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ASSIGNMENT.

1. The IUPAC names of the compounds are as follows:
   i. HCOOH – Methanoic acid
   ii. $HOOCCH_2CH_2CH_2COOH$ – Pentane 1, 5-dioic acid.
   iii. $CH_3CH_2CH_2COOH$ – Butanoic acid
   iv. $HO_2C\text{-}CO_2H$ – Ethanedioic acid
   v. $CH_3 (CH_2)_4COOH$ – Hexanoic acid.
   vi. $CH_3CH{=}CHCH_2CH_2COOH$ – Hex-4-eneoic acid

2. Physical properties of carboxylic acid are:
   i. Physical appearance: The smaller members (with carbon atom up to 10) of the aliphatic carboxylic acid series are colorless, volatile liquids with strong odors. Larger carboxylic acids (carbon atoms greater than 10) are solid, which are crystalline solids.
   ii. Boiling point: Carboxylic acids have much higher boiling point than hydrocarbons, alcohols, ethers, aldehydes, or ketones of similar molecular weight. Even the simplest carboxylic acid, formic acid boils at 101℃ (214°F), which is considerably higher than the boiling point of ethanol (ethyl alcohol), C_2H_5OH, which boils at 78.5°F although, the two have nearly identical molecular weight.
   iii. Solubility: The solubility of carboxylic acids in water is similar to that of alcohols, aldehydes and ketones. Acids with fewer than about five carbons dissolve in water; those with a higher molecular weight are insoluble owing to the larger hydrocarbon portion which is hydrophobic.

3. Two industrial preparations of carboxylic acid are:

i. From Carbon (ii) Oxide:

Methanoic acid (formic acid) is formed by the addition of carbon(ii)oxide under pressure to hot aqueous solution of sodium hydroxide. The free carboxylic acid is liberated by a careful reaction with tetraoxosulphate(vi) acid (H_2SO_4)

$$\mathbf{CO \xrightarrow{NaOH} HCOONa \xrightarrow{H_2SO_4} HCOOH + NaHSO4}$$

ii. From ethanal:

Ethanoic acid is obtained by the liquid phase oxidation of air of 5% solution of ethanal to ethanol using manganate (ii) ethanoate as the catalyst. Ethanal is first obtained from ETHYLENE (ETYHNE).

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

4. SYNTHETIC PREPARATION OF CARBOXYLIC ACIDS:

i. Oxidation of primary alcohols and aldehydes:

This process can be used to prepare carboxylic acids using the usual oxidizing agents (i.e. K_2CrO_7 or $KMnO_4$) in acidic solution.

$$CH_3CH_2OH \xrightarrow{[O]\ excess\ acid/KMnO_4} CH_3CHO \xrightarrow{[O]} CH_3COOH$$

ii. Carbonation of Grignard reagent:

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

$$\mathbf{C_6H_4MgBr + CO_2 \xrightarrow{(C_2H_5)_2O} C_6H_5COOMgBr \xrightarrow{H2O} C_6H_5COOH + MgBrOH}$$

iii. Hydrolysis of nitriles(cyanides) or esters:

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

$$CH_3CH_2COOCH_3 \xrightarrow{H_2O/H^+\ reflux} CH_3CH_2COOH + CH_3OH$$

5. Chemical reactions of carboxylic acids are;

i. Reduction of carboxylic acid:

Carboxylic acids are easily reduced by strong reducing agents such as lithium aluminum hydride ($LiAlH_4$). They are reduced to alcohols.

$$CH3CH2CH2COOH \xrightarrow{LiAlH_4} CH3CH2CH2CH2OH$$

(BUTANOIC ACID) (BUTANOL)

ii. Decarboxylation of carboxylic acid:

This process is often very slow. It involves the removal of the carboxyl group to give a hydrocarbon or its derivatives. Carboxylic acids with a strong electron attracting group e.g. –COOH, -CN, NO2, C=O decarboxylate readily on heating 100 -150 while others decarboxylate when their salts are heated with soda lime. This process is referred to as thermal decomposition.

$$CH_3CH_2COONaOOH + NaOH \xrightarrow{fuse} CH_3CH_2CH_3 + Na_2CO_3$$

iii. Esterification of carboxylic acid:

In the presence of a strong acid catalyst, carboxylic acids react with alcohols to form esters.

$$\mathbf{CH_3CH_2CH_2COOH + CH_3CH_2CH_2OH \xrightleftharpoons{H+} CH_3CH_2CH_2COOCH_2CH_2CH_3 + H_2O}$$