

Chapter 4
Solutions to Selected Integrative and Advanced Exercises

60. (M) We determine the amount of HCl present initially, and the amount desired.

$$\text{amount HCl present} = 250.0 \text{ mL} \times \frac{1.023 \text{ mmol HCl}}{1 \text{ mL soln}} = 255.8 \text{ mmol HCl}$$

$$\text{amount HCl desired} = 250.0 \text{ mL} \times \frac{1.000 \text{ mmol HCl}}{1 \text{ mL soln}} = 250.0 \text{ mmol HCl}$$

$$\text{mass Mg} = (255.8 - 250.0) \text{ mmol HCl} \times \frac{1 \text{ mmol Mg}}{2 \text{ mmol HCl}} \times \frac{24.3 \text{ mg Mg}}{1 \text{ mmol Mg}} = 70. \text{ mg Mg}$$

76. (D) The balanced equation is $2 \text{ NH}_3(\text{g}) + 3 \text{ CuO}(\text{s}) \rightarrow \text{N}_2(\text{g}) + 3 \text{ Cu}(\text{s}) + 3 \text{ H}_2\text{O}(\text{g})$

$$\% \text{ yield} = \frac{6.63 \text{ g}}{\text{theoretical yield}} \times 100 \%$$

$$18.1 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17.03 \text{ g NH}_3} \times \frac{1 \text{ mol N}_2}{2 \text{ mol NH}_3} \times \frac{28.01 \text{ g N}_2}{1 \text{ mol N}_2} = 14.9 \text{ g N}_2$$

$$90.4 \text{ g CuO} \times \frac{1 \text{ mol CuO}}{79.55 \text{ g CuO}} \times \frac{1 \text{ mol N}_2}{3 \text{ mol CuO}} \times \frac{28.01 \text{ g N}_2}{1 \text{ mol N}_2} = 10.6 \text{ g N}_2$$

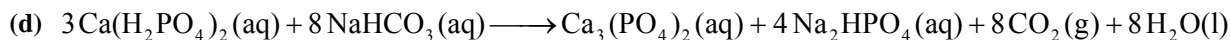
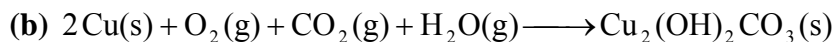
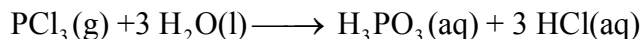
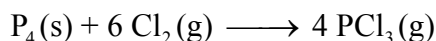
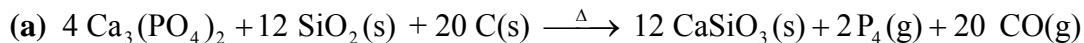
CuO is the limiting reagent. The theoretical yield of N₂ is 10.6 grams.

$$\% \text{ yield} = \frac{6.63 \text{ g}}{10.6 \text{ g}} \times 100 \% = 62.5 \%$$

79. (M) Balanced equation: $3 \text{ CH}_3\text{COOH} + \text{PCl}_3 \rightarrow 3 \text{ CH}_3\text{COCl} + \text{H}_3\text{PO}_3$

$$\begin{aligned} \text{mass acid} &= 75 \text{ g CH}_3\text{COCl} \times \frac{100.0 \text{ g calculated}}{78.2 \text{ g produced}} \times \frac{1 \text{ mol CH}_3\text{COCl}}{78.5 \text{ g CH}_3\text{COCl}} \times \frac{3 \text{ mol CH}_3\text{COOH}}{3 \text{ mol CH}_3\text{COCl}} \\ &\times \frac{60.1 \text{ g pure CH}_3\text{COOH}}{1 \text{ mol CH}_3\text{COOH}} \times \frac{100 \text{ g commercial}}{97 \text{ g pure CH}_3\text{COOH}} = 76 \text{ g commercial CH}_3\text{COOH} \end{aligned}$$

94. (E)



96. (M) $\text{mass CaCO}_3 = 0.981 \text{ g CO}_2 \times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} \times \frac{1 \text{ mol CaCO}_3}{1 \text{ mol CO}_2} \times \frac{100.1 \text{ g CaCO}_3}{1 \text{ mol CaCO}_3} = 2.23 \text{ g CaCO}_3$

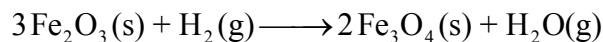
$$\% \text{ CaCO}_3 = \frac{2.23 \text{ g CaCO}_3}{3.28 \text{ g sample}} \times 100 \% = 68.0 \% \text{ CaCO}_3(\text{by mass})$$

97. (D) We determine the empirical formula, basing our calculation on 100.0 g of the compound.

$$\text{amount Fe} = 72.3 \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} = 1.29 \text{ mol Fe} \quad \div 1.29 \longrightarrow 1.00 \text{ mol Fe}$$

$$\text{amount O} = 27.7 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 1.73 \text{ mol O} \quad \div 1.29 \longrightarrow 1.34 \text{ mol O}$$

The empirical formula is Fe_3O_4 and the balanced equation is as follows.



102. (D) Let V be the volume of $0.0175 \text{ M CH}_3\text{OH}(\text{aq})$ that is required.

$$\begin{aligned} \text{moles CH}_3\text{OH in solution C} &= \text{moles CH}_3\text{OH in solution A} + \text{moles CH}_3\text{OH in solution B} \\ (V + 0.0500) \times 0.0200 \text{ M} &= (V \times 0.0175 \text{ M}) + (0.050 \times 0.0248 \text{ M}) \end{aligned}$$

$$\text{Solve for } V: V = 0.0960 \text{ L} = 96.0 \text{ mL}$$

$$\begin{aligned} \mathbf{103. (M)} \quad & \frac{1.52 \text{ g Na}}{1 \times 10^6 \text{ g sol}} \times \frac{1 \text{ g sol}}{1 \text{ mL sol}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ mol Na}}{22.9898 \text{ g Na}} \times \frac{1 \text{ mol NaCl}}{1 \text{ mol Na}} \times \frac{58.4425 \text{ g NaCl}}{1 \text{ mol NaCl}} \\ &= 0.003864 \text{ M NaCl} \end{aligned}$$

107. (M) Let us first determine the moles of NH_4NO_3 in the dilute solution.

$$\text{mass}_{\text{NH}_4\text{NO}_3} = 1000 \text{ mL} \times \frac{2.37 \times 10^{-3} \text{ g N}}{1 \text{ mL}} \times \frac{1 \text{ mol N}}{14.007 \text{ g N}} \times \frac{1 \text{ mol NH}_4\text{NO}_3}{2 \text{ mol N}} = 0.0846 \text{ mol NH}_4\text{NO}_3$$

$$\text{volume of solution} = 0.0846 \text{ mol NH}_4\text{NO}_3 \times \frac{1 \text{ L soln}}{0.715 \text{ mol NH}_4\text{NO}_3} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 118 \text{ mL soln}$$

113. (D) One way to solve this problem would be to calculate the mass of CO_2 produced from a 0.220 g sample of each alcohol. The results are 0.303 g CO_2 from $0.220 \text{ g CH}_3\text{OH}$ and 0.421 g CO_2 from $0.220 \text{ g CH}_3\text{CH}_2\text{OH}$. Obviously a mixture has been burned. But we have sufficient information to determine the composition of the mixture. First we need the balanced equations for the combustion reactions. Then, we represent the mass of CH_3OH by x .



$$\begin{aligned} \text{mass CO}_2 = 0.352 \text{ g CO}_2 &= \left(x \text{ g CH}_3\text{OH} \times \frac{1 \text{ mol CH}_3\text{OH}}{32.04 \text{ g CH}_3\text{OH}} \times \frac{2 \text{ mol CO}_2}{2 \text{ mol CH}_3\text{OH}} \times \frac{44.01 \text{ g CO}_2}{1 \text{ mol CO}_2} \right) \\ &+ \left((0.220 - x) \text{ g CH}_3\text{CH}_2\text{OH} \times \frac{1 \text{ mol CH}_3\text{CH}_2\text{OH}}{46.07 \text{ g CH}_3\text{CH}_2\text{OH}} \times \frac{2 \text{ mol CO}_2}{1 \text{ mol C}_2\text{H}_5\text{OH}} \times \frac{44.01 \text{ g CO}_2}{1 \text{ mol CO}_2} \right) \\ &= 1.374x + (0.220 - x)1.911 = 0.421 - 0.537x \end{aligned}$$

$$-0.537x = 0.352 - 0.420 = -0.068 \quad \text{or} \quad x = \frac{-0.068}{-0.537} = 0.127 \text{ g CH}_3\text{OH}$$

$$\text{By difference, the mass of CH}_3\text{CH}_2\text{OH is } 0.220 \text{ g} - 0.127 \text{ g} = 0.093 \text{ g CH}_3\text{OH}$$

119. (M) Compute the amount of AgNO_3 in the solution on hand and the amount of AgNO_3 in the desired solution. the difference is the amount of AgNO_3 that must be added; simply convert this amount to a mass.

$$\text{amount AgNO}_3 \text{ present} = 50.00 \text{ mL} \times \frac{0.0500 \text{ mmol AgNO}_3}{1 \text{ mL soln}} = 2.50 \text{ mmol AgNO}_3$$

$$\text{amount AgNO}_3 \text{ desired} = 100.0 \text{ mL} \times \frac{0.0750 \text{ mmol AgNO}_3}{1 \text{ mL soln}} = 7.50 \text{ mmol AgNO}_3$$

$$\begin{aligned} \text{mass AgNO}_3 &= (7.50 - 2.50) \text{ mmol AgNO}_3 \times \frac{1 \text{ mol AgNO}_3}{1000 \text{ mmol AgNO}_3} \times \frac{169.9 \text{ g AgNO}_3}{1 \text{ mol AgNO}_3} \\ &= 0.850 \text{ g AgNO}_3 \end{aligned}$$

123. (D) There are many ways one can go about answering this question. We must use all of the most concentrated solution and dilute this solution down using the next most concentrated solution. Hence, start with 345 mL of 0.129 M then add x mL of the 0.775 M solution. The value of x is obtained by solving the following equation.

$$1.25 \text{ M} = \frac{(1.29 \text{ M} \times 0.345 \text{ L}) + (0.775 \text{ M} \times x)}{(0.345 + x) \text{ L}}$$

$$1.25 \text{ M} \times (0.345 + x) \text{ L} = (1.29 \text{ M} \times 0.345 \text{ L}) + (0.775 \text{ M} \times x)$$

$$0.43125 + 1.25x = 0.44505 + 0.775x \quad \text{Thus, } 0.0138 = 0.475x$$

$$x = 0.029 \text{ L or } 29 \text{ mL}$$

A total of $(29 \text{ mL} + 345 \text{ mL}) = 374 \text{ mL}$ may be prepared this way.