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MATRIC NO: 19/mhs04/002

ASSIGNMENT TITLE: Assignment on Carboxylic Acid

COURSE TITLE: General Chemistry II

COURSE CODE: CHM 102

Question

1.) Give the IUPAC names of the following compounds HCOOH, $HOOCCH_2CH_2CH_2COOH$, $CH_3CH_2CH_2COOH$, $HO_2C\text{-}CO_2H$, $CH_3(CH_2)_4COOH$, $CH_3CH{=}CHCH_2CH_2COOH$

Answer

HCOOH – Methanoic acids

$HOOCCH_2CH_2CH_2COOH$ – Penta-1, 5 dioic acid

$CH_3CH_2CH_2COOH$ – Butanoic acid

$HO_2C\text{-}CO_2H$ – Ethanedioic acid

$CH_3(CH_2)_4COOH$ – Hexanoic acid

$CH_3CH{=}CHCH_2CH_2COOH$ – Hex-4-enioic acid

2. Discuss briefly the physical properties of carboxylic acids under the following headings i. Physical appearance ii. Boiling point iii. Solubility

Answer

i. Physical appearances

Simple aliphatic carboxylic acids up to C_{10} are liquids at room temperature while 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 points

Their boiling point increases with increasing relative molecular mass. Aromatic carboxylic acids are crystalline solids and they have higher melting points than their aliphatic counterparts of comparable relative molecular mass.

iii. Solubility

Low molecular mass carboxylic acids with up to four carbon atoms in their molecules are soluble in water. This is so because of their ability to form hydrogen bonds with water molecules. The water solubility of the acids decreases as the relative molecular mass increases because their 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 carbon (II) oxide under pressure to hot aqueous solution of sodium hydroxide. The free carboxylic acid is liberated by careful reaction with tetraoxosulphate(VI)acid (H_2SO_4)

$$CO \xrightarrow{NaOH} HCOONa \xrightarrow{H2SO4} HCOOH + NaHSO_4$$

ii) 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 is obtained from ethylene)

$$HC \equiv CH \xrightarrow{dil.\ H2SO4/HgSO4} CH_3CHO \xrightarrow{O2/\ (CH3COO)2Mn} CH_3COOH$$

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

i) Oxidation of primary alcohols and aldehydes

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

$$RCH_2OH \xrightarrow{[o],\ excess\ acid/KMnO4} RCHO \xrightarrow{[O]} RCOOH$$

ii) Carbonation of Grignard reagent

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

$$RMgBr + CO_2 \xrightarrow{(C2H5)2O} RCOOMgBr \xrightarrow{H2O/\ dil.\ acid} RCOOH + MgBrOH$$

R may be 1^o, 2^o, 3^o aliphatic alkyl or aryl radical

iii) Hydrolysis of nitriles (cyanides) or esters

The hydrolysis of nitriles and also the hydrolysis of esters can produce carboxylic acids.

$$RCN + 2H_2O \xrightarrow{H+} RCOOH + NH_4^+ \quad (R=\text{alkyl or aryl radical})$$

$$CH_3CN + 2H_2O \xrightarrow{H+} CH_3COOH + NH_4^+$$

$$RCOOR' \xrightarrow{H2O/H+\ reflux} RCOOH + R'OH$$

$$CH_3COOCH_3 \xrightarrow{H2O/H+\ reflux} CH_3COOH + CH_3OH$$

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

Reduction

$$4RCOOH + 3LiAlH_4 \xrightarrow{(C2H5)2O} (RCH_2O)_4\,AlLi + 2LiAlO_2 + 4H_2$$

$$\downarrow 4H_2O$$

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

$$CH_3CH_2COOH \xrightarrow{LiAlH4} CH_3CH_2CH_2OH$$

Propanoic acid — Propanol

Decarboxylation

$$RCOOH \longrightarrow R\text{-}H + CO_2$$

$$CH_3CH_2COOH \longrightarrow CH_3CH_3 + CO_2$$

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

Esterification

$$CH_3CH_2COOH + CH_3CH_2OH \xleftrightarrow{H+} CH_3CH_2COOCH_2CH_3 + H_2O.$$