2. 1. Ionic compounds get pulled apart (dissociate) into their individual ions surrounded by water molecules. Molecular compounds get pulled apart and separate into their individual molecules surrounded by water molecules. Molecules of acid-forming compounds ionize in water to form aqueous hydrogen ions and anions. Many chemical reactions occur best when the reactants are dissolved in water.
   2. Amount concentration (mol/L); percent concentration (%V/V, %W/V, %W/W); and parts per million (ppm). Amount concentration is most useful for chemists during laboratory work. Percent concentration is more useful for consumers buying and using chemical products. Parts per million is useful for solutions where the solute concentration is very low (e.g., bottled water and environmental concerns such as concentration of toxins in a body of water).
   3. Yes, there is a limit to how much of a substance can dissolve to make a solution. It is called the saturation point—the maximum quantity of solute that can dissolve in a given quantity of solvent at a given temperature.

Chapter 5 REVIEW

(Pages 231–233)

Part 1

1. C
2. B
3. 1.50
4. D
5. A
6. 10.4
7. 1.23
8. C
9. 70.1
10. C
11. B
12. A
13. D

Solutions:

3. $[\text{F}^-(\text{aq})] = \dfrac{0.375\ \text{mg}}{0.250\ \text{L}} = 1.50\ \text{ppm}$

6. $m_{\text{Ca(HCO}_3)_2} = 52.0\ \cancel{\text{L}} \times \dfrac{200\ \text{mg}}{1\ \cancel{\text{L}}} = 1.04 \times 10^4\ \text{mg} = 10.4\ \text{g}$

7. $c_{\text{Ca(HCO}_3)_2} = \dfrac{200\ \text{m}\cancel{\text{g}}}{1\ \text{L}} \times \dfrac{1\ \text{mol}}{162.12\ \cancel{\text{g}}} = 1.23\ \text{mmol/L}$

9. $m_{\text{KOH}} = 0.500\ \cancel{\text{L}} \times \dfrac{2.50\ \cancel{\text{mol}}}{1\ \cancel{\text{L}}} \times \dfrac{56.11\ \text{g}}{1\ \cancel{\text{mol}}} = 70.1\ \text{g}$

Part 2

14. A homogeneous mixture is a uniform mixture of only one phase (e.g., NaCl(aq)), whereas in a heterogeneous mixture, the different substances are visible as two or more phases (e.g., oil and vinegar dressing, or bubble tea).

15. According to the evidence collected, solution A must be the sulfuric acid, solution B must be glucose, solution C must be calcium hydroxide, and solution D must be potassium chloride.
16. (a) Electrolytes can be distinguished from nonelectrolytes by testing solutions of the compound with an ohmmeter, or conductivity meter. Electrolytes form conducting solutions; nonelectrolytes form nonconducting solutions.
    (b) Acids, bases, and neutral compounds can be distinguished by testing a solution of each compound with blue and red litmus. In an acidic solution, blue litmus changes to red (but red litmus remains unchanged); in a basic solution, red litmus change to blue (but blue litmus remains unchanged); and in a neutral solution, neither red nor blue litmus changes colour.
17. A standard solution is one for which the concentration is accurately known. It is necessary for accurate chemical analysis and for precise control of chemical reactions.
18. Standard solutions are prepared either by dissolving a measured mass of a solid solute to make a known volume of solution, or by diluting an existing (more concentrated) solution of known concentration to decrease its concentration.
19. When a chemical (such as glucose) is dissolved in a solvent (such as blood), chemical reactions can actually occur (or occur more rapidly). Pieces of solid glucose travelling through the body could damage the delicate blood vessels and other cells.
20. Empirically, when dissolving a chemical is an endothermic reaction, the temperature of the surroundings decreases.
    Theoretically, when dissolving a chemical is endothermic, the total energy absorbed to break the bonds of the solute (in this case, ionic bonds between the sodium and the nitrate ions) and the intermolecular bonds in the solvent is greater than the energy released when bonds are created between the water molecules and the individual ions, resulting in a net energy gain for the reaction. The energy needed for the endothermic dissolving is taken from the surrounding area, causing the decrease in temperature.
21. In chemistry labs, concentration is expressed as an amount concentration (mol/L). The concentration of household products is expressed as a percent concentration (%V/V, %W/V, %W/W). In environmental studies, concentration is most often expressed in parts per million (ppm).
22.

$$m_{\text{serving}} = 3.0\ \cancel{\text{g fat}} \times \frac{100\ \text{g}}{5.9\ \cancel{\text{g fat}}}$$
$$= 51\ \text{g or } 0.051\ \text{kg}$$

$$m_{\text{serving}} = 3.0\ \cancel{\text{g fat}} \times \frac{100\ \text{g serving}}{2.0\ \cancel{\text{g fat}}}$$
$$= 0.15\ \text{kg}$$

$$m_{\text{serving}} = 3.0\ \cancel{\text{g fat}} \times \frac{100\ \text{g serving}}{1.2\ \cancel{\text{g fat}}}$$
$$= 0.25\ \text{kg}$$

The serving sizes containing 3.0 g of fat for the three choices of yogurt are as follows: For 5.9% MF yogurt, a 51 g or 0.051 kg serving; for 2.0% MF yogurt, a 0.15 kg serving; and for 1.2% MF yogurt, a 0.25 kg serving.
23. (White) vinegar is most commonly sold in stores as a 5% (by volume) solution of acetic acid, $CH_3COOH(aq)$. (*Commercial labelling is always a guaranteed legal minimum.*)

$$V_{CH_3COOH} = 15\ \text{mL} \times \frac{100\ \cancel{\text{mL}}}{5\ \cancel{\text{mL}}}$$
$$= 0.3\ \text{L}$$

The volume of vinegar containing 15 mL of acetic acid is 0.3 L.

24. (a) $c_{Cu(NO_3)_2} = \frac{0.35 \text{ mol}}{0.500 \text{ L}}$

$= 0.70 \text{ mol/L}$

The amount concentration of the copper(II) nitrate is 0.70 mol/L.

(b) $n_{NaOH} = 10.0 \text{ g} \times \frac{1 \text{ mol}}{40.00 \text{ g}}$

$= 0.250 \text{ mol}$

$c_{NaOH} = \frac{0.250 \text{ mol}}{2.00 \text{ L}}$

$= 0.125 \text{ mol/L}$

or $c_{NaOH} = 10.0 \text{ g} \times \frac{1 \text{ mol}}{40.00 \text{ g}} \times \frac{1}{2.00 \text{ L}}$

$= 0.125 \text{ mol/L}$

The amount concentration of the sodium hydroxide is 0.125 mol/L.

(c) $V_i c_i = V_f c_f$

$c_f = \frac{V_i c_i}{V_f}$

$= \frac{25 \text{ mL} \times 11.6 \text{ mol/L}}{145 \text{ mL}}$

$= 2.0 \text{ mol/L}$

or $c_f = 11.6 \text{ mol/L} \times \frac{25 \text{ mL}}{145 \text{ mL}} = 2.0 \text{ mol/L}$

The final amount concentration of hydrochloric acid is 2.0 mol/L.

(d) 16 ppm of $Mg^{2+}(aq)$ = 16 mg/L

$n_{Mg^{2+}} = 16 \text{ mg} \times \frac{1 \text{ mol}}{24.31 \text{ g}}$

$= 0.66 \text{ mmol}$

$c_{Mg^{2+}} = \frac{0.66 \text{ mmol}}{1.00 \text{ L}}$

$= 0.66 \text{ mmol/L}$

or $c_{Mg^{2+}} = \frac{16 \text{ mg}}{1 \text{ L}} \times \frac{1 \text{ mol}}{24.31 \text{ g}} = 0.66 \text{ mmol/L}$

The amount concentration of magnesium ions is 0.66 mmol/L.

25. $n_{Na_2C_2O_4} = 0.2500 \text{ L} \times \frac{0.375 \text{ mol}}{1 \text{ L}}$

$= 0.0938 \text{ mol}$

$m_{Na_2C_2O_4} = 0.0938 \text{ mol} \times \frac{134.00 \text{ g}}{1 \text{ mol}}$

$= 12.6 \text{ g}$

or $m_{Na_2C_2O_4} = 0.2500 \text{ L} \times \frac{0.375 \text{ mol}}{1 \text{ L}} \times \frac{134.00 \text{ g}}{1 \text{ mol}}$

$= 12.6 \text{ g}$

The mass of sodium oxalate required is 12.6 g.

26. $V_i c_i = V_f c_f$

$$V_i = \frac{V_f c_f}{c_i}$$

$$= \frac{500 \text{ mL} \times 1.25 \cancel{\text{mol}}/\text{L}}{14.6 \cancel{\text{mol}}/\text{L}}$$

$$= 42.8 \text{ mL}$$

or $V_i = 500 \text{ mL} \times \frac{1.25 \cancel{\text{mol/L}}}{14.6 \cancel{\text{mol/L}}} = 42.8 \text{ mL}$

The volume of concentrated phosphoric acid solution required is 42.8 mL.

27. $n_{C_6H_{12}O_6} = 4.7 \text{ L} \times \frac{7.8 \text{ mmol}}{1 \text{ L}} = 37 \text{ mmol}$

$$m_{C_6H_{12}O_6} = 37 \text{ mmol} \times \frac{180.18 \text{ g}}{1 \text{ mol}} = 6.6 \times 10^3 \text{ mg}$$

or $m_{C_6H_{12}O_6} = 4.7 \cancel{\text{L}} \times \frac{7.8 \text{ m}\cancel{\text{mol}}}{1 \cancel{\text{L}}} \times \frac{180.18 \text{ g}}{1 \cancel{\text{mol}}} = 6.6 \times 10^3 \text{ mg}$

The mass of glucose present in 4.7 L of blood is 6.6 g.

28. (a) $n_{C_6H_{12}O_6} = 0.1000 \text{ L} \times \frac{3.1 \text{ mmol}}{1 \text{ L}} = 0.31 \text{ mmol}$

$$m_{C_6H_{12}O_6} = 0.31 \text{ mmol} \times \frac{180.18 \text{ g}}{1 \text{ mol}} = 56 \text{ mg}$$

or $m_{C_6H_{12}O_6} = 0.1000 \cancel{\text{L}} \times \frac{3.1 \text{ m}\cancel{\text{mol}}}{1 \cancel{\text{L}}} \times \frac{180.18 \text{ g}}{1 \cancel{\text{mol}}} = 56 \text{ mg}$

The mass of solid glucose required is 56 mg.

(b) **Materials**

- eye protection
- stirring rod
- laboratory scoop
- pure water bottle
- 56 mg pure glucose
- medicine dropper
- laboratory apron
- milligram balance
- 100 mL volumetric flask and stopper
- funnel
- 100 mL beaker
- meniscus finder

(c) **Procedure**

1. Measure 56 mg of glucose in a clean, dry 100 mL beaker.
2. Dissolve the solid in 40 mL to 50 mL of pure water.
3. Transfer the solution to a 100 mL volumetric flask. Make sure you rinse the beaker into the flask.
4. Add pure water, using the dropper and meniscus finder, until the volume of solution is 100.0 mL.
5. Stopper the flask and mix contents thoroughly by inverting the flask several times.

29. Medical research has established the biology of people with diabetes. Chemical research into the properties of glucose solutions has established the principles of the glucose meter. Because diabetics need to monitor their blood glucose concentration levels daily, the technology of monitors was developed from scientific research. This technology benefits society in that most diabetics can now lead a normal life, a life made easier by the science and technology created to help them.

30. The reaction is exothermic because the temperature of the surroundings increases when the acid is diluted.

31. In general, add concentrated reagents such as acids to water when diluting, not the other way around. The reason for this is that, if you add water to highly concentrated acid, you may initially form a localized concentrated solution of acid as a thin layer between the denser acid and overlying water. So much heat may be released to the small amount of water in the layer of contact that the solution may boil violently at this level, splashing hot concentrated acid out of the container. If you add concentrated acid to water, the denser acid sinks and mixes as you pour, so the solution that forms is continuously diluted by the surrounding water. The heat released is dissipated, so it is not enough to cause localized boiling. Concentrated sulfuric, nitric, phosphoric and (glacial) acetic acids are particularly dangerous to dilute, but it is good practice to habitually add *any* acid to water when diluting.

32. $V_i c_i = V_f c_f$

$$V_i = \frac{V_f c_f}{c_i}$$

$$= \frac{2.00\ \text{L} \times 0.250\ \cancel{\text{mol}}/\text{L}}{17.8\ \cancel{\text{mol}}/\text{L}}$$

$$= 0.0281\ \text{L} = 28.1\ \text{mL}$$

or $V_i = 2.00\ \text{L} \times \dfrac{0.250\ \cancel{\text{mol/L}}}{17.8\ \cancel{\text{mol/L}}} = 0.0281\ \text{L}$

The volume of concentrated sulfuric acid solution required is 28.1 mL.

33. (a) $KCl(aq) \rightarrow K^+(aq) + Cl^-(aq)$
(b) $Na_2SO_4(aq) \rightarrow 2\ Na^+(aq) + SO_4^{2-}(aq)$
(c) $Na_3PO_4(aq) \rightarrow 3\ Na^+(aq) + PO_4^{3-}(aq)$

34. (a) $KNO_3(aq) \rightarrow K^+(aq) + NO_3^-(aq)$

$$[K^+(aq)] = 0.14\ \text{mol/L} \times \frac{1}{1} = 0.14\ \text{mol/L}$$

$$[NO_3^-(aq)] = 0.14\ \text{mol/L} \times \frac{1}{1} = 0.14\ \text{mol/L}$$

(b) $CaCl_2(aq) \rightarrow Ca^{2+}(aq) + 2\ Cl^-(aq)$

$$[Ca^{2+}(aq)] = 0.14\ \text{mol/L} \times \frac{1}{1} = 0.14\ \text{mol/L}$$

$$[Cl^-(aq)] = 0.14\ \text{mol/L} \times \frac{2}{1} = 0.28\ \text{mol/L}$$

(c) $(NH_4)_3PO_4(aq) \rightarrow 3\ NH_4^+(aq) + PO_4^{3-}(aq)$

$$[NH_4^+(aq)] = 0.14\ \text{mol/L} \times \frac{3}{1} = 0.42\ \text{mol/L}$$

$$[PO_4^{3-}(aq)] = 0.14\ \text{mol/L} \times \frac{1}{1} = 0.14\ \text{mol/L}$$

Extension

35.(a) **Comparison of Two Oil Products**

	Bunker sea oil	Pole treating oil
Uses	used as a fuel in large marine diesel engines, power generating plants and industrial furnaces also used for paving materials	used to treat wood products such as telephone poles and railroad ties
Solubility	insoluble in water	very soluble in water
Viscosity	high At 10 °C, it has the consistency of honey. At 0 °C, it hardly flows at all.	moderate
Density	slightly less dense than water	less dense than water