1.5 ALCOHOLS AND ETHERS

PRACTICE

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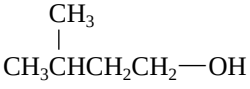
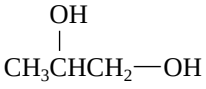
Understanding Concepts

1. (a) 2-butanol
   (b) 1,4-pentanediol
   (c) 1,3-dihydroxybenzene
2. (a)



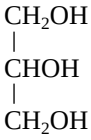
3-methyl-1-butanol

(b)



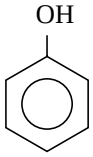
1,2-propanediol

(c)



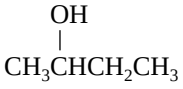
glycerol

(d)



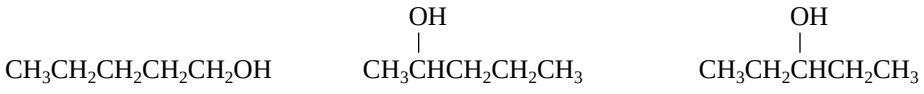
phenol

3. (a)



2-butanol

(b)



1-pentanol 2-pentanol 3-pentanol

PRACTICE

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Understanding Concepts

4. The presence of a hydroxyl group in methanol makes the molecule more polar than methane, and allows hydrogen bonding between molecules. This increase in intermolecular forces results in a higher boiling point.
5. Lowest b.p. Highest b.p.
   butane, 1-butanol, octane, 1-octanol

A longer carbon chain allows more intermolecular attractions such as van der Waals forces; thus, octane has a higher boiling point than does butane. The alcohols generally have higher boiling points than the alkanes because of the presence of the hydroxyl groups. Octanol has a higher boiling point than does butanol, also because of its longer carbon chain.

Making Connections

6. Each molecule of glycerol contains three hydroxyl groups which can hydrogen bond with water, interfering with the attractions between water molecules, and thus interfering with the freezing of water. When water in tissues does not freeze, there is less damage to the tissues.

PRACTICE

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Understanding Concepts

7. (a) $CH_3CH{=}CHCH_3 + H_2O \rightarrow CH_3\overset{H}{\overset{|}{C}}H-\overset{OH}{\overset{|}{C}}HCH_3$

   (b) ethene + hydrogen hypochlorite $\rightarrow$ 2-chloroethanol

8 (a) $CH_3CH_2\overset{OH}{\overset{|}{C}}H_2 \xrightarrow{H_2SO_4} CH_3CH{=}CH_2 + H_2O$

   (b) 1-butanol $\xrightarrow{H_2SO_4}$ 1-butene + water

9. (a) $C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$

   (b) $2\ CH_3CH(OH)CH_3 + 9\ O_2 \rightarrow 6\ CO_2 + 8\ H_2O$

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Making Connections

10. (a) Fuel cell technology – in the direct methanol fuel cell chamber, a catalyst-coated membrane separates two chambers: a negatively charged chamber containing methanol/water solution, and a positively charged chamber containing air. Hydrogen ions pass through the membrane, creating an electric current.

    (b) Advantages: cleaner burning, CO_2 emissions half those of burning gasoline; methanol is readily broken down by microorganisms; methanol can be produced from renewable sources such as wood and sewage.
    Disadvantages: less energy per litre; higher fuel cost per kilometre; methanol refuelling stations not readily available.

    (c) For: environmental benefits; renewable resource.
    Against: cost to manufacturers and consumers; low-energy fuel; building system of refuelling stations.

PRACTICE

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Making Connections

11. (a) methoxypropane

    (b) ethoxypropane

PRACTICE

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Understanding Concepts

12. (Sample answer)
    Alcohol: $2\ C_5H_{11}OH + 15\ O_2 \rightarrow 10\ CO_2 + 12\ H_2O$
    Ether: $2\ C_2H_5{-}O{-}C_3H_7 + 15\ O_2 \rightarrow 10\ CO_2 + 12\ H_2O$

13. (a) $CH_3{-}CH_2{-}O{-}CH_2{-}CH_3$ and $CH_3{-}O{-}CH_2{-}CH_2{-}CH_3$
    Yes, they are structural isomers.

    (b) $2\ CH_3CH_2OH \xrightarrow{H_2SO_4} CH_3CH_2OCH_2CH_3 + H_2O$

SECTION 1.5 QUESTIONS

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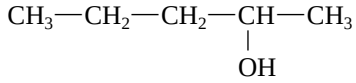
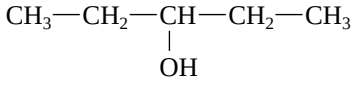
Understanding Concepts

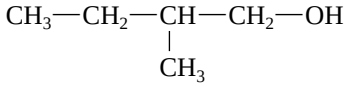
1. $CH_3-CH_2-CH_2-CH_2-CH_2-OH$ (1-pentanol)



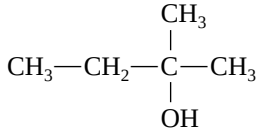
2-pentanol



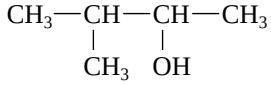
3-pentanol



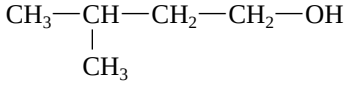
2-methyl-1-butanol



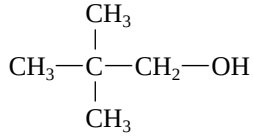
2-methyl-2-butanol



3-methyl-2-butanol



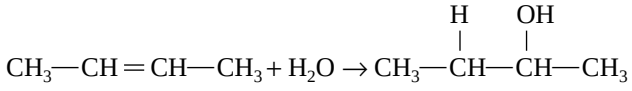
3-methyl-1-butanol



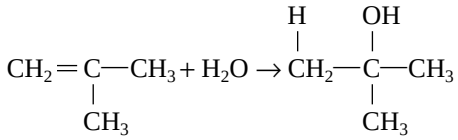
2,2-dimethyl-1-propanol

2. Propane is a hydrocarbon, nonpolar, with weak intermolecular forces; thus, it has a low boiling point and is a gas at room temperature. 2-propanol is an alcohol, with a polar hydroxyl group, with strong intermolecular hydrogen bonds; thus, it has a higher boiling point than propane and is a liquid at room temperature.
3. $CH_2=CH-CH_2-CH_2-CH_2-CH_3$ 1-hexene
   $CH_3-CH=CH-CH_2-CH_2-CH_3$ 2-hexene

4. (a)



(b)



5. $CH_3-O-CH_2-CH_2-CH_3$ methoxypropane
   $CH_3-CH_2-O-CH_2-CH_3$ ethoxyethane
6. (a) addition, hydration
   $CH_2=CH_2 + H_2O \rightarrow CH_3CH_2OH$
   (b) elimination, dehydration
   $CH_3CH(OH)CH_2CH_3 \rightarrow CH_2=CHCH_2CH_3 + CH_3CH=CHCH_3 + H_2O$
   (c) combustion
   $CH_3CH_2OCH_2CH_3 + 6\ O_2 \rightarrow 4\ CO_2 + 5\ H_2O$
   (d) addition
   $CH_2=CH_2 + HOCl \rightarrow CH_2(Cl)CH_2OH$
   (e) combustion
   $2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O$
7. (a) glycerol: Glycerol has three hydroxyl groups per molecule, ethylene glycol has two. Glycerol can form more hydrogen bonds and has a higher boiling point.
   (b) water: Water has hydroxyl groups which can hydrogen bond; methoxymethane has no hydroxyl groups.Water has a higher boiling point.
   (c) propanol: Both alcohols have hydroxyl groups but propanol has a longer carbon chain and thus has greater van der Waals intermolecular forces.
   (d) propanol: Propanol has hydroxyl groups capable of hydrogen bonding while methoxyethane does not. Propanol has a higher boiling point.

Applying Inquiry Skills

8. **Experimental Design**

Diethylene glycol has a boiling point (244°C) higher than that of ethanol (78°C) and water (100°C). Use condensation equipment to separate fractions, removing the fraction corresponding to the boiling point of ethylene glycol.

Procedure

1. Set up condensation equipment (e.g., round-bottomed flask with thermometer, retort equipment, water-cooled condenser, collection flask).
2. Gently heat wine until alcohol and water evaporate and collect condensed fractions.
3. When temperature approaches 244°C, change collection flask and collect fraction above 244°C (ethylene glycol) and discard.

Safety Precautions

Do not use open flame. Work in a well-ventilated area. Wear eye and face protection and an apron.

Making Connections

9. (a) $2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O$
   $CH_3CH_2OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$
   (b) Ethanol has a longer nonpolar carbon chain which makes it a better solvent for the nonpolar hydrocarbons in gasoline.
   (c) Environmental benefits to burning alcohols as fuel: clean burning (lower carbon monoxide emissions than regular gasoline); low in reactivity and high in oxygen content, making it an effective tool in reducing ozone pollution; safe replacement for toxic octane enhancers in gasoline such as benzene, toluene, and xylene.
   (d) Methanol and ethanol, having both polar hydroxyl groups and nonpolar carbon chains, are soluble in both water and in gasoline; thus, water droplets are dissolved in the alcohol and do not form ice, which blocks gasoline flow.