Assignment Title: Assignment on carboxylic acid

Course Title: General Chemistry II

Course Code: CHM 102

Name: Okam, Emmanuel Chijioke

COLLEGE: Medicine and Health Sciences DEPARTMENT: Medicine and

Surgery LEVEL: 100

Question

Assignment

1. Give the IUPAC names of the following compounds

ANS.

- 1. HCOOH = Methanoic acid
- 2. HOOCCH₂CH₂CH₂COOH= H Pentan-1,5-dioic acid
- 3. CH₃CH₂CH₂COOH = Butanoic acid
- 4. $HO_2C-CO_2H=$ Ethanedioic acid
- 5. $CH_3(CH_2)_4COOH = Hexanoic acid$
- 6. CH₃CH=CHCH₂CH₂COOH= Hex-4-eneoic acid
- 2. Discuss briefly the physical properties of carboxylic acids under the following headings <u>ANSWER</u>.

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

Boiling point 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

- iv. 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
 - From Carbon(II) oxide (methanic acid=carbon 11 oxid under pressure+hot aqeous solution of sodium hydroxide)

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
$$\longrightarrow$$
 HCOONa \longrightarrow HCOOH + NaHSO₄

2. 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

$$HC = CH - \frac{dil. H_2SO_4/HgSO_4}{CH_3COO)_2Mn} CH_3COOH$$

- 4. With equations and brief explanation discuss the synthetic preparation of carboxylic acid ANSWER.
 - 1. 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 K₂Cr₂O₇ or KMnO₄) in acidic solution

2. Carbonation of Grignard reagent

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

$$RMgBr + CO_2 - (C_2H_5)_2O \longrightarrow RCOOMgBr - H_2O/dil. acid RCOOH + MgBrOH$$

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

In the preparation of benzoic acid, the reagent is added to solid carbon (IV) oxide (dry ice) which also serves as coolant to the reaction mixture

$$C_6H_5MgBr + CO_2 \longrightarrow C_6H_5COOMgBr \longrightarrow H_2O/H^+ \longrightarrow C_6H_5COOH +$$

$$MgBrOH$$

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

ANSWER

1. Reduction to primary alcohol

Carboxylic acids are very difficult to reduce by catalytic hydrogenation or dissolving metals but lithium tetrahydridoaluminate (III) and diborane form intermediate compounds with the acids which liberate the alcohol on hydrolysis

$$4RCOOH + 3LiAlH_4 \qquad \qquad (C_2H_5)_2O \longrightarrow (RCH_2O)_4AlLi + 2LiAlO_2 + 4H_2$$

$$4H_2O$$

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

$$CH_3CH_2CH_2COOH \qquad \qquad LiAlH_4 \longrightarrow CH_3CH_2CH_2CH_2OH$$

Butanoic acid Butanol

2. Decarboxylation

This involves removal of the carboxyl group from the acid to give a hydrocarbon or its derivative.

Thermal decarboxylation

Carboxylic acids with a strong electron attracting group eg –COOH, -CN,NO₂, C=O decarboxylate readily on heating to 100-150°C while others decarboxylate when their salts are heated with soda lime

$$CH_3CH_2COONa + NaOH$$
 \longrightarrow $CH_3CH_2CH_3 + Na_2CO_3$ Kolbe synthesis

$$2CH_3CH_2COONa + 2H_2O$$
 — electrolysis/aq. CH_3OH \rightarrow $CH_3(CH_2)_2CH_3 + CO_2$ (anode) + $2NaOH + H_2$ (cathode)

3. Esterification

In the presence of strong acid catalyst, carboxylic acids react with alcohols to form esters $CH_3CH_2CH_2COOH + CH_3CH_2CH_2OH \longleftrightarrow H^+ \longrightarrow CH_3CH_2CH_2COOCH_2CH_2CH_3 + H_2O.$