1. The boiling point of butan-1-ol is 118 °C. The boiling point of 2-methylpropan-2-ol is 82 °C.

Why is the boiling point of butan-1-ol higher than that of 2-methylpropan-2-ol?

A butan-1-ol has stronger induced dipole–dipole interactions because it has more electrons

B butan-1-ol has stronger induced dipole–dipole interactions because it has a straight-chain structure → chains can pack together closer

C butan-1-ol can form hydrogen bonds while 2-methylpropan-2-ol cannot

D butan-1-ol is more stable because it is a primary alcohol

Your answer B

[1]

Hydrogen bromide reacts with 3-methylbut-1-ene. Electrophilic addition

What is the structure of the major intermediate formed in the mechanism?

2. This question is about alcohols.

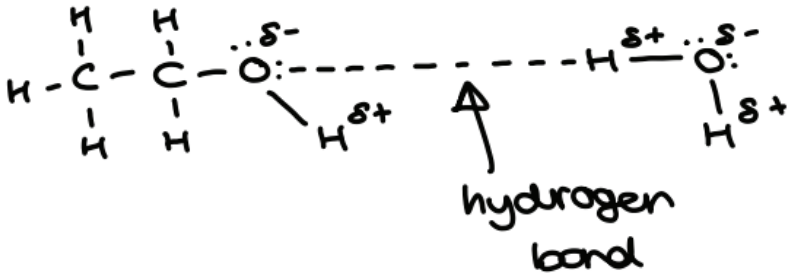
(a) Construct an equation for the complete combustion of an unsaturated alcohol with 5 carbon atoms.

$C_5H_{10}O + 7O_2 \longrightarrow 5CO_2 + 5H_2O$ **[1]**

(b) Many alcohols, including ethanol, are soluble in water.

(i) Explain, with the aid of a diagram, why ethanol is soluble in water.

Include relevant dipoles and lone pairs.



[2]

(ii) The solubility of hexan-1-ol and hexane-1,6-diol in water is shown below in **Table 19.1**.

Alcohol	Solubility in water / g dm^{-3}
hexan-1-ol	5.9
hexane-1,6-diol	500

Table 19.1

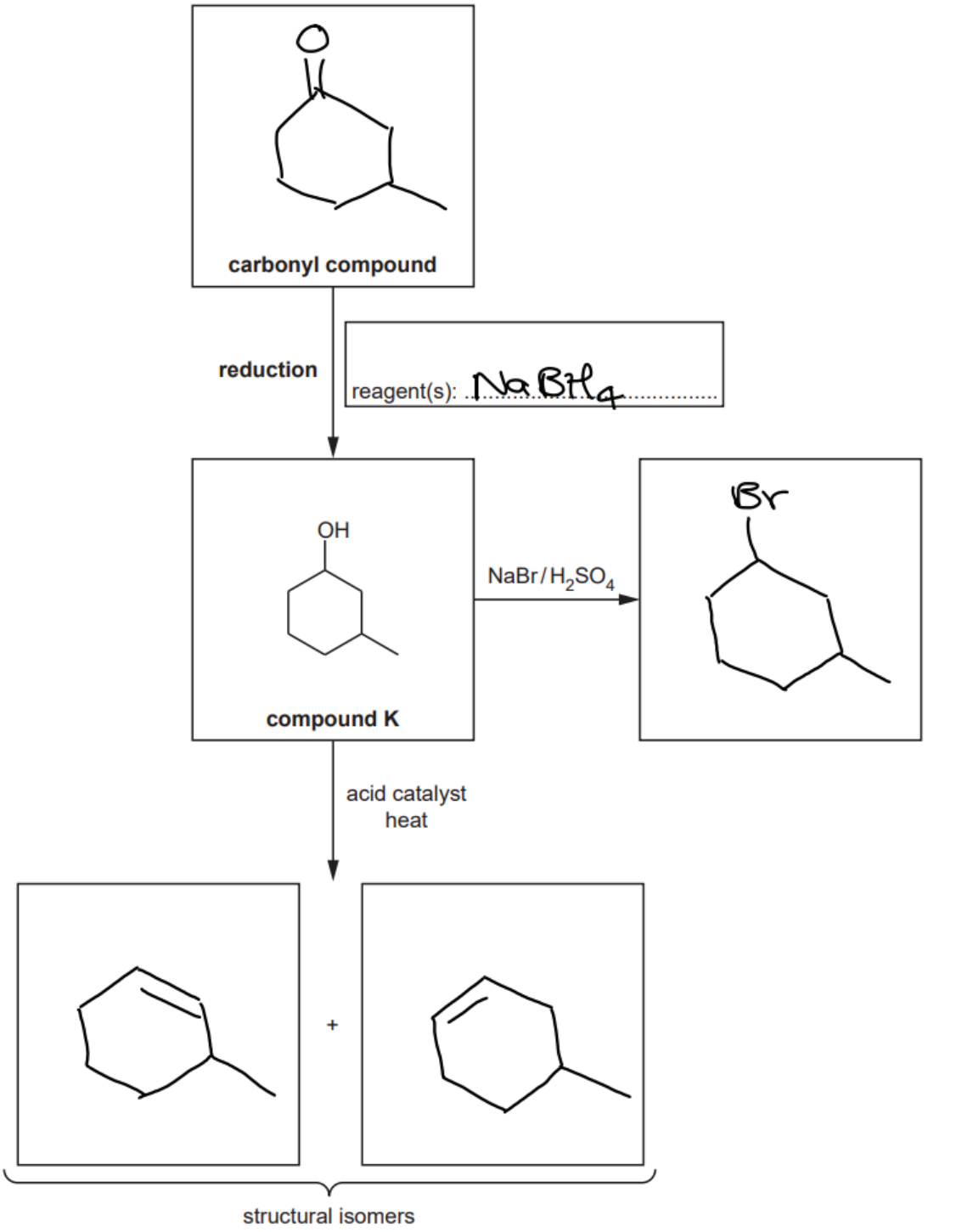
Explain the difference in solubility of hexan-1-ol and hexane-1,6-diol.

hexane-1,6-diol has more OH groups therefore can form more hydrogen bonds in water

[1]

(c) Alcohols are important in organic synthesis and can be formed by the reduction of carbonyl compounds.

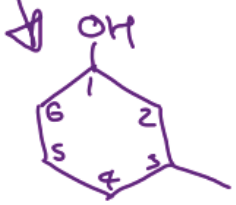
(i) Complete the flowchart by filling in each box.



[5]

(ii) What is the name of compound **K**?

3-methyl cyclohexanol [1]



(d) Butan-1-ol can be oxidised to form two different organic products, depending on the reaction conditions used.

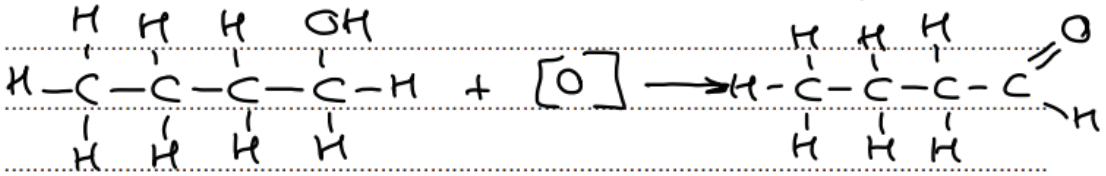
Describe both oxidation reactions of butan-1-ol.

For each reaction include

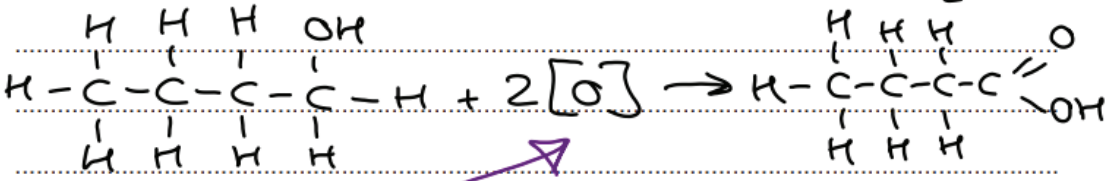
- the structure of the organic product
- a balanced equation
- the essential reaction conditions.

In your equations you may use [O] to represent the oxidising agent.

distillation: H^+, $Cr_2O_7^{2-}$



$+ H_2O$



reflux: H^+, $Cr_2O_7^{2-}$

balanced equation with different ratio of [O] compared to aldehydes [5]

3. Ethanol can be prepared by different reactions.

atom economy = $\frac{M_r \text{ (desired product)}}{\text{sum of } M_r \text{ for all reactants}} \times 100$

Which reaction has the lowest atom economy?

A $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

B $C_2H_4 + H_2O \rightarrow C_2H_5OH$ – 1 product ∴ 100% atom economy

C $C_2H_5Br + H_2O \rightarrow C_2H_5OH + HBr$ – Br is a very high A_r atom ∴ lowering atom economy

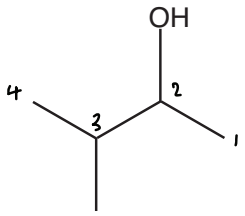
D $CH_3COOC_2H_5 + H_2O \rightarrow C_2H_5OH + CH_3COOH$

Your answer C

CO_2 and CH_3COOH are lower M_r side products than HBr (good approximation without using equation!) **[1]**

4. This question is about reactions of organic compounds containing carbon, hydrogen and oxygen.

(a) A chemist investigates two reactions of alcohol **A**, shown below.



alcohol A

(i) What is the systematic name of alcohol **A**?

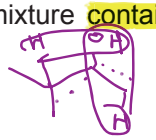
3-methylbutan-2-ol ..... **[1]**

(ii) What is the structural formula of alcohol **A**?

$(CH_3)_2CHCHOHCH_3$ ..... **[1]**

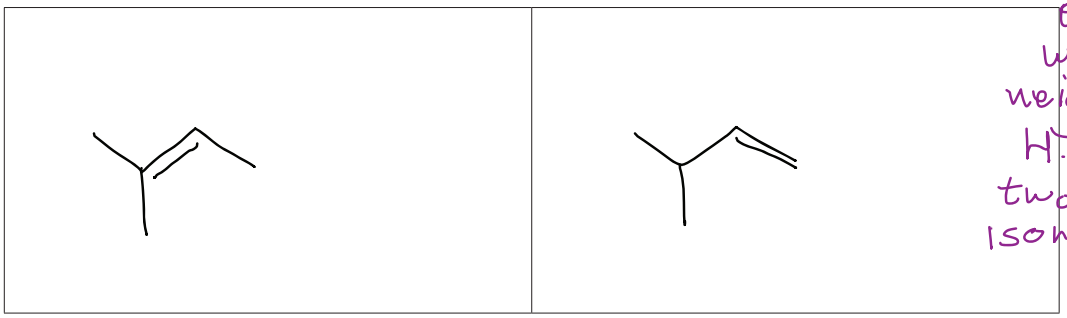
(iii) The chemist heats alcohol **A** with an acid catalyst to form a mixture containing **two** alkenes.

elimination reaction



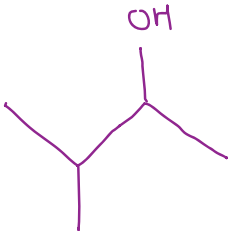
OH is eliminated with either neighbouring H. Forming two structural isomers.

Draw the structures of the **two** alkenes formed in this reaction.

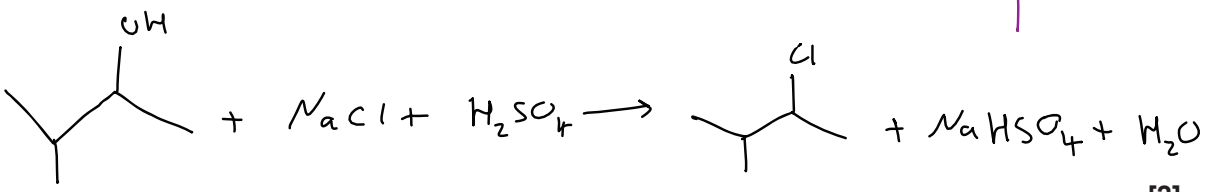


[2]

(iv) The chemist heats alcohol **A** with sodium chloride and sulfuric acid.



Construct a balanced equation for this reaction.
Show structures for the organic compounds in your equation.

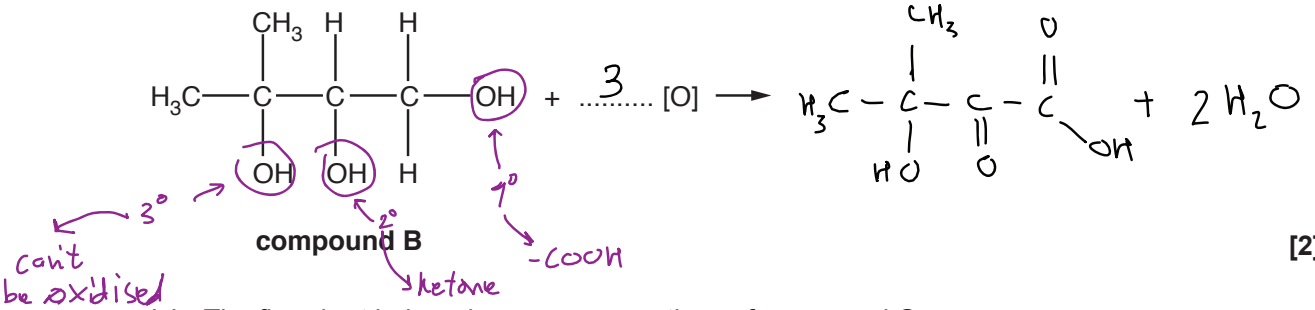


[2]

oxidising agent

(b) Compound **B**, shown below, is refluxed with excess acidified potassium dichromate(VI) to form a single organic product.

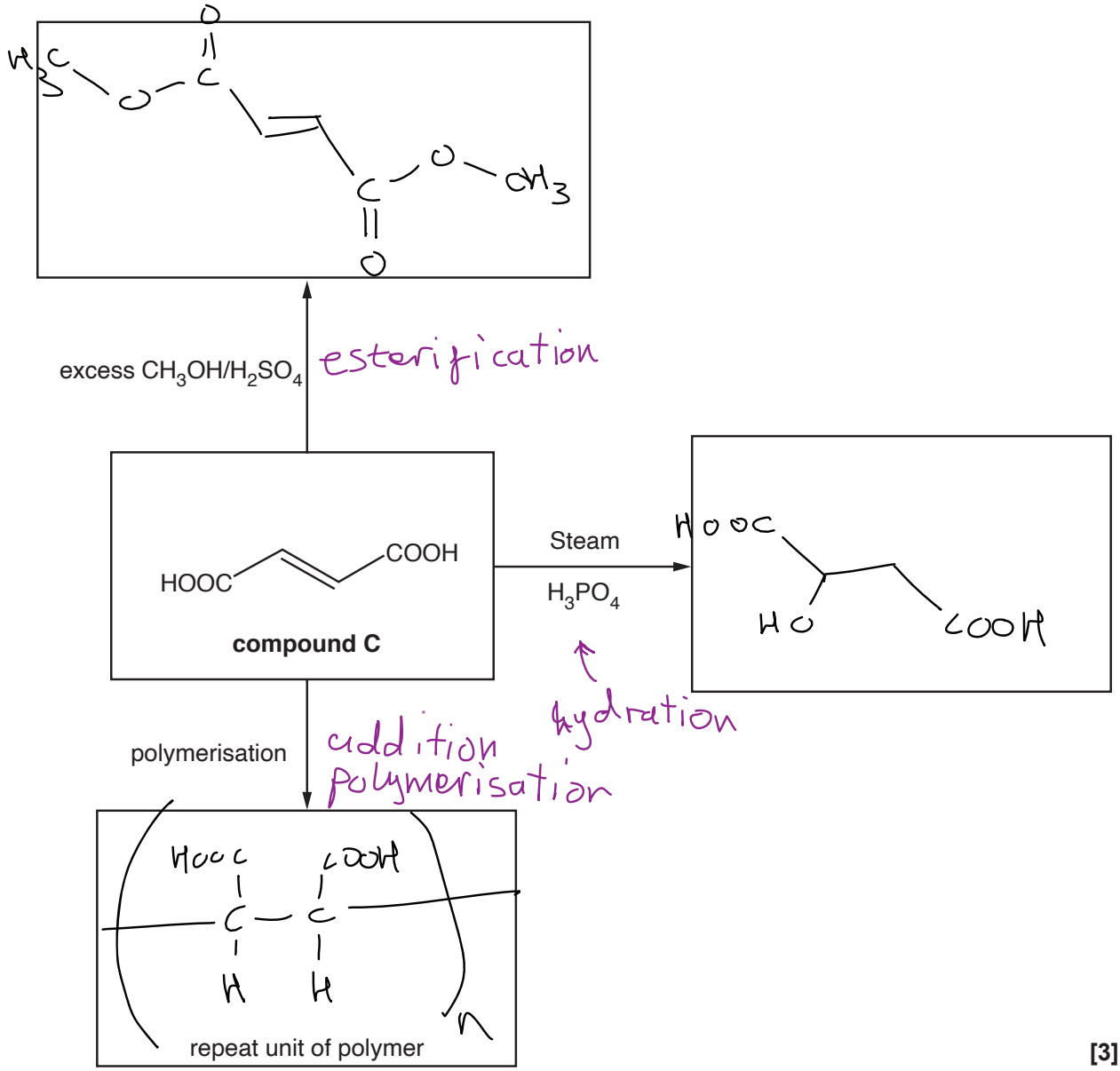
Complete the equation for this reaction.



[2]

(c) The flowchart below shows some reactions of compound **C**.

In the boxes, draw the organic products of these reactions.



[3]

5. Which of these reagent(s) will **not** react with $HOCH_2CH_2CH_2COOH$?

alcohol carboxylic acid

A NaCN in ethanol reagents for haloalkane → nitrile

B C_2H_5OH in the presence of an acid catalyst esterification with COOH

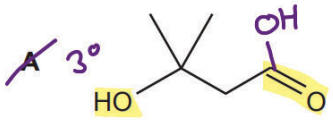
C $(CH_3CO)_2O$ = acid anhydride + OH → ester

D concentrated H_2SO_4 OH → alkene

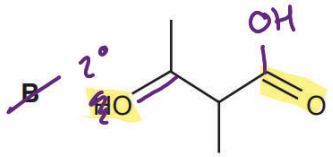
Your answer A

[1]

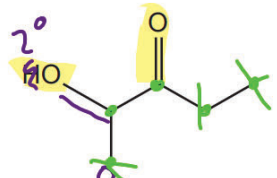
6. Which compound can be refluxed with acidified potassium dichromate(VI) to form an organic product with molecular formula $C_5H_8O_2$?

A 

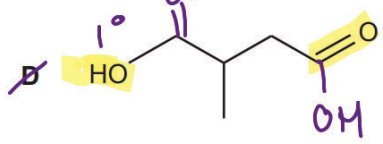
30's

B 

30's

C 

$C_5H_8O_2$

D 

40's

Your answer C

[1]

7. Which alcohol reacts with an acid catalyst to form a mixture of stereoisomers?

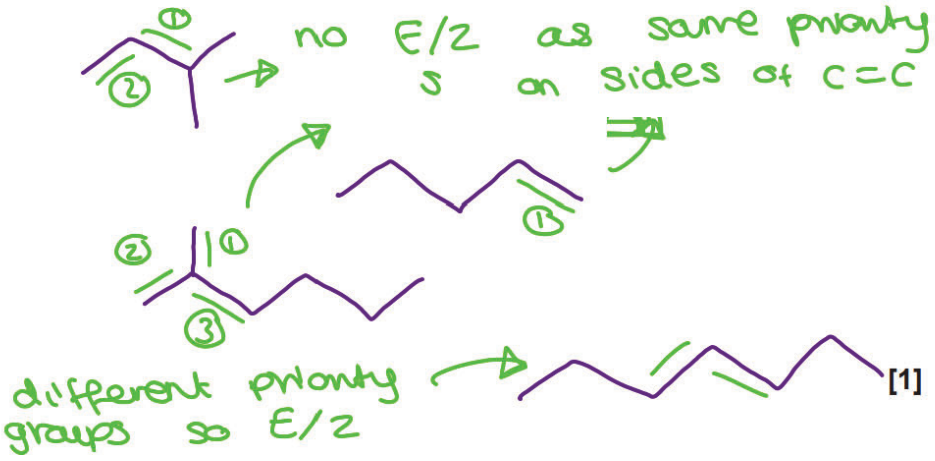
~~A~~ 3-methylbutan-2-ol

~~B~~ pentan-1-ol

~~C~~ 2-methylhexan-2-ol

D heptan-4-ol

Your answer D



[1]

8. Which of the following reactions produce propan-1-ol?

✓ 1 The alkaline hydrolysis of 1-chloropropane.

✓ 2 The acid hydrolysis of propyl methanoate.

~~✓~~ 3 The acid hydrolysis of propanenitrile.

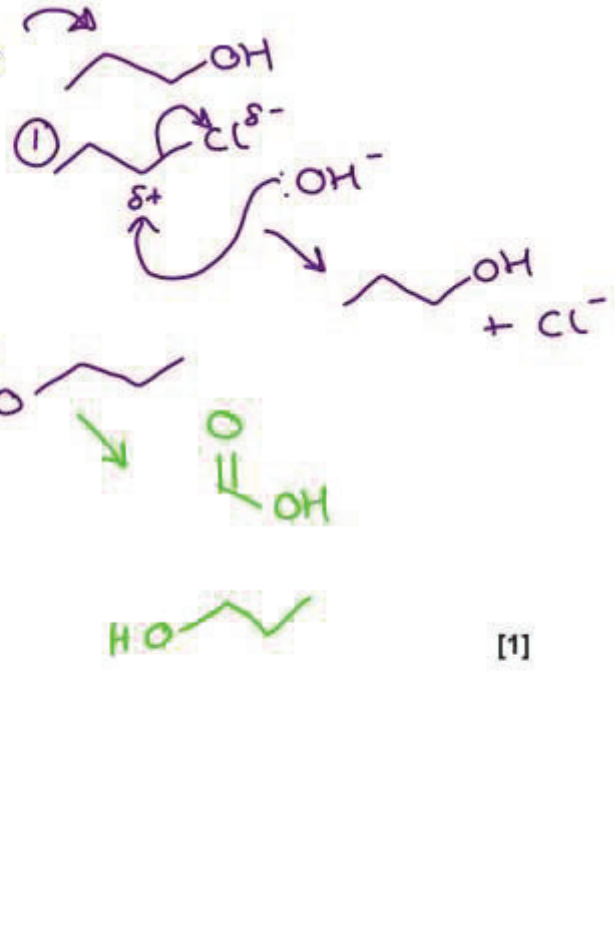
A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer B



[1]

9. Alcohols can be used to prepare organic compounds with different functional groups.

(a) $HO(CH_2)_4OH$ can be oxidised to form $HOOC(CH_2)_2COOH$.

(i) State the reagents and conditions and write an equation for this oxidation.

In the equation, use [O] for the oxidising agent.

Reagents and conditions: $K_2Cr_2O_7$, H^+ (acidified) and reflux distillation would form an aldehyde

Equation:

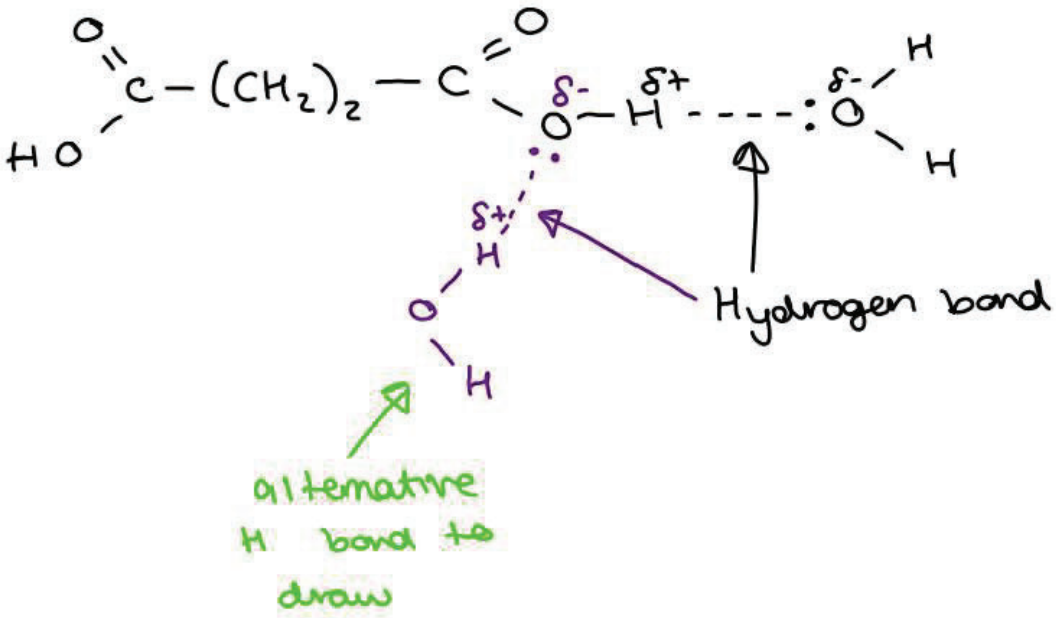
$$HO(CH_2)_4OH + 4[O] \longrightarrow HOOC(CH_2)_2COOH + 2H_2O$$

balance the lost H's in H_2O

[3]

(ii) $HOOC(CH_2)_2COOH$ is soluble in water.

Explain, using a labelled diagram, why $HOOC(CH_2)_2COOH$ is soluble in water.



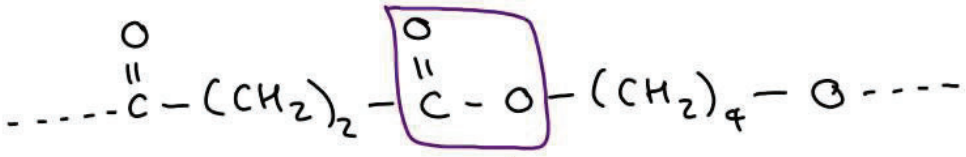
[2]

(b) $HOOC(CH_2)_2COOH$ and $HO(CH_2)_4OH$ react together to form polymer **E**.

alcohol + carboxylic acid → ester + water

(i) Draw **one** repeat unit of polymer **E**.

The functional groups should be clearly displayed.



ester link (one repeat unit = one ester link)

[2]

(ii) Governments are encouraging the development of biodegradable polymers to reduce dependency on persistent plastic waste derived from fossil fuels.

Polymer **E** is a biodegradable polymer.

Suggest why polymer **E** is able to biodegrade.

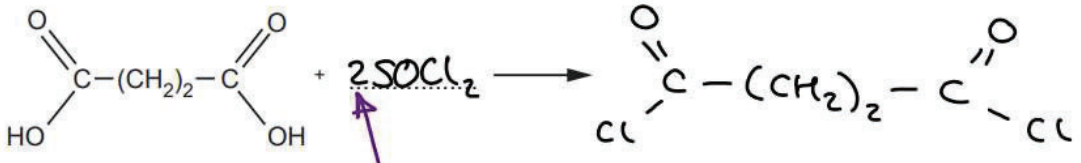
ester group can be broken down via hydrolysis **[1]**

(iii) A large yield of polymer **E** can be obtained by reacting a diacyl dichloride with $HO(CH_2)_4OH$.

The diacyl dichloride is prepared from $HOOC(CH_2)_2COOH$.

reaction map shows this

Complete the equation for the formation of a diacyl dichloride from $HOOC(CH_2)_2COOH$.



because diacyl dichloride

$+ 2SO_2 + 2HCl$

OH's lost from carboxylic acid and balanced here

[3]