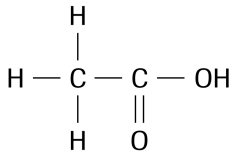
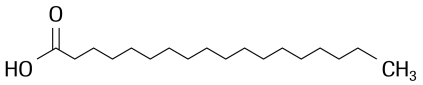
Observations

(b) to (e)

Table 1 Properties of Carboxylic Acids

Property	Acetic acid	Stearic acid
structural formula	 ethanoic acid	 stearic acid
molar mass	60.05 g/mol	284.50 g/mol
melting point	16.7ºC	69ºC
boiling point	118ºC	383ºC
solubility in water	soluble in water	low solubility in water
solubility in vegetable oil	low solubility in vegetable oil	soluble in vegetable oil
reaction with base	reacts with base	does not readily react with base

Analysis

(f) Both acids contain the polar carboxyl group. In addition, stearic acid has a long hydrocarbon group with stronger van der Waals attractions than in the shorter ethanoic acid. For this reason, stearic acid has a higher melting point and boiling point than ethanoic acid.

(g) Acetic acid is more soluble in water than is stearic acid, and less soluble in oil. Stearic acid, with its long hydrocarbon component, has a longer nonpolar component and is thus more soluble in the nonpolar oil.

(h) Acetic acid reacts with sodium hydrogen carbonate, as acids do. Stearic acid is not soluble in water and does not show a reaction with aqueous sodium hydrogen carbonate.

Evaluation

(i) [Sample answer] Yes, the Procedure allowed the collection of appropriate evidence regarding all aspects of this investigation, except for the reaction with sodium hydrogen carbonate. Since stearic acid was not highly soluble in water, it is inconclusive whether it reacts with sodium hydrogen carbonate.

(j) [Sample answer] Answers obtained in the Analysis are in agreement with the Prediction. The theoretical model of carboxylic acids helped to predict the chemical properties of these acids. The effect of the polar and nonpolar components of each acid could be used to predict physical and chemical properties of the compounds.

3.13 ESTERS

SECTION 3.13 QUESTIONS

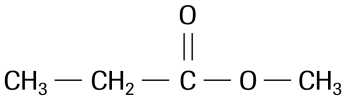
(Page 225)

Understanding Concepts

1. An ester contains an –OR group in place of the –OH group in the carboxylic acid. Both carboxylic acids and esters contain a carbonyl group.

2. Carboxylic acids contain a carbonyl group and a hydroxyl group (together making up the carboxyl group). Esters also contain a carbonyl group, but not the hydroxyl group. Since both groups contribute to the polarity of the molecule, esters are less polar than are carboxylic acids, and are therefore less soluble in water.
3. In esterification, an organic acid and an alcohol react to produce an ester and water. In the reaction between the inorganic acid HCl and the inorganic base NaOH, a salt, NaCl, and water are produced. Thus, an esterification is similar to a neutralization reaction between inorganic acids and bases.
4. A hydrolysis reaction is a reaction in which a bond is broken by the addition of the components of water, forming two or more products. An ester can undergo a hydrolysis reaction to form an acid and an alcohol. It may be considered the reverse of an esterification reaction.
5. Student examples will vary.

Front:

Family name and general formula	**Examples**		
	IUPAC name	**Common name**	**Structural formula**
Esters R–COO–R′	methyl propanoate	(none)	

Back:

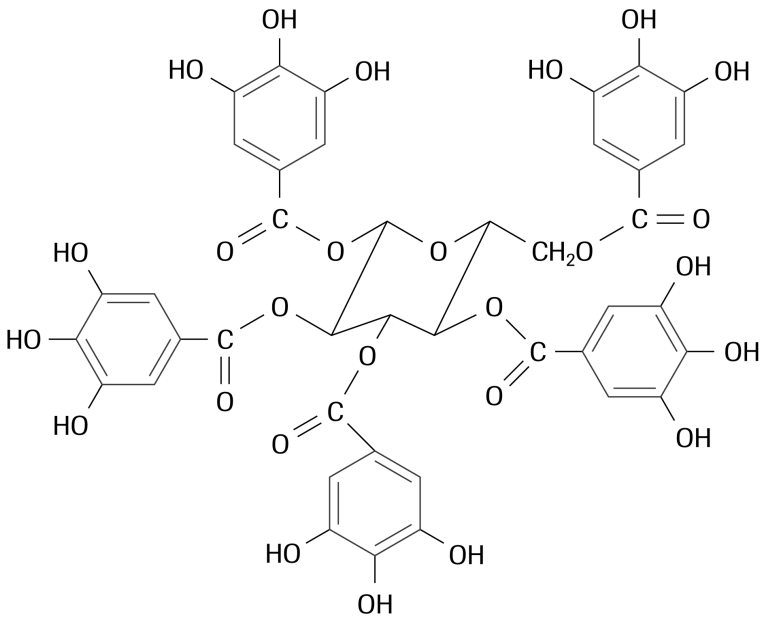
Family	**Characteristic properties**	**Characteristic functional groups**	**Intermolecular forces**
Esters	less soluble in water than their parent acids; lower melting and boiling points than parent acids; not acidic; often have distinctive odours, e.g., fruity, peppermint.	R–COO–R′	van der Waals forces

Applying Inquiry Skills

6. Students should give three suggestions.
   (i) Test each liquid with litmus. The carboxylic acid will turn blue litmus pink, while the ester will not.
   (ii) Add water to each liquid. The carboxylic acid dissolves readily in water, while the ester dissolves less readily.
   (iii) Determine the boiling point of each liquid by heating gently in a fume hood until it starts to boil. The carboxylic acid has a higher boiling point than does the ester.
   (iv) Carefully waft each liquid to detect any odour. Esters generally have distinctive odours.

Making Connections

7. (a)



(b) Animal hides decompose quickly unless they are cured to remove the water from the skin. The hide is first soaked in water to remove water-soluble substances. Hair is removed by soaking the hide in a mixture of lime and water, followed by an enzyme mixture. The hair and any remaining tissue is removed by machine, and the hide is washed and treated with tannic acid. The tannic acid displaces water from the spaces between the hide's protein fibres, allowing the fibres to cement together to form strong water-resistant leather.

3.14 ACTIVITY: SYNTHESIS OF ESTERS

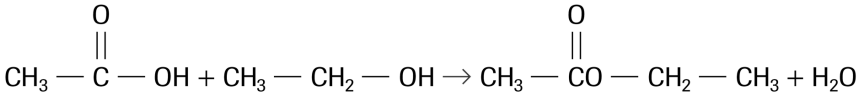
(Pages 226–227)

Analysis

(a) **Table 2** Summary of Condensation Reactions

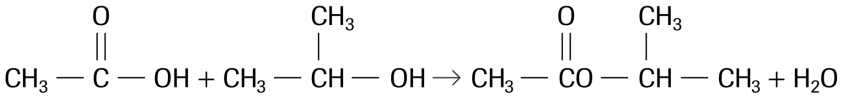
	Reaction 1	**Reaction 2**	**Reaction 3**
IUPAC name of alcohol used	ethanol	2-propanol	1-pentanol
Structural formula of alcohol used	CH_3CH_2OH	$CH_3CH(OH)CH_3$	$CH_3CH_2CH_2CH_2CH_2OH$
IUPAC name of carboxylic acid used	ethanoic acid	ethanoic acid	ethanoic acid
Structural formula of carboxylic acid used	CH_3COOH	CH_3COOH	CH_3COOH
IUPAC name of ester produced	ethyl ethanoate	isopropyl ethanoate	pentyl ethanoate
Structural formula of ester produced	$CH_3COOCH_2CH_3$	$CH_3COOCHCH_3CH_3$	$CH_3COOCH_2CH_2CH_2CH_2CH_3$
Odour of ester produced	fruity	fruity	banana

(b) **Reaction in Tube #1**



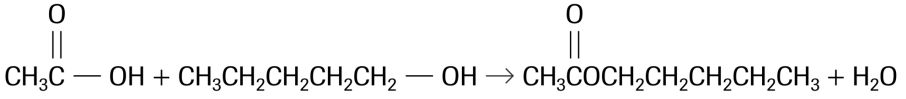
ethanoic acid ethanol ethyl ethanoate water

Reaction in Tube #2



ethanoic acid 2-propanol isopropyl ethanoate water

Reaction in Tube #3



ethanoic acid 1-pentanol pentyl ethanoate water

(c) The concentrated sulfuric acid acts as a catalyst.

(d) The esters are insoluble in aqueous solution because each ester formed a layer on top of the cold water in the evaporating dish. This effect is caused by the loss of the hydroxyl group from the carboxyl group when the ester bond is formed. Thus, the ability to hydrogen bond with water is lost.