NAME: Okodugha Favour Ebosehulu-E. DEPT: MBBS

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Chemistry Assignment IV

1 Give the IUPAC names of the following compounds

a $HCOOH$

Answer: Methanoic acid

b $HOOCCH_2CH_2CH_2COOH$

Answer: Pentan-1,5-dioic acid

c $CH_3CH_2CH_2COOH$

Answer: Butanoic acid

d HO_2C-CO_2H

Answer: Ethanedioic acid

e $CH_3(CH_2)_4COOH$

Answer: Hexanoic acid

f $CH_3CH=CHCH_2CH_2COOH$

Answer: Hex-4-eneoic acid

2 Discuss briefly the physical properties of carboxylic acids under the following headings

i Physical appearance

Answer: All simple aliphatic carboxylic acids up to C_{10} are liquids at room temperature. Most other carboxylic acids are solid at while anhydrous carboxylic acid (acetic acid) also known as glacial ethanoic acid becomes an ice-like solid below room temperature.

ii Boiling point

Answers: Their boiling points increases with increasing

relative molecular mass.

ii Solubility:
Answer: The water solubility of the acids decreases as the molecular mass increases because the structures become relatively more hydrocarbon in nature and more covalent. All carboxylic acids are soluble in organic solvents.

3 Write two industrial preparations of carboxylic acids.
Answers:
a From Carbon(II) oxide
Methanoic acid is manufactured by adding carbon(II) oxide under pressure to a hot aqueous solution of sodium hydroxide. The free carboxylic acid is liberated by careful reaction with dil H_2SO_4.

$$CO_{(g)} \xrightarrow{NaOH_{(aq)}} HCOONa_{(aq)} \xrightarrow{H_2SO_{4(aq)}} HCOOH_{(l)} + NaHSO_{4(s)}$$

b From ethanol
~~Ethanoic acid is formed commercially by the liquid oxidation~~ Can be produced
Ethanoic acid is formed commercially by the liquid phase air oxidation of 5% solution of ethanal using manganese(II) ethanoate catalyst. Ethanal itself is obtained from ethylene

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

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

Answers

a) Oxidation of primary alcohols and aldehydes

Primary alcohols and aldehydes can be used to produce carboxylic acids by oxidation using the usual oxidizing agents such as $K_2Cr_2O_7$, etc., in an acidic solution.

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

b) Carbonation of Grignard reagent

Aliphatic carboxylic acids are obtained by bubbling carbon(iv) oxide into the Grignard reagent and then hydrolysed with dilute acid.

$$RMgBr + CO_2 \xrightarrow{(C_2H_5)_2O} RCOOMgBr \xrightarrow{H_2O/\text{dil. acid}} RCOOH + MgBr.OH$$

c) Hydrolysis of nitriles (cyanides) or esters

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

Example:

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

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

Answers

a) Reduction

$$CH_3COOH_{(g)} + 4[H] \longrightarrow CH_3CH_2OH_{(aq)} + H_2O_{(l)}$$

Ethanoic acid from $LiAlH_4$ — ethanol

b) Decarboxylation

$$CH_3COOH(g) + \text{sodalime} \longrightarrow CO_2(g) + CH_4(g)$$

c) Esterification

$$CH_3CH_2CH_2COOH(l) + CH_3CH_2CH_2OH \xrightleftharpoons{H^+} CH_3CH_2CH_2COO\text{-}CH_2CH_2CH_3 + H_2O$$