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Course: Chem 102
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1) Give the IUPAC Names of the following Compounds:
a) $HCOOH$ ——— Methanoic Acid.
b) $HOOCH_2CH_2CHCOOH$ ——— Pentan-1,5-dioic acid
c) $CH_3CH_2CH_2COOH$ ——— Butanoic acid
d) HO_2C-CO_2H ——— Ethanedioic acid
e) $CH_3[CH_2]_4COOH$ ——— Hexanoic acid
f) $CH_3CH=CHCH_2CHCOOH$ ——— Hex-4-enoic acid

2a) 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.

b) Boiling point:
This increases with increasing relative molecular

Mass. Aromatic carboxylic acids are crystalline solids and have tighter melting points than their aliphatic counterparts of comparable relative molecular mass.

(c) Solubility:
lower molecular mass carboxylic acids with up to four carbon atoms in their molecules are soluble in water, this is 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. Carboxylic acids are soluble in organic solvents.

3) Write two industrial preparations of carboxylic acids.

Answers

(a) 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 butandioic acids as by-products.

$$C_5-C_7 \xrightarrow{O_2/\text{High temperature and Pressure}} C_5-C_7 \text{ carboxylic acid}$$

b) From ethanal

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.

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

2a) With equations and brief explanations, discuss the synthetic preparations of carboxylic acids.

Answer

Hydrolysis of nitriles (cyanides) or esters

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

$$RCOOR \xrightarrow{H_2O/H^+ \text{ reflux}} RCOOH + R^2OH$$

R = alkyl or aryl radical

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

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

5a) Reduction

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

$$\downarrow$$

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

$$CH_3CH_2CH_2COOH \xleftarrow{LiAlH_4} CH_3CH_2CH_2CH_2OH$$

Butanoic Acid — Butanol

b) Decarboxylation

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

Kolbe Synthesis

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

(anode) (cathode)

c) Esterification

$$CH_3CH_2CH_2COOH + CH_3CH_2CH_2OH \xleftrightarrow{H^+} CH_3CH_2CH_2COOCH_3 + H_2O$$