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1) Give the IUPAC names of the following compounds

i) $HCOOH$ ——→ Methanoic acid

ii) $HOOCCH_2CH_2CH_2COOH$ ——→ Pentan-1,5-dioic acid

iii) $CH_3CH_2CH_2COOH$ ——→ Butanoic acid

iv) $HO_2C-C.O_2H$ ——→ Ethanedioic acid

v) $CH_3[CH_2]_4COOH$ ——→ Hexanoic acid

vi) $CH_2CH=CHCH_2CH_2COOH$ ——→ Hex-4-enoic acid

2) Discuss briefly the physical properties of Carboxylic acids under the following heading: Physical appearance, Boiling point & Solubility

i) Physical Appearance

* All Simple aliphatic Carboxylic acids up to C_{10} are liquids at room temperature. Most other Carboxylic acids are Solid at room temperature although Anhydrous Carboxylic acid (Ecoic 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) Write two Industrial preparations of Carboxylic acids.

i) from Petroleum

Liquid phase air oxidation of C_5-C_8 alkanes, obtainable from petroleum at high temperature and pressure will give C_1-C_2 Carboxylic acids with methanoic, propanoic and butanedioic acids as by-products.

b) From Ethanol

Ethanoic acid is obtained commercially by the liquid phase air-oxidation of 5% solution of ethanol to ethanoic acid using manganese (II) ethanoate catalyst. Ethanol itself is obtained from ethylene.

$HC \equiv CH \xrightarrow{dil.H_2SO_4/HgSO_4} CH_3CHO \xrightarrow{O_2/(CH_3COO)_2Mn} CH_3COOH$

4) With equations and brief explanations, discuss the Synthetic preparation of carboxylic acid.

Hydrolysis of nitriles (cyanides) or esters

$RCN + 2H_2O \xrightarrow{H^+} RCOOH + NH_4^+$

$RCOOR \xrightarrow{H_2O/H^+ \text{ reflux}} RCOOH + R'OH$

$C_6H_5CH_2CN + 2H_2O \xrightarrow{H^+} C_6H_5CH_2COOH + NH_4^+$

$CH_3CH_2COOCH_3 \xrightarrow{H_2O/H^+ \text{ reflux}} CH_3CH_2COOH + CH_3OH$

} R = alkyl or acyl radical

5) With chemical equation only outline the reduction, decarboxylic acid esterification of carboxylic acid.

(a) Reduction

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

$(RCH_2O)_4AlLi + 4H_2O \rightarrow 4RCH_2OH + Al(OH)_3 + LiOH$

$CH_3CH_2CH_2COOH \xrightarrow{LiAlH_4} CH_3CH_2CH_2CH_2OH$

Butanoic acid — Butanol

(b) Decarboxylation

$CH_3CH_2CH_2COONa + NaOH \xrightarrow{\text{Fuse}} CH_3CH_2CH_3 + Na_2CO_3$

Kolbe Synthesis

$2CH_3CH_2COONa + 2H_2O \xrightarrow{\text{electrolysis/fig. } CH_3OH} CH_3(CH_2)CH_3 + CO_2 + 2NaOH + H_2$

(CO_2 (cathode), H_2 (cathode))

(c) Esterification

$CH_3CH_2CH_2COOH + CH_3CH_2CH_2OH \xrightarrow{H^+} CH_3CH_2CH_2COOCH_2CH_2CH_3 + H_2O$