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Mechanical Engineering 19/ENG06/037

1 Give the (upac names) of the following

a $HCOOH$ ——→ Methanoic acid

b $HOOCCH_2CH_2CH_2COOH$ —— 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 $CH_3CH=CHCH_2CH_2COOH$ —— Hex-4-enoic acid

2 Discuss briefly the physical properties of carboxylic acid the following headings; ph
pearance boiling point solubility

Answers

Physical appearance: All simple aliphatic carboxylic acids up to C_{10} are liquids a
m temperature. Most other carboxylic acids are solid at room temperature although anhydrous
boxylic acid (acetic acid) also known as glacial ethanoic acid freezes to an ice like
id below the room temperature

Boiling point :- This increases with increasing relative molecular masses. Aromati
arboxylic acids are crystalline solids and have higher melting points than their
iphatic counterparts of comparable relative molecular mass

Solubility:- Lower molecular mass carboxylic acids with up to four carbon atoms
their molecules are soluble in water; this is largely due to their ability to form hydrogen
ds with water molecules.

The water solubility of the ~~bonds~~ acids decreases as the relative molecular mass inc
because the structure becomes relatively more hydrocarbon in nature and tend
ent. All carboxylic acids are soluble in organic solvents

3) Write two industrial preparations of carboxylic acids

Answer

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 acid butanedioic acids as by-products

$$C_5-C_7 \xrightarrow{O_2 \text{ (High temperature pressure)}} C_5-C_7 \text{ carboxylic acid}$$

b From ethanal

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

$$HC \equiv CH \xrightarrow{dilH_2SO_4/HgSO_4} CH_3CHO \xrightarrow{O_2/(CH_3COO)_2Mn} CH_3COOH$$

4. With a balanced and brief explanation discuss the synthetic preparation of carboxylic acid

Answer

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 aryl radical

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

Answer

(a) Reduction

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

$$\downarrow 4H_2O$$

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

$$\underset{\text{Butanoic acid}}{CH_3CH_2CH_2COOH} \xrightarrow{LiAlH_4} \underset{\text{Butanol}}{CH_3CH_2CH_2CH_2OH}$$

b. Decarboxylation

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

Kolbe Synthesis

$$2CH_3CH_2COONa + 2H_2O \xrightarrow{\text{electrolysis (aq. } CH_3CO_2H)} CH_3(CH_2)CH_3 + \underset{\text{(anode)}}{CO_2} + \underset{\text{cathode}}{2NaOH + H_2}$$

c. Esterification

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