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QUESTION 1

Give the IUPAC names of the following compounds.

- a. HCOOH
- b. $HOOCCH_2CH_2CH_2COOH$
- c. $CH_3CH_2CH_2COOH$
- d. HO_2C-CO_2H
- e. CH₃(CH₂)₄COOH
- f. CH₃CH=CHCH₂CH₂COOH

Answer

- a. HCOOH Methanoic acid
- b. HOOCCH₂CH₂CH₂COOH pentan-1, 5-dioic acid
- c. CH₃CH₂CH₂COOH Butanoic acid
- d. HO_2C-CO_2H Ethanedioic acid
- e. CH₃(CH₂)₄COOH Hexanoic acid
- f. CH₃CH=CHCH₂CH₂COOH –Hex-4- eneoic acid

QUESTION 2

Discuss briefly physically properties of carboxylic acids under the following headings

- i. Physical appearance
- ii. Boiling point
- iii. Solubility

Answer

i. <u>PHYSICAL APPEARANCE</u>: Simple Aliphatic carboxylic acids that are up to C₁₀ are liquid 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.

- BOILING POINT: The boiling point increases with an increase in relative molecular mass.
 Aromatic carboxylic acids are crystalline solids and have higher melting points than their aliphatic counterparts of comparable relative molecular mass.
- iii. <u>SOLUBILTY</u>: Lower molecular mass of carboxylic acids that are up to four carbon atoms are soluble in water, this is due to their ability to form hydrogen bonds with water molecules. As the relative molecular mass increases the solubility of the acids decreases this is because the structure becomes relatively more hydrocarbon in nature and hence covalent. All carboxylic acids are soluble in organic solvents.

QUESTION 3

Write two industrial preparations of carboxylic acids.

Answer

 i. <u>From Carbon (II) oxide</u>: Methanoic acid '9formic acid) is manufactured by adding carbon(II)oxide under pressure of hot aqueous solution of sodium hydroxide. The free carboxylic acid is liberated by careful reactions with tetraoxosulphate(VI)acid (H₂SO₄)

CO <u>NaOH</u> HCOONa <u>H₂SO₄</u> HCOOH + NaHSO₄

ii. <u>From Petroleum</u>: Liquid phase air oxidation of C5-C7 alkanes, obtainable from petroleum at high temperature and pressure will give C₅-C₇ carboxylic acids with Methanoic, propanoic and butanedioic acids as by-products.

C₅-C₇ O₂/ High temperature and pressure C₅-C₇ carboxylic acids

QUESTION 4

With equations discuss the synthetic preparation of carboxylic acid.

Answer

i. <u>Oxidation of primary alcohols and aldehydes</u>: The 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

RCH₂OH [0], excess acid/KMnO₄ RCHO [0] RCOOH

ii. <u>Carbonation of Grignard reagent</u>: Aliphatic carboxylic acids are obtained by bubbling carbon (IV) oxide into the Grignard reagent and then hydrolyzed with dilute acid. **RMgBr + CO₂** (C₂H₅)₂O \rightarrow **RCOOMgBr** H₂O/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

 $C_{6}H_{5}MgBr + CO_{2} \xrightarrow{(C_{2}H_{5})_{2}O} \xrightarrow{C_{6}H_{5}COOMgBr} \xrightarrow{H_{2}O/H^{+}} C_{6}H_{5}COOH + MgBrOH$

iii. <u>Hydrolysis of nitriles (cyanides) or esters</u> RCN + 2H₂O <u>H⁺</u> RCOOH + NH₄⁺ (R=alkyl or aryl radical) RCOOR' <u>H₂O/H⁺ reflux</u> RCOOH + R'OH C₆H₅CH₂CN + 2H₂O <u>H⁺</u> C₆H₅CH₂COOH + NH₄⁺ CH₃CH₂COOCH₃ <u>H₂O/H⁺ reflux</u> CH₃CH₂COOH + CH₃OH QUESTION 5

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

Answer

i.	Reduction to primary alcohol	
	$4\text{RCOOH} + 3\text{LiAlH}_4 \qquad (C_2\text{H}_5)_2^{\circ} \qquad (\text{RCH}_2\text{O})_4 \text{AlLi} + 2\text{LiAlO}_2 + 4\text{H}_2$	
	4H ₂ O	
	$4RCH_2OH + Al (OH)_3 + LiOH$	
	CH ₃ CH ₂ CH ₂ COOH LiAlH ₄ CH ₃ CH ₂ CH ₂ CH ₂ OH	
	Butanoic acid Butanol	
ii.	Decarboxylation	
	CH ₃ CH ₂ CH ₂ COONa + NaOH <u>fuse</u> CH ₃ CH ₂ CH ₃ + Na ₂ CO ₃	
	Kolbe synthesis	
	2CH ₃ CH ₂ COONa + 2H ₂ O <u>electrolysis/aq. CH₃OH</u> CH ₃ (CH ₂) ₂ CH ₃ +CO _{2 (anot}	le)
	$+ 2NaOH + H_{2 (cathode)}$	

iii. Esterification

 $CH_{3}CH_{2}CH_{2}COOH + CH_{3}CH_{2}CH_{2}OH \longleftrightarrow H^{+} \rightarrow CH_{3}CH_{2}CH_{2}COO CH_{2}CH_{2}CH_{3} + H_{2}O.$