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NAME; AKHIANO HELEN KENNEDY
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1i $HCOOH$ - Methanoic acid
ii $HOOCCH_2CH_2CH_2COOH$ - Pentan-1,5-dioic acid
iii $CH_3CH_2CH_2COOH$ - Butanoic acid
iv HO_2C-CO_2H - Ethanedioic acid
v $CH_3(CH_2)_4COOH$ - Hexanoic acid
vi $CH_3CH=CHCH_2CH_2COOH$ - Hex-4-enoic acid

2 i PHYSICAL APPEARANCE;
All simple aliphatic carboxylic acids up to C10 are liquids at room temperature. Most other carboxylic acids are solid at room temperature although anhydrous carboxylic acid (acetic acid) also known as glacial ethanoic acid freezes to an ice-like solid below the room temperature

ii BOILING POINT;
This increases with increasing relative molecular mass. Aromatic carboxylic acids are crystalline solids and have higher melting points than their aliphatic counterparts of comparable relative molecular mass.

iii SOLUBILITY
Lower molecular mass carboxylic acids with up to four carbon atoms in their molecules are soluble in water this largely due to their ability to form hydrogen bonds with water molecules. The water solubility of the acids decreases as the relative molecular mass increases because the structure becomes relatively more hydrocarbon in nature and hence covalent. All carboxylic acids are

soluble in organic solvents.

3 i] From Carbon(II) oxide

Methanoic acid (formic acid) is manufactured by adding carbon(II) oxide under pressure to hot aqueous solution of sodium hydroxide. The free carboxylic acid is liberated by careful reaction with tetraoxosulphate(vi) acid (H_2SO_4)

$$CO + NaOH \longrightarrow HCOONa$$

$$HCOONa + H_2SO_4 \longrightarrow HCOOH + NaHSO_4$$

ii] From petroleum

Liquid phase air oxidation of $C_5 - C_7$ alkanes, obtainable from petroleum at high temperature and pressure will give $C_5 - C_7$ carboxylic acids with methanoic, propanoic and butanedioic acids as by-products.

$$C_5 - C_7 \text{ alkanes} \xrightarrow{O_2 / \text{high temperature}} C_0 - C_7 \text{ carboxylic acid}$$

4 The oxidation of primary alcohols and aldehydes can yield carboxylic acids. They can be used to prepare carboxylic acids using the usual oxidizing agents, i.e. $K_2Cr_2O_7$ or $KMnO_4$ in acidic solution

$$RCH_2OH + [O] \xrightarrow{\text{excess acid/}KMnO_4} RCHO + [O] \longrightarrow RCOOH$$

5 i) Reduction of carboxylic acids;

$$4RCOOH + 3LiAlH_4 \xrightarrow{(C_2H_5)_2O} (RCH_2O)_4AlLi + 2LiAlO_2 + 4H_2$$

$$\downarrow 4H_2O$$

$$4RCH_2OH + Al(OH)_3 + LiOH$$

$$CH_3CH_2CH_2COOH \xrightarrow{LiAlH_4} CH_3CH_2CH_2CH_2OH$$

Butanoic acid — Butanol

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ii | Decarboxylation of carboxylic acids;

$CH_3CH_2CH_2COONa + NaOH \xrightarrow{fuse} CH_3CH_2CH_3 + Na_2CO_3$

Kolbe synthesis

$2CH_3CH_2COONa + 2H_2O \xrightarrow{electrolysis\ aq.\ CH_3OH} CH_3(CH_2)_2CH_3 + CO_{2(anode)} + 2NaOH + H_{2(cathode)}$

iii | Esterification of carboxylic acids;

$CH_3CH_2CH_2COOH + CH_3CH_2CH_2OH \underset{}{\overset{H^+}{\rightleftharpoons}} CH_3CH_2CH_2COOCH_2CH_2CH_3 + H_2O$