently with water, producing white smoke. This reaction has been used to produce naval smoke screens to hide ships.

Suggest the type of reaction taking place **and** the compound producing the white smoke.

(2)

Type of reaction

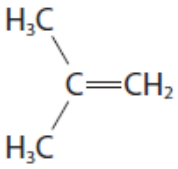
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Compound

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(c) Many bicycles use an inner tube inside the tyre.

A common material used for inner tubes is the addition polymer formed from 2-methylpropene.

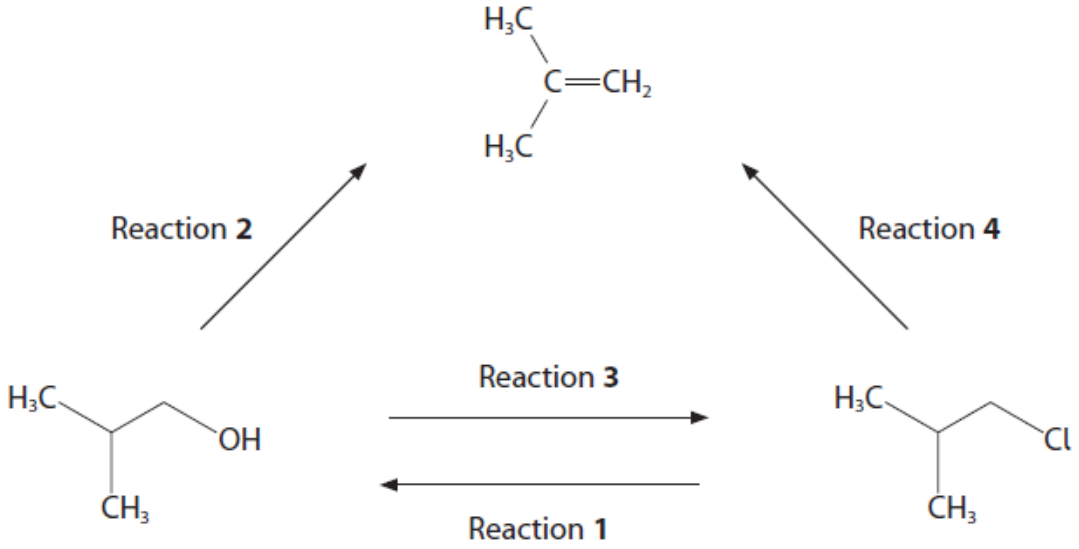


2-methylpropene

Draw a section of the polymer showing two repeat units.

(2)

(d) A reaction scheme involving 2-methylpropene is shown.



(i) For Reaction **1**, give the name or formula of a suitable reagent, stating the conditions for the reaction.

(2)

Reagent

.....

Conditions

.....

(ii) For Reaction **2**, give the name or formula of a suitable reagent, stating the type of reaction taking place.

(2)

Reagent

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Type of reaction

.....

(iii) For Reaction **3**, give the name or formula of a suitable reagent, writing an equation for the

reaction taking place.

(2)

Reagent

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Equation

(iv) For Reaction **4**, the reagent used is potassium hydroxide (KOH).

Give the conditions required for this reaction, stating the role of the hydroxide ions in this reaction.

(2)

Conditions

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Role of hydroxide ions

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(e) Many cyclists carry a small cylinder of carbon dioxide to inflate their inner tube if it is punctured. The carbon dioxide is stored under pressure.



(Source: © Douglas Sacha/Getty Images)

A gas cylinder contains 16.0 g of carbon dioxide (CO_2).
The cylinder has a volume of 20 cm^3 .

Calculate the pressure in the cylinder at 25 °C. Include units in your answer.
Assume that all the CO_2 in the cylinder is a gas.

[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1}]

(5)

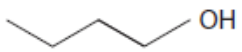
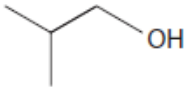
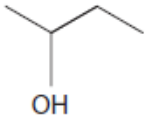
(Total for question = 20 marks)

Q5.

Biobutanol is a possible alternative to bioethanol as an additive to petrol.

(a) (i) Complete the table for the four isomers of C_4H_9OH which are alcohols.

(3)

Skeletal formula	Name	Classification	Boiling temperature / °C
	butan-1-ol	primary	117
			108
			99
	2-methylpropan-2-ol		82

(ii) Explain the difference in boiling temperature between butan-1-ol and 2-methylpropan-2-ol.

(2)

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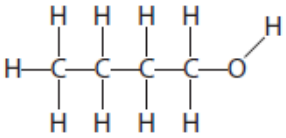
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(iii) The displayed formula of butan-1-ol is shown.

Complete the diagram to show the strongest intermolecular force between **two** molecules of butan-1-ol. Include the intermolecular bond angle.

(2)



(b) (i) Complete the equation for the combustion of butan-1-ol.

State symbols are not required.

(1)



(ii) Calculate a value for the enthalpy change of combustion of butan-1-ol using the equation in (b)(i) and the mean bond enthalpies in the table.

(3)

Bond	C—C	C—O	C=O	C—H	O—H	O=O
Mean bond enthalpy / kJ mol^{-1}	347	358	805	413	464	498

(iii) A data book value of the molar enthalpy change of combustion of butan-1-ol is −2670 kJ mol^{-1}

Give **two** reasons for the difference between this value and the value calculated in (b)(ii).

(2)

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(c) Biobutanol has some advantages over bioethanol.

(i) The combustion of bioethanol releases 23 MJ dm^{-3} compared to petrol which releases 32 MJ dm^{-3}.

Calculate the energy released in MJ dm^{-3} for the combustion of biobutanol.

Biofuel	Formula	$\Delta_c H$ / kJ mol^{-1}	Density / g cm^{-3}
biobutanol	C_4H_9OH	−2670	0.810

(2)

(ii) Biobutanol can be mixed with petrol in any proportion whereas bioethanol cannot.

Petrol is a mixture of liquid alkanes.

Explain why petrol is more miscible with biobutanol than with bioethanol.

(2)

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(Total for question = 17 marks)

Q6.

(a) The concentration of atmospheric carbon dioxide is at its highest level for 800 000 years.

Carbon Capture and Utilisation (CCU) uses waste carbon dioxide from industrial processes to make green fuels,
methanol, plastics or pharmaceuticals. One method uses the reaction between carbon dioxide and hydrogen to make methanol.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \qquad \Delta_r H = -49.5\,kJ\,mol^{-1}$$

The conditions for this industrial reaction are a pressure of 50 atm, a temperature of 250 °C and a copper catalyst.

(i) Explain why high pressure is used.

(2)

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(ii) Discuss the factors leading to a choice of 250 °C in this process.

(3)

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(iii) Give a reason why using a catalyst to increase the rate makes the process more sustainable.

(1)

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(b) Methanol can be oxidised to produce methanoic acid.

(i) State the reagents and reaction conditions for this oxidation in the laboratory.

(2)

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(ii) Complete the equation to show the products of this oxidation.

State symbols are not required.

(1)

$CH_3OH + \ldots\ldots [O] \rightarrow$

(iii) Give a chemical test, and its positive result, that could be used to confirm the functional group in methanoic acid.

(2)

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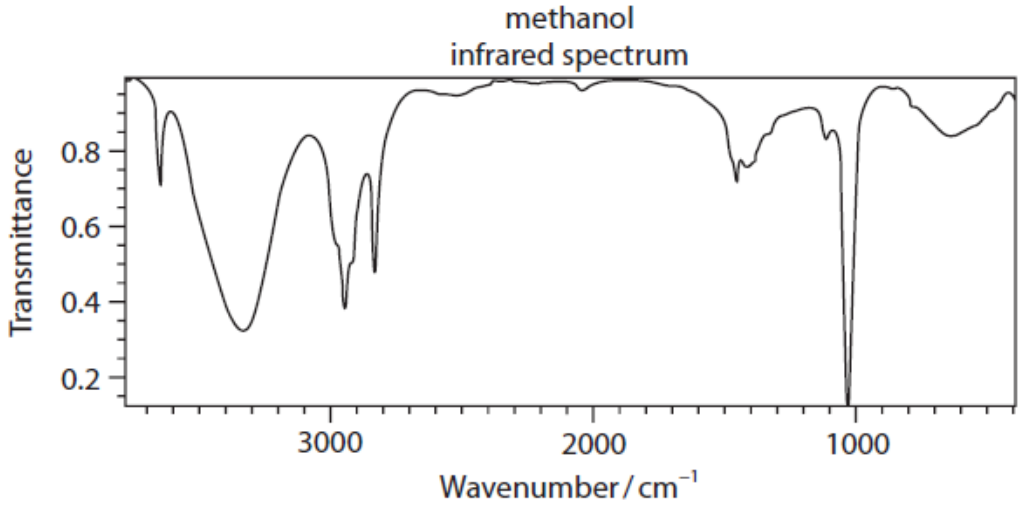
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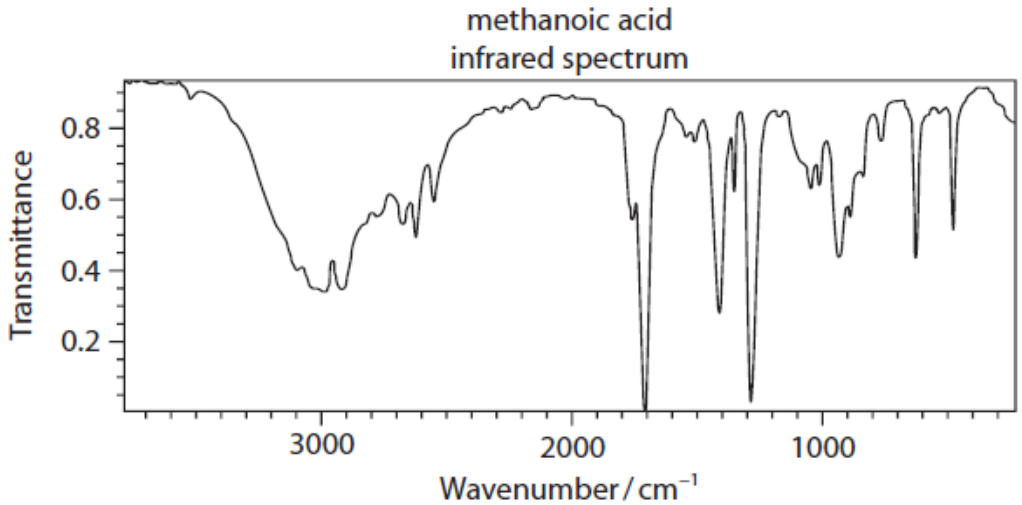
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(iv) The infrared spectra of methanol and methanoic acid are shown.

Explain how these could be used to show that **all** the methanol has been converted to methanoic acid,
quoting relevant bonds and wavenumbers.
Use your Data Booklet.

(3)





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(c) (i) Methanol produced from petrol by CCU may be mixed with petrol derived from fossil fuels.

A concentration of 5% by mass of methanol is used.

Explain how the use of this fuel would affect the increase in global temperatures.

(2)

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(ii) Calculate the mass of carbon dioxide released when 1 mol of octane (C_8H_{18}) is burned completely.

(1)

(iii) A motorist who uses 1200 kg of fuel each year in a car changes to a fuel with 5% of the mass of petrol replaced by methanol produced by CCU.

Calculate the annual reduction, in kg, of carbon dioxide released by the car.

[Assume petrol has the same molecular formula as octane and the added methanol does not contribute any additional carbon dioxide when burned.]

(2)

(Total for question = 19 marks)

Q7.

Iodine can be extracted from seaweed. The seaweed is heated strongly to burn off the organic matter. The resultant ash is boiled in water to dissolve the iodide ions, and the mixture is filtered.

(a) Acidified hydrogen peroxide (H_2O_2) is added to the filtrate.

A redox reaction takes place with iodine and water as the only products.

(i) Write half-equations for the oxidation and reduction reactions that take place.

State symbols are not required.

(2)

(ii) Use your answers to (a)(i) to write the overall equation for this redox reaction.

State symbols are not required.

(1)

(b) The iodine is separated from the aqueous solution using solvent extraction.

The aqueous solution is mixed with cyclohexane in a separating funnel, forming two layers.

The mixture is then shaken gently and left until the layers separate.

Most of the iodine dissolves in the cyclohexane layer.

(i) State the colour of each layer **after** separation.

(2)

Aqueous layer
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Cyclohexane layer
.....

(ii) Explain why iodine is very soluble in cyclohexane but only slightly soluble in water.

(2)

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(c) The cyclohexane layer is then removed from the separating funnel and dried.

Identify, by name or formula, a suitable drying agent.

(1)

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(Total for question = 8 marks)

Q8.

A chloroalkane is heated with dilute aqueous sodium hydroxide and the pure organic product is obtained.

When the organic product is warmed with acidified potassium dichromate(VI) solution, there is no change in colour.

The chloroalkane could be

(1)

☒ **A** 1-chlorobutane

☒ **B** 2-chloro-2-methylpropane

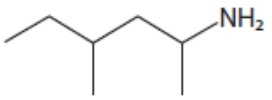
☒ **C** 1-chloro-2-methylpropane

☒ **D** 2-chlorobutane

(Total for question = 1 mark)

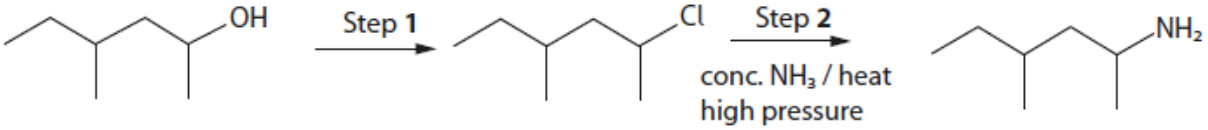
Q9.

The compound DMAA was originally synthesised as a decongestant.



DMAA

A suggested synthetic route for DMAA is shown.



compound **A**

(a) (i) Give the systematic name of compound **A**.

(1)

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(ii) Identify, by name or formula, a suitable reagent for Step **1**.

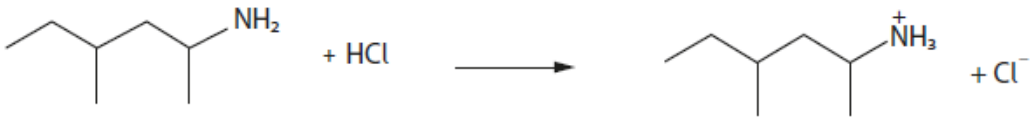
(1)

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(iii) Give the mechanism for the reaction in Step **2**.
Include curly arrows, and any relevant dipoles and lone pairs.

(4)

(b) DMAA is only slightly soluble in water but dissolves readily in hydrochloric acid to form an aqueous solution.



DMAA

(i) Explain the type of bonding that occurs between the nitrogen atom and the hydrogen ion, when the positive ion forms.

(3)

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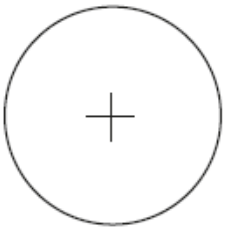
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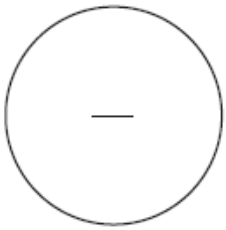
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(ii) Complete the diagrams to show how the ions formed in the reaction between DMAA and hydrochloric acid interact with water molecules.

(3)





(Total for question = 12 marks)

Q10.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Some alcohols react with concentrated phosphoric(V) acid, H_3PO_4, to form alkenes.

(a) What type of reaction occurs?

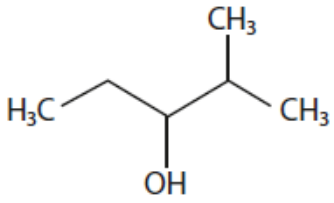
☐ **A** addition

☐ **B** elimination

☐ **C** hydrolysis

☐ **D** substitution

(b) The structure of 2-methylpentan-3-ol is shown.



This alcohol reacts with concentrated phosphoric(V) acid.

How many different alkenes can form?

☐ **A** one

☐ **B** two

☐ **C** three

☐ **D** four

(Total for question = 2 marks)

Q11.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which reagent would convert an alcohol into an alkene?

☒ **A** acidified potassium dichromate(VI)

☒ **B** anhydrous calcium sulfate

☒ **C** concentrated phosphoric acid

☒ **D** ethanolic potassium hydroxide

(Total for question = 1 mark)

Q12.

Ethanol can be made in industry by the reaction of ethene with steam, using a phosphoric(V) acid catalyst.

$$CH_2{=}CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g) \quad \Delta_rH = -45 \text{ kJ mol}^{-1}$$

The reaction is carried out at 300°C and 60 atm. An initial yield of 5 % is achieved when the ethene and steam first pass through the reactor.

*(a) Explain the chemical reasons for the conditions used and why such a low initial yield is acceptable in the industrial process.

(6)

(b) The product of the reaction is a mixture of ethanol and water.

Explain why ethanol and water mix together fully.

You may find it helpful to draw a diagram.

(3)

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(c) Ethanol can be oxidised using a solution of acidified potassium dichromate(VI), $K_2Cr_2O_7(aq)$.

Ethanoic acid and another organic compound, **Y**, are both possible products.

(i) Draw the structure of **Y**.

(1)

(ii) State the conditions needed to maximise the yield of each product.

(2)

Conditions for maximum yield of **Y**

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Conditions for maximum yield of ethanoic acid

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(Total for question = 12 marks)

Q13.

This question is about ethanol and bioethanol.

The main fuel used as a petrol substitute is bioethanol. Bioethanol is ethanol that has been produced by fermentation. The starting material is usually some form of plant material rich in starch, such as wheat, maize or potatoes. Enzymes in yeast convert this material to simple carbohydrates such as glucose ($C_6H_{12}O_6$) and then to ethanol and carbon dioxide.

$$C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2$$

The mixture is left for several days until fermentation is complete.
The percentage of ethanol is never greater than 15 % because higher concentrations of ethanol kill the yeast.

A common blend of fuel is 95 % petrol and 5 % bioethanol. The engine does not need to be modified for this mixture.

(a) Give **one** advantage and **one** disadvantage of using bioethanol in petrol.

(2)

Advantage

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Disadvantage

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(b) Suggest why this fermentation must be carried out in the absence of air.

(1)

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(c) Suggest how the ethanol can be obtained, after filtering the fermentation mixture.

(1)

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(d) Ethanol is hygroscopic, which means it readily absorbs water from the air.

(i) Give a possible reason why ethanol is able to absorb water.

(1)

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(ii) Suggest a problem arising from the hygroscopic nature of ethanol when using this fuel in a motor vehicle.

(1)

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(e) Ethanol can also be produced by the hydration of ethene.

$$CH_2 = CH_2(g) + H_2O(g) \leftrightarrow CH_3CH_2OH(g) \qquad \Delta H = -45 \text{ kJ mol}^{-1}$$

*(i) Typical conditions are 300 °C and 60 atm with a catalyst of phosphoric acid.

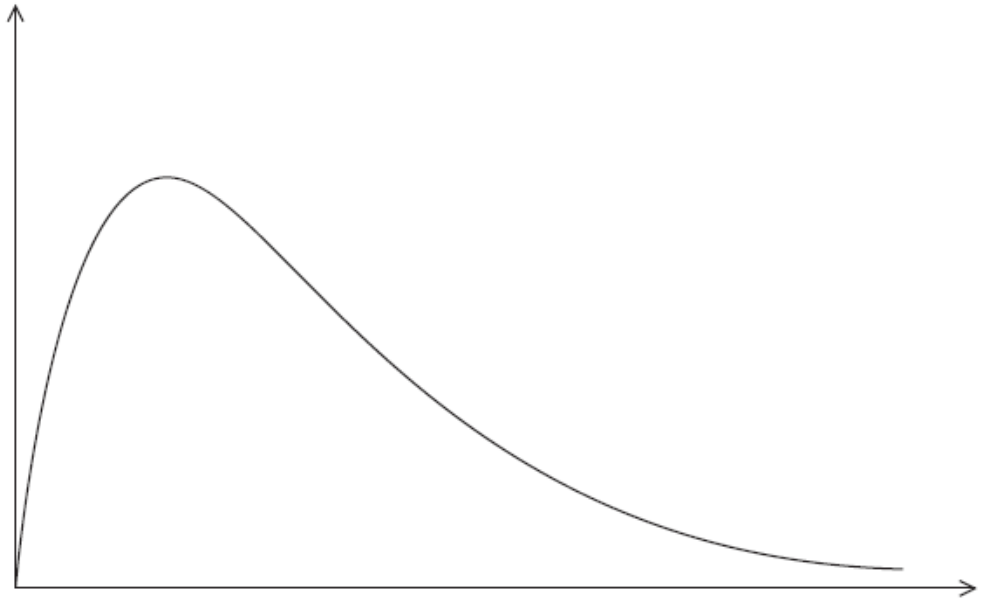
Explain why these conditions are used, by describing the effect of changing the temperature and pressure on rate of reaction, equilibrium yield and cost.

(6)

(ii) The rate of this reaction is increased by using a catalyst of phosphoric acid.

Label the axes on the Maxwell–Boltzmann distribution curve and use it to explain how a catalyst increases the rate of reaction.

(4)



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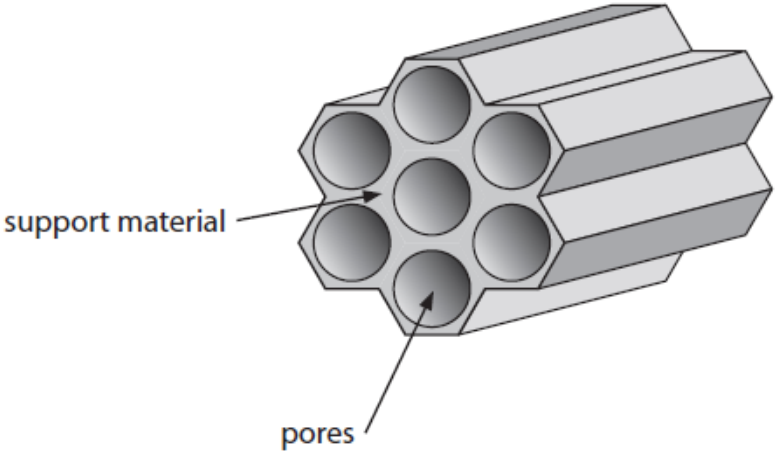
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(f) Catalysts such as phosphoric acid are bonded to a support material that contains lots of pores.



(i) Suggest the advantage of using support materials containing lots of pores.

(1)

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(ii) Under these conditions, only about 5 % of the ethene is converted into ethanol as it passes over the catalyst.

Suggest how the overall yield of this process can be improved to make it economically viable.

(2)

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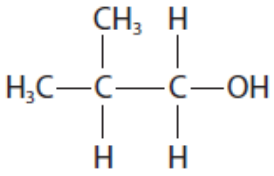
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(Total for question = 19 marks)

Q14.

This question is about the four structural isomers with the formula $C_4H_{10}O$ which are alcohols.

One of the isomers, 2-methylpropan-1-ol, is shown.



(a) 2-methylpropan-1-ol is a primary alcohol.

Explain what is meant by the terms *alcohol* and *primary*.

(2)

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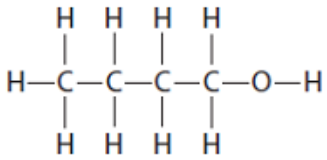
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(b) Complete the table for the other three structural isomers of $C_4H_{10}O$ which are alcohols.

(5)

Name		butan-2-ol	
Displayed formula			
Classification of alcohol			tertiary

(c) 2-methylpropan-1-ol can be oxidised to 2-methylpropanoic acid, in a two-step process.

$$(CH_3)_2CHCH_2OH \xrightarrow{\text{Step 1}} (CH_3)_2CHCHO \xrightarrow{\text{Step 2}} (CH_3)_2CHCOOH$$

(i) Identify by name or formula the reagents needed to prepare the oxidising mixture.

(2)

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(ii) Write the equation for Step **1** using [O] to represent the oxygen from the oxidising agent.

(1)

(iii) Infrared spectroscopy provides information on functional groups.

In an experiment, a sample of 2-methylpropan-1-ol was treated with an oxidising agent.

Show that infrared spectroscopy can be used to show that both the alcohol and the aldehyde are present in the resulting mixture.
In your answer refer to any relevant wavenumber ranges and bonds responsible for the infrared spectrum.
Refer to page 7 of the Data Booklet.

(2)

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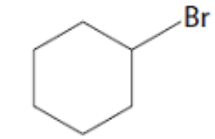
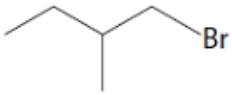
(Total for question = 12 marks)

Q15.

This question is about some halogenoalkanes.

(a) Give the classification of each halogenoalkane shown in the table as primary, secondary or tertiary.

(1)

Halogenoalkane	Classification
	
	

(b) Samples of 1-iodobutane and 2-chloro-2-methylpropane were hydrolysed using aqueous silver nitrate in ethanol.

Explain whether or not it is possible to predict the relative rate of hydrolysis of these two compounds.

(3)

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(c) Butylamine is formed when 1-bromobutane reacts with excess concentrated alcoholic ammonia.

$$CH_3CH_2CH_2CH_2Br + 2NH_3 \rightarrow CH_3CH_2CH_2CH_2NH_2 + NH_4Br$$

(i) Give a reason why this reaction should be carried out by heating the reactants in a sealed tube rather than heating under reflux.

(1)

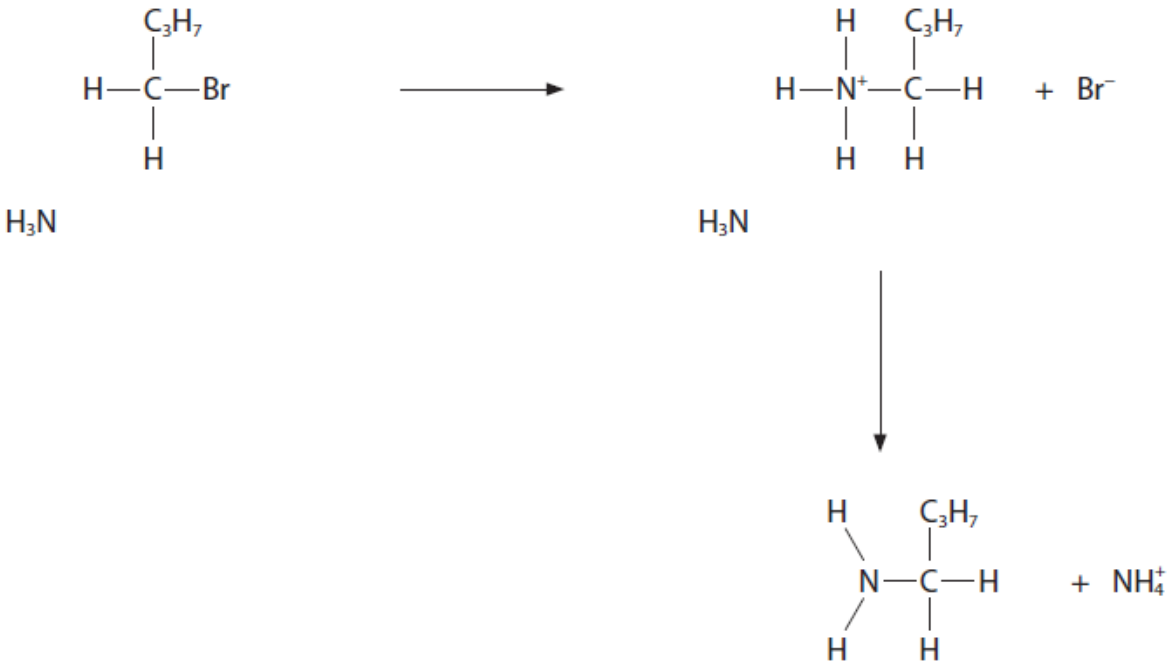
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(ii) Complete the mechanism for this reaction by adding curly arrows, and any relevant lone pairs and dipoles.

(4)



(d) Bromoethane is prepared by reacting ethanol with potassium bromide and concentrated sulfuric acid.

$$C_2H_5OH + KBr + H_2SO_4 \rightarrow C_2H_5Br + KHSO_4 + H_2O$$

Calculate the maximum mass of bromoethane that could be prepared from 4.65 g of ethanol, 14.90 g of potassium bromide and a solution containing 16.35 g of H_2SO_4.

[Ar values: H = 1.0 C = 12.0 O = 16.0 S = 32.1 K = 39.1 Br = 79.9]

(3)

*(e) The reaction between 2-bromopropane and potassium hydroxide takes place under two different conditions:

- in aqueous solution
- in ethanolic solution.

Compare and contrast these two reactions.

Include equations for the reactions.
Detailed mechanisms of these reactions are **not** required.

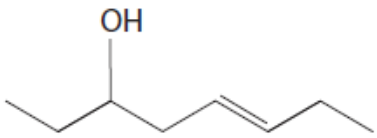
(6)

(Total for question = 18 marks)

Q16.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

(a) What is the name of compound L?



L

(1)

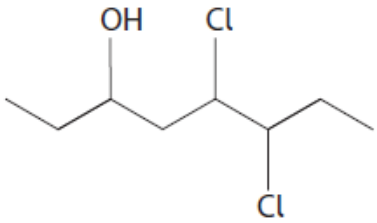
☒ **A** *Z*-oct-3-en-3-ol

☒ **B** *E*-oct-3-en-3-ol

☒ **C** *Z*-oct-5-en-3-ol

☒ **D** *E*-oct-5-en-3-ol

(b) Compound L can be converted into compound M.



M

Which reagent should be used?

(1)

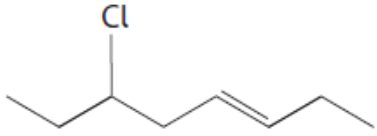
☒ **A** $Cl_2(g)$

☒ **B** HCl(g)

☒ **C** $PCl_5(s)$

☒ **D** KCl(aq)

(c) Compound L can also be converted into compound N.



N

Which reagent should be used?

☒ **A** $Cl_2(g)$

☒ **B** HCl(g)

☒ **C** $PCl_5(s)$

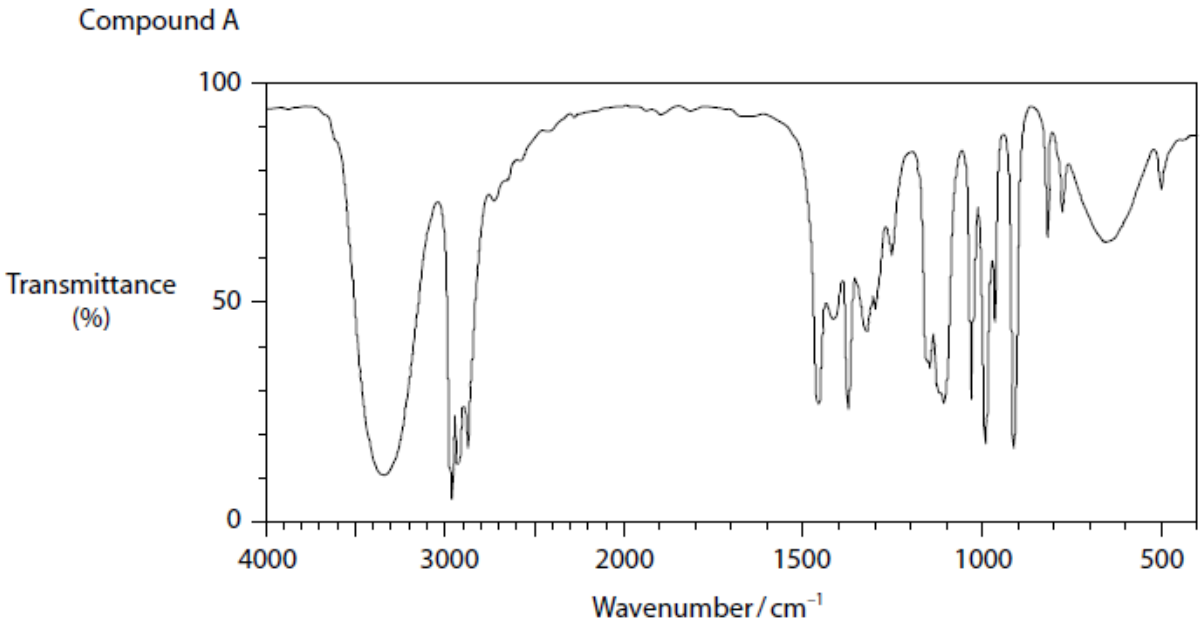
☒ **D** KCl(aq)

(Total for question = 3 marks)

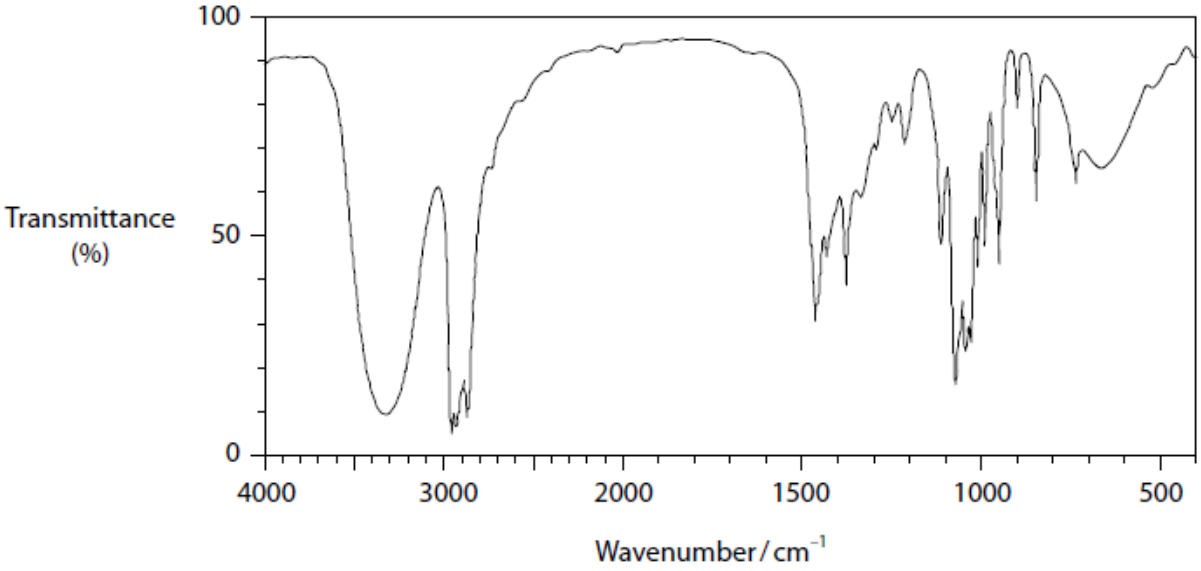
Q17.

Three compounds, A, B and C, each have the same molecular formula $C_4H_{10}O$ and are known to be alcohols.

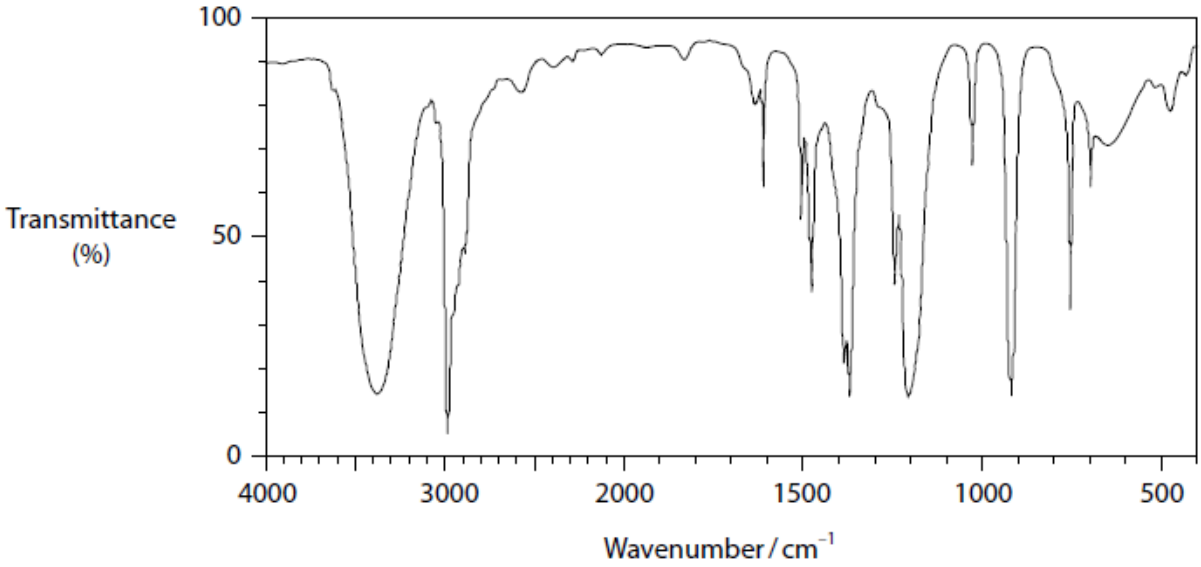
(a) The infrared spectra of compounds A, B and C are shown.



Compound B



Compound C



(i) Identify one feature, common to all three infrared spectra, which shows that A, B and C are all alcohols.

(1)

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(ii) State, giving a reason for your answer, if it is possible to identify each of these three alcohols on the basis of the infrared spectra alone.

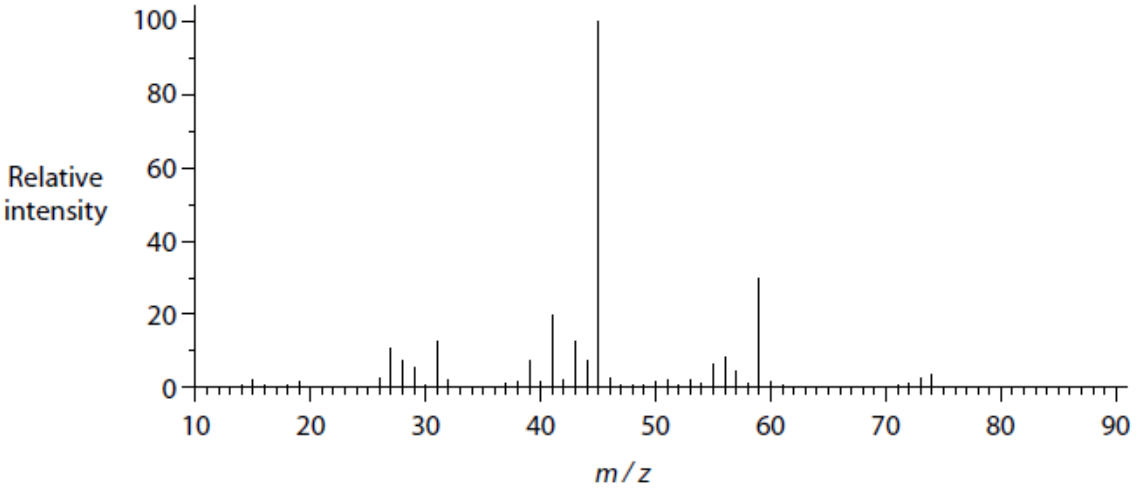
(1)

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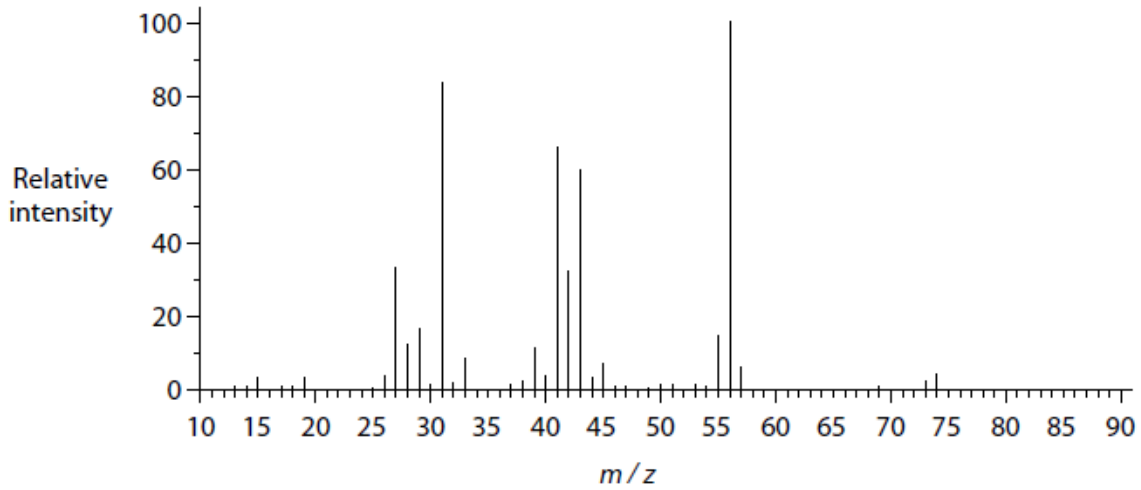
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(b) The mass spectra of the compounds A, B and C are shown.

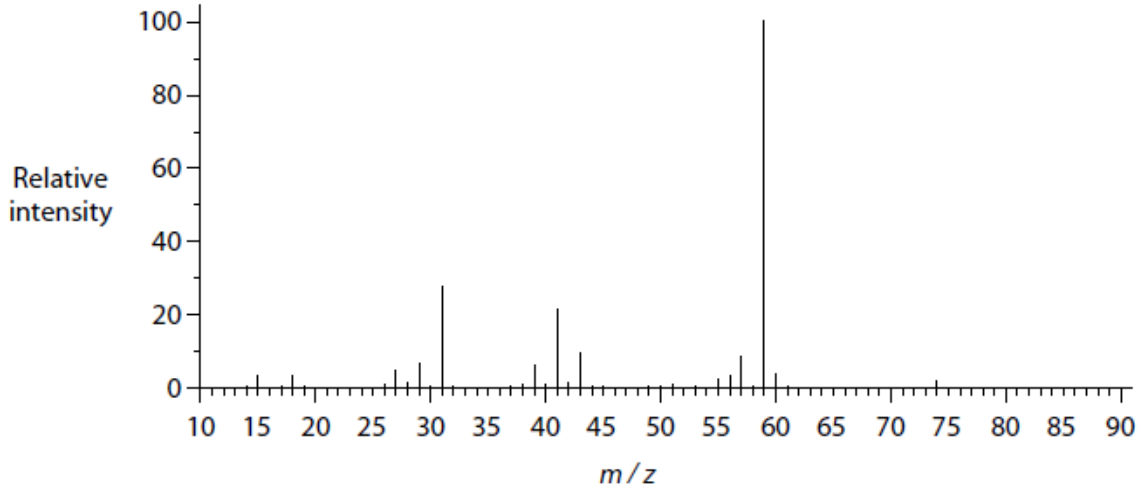
Compound A



Compound B



Compound C



(i) Identify one feature common to the mass spectra of compounds A, B and C which shows that the molecular formula is $C_4H_{10}O$.

(1)

.....

.....

(ii) Using the fragmentation patterns, a student proposed that:

compound A is butan-2-ol
compound B is butan-1-ol
compound C is 2-methylpropan-2-ol

State how the appearance in the spectra of the following peaks supports the student's conclusion.

(3)

the fragment causing the peak at m/z = 45 for compound A

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the fragment causing the peak at m/z = 31 for compound B

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.....

the fragment causing the peak at m/z = 59 for compound C

.....

.....

(c) To help with the identification of compounds A and B, the student decided to mix each of them with potassium dichromate(VI) and dilute sulfuric acid solutions, and then distil the mixture immediately.

(i) Identify, by name and structural formula, the organic compound present at the conclusion of each of these two oxidation reactions.

(3)

Organic compound used	Name of oxidation product	Structural formula of oxidation product
A, butan-2-ol		
B, butan-1-ol		

(ii) To identify A and B, the student decided that one further chemical test should be used on their oxidation products.

Give a suitable reagent and expected observations that could be used to distinguish between the oxidation products of A and B.

(3)

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(Total for question = 12 marks)

Q18.

This question is about two isomeric alcohols and two isomeric carbonyl compounds.

propan-1-ol, $CH_3CH_2CH_2OH$ and propan-2-ol, $CH_3CH(OH)CH_3$

propanal, CH_3CH_2CHO and propanone, CH_3COCH_3

(a) Which reaction is possible?

(1)

☒ **A** reducing propan-1-ol to propanal

☒ **B** oxidising propan-1-ol to propanal

☒ **C** reducing propanal to propanone

☒ **D** oxidising propan-1-ol to propanone

(b) Which compound would be expected to give a significant peak at $m / z = 31$ in its mass spectrum?

(1)

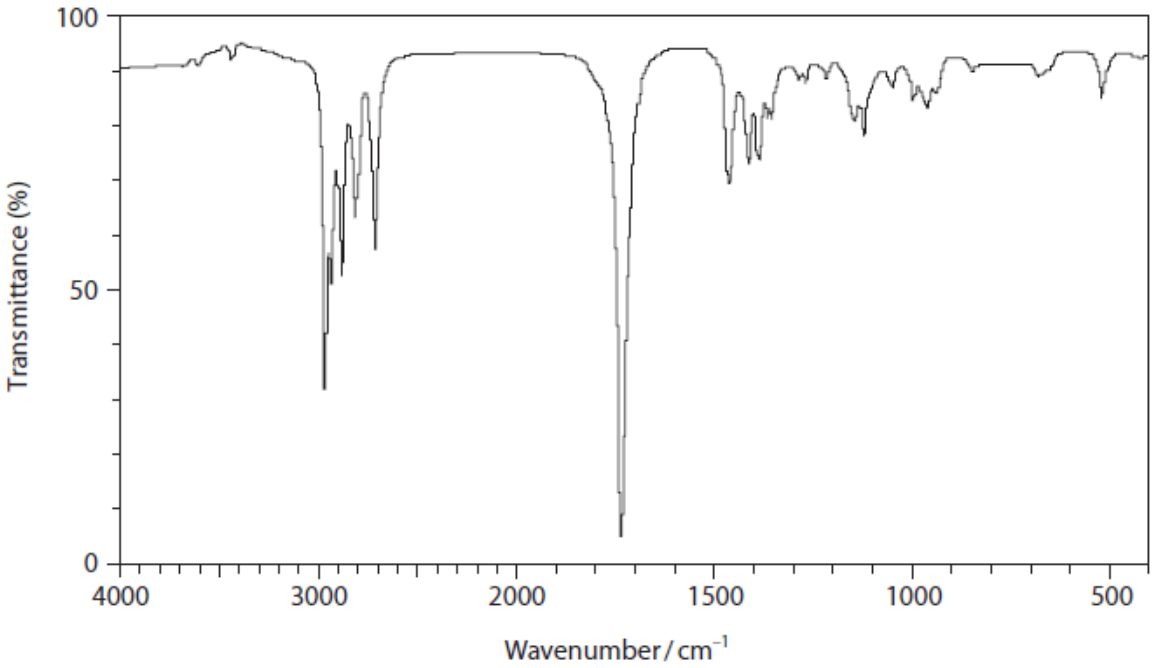
☒ **A** propan-1-ol

☒ **B** propan-2-ol

☒ **C** propanal

☒ **D** propanone

(c) The infrared spectrum of one of the four compounds is shown.



Identify the compound, using the infrared absorptions from the Data Booklet.

(1)

☒ **A** propan-1-ol

☒ **B** propan-2-ol

☒ **C** propanal

☒ **D** propanone

(Total for question = 3 marks)

Q19.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

How many moles are there in 15.1 cm^3 of liquid propan-1-ol?

[Density of propan-1-ol = 0.80 g cm^{-3} M_r of propan-1-ol = 60]

☒ **A** (0.80 × 15.1) ÷ 60

☒ **B** 0.80 ÷ (60 × 15.1)

☒ **C** 60 ÷ (0.80 × 15.1)

☒ **D** (60 × 15.1) ÷ 0.80

(Total for question = 1 mark)

Q20.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

The oxidation of propan-1-ol by acidified potassium dichromate(VI) forms propanoic acid with a yield of 36 % by mass.

What mass of propan-1-ol is needed to form 37.0 g of propanoic acid in this reaction?

[M_r of propanoic acid = 74 M_r of propan-1-ol = 60]

☒ **A** 10.8 g

☒ **B** 36.0 g

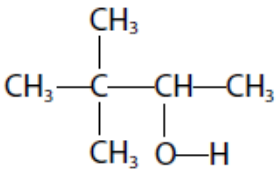
☒ **C** 40.8 g

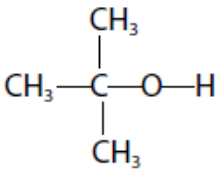
☒ **D** 83.3 g

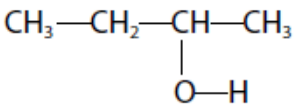
(Total for question = 1 mark)

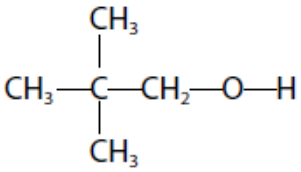
Q21.

Which of the following compounds could be oxidised to a carboxylic acid by refluxing with potassium dichromate(VI) and dilute sulfuric acid?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for question = 1 mark)

Q22.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of these compounds does **not** react with acidified potassium dichromate(VI)?

☒ **A** CH_3CH_2OH

☒ **B** $CH_3CHOHCH_3$

☒ **C** CH_3CH_2CHO

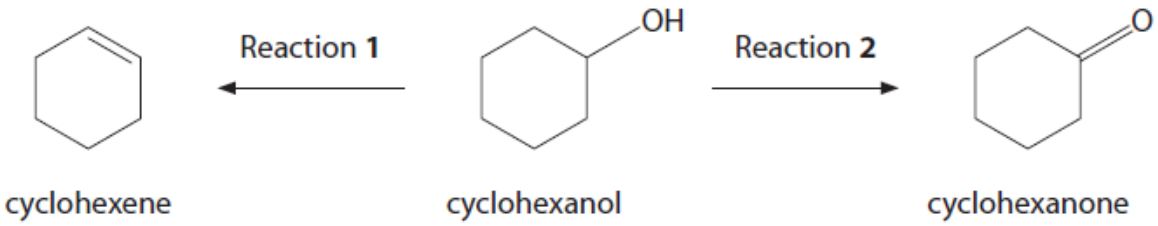
☒ **D** CH_3COCH_3

(Total for question = 1 mark)

Q23.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Two reactions of cyclohexanol are shown.



(a) What is the reagent for Reaction 1?

(1)

☒ **A** acidified potassium manganate(VII)

☒ **B** aqueous bromine

☒ **C** concentrated phosphoric(V) acid

☒ **D** phosphorus(V) chloride

(b) The reagent for Reaction 2 is acidified potassium dichromate(VI).

Which equation best represents this reaction?

(1)

☒ **A** $C_6H_{11}OH \rightarrow C_6H_{10}O + H_2$

☒ **B** $C_6H_{11}OH \rightarrow C_6H_{10}O + 2[H]$

☒ **C** $C_6H_{11}OH + [O] \rightarrow C_6H_{10}O + H_2O$

☒ **D** $C_6H_{11}OH + \frac{1}{2}O_2 \rightarrow C_6H_{10}O + H_2O$

(c) Cyclohexanol and cyclohexene each has a peak in their infrared spectrum which is **not** present for the other compound.

Which are these peaks?

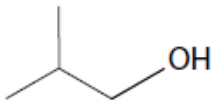
(1)

	Peak only in cyclohexanol / cm^{-1}	Peak only in cyclohexene / cm^{-1}
☒ **A**	2962-2853	1669-1645
☒ **B**	2962-2953	1720-1700
☒ **C**	3750-3200	1669-1645
☒ **D**	3750-3200	1720-1700

(Total for question = 3 marks)

Q24.

2-methylpropan-1-ol has the skeletal formula:



(a) 2-methylpropan-1-ol can be converted to 1-bromo-2-methylpropane.

Give the reagents and conditions used for this reaction.

(2)

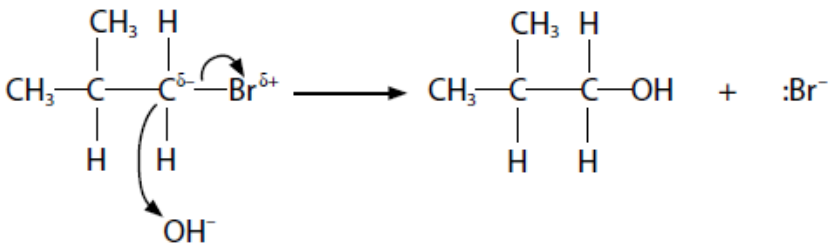
Reagents

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Conditions

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(b) 1-bromo-2-methylpropane can be converted back to 2-methylpropan-1-ol by heating with aqueous alkali. A student suggested the following mechanism for the reaction.



Identify and correct the three mistakes in the mechanism shown.

(3)

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(c) 1-bromo-2-methylpropane can be converted to 2-methylpropene.

Give the reagents and conditions used for this reaction.

(2)

Reagents

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Conditions

.....

(Total for question = 7 marks)

Q25.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of these compounds is a tertiary alcohol?

☒ **A** 2-methylpropan-2-ol

☒ **B** 3-methylbutan-2-ol

☒ **C** 2,2-dimethylpropan-1-ol

☒ **D** 3,3-dimethylbutan-2-ol

(Total for question = 1 mark)

Q26.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

How many structural isomers with the molecular formula $C_5H_{10}O$ react with Benedict's or Fehling's solutions?

☐ **A** 2

☐ **B** 3

☐ **C** 4

☐ **D** 5

(Total for question = 1 mark)

Q27.

Propanoic acid, CH_3CH_2COOH, is a colourless liquid used as a preservative in animal feed. Propanoic acid can be formed by oxidising the alcohol propan-1-ol.

(a) Write the balanced equation for the oxidation of propan-1-ol to form propanoic acid.

Use [O] to represent the oxygen from the oxidising agent.
State symbols are not required.

(1)

*(b) Propan-1-ol is heated with a concentrated solution of acidified potassium dichromate(VI).

Explain how the conditions used affect the rate of the reaction **and** ensure that propanoic acid is the only organic product.

(6)

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(c) A student suggested using universal indicator to check for the presence of

propanoic acid formed in the reaction mixture.

Give a reason why the result of this test is **not** likely to be conclusive.

(1)

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(d) The permitted mass of propanoic acid used in animal feed is in the range

1000–3000 mg kg^{-1}. A titration method may be used to check the concentration of propanoic acid in animal feed.

A 50.0 cm^3 sample of propanoic acid solution was extracted from 50 g of an animal feed.
The sample was added to a volumetric flask and the volume made up to 250.0 cm^3 and mixed thoroughly. A pipette was used to transfer 25.0 cm^3 of the diluted acid into a conical flask containing an indicator.

The contents of the conical flask were titrated with a solution of sodium hydroxide, NaOH(aq), with concentration 0.00668 mol dm^{-3}.

The procedure was repeated twice and the results obtained are shown.

	Run 1	Run 2	Run 3
Titre / cm^3	23.20	22.10	22.20

(i) Phenolphthalein is a suitable indicator for this titration.

State the colour **change** at the end-point.

(2)

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(ii) Suggest **two** possible reasons why the titre for Run 1 is greater than the other two titres.

(2)

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(iii) The equation for the reaction of propanoic acid with sodium hydroxide is

$$CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$$

Calculate the mass in grams of propanoic acid extracted from the animal feed.

Give your answer to an appropriate number of significant figures.

(5)

(iv) Use your answer to (d)(iii) to determine whether the acid in this sample lies within the permitted range for use in animal feed.

(2)

(v) Suggest how the animal feed would be affected if the amount of propanoic acid was outside the permitted range.

(1)

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(Total for question = 20 marks)

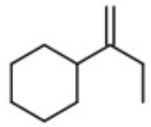
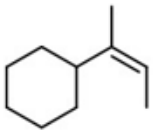
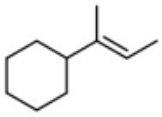
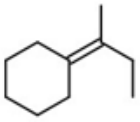
Mark Scheme

Q1.

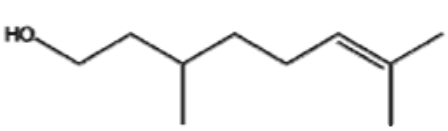
Question number	Answer	Mark
	The only correct answer is B (P and Q only) ***A*** *is incorrect because* ***Q*** *is also primary alcohol and will be oxidised to a carboxylic acid* ***C*** *is incorrect because* ***R*** *is a secondary alcohol and will be oxidised to a ketone* ***D*** *is incorrect because* ***R*** *is a secondary alcohol and will be oxidised to a ketone and* ***S*** *is a tertiary alcohol so is not easily oxidised*	**(1)**

Q2.

Question Number	Answer	Additional guidance	Mark
(a)	ıswer that makes reference to the following points: • add PCl_5 / phosphorus(V) chloride /phosphorus pentachloride **(1)** • misty fumes evolved (that turn damp blue litmus red / form white smoke with ammonia) **(1)** OR • Add sodium / Na **(1)** • Effervescence / bubbles seen / fizzing **(1)** OR • Add Lucas' Reagent **(1)** • Solution turns cloudy immediately / quickly **(1)**	M2 dependent on correct reagent seen in M1. Allow PCl_3 Allow steamy fumes / white fumes Do not award white smoke **unless** in conjunction with exposure of fumes to ammonia Ignore gas given off / hydrogen given off Do not award heat with acidified dichromate(VI) ions	**(2)**

Question Number	Answer	Additional guidance	Mark
(b)(i)	 **(1)**  **(1)**  **(1)**  **(1)**	Allow any unambiguous type of structure	**(4)**

Question Number	Answer	Additional guidance	Mark
(b)(ii)	A description that makes reference to any two from the four following points: • Peak at 3750 – 3200 (cm^{-1}) due to O-H bond present in reactant / absent in product **(1)** • Peak at 1000-1300 (cm^{-1}) due to C-O bond present in reactant / absent in product **(1)** • Peak at 1669 – 1645 (cm^{-1}) due to C=C bond present in product / absent in reactant **(1)** • Peak at 3095 – 3010 (cm^{-1}) due to **C-H bond** present in **alkene** in product / absent in reactant **(1)**	Allow two peaks quoted or two bonds for one mark Allow any wavenumber or range of wavenumbers within the allowable range.	**(2)**

Question Number	Answer	Additional guidance	Mark
(c)	• Longest chain has eight carbon atoms, with terminal OH group **(1)** • rest of structure correct **(1)**	 Accept structural , skeletal or displayed formulae Ignore connectivity except O-H-C Allow 1 mark for correct displayed formulae with missing hydrocarbon hydrogens Allow 1 mark for correct structure of 2,6dimethylhept-5-en-1-ol	**(2)**

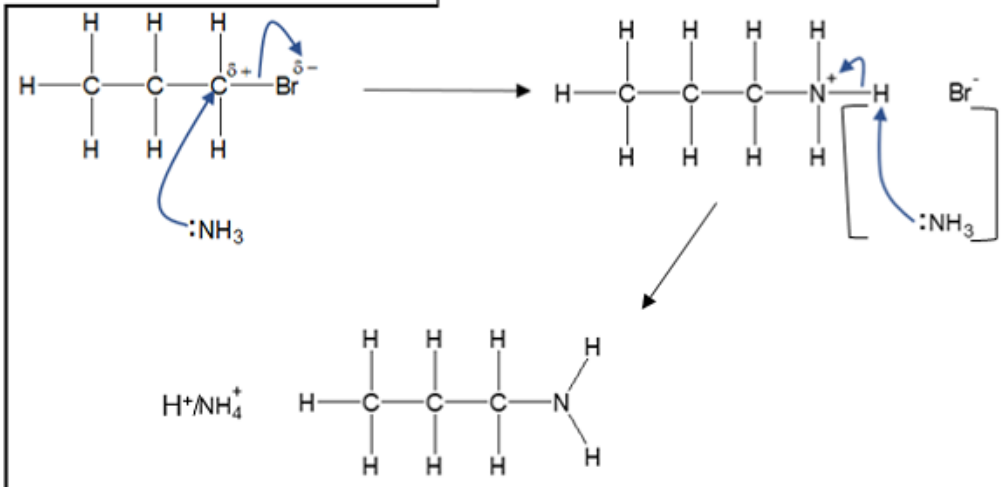
Q3.

Q	Answer	Additional Guidance	Mark
(a)	• identification of suitable reagent(s)	50% / concentrated **and** sulfuric acid / H_2SO_4 **and** potassium bromide / KBr Allow Other named bromides Phosphorus **and** bromine Phosphorus(V) bromide / PBr_5 Phosphorus(III) bromide / PBr_3 Thionyl bromide / $SOBr_2$ If the name and the formula are given, then both must be correct Do not award dilute sulfuric acid	**1**

Q	Answer	Additional Guidance	Mark
(b)(i)	• conditions	Ethanolic / alcoholic (solution) Allow ethanol / alcohol Ignore heat / solid / reflux Do not award aqueous solution	**1**

Q	Answer	Additional Guidance	Mark
(b)(ii)	• C_4H_7N	Allow elements in any order Ignore C_3H_7CN	**1**

Q	Answer	Additional Guidance	Mark
(b)(iii)	• nucleophilic **(1)** • substitution **(1)**	Allow nucleophile for nucleophilic Mark independently List principle applies (further incorrect answers will each lose a mark) Allow phonetic spelling	**2**

Q	Answer	Additional Guidance	Mark
(b)(iv)	• dipole and arrow from C–Br bond to $Br^{\delta-}$ or just beyond **(1)** • arrow from ammonia to $C^{\delta+}$ **and** 1 or 2 correct curly arrows on intermediate (each from bond or lone pair to atom) **(1)** **(1)**  • intermediate with charge **(1)** • ammonium / H^+ **and** bromide ion **OR** HBr **OR** NH_4Br	Accept bromide and H^+/ammonium ions shown anywhere on answer (i.e. they don't have to be with intermediate and final product respectively) Allow 3rd arrow for M2 to be from bromide lone pair to the hydrogen atom Negative charge on ammonia should be penalised once only Accept correct SN2 mechanism for 4 marks	4
		Total for Question = 9 marks)	

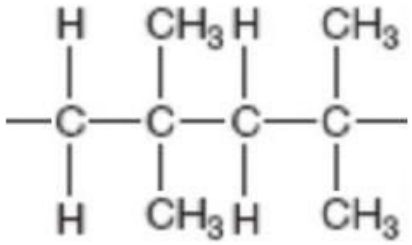
Q4.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	$TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2CO$	Ignore state symbols even if incorrect Allow multiples	1

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Question Number	Answer	Additional Guidance	Mark
(a)(ii)	• Ti is reduced **and** from +4 to 0 **(1)** • Mg is oxidised **and** from 0 to +2 **(1)**	Four correct oxidation numbers with no or incorrect mention of reduced or oxidised scores (1) Ti is reduced as it gains electrons and Mg is oxidised as it loses electrons with no or incorrect oxidation numbers scores (1)	**2**

Question Number	Answer	Additional Guidance	Mark
(b)	• hydrolysis **(1)** • titanium((IV)) oxide/TiO_2 **(1)**	Do not award hydration Ignore hydrogen chloride/HCl Allow titanium((IV))hydroxide/$Ti(OH)_4$	**2**

Question Number	Answer	Additional Guidance	Mark
(c)	 • correct repeating unit **(1)** • two repeating units and extension **(1)** Note M2 depends on M1 or near miss eg missing a H	Allow adjacent pairs of methyl groups Ignore square brackets and subscript n/2 Ignore connectivity of CH_3	**2**

Question Number	Answer	Additional Guidance	Mark
(d)(i)	An answer that makes reference to the following points: • reagent: potassium hydroxide / KOH (1) • conditions: aqueous/water (1) M2 dependent on M1or near miss e.g. OH^- will not score M1 but will allow access to M2.	Allow sodium hydroxide / NaOH Ignore any reference to concentration or heat Allow dilute	2

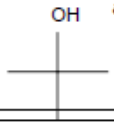
Question Number	Answer	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to the following points: • reagent: (concentrated) phosphoric((V)) acid / H_3PO_4 (1) • reaction type: elimination/dehydration (1) Independent marks	Allow (concentrated) sulfuric acid Ignore heat Do not award H_3PO_3 Allow passing vapour over porous pot / alumina or any surface catalyst **and** heat	2

Question Number	Answer	Additional Guidance	Mark
(d)(iii)	An answer that makes reference to the following points: • reagent: phosphorus(V) chloride/ phosphorus pentachloride/PCl_5 (1) • equation: $C_4H_9OH + PCl_5 \rightarrow C_4H_9Cl + HCl + POCl_3$ (1)	Allow thionyl chloride / $SOCl_2$ Allow phosphorus (III) chloride / phosphorus trichloride / PCl_3 Allow $C_4H_9OH + SOCl_2 \rightarrow C_4H_9Cl + HCl + SO_2$ $3C_4H_9OH + PCl_3 \rightarrow 3C_4H_9Cl + H_3PO_3$ Allow skeletal, structural, displayed or molecular formulae	2

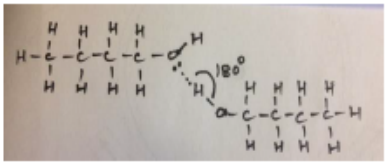
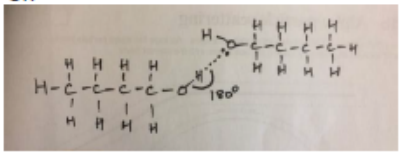
Question Number	Answer	Additional Guidance	Mark
(d)(iv)	An answer that makes reference to the following points: • conditions: alcoholic (1) • role of the hydroxide ions: base (1) Note answers may be given on either line	Allow ethanol/ethanolic Ignore heat and concentration Allow proton acceptor/reacts with H^+	2

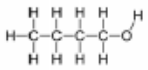
Question Number	Answer	Additional Guidance	Mark
(e)	An answer that makes reference to the following points: • moles of carbon dioxide (1) • conversion of cm^3 to m^3 (1) • conversion of °C to K (1) • rearrangement of the ideal gas equation (1) • calculation of pressure and correct units given (1)	Examples of calculation 16 ÷ 44 = 0.36364 (mol)/ 4÷11(mol) 20 ÷ 1000000 = 2×10^{-5} / 0.00002 (m^3) 273 + 25 = 298 (K) $p = \frac{nRT}{V}$ $\frac{0.3636 \times 8.31 \times 298}{2 \times 10^{-5}}$ = 45025000 Pa / 45025 kPa 4.5 x 10^7 Pa / 45MPa Ignore SF except 1 Allow TE for answers to M1, M2 and M3 But no TE on wrong rearrangement of gas equation Correct answer, including units with or without working scores (5)	5

Q5.

Question Number	Answer		Additional Guidance	Mark
(a)(i)	• (2)-methylpropan-1-ol and primary	(1)	All 6 correct scores 3 4 or 5 correct scores 2 2 or 3 correct scores 1	(3)
	• butan-2-ol and secondary	(1)		
	•  and tertiary	(1)	Ignore bond lengths and bond angles Do not award displayed formula	

Question Number	Answer		Additional Guidance	Mark
(a)(ii)	An explanation that makes reference to the following points:		Accept reverse argument (butan-1-ol has a higher boiling temperature than 2-methylpropan-2-ol because)	(2)
	• Identification of (at least) one of the intermolecular forces and a comparison of its strength in the two molecules	(1)	the instantaneous dipoles-induced dipoles / London forces / dispersion forces / van der Waals forces are stronger between straight chains Allow There are more London forces OR the hydrogen bonding is stronger between straight chain molecules	
	• an explanation for this difference	(1)	the straight chain molecule/ butan-1-ol has greater surface area / more points of contact OR as the -OH group is more exposed / less hindered (so less energy is needed to break the intermolecular forces) If the explanation is in terms of London forces, ignore 'hydrogen bonding is similar / same' Ignore 'references to"longer carbon chain" Do not award Any reference to longer carbon bonds/breaking covalent bonds	

Question Number	Answer	Additional Guidance	Mark
(a)(iii)	• O---H—O (1) • bond O-H-O must be shown as (approximately) linear (1) **and** angle labelled as 180°	Example of diagrams:  OR  Do not penalise omission of lone pair on the oxygen or errors in the carbon chain e.g. missing Hs Do not award hydrogen bond shown as a solid line (M1) H—O---H bond shown as 180° (M2) Incorrect -OH attachment to chain (M2) ignore bond lengths	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	• balanced equation	 + 6 O=O ⟶ 4 O=C=O + 5 H−O−H	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	• calculation or working of energy needed to break bonds (1) • calculation or working of energy released when bonds are made (1) • calculation of energy change and give a sign (1)	Here, and throughout the paper do not penalise mol⁻ for mol^{-1} Energy to break all bonds: (3x347) + (9x413) + 358 + 464 + (6x498) = 8568 (kJ mol^{-1}) Energy released when all bonds made: (10x464) + (8x805) = 11080(kJ mol^{-1}) −11080 + 8568 = −2512 (kJ mol^{-1}) Do not award incorrect units TE on incorrect balancing of equation and TE at each stage of calculation Ignore SF except 1SF Correct answer no working scores (3) Comment Common error is the use of 6.5 x 498 (forgets about the alcohol oxygen). This gives −2263 kJ mol^{-1} scores 2.	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	An answer that makes reference to the following points: • mean bond enthalpies do not refer to specific compounds such as butan-1-ol/ mean bond enthalpies are averages/mean for different molecules/bonds in different environments/compounds **(1)** • butan-1-ol is a liquid and bond enthalpies refer to gases OR mean bond enthalpy calculations do not include changes of state **(1)**	Ignore just "mean bond enthalpies are an average" Ignore references to standard conditions Just 'different states'	**(2)**

Question Number	Answer	Additional Guidance	Mark
(c)(i)	• calculation of energy produced per gram **(1)** • calculation of energy produced per cm^3 **(1)** OR • calculation of moles in 1 cm^3 **(1)** • calculation of energy produced per cm^3 **(1)**	Example of calculations: (–)2670 ÷ 74 = (–)36.081/36.1 / 36 ($kJ\ g^{-1}$) 36.1 x 0.81= 29.226/29.2 / 29 ($MJ\ dm^{-3}$) 0.81 / 74 = 0.010946 (moles) 0.010946 x (–)2670 = 29.226/29.2 / 29 ($MJ\ dm^{-3}$) Units, if given, must be correct in $MJ\ dm^{-3}$ Correct answer with no working scores (2) Ignore sign and SF except 1SF	**(2)**

Question Number	Answer	Additional Guidance	Mark
(c)(ii)	An answer that makes reference to the following points: • biobutanol has a longer hydrocarbon / alkane chain/ more electrons than bioethanol **(1)** • so more/stronger London forces / dispersion forces / Van der Waals forces between biobutanol and petrol (than bioethanol and petrol) **(1)**	Ignore references to polarity, non-polar parts Allow London forces in biobutanol and petrol are similar Do not award just "biobutanol has stronger London forces than bioethanol"	**(2)**

Q6.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	An explanation that makes reference to the following points: EQUILIBRIUM • there are more (gaseous) moles/molecules on LHS / less (gaseous) moles on RHS **(1)** • (so high pressure) moves equilibrium to RHS / increases yield of methanol **(1)** OR KINETIC • an increase in pressure increases the number/rate of collisions (of molecules) **(1)** • (So) increases the rate of reaction **(1)**	NOTE If two marks are scored they must be derived from either the kinetic or equilibrium explanations. If both explanations are used any incorrect statement negates one mark. Any reference to atoms scores 0 for M1 If numbers of moles given, they must be correct M2 depends on M1 for both explanations	**(2)**

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	An explanation that makes reference to the following points: • the (forward) reaction is exothermic **(1)** • a lower temperature would increase the yield /move equilibrium to RHS or reverse argument **(1)** • a (compromise) temperature is used to ensure the rate is fast enough (without the equilibrium position moving too far to the LHS) ALLOW (increased/high/stated) temperature increases the rate of reaction **(1)**	Note: if (forward) reaction is identified as endothermic then neither M1 nor M2 can be scored Ignore references to cost/economics/ environmental	**(3)**

Question Number	Answer	Additional Guidance	Mark
(a)(iii)	An explanation that makes reference to one of the following points: (a catalyst) allows a lower temperature to be used / less energ is needed (1) (a copper catalyst is specific for methanol) so there is less waste/fewer other products/improves atom economy (1) (a catalyst) is not used up/can be used again (1)	Ignore just increases rate/ lowers activation energy	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	Reagents • sodium / potassium dichromate ((VI)) / $Na_2Cr_2O_7$/$K_2Cr_2O_7$/ $Cr_2O_7^{2-}$ **and** acidified / H+ / sulfuric acid (1) Reaction conditions • (Heat under) **reflux** (1)	Do not award potassium manganate(VII) M2 dependent on M1 or near miss	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	$CH_3OH + 2[O] \longrightarrow HCOOH + H_2O$ (1)	Allow; CH_2O_2,CHOOH,HCO_2H	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	Functional group test add any carbonate /hydrogencarbonate OR add magnesium (powder/ribbon) (1) OR addition of any alcohol (and strong acid to form an ester) Positive result (1) effervescence / bubbles / gas given off (turns lime water cloudy OR burns with a "pop") OR Fruity smell	Do not award the addition of Na or PCl_5 Ignore reference to indicator M2 depends on M1 or near miss	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(iv)	• infra red absorption at 3750 - 3200 cm^{-1} /3300 cm^{-1} due to O-H of alcohol/methanol **(1)** • infra red absorption at 1725 - 1700 cm^{-1} /1700 cm^{-1} due to C=O group (of carboxylic acid/methanoic acid) **(1)** • peaks due to methanol/alcohol would disappear/be absent **(1)**	Allow the peak at 1020 for methanol in the fingerprint region Accept infra red absorption at 3300 - 2500 cm^{-1} /2500 cm^{-1} showing O-H group of COOH Allow the fingerprint region would change Penalise use of OH^-/-OH once only. In M1 and M2 penalise absence of bonds once only	**(3)**

Question Number	Answer	Additional Guidance	Mark
(c)(i)	An explanation that makes reference to two of the following points: • burning (petrol/methanol/fuel) produces CO_2 /greenhouse gases/contributes to global warming **(1)** • the methanol is made from captured CO_2 / is made from CO_2 that would have been released anyway **(1)** • the increase in global temperatures will be reduced **(1)**	IGNORE references to ozone depletion Do not award : methane is produced	**(2)**

Question Number	Answer	Additional Guidance	Mark
(c)(ii)	• 352g carbon dioxide (released per mole octane) **(1)**	Example calculation: 8 x 44 = 352 (g)	**(1)**

Question Number	Answer	Additional Guidance	Mark
(c)(iii)	• Mass petrol reduction per year (1) • Mass CO_2 reduction (1) OR • Moles of petrol used per year (1) • 5% reduction in CO_2 (1) OR • 5% reduction in moles of petrol used per year (1) • Mass CO_2 produced (1)	Example of calculation: 1200 x 0.05 = 60 (kg) 60 ÷ 114 x 352 = 185.26 kg (1200 x 1000) ÷ 114 = 10526 (moles) 352 x 10526 x 5 ÷ 100 = 185260 g = 185.26 kg 1200 x 1000 x 0.05 ÷ 114 = 526.3 (moles) 526.3 x 352 ÷ 1000 = 185.26 kg IGNORE SF except 1 SF correct answer with no working scores 2	(2)

Q7.

Question Number	Answer	Additional guidance	Mark
(a)(i)	• $2I^- \rightarrow I_2 + 2e^{(-)}$ (1) • $2H^+ + 2e^- + H_2O_2 \rightarrow 2H_2O$ (1)	Allow $2I^- - 2e^{(-)} \rightarrow I_2$ Ignore state symbols, even if incorrect Allow multiples Allow equations in either order	(2)

Question Number	Answer	Additional guidance	Mark
(a)(ii)	$2I^- + 2H^+ + H_2O_2 \rightarrow I_2 + 2H_2O$ OR $2HI + H_2O_2 \rightarrow I_2 + 2H_2O$	Ignore state symbols, even if incorrect Allow multiples No TE from (a)(i) Do not award uncancelled electrons	(1)

Question Number	Answer	Additional guidance	Mark
(b)(i)	An answer that makes reference to the following points: (pale) yellow aqueous layer **(1)** Pink cyclohexane layer **(1)**	 Do not award just 'brown' / colourless / orange allow light brown / pale brown / yellowbrown / straw Allow purple / violet Do not award red / grey	**(2)**

Question Number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that makes reference to the following points: Cyclohexane and iodine form London forces (between molecules) **(1)** Hydrogen bonds between water molecules are stronger than London forces (between iodine and water molecules so less soluble in aqueous layer) **(1)**	 Allow 'van der Waals' / dispersion forces / instantaneous dipole – induced dipole forces Allow 'Hydrogen bonds in water are strong' Allow one mark for answers that compare type of attraction without any reference to magnitude or answers based solely on polarity e.g. Just 'iodine forms London forces with cyclohexane but cannot form hydrogen bonds with water' scores 1 mark 'iodine and cyclohexane are non-polar, but water is polar' scores 1 e.g. 'Intermolecular forces formed by iodine and water are weaker than intermolecular forces in water' scores 1	**(2)**

Question Number	Answer	Additional guidance	Mark
(c)	(Anhydrous) sodium sulfate /Na_2SO_4 / magnesium sulfate / $MgSO_4$ / calcium chloride / $CaCl_2$ / calcium sulfate / $CaSO_4$ / calcium oxide / CaO	Allow silica gel Do not award concentrated sulfuric acid / phosphoric acid Do not award $CuSO_4$ / $CaCO_3$	**(1)**

Q8.

Question Number	Answer	Mark
	The only correct answer is B (2-chloro-2-methylpropane) *A is incorrect because a primary alcohol would be formed which would be oxidised* *C is incorrect because a primary alcohol would be formed which would be oxidised* *D is incorrect because a secondary alcohol would be formed which would be oxidised*	**(1)**

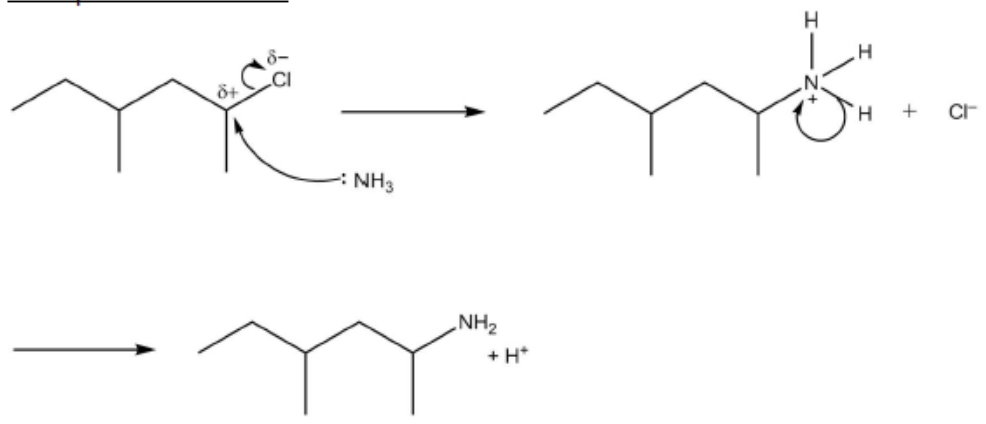
Q9.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	• 4-methylhexan-2-ol	Allow 4-methyl-2-hexanol Allow 4-methylhexane-2-ol Ignore incorrect punctuation Do not award 4-methylhex-2-ol	**1**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	• PCl_5 / phosphorus(V) chloride / phosphorus pentachloride	Allow **concentrated** hydrochloric acid / conc.HCl or thionyl chloride / $SOCl_2$ Allow PCl_3 / phosphorus(III) chloride / phosphorus trichloride Allow conc.H_2SO_4 and KCl If name and the formula are given, both must be correct Ignore just HCl / hydrochloric acid	1

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(iii)	A mechanism that includes the following points • arrow from lone pair on nitrogen atom in ammonia to carbon atom **(1)** • dipole shown and arrow from C–Cl bond to Cl or just beyond **(1)** • formula of intermediate including the + charge on the N atom **and** Cl^- **(1)** • arrow from N-H bond of the intermediate to N(+ and formulae of products) **(1)**	See example mechanism below M1 and M2 can be awarded if shown in 2 steps, via a carbocation Ignore any bases Ignore missing H^+ Ignore errors in hydrocarbon chain	4

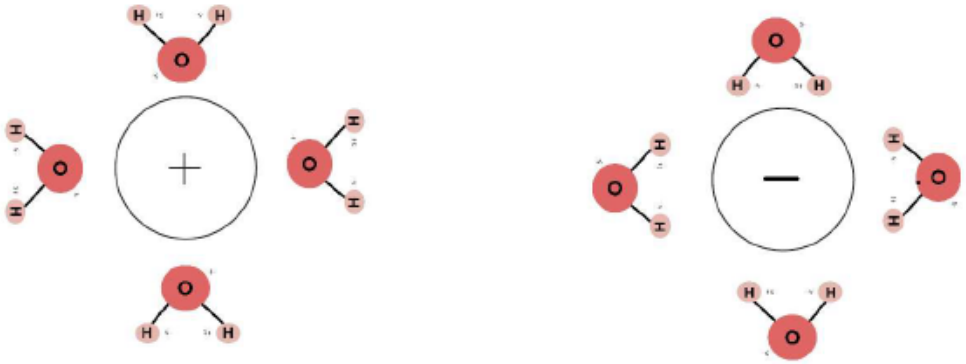
Example of mechanism



Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(i)	An explanation that makes reference to the following points: • (the bond formed is a) dative (covalent) / coordinate bond **(1)** • As the (lone) pair of electrons on the nitrogen (atom) **(1)** • (form the bond) as hydrogen (ion) has an empty orbital / no electrons **(1)**	Allow 'two electrons from the nitrogen' Ignore 'lone pair on the ammonia' Allow can be donated to / shared with the hydrogen (ion) Do not award hydrogen atom	**3**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	A diagram that includes the following points: • dipole on at least one of the water molecules **(1)** • DMAA ion is attracted to slightly negative oxygen atoms (in water) **(1)** • chloride ion is attracted to slightly positive hydrogen atoms (in water) **(1)**	must be at least 2 water molecules surrounding an ion Ignore lone pairs on oxygen Allow orientation showing only 1 H attracted to ion Allow slight positive charge shown on only 1 H atom Correct diagram but with missing dipoles loses M1 but can score M2 and M3 Ignore attempts to show 'force' or 'bond' e.g. with dashes / arrows Ignore any additions to the circles	**3**

Example of diagram for Qbii



Q10.

Question Number	Correct Answer	Mark
(a)	**The only correct answer is B** (elimination) ***A*** *is incorrect as alcohols do not have a double bond* ***C*** *is incorrect as water is a product not a reactant* ***D*** *is incorrect as C=C double bonds do not form via substitution reactions*	**1**

Question Number	Correct Answer	Mark
(b)	**The only correct answer is C** (three) ***A*** *is incorrect as the OH group is not terminal or in a symmetrical alcohol* ***B*** *is incorrect as 4-methylpent-2-ene has E/Z isomers* ***D*** *is incorrect as 2-methylpent-2-ene does not have E/Z isomers*	**1**

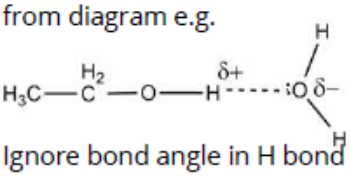
Q11.

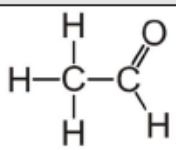
Question Number	Answer	Mark
	The only correct answer is C (concentrated phosphoric acid) ***A*** *is incorrect because this would oxidise the alcohol* ***B*** *is incorrect because this is a drying agent* ***D*** *is incorrect because this produces an alkene from a halogenoalkane*	**(1)**

Q12.

Q	Acceptable Answers	Additional Guidance	Mark
(a)	This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. **Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points** 6 / 4 5-4 / 3 3-2 / 2 1 / 1 0 / 0 The following table shows how the marks should be awarded for structure and lines of reasoning **Number of marks awarded for structure of answer and sustained lines of reasoning** Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout / 2 Answer is partially structured with some linkages and lines of reasoning / 1 Answer has no linkages between points and is unstructured / 0 Indicative Points	Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with four indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there were no linkages between the points, then the same indicative marking points would yield and overall score of 3 marks (3 marks for indicative content and zero marks for linkages). Note – allow reverse arguments where appropriate e.g. IP1 and IP5	6

• **IP1** High temperature increases rate as more particles have $E \geq E_a$ • **IP2** Catalyst increases rate by providing alternative mechanism / catalysts lower activation energy • **IP3** but high temperature reduces yield / moves eqm to LHS as reaction is exothermic • **IP4** so (high) temperature (of 300°) is a compromise (between rate and yield) • **IP5** high pressure increases the yield as reaction / equilibrium moves to side of fewest particles / high pressure increases rate as more particles in the same volume • **IP6** (low yield acceptable) as unconverted reactants can be recycled / passed through reactor again	May be shown on a labelled diagram Allow compromise between temperature or pressure and energy costs / equipment to withstand pressure/ costs to maintain temperature / costs to maintain pressure Allow (low yield acceptable) as ethanol is removed as it forms to move equilibrium to RHS Ignore any references to environmental effects / atom economy	

Q	Acceptable Answers	Additional Guidance	Mark
(b)	An explanation that makes reference to the following points: • when they mix can form hydrogen bonds (to each other) **(1)** • as both compounds have hydrogen bonds (between their molecules) OR forces that form are similar in strength or stronger than hydrogen bonds in water / ethanol **(1)** • from the lone pair / slight negative charge on an oxygen (atom in one molecule) to a slightly positive hydrogen (atom in the other molecule) (on OH group or water) **(1)**	Ignore references to other intermolecular forces Allow ethanol-water forces can overcome ethanol-ethanol / water-water forces M1 and M3 can be awarded from diagram e.g.  Ignore bond angle in H bond diagram Ignore hydrocarbon structure on ethanol	**3**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(i)		Allow  Allow CH_3CHO Allow 'hybrid' structure e.g. skeletal but with some parts of the structure displayed Ignore bond angles Ignore correct molecular formulae Ignore attempts to write a balanced equation Ignore names even if incorrect Note Look out for structures drawn above the stem If 2 structures shown, e.g. skeletal and displayed, but one is incorrect then award 0 marks	1

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(ii)	An answer that makes reference to the following points: • Y - Distil (off Y from reaction mixture as it forms) **(1)** • Ethanoic acid – (heat under) reflux **(1)**	Note if both answers given but the wrong way round allow 1 mark If no other mark is awarded, controlling the amount of oxidising agent in either case scores (1) Ignore temperatures if given	2

Q13.

Question Number	Answer	Additional Guidance	Mark
(a)	A description that makes reference to the following points: • advantage: (it is produced from) renewable / sustainable (resources) **or** it produces fewer emissions (of CO_2 / greenhouse gases) (1) • disadvantage: it uses up land (that could be used for food production)/uses a food crop that could be eaten **or** it produces less energy (per mole / g) (1)	Do not award no greenhouse gases Ignore cleaner fuel/ more efficient combustion Ignore reference to engine modifications/carbon neutrality/using less oil/good for the environment Ignore just ' it uses lots of crops' Ignore references to time to grow crops/time to carry out fermentation/cost Ignore produces CO_2 Do not award any references to ozone depletion	(2)

Question Number	Answer	Additional Guidance	Mark
(b)	• **ethanol** can be oxidised	Allow **ethanol** can react with oxygen Allow possible (organic) products of oxidation e.g. carboxylic acid / ethanoic acid / aldehyde / ethanal Ignore just 'oxidation takes place' or 'it can be oxidised' Allow to ensure only anaerobic respiration takes place. Allow aerobic respiration would take place (in the air) (producing water and carbon dioxide) Do not award yeast reacts with oxygen Do not award to prevent combustion/ethanol would burn	(1)

Question Number	Answer	Additional Guidance	Mark
(c)	• (fractional) distillation	Allow distil the mixture	(1)

Question Number	Answer	Additional Guidance	Mark
(d)(i)	• ethanol forms hydrogen bonds (with water)	Ignore both are polar/ they are miscible Ignore comments about solubility/like dissolves like	(1)

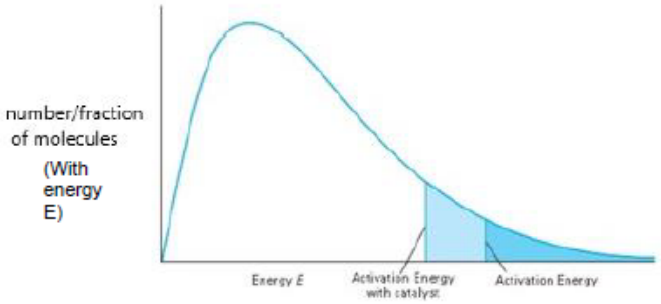
Question Number	Answer	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to one of the following points: • (water can cause) corrosion / rusting • reduce the energy efficiency of the engine/fuel/ethanol • causes phase separation of the fuel	Ignore damages the engine Allow water does not burn/ fewer km per l / miles per gallon Allow just 'reduced efficiency' Ignore references to ethanol being diluted	(1)

Question Number	Answer	Additional Guidance	Mark
* (e)(i)	This question assesses the student's ability to show a coherent and logically structured Answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the Answer is structured and shows lines of reasoning. The following table shows how the Marks should be awarded for indicative content. Number of indicative Marking points seen in Answer / Number of Marks awarded for indicative Marking points 6 / 4 5-4 / 3 3-2 / 2 1 / 1 0 / 0 The following table shows how the Marks should be awarded for structure and lines of reasoning. Number of Marks awarded for structure of Answer and sustained lines of reasoning	Guidance on how the Mark scheme should be applied. The Mark for indicative content should be added to the Mark for lines of reasoning. For example, a response with five indicative Marking points that is partially structured with some linkages and lines of reasoning scores 4 Marks (3 Marks for indicative content and 1 Mark for partial structure and some linkages and lines of reasoning). If there were no linkages between the points, then the same indicative Marking points would yield an overall score of 3 Marks (3 Marks for indicative content and no Marks for linkages).	(6)

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	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2		In general it would be expected that 5 or 6 indicative points would get 2 reasoning Marks, and 3 or 4 indicative points would get 1 Mark for reasoning, and 0, 1 or 2 indicative points would score zero Marks for reasoning. If there is any incorrect chemistry, deduct Mark(s) from the reasoning. If no reasoning Mark(s) awarded do not deduct Mark(s).	
	Answer is partially structured with some linkages and lines of reasoning	1			
	Answer has no linkages between points and is unstructured	0			
	Indicative content **IP1** if temperature increases, **rate** increases (because more particles have energy greater than E_a) **IP2** if temperature increases, yield decreases (because forward reaction is exothermic/ reaction moves in the endothermic direction) **IP3** if pressure increases, rate increases (because particles are more crowded and) collision frequency increases) **IP4** if pressure increases, yield increases(as there are fewer particles on the RHS of the equation)				

	IP5 the catalyst allows the use of lower temperature/less energy (for the same rate) **IP6** high pressure (and temperature) are very expensive	Allow reaction shifts to the left as an alternative to decreases yield Allow reaction shifts to the right as an alternative to increase yield Ignore fewer atoms on the RHS Ignore any reference to how the catalyst works and the effect of catalyst on rate and yield Allow conditions used are compromise between yield **and** cost / rate **and** cost Allow reverse argument for all points	

Question Number	Answer	Additional Guidance	Mark
(e)(ii)	An explanation that makes reference to the following points: (1) • correct labelling of both axes. (1) • activation energy labelled (1) • activation energy with a catalyst shown to the left of the uncatalysed activation energy. (1)	 M1, M2 and M3 shown on the diagram Both Ea and the catalysed Ea must be to the right of the peak and on the same curve if another temp curve is drawn M4 can be shown on the diagram with labelled shading Allow more particles have activation energy Do not award catalyst increases yield / particles have more energy/ particles move faster/ greater collision frequency Ignore more frequent successful collisions	(4)

	• more particles have energy greater than the activation energy with the catalyst / more particles to the right of the activation energy / greater area to the right of the activation energy		

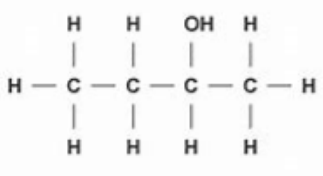
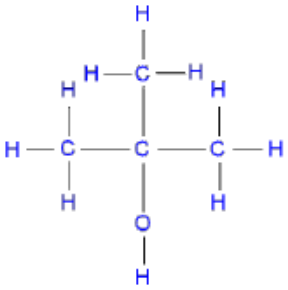
Question Number	Answer	Additional Guidance	Mark
(f)(i)	• large(r) surface area (so faster rate of reaction)	Accept more (active) sites Allow more / greater surface Ignore greater area / area of contact	(1)

Question Number	Answer	Additional Guidance	Mark
(f)(ii)	A description that makes reference to the following points: • remove the ethanol (1) • recycle the (unused) reactants (1)	Accept condense the ethanol Allow remove the ethanol to shift the eqm to the right scores (2) Ignore any reference to temperature, pressure or catalyst Ignore any reference to adding more reactants	(2)

Q14.

Question Number	Answer	Additional Guidance	Mark
(a)	An explanation that makes reference to the following points: • contains the OH group/OH is the alcohol group (1) • primary means the C bonded to the OH (group) is attached to 1 (or 0) alkyl group / carbon atom/ R group (1)	Accept a hydrocarbon in which one H atom has been replaced by an OH group Allow contains O-H bond Allow contains a C-OH bond Ignore hydroxyl Do not award hydroxide/ OH^- Allow the OH group is attached to a carbon atom bonded to 2 (or 3) H atoms Do not award the OH is attached to a single R/alkyl/carbon group	2

Question Number	Answer	Additional Guidance	Mark
(b)			5

Name	**butan-1-ol**		**(2-)methylpropan-2-ol**	(2)	One mark for each name
Displayed formula				(2)	One mark for each correct displayed formula
Nature of alcohol	**primary**	**secondary**		(1)	One mark for both alcohol types One mark for both alcohol types Allow CH_3 and OH undisplayed Penalise missing Hs only once.

Question Number	Answer		Additional Guidance	Mark
(c)(i)	An answer that makes reference to the following points:			2
	• potassium dichromate((VI)) / $K_2Cr_2O_7$	(1)	Allow sodium dichromate((VI)) / $Na_2Cr_2O_7$ If oxidation state is given it must be correct Do not award potassium manganate(VII) / potassium permanganate	
	• sulfuric acid / H_2SO_4	(1)	Do not award hydrochloric acid Ignore just 'acidified' Ignore concentration of sulfuric acid Ignore heat	
	Note M2 depends on M1 or a near miss such as potassium permanganate or potassium dichromate with the wrong oxidation number		If no other mark is scored acidified dichromate / H^+ and $Cr_2O_7^{2-}$ score (1)	

Question Number	Answer	Additional Guidance	Mark
(c)(ii)	• $(CH_3)_2CHCH_2OH + [O] \rightarrow (CH_3)_2CHCHO + H_2O$	Allow $C_4H_{10}O + [O] \rightarrow C_4H_8O + H_2O$ The [O] may be above the arrow Allow displayed/molecular/skeletal	1

Question Number	Answer	Additional Guidance	Mark
(c)(iii)	An answer that makes reference to two of the following points: • (resulting mixture) would give a peak due to O–H bond in alcohols at 3750-3200 (cm^{-1}) (1) • would give a peak due to C=O bond in aldehydes at 1740-1720 (cm^{-1}) or would give a peak due to C–H bond in CHO at 2900-2820 and/ or 2775-2700 (cm^{-1}) (1)	Ignore any reference to the size/width of the peaks due to stretching etc Allow (resulting mixture) would give a peak due to OH (in alcohols) at 3750-3200 (cm^{-1}) Do not award -OH Do not award 1720-1700 (cm^{-1}) for C=O in ketones Allow any range within the range. Do not award single numbers but penalise once only If no other marks have been scored a correct wave number range for both the O-H and C=O score (1) 3750-3200 (cm^{-1}) 1740-1720 (cm^{-1})	

Q15.

Question Number	Answer	Additional Guidance	Mark
(a)	• both classifications correct	Example of table: Halogenoalkane | Classification Br | secondary Br | primary Allow 2° for secondary Allow 1° for primary Ignore halogenoalkane	(1)

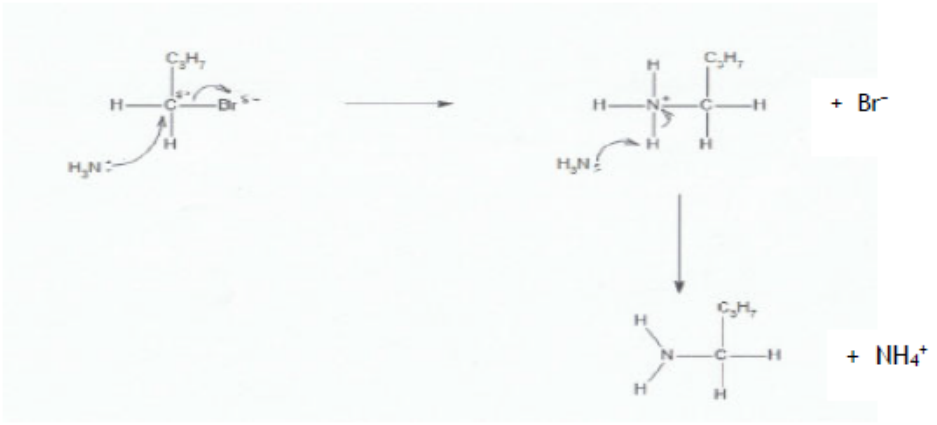
Question Number	Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to the following points: • 2-chloro-2- methylpropane should react faster than 1-iodobutane because it is tertiary (1) • 1-iodobutane should react faster than 2-chloro-2-methylpropane because the C–I bond enthalpy is lower enthalpy is lower than C–Cl (1) • it is not possible to predict the relative effects of these two opposing factors / structure and bond enthalpies (1)	Stand alone mark Allow tertiary / branched chain / more branched halogenoalkanes have a higher rate of hydrolysis than primary halogenoalkanes Do not award secondary for 2-chlor-2-methylpropane Do not award tertiary carbocation Stand alone mark Allow just 'the C–I bond is weaker / has a lower bond enthalpy than C–Cl' Ignore just 'bonds in 1-iodobutane are weaker' Do not award H–I / H–Cl bonds Conditional on two opposing factors If M1 and M2 scored, allow 'so it is not possible to predict the relative rate of hydrolysis'	(3)

Question Number	Answer	Additional Guidance	Mark
(c)(i)	• **ammonia** (gas) would escape (from the condenser when heated under reflux) **or** to prevent **ammonia** (gas) escaping (from the condenser when heated under reflux)	Ignore just 'ammonia will evaporate' Ignore concentrated alcoholic Ignore references to safety Ignore just 'gas / reactant escapes' Do not award any other substance escaping	(1)

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Question Number	Answer	Additional Guidance	Mark
(c)(ii)	• lone pair on N of NH_3 **and** curly arrow from lone pair on N to, or towards C **(1)** • dipole on C-Br **and** curly arrow from C-Br bond to, or just beyond, Br **(1)** • lone pair on N of NH_3 **and** curly arrow from lone pair on N to, or towards H **(1)** • curly arrow from N-H bond to, or towards N **(1)**	Penalise missing lone pair on N once only Penalise negative charge on NH_3 once only Penalise half-arrow heads once only Do not award any charge / dipole on H Ignore any changes to final products	**(4)**

Example of mechanism:



Question Number	Answer	Additional Guidance	Mark
(d)	• calculation of amounts of KBr and H_2SO_4 (1)	Example of calculation: amount KBr = $\frac{14.90}{119}$ = 0.12521 (mol) amount H_2SO_4 = $\frac{16.35}{98.1}$ = 0.16667 (mol) Allow use of 98 for M_r of H_2SO_4 giving 0.16684 (mol)	(3)
	• calculation of amount of C_2H_5OH **and** statement or implication that this is the limiting quantity (1)	amount C_2H_5OH = $\frac{4.65}{46}$ = 0.10109 / 0.10 / 0.1 (mol) **and** any indication that the limiting reagent is C_2H_5OH e.g. by use of mol of ethanol in M3	
	• calculation of maximum mass of C_2H_5Br formed (1)	(maximum amount C_2H_5Br formed = 0.10109 (mol) maximum mass C_2H_5Br formed = 0.10109 x 108.9 = 11.008 / 11.01 / 11.0 / 11 (g) Allow use of 109 for M_r of C_2H_5Br giving 11.018 (g) Ignore SF except 1 SF, but allow 0.1 for mol C_2H_5OH	

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points 6 / 4 5–4 / 3 3–2 / 2 1 / 1 0 / 0 The following table shows how the marks should be awarded for structure and lines of reasoning.	Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).	(6)

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	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.	2
Answer is partially structured with some linkages and lines of reasoning.	1
Answer has no linkages between points and is unstructured.	0

Comment:
Look for the indicative marking points first, then consider the mark for structure of answer and sustained line of reasoning

In general it would be expected that 5 or 6 indicative points would get
2 reasoning marks, and
3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.

General points to note
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).

Indicative content	Penalise use of incorrect halogenoalkane once only
• **IP1 –Similarity** Both reactions involve hydroxide ions / OH^-	Allow OH^- shown with both reactions anywhere in the answer e.g. in the equations Allow both reactions need heat (under reflux)
• **IP2 – Type of reaction** Reaction with aqueous solution is substitution **and** reaction with ethanolic solution is elimination	Ignore displacement for substitution Ignore dehydration for elimination Do not award dehydrogenation for elimination
• **IP3 – Type of reagent** (OH^- is a) nucleophile in aqueous solution **and** a base in ethanolic solution	If IP2 and IP3 not awarded, allow 1 IP for just 'nucleophilic substitution' or 'elimination by a base'
• **IP4 – Products** In aqueous solution propan-2-ol / an alcohol forms **and** in ethanolic solution propene / an alkene forms	This can be scored from the equations
• **IP5 – Equation in aqueous solution** $CH_3CHBrCH_3 + OH^- \rightarrow CH_3CHOHCH_3 + Br^-$	In IP5 and IP6, allow displayed formulae / any combination of displayed and structural formulae / skeletal formula Allow KOH / KBr / $K^+ + OH^-$ / $K^+ + Br^-$ The equations must be balanced Ignore state symbols even if incorrect Ignore mechanisms even if incorrect
• **IP6 – Equation in ethanolic solution** $CH_3CHBrCH_3 + OH^- \rightarrow CH_3CH{=}CH_2 + H_2O + Br^-$	

Q16.

Question Number	Answer	Mark
(a)	**The only correct answer is D** (*E*-oct-5-en-3-ol) ***A*** *is incorrect because the wrong priority has been assigned and the E/Z nomenclature is incorrect* ***B*** *is incorrect because the wrong priority has been assigned* ***C*** *is incorrect because this is the name of the Z isomer*	**(1)**

Question Number	Answer	Mark
(b)	**The only correct answer is A** ($Cl_2(g)$) ***B*** *is incorrect because only one chlorine atom would be added* ***C*** *is incorrect because PCl_5 does not react with a C=C bond* ***D*** *is incorrect because potassium chloride does not react with either a C=C bond or -OH group*	**(1)**

Question Number	Answer	Mark
(c)	**The only correct answer is C** ($PCl_5(s)$) ***A*** *is incorrect because chlorine does not react with an alcohol* ***B*** *is incorrect because hydrogen chloride does not react with an alcohol* ***D*** *is incorrect because potassium chloride does not react with either a C=C bond or -OH group*	**(1)**

Q17.

Question number	Answer	Additional guidance	Mark
(a)(i)	• peak in the range 3750 - 3200 cm^{-1} and O-H (stretching) bond in alcohols	Must identify the bond and give the wavenumber range Allow peak at ~3375 cm^{-1}	1

Question number	Answer	Additional guidance	Mark
(a)(ii)	• not possible - All three contain the same bonds or possible - the fingerprint regions differ/by comparing the spectra to reference spectra	No mark for unjustified answer	1

Question number	Answer	Additional guidance	Mark
(b)(i)	• (all show) parent/molecular ion peak at 74	Allow peak furthest to the right/highest m/z peak at 74 Do not award just 'peak at 74'	1

Question number	Answer		Additional guidance	Mark
(b)(ii)	• fragment $^{+}CH_3CHOH = 45$	(1)		3
	• fragment $^{+}CH_2OH = 31$	(1)		
	• fragment $^{+}(CH_3)_2COH = 59$	(1)	Ignore missing charge on fragments	

Question number	Answer			Additional guidance	Mark
(c)(i)				Allow displayed or skeletal formulae 1 mark for 2 correct names and 1 mark for each correct formula	3
	Organic compound used	Name of oxidation product	Structural formula of oxidation product		
	A	Butanone **and**	$CH_3CH_2COCH_3$	(1)	
	B	Butanal (1)	$CH_3CH_2CH_2CHO$	(1)	

Question number	Answer		Additional guidance	Mark
(c)(ii)	An answer that makes reference to the following points:			3
	• reagent: Benedict's/Fehling's	(1)	Allow Tollens' or iodine + alkali	
	• (oxidation product of) compound A: no change	(1)		
	• (oxidation product of) compound B: (Benedict's/Fehlings test) red precipitate.	(1)	(Tollens' reagent) silver mirror with (oxidation product of) B. No reaction with (oxidation product of) A (iodine + alkali) yellow precipitate (iodoform) with (oxidation product of) A. No reaction with oxidation product of B If (butanoic) acid in (c)(i), allow reagent: sodium carbonate/sodium hydrogencarbonate (solution) Observations: (oxidation product of) compound B: bubbles/fizzes	

Q18.

Question Number	Answer	Mark
(a)	**The only correct answer is B** (oxidising propan-1-ol to propanal) *A is incorrect because reducing an alcohol would produce an alkane* *C is incorrect because reducing propanal would produce propan-1-ol* *D is incorrect because oxidising propan-1-ol would produce propanal or propanoic acid*	**(1)**

Question Number	Answer	Mark
(b)	**The only correct answer is A** (propan-1-ol) *B is incorrect because propan-2-ol would not be expected to form a $^+CH_2OH$ fragment* *C is incorrect because propanal would not be expected to form a $^+CH_2OH$ fragment* *D is incorrect because propanone would not be expected to form a $^+CH_2OH$ fragment*	**(1)**

Question Number	Answer	Mark
(c)	**The only correct answer is C** (propanal) *A is incorrect because propan-1-ol would have a broad absorption at 3750-3200 cm^{-1} due to –OH* *B is incorrect because propan-2-ol would have a broad absorption at 3750-3200 cm^{-1} due to –OH* *D is incorrect because the absorption due to C=O in propanone would be at 1720-1700 cm^{-1} and C-H stretching vibrations at 2775-2700 cm^{-1} would be absent*	**(1)**

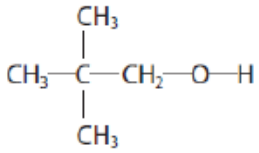
Q19.

Question Number	Correct Answer	Mark
	The only correct answer is A ((0.80 × 15.1) ÷ 60) ***B*** *is incorrect as mass does* ***not*** *equal density ÷ volume* ***C*** *is incorrect as moles does* ***not*** *equal M_r ÷ mass* ***D*** *is incorrect as mass does* ***not*** *equal volume ÷ density*	**1**

Q20.

Question Number	Correct Answer	Mark
	The only correct answer is D (83.3 g) ***A*** *is incorrect as the scaling of the reacting amount to take into account the yield of 36% is incorrect (36/100)* ***B*** *is incorrect as the reacting amount has not been scaled to take into account the yield of 36%* ***C*** *is incorrect as the scaling of the reacting amount to take into account the yield of 36% in incorrect (136/100)*	1

Q21.

Question number	Answer	Mark
	 D	1

Q22.

Question Number	Answer	Mark
	The only correct answer is D (CH_3COCH_3) *A is not correct because it is a primary alcohol so will react* *B is not correct because it is a secondary alcohol so will react* *C is not correct because it is an aldehyde so will react*	**(1)**

Q23.

Question number	Answer	Mark
(a)	**The only correct answer is C** (concentrated phosphoric(V) acid) ***A*** *is incorrect because acidified potassium manganate(VII) converts an alkene into a diol* ***B*** *is incorrect because aqueous bromine reacts with an alkene to form a bromoalcohol* ***D*** *is incorrect because phosphorus(V) chloride reacts with an alcohol to form a chloroalkane*	(1)

Question number	Answer	Mark
(b)	**The only correct answer is C** ($C_6H_{11}OH + [O] \rightarrow C_6H_{10}O + H_2O$) ***A*** *is incorrect because [O] is needed from the oxidising agent and hydrogen gas would not be produced* ***B*** *is incorrect because [O] is needed from the oxidising agent and hydrogen atoms would not be produced* ***D*** *is incorrect because the oxidising agent is not oxygen gas*	(1)

Question number	Answer	Mark
(c)	**The only correct answer is C** (3750-3200, 1669-1645) ***A*** *is incorrect because there is a C-H bond in both compounds* ***B*** *is incorrect because there is a C-H bond in both compounds and there is no C=O in cyclohexene* ***D*** *is incorrect because there is no C=O in cyclohexene*	(1)

Q24.

Question number	Answer		Additional guidance	Mark
(a)	• KBr/potassium bromide **and** (50%) sulfuric acid	(1)	Both needed for M1 Ignore acid concentration Allow HBr (dry) PBr_3/Phosphorus(III) bromide PBr_5/Phosphorus(V) bromide	2
	• (heat under) reflux	(1)	Do not allow just heat M2 conditional on correct or near correct M1	

Question number	Answer		Additional guidance	Mark
(b)	• C-Br dipole reversed	(1)	Allow in any order	3
	• OH^- to C arrow reversed	(1)		
	• lone pair missing (from OH^-)	(1)		

Question number	Answer		Additional guidance	Mark
(c)	• KOH/potassium hydroxide	(1)	Allow NaOH/sodium hydroxide Ignore OH^- / alkali	2
	• ethanol(ic)/alcohol(ic) **and** heat (under reflux)	(1)	M2 dependent on M1	

Q25.

Question Number	Answer	Mark
	The only correct answer is A (2-methylpropan-2-ol) *B is not correct because it is a secondary alcohol.* *C is not correct because it is a primary alcohol* *D is not correct because it is a secondary alcohol*	**(1)**

Q26.

Question Number	Answer	Mark
	The only correct answer is C (4) *A is not correct because there are 4 isomers* *B is not correct because there are 4 isomers* *D is not correct because there are 4 isomers*	1

Q27.

Question Number	Answer	Additional guidance	Mark
(a)	$CH_3CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2COOH + H_2O$	Ignore state symbols even if incorrect Allow multiples Allow 2 correct equations via aldehyde Allow molecular formulae Ignore reagents above the arrow	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points 6 / 4 5-4 / 3 3-2 / 2 1 / 1 0 / 0	Guidance on how the mark scheme should be applied. The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).	(6)

The following table shows how the marks should be awarded for structure and lines of reasoning

	Number of marks awarded for structure of answer and sustained lines of reasoning
Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.

If there is any incorrect chemistry, deduct mark(s) from the reasoning.
If no reasoning mark(s) awarded do not deduct mark(s).

Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.

Indicative content

1. The higher the concentration (of acid or $Cr_2O_7^{2-}$) the higher the rate
2. Because the collision frequency increases
3. The higher the temperature the faster the rate
4. Because more particles have an energy greater than the activation energy / more successful collisions
5. Excess / concentrated oxidising agent ensures complete oxidation
6. Heat under reflux ensures complete oxidation

I2 can be scored independent of I1

must be linked to heating / higher temperature.

Allow 'more effective collisions',

Allow 'only propanoic acid is formed' / 'no propanal is formed' as alternative for 'complete oxidation' in I5 and I6

Ignore any reference to pressure

Question Number	Answer	Additional guidance	Mark
(c)	• colour of the potassium dichromate(VI) / chromium(III) will mask the colour of the indicator or the reaction mixture will contain hydrogen ions / acid (present from the oxidising agent)	Ignore references to 'not a sharp colour change' Allow any named mineral acid	(1)

Question Number	Answer	Additional guidance	Mark
(d)(i)	An answer that makes reference to the following points • colourless **(1)** to • (pale) pink **(1)**	Colours in the reverse order scores one Do not award red / purple	**(2)**

Question Number	Answer	Additional guidance	Mark
(d)(ii)	An answer that makes reference to two of the following points: • First titre likely to be a rangefinder / rough titration / estimate (so done quickly) **(1)** • There was an air bubble (in the burette jet which fills before the titration starts) **(1)** • **Burette** rinsed with water (rather than sodium hydroxide) **(1)**	Allow 'not added dropwise' (near end point) / 'overshot at end point' Allow 'some water still in the burette after rinsing' **Ignore** pre-titration errors parallax errors water in conical flask **Do not award** lack of swirling of conical flask water in pipette	**(2)**

Question Number	Answer	Additional guidance	Mark
(d)(iii)	• calculation of average titre **(1)** • calculation of moles of NaOH(aq) in average titre and deduction of moles of propanoic acid in 25.0 cm^3 **(1)** • calculation of moles of propanoic acid in 250 cm^3 **(1)** • Evidence of correct *M*, **(1)** • calculation of mass of propanoic acid in the sample **(1)**	Example of calculation (22.20 + 22.10) / 2 = 22.15 cm^3 (22.15/1000) x 0.00668 = 1.47962 x 10^{-4} (mol) 1:1 reaction so = 1.47962 x 10^{-4} (mol) 1.47962 x 10^{-4} x 10 = 1.47962 x 10^{-3} (mol) 74 (g mol^{-1}) 1.47962 x 10^{-3} x 74 = 0.10949 (g) = 0.109 (g) / 0.11 (g) Correct answer with no working scores 5 Final answer to 2 or 3 SF Allow TE at each stage	**(5)**

Question Number	Answer	Additional guidance	Mark
(d)(iv)	calculation of mass of propanoic acid in mg **(1)** calculation of mass of propanoic acid in mg kg^{-1} and comparison to limit **(1)**	Example of calculation 0.109 x 10^3 = 109 (mg) Comment This mark may be evident in d(iii) 109 x 20 = 2180 (mg kg^{-1}) so within permitted range M1 is subsumed by M2 Allow TE from (d)(iii) Ignore SF except 1 SF	**(2)**

Question Number	Answer	Additional guidance	Mark
(d)(v)	An answer that makes reference to one of the following points: • (below the limit) the food would become mouldy (too quickly) / would not stop the food decomposing / would not be an effective preservative • (or above the limit) the food tastes bad / becomes (too) acidic / becomes inedible / becomes corrosive / becomes toxic	Ignore harmful	(1)