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a. Methanoic acid

b. Pentan-1, 5-dioic acid

Butanoic acid

Ethanedioc acid

Hexanoic acid

Hex-4-eneioc acid

2. a. PHYSICAL APPEARANCE

Most other carboxylic acids are solid at room temperature; all simple aliphatic carboxylic acids up to C10 are liquids at room temperature, anhydrous carboxylic acid also known as glacial ethanoic acid freezes to an ice like solid below room temperature.

b. BOILING POINT

Boiling point is directly proportional to relative molecular mass, therefore as boiling point increases so does the relative molecular mass. Aromatic carboxylic acids are crystalline solids and have higher melting points than their aliphatic counterparts of comparable relative molecular mass.

c. SOLUBILITY

Solubility of these acids is inversely proportional to their relative molecular mass, therefore the solubility of these acids in water decreases as their relative molecular mass increases. Lower molecular mass of carboxylic acids with up to four carbon atoms in their molecules are soluble in water because of their ability to form hydrogen bonds with water. All carboxylic acids are soluble in organic solvents.

3. INDUSTRIAL PREPARATIONS

A. 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.

B. FROM PETROLEUM

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 butanedioc acids as by products.

4. OXIDATION OF PRIMARY ALCOHOLS AND ALDEHYDES.

Oxidation of primary alcohols and aldehydes can be used to prepare carboxylic acids using the usual the oxidizing agents (EG: $K_2Cr_2O_7/KMnO_4$) in acidic solution.

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

5. A. REDUCTION PROCESS

$$4RCOOH + 3LiAlH_4 \xrightarrow{(C_2H_5)_2O} (RCH_2O)_4AlLi + LiAlO_2 + 4H_2$$

$$(RCH_2O)_4AlLi + LiAlO_2 + 4H_2 \xrightarrow{4H_2O} 4RCH_2OH + Al(OH)_3 + LiOH$$

$$CH_3CH_2CH_2COOH \xrightarrow{LiAlH_4} CH_3CH_2CH_2CH_2OH$$

BUTANOIC ACID BUTANOL

B. DECARBOXYLATION PROCESS

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

Kolbe synthesis

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

c. ESTERIFICATION PROCESS

$$CH_3CH_2CH_2COOH + CH_3CH_2CH_2OH \xrightarrow{H^+} CH_3CH_2CH_2COOCH_2CH_2CH_3 + H_2O$$