10. (a) Acetone contains a carbonyl group that is polar and makes it soluble in aqueous solutions.
(b) $c = 20 \text{ mg}/100 \text{ mL}$

$c = 200 \text{ mg/L}$

$M_{CH_3C(O)CH_3} = 58.09 \text{ g/mol}$

$$n = \frac{200 \text{ mg}}{58.09 \text{ g/mol}}$$

$n = 0.003 \text{ mol}$

$c = 0.003 \text{ mol/L}$

(c) People who are severely starved or dieting do not have a ready supply of sugars in their bodies and are breaking down fats for energy. The acetone produced in the process is exhaled with the breath.
(d) Diabetic ketoacidosis (DKA) is a condition that occurs when blood sugar levels get too high. The signs of DKA include nausea and vomiting (which can lead to dehydration), stomach pain, and deep and rapid breathing. Other symptoms include a flushed face, dry skin and mouth, a fruity odour to the breath, a rapid and weak pulse, and low blood pressure. DKA may be avoided by taking the correct amount of insulin, or exercise. In emergency situations, the person must be given fluids and insulin right away, or ketoacidosis can lead to coma and even death.

1.7 CARBOXYLIC ACIDS AND ESTERS

Try This Activity: Making Flavoured Vinegar

(Page 58)

(a) $CH_3—CH_2—OH + (O) \rightarrow CH_3—CH{=}O$

$$CH_3—CH{=}O + (O) \rightarrow CH_3—\underset{\displaystyle OH}{\overset{\displaystyle O}{\overset{|}{C}}}—O$$

(b) To test for acid, use pH meter or pH paper; or mix with baking soda and look for bubbles of CO_2 formed.
(c) Heating the jars of vinegar has the effect of stopping further reaction by the yeast; the high temperature kills the yeast.

PRACTICE

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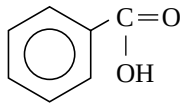
Understanding Concepts

1. (a) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—\underset{\displaystyle OH}{\overset{\displaystyle O}{\overset{|}{C}}}{=}O$

octanoic acid

(b) 

benzoic acid

(c) $$CH_3—CH_2—\underset{\displaystyle CH_3}{\overset{|}{CH}}—\underset{\displaystyle OH}{\overset{\displaystyle O}{\overset{|}{C}}}{=}O$$

2-methylbutanoic acid

2. (a) methanoic (formic) acid
(b) 3-ethylpentanoic acid
(c) 2,3-diethylhexanoic acid

PRACTICE

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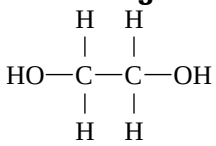
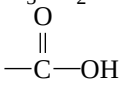
Understanding Concepts

3.



1,2-ethanediol

4. The gas (A) has the lowest boiling point and must be the alkane, the least polar molecule. The liquid (B) has the next highest boiling point and must be the alcohol, which has a hydroxyl group. The solid (C) has a higher melting point than the liquid, and must be the acid which, with its carboxyl group, is the most polar of the three compounds.
5. $CH_3CH_2CH_2OH + (O) \rightarrow CH_3CH_2CHO + H_2O$
   $CH_3CH_2CHO + (O) \rightarrow CH_3CH_2COOH$
6.



carboxyl group

The hydroxyl group in this functional group is polar and can hydrogen bond, making the molecule soluble in water. The carbonyl group is also polar and, with the hydroxyl group, increases intermolecular attractions and thus raises the melting and boiling points of carboxylic acids.

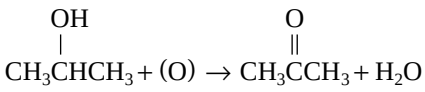
7. $CH_3CH_2OH + (O) \rightarrow CH_3CHO + H_2O$
   $CH_3CHO + (O) \rightarrow CH_3COOH$

Applying Inquiry Skills

8. Melting and boiling points: the aldehyde and the ketone are more likely liquid at room temperature and the carboxylic acid solid; the carboxyl group in the acid is polar and also can hydrogen bond while the aldehyde and ketone do not contain the hydroxyl group. Litmus and pH test: Carboxylic acids turn litmus red, an acidic pH. Controlled oxidation: The aldehyde can be further oxidized, changing the colour of an oxidizing agent such as sodium dichromate or potassium permanganate, the ketone and the acid will not.

Making Connections

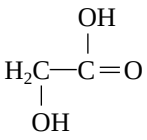
9. Examples: 2-propanol (rubbing alcohol), ethylene glycol (antifreeze). These do not turn sour. For example,



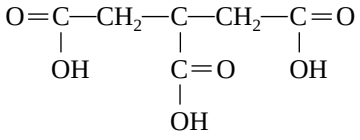
alcohol oxidation

Ketones are not further oxidized by (O).

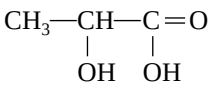
10. (a) "Alpha hydroxy" is an incomplete name; a parent molecule name is needed, e.g., alpha hydroxy butanoic acid.
    (b)



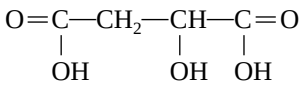
glycolic acid



citric acid



lactic acid



malic acid

    (c) These acids have the polar carboxyl group and hydroxyl group; they also have a nonpolar hydrocarbon chain.
    (d) With the outer layer of the skin removed, the new skin layer is more exposed to the harmful UV rays of the Sun.

PRACTICE

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Understanding Concepts

11. (a) $HCOOH + CH_3CH_2OH \rightarrow HCOOCH_2CH_3 + HOH$
methanoic acid + ethanol → ethyl methanoate + water
rum flavour

(b) $Ø\text{-}COOH + CH_3CH_2OH \rightarrow Ø\text{-}COOCH_2CH_3 + HOH$
benzoic acid + ethanol → ethyl benzoate + water
cherry flavour

(c) $CH_3CH_2CH_2COOH + CH_3OH \rightarrow CH_3CH_2CH_2COOCH_3 + HOH$
butanoic acid + methanol → methyl butanoate + water
apple flavour

(d) $CH_3COOH + CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_2CH_2OH \rightarrow CH_3COOCH_2CH_2\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_3 + HOH$
ethanoic acid + 3-methylbutanol → 3-methylbutyl ethanoate + water
banana flavour

12. (a) ethyl propanoate (from propanoic acid and ethanol)
(b) methyl butanoate (from butanoic acid and methanol)
(c) butyl methanoate (from methanoic acid and 1-butanol)
(d) propyl ethanoate (from ethanoic acid and 1-propanol)

PRACTICE

(Page 67)

Understanding Concepts

13. An ester contains an —OR group in place of the —OH in the carboxylic acid. The OH group is responsible for the acidic properties of carboxylic acids, and also for hydrogen bonding; thus, esters have lower melting and boiling points, are less soluble in water, and are less acidic.
14. The experimental conditions include the presence of an acid or a base, and heat.
$HCOOCH_2CH_3 + NaOH \rightarrow HCOO^-Na^+ + CH_3CH_2OH$
sodium methanoate + ethanol
(sodium formate)

Applying Inquiry Skills

15. **Experimental Design**
Heat ethanol and acetic acid, in the presence of concentrated sulfuric acid.

Procedure

1. In a test tube, mix approximately equal amounts of ethanol and acetic acid.
2. Under the fume hood, add a few drops of concentrated sulfuric acid. Heat test tube and contents in hot-water bath.

Safety Precautions:
Concentrated sulfuric acid is highly corrosive. Avoid contact with skin and clothing. Wear eye protection and a lab apron. Work under a fume hood and keep test tubes in hot-water bath away from people. Ethanol is flammable, so there should be no open flames in the vicinity. Dispose of materials in designated labelled containers.

Making Connections

16. $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$
nitric acid + sodium hydroxide → sodium nitrate + water
$CH_3COOH + CH_3CH_2CH_2OH \rightarrow CH_3COOCH_2CH_2CH_3 + H_2O$
ethanoic acid + propanol → propyl ethanoate + water

SECTION 1.7 QUESTIONS

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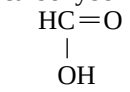
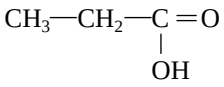
Understanding Concepts

1. (a) propyl propanoate
   (b) 2-methylpentyl propanoate
   (c) 2-bromopropanoic acid
   (d) ethanoic acid
   (e) carboxybenzene or phenylmethanoic acid (commonly called benzoic acid)
2. (a)



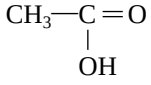
methanoic acid

(b)

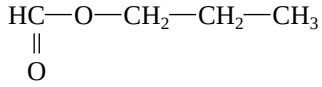


propanoic acid

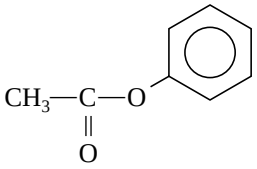
(c)



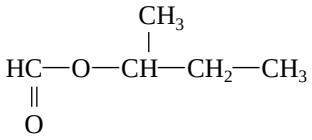
(d)



(e)

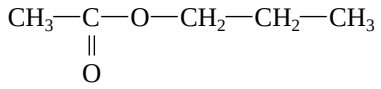


3. (a)



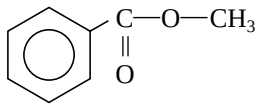
1-methylpropyl methanoate

(b)



propyl ethanoate

(c)



methyl benzoate

4. (a) propanoic acid and 1-pentanol
   (b) 2-ethylpentanoic acid and propanol
   (c) benzoic acid and methanol

Applying Inquiry Skills

5. Heat the ester with a concentrated NaOH solution. The reaction is complete when the insoluble ester changes to soluble products.
6. Esters are less soluble than acids or alcohols in water and can be separated by pouring the reaction mixture into cold water; the ester forms an insoluble layer on top of the water.

Making Connections

7. Examples of controlled oxidation reactions: cellular respiration; rusting of iron; tarnishing of silver; souring of wine.

   Controlled oxidations are "preferred" when temperature must be kept low, and rate of oxidation controlled, e.g., molecules of food are "burned" to release energy in the cell, at body temperatures.

   Uncontrolled oxidations are ideal when we want energy released quickly, raising the surrounding temperature, e.g., burning of wood as fuel.

8. (Answers may include the following occupations: chemist in perfume industry, wine industry, pharmaceutical industry, or cosmetics industry; nutritionist; forensic scientist. Sample answer)

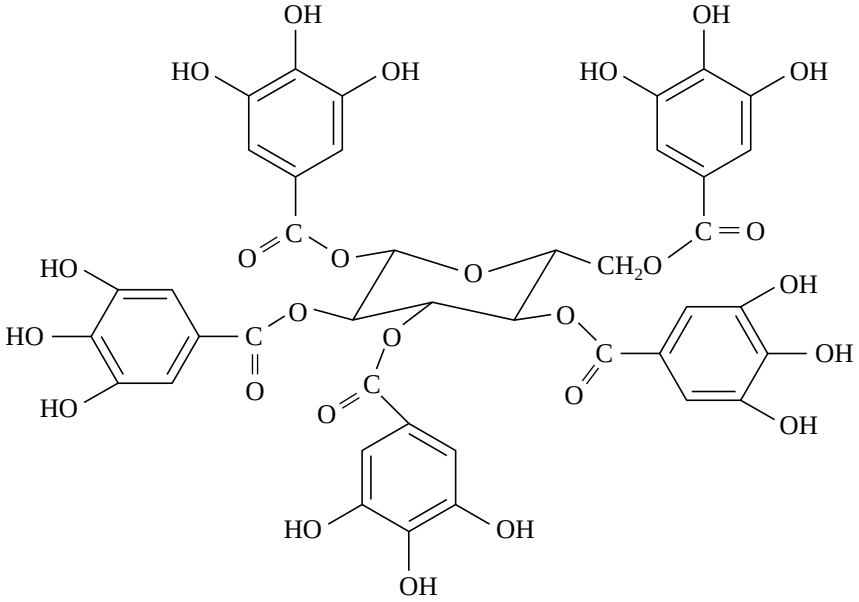
   Chemist in wine industry

   Strengths and qualities needed – strong scientific background, strong technical analytical skills, research skills, good teamwork skills

   Academic training – undergraduate or graduate degree in science, particularly in chemistry, biology, or biochemistry

   Degree in Oenology and Viticulture available at Brock University (See weblinks.)

   Job opportunities – wineries in Ontario and other parts of Canada (See weblinks.)

9. 

   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 and hair is removed by soaking 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 a strong water-resistant leather.

1.8 AMINES AND AMIDES

PRACTICE

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Understanding Concepts

1. putrescine: 1,4-diaminobutane; cadaverine: 1,5-diaminopentane
2. (a) diethylamine, *N*-ethylaminoethane; 2° amine
   (b) trimethylamine, *N*,*N*-diethylaminoethane; 3° amine
   (c) *i*-propylamine, 2-aminopropane; 1° amine
   (d) *n*-hexylamine, 1-aminohexane; 1° amine
   (e) 2-bromo-6-*N*-methylaminohexane; *N*-methyl-*N*-5-bromohexylamine; 2° amine; 2° amine