4.26

(a) $Cr_2(SO_4)_3(aq) + 3(NH_4)_2CO_3(aq) \longrightarrow Cr_2(CO_3)_3(s) + 3(NH_4)_2SO_4(aq)$

$2Cr^{3+}(aq) + 3SO_4^{2-}(aq) + 6NH_4^+(aq) + 3CO_3^{2-}(aq) \longrightarrow Cr_2(CO_3)_3(s) + 6NH_4^+(aq) + 3SO_4^{2-}(aq)$

net ionic equations: $2Cr^{3+}(aq) + 3CO_3^{2-}(aq) \longrightarrow Cr_2(CO_3)_3(s)$

spectator ions: SO_4^{2-}, NH_4^+

(b) $Ba(NO_3)_2(aq) + K_2SO_4(aq) \longrightarrow BaSO_4(s) + 2KNO_3(aq)$

$Ba^{2+}(aq) + 2NO_3^-(aq) + 2K^+(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s) + 2K^+(aq) + 2NO_3^-(aq)$

net ionic equation: $Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$

spectator ions: NO_3^-, K^+

(c) $Fe(NO_3)_2(aq) + 2KOH(aq) \longrightarrow Fe(OH)_2(s) + 2KNO_3(aq)$

$Fe^{2+}(aq) + 2NO_3^-(aq) + 2K^+(aq) + 2OH^-(aq) \longrightarrow Fe(OH)_2(s) + 2K^+(aq) + 2NO_3^-(aq)$

net ionic equation: $Fe^{2+}(aq) + 2OH^-(aq) \longrightarrow Fe(OH)_2(s)$

spectator ions: NO_3^-, K^+

4.46

(a) $2CH_3COOH(aq) + Ba(OH)_2(aq) \longrightarrow Ba(CH_3COO)_2(aq) + 2H_2O(l)$

(acetic acid; barium hydroxide; ↑ balanced equation; ↳ strong base)

ionic equation: $2CH_3COOH(aq) + Ba^{2+}(aq) + 2OH^-(aq) \longrightarrow Ba^{2+}(aq) + 2CH_3COO^-(aq) + 2H_2O(l)$

(↗ weak acid)

net ionic equation: $CH_3COOH(aq) + OH^-(aq) \rightarrow CH_3COO^-(aq) + H_2O(l)$

(b) balanced molecular equation:

$$Cr(OH)_3(s) + 3HNO_2(aq) \longrightarrow Cr(NO_2)_3(aq) + 3H_2O(l)$$

ionic equation & net ionic equation (nothing is crossed out from the ionic equation)

$$Cr(OH)_3(s) + 3HNO_2(aq) \longrightarrow Cr^{3+}(aq) + 3NO_2^-(aq) + 3H_2O(l)$$

HNO₂: weak acid

(c) balanced molecular equation:

$$HNO_3(aq) + NH_3(aq) \longrightarrow NH_4NO_3(aq)$$

HNO₃: strong acid; NH₃: weak base

ionic equation:

$$H^+(aq) + NO_3^-(aq) + NH_3(aq) \longrightarrow NH_4^+(aq) + NO_3^-(aq)$$

net ionic equation:

$$H^+(aq) + NH_3(aq) \longrightarrow NH_4^+(aq)$$

4.51

(a) oxidation number:

$$\underset{0}{N_2}(g) + 3\underset{0}{H_2}(g) \longrightarrow 2\underset{-3}{N}\underset{+1}{H_3}(g)$$

∴ H is oxidized, N is reduced

(b) oxidation number:

$$3\underset{+2}{Fe}(NO_3)_2(aq) + 2\underset{0}{Al}(s) \longrightarrow 3\underset{0}{Fe}(s) + 2\underset{+3}{Al}(NO_3)_3(aq)$$

Fe reduced from +2 to 0, Al oxidized from 0 to +3

∴ Al is oxidized, Fe is reduced

(c) oxidation number:

$$\underset{0}{Cl_2}(aq) + 2\underset{+1\ -1}{NaI}(aq) \longrightarrow \underset{0}{I_2}(aq) + 2\underset{+1\ -1}{NaCl}(aq)$$

Cl reduced from 0 to −1, I oxidized from −1 to 0.

∴ I is oxidized, Cl is reduced

(d) oxidation number:

$$\underset{+2\ -2}{PbS}(s) + 4\underset{+1\ -1}{H_2O_2}(aq) \longrightarrow \underset{+2\ +6\ -2}{PbSO_4}(s) + 4\underset{+1\ -2}{H_2O}(l)$$

S oxidized from −2 to +6, O reduced from −1 to −2

∴ S is oxidized, O is reduced

4.72.

(a) moles $NaOH$ = $42.0\,mL\ soln \times \frac{1\,L\ soln}{1000\,mL\ soln} \times \frac{0.170\,mol\ NaOH}{1\,L\ soln}$ + $37.6\,mL\ soln \times \frac{1\,L\ soln}{1000\,mL\ soln} \times \frac{0.400\,mol\ NaOH}{1\,L\ soln}$

$= 7.14 \times 10^{-3}\,mol\ NaOH + 15.04 \times 10^{-3}\,mol\ NaOH = 22.18 \times 10^{-3}\,mol\ NaOH$

$NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$ moles of Na^+ & OH^- is same as $NaOH$. $42.0\,mL + 37.6\,mL = 0.0796\,L$

concentration Na^+ & OH^- = $\frac{0.02218\,mol}{0.0796\,L} = 0.2786\,M$

(b) moles Na_2SO_4 = $44.0\,mL\ soln \times \frac{1\,L\ soln}{1000\,mL\ soln} \times \frac{0.100\,mol\ Na_2SO_4}{1\,L\ soln} = 0.0044\,mol$

moles KCl = $25.0\,mL\ soln \times \frac{1\,L\ soln}{1000\,mL\ soln} \times \frac{0.150\,mol\ KCl}{1\,L\ soln} = 0.00375\,mol$

$Na_2SO_4(aq) \rightarrow 2Na^+(aq) + SO_4^{2-}(aq)$ moles $Na^+ = 0.0088\,mol$ moles $SO_4^- = 0.0044\,mol$

$KCl(aq) \rightarrow K^+(aq) + Cl^-(aq)$ moles K^+ & $Cl^- = 0.00375\,mol$

concentration Na^+ = $\frac{0.0088\,mol}{0.069\,L} = 0.13\,M$

concentration SO_4^- = $\frac{0.0044\,mol}{0.069\,L} = 0.064\,M$

concentration K^+ & Cl^- = $\frac{0.00375\,mol}{0.069\,L} = 0.054\,M$

(b) $\frac{3.60\,g\ KCl}{15.0\,mL} \times \frac{1\,mol\ KCl}{74.55\,g\ KCl} \times \frac{1000\,mL}{1\,L} = 0.644\,M$ $KCl(aq) \rightarrow K^+(aq) + Cl^-(aq)$, $CaCl_2(aq) \rightarrow Ca^{2+}(aq) + 2Cl^-(aq)$

concentration $K^+ = 0.644\,M$

concentration $Ca^{2+} = 0.250\,M$

concentration $Cl^- = 0.250\,M \times 2 + 0.644\,M = 1.144\,M$

4.82

(a) moles $Ba(OH)_2 = 50.0\ mL \times \frac{1\ L}{1000\ mL} \times \frac{0.101\ mol}{1\ L} = 0.00505\ mol$

$Ba(OH)_2(aq) + 2HCl(aq) \longrightarrow 2H_2O(l) + BaCl_2(aq)$ 1 mol $Ba(OH)_2$ needs 2 mol HCl

$mL\ HCl = \frac{0.00505\ mol \times 2}{0.120\ M\ (mol/L)} \times \frac{1000\ mL}{1\ L} = 84.17\ mL$

(b) moles $NaOH = 0.200\ g \times \frac{1\ mol}{39.997\ g} = 0.005\ mol$

NaOH molar mass

$2NaOH(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O$ 1 mol H_2SO_4 needs 2 mol NaOH

$mL\ H_2SO_4 = 0.00505\ mol \times \frac{1\ mol\ H_2SO_4}{2\ mol\ NaOH} \times \frac{1\ L}{0.125\ mol} \times \frac{1000\ mL}{1\ L} = 20.0\ mL$

(c) moles $Na_2SO_4 = \frac{0.752\ g}{142.04\ g} = 0.00529\ mol$

Na_2SO_4 molar mass

$BaCl_2(aq) + Na_2SO_4(aq) \longrightarrow BaSO_4(s) + 2NaCl(aq)$ 1 mol $BaCl_2$ need 1 mol Na_2SO_4

$M\ BaCl_2 = 0.00529\ mol \times \frac{1\ mol\ BaCl_2}{1\ mol\ Na_2SO_4} \times \frac{1}{0.0558\ L} = 0.0948\ M$

(d) moles $HCl = 42.7\ mL \times \frac{1\ L}{1000\ mL} \times \frac{0.208\ mol}{1\ L} = 0.00888\ mol$

$2HCl(aq) + Ca(OH)_2(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$ 1 mol $Ca(OH)_2$ need 2 mol H_2O

$gram\ Ca(OH)_2 = 0.00888\ mol \times \frac{1\ mol\ Ca(OH)_2}{2\ mol\ HCl} \times \frac{74.093\ g}{1\ mol} = 0.329\ g$