Back:

Family	Characteristic properties	Characteristic functional groups	Intermolecular forces
Amines	often have unpleasant odours; react with carboxylic acids to form amides; have higher boiling points and melting points than similar-sized hydrocarbons, lower boiling points and melting points than similar-sized alcohols; smaller amines are readily soluble in water	$-\overset{\vert}{N}-$	hydrogen bonds due to any –NH groups; van der Waals forces due to polar C–N bonds
Amides	generally insoluble in water	$-\overset{\overset{O}{\Vert}}{C}-\overset{\vert}{N}-$	hydrogen bonds due to any –NH groups

UNIT 3 PERFORMANCE TASK: MAKING SOAP

(Pages 253–255)

Analysis

(a) The functional groups of glycerol are all hydroxyl groups, –OH. Glycerol is therefore an alcohol. It forms hydrogen bonds in addition to van der Waals forces.

(b) The functional group of stearic acid is the carboxyl group, –COOH, made up of a carbonyl group and a hydroxyl group. Stearic acid is a carboxylic acid. It forms hydrogen bonds in addition to van der Waals forces due to the polar carbonyl groups. Stearic acid has low solubility in water because its long hydrocarbon chain “nullifies” the polarity of the carboxyl group, rendering it a more nonpolar molecule that has low solubility in a polar solvent.

(c) Water is formed. Therefore, this reaction is a condensation reaction.

$$\begin{array}{lcrcrc}
CH_3-(CH_2)_{16}-COOH & & HO-CH_2 & & CH_3-(CH_2)_{16}-COO-CH_2 & \\
 & & \vert & & \vert & \\
CH_3-(CH_2)_{16}-COOH & + & HO-CH & \rightarrow & CH_3-(CH_2)_{16}-COO-CH & +\ 3\ H_2O \\
 & & \vert & & \vert & \\
CH_3-(CH_2)_{16}-COOH & & HO-CH_2 & & CH_3-(CH_2)_{16}-COO-CH_2 &
\end{array}$$

(d)

$$\begin{array}{ccccccc}
 & & H & & O & & \\
 & & \vert & & \Vert & & \\
H & - & C & - & C & - & OH \\
 & & \vert & & & & \\
 & & H & & & &
\end{array}$$

ethanoic acid (acetic acid)

$CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow CH_3COONa_{(aq)} + H_2O_{(l)}$

Evaluation

(e) [Sample answer] The soap did not harden; it remained greasy. We perhaps need to use more $NaOH_{(aq)}$. The soap did not lather very well. It is possible that using distilled water in the procedure would solve this problem.

Synthesis

(f) We would predict that glycerol has a higher boiling point than 1-propanol because glycerol has three hydroxyl groups and 1-propanol has one. Glycerol would therefore form more hydrogen bonds than would 1-propanol, and thus more energy is required to separate the glycerol molecules to form a gaseous state.

(g) Glycerol is probably soluble in polar solvents because of the polar hydroxyl groups. It may be slightly soluble in nonpolar solvents because of the three-carbon backbone.

(h) Carbon dioxide and water would form as a result of the combustion of glycerol:

$$\begin{array}{l}
\ \ CH_2OH \\
\ \ \ \vert \\
2\ CHOH + 7\ O_2 \rightarrow 6\ CO_2 + 8\ H_2O \\
\ \ \ \vert \\
\ \ CH_2OH
\end{array}$$

(i) Use organic solvents in a well-ventilated location or fume hood, away from ignition sources such as electrical sparks, open flames, and hot surfaces. Do not store solvents in direct sunlight or near heat sources, or in basements. Return unused portions immediately to the appropriate storage containers. Dispose of small amounts of ethanol (according to environmental restrictions) in the sink, followed by plenty of water.

(j) Detergents are made from long hydrocarbon chains and sulfuric acid. They are similar to soap molecules, which also have long carbon chains and a salt group at one end. Advantages of detergents are that they do not produce an insoluble “scum” with the calcium and magnesium ions in hard water, and they are generally less expensive than soap. Disadvantages of detergents are that they are generally not biodegradable and may damage the environment. They are made from non-renewable petroleum products.

UNIT 3 REVIEW

(Pages 256–259)

Understanding Concepts

1. (a) $HC{\equiv}CH$
   (b) $CH_3CH(OH)CH_3$
   (c)
   CH_3CCH_3
   ||
   O
   (d) CH_3COOH
2. (a) Fractional distillation separates the mixture of hydrocarbons in petroleum, collecting the fractions used in gasoline. Cracking converts larger straight-chain hydrocarbons into the shorter branched-chain hydrocarbons that are valuable in gasoline.
   (b) Three other useful fuels are jet fuel, kerosene, and diesel oil.
3. C, B, D, A. The reason for this order is that more polar compounds have higher boiling points as a result of increased intermolecular forces. C is an alkane and is nonpolar. B is more polar than C because of its carbonyl group. D is more polar than B because of its –OH group, which is capable of hydrogen bonding. A is more polar than D because it has an –OH group and a carbonyl group.
4. (a) acetone (propanone)
   CH_3CCH_3
   ||
   O
   (b) acetic acid (ethanoic acid)
   CH_3COH
   ||
   O
   (c) formaldehyde (methanal)
   HCHO
   (d) glycerol (1,2,3-propantriol)
   CH_2 — CH — CH_2
   | | |
   OH OH OH
   (e) diethyl ether (ethoxyethane)
   CH_3CH_2—O—CH_2CH_3
5. (a) ethanol, 1-pentanol: Both molecules have a polar hydroxyl group, but the longer hydrocarbon chain in the pentanol increases its intermolecular van der Waals attractions.
   (b) ethoxyethane, propanone: The carbonyl group in the ketone makes it more polar. Therefore, it has stronger intermolecular attractions.
   (c) ethanal, ethanoic acid: The acid has an additional hydroxyl group that the aldehyde does not have, making it more polar and capable of hydrogen bonding; thus, the acid has stronger intermolecular attractions.
6. (a) propane, 1-propanol: Propane does not contain any polar groups and is therefore insoluble in water. Propanol contains a hydroxyl group, which allows hydrogen bonding and solubility in water.