

Chapter 4: 17, 21, 23, 26, 27, 30, 37, 41, 44, 48, 50, 51, 56, 58, 60, 66, 69, 71, 85, 94

17. a. $\text{NaBr} \longrightarrow \text{Na}^+ + \text{Br}^-$
 b. $\text{MgCl}_2 \longrightarrow \text{Mg}^{2+} + 2 \text{Cl}^-$
 c. $\text{Al}(\text{NO}_3)_3 \longrightarrow \text{Al}^{3+} + 3 \text{NO}_3^-$
 d. $(\text{NH}_4)_2\text{SO}_4 \longrightarrow 2 \text{NH}_4^+ + \text{SO}_4^{2-}$
 e. $\text{NaOH} \longrightarrow \text{Na}^+ + \text{OH}^-$
 f. $\text{FeSO}_4 \longrightarrow \text{Fe}^{2+} + \text{SO}_4^{2-}$
 g. $\text{KMnO}_4 \longrightarrow \text{K}^+ + \text{MnO}_4^-$
 h. $\text{HClO}_4 \longrightarrow \text{H}^+ + \text{ClO}_4^-$
 i. $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2 \longrightarrow \text{NH}_4^+ + \text{C}_2\text{H}_3\text{O}_2^-$

21. a.
$$\frac{5.623 \text{ g NaHCO}_3 \times \frac{1 \text{ mole NaHCO}_3}{84.008 \text{ g NaHCO}_3}}{0.2500 \text{ L}} = \mathbf{0.2677 \text{ M NaHCO}_3}$$

b.
$$\frac{184.6 \text{ mg K}_2\text{Cr}_2\text{O}_7 \times \frac{1 \text{ g K}_2\text{Cr}_2\text{O}_7}{10^3 \text{ mg K}_2\text{Cr}_2\text{O}_7} \times \frac{1 \text{ mole K}_2\text{Cr}_2\text{O}_7}{294.20 \text{ g K}_2\text{Cr}_2\text{O}_7}}{500.0 \text{ mL} \times \frac{1 \text{ L}}{10^3 \text{ mL}}} = \mathbf{1.255 \times 10^{-3} \text{ M K}_2\text{Cr}_2\text{O}_7}$$

c.
$$\frac{0.1025 \text{ g Cu} \times \frac{1 \text{ mole Cu}}{63.55 \text{ g Cu}} \times \frac{1 \text{ mole Cu}^{2+}}{1 \text{ mole Cu}}}{200.0 \text{ mL} \times \frac{1 \text{ L}}{10^3 \text{ mL}}} = \mathbf{8.065 \times 10^{-3} \text{ M Cu}^{2+}}$$

23. a. $\text{Ca}(\text{NO}_3)_2 \longrightarrow \text{Ca}^{2+} + 2 \text{NO}_3^-$

$$\frac{0.100 \text{ mole Ca}(\text{NO}_3)_2}{0.100 \text{ L}} = 1.00 \text{ M Ca}(\text{NO}_3)_2$$

$$\frac{1.00 \text{ mole Ca}(\text{NO}_3)_2}{\text{L}} \times \frac{1 \text{ mole Ca}^{2+}}{1 \text{ mole Ca}(\text{NO}_3)_2} = \mathbf{1.00 \text{ M Ca}^{2+}}$$

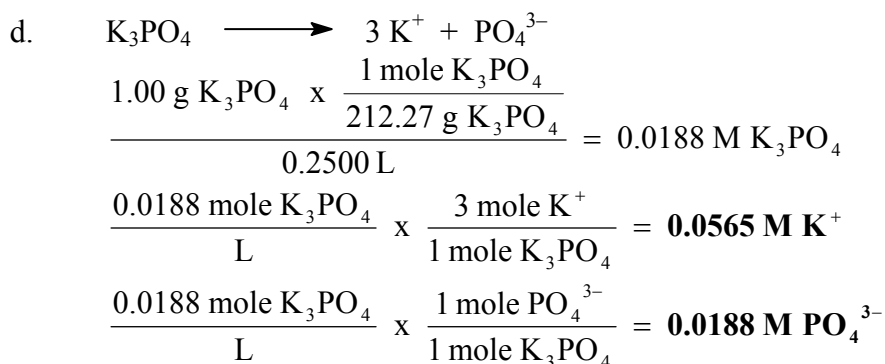
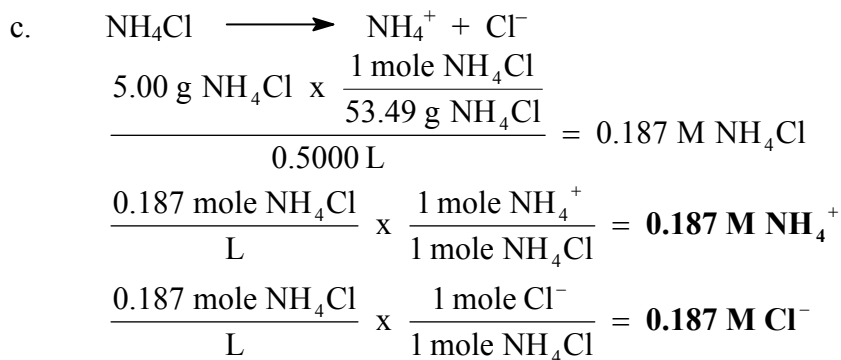
$$\frac{1.00 \text{ mole Ca}(\text{NO}_3)_2}{\text{L}} \times \frac{2 \text{ mole NO}_3^-}{1 \text{ mole Ca}(\text{NO}_3)_2} = \mathbf{2.00 \text{ M NO}_3^-}$$

b. $\text{Na}_2\text{SO}_4 \longrightarrow 2 \text{Na}^+ + \text{SO}_4^{2-}$

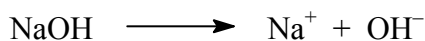
$$\frac{2.5 \text{ mole Na}_2\text{SO}_4}{1.25 \text{ L}} = 2.0 \text{ M Na}_2\text{SO}_4$$

$$\frac{2.0 \text{ mole Na}_2\text{SO}_4}{\text{L}} \times \frac{2 \text{ mole Na}^+}{1 \text{ mole Na}_2\text{SO}_4} = \mathbf{4.0 \text{ M Na}^+}$$

$$\frac{2.0 \text{ mole Na}_2\text{SO}_4}{\text{L}} \times \frac{1 \text{ mole SO}_4^{2-}}{1 \text{ mole Na}_2\text{SO}_4} = \mathbf{2.0 \text{ M SO}_4^{2-}}$$



26. $\frac{0.100 \text{ mole NaOH}}{\text{L}} \times 0.100 \text{ L} = 0.0100 \text{ mole NaOH}$

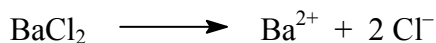


$$0.0100 \text{ mole NaOH} \times \frac{1 \text{ mole Na}^+}{1 \text{ mole NaOH}} = 0.0100 \text{ mole Na}^+$$

$$0.0100 \text{ mole NaOH} \times \frac{1 \text{ mole OH}^-}{1 \text{ mole NaOH}} = 0.0100 \text{ mole OH}^-$$

$0.0100 \text{ mole} + 0.0100 \text{ mole} = \underline{0.0200 \text{ mole ions}}$

$$\frac{0.200 \text{ mole BaCl}_2}{\text{L}} \times 0.0500 \text{ L} = 0.0100 \text{ mole BaCl}_2$$

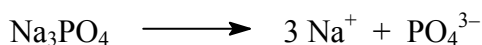


$$0.0100 \text{ mole BaCl}_2 \times \frac{1 \text{ mole Ba}^{2+}}{1 \text{ mole BaCl}_2} = 0.0100 \text{ mole Ba}^{2+}$$

$$0.0100 \text{ mole BaCl}_2 \times \frac{2 \text{ mole Cl}^-}{1 \text{ mole BaCl}_2} = 0.0200 \text{ mole Cl}^-$$

$$0.0100 \text{ mole} + 0.0200 \text{ mole} = \underline{0.0300 \text{ mole ions}}$$

$$\frac{0.150 \text{ mole Na}_3\text{PO}_4}{\text{L}} \times 0.0750 \text{ L} = 0.01125 \text{ mole Na}_3\text{PO}_4$$



$$0.01125 \text{ mole Na}_3\text{PO}_4 \times \frac{3 \text{ mole Na}^+}{1 \text{ mole Na}_3\text{PO}_4} = 0.03375 \text{ mole Na}^+$$

$$0.01125 \text{ mole Na}_3\text{PO}_4 \times \frac{1 \text{ mole PO}_4^{3-}}{1 \text{ mole Na}_3\text{PO}_4} = 0.01125 \text{ mole PO}_4^{3-}$$

$$0.03375 \text{ mole} + 0.01125 \text{ mole} = \underline{\mathbf{0.0450 \text{ mole ions}}}$$

27.
$$\frac{0.400 \text{ mole NaOH}}{\text{L}} \times 0.2500 \text{ L} \times \frac{40.00 \text{ g NaOH}}{1 \text{ mole NaOH}} = \mathbf{4.00 \text{ g NaOH}}$$

30. a.
$$\frac{0.50 \text{ mole H}_2\text{SO}_4}{\text{L}} \times 1.00 \text{ L} \times \frac{1 \text{ L}}{18 \text{ mole H}_2\text{SO}_4} = \mathbf{0.028 \text{ L}}$$

28 mL diluted to 1.00 L

b.
$$\frac{0.50 \text{ mole HCl}}{\text{L}} \times 1.00 \text{ L} \times \frac{1 \text{ L}}{12 \text{ mole HCl}} = \mathbf{0.042 \text{ L}}$$

42 mL diluted to 1.00 L

c.
$$\frac{0.50 \text{ mole NiCl}_2}{\text{L}} \times 1.00 \text{ L} \times \frac{1 \text{ mole NiCl}_2 \cdot 6 \text{ H}_2\text{O}}{1 \text{ mole NiCl}_2} \times \frac{237.71 \text{ g NiCl}_2 \cdot 6 \text{ H}_2\text{O}}{1 \text{ mole NiCl}_2 \cdot 6 \text{ H}_2\text{O}}$$

$$= \mathbf{1.2 \times 10^2 \text{ g NiCl}_2 \cdot 6 \text{ H}_2\text{O}}$$

$1.2 \times 10^2 \text{ g NiCl}_2 \cdot 6 \text{ H}_2\text{O}$ dissolved in enough water to give to 1.00 L

d.
$$\frac{0.50 \text{ mole HNO}_3}{\text{L}} \times 1.00 \text{ L} \times \frac{1 \text{ L}}{16 \text{ mole HNO}_3} = \mathbf{0.031 \text{ L}}$$

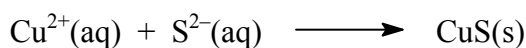
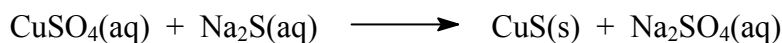
31 mL diluted to 1.00 L

e.
$$\frac{0.50 \text{ mole Na}_2\text{CO}_3}{\text{L}} \times 1.00 \text{ L} \times \frac{105.99 \text{ g Na}_2\text{CO}_3}{1 \text{ mole Na}_2\text{CO}_3} = \mathbf{53 \text{ g Na}_2\text{CO}_3}$$

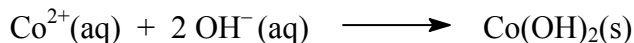
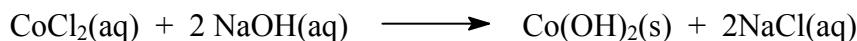
53 g Na₂CO₃ dissolved in enough water to give to 1.00 L

37. a. $\text{FeSO}_4(\text{aq}) + \text{KCl}(\text{aq}) \longrightarrow \text{NR}$
- b. $2 \text{Al}(\text{NO}_3)_3(\text{aq}) + 3 \text{Ba}(\text{OH})_2(\text{aq}) \longrightarrow 2 \text{Al}(\text{OH})_3(\text{s}) + 3 \text{Ba}(\text{NO}_3)_2(\text{aq})$
- c. $\text{CaCl}_2(\text{aq}) + \text{Na}_2\text{SO}_4(\text{aq}) \longrightarrow \text{CaSO}_4(\text{s}) + 2 \text{NaCl}(\text{aq})$
- d. $\text{K}_2\text{S}(\text{aq}) + \text{Ni}(\text{NO}_3)_2(\text{aq}) \longrightarrow \text{NiS}(\text{s}) + 2 \text{KNO}_3(\text{aq})$

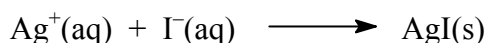
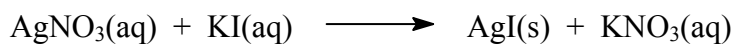
41. a. Spectator ions = Na^+ (grey) and SO_4^{2-} (green)



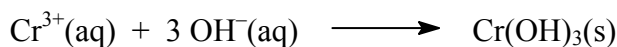
- b. Spectator ions = Na^+ (grey) and Cl^- (green)



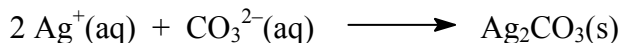
- c. Spectator ions = K^+ (red) and NO_3^- (blue)



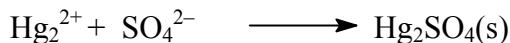
44. a. $\text{CrCl}_3(\text{aq}) + 3 \text{NaOH}(\text{aq}) \longrightarrow \text{Cr}(\text{OH})_3(\text{s}) + 3 \text{NaCl}(\text{aq})$



- b. $2 \text{AgNO}_3(\text{aq}) + (\text{NH}_4)_2\text{CO}_3(\text{aq}) \longrightarrow \text{Ag}_2\text{CO}_3(\text{s}) + 2 \text{NH}_4\text{NO}_3(\text{aq})$



- c. $\text{CuSO}_4(\text{aq}) + \text{Hg}_2(\text{NO}_3)_2(\text{aq}) \longrightarrow \text{Cu}(\text{NO}_3)_2(\text{aq}) + \text{Hg}_2\text{SO}_4(\text{s})$

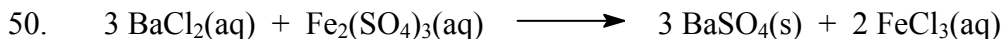


- d. $\text{Sr}(\text{NO}_3)_2(\text{aq}) + \text{KI}(\text{aq}) \longrightarrow \text{NR}$

48. $3 \text{Pb}(\text{NO}_3)_2(\text{aq}) + 2 \text{Na}_3\text{PO}_4(\text{aq}) \longrightarrow \text{Pb}_3(\text{PO}_4)_2(\text{s}) + 6 \text{NaNO}_3(\text{aq})$

$$\frac{0.250 \text{ mole Pb}(\text{NO}_3)_2}{\text{L}} \times 0.150 \text{ L} \times \frac{2 \text{ mole Na}_3\text{PO}_4}{3 \text{ mole Pb}(\text{NO}_3)_2} \times \frac{1 \text{ L}}{0.100 \text{ mole Na}_3\text{PO}_4}$$

$$= 0.250 \text{ L} = \mathbf{250. \text{ mL } \text{Na}_3\text{PO}_4 \text{ solution}}$$

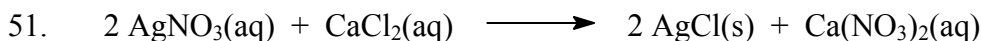


$$\frac{0.100 \text{ mole BaCl}_2}{\text{L}} \times 0.100 \text{ L} \times \frac{3 \text{ mole BaSO}_4}{3 \text{ mole BaCl}_2} \times \frac{233.4 \text{ g BaSO}_4}{1 \text{ mole BaSO}_4}$$

$$= \mathbf{2.33 \text{ g BaSO}_4}$$

$$\frac{0.100 \text{ mole Fe}_2(\text{SO}_4)_3}{\text{L}} \times 0.100 \text{ L} \times \frac{3 \text{ mole BaSO}_4}{1 \text{ mole Fe}_2(\text{SO}_4)_3} \times \frac{233.4 \text{ g BaSO}_4}{1 \text{ mole BaSO}_4}$$

$$= 7.00 \text{ g BaSO}_4$$



$$\frac{0.20 \text{ mole AgNO}_3}{\text{L}} \times 0.1000 \text{ L} \times \frac{2 \text{ mole AgCl}}{2 \text{ mole AgNO}_3} \times \frac{143.4 \text{ g AgCl}}{1 \text{ mole AgCl}}$$

$$= \mathbf{2.9 \text{ g AgCl}}$$

$$\frac{0.15 \text{ mole CaCl}_2}{\text{L}} \times 0.1000 \text{ L} \times \frac{2 \text{ mole AgCl}}{1 \text{ mole CaCl}_2} \times \frac{143.4 \text{ g AgCl}}{1 \text{ mole AgCl}}$$

$$= 4.3 \text{ g AgCl}$$

Ag^+ :

AgNO_3 limiting; $\mathbf{0.00 \text{ M Ag}^+}$

Ca^{2+} :

$$\frac{0.20 \text{ mole AgNO}_3}{\text{L}} \times 0.1000 \text{ L} \times \frac{1 \text{ mole CaCl}_2}{2 \text{ mole AgNO}_3} = 0.010 \text{ mole CaCl}_2 \text{ used up}$$

$$\frac{0.15 \text{ mole CaCl}_2}{\text{L}} \times 0.1000 \text{ L} - 0.010 \text{ mole CaCl}_2 = \mathbf{0.005 \text{ mole CaCl}_2 \text{ remaining}}$$

$$\frac{0.20 \text{ mole AgNO}_3}{\text{L}} \times 0.1000 \text{ L} \times \frac{1 \text{ mole Ca}(\text{NO}_3)_2}{2 \text{ mole AgNO}_3} = \mathbf{0.010 \text{ mole Ca}(\text{NO}_3)_2 \text{ formed}}$$

There is 1 mole of Ca^{2+} / 1 mole of each compound, therefore the total Ca^{2+} is:

$0.005 \text{ mole} + 0.010 \text{ mole} = 0.015 \text{ mole}$ (Note: this is identical to moles of CaCl_2 originally added. Ca^{2+} does not precipitate in this reaction.)

$$\frac{0.015 \text{ mole Ca}^{2+}}{0.1000 \text{ L} + 0.1000 \text{ L}} = \mathbf{0.075 \text{ M Ca}^{2+}}$$

Cl^- :

$$\frac{0.15 \text{ mole CaCl}_2}{\text{L}} \times 0.1000 \text{ L} - 0.010 \text{ mole CaCl}_2 = \underline{0.005 \text{ mole CaCl}_2 \text{ remaining}}$$

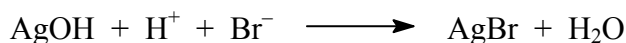
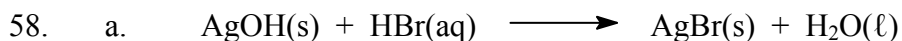
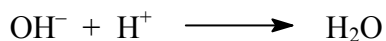
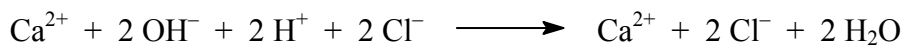
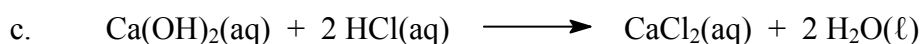
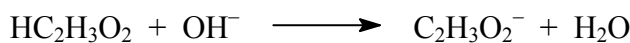
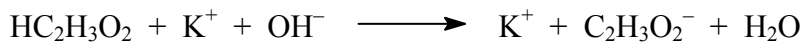
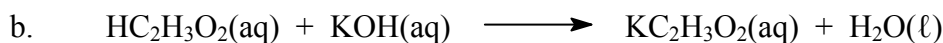
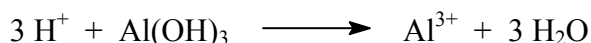
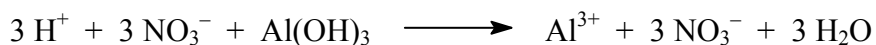
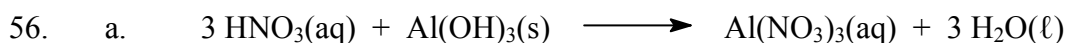
$$0.005 \text{ mole CaCl}_2 \times \frac{2 \text{ mole Cl}^-}{1 \text{ mole CaCl}_2} = \underline{0.010 \text{ mole Cl}^- \text{ not in AgCl}}$$

$$\frac{0.010 \text{ mole Cl}^-}{0.1000 \text{ L} + 0.1000 \text{ L}} = \mathbf{0.050 \text{ M Cl}^-}$$

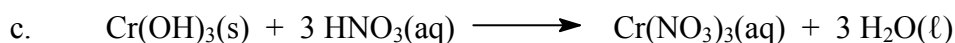
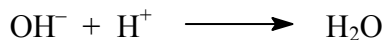
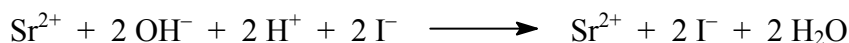
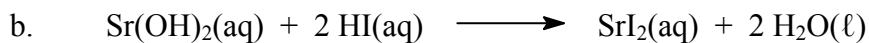
NO_3^- :

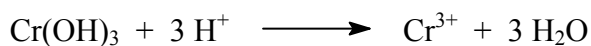
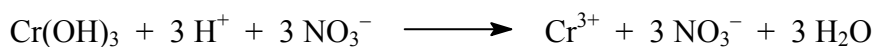
$$\frac{0.20 \text{ mole AgNO}_3}{\text{L}} \times 0.1000 \text{ L} \times \frac{1 \text{ mole Ca(NO}_3)_2}{2 \text{ mole AgNO}_3} \times \frac{2 \text{ mole NO}_3^-}{1 \text{ mole Ca(NO}_3)_2} = \underline{0.020 \text{ mole NO}_3^-}$$

$$\frac{0.020 \text{ mole NO}_3^-}{0.1000 \text{ L} + 0.1000 \text{ L}} = \mathbf{0.10 \text{ M NO}_3^-}$$

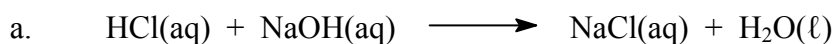


Same

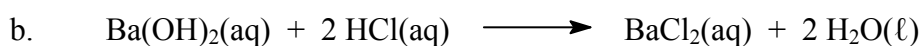




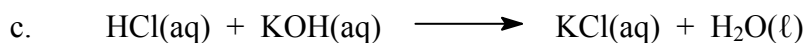
60. $\frac{0.200 \text{ mole HCL}}{\text{L}} \times 0.02500 \text{ L} = 0.00500 \text{ mole HCL}$



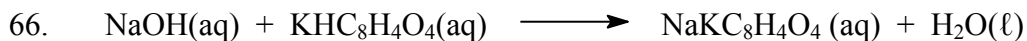
$$0.00500 \text{ mole HCl} \times \frac{1 \text{ mole NaOH}}{1 \text{ mole HCl}} \times \frac{1 \text{ L}}{0.100 \text{ mole NaOH}} = 0.0500 \text{ L} = \mathbf{50.0 \text{ mL}}$$



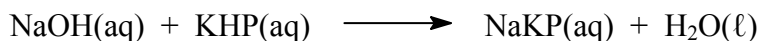
$$0.00500 \text{ mole HCl} \times \frac{1 \text{ mole Ba(OH)}_2}{2 \text{ mole HCl}} \times \frac{1 \text{ L}}{0.0500 \text{ mole Ba(OH)}_2} = 0.0500 \text{ L} = \mathbf{50.0 \text{ mL}}$$



$$0.00500 \text{ mole HCl} \times \frac{1 \text{ mole KOH}}{1 \text{ mole HCl}} \times \frac{1 \text{ L}}{0.250 \text{ mole KOH}} = 0.0200 \text{ L} = \mathbf{20.0 \text{ mL}}$$



or



$$\frac{0.1082 \text{ g KHP} \times \frac{1 \text{ mole KHP}}{204.22 \text{ g KHP}} \times \frac{1 \text{ mole NaOH}}{1 \text{ mole KHP}}}{34.67 \text{ mL} \times \frac{1 \text{ L}}{10^3 \text{ mL}}} = \mathbf{0.01528 \text{ M NaOH}}$$

