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Mechatronics Engineering
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CHEM 102

Give the IUPAC Names of the following compounds
$HCOOH$ $HOOCH_2CH_2COOH$ → Penta-1,5-dioic acid
$CH_3CH_2CH_2COOH$ ~~HO_2C-CO_2H~~ → Butanoic Acid
$CH_3(CH_2)_4COOH$ $CH_3CH=CHCH_2CH_2COOH$ → Hexanoic Acid.
HO_2C-CO_2H → Ethanedoic Acid.

Discuss briefly the Physical Properties of Carboxylic acids under the following headings.

Physical appearance – All simple Aliphatic carboxylic acids up to C_{10} are liquids at room temperature. Most carboxylic acids are solids at room temperature.

Boiling Points – The boiling points increases with increasing relative molecular mass.

Solubility – lower molecular mass carboxylic acids with up to 4 carbon atoms in their molecules are soluble in water; this largely due to their ability to form hydrogen bonds with water molecules.

Write two industrial Preparations of Carboxylic acids

1) From Carbon (II) oxide

Methanoic acids (formic acid) is manufactured by adding carbon (II) oxide under pressure to hot aqueous solution of sodium hydroxide.

$$CO + NaOH \longrightarrow HCOONa \xrightarrow{H_2SO_4} HCOOH + NaHSO_4$$

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 butanedoic acids as by-Products.

$$C_5C_7 \xrightarrow{O_2/\text{High temp \& Pressure}} C_5C_7 \text{ Carboxylic acids}$$

3) De carboxylation

$$CH_3CH_2CH_2COONa + NaOH \longrightarrow CH_3CH_2CH_3 + Na_2CO_3$$

Kolbe synthesis

$$2CH_3CH_2COONa + 2H_2O \xrightarrow{\text{electrolysis}} CH_3OH$$

$$CH_3(CH_2)_2CH_3 + CO_2 + 2NaOH + H_2.$$

4) with equations and brief explanation discuss the synthetic preparation of carboxylic acid.

a) oxidation of primary alcohols and aldehydes

Oxidation of primary alcohols and aldehydes can be used to prepare carboxylic acids using the usual oxidizing agents.

$$RCH_2OH \xrightarrow{[O]\ \text{excess acids / } KMnO_4} RCOOH \xrightarrow{[O]} RCHO$$

b) Hydrolysis of nitriles (cyanides) or esters

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

$$RCOOR' \xrightarrow{H_2O/H^+} C_6H_5CH_2CN + 2H_2O \xrightarrow{RCOOH + R'OH} C_6H_5CH_2COOH + N_4$$

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

5 with chemical equation only, outline the reduction, decarboxylation and esterification of carboxylic acids

1) Reduction to primary alcohols

Carboxylic acids are very difficult to reduce by catalytic hydrogenation

$$4RCOOH + 3LiAlH_4 \longrightarrow (RCH_2O)_4AlLi + 2LiAlO_2 + 4H_2$$

$$\xrightarrow{4H_2O} 4RCH_2OH + Al(OH)_3 + LiOH$$

$$CH_3CH_2CH_2COOH \longrightarrow CH_3CH_2CH_2CH_2OH$$

Butanoic acid — Butanol

2) Esterification

$$CH_3CH_2CH_2COOH + CH_3CH_2CH_2OH \xrightarrow{H^+} CH_3CH_2CH_2COO \longrightarrow$$

$$CH_2CH_2CH_3 + H_2O$$