

- (b) The alcohols **C** and **D** are isomers of each other with molecular formula $C_4H_{10}O$. Both isomers are branched.

When **C** is heated under reflux with acidified potassium dichromate(VI) no colour change is observed.

When **D** is heated under reflux with acidified potassium dichromate(VI) the colour of the mixture changes from orange to green and **E**, $C_4H_8O_2$, is produced.

E reacts with aqueous sodium carbonate to form carbon dioxide gas.

- (i) Identify **C**, **D** and **E**.

C	D	E
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[3]

May/June 2017 9701/22 · Q4 (b)(i)

- (iii) The addition of concentrated sulfuric acid to solid sodium bromide, NaBr, produces brown fumes and an acidic gas that decolourises acidified potassium manganate(VII) solution. This acidic gas is a significant contributor to acid rain.

Write the equation for the reaction of concentrated sulfuric acid with sodium bromide.

..... [2]

May/June 2017 9701/23 · Q2 (c)(iii)

- (iii) Alcohols can be classified as primary, secondary or tertiary.

Identify with a tick (✓) the alcohol group(s) present in **Z**.

	alcohol group present in Z
primary	
secondary	
tertiary	

[1]

- (b) Prenol reacts with steam to form a mixture of three isomers, **J**, **K** and **L**, of molecular formula $C_5H_{12}O_2$.
- (i) When **J** is heated with excess acidified potassium dichromate(VI) it forms an organic product which shows no reaction with 2,4-DNPH.

Draw the structure of **J**.

[1]

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K and **L** are stereoisomers with molecular formula $C_5H_{12}O_2$.

K and **L** both react when heated with excess acidified potassium dichromate(VI) to form **M**, $C_5H_8O_3$.

M forms an orange precipitate on reaction with 2,4-DNPH.

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- (e) Lucas's reagent is a mixture of HCl and ZnCl_2 . Primary, secondary and tertiary alcohols can be distinguished by their reaction with Lucas's reagent.

Alcohols react with the HCl in Lucas's reagent to form halogenoalkanes.

ZnCl_2 acts as a homogeneous catalyst for these reactions.

- (i) Explain the meaning of the term *homogeneous*.

.....
..... [1]

- (iii) The fastest reaction shown by Lucas's reagent is with a tertiary alcohol.

Draw the structure of the tertiary alcohol that is an isomer of pentan-3-ol.

[1]

- (iv) Tertiary alcohols tend to react with Lucas's reagent using the same mechanism as in their reaction with HCl .

Suggest the type of reaction shown by tertiary alcohols with Lucas's reagent.

..... [1]

[Total: 17]

- (b) Iodoalkanes contain carbon-iodine bonds.

The simplest iodoalkane is CH_3I .

- (i) CH_3I can be made from methanol, CH_3OH .

Identify a reagent that can convert CH_3OH to CH_3I .

..... [1]

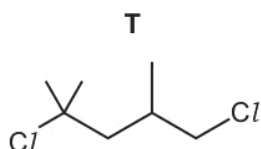
- (v) **L** reacts with hot concentrated acidified $\text{KMnO}_4(\text{aq})$ to form propanone and one other organic product.

Identify the other organic product.

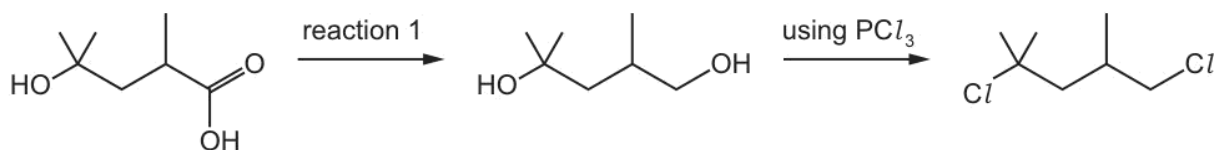
..... [1]

Oct/Nov 2020 9701/21 · Q4 (b)(i), (c)(v)

- (c) PCl_3 is used to convert alcohols to chloroalkanes, such as compound **T**.



A possible synthesis of **T** is shown.



- (i) Identify a reagent that could be used in reaction 1.

..... [1]

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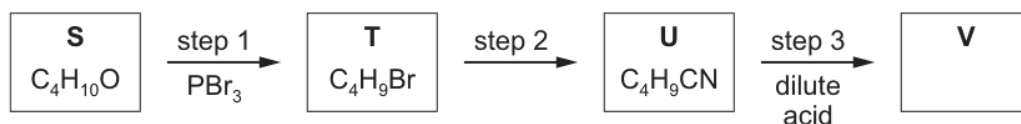
- (c) Hydroxyethanal is converted to ethanedioic acid, $(\text{CO}_2\text{H})_2$, when it reacts with excess acidified dichromate(VI) ions, $\text{Cr}_2\text{O}_7^{2-}$.

- (i) State the role of acidified $\text{Cr}_2\text{O}_7^{2-}$ in this reaction.

..... [1]

March 2021 9701/22 · Q4 (c)(i)

(b) **S** is converted to **V** in a three-step reaction sequence.



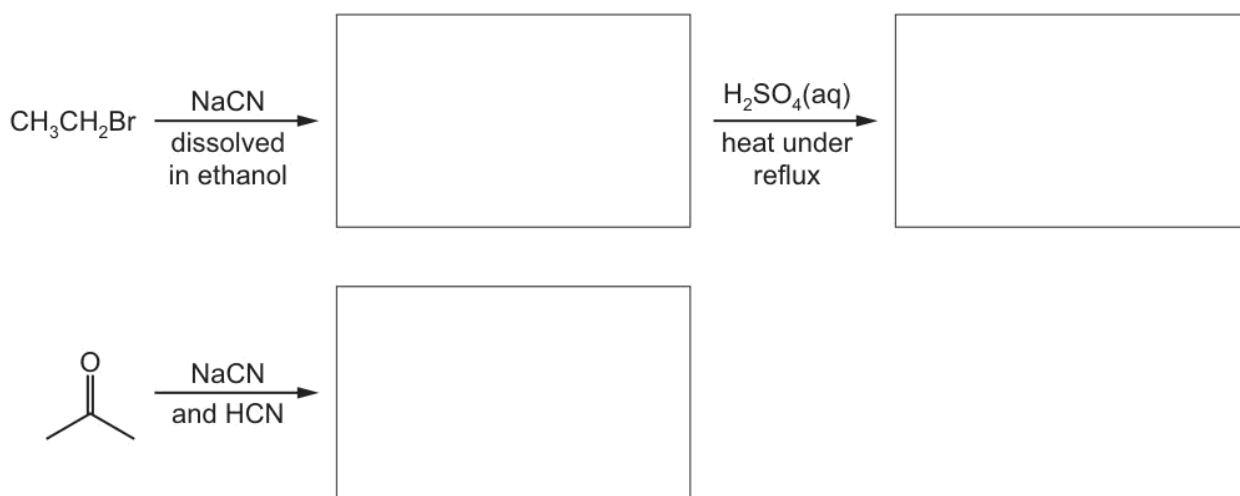
In step 1, the secondary alcohol **S** reacts with PBr_3 to produce **T**, which has molecular formula C_4H_9Br .

(i) Give the systematic name of **T**.

..... [1]

May/June 2021 9701/22 · Q5 (b)(i)

(ii) Draw the structure of the organic products formed in the following reactions.



[3]

[Total: 13]

- (iii) Al_2O_3 is used as a catalyst in the dehydration of alcohols.

State the effect of using Al_2O_3 as a catalyst in the dehydration of alcohols. Use the Boltzmann distribution in Fig. 2.1 to help explain your answer.

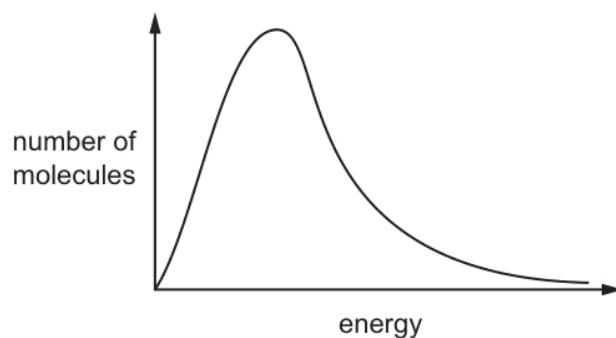


Fig. 2.1

.....

.....

..... [3]

March 2022 9701/22 · Q2 (b)(iii)

- (iii) The reaction of $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ and NaOH is different depending on whether water or ethanol is used as a solvent.

Complete Table 3.2 to identify the organic and inorganic products of the reaction of $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ and NaOH in each solvent.

Table 3.2

solvent	organic product(s)	inorganic product(s)
water		
ethanol		

[2]

[Total: 20]

- (b) Two organic products are produced when a sample of **T** is heated under reflux with excess acidified concentrated KMnO_4 .

Draw the structure of the two organic products, from this reaction, in the boxes.



[2]

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May/June 2022 9701/21 · Q3 (b)

- (ii) Construct an ionic equation to describe the formation of the yellow precipitate produced when **M** reacts with $\text{AgNO}_3(\text{aq})$ in ethanol.

..... [1]

- (iii) Describe which reagent, **Q** or **M**, will produce a precipitate more quickly when each is added to $\text{AgNO}_3(\text{aq})$ in ethanol. Explain your answer.

reagent

.....
.....

[1]

May/June 2022 9701/23 · Q4 (b)(ii), (b)(iii)

- (a) (i) **M** reacts with hot concentrated acidified $\text{KMnO}_4(\text{aq})$ to form **N**, $\text{C}_6\text{H}_{10}\text{O}_3$, in reaction 1.

Draw the structure of **N**.

[1]

- (ii) **N** is reduced by NaBH_4 to form 5-hydroxyhexanoic acid in reaction 2.

Construct an equation for reaction 2 using molecular formulae.

In the equation, use $[\text{H}]$ to represent one atom of hydrogen from the reducing agent.

..... [1]

- (iii) Reaction 2 is a nucleophilic addition.

Suggest why reaction 2 creates a mixture of two organic compounds.

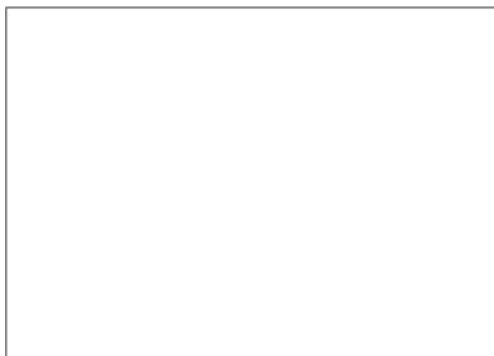
.....
..... [2]

- (iv) Draw lactone **P**, the product of reaction 3.

[1]

- (iii) Organic compound **M** forms when 2-bromo-2-methylpropane is heated with **ethanolic** OH^- .

Draw the structure of **M**.



[1]

[Total: 17]

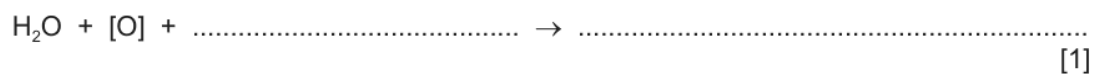
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- (v) Complete the equation for the reaction of **E** with cold dilute acidified $\text{KMnO}_4(\text{aq})$ to form **F**. In the equation, $[\text{O}]$ represents cold dilute acidified $\text{KMnO}_4(\text{aq})$.



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- (c) PCl_5 reacts with alcohols to form chloroalkanes.

- (i) Identify this type of reaction.

..... [1]

Oct/Nov 2022 9701/23 · Q3 (c)(i)

- (b) $\text{CH}_3\text{CH}_2\text{COOH}$ can also be formed from propan-1-ol and potassium dichromate(VI).
State the conditions required.

..... [1]

May/June 2023 9701/22 · Q3 (b)

- (vi) Propene also reacts with steam. A mixture of organic products is produced.

Explain why propan-2-ol is produced in the higher yield.

.....
.....
..... [2]

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- (iii) Under certain conditions, 0.0020 mol of **Q** reacts with an excess of sodium to produce a total of 44.8 cm^3 of gas at s.t.p.

Calculate the number of hydroxyl groups present in a molecule of **Q**.

Show your working.

number of hydroxyl groups = [2]

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- (ii) Use the information in (a) and (b)(i) to draw the structure of **X** in the box in Fig. 5.3.

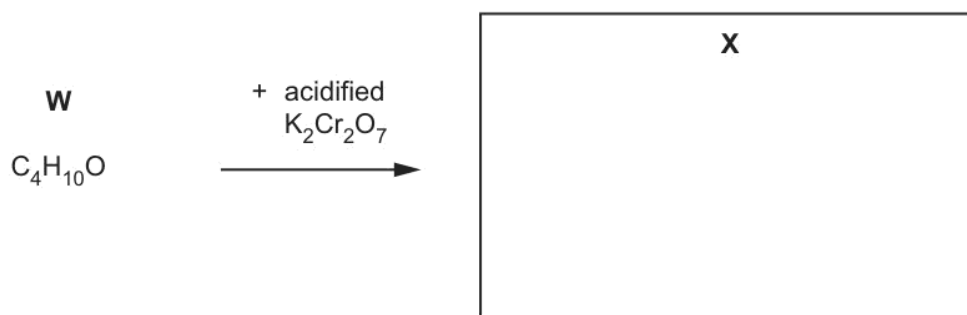


Fig. 5.3

[1]

May/June 2024 9701/22 · Q5 (b)(ii)

(d) **Y** is made from **Q** in a three-step reaction.

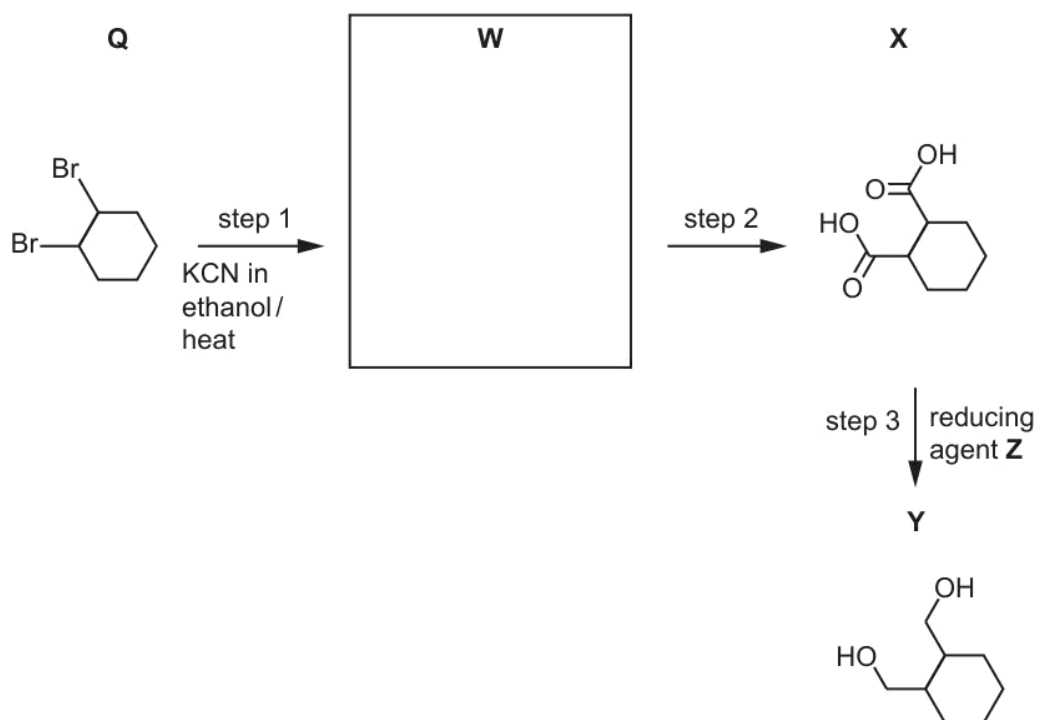


Fig. 5.4

(i) Draw the structure of **W** in the box in Fig. 5.4.

[1]

- (a) Table 4.1 gives details of tests on **J** to **M**. In each test, only **two** compounds give a positive result.

Complete Table 4.1.

Table 4.1

reagent	observation of positive result	compounds that give a positive result
acidified $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$		J and L
alkaline $\text{I}_2(\text{aq})$	yellow precipitate	
	orange precipitate	J and K
$\text{Na}(\text{s})$		

[5]



(b) **K** reacts with HCN in the presence of a KCN catalyst, forming **N**.

(i) Complete Fig. 4.2 to show the mechanism for this reaction.

Include charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.



Fig. 4.2

[4]

(ii) Identify the class of compound of which **N** is a member.

..... [1]

- (iv) Suggest **two** reasons why hot concentrated acidified potassium manganate(VII) is **not** a suitable reagent for producing **Q** from vitamin C.

1

.....

2

.....

[2]

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- (e) Alkene **Z** contains two C=C bonds. **Z** reacts with an excess of hot concentrated acidified KMnO_4 to produce **only** CH_3COCH_3 , $\text{HOOCCH}_2\text{COOH}$, CO_2 and H_2O .

Suggest the structure of **Z**.

[2]

[Total: 16]

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- (ii) Identify the gas produced when Na(s) is added to separate samples of each alcohol.

..... [1]

- (iii) Describe the role of Na(s) when it reacts with alcohols.

..... [1]

- (d) Table 4.1 shows the results of two tests on separate samples of **A**, **B** and **C**.

Table 4.1

compound	heat under reflux with acidified $\text{K}_2\text{Cr}_2\text{O}_7$	warm with alkaline $\text{I}_2(\text{aq})$
A	remains orange	no visible change
B	orange to green	no visible change
C	orange to green	pale yellow precipitate

- (i) Deduce the structure of **A**.

[1]

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- (iii) State the systematic name of the alcohol used to make **E**.

..... [1]

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- (d) **F** is an isomer of **E**.

F reacts with HCl(aq) to produce **G** and **H**.

G is a secondary alcohol.

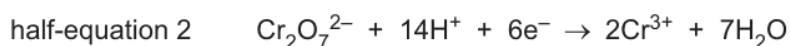
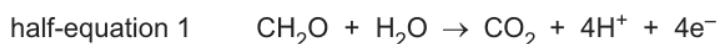
H is also produced when HCl(aq) is added to CH_3CN .

- (i) Construct an equation for the acid hydrolysis of CH_3CN with HCl(aq) .

..... [1]

May/June 2025 9701/24 · Q4 (c)(iii), (d)(i)

- (c) Acidified dichromate(VI) ions will convert methanal, CH_2O , to carbon dioxide. The movement of electrons to or from relevant species is shown in the following half-equations.



- (i) Identify the species that is reduced in half-equation 2. Explain your answer.

..... [1]

Oct/Nov 2025 9701/21 · Q1 (c)(i)

- (e) Cyclopentene, C_5H_8 , reacts with hot concentrated acidified $KMnO_4$ to form compound **W**, $C_5H_8O_4$.
- (i) Draw the structure of **W**.

[1]

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- (c) Reaction 3 takes place when $CH_3CH_2CH_2OH$ is heated under reflux with acidified potassium dichromate(VI) solution.
- (i) State the colour change that takes place in the reaction mixture.

..... [1]

Oct/Nov 2025 9701/22 · Q4 (c)(i)

- (iv) **Q** is oxidised by hot concentrated acidified $KMnO_4(aq)$, forming two different organic products.

Construct an equation for this reaction. Use [O] to represent an atom of oxygen from the oxidising agent.

$(CH_3)_2C=CHCH_3$ [2]

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