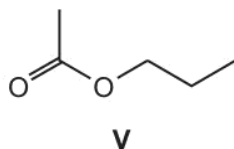


- (a) The structure of ester **V** is shown.



- (i) Name **V**.

..... [1]

V reacts with a reagent to form a salt of a carboxylic acid and an alcohol.

- (ii) Identify a reagent that could be used in this reaction.

..... [1]

- (iii) Draw the displayed formula of the alcohol made during this reaction.

[1]

- (iv) State one other possible use for **V**, apart from as a food flavouring.

..... [1]

- (b) Ester **W** is made up of 54.5% carbon, 9.1% hydrogen and 36.4% oxygen.

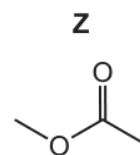
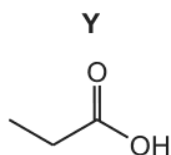
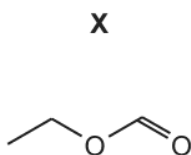
- (i) Calculate the empirical formula of **W**.

[3]

- (ii) State what additional information is required to determine the molecular formula of **W**.

..... [1]

(c) Compounds **X**, **Y** and **Z** are shown. They all have the same molecular formula.



(i) Deduce the molecular formula of **X**, **Y** and **Z**.

..... [1]

(ii) In three experiments, sodium is added to separate samples of **X**, **Y** and **Z**.

Complete the table to show the observations for each of these three experiments. Ignore any temperature changes which may occur.

experiment	observations
Na + X	
Na + Y	
Na + Z	

[2]

(d) Sodium carbonate solution reacts with methanoic acid.

Write the equation for this reaction.

..... [1]

[Total: 12]

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12

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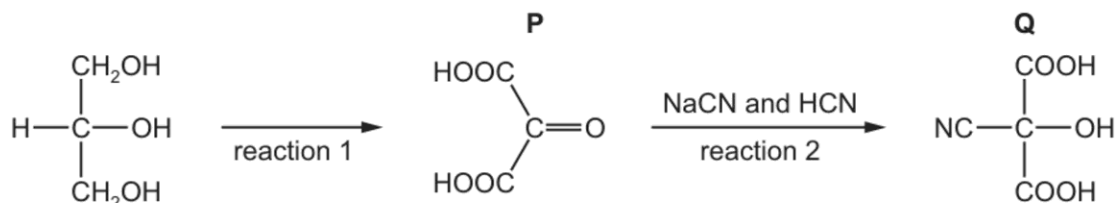
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9701/22/M/J/19

May/June 2019 9701/22 · Q5 (a)(i), (a)(ii), (a)(iii), (a)(iv), (b)(i), (b)(ii), (c)(i), (c)(ii), (d) (cont.)

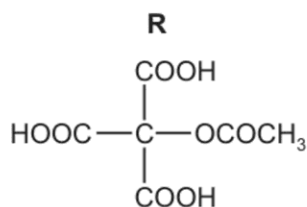
(a) A series of reactions starting from glycerol is shown.



(i) Suggest the reagent(s) and conditions for reaction 1.

.....
 [2]

(v) When **Q** is heated with excess aqueous ethanoic acid in the presence of a catalytic amount of sulfuric acid, two reactions take place to form compound **R**.

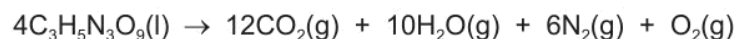


Identify the two types of reaction that occur.

1
 2 [2]

- (b) Glycerol can be used as a starting material in the manufacture of nitroglycerine, $C_3H_5N_3O_9$.

Nitroglycerine decomposes rapidly on heating to form a mixture of gases.



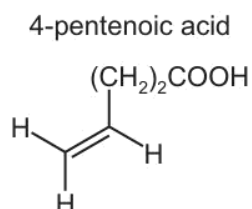
A sample of nitroglycerine decomposes, releasing 1.06 dm^3 of $O_2(g)$ at 850 K and $1.00 \times 10^5 \text{ Pa}$.

- (i) Calculate the mass of nitroglycerine that decomposes.

mass of nitroglycerine = g [3]

- (c) Fats are compounds made from glycerol and unsaturated carboxylic acids.

4-pentenoic acid is an example of an unsaturated carboxylic acid.



- (i) Give the molecular formula of 4-pentenoic acid.

..... [1]

- (d) A reaction of another unsaturated carboxylic acid, **T**, is shown.



- (i) **T** is one of a pair of geometrical (*cis-trans*) isomers.

Draw the other geometrical isomer of **T** and explain why the molecules exhibit this form of isomerism.

.....
.....
..... [3]

- (ii) Identify the reagent used to convert **T** to **U**.

..... [1]

March 2020 9701/22 · Q3 (a)(i), (a)(v), (b)(i), (c)(i), (d)(i), (d)(ii) (cont.)

- (iii) From the list, identify a species which can be used to distinguish between solutions of propanoic acid and propan-1-ol. Describe any relevant observations.

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

May/June 2020 9701/21 · Q5 (a)(iii)

- (f) Propanoic acid, $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$, is reduced by LiAlH_4 .

- (i) Write an equation to show this reaction. Use $[\text{H}]$ to represent an atom of hydrogen from the reducing agent.

..... [1]

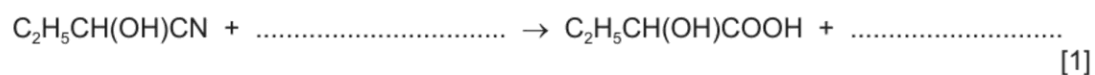
- (g) Organic compound **W** is an ester which is a structural isomer of propanoic acid.

- (i) State the molecular formula of **W**.

..... [1]

May/June 2020 9701/21 · Q6 (f)(i), (g)(i)

- (iv) Complete the equation for the reaction in step 2, when **S** is heated under reflux with HCl(aq) .



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Oct/Nov 2020 9701/21 · Q3 (c)(iv)

- (b) **V** contains two types of functional group: a carboxylic acid and an alkene.

- (i) Describe a chemical test and observation which confirms the presence of a carboxyl functional group.

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

May/June 2022 9701/21 · Q4 (b)(i)

- (c) Biodiesel **T** is a fuel made from vegetable oil **R**. Fig. 5.1 shows the production of **T** from **R** in a two-step process.

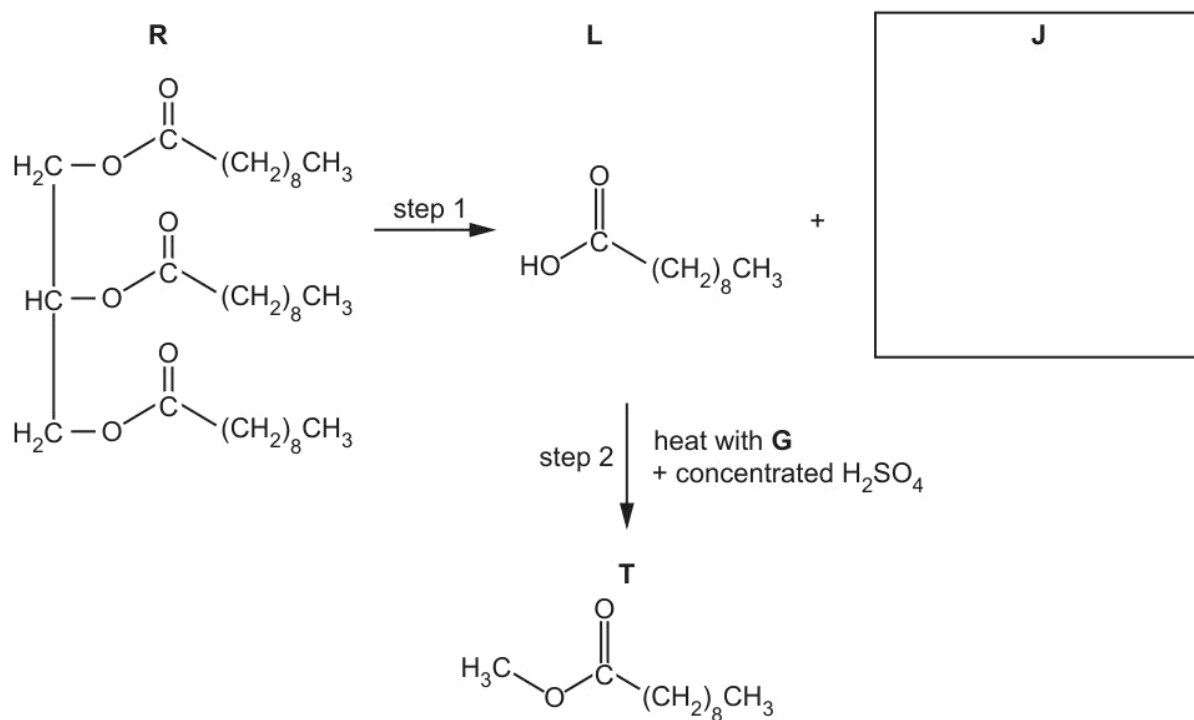


Fig. 5.1

- (i) In step 1 all three ester groups in **R** react. Suggest a suitable reagent and conditions for step 1.

..... [1]

- 4 (a) Propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$, reacts with reducing agent **Q** to produce propan-1-ol, $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$.

(i) Suggest the formula of reducing agent **Q**.

..... [1]

(ii) Complete the equation to show the reduction of propanoic acid to propan-1-ol.
Use [H] to represent one atom of hydrogen from **Q**.

..... $\text{CH}_3\text{CH}_2\text{COOH}$ +[H] → [1]

(ii) Identify the reagent and conditions required in step 2.

..... [1]

(iv) Name the type of reaction that occurs in step 3.

..... [1]

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(ii) Deduce a possible name for **B**.

..... [1]

May/June 2025 9701/22 · Q4 (a)(i), (a)(ii), (b)(ii), (b)(iv), (d)(ii), (d)(iii) (continued ·)

(iii) Deduce the identity of **C**.

..... [1]

[Total: 13]

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[Turn over]

12

May/June 2025 9701/22 · Q4 (a)(i), (a)(ii), (b)(ii), (b)(iv), (d)(ii), (d)(iii) (cont.)

(c) **E** is made when a carboxylic acid and an alcohol react together.

(i) Name the type of reaction that takes place during this esterification reaction.

..... [1]

(ii) Write an equation for the formation of **E** from a carboxylic acid and an alcohol. Use structural formulae to represent the organic species.

..... [1]

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

(d) **W** reacts with reagent **X** to produce ethanoic acid and pentanoic acid.

(i) State the role of **X** in this reaction.

..... [1]

May/June 2025 9701/24 · Q5 (d)(i)

(d) $\text{CH}_3\text{CH}_2\text{COOH}$ reacts with an unsaturated alcohol **R** to form unsaturated ester **S**.

(i) State the **type** of reaction that forms **S**.

..... [1]

Oct/Nov 2025 9701/22 · Q4 (d)(i)