Chapter 5 Answers

Practice Examples

1a. 0.540 M Cl^-

1b. (a) 7.9×10^{-5} M F^- ; (b) 3.1 kg CaF_2

2a. (a) $Al^{3+}(aq) + 3\ OH^-(aq) \rightarrow Al(OH)_3(s)$

(b) No reaction occurs.

(c) $Pb^{2+}(aq) + 2\ I^-(aq) \rightarrow PbI_2(s)$

2b. (a) $Al^{3+}(aq) + PO_4^{3-}(aq) \rightarrow AlPO_4(s)$

(b) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

(c) $Pb^{2+}(aq) + CO_3^{2-}(aq) \rightarrow PbCO_3(s)$

3a. The acid and base react to form a salt solution of ammonium propionate.
$NH_3(aq) + HC_3H_5O_2(aq) \rightarrow NH_4^+(aq) + C_3H_5O_2^-(aq)$

3b. $CaCO_3(s) + 2\ HC_2H_3O_2(aq) \rightarrow CO_2(g) + H_2O(l) + Ca^{2+}(aq) + 2\ C_2H_3O_2^-(aq)$

4a. (a) It is not an oxidation–reduction reaction; (b) This is an oxidation–reduction reaction.

4b. Vanadium is oxidized, manganese is reduced.

5a. *Oxidation*: $\{Al(s) \rightarrow Al^{3+}(aq) + 3\ e^-\} \times 2$

Reduction: $\{2\ H^+(aq) + 2\ e^- \rightarrow H_2(g)\} \times 3$

Net equation: $2\ Al(s) + 6\ H^+(aq) \rightarrow 2\ Al^{3+}(aq) + 3\ H_2(g)$

5b. *Oxidation*: $2\ Br^-(aq) \rightarrow Br_2(l) + 2\ e^-$

Reduction: $Cl_2(g) + 2\ e^- \rightarrow 2\ Cl^-(aq)$

Net equation: $2\ Br^-(aq) + Cl_2(g) \rightarrow Br_2(l) + 2\ Cl^-(aq)$

6a. $MnO_4^-(aq) + 8\ H^+(aq) + 5\ Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + 5\ Fe^{3+}(aq)$

6b. $3\ UO^{2+}(aq) + Cr_2O_7^{2-}(aq) + 8\ H^+(aq) \rightarrow 3\ UO_2^{2+}(aq) + 2\ Cr^{3+}(aq) + 4\ H_2O(l)$

7a. $S(s) + 2\ OH^-(aq) + 2\ OCl^-(aq) \rightarrow SO_3^{2-}(aq) + H_2O(l) + 2\ Cl^-(aq)$

7b. $2\,MnO_4^-(aq) + 3SO_3^{2-}(aq) + H_2O(l) \rightarrow 2\,MnO_2(s) + 3SO_4^{2-}(aq) + 2\,OH^-(aq)$

8a. Since the oxidation state of H is 0 in H_2 (g) and is +1 in both NH_3(g) and H_2O(g), hydrogen is oxidized. A substance that is oxidized is called a reducing agent. The oxidation state of the element N decreases during this reaction, meaning that NO_2 (g) is reduced. The substance that is reduced is called the oxidizing agent.

8b. Au has been oxidized and, thus, Au(s) (oxidization state = 0), is the reducing agent. O has been reduced and thus, O_2(g) (oxidation state = 0) is the oxidizing agent.

9a. 0.1019 M

9b. 0.130 M

10a. 65.4% Fe

10b. 0.03129 M

Integrative Example

A. 49.89%

B. 1.32%

Exercises

1a. Weak electrolyte

1b. Strong electrolyte

1c. Strong electrolyte

1d. Nonelectrolyte.

1e. Strong electrolyte

3. HCl is practically 100% dissociated into ions. The apparatus should light up brightly. A solution of both HCl and $HC_2H_3O_2$ will yield similar results.

5a. Barium bromide: strong electrolyte

5b. Propionic acid: weak electrolyte

5c. Ammonia: weak electrolyte

7a. 0.238 M K^+

7b. 0.334 M NO_3^-

7c. 0.166 M Al^{3+}

7d. 0.627 M Na^+

9. 3.04×10^{-3} M OH^-

11a. 3.54×10^{-4} M Ca^{2+}

11b. 8.39×10^{-3} M K^+

11c. 3.44×10^{-3} M Zn^{2+}

13. The solution containing 8.1 mg K^+ per mL gives the largest K^+ of the three solutions.

15. 4.3×10^{2} mg MgI_2

17. 0.732 M

19a. $Pb^{2+}(aq) + 2\ Br^-(aq) \rightarrow\ PbBr_2(s)$

19b. No reaction occurs (all are spectator ions).

19c. $Fe^{3+}(aq) + 3\ OH^-(aq) \rightarrow Fe(OH)_3(s)$

21a. No reaction occurs.

21b. $Cu^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CuCO_3(s)$

21c. $3Cu^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow\ Cu_3(PO_4)_2(s)$

23a. Add $K_2SO_4(aq)$; $BaSO_4(s)$ will form and $MgSO_4$ will not precipitate.

23b. $H_2O(l)$; $Na_2CO_3(s)$ dissolves, but $MgCO_3$ (s) will not dissolve (appreciably).

23c. Add KCl(aq); AgCl(s) will form, while $Cu(NO_3)_2$ (s) will dissolve.

25a. $Sr(NO_3)_2(aq) +\ K_2SO_4(aq)$: $Sr^{2+}(aq) + SO_4^{2-}(aq) \rightarrow\ SrSO_4(s)$

25b. $Mg(NO_3)_2(aq) +\ NaOH(aq)$: $Mg^{2+}(aq) + 2\ OH^-(aq) \rightarrow\ Mg(OH)_2(s)$

25c. $BaCl_2(aq) +\ K_2SO_4(aq)$: $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

27a. $OH^-(aq) +\ HC_2H_3O_2(aq) \rightarrow\ H_2O(l) +\ C_2H_3O_2^-(aq)$

27b. No reaction occurs. This is the physical mixing of two acids.

27c. $FeS(s) + 2\ H^+(aq) \rightarrow\ H_2S(g) +\ Fe^{2+}(aq)$

27d. $HCO_3^-(aq) + H^+(aq) \rightarrow "H_2CO_3(aq)" \rightarrow H_2O(l) + CO_2(g)$

27e. $Mg(s) + 2\ H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$

29. As a salt: $NaHSO_4(aq) \rightarrow Na^+(aq) + HSO_4^-(aq)$

As an acid: $HSO_4^-(aq) + OH^-(aq) \rightarrow H_2O(l) + SO_4^{2-}(aq)$

31. Use (b), $NH_3(aq)$. NH_3 affords the OH^- ions necessary to form $Mg(OH)_2(s)$.

33a. The O.S. of H is $+1$, that of O is -2, that of C is $+4$, and that of Mg is $+2$ on each side of this equation. This is not a redox equation.

33b. The O.S. of Cl is 0 on the left and -1 on the right side of this equation. The O.S. of Br is -1 on the left and 0 on the right side of this equation. This is a redox reaction.

33c. The O.S. of Ag is 0 on the left and $+1$ on the right side of this equation. The O.S. of N is $+5$ on the left and $+4$ on the right side of this equation. This is a redox reaction.

33d. On both sides of the equation the O.S. of O is -2, that of Ag is $+1$, and that of Cr is $+6$. Thus, this is not a redox equation.

35a. $2SO_3^{2-}(aq) + 6\ H^+(aq) + 4\ e^- \rightarrow S_2O_3^{2-}(aq) + 3\ H_2O(l)$

35b. $2\,NO_3^-(aq) + 10\ H^+(aq) + 8\ e^- \rightarrow N_2O(g) + 5\ H_2O(l)$

35c. $Al(s) + 4\ OH^-(aq) \rightarrow Al(OH)_4^-(aq) + 3\ e^-$

37a. $10\ I^-(aq) + 2\ MnO_4^-(aq) + 16\ H^+(aq) \rightarrow 5\ I_2(s) + 2\ Mn^{2+}(aq) + 8\ H_2O(l)$

37b. $3\ N_2H_4(l) + 2\ BrO_3^-(aq) \rightarrow 3\ N_2(g) + 2\ Br^-(aq) + 6\ H_2O(l)$

37c. $Fe^{2+}(aq) + VO_4^{3-}(aq) + 6\ H^+(aq) \rightarrow Fe^{3+}(aq) + VO^{2+}(aq) + 3\ H_2O(l)$

37d. $3\ UO^{2+}(aq) + 2\ NO_3^-(aq) + 2\ H^+(aq) \rightarrow 3\ UO_2^{2+}(aq) + 2\ NO(g) + H_2O(l)$

39a. $2\ MnO_2(s) + ClO_3^-(aq) + 2\ OH^-(aq) \rightarrow 2MnO_4^-(aq) + Cl^-(aq) + H_2O(l)$

39b. $2\ Fe(OH)_3(s) + 3\ OCl^-(aq) + 4\ OH^-(aq) \rightarrow 2FeO_4^{2-}(aq) + 3\ Cl^-(aq) + 5\ H_2O(l)$

39c. $6\ ClO_2(aq) + 6\ OH^-(aq) \rightarrow 5ClO_3^-(aq) + Cl^-(aq) + 3\ H_2O$

39d. $3\ Ag(s) + CrO_4^{2-} + 4\ H_2O(l) \rightarrow 3\ Ag^+(aq) + Cr(OH)_3(s) + 5\ OH^-$

41a. $3\ Cl_2(g) + 6\ OH^-(aq) \rightarrow 5\ Cl^-(aq) + \ ClO_3^-(aq) + 3\ H_2O(l)$

41b. $2\ S_2O_4^{2-}(aq) + \ H_2O(l) \rightarrow 2\ HSO_3^-(aq) + \ S_2O_3^{2-}(aq)$

43a. $5\ NO_2^-(aq) + 2\ MnO_4^-(aq) + 6\ H^+(aq) \rightarrow 5\ NO_3^-(aq) + 2\ Mn^{2+}(aq) + 3\ H_2O(l)$

43b. $3\ Mn^{2+}(aq) + 2\ MnO_4^-(aq) + 4\ OH^-(aq) \rightarrow 5\ MnO_2(s) + 2\ H_2O(l)$

43c. $Cr_2O_7^{2-}(aq) + 8\ H^+(aq) + 3\ C_2H_5OH \rightarrow \ 2\ Cr^{3+}(aq) + 7\ H_2O(l) + 3\ CH_3CHO$

45a. $CH_4(g) + 4\ NO(g) \rightarrow 2\ N_2(g) + CO_2(g) + 2\ H_2O(g)$

45b. $16\ H_2S(g) + 8\ SO_2(g) \rightarrow 3\ S_8(s) + 16\ H_2O(g)$

45c. $10\ NH_3(g) + 3\ Cl_2O(g) \rightarrow 6\ NH_4Cl(s) + 2\ N_2(g) + 3\ H_2O(l)$

47a. $SO_3^{2-}(aq)$ is the reducing agent; $MnO_4^-(aq)$ is the oxidizing agent.

47b. $H_2(g)$ is the reducing agent; $NO_2(g)$ is the oxidizing agent.

47c. $\left[Fe(CN)_6\right]^{4-}(aq)$ is the reducing agent; $H_2O_2(aq)$ is the oxidizing agent.

49. 13.3 mL $NaOH(aq)$ soln

51. 3.546 mL KOH solution

53. 0.1230 M NaOH

55. 0.077 M NaOH

57. Acidic

59. 34 mL base

61. Answer is (d).

63. 1.968×10^{-2} M

65. 53.23% Fe

67. 37.0 g $Na_2C_2O_4$

Integrative and Advanced Exercises

71. $3\,Ca^{2+}(aq) + 2\,HPO_4^{2-}(aq) \longrightarrow Ca_3(PO_4)_2(s) + 2\,H^+(aq)$

74. 108 ppm Mg

75. 0.0874 L

80a. $4\ FeS_2(s) + 15\ O_2(g) + 2\ H_2O(l) \rightarrow 4\ Fe^{3+}(aq) + 8\ SO_4^{2-}(aq) + 4\ H^+(aq)$

80b. 23.4 g $CaCO_3$

83. 44.6 g Cl_2

85. 5.0×10^2 g $ClO_2(g)$

88a. 45.9 g

88b. 1.00 L

89. % $Mg(OH)_2$ = 21.6; %$Al(OH)_3$ = 78.4.

91. 0.4346 %

93a. $CaO(s) + H_2O(l) \rightarrow Ca^{2+}(aq) + 2\ OH^-(aq)$

$H_2PO_4^-(aq) + 2\ OH^-(aq) \rightarrow PO_4^{3-}(aq) + 2\ H_2O(l)$

$HPO_4^-(aq) + OH^-(aq) \rightarrow PO_4^{3-}(aq) + H_2O(l)$

$5\ Ca^{2+}(aq) + 3\ PO_4^{3-}(aq) + OH^-(aq) \rightarrow Ca_5(PO_4)_3OH(s)$

93b. 0.302 kg

Feature Problems

94. x = 1.03

95. 91.0% MnO_2

97. Before the breath test: 8×10^{-4} M; After the breath test 3×10^{-4} mol/L.

Self-Assessment Exercises

102. The answer is (b).

103. The answer is (d).

104. The answer is (c).

105. The answer is (a).

106. $2I^- + Pb^{2+} \rightarrow PbI_2\ (s)$

107. $CO_3^{2-} + 2H^+ \rightarrow H_2O\ (l) + CO_2(g)$

108a. $3\ Zn^{2+} + PO_4^{3-} \rightarrow Zn_3(PO_4)_2\ (s)$

108b. $Cu^{2+} + 2\ OH^{-} \rightarrow Cu(OH)_2\ (s)$

108c. $Ni^{2+} + CO_3^{2-} \rightarrow NiCO_3\ (s)$

109a. Species oxidized: N in NO

109b. Species reduced: O_2

109c. Oxidizing agent: O_2

109d. Reducing agent: NO

109e. Gains electrons: O_2

109f. Loses electrons: NO

110. The answer is (b).

111. The answer is (d).

112. The answer is (a).

113a. False

113b. True

113c. False

113d. False

113e. True

114a. No

114b. Yes

114c. Yes

114d. No