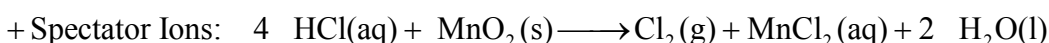
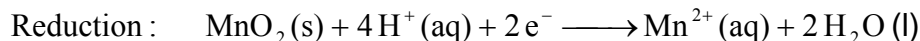
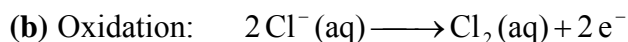
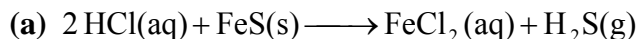
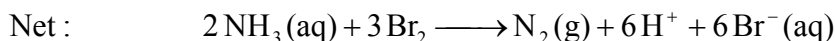
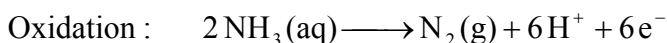


Chapter 5
Solutions to Selected Integrative and Advanced Exercises

70. (M)



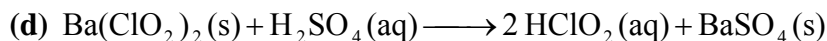
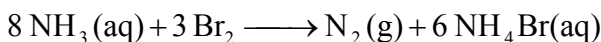
(c) Because $\text{NH}_3(\text{aq})$ is a weak base, the reaction takes place in alkaline solution.



The spectator ion is $\text{NH}_4^+(\text{aq})$; first, add 6 $\text{NH}_3(\text{aq})$ on each side, to “neutralize” H^+ .



Then, recognize that $\text{NH}_3(\text{aq}) + \text{H}^+(\text{aq}) \longrightarrow \text{NH}_4^+(\text{aq})$, and $\text{NH}_4\text{Br}(\text{aq})$ is really $\text{NH}_4^+(\text{aq}) + \text{Br}^-(\text{aq})$.



72. (M) We can calculate the initial concentration of OH^- .

$$[\text{OH}^-] = \frac{0.0250 \text{ mol Ba}(\text{OH})_2}{1 \text{ L soln}} \times \frac{2 \text{ mol OH}^-}{1 \text{ L soln}} = 0.0500 \text{ M}$$

We can determine the ratio of the dilute (volumetric flask) to the concentrated (pipet) solutions.

$$V_c \times C_c = V_d \times C_d = V_c \times 0.0500 \text{ M} = V_d \times 0.0100 \text{ M} \quad \frac{V_d}{V_c} = \frac{0.0500 \text{ M}}{0.0100 \text{ M}} = 5.00$$

If we pipet 0.0250 M $\text{Ba}(\text{OH})_2$ with a 50.00-mL pipet into a 250.0-mL flask, and fill this flask, with mixing, to the mark with distilled water, the resulting solution will be 0.0100 M OH^- .

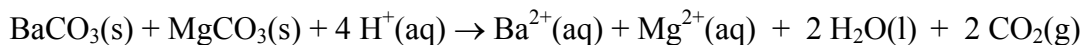
76. (D)

(a) Cu^{2+} would produce a colored solid, while for $\text{NH}_4^+/\text{Na}^+$, no solids are expected (these cations form very soluble salts). Therefore, Cu^{2+} , NH_4^+ , and Na^+ are not present. Thus the possible cations are Ba^{2+} and Mg^{2+} (both give colorless solutions).

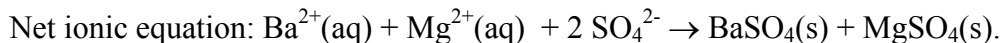
(b) Gas evolution when the solid reacts with $\text{HCl}(\text{aq})$ suggests the presence of carbonate (CO_3^{2-}).



If the solid is indeed a mixture of carbonates, the net ionic equation for the reaction of the solid with $\text{HCl}(\text{aq})$ would be:



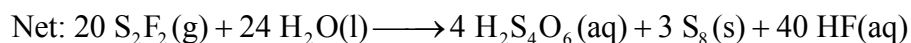
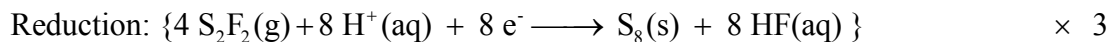
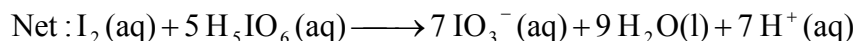
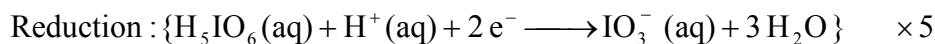
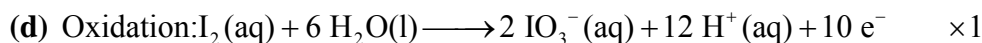
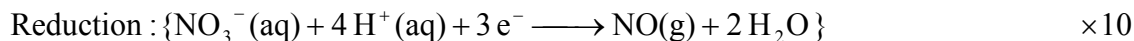
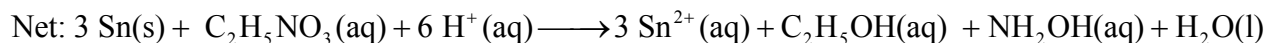
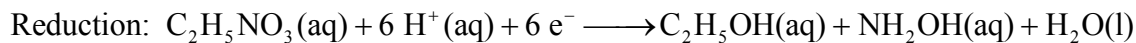
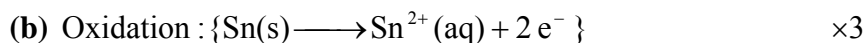
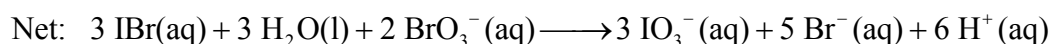
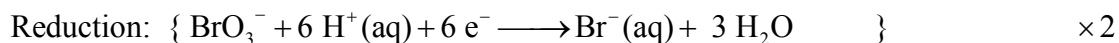
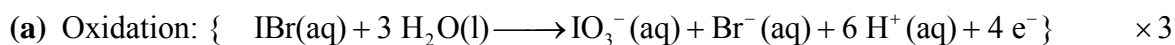
The solution above contains $\text{Ba}^{2+} + \text{Mg}^{2+}$ ions, so the addition of $(\text{NH}_4)_2\text{SO}_4(\text{aq})$ should result in the formation of the insoluble sulfates of these two metal ions. This is consistent with the observations.



If the solution above the solid should contain small quantities of all of the ions present in the solid, then it should contain $\text{Ba}^{2+}(\text{aq})$, $\text{Mg}^{2+}(\text{aq})$, and $\text{CO}_3^{2-}(\text{aq})$. Addition of KOH should result in the formation of the hydroxide of the two metal ions and potassium carbonate.

Note: K_2CO_3 and $\text{Ba}(\text{OH})_2$ are both relatively soluble species, hence, neither of these species should precipitate out of solution. However, $\text{Mg}(\text{OH})_2$, is relatively insoluble. A precipitate ($\text{Mg}(\text{OH})_2(\text{s})$ which is white) is expected to form. This is consistent with the observations provided. We can conclude that the solid is likely a mixture of $\text{BaCO}_3(\text{s})$ and $\text{MgCO}_3(\text{s})$. Without additional data, this conclusion would indeed explain all of the observations provided.

77. (M)



81. (D) The neutralization reaction is $\text{H}_2\text{SO}_4(\text{aq}) + \text{Ba}(\text{OH})_2(\text{aq}) \longrightarrow \text{BaSO}_4(\text{s}) + 2 \text{H}_2\text{O}(\text{l})$.

First, we determine the molarity of H_2SO_4 in the 10.00 mL of diluted acid.

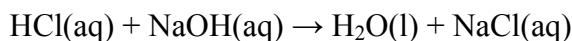
$$\text{molarity of H}_2\text{SO}_4 = \frac{32.44 \text{ mL base} \times \frac{0.00498 \text{ mmol Ba}(\text{OH})_2}{1 \text{ mL base}} \times \frac{1 \text{ mmol H}_2\text{SO}_4}{1 \text{ mmol Ba}(\text{OH})_2}}{10.00 \text{ mL acid}} = 0.0162 \text{ M H}_2\text{SO}_4$$

Next, we determine the molarity of H_2SO_4 in the concentrated solution, using $V_c \times C_c = V_d \times C_d$.

$$1.00 \text{ mL} \times C_c = 250.0 \text{ mL} \times 0.0162 \text{ M} \quad C_c = \frac{250.0 \text{ mL} \times 0.0162 \text{ M}}{1.00 \text{ mL}} = 4.05 \text{ M H}_2\text{SO}_4$$

$$\% \text{H}_2\text{SO}_4 = \frac{4.05 \text{ mol H}_2\text{SO}_4}{1 \text{ L soln}} \times \frac{98.08 \text{ g H}_2\text{SO}_4}{1 \text{ mol H}_2\text{SO}_4} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1 \text{ mL}}{1.239 \text{ g}} \times 100\% = 32.1\% \text{ H}_2\text{SO}_4$$

86. (M) $\text{CaCO}_3(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$



$$n_{\text{HCl}(\text{initial})} = 0.05000 \text{ L} \times 0.5000 \text{ M} = 0.02500 \text{ mol HCl}$$

$$n_{\text{OH}^-} = 0.04020 \text{ L} \times 0.2184 \text{ M} = 0.00878 \text{ mol OH}^-$$

$$n_{\text{HCl}(\text{excess})} = 0.00878 \text{ mol OH}^- \times \frac{1 \text{ mol HCl}}{1 \text{ mol OH}^-} = 0.00878 \text{ mol HCl}$$

$$n_{\text{HCl}(\text{reacted})} = n_{\text{HCl}(\text{initial})} - n_{\text{HCl}(\text{excess})} = 0.02500 \text{ mol HCl} - 0.00878 \text{ mol HCl} = 0.01622 \text{ mol HCl}$$

$$\text{mass Ca}^{2+} = 0.01622 \text{ mol HCl} \times \frac{1 \text{ mol CaCO}_3}{2 \text{ mol HCl}} \times \frac{1 \text{ mol Ca}^{2+}}{1 \text{ mol CaCO}_3} \times \frac{40.078 \text{ g Ca}^{2+}}{1 \text{ mol Ca}^{2+}} \times \frac{1000 \text{ mg Ca}^{2+}}{1 \text{ g Ca}^{2+}} = 325 \text{ mg Ca}^{2+}$$

87. (M) Let X_{KOH} = mass of KOH in grams and X_{LiOH} be the mass of LiOH in grams.

(Note: Molar masses: $\text{KOH} = 56.1056 \text{ g mol}^{-1}$ and $\text{LiOH} = 23.9483 \text{ g mol}^{-1}$)

$$\text{moles of HCl} = C \times V = 0.3520 \text{ M} \times 0.02828 \text{ L} = 0.009956 \text{ mol HCl}$$

We can set up two equations for the two unknowns:

$$X_{\text{KOH}} + X_{\text{LiOH}} = 0.4324 \text{ g} \quad \text{and since moles of HCl} = \text{moles of OH}^- \text{ (Stoichiometry is 1:1)}$$

$$0.009956 \text{ mol OH}^- = \frac{X_{\text{KOH}}}{56.1056} + \frac{X_{\text{LiOH}}}{23.9483}$$

Make the substitution that $X_{\text{KOH}} = 0.4324 \text{ g} - X_{\text{LiOH}}$

$$0.009956 \text{ mol OH}^- = \frac{(0.4324 - X_{\text{LiOH}})}{56.1056} + \frac{X_{\text{LiOH}}}{23.9483} = \frac{0.4324}{56.1056} - \frac{X_{\text{LiOH}}}{56.1056} + \frac{X_{\text{LiOH}}}{23.9483}$$

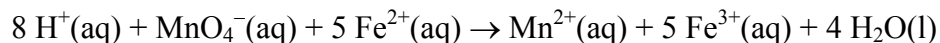
$$\text{Collect terms: } 0.009956 \text{ mol OH}^- = 0.007707 \text{ mol OH}^- + 0.02393X_{\text{LiOH}} \text{ mol OH}^-$$

$$0.009956 \text{ mol OH}^- - 0.007707 \text{ mol OH}^- = 0.02393X_{\text{LiOH}} \text{ mol OH}^- = 0.002249 \text{ mol OH}^-$$

$$X_{\text{LiOH}} = 0.09397 \text{ g LiOH} \quad \text{hence, } X_{\text{KOH}} = 0.4324 \text{ g} - 0.09397 \text{ g} = 0.3384 \text{ g}$$

$$\text{Mass \% LiOH} = \frac{0.09397 \text{ g}}{0.4324 \text{ g}} \times 100\% = 21.73\% \quad \text{Mass \% KOH} = \frac{0.3384 \text{ g}}{0.4324 \text{ g}} \times 100\% = 78.26\%$$

90. (D) The first step is to balance the chemical equation. Using the method outlined in the text, we obtain the following result:



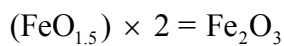
$$0.04217 \text{ L} \times \frac{0.01621 \text{ mol KMnO}_4}{1 \text{ L}} \times \frac{1 \text{ mol MnO}_4^-}{1 \text{ mol KMnO}_4} \times \frac{5 \text{ mol Fe}^{2+}}{1 \text{ mol MnO}_4^-} = 0.003418 \text{ mol Fe}^{2+}$$

$$0.003418 \text{ mol Fe in sample} \times \frac{55.847 \text{ g}}{1 \text{ mol}} = 0.1909 \text{ g Fe}$$

$$0.2729 \text{ g sample} - 0.1909 \text{ g Fe} = 0.0820 \text{ g oxygen}$$

$$0.0820 \text{ g O} \times \frac{1 \text{ mol}}{16.00 \text{ g}} = 0.005125 \text{ mol O} \div 0.003418 = 1.5$$

$$0.003418 \text{ mol Fe} \div 0.003418 = 1$$



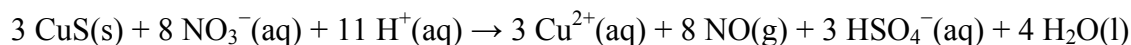
91. (M)

$$0.1386 \text{ g AgI} \times \frac{1 \text{ mol AgI}}{234.77 \text{ g AgI}} \times \frac{1 \text{ mol CHI}_3}{3 \text{ mol AgI}} \times \frac{1 \text{ mol C}_{19}\text{H}_{16}\text{O}_4}{1 \text{ mol CHI}_3} \times \frac{308.33 \text{ g C}_{19}\text{H}_{16}\text{O}_4}{1 \text{ mol C}_{19}\text{H}_{16}\text{O}_4}$$

$$= 0.06068 \text{ g C}_{19}\text{H}_{16}\text{O}_4$$

$$\% \text{ C}_{19}\text{H}_{16}\text{O}_4 = \frac{0.06068 \text{ g}}{13.96 \text{ g}} \times 100 = 0.4346 \%$$

92. (M) The first step is to balance the chemical equation. By using the method described in the text, we obtain the following result:



The next step is to calculate the volume of solution required:

$$1 \text{ kg CuS} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol CuS}}{95.61 \text{ g CuS}} \times \frac{8 \text{ mol HNO}_3}{3 \text{ mol CuS}} \times \frac{63.02 \text{ g HNO}_3}{1 \text{ mol HNO}_3} = 1757.7 \text{ g HNO}_3$$

$$1757.7 \text{ g HNO}_3 \times \frac{100 \text{ g soln}}{70 \text{ g HNO}_3} \times \frac{1 \text{ mL soln}}{1.40 \text{ g soln}} = 1793.6 \text{ mL} = 2000 \text{ mL (to 1 sig fig)}$$