

PROSPERITY ACADEMY

**AS CHEMISTRY 9701**

**Crash Course**

RUHAB IQBAL

# **CARBOXYLIC ACIDS AND ESTERS**

**COMPLETE NOTES**



**0331 - 2863334**



**ruhab.prosperityacademics  
@gmail.com**



Carboxylic Acids:- Organic compounds containing the functional group  $-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{H}$

Physical properties:-

- higher melting and boiling points due to hydrogen bonding and permanent dipoles.
- small carboxylic acids are soluble in water due to hydrogen bonding

Formation of Carboxylic acids:-

- 1) Through oxidation of primary alcohol & aldehyde:- Done already in Alcohols and Aldehydes
- 2) Through nitrile hydrolysis:- Done already in Alcohols

Chemical properties:- Carboxylic acids show the following reactions.

1) All acid-like reactions



2) Esterification:- Already discussed in Alcohols

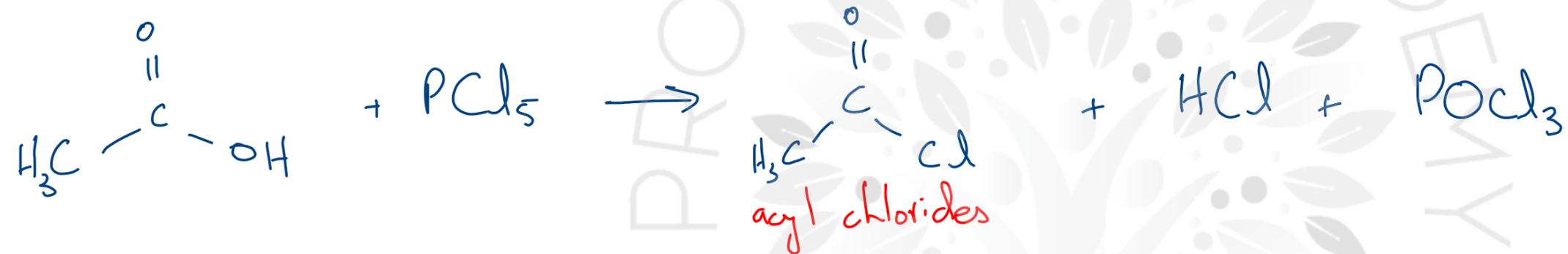
Observation: effervescence

3) Reduction:-  $\text{LiAlH}_4$  in dry ether



- $\text{NaBH}_4$  cannot be used (Its not strong enough)
- Reaction will always give alcohol, cannot be stopped at aldehyde

4) Chlorination:-  $\text{PCl}_5$  is used (test for OH)

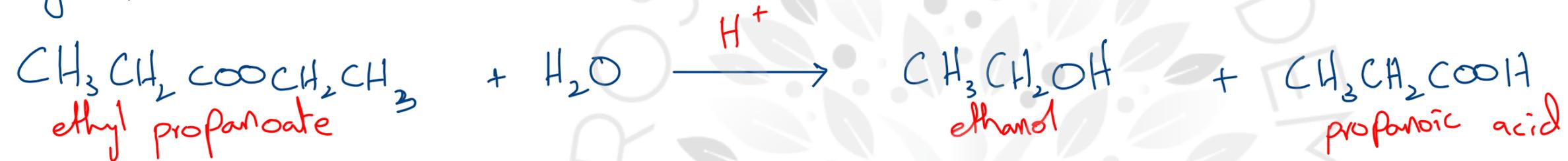


Esters:- Organic compounds containing  $-\overset{\overset{\text{O}}{\parallel}}{\text{C}}-\text{O}-$

Uses:- perfumes, glue, artificial food flavourings

Hydrolysis of esters:-

1) Using Acidic conditions:-



2) Using Alkaline conditions:-

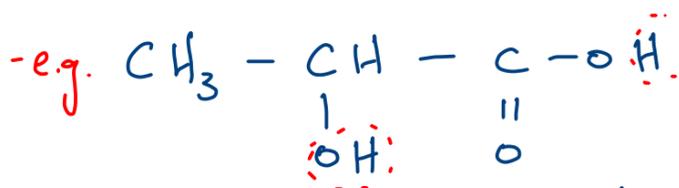
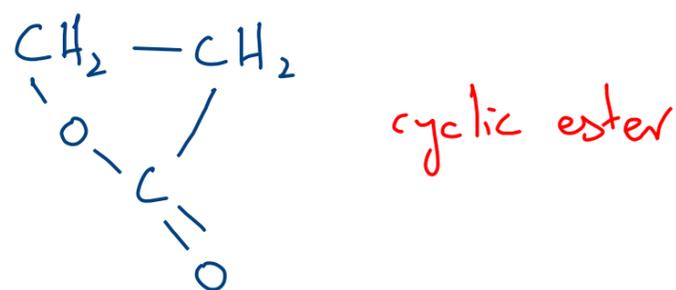
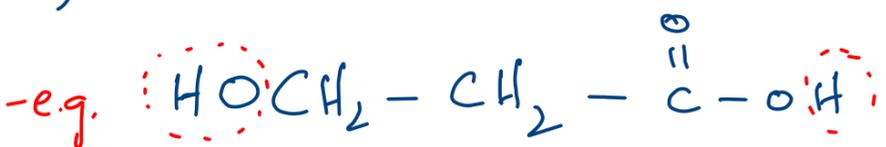


- A lot more better than 1st reaction as alcohol can be distilled easily
- Then dil HCl can be added to convert salt to carboxylic acid
- Then distil off acid.

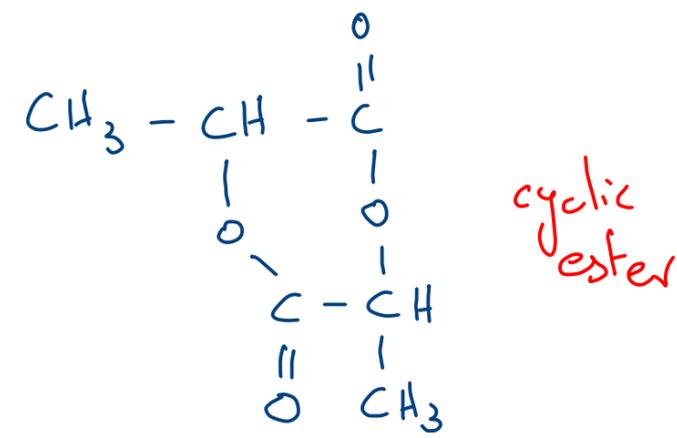
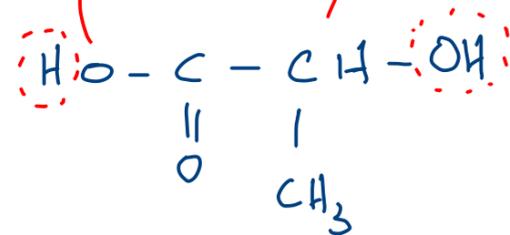
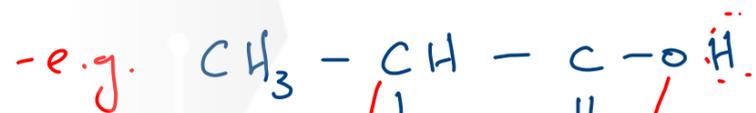
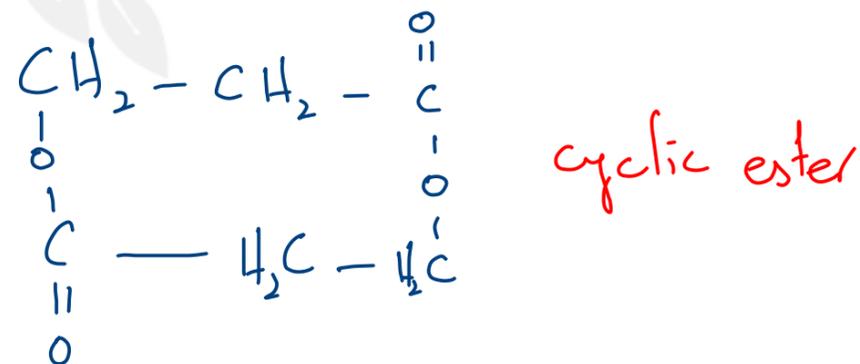
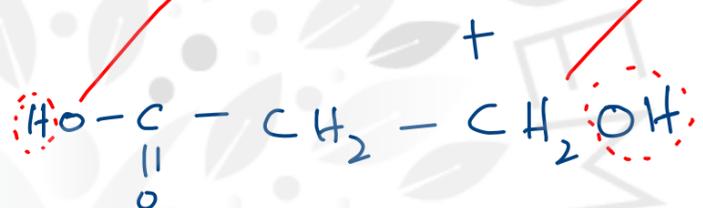
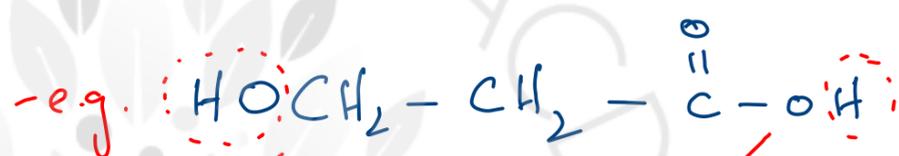
**Hydroxy Carboxylic Acids:-** Organic compounds containing OH and COOH groups.

When heated with conc.  $H_2SO_4$ , hydroxy carboxylic acids can make esters with themselves:-

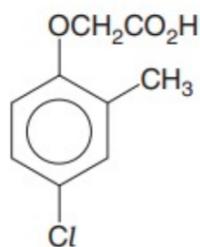
1) Self esterification



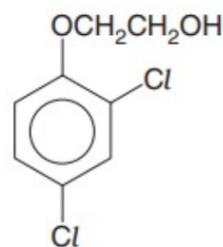
2) Esterification with another unit



2 MCPA and 2,4-D are two widely-used selective weedkillers.



MCPA

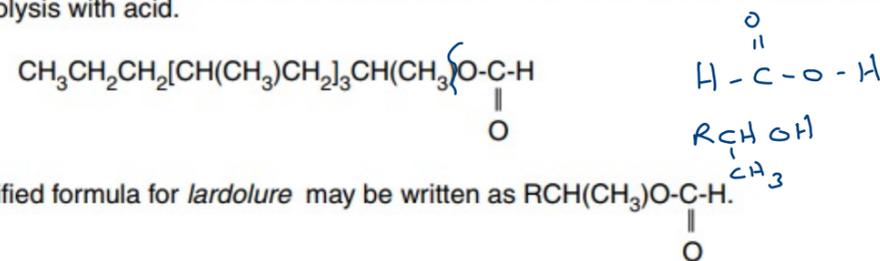


2,4-D

Which reagent will distinguish MCPA from 2,4-D?

- A acidified  $\text{AgNO}_3(\text{aq})$
- B Fehling's solution
- C Na
- D**  $\text{Na}_2\text{CO}_3(\text{aq})$

3 The acarid mite releases *lardolure* to attract other mites to a host: this chemical can be destroyed by hydrolysis with acid.

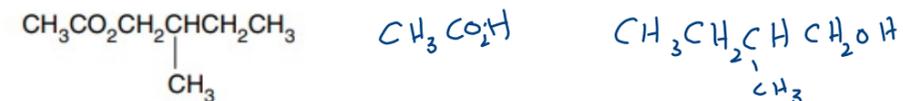


A simplified formula for *lardolure* may be written as  $\text{RCH}(\text{CH}_3)\text{O}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$ .

What are the products of its hydrolysis?

- A  $\text{RCH}(\text{CH}_3)\text{CO}_2\text{H} + \text{CH}_3\text{OH}$
- B  $\text{RCH}(\text{CH}_3)\text{CO}_2\text{H} + \text{HCO}_2\text{H}$
- C  $\text{RCH}(\text{CH}_3)\text{OH} + \text{CO}_2$
- D**  $\text{RCH}(\text{CH}_3)\text{OH} + \text{HCO}_2\text{H}$

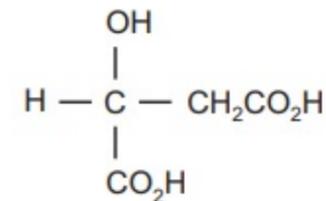
4 An ester with an odour of banana has the following formula.



In which of the following do the substances react together, under suitable conditions, to produce this ester?

- A  $\text{CH}_3\text{CH}_2\underset{\text{CH}_3}{\text{CH}}\text{CH}_2\text{CO}_2\text{H} + \text{CH}_3\text{OH}$
- B  $\text{CH}_3\text{CH}_2\underset{\text{CH}_3}{\text{CH}}\text{CO}_2\text{H} + \text{CH}_3\text{CH}_2\text{OH}$
- C**  $\text{CH}_3\text{CO}_2\text{H} + \text{CH}_3\text{CH}_2\underset{\text{CH}_3}{\text{CH}}\text{CH}_2\text{OH}$
- D  $\text{CH}_3\text{CO}_2\text{H} + \text{CH}_3\text{CH}_2\underset{\text{CH}_3}{\text{CH}}\text{CH}_2\text{OH}$

7 Malic acid occurs in apples.

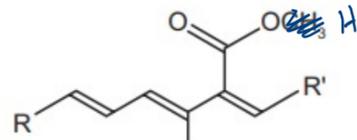


malic acid

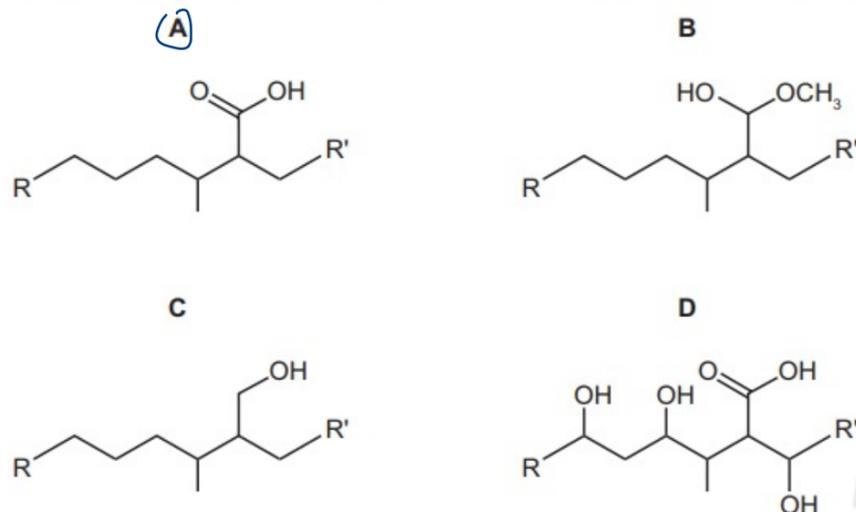
Which substance will react with all three  $-\text{OH}$  groups present in the malic acid molecule?

- A ethanol in the presence of concentrated sulphuric acid
- B potassium hydroxide
- C** sodium
- D sodium carbonate

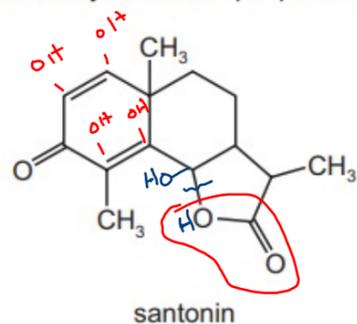
25 Part of the structure of strobilurin, a fungicide, is shown. R and R' are inert groups.



If strobilurin is first warmed with aqueous sulfuric acid, and its product then treated with hydrogen in the presence of a palladium catalyst, what could be the structure of the final product?



39 Santonin is a drug that was once widely used to expel parasitic worms from the body.

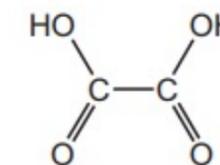


When santonin is first treated with warm dilute  $\text{H}_2\text{SO}_4$ , and then the product of this reaction is treated with cold acidified  $\text{KMnO}_4$ , a final product **X** is obtained.

How many atoms of hydrogen in each molecule of product **X** can be displaced with sodium metal?

- A 2      B 4      C 5      (D) 6

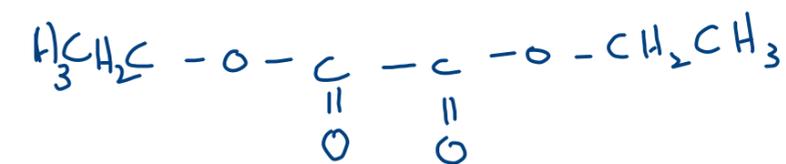
46 The diagram shows the structure of ethanedioic acid.



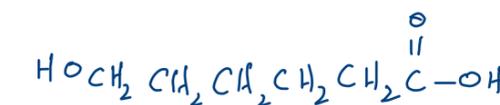
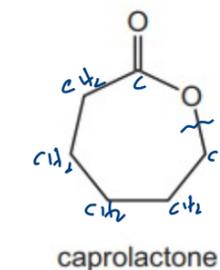
Ethanedioic acid reacts with ethanol in the presence of a few drops of concentrated sulfuric acid to form a diester. The molecular formula of the diester is  $\text{C}_6\text{H}_{10}\text{O}_4$ .

What is the structural formula of the diester?

- A  $\text{CH}_3\text{CH}_2\text{CO}_2\text{CO}_2\text{CH}_2\text{CH}_3$   
 (B)  $\text{CH}_3\text{CH}_2\text{OCOCOC}_2\text{H}_5$   
 C  $\text{CH}_3\text{CH}_2\text{O}_2\text{CO}_2\text{CCH}_2\text{CH}_3$   
 D  $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_2\text{OCOCH}_3$



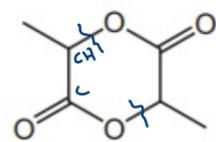
70 Caprolactone is a cyclic ester. It is being used increasingly for the manufacture of specialist polymers.



From which compound could caprolactone be made by a single reaction?

- A  $\text{OHCCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$   
 B  $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$   
 (C)  $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$   
 D  $\text{HO}_2\text{CCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$

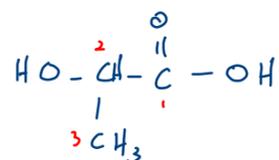
82 Lactide is an intermediate in the manufacture of a synthetic fibre.



lactide

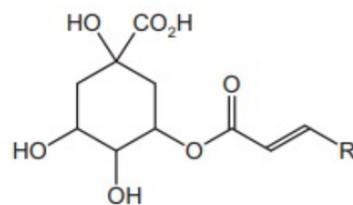
Which compound, on heating with an acid catalyst, can produce lactide?

- A hydroxyethanoic acid
- B 2-hydroxybutanoic acid
- C 2-hydroxypropanoic acid**
- D 3-hydroxypropanoic acid



2-hydroxy propanoic acid

86 Chlorogenic acid is found in green coffee beans and is used in treatments for weight loss.

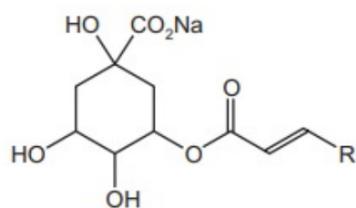


chlorogenic acid

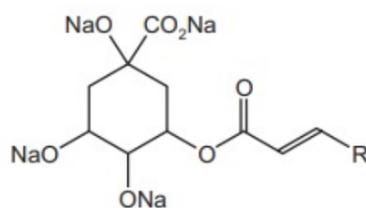
R = C<sub>6</sub>H<sub>5</sub>O<sub>2</sub> and takes no part in the reaction with sodium carbonate.

What is produced in good yield when chlorogenic acid is treated with an excess of sodium carbonate solution at room temperature?

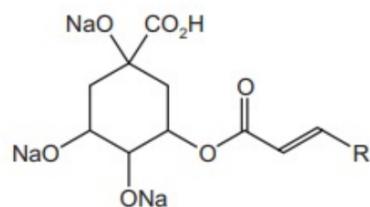
**A**



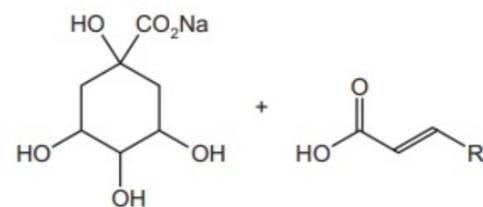
B



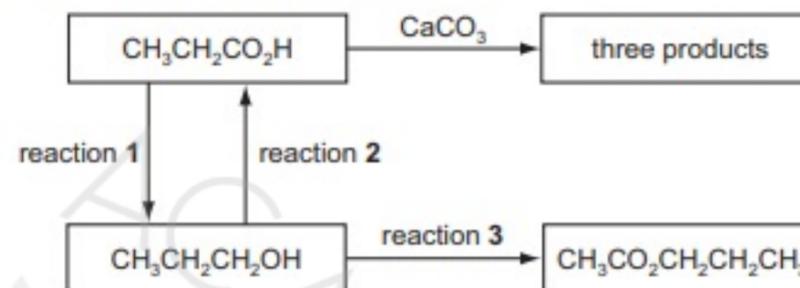
C



D



9 A series of reactions based on propanoic acid is shown.



(a) Write an equation for reaction 1, using [H] to represent the reducing agent.



(b) (i) What type of reaction is reaction 2?

oxidation

[1]

(ii) Suggest a suitable reagent and conditions for reaction 2.

Acidified K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + heat under reflux

[2]

(c) Write an equation for the reaction of propanoic acid with calcium carbonate, CaCO<sub>3</sub>.



(d) (i) Suggest a suitable reagent and conditions for reaction 3.

CH<sub>3</sub>CO<sub>2</sub>H + conc. H<sub>2</sub>SO<sub>4</sub> + heat

[2]

(ii) Identify the other product of reaction 3.

H<sub>2</sub>O

[1]

- 4 Each of the three organic compounds, **V**, **W**, and **X**, has the empirical formula  $\text{CH}_2\text{O}$ . The number of carbon atoms in each of their molecules is shown in the table.

| compound | number of C atoms |
|----------|-------------------|
| <b>V</b> | 1                 |
| <b>W</b> | 2                 |
| <b>X</b> | 3                 |

aldehyde

**V** gives a brick red precipitate when warmed with Fehling's reagent; **W** and **X** do not.

**W** is a fruity smelling liquid. ester

In **X**, the carbon atoms are bonded directly to one another.

**X** gives an effervescence when shaken with  $\text{Na}_2\text{CO}_3(\text{aq})$ ; **V** and **W** do not.

- (a) Give the structural formula of **V**.



[1]

- (b) (i) What functional group is present in **W**?

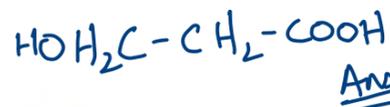
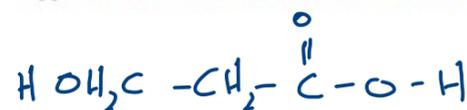
ester

- (ii) Give the structural formula of **W**.



- (c) When **X** is heated under reflux with acidified  $\text{K}_2\text{Cr}_2\text{O}_7$ , the product, **Y**, gives no reaction with 2,4-dinitrophenylhydrazine reagent. primary alcohol + carboxylic acid  
not carbonyl

- (i) Give the structural formula of **X**.



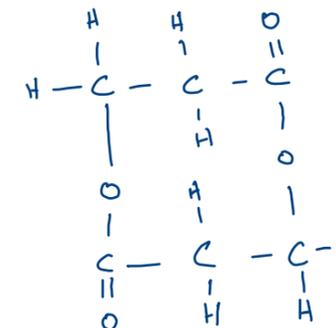
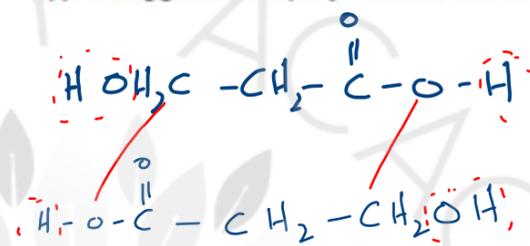
- (ii) Give the structural formula of **Y**, the compound formed from **X**.



- (d) When **X** is warmed with a little concentrated sulfuric acid, a small amount of a cyclic compound, **Z**, is formed.

**Z** has the molecular formula  $\text{C}_6\text{H}_8\text{O}_4$ .

- (i) Suggest a displayed formula for **Z**.



- (ii) What type of reaction occurs when **Z** is formed from **X**?

esterification

[2]

- 6 A student reacted together an alcohol and a carboxylic acid under appropriate conditions to produce an ester.  
A sweet smelling organic liquid, **Q**, with the empirical formula  $C_2H_4O$  was produced.  
The  $M_r$  of **Q** was found by experiment to be 87.5.

(a) What is the molecular formula of **Q**?

$$n = 87.5 / (24 + 4 + 16) \approx 2$$



[1]

(b) In the boxes below, draw the structural formulae of **four** isomers with this formula that are esters.

|                             |                             |
|-----------------------------|-----------------------------|
| $HCOOCH_2CH_2CH_3$<br><br>W | $CH_3COOCH_2CH_3$<br><br>X  |
| $CH_3CH_2COOCH_3$<br><br>Y  | $HCOOCH(CH_3)CH_3$<br><br>Z |

[4]

A sample of **Q** was hydrolysed by heating with aqueous sulfuric acid.  
The resulting mixture was heated under reflux with acidified potassium dichromate(VI) to give a **single** organic product, **R**.  
The product, **R**, was collected and subjected to the following tests.

A sample of **R** gave no reaction with Tollens' reagent.

A second sample of **R** gave no reaction with 2,4-dinitrophenylhydrazine reagent.

A third sample of **R** gave an effervescence with sodium carbonate.

(c) (i) What does the result of the test with Tollens' reagent show about **R**?

R is not an aldehyde

(ii) What does the result of the test with 2,4-dinitrophenylhydrazine reagent show about **R**?

R is not a carbonyl

(iii) What functional group does the result of the test with sodium carbonate show to be present in **R**?

R contains  $COOH$

[3]

(d) (i) What is the identity of the single organic compound, **R**?

$CH_3COOH$

(ii) Which of your structures, **W**, **X**, **Y** or **Z**, represents the ester, **Q**?

X

[2]

(e) Which, if any, of your esters, **W**, **X**, **Y** or **Z**, is chiral?

no ester is chiral

[1]