CHEMISTRY ONLINE
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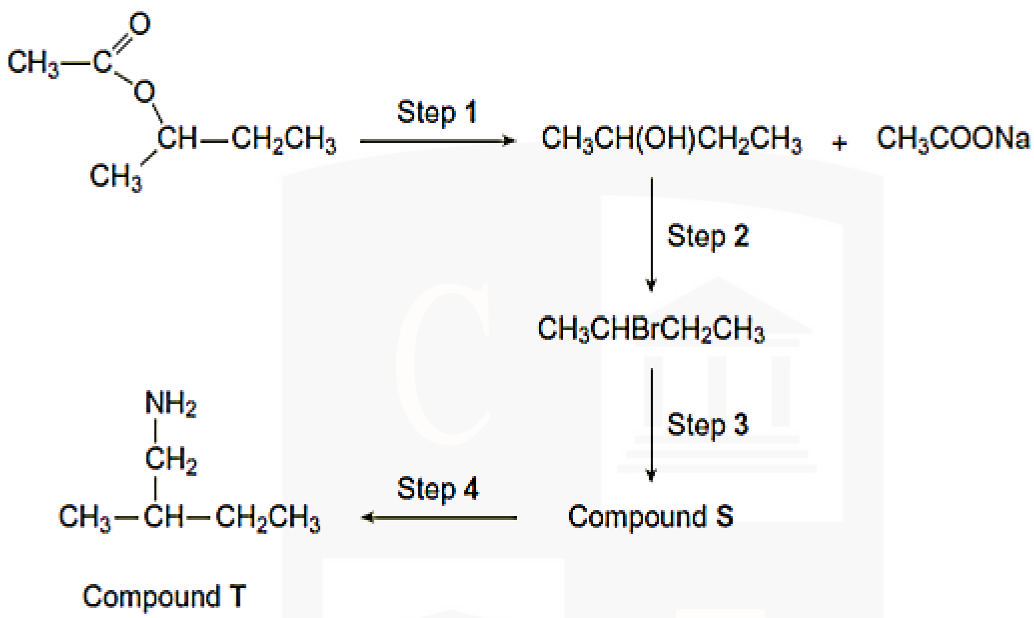
CHEMISTRY

ORGANIC CHEMISTRY II

Level & Board	AQA (A-LEVEL)
TOPIC:	CARBOXYLIC ACIDS
PAPER TYPE:	SOLUTION - 4
TOTAL QUESTIONS	10
TOTAL MARKS	54

Carboxylic Acids and Derivatives - 4

1.



(a)

Reagent and Conditions:

Reagent:
Sodium hydroxide (NaOH)

Conditions:
Aqueous and warm

Step-by-Step Process:

Mixing:
Dissolve NaOH in water to make an aqueous solution.

Reaction:

Add the ester to the aqueous NaOH solution and heat the mixture gently (warm it) to promote hydrolysis of the ester to the corresponding alcohol and carboxylate salt.

Isolation of the Alcohol:

Reaction:
Heat the ester with aqueous NaOH to hydrolyze it.

Separation:
Use fractional distillation to isolate the secondary alcohol from the reaction mixture.

(3)

(b)
Compound S

S: $CH_3CH(CN)CH_2CH_3$

Step 3:

Formation of the Nitrile

Reagent:
Potassium cyanide (KCN)

Condition:
Alcoholic (or ethanolic) solution

Step 4:

Reduction of the Nitrile to Amine

Reagent: Hydrogen (H_2)
Condition: Nickel (Ni) or palladium (Pd) catalyst, or in ethoxyethane (ether)

(5)

2.

Reason for Using Aqueous Ethanol as a Solvent:

Aqueous ethanol is a suitable solvent because it can dissolve both the coconut oil and KOH, acting as a mutual solvent to ensure that the reactants are miscible.

Safety Precaution:

Use a water bath for heating the mixture.

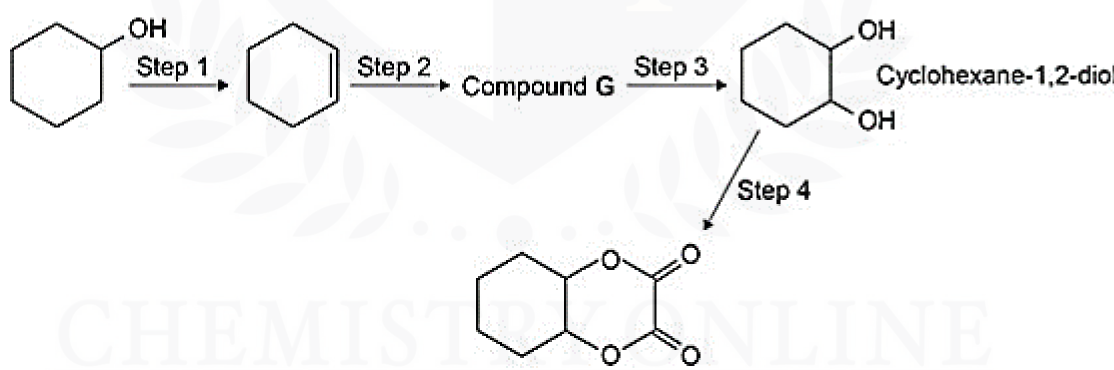
Justification:

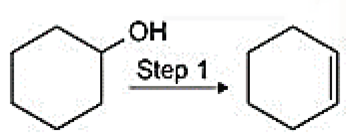
This prevents the risk of fire, as ethanol is flammable.
Using a water bath provides indirect heating, reducing the chance of igniting the ethanol vapors.

(3)

3.

(a)





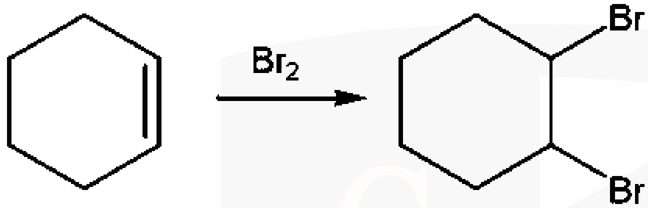
Reagent:
Concentrated sulfuric acid (H_2SO_4)

Condition:
Acid-catalyzed elimination (dehydration)

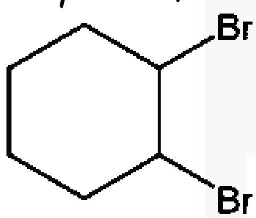
(2)

(b)

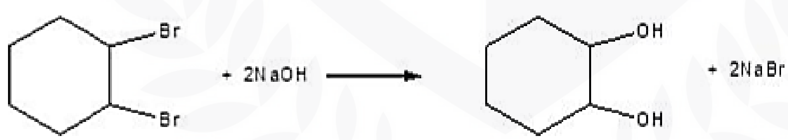
Step 2
Reagent: Br_2
Equation:



Compound G:



Step 3
Reagent: NaOH
Equation:



(4)

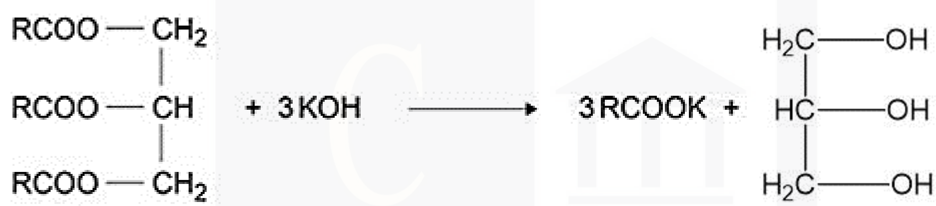
4.

(a)

Name of the compound:
Potassium Carboxylate salt

Type of compound:
Fatty acid salt

Equation:



Use:

One common use of carboxylate salts is as soaps. They are widely used for cleaning purposes in various household and industrial applications, as well as in personal hygiene products.

(3)

(b)

$638-(173+3\times15)=420.$

$n=420/14\times3$
$n=10$

$n=10$

Explaination:

Find Mr of the alkyl chain:

The relative molecular mass of the ester fragment (173) corresponds to the alkyl chain in the triester molecule.

Calculate Mr of three -CH_3 groups:

Subtract the Mr of the ester fragment (173) and the Mr of three -CH_3 groups (15 each) from the total molecular mass of the triester (638).

This gives:

$638-(173+3\times15)=420.$

Determine the number of -CH_2- units (n):

Divide the calculated Mr of the alkyl chain (420) by the molecular mass of a single -CH_2- unit (14).

This gives the total number of -CH_2- units in the alkyl chain.

Since each -CH_2- unit contributes to nn in the alkyl chain, divide this total by 33 to get n.

This gives
$n=420/14\times3$
$n=10$
$n=10$
$n=10$ represents the number of -CH_2- units in the alkyl chain of the triester molecule,

(3)

(c)
Calculate the moles of HCl used:

Amount $HCl=0.100\times0.01565=1.565\times10^{-3}$ mol

Calculate the initial amount of KOH:

Initial amount KOH = $0.421 / 56.1 = 7.50\times10^{-3}$ mol

Amount KOH used$=7.50\times10^{-3}$ mol -1.565×10^{-3} mol
$=5.939\times10^{-3}$mol

Calculate the amount of triester:

Amount ester$=5.939\times10^{-3}$mol/3
$=1.980\times10-3$ mol

Calculate the mass of the triester:

Mass ester$=(1.980\times10^{-3})\times638=1.263$ g

Calculate the percentage by mass:
Percentage by mass=(Mass ester/1.45)×100
=(1.263/1.45)×100
=87.1%

(6)

5.

An alcohol:

$CH_3CH_2CH_2CH_2OH$

Acid anhydride:

$(CH_3CO)_2O$

Equation:

$CH_3CH_2CH_2CH_2OH + (CH_3CO)_2O \rightarrow CH_3COOCH_2CH_2CH_2CH_3 + CH_3COOH$

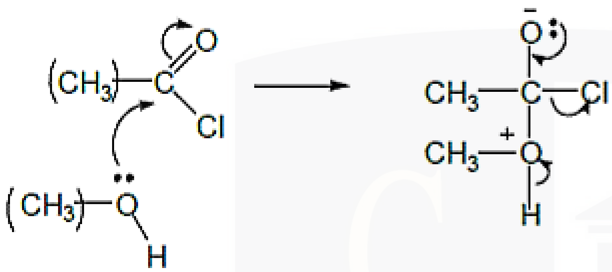
(3)

6.

Name of the mechanism:

Nucleophilic addition-elimination

Mechanism:



Product:
CH_3COOCH_3

(5)

7.

(a)

Chemical Reagents:

Tollens' or Fehling's reagents

Observation with Tollens' Reagent:

Formation of a silver mirror

Observation with Fehling's Reagent:

Formation of a red precipitate

(2)

(b)

Chemical Reagent:

Sodium carbonate (solution) or Group II metal carbonate.

Observation:

Effervescence or evolves a gas.

(2)

(c)

Propanoic acid will have the highest boiling point among propan-1-ol, propanal, and propanoic acid because it contains hydrogen bonding, which results in stronger intermolecular forces compared to the other compounds.

While propan-1-ol can also form hydrogen bonds through its -OH group, propanoic acid can form additional hydrogen bonds through both the -OH group and the carbonyl group, leading to stronger intermolecular forces. Propanal, on the other hand, can only undergo dipole-dipole interactions, making its intermolecular forces weaker compared to propanoic acid.

So, due to the presence of stronger intermolecular forces, propanoic acid has the highest boiling point.

(2)

8. C

(1)

9.

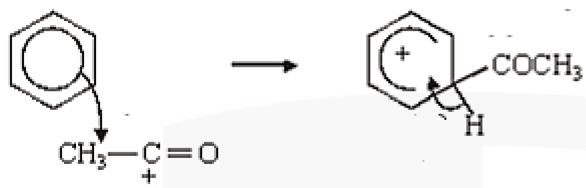
(a)

$[CH_3CO]^+$ is the intermediate formed from ethanoyl chloride.

(2)

(b)

Mechanism:



Product:

(4)

10.

(a)

- ***Hydrogen Chloride (HCl):***
  There is a (weak) dipole-dipole attraction between HCl molecules.

- ***Ethanoic Acid (CH_3 COOH):***
  There are (strong) hydrogen bonds between CH_3 COOH molecules.
  So,

  - ***HCl:***
  Weak dipole-dipole interactions → gas at room temperature.
  - ***CH_3 COOH:***
  Strong hydrogen bonds → liquid at room temperature.

The strong hydrogen bonds in ethanoic acid lead to higher boiling and melting points compared to the weaker dipole-dipole interactions in hydrogen chloride, resulting in the different physical states of these substances at room temperature.

(2)

(b)

Ethanoic anhydride offers two key industrial advantages over ethanoyl chloride in the manufacture of aspirin:

Cost:
Ethanoic anhydride is cheaper compared to ethanoyl chloride.

Safety and Control:

The reaction with ethanoic anhydride is less corrosive, less violent, and more easily controlled, making it safer to use in industrial settings.

(2)

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