15. $n = cV$

$$V = \frac{n}{c}$$

$$= \frac{0.425\ \cancel{\text{mol}}\ \text{L}}{0.125\ \frac{\cancel{\text{mol}}}{\text{L}}}$$

$$= 3.40\ \text{L}$$

16. $n = cV$

$$c = \frac{n}{V}$$

$$= \frac{0.385\ \text{mol}}{225\ \cancel{\text{mL}}} \times \frac{1000\ \cancel{\text{mL}}}{1\ \text{L}}$$

$$= 1.71\ \frac{\text{mol}}{\text{L}}$$

17. Moles of sulfate:

$$n = cV$$

$$= \left(0.200\ \frac{\text{mol}}{\cancel{\text{L}}}\right)(50.0\ \cancel{\text{mL}})\left(\frac{1\ \cancel{\text{L}}}{1000\ \cancel{\text{mL}}}\right)$$

$$= 0.0100\ \text{mol}$$

Moles of lead:

$$n = cV$$

$$= \left(0.100\ \frac{\text{mol}}{\cancel{\text{L}}}\right)(80.0\ \cancel{\text{mL}})\left(\frac{1\ \cancel{\text{L}}}{1000\ \cancel{\text{mL}}}\right)$$

$$= 0.00800\ \text{mol}$$

The limiting ion is lead so only 0.00800 moles of lead sulfate can form.

Molar mass of $PbSO_4(s)$:

$$M_{PbSO_4} = M_{Pb} + M_s + 4M_O$$

$$= 207.2\ \frac{\text{g}}{\text{mol}} + 32.07\ \frac{\text{g}}{\text{mol}} + \left(4 \times 16.00\ \frac{\text{g}}{\text{mol}}\right)$$

$$= 303.27\ \frac{\text{g}}{\text{mol}}$$

Mass of 0.00800 mol of lead sulfate:

$$n = \frac{m}{M}$$

$$m = nM$$

$$= (0.00800\ \cancel{\text{mol}})\left(303.27\ \frac{\text{g}}{\cancel{\text{mol}}}\right)$$

$$= 2.42616\ \text{g}$$

$$= 2.43\ \text{g}$$

18. a. lead (II) chromate

b. $2K^+(aq) + CrO_4^{2-}(aq) + Pb^{2+}(aq) + 2NO_3^-(aq) \rightarrow PbCrO_4(s) + 2K^+(aq) + 2NO_3^-(aq)$

c. 0.58 g

19. A concentrated acid has a large number of acid molecules in solution, while a dilute acid has a smaller number of acid molecules in solution.

20. A strong base completely dissociates in water, whereas a weak base does not dissociate completely.

21. A weak base can be concentrated, because concentration is based on the amount of material in solution, not the degree of ionization; therefore, the statement is true.

22. 0.182 mol/L

23. The first proton is lost from the sulfuric molecule due to the interactions of the polar water molecule. Once this proton is lost, HSO_4^- remains and due to the negative charge, the second proton (which is positively charged) is more difficult for water molecules to strip off the ion.

24. a. $x = -1.56$ or $x = 2.56$

b. $x = -1.46$ or $x = 5.46$

c. $x = -1.85$ or $x = 0.18$

25. a. $x = 0.50$

b. 4.20×10^{-4}

26. a. 2^6

b. a^{10}

c. x^4y^4

d. 3^4

27. a. 3

b. 4

c. 8

d. 12

e. −12

28. a. 2.87×10^2

b. 5.95×10^{-3}

c. 1.79×10^6

d. 4.12×10^{-7}

29. a. The function key *LOG* is used to take the logarithm of a number. The function key 10^x is used to take the antilogarithm or to find the number that you raise the base to in order to obtain a specific number.

b. *Sample answer*: $\log 0.001 = x$ and $10^{2.961} = x$;

c. The pH scale for acids and bases is based on logarithms.

Chapter 7 Chemical Equilibrium

Answers to Learning Check Questions

(Student textbook page 422)

1. A reversible reaction is a reaction that can proceed in both the forward and the reverse directions.

2. The double arrows indicate that the reaction is reversible.

3. The rope-pulling team as a whole (comparable to a chemical system) may not appear to be moving, but the individual participants (comparable to particles in a chemical system) are engaged in movement to maintain their position.

4. Equilibrium does not mean an equal balance in concentrations of reactants and products but, rather, a balance in the reaction rates of the forward and reverse processes.

5. Changing: the reaction is still occurring, so reactants still form products while products are re-forming reactants Balanced: these two processes are occurring at the same rate

6. $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$

(Student textbook page 427)

7. Only the liquid and the water vapour in the sealed jar can reach equilibrium because it is the only system that is closed to the surroundings.

8. *Similarities:* both involve a balance in forward and reverse reaction rates, and both involve constant macroscopic properties.

   Differences: different states of matter exist in the heterogeneous equilibrium, whereas all substances in a homogeneous equilibrium are in the same state.

9. If the stopper were removed, the iodine gas would escape, thus preventing the reverse reaction from occurring. As a result, the open system could not reach equilibrium.

10. The law of mass action states that there is a constant ratio between the concentrations of products and the concentrations of reactants. This ratio (where the balanced coefficients of the reaction are used as exponents) is the equilibrium constant.

11. If a chemical system is not at equilibrium, then it is not accurate to write an equilibrium constant expression or a constant. A reaction quotient is written for chemical systems when they are not at equilibrium.

12. If $K_{eq} > 1$, the denominator of the equilibrium constant is less than the numerator, and since the denominator contains information regarding reactants, product formation is favoured. If $K_{eq} \approx 1$, the numerator is approximately equal to the denominator, and approximately equal concentrations of reactants and products exist. If $K_{eq} < 1$, the denominator of the equilibrium constant is greater than the numerator, and since the denominator contains information regarding reactants, reactant formation is favoured.

(Student textbook page 435)

13. When an external influence (such as a change in temperature or pressure) on a system at equilibrium causes a change, the system will eventually move to a new equilibrium.

14. The forward reaction is favoured, as initially more reactant particle collisions will occur, which temporarily increases the rate of the forward reaction, until equilibrium is restored.

15. You exhale $CO_2(g)$, which causes a decrease in the carbon dioxide gas concentration in the system. As a result, the reaction will shift in the forward direction to form more $CO_2(g)$ and this causes a decrease in the carbonic acid level in the blood.

16. The addition of the inert gas will increase the pressure inside the container, but it does not have an effect on the equilibrium, as this increase in pressure affects the reactants and products equally, so both rates of reaction remain the same.

17. With a pressure increase (due to a volume decrease), the system will shift to favour the reaction that takes up the smaller volume, which will be in the direction of the lesser amount in moles of gas. With a pressure decrease (due to a volume increase), the system will shift to favour the reaction that takes up the larger volume, which will be in the direction of the greater amount in moles of gas.

18. Assuming the reaction vessel is kept at a constant temperature:

    a. No change
    b. No change
    c. No change
    d. No change
    e. No change
    f. No change

(Student textbook page 438)

19. *Similarities*: both involve a difference in thermal energy during the reaction.

    Differences: exothermic reactions give off thermal energy, whereas endothermic reactions absorb thermal energy.

20. **a.** When heated, the endothermic reaction (that is, forward reaction) is favoured to absorb the heat added, and more heat is available to enable the reaction to occur.