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Matric No: 19/MHS01/013
Course: Chem 102 (Assignment on Carboxylic acid)

(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-CO_2H – Ethanedioic acid
(v) $CH_3CH=CHCH_2CH_2COOH$ – Hex-4-eneoic

(2) Discuss briefly the physical properties of carboxylic acids under the following heading:
(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 (acetic acid) also known as glacial ethanoic acid freezes to an ice-like solid below the room temperature.

(ii) Boiling point: It 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 Carbon (II) oxide

Methanoic acid (formic acid) is manufactured by adding CO under pressure to hot aqueous solution of NaOH. The free carboxylic acid is liberated by careful reaction with H_2SO_4

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

(ii) From ethanol

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

$$HC \equiv CH \xrightarrow{\frac{1}{2}H_2SO_4/HgSO_4} CH_3CHO \xrightarrow{O_2/(CH_3COO)_2Mn} CH_3COOH$$

(4) With equations and brief explanation, discuss the synthetic preparation of carboxylic acid

(ii) Oxidation of primary alcohols and aldehydes

Oxidation of primary alcohols and aldehydes can be used to prepare carboxylic acids using the usual oxidizing agents (i.e $K_2Cr_2O_7$ or $KMnO_4$) in acidic solution

i.e $RCH_2OH \xrightarrow{[O]\ \text{excess acid/KMnO}_4} RCHO \xrightarrow{[O]} RCOOH$

(5) With chemical equation only, outline the reduction, decarboxylation and esterification of carboxylic acid.

(i) Reduction to primary alcohol:

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

$$\downarrow 4H_2O$$

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

$$CH_3CH_2CH_2COOH \xrightarrow{LiAlH_4} CH_3CH_2CH_2CH_2OH$$

Butanoic acid — Butanol

(ii) Decarboxylation:

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

Kolbe synthesis

$$2CH_3CH_2COONa + 2H_2O \xrightarrow{\text{electrolysis (aq. CH}_3\text{COONa)}} CH_3(CH_2)_2CH_3 + CO_2 + \text{gas}$$

$2NaOH$ + H_2 at cathode

(iii) Esterification:

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

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