Amount in moles, n, of the NaCl(s):

$$n_{NaCl} = \frac{m}{M}$$
$$= \frac{2.5\ \cancel{g}}{58.44\ \cancel{g}/\text{mol}}$$
$$= 4.2778 \times 10^{-2}\ \text{mol}$$

Molar concentration, c, of the NaCl(aq):

$$c = \frac{n}{V}$$
$$= \frac{4.2778 \times 10^{-2}\ \text{mol}}{0.100\ \text{L}}$$
$$= 0.42778\ \text{mol/L}$$
$$= 0.43\ \text{mol/L}$$

The molar concentration of the saline solution is 0.43 mol/L.

Check Your Solution

The units are correct and the answer correctly shows two significant digits. The dilution of the original concentrated solution is correct and the change to mol/L seems reasonable.

Section 8.4 Preparing Solutions in the Laboratory

Solutions for Practice Problems

Student Edition page 386

51. Practice Problem (page 386)

Suppose that you are given a stock solution of 1.50 mol/L ammonium sulfate, $(NH_4)_2SO_4(aq)$.
What volume of the stock solution do you need to use to prepare each of the following solutions?

a. 50.0 mL of 1.00 mol/L $(NH_4)_2SO_4(aq)$
b. 2×10^2 mL of 0.800 mol/L $(NH_4)_2SO_4(aq)$
c. 250 mL of 0.300 mol/L $NH_4^+(aq)$

What Is Required?

You need to calculate the initial volume, V_1, of $(NH_4)_2SO_4(aq)$ stock solution needed to prepare each given dilute solution.

What Is Given?
You know the concentration of the stock solution: $c_1 = 1.50$ mol/L
You know the final volume and concentration of each dilute solution.
a. $(NH_4)_2SO_4(aq)$: $V_2 = 50.0$ mL; $c_2 = 1.00$ mol/L
b. $(NH_4)_2SO_4(aq)$: $V_2 = 200$ mL; $c_2 = 0.800$ mol/L
c. $NH_4^+(aq)$: $V_2 = 250$ mL; $c_2 = 0.300$ mol/L

Plan Your Strategy
Convert the volume of each solution from millilitres to litres:
1 mL = 1×10^{-3} L
Write the dilution equation.
Rearrange the equation to solve for V_1.
Substitute the data into the equation to calculate V_1.
For part **c**, write the balanced equation for the dissociation of $(NH_4)_2SO_4(s)$ and use the mole ratio from this equation to determine the concentration of $(NH_4)_2SO_4$ needed to obtain the required amount of $NH_4^+(aq)$.

Act on Your Strategy
a. 50.0 mL of 1.00 mol/L ammonium sulfate
Volume conversion:

$$\begin{aligned} V_2 &= 50.0\ \cancel{\text{mL}} \times 1 \times 10^{-3}\ \text{L}/\cancel{\text{mL}} \\ &= 0.050\ \text{L} \end{aligned}$$

Dilution equation:

$$c_1V_1 = c_2V_2$$

Rearranged formula to solve for V_1:

$$c_1V_1 = c_2V_2$$

$$\frac{\cancel{c_1}V_1}{\cancel{c_1}} = \frac{c_2V_2}{c_1}$$

$$V_1 = \frac{c_2V_2}{c_1}$$

Substitution to solve for V_1:

$$\begin{aligned} V_1 &= \frac{c_2V_2}{c_1} \\ &= \frac{1.00\ \cancel{\text{mol/L}} \times 0.050\ \text{L}}{1.50\ \cancel{\text{mol/L}}} \\ &= 0.0333\ \text{L} \end{aligned}$$

The initial volume of $(NH_4)_2SO_4(aq)$ stock solution required is 0.0333 L.

b. 2×10^2 mL of 0.800 mol/L ammonium sulfate
Volume conversion:

$$V_2 = 2\times10^2 \ \cancel{\text{mL}} \times 1 \times 10^{-3} \ \text{L}/\cancel{\text{mL}}$$
$$= 0.200 \ \text{L}$$

Dilution equation:

$$c_1V_1 = c_2V_2$$

Rearranged formula to solve for V_1:

$$c_1V_1 = c_2V_2$$
$$\frac{\cancel{c_1}V_1}{\cancel{c_1}} = \frac{c_2V_2}{c_1}$$
$$V_1 = \frac{c_2V_2}{c_1}$$

Substitution to solve for V_1:

$$V_1 = \frac{c_2V_2}{c_1}$$
$$= \frac{0.800 \ \cancel{\text{mol/L}} \times 0.200 \ \text{L}}{1.50 \ \cancel{\text{mol/L}}}$$
$$= 0.10666 \ \text{L}$$
$$= 0.107 \ \text{L}$$

Volume conversion:

$$V_1 = 0.107 \ \cancel{\text{L}} \times 1 \times 10^3 \ \text{mL}/\cancel{\text{L}}$$
$$= 107 \ \text{mL}$$

The initial volume of $(NH_4)_2SO_4(aq)$ stock solution required is 107 mL.

c. 250 mL of 0.300 mol/L ammonium ions
Dissociation equation: $(NH_4)_2SO_4(s) \rightarrow 2NH_4^+(aq) + SO_4^{2-}(aq)$
Mole ratio: 1 mole 2 moles 1 mole

Molar concentration of $(NH_4)_2SO_4(aq)$:

$$\frac{2\text{ mol NH}_4^+}{1\text{ mol (NH}_4)_2\text{SO}_4} = \frac{0.300\text{ mol/L NH}_4^+}{c}$$

$$c \times 2\text{ mol NH}_4^+(\text{aq}) = 1\text{ mol }(\text{NH}_4)_2\text{SO}_4(\text{aq}) \times 0.300\text{ mol/L NH}_4^+(\text{aq})$$

$$c = \frac{1\cancel{\text{mol}}\,(\text{NH}_4)_2\text{SO}_4(\text{aq}) \times 0.300\text{ mol/L }\cancel{\text{NH}_4^+(\text{aq})}}{2\text{ mol }\cancel{\text{NH}_4^+(\text{aq})}}$$

$$= 0.150\text{ mol/L (NH}_4)_2\text{SO}_4(\text{aq})$$

The molar concentration of $(NH_4)_2SO_4(aq)$ is 0.150 mol/L.

Volume conversion:

$$V_2 = 250\,\cancel{\text{mL}} \times 1 \times 10^{-3}\text{ L/}\cancel{\text{mL}}$$
$$= 0.250\text{ L}$$

Dilution equation:

$$c_1V_1 = c_2V_2$$

Rearranged equation to solve for V_1:

$$c_1V_1 = c_2V_2$$
$$\frac{\cancel{c_1}V_1}{\cancel{c_1}} = \frac{c_2V_2}{c_1}$$
$$V_1 = \frac{c_2V_2}{c_1}$$

Substitution to solve for V_1:

$$V_1 = \frac{c_2V_2}{c_1}$$
$$= \frac{0.150\,\cancel{\text{mol/L}} \times 0.250\text{ L}}{1.50\,\cancel{\text{mol/L}}}$$
$$= 0.0250\text{ L}$$

The initial volume of $(NH_4)_2SO_4(aq)$ stock solution required is 0.0250 L.

Check Your Solution
The units and number of significant digits are correct. The initial volume of concentrated solution is always less than the final volume of dilute solution. The answers seem reasonable.

52. Practice Problem (page 386)
What is the concentration of the solution that is obtained by diluting 60.0 mL of 0.580 mol/L potassium hydroxide to each of the following volumes?
a. 350 mL
b. 180 mL
c. 3.00 L

What Is Required?
You need to calculate the final concentration, c_2, of the resulting solutions obtained when a solution of potassium hydroxide is diluted.

What Is Given?
You know the initial concentration and initial volume of the potassium hydroxide solution:
c_1 = 60.0 mL
V_1 = 0.580 mol/L
You know the final volume of each dilute solution:
a. V_2 = 350 mL
b. V_2 = 180 mL
c. V_2 = 3.00 L

Plan Your Strategy
Where necessary, convert the volume of the solution from millilitres to litres: 1 mL = 1×10^{-3} L
Write the dilution equation.
Rearrange the equation to solve for c_2.
Substitute the data into the equation to calculate c_2.

Act on Your Strategy
a. 350 mL of potassium hydroxide
Volume conversion:

$$\begin{aligned} V_1 &= 350\ \cancel{\text{mL}} \times 1 \times 10^{-3}\ \text{L}/\cancel{\text{mL}} \\ &= 0.350\ \text{L} \end{aligned}$$

Dilution equation:

$$c_1V_1 = c_2V_2$$

Rearranged equation to solve for c_2:

$$c_1V_1 = c_2V_2$$

$$\frac{c_1V_1}{V_2} = \frac{c_2\cancel{V_2}}{\cancel{V_2}}$$

$$c_2 = \frac{c_1V_1}{V_2}$$

Substitution to solve for c_2:

$$\begin{aligned}c_2 &= \frac{c_1V_1}{V_2}\\ &= \frac{0.580\ \text{mol/L} \times 0.0600\ \cancel{\text{L}}}{0.350\ \cancel{\text{L}}}\\ &= 0.099428\ \text{mol/L}\\ &= 0.0994\ \text{mol/L}\end{aligned}$$

The final concentration of the potassium hydroxide solution is 0.0994 mol/L.

b. 180 mL of potassium hydroxide
Volume conversion:

$$\begin{aligned}V_1 &= 180\ \cancel{\text{mL}} \times 1 \times 10^{-3}\ \text{L}/\cancel{\text{mL}}\\ &= 0.180\ \text{L}\end{aligned}$$

Dilution equation:

$$c_1V_1 = c_2V_2$$

Rearranged equation to solve for c_2:

$$c_1V_1 = c_2V_2$$

$$\frac{c_1V_1}{V_2} = \frac{c_2\cancel{V_2}}{\cancel{V_2}}$$

$$c_2 = \frac{c_1V_1}{V_2}$$

Substitution to solve for c_2:

$$c_2 = \frac{c_1V_1}{V_2}$$
$$= \frac{0.580 \text{ mol/L} \times 0.0600 \cancel{\text{L}}}{0.180 \cancel{\text{L}}}$$
$$= 0.19333 \text{ mol/L}$$
$$= 0.193 \text{ mol/L}$$

The final concentration of the potassium hydroxide solution is 0.193 mol/L.

c. 3.00 L of potassium hydroxide
Dilution equation:

$$c_1V_1 = c_2V_2$$

Rearranged equation to solve for c_2:

$$c_1V_1 = c_2V_2$$
$$\frac{c_1V_1}{V_2} = \frac{c_2\cancel{V_2}}{\cancel{V_2}}$$
$$c_2 = \frac{c_1V_1}{V_2}$$

Substitution to solve for c_2:

$$c_2 = \frac{c_1V_1}{V_2}$$
$$= \frac{0.580 \text{ mol/L} \times 0.0600 \cancel{\text{L}}}{3.00 \cancel{\text{L}}}$$
$$= 0.0116 \text{ mol/L}$$

The final concentration of the potassium hydroxide solution is 0.0116 mol/L.

Check Your Solution
The units and number of significant digits are correct. Comparing answers: V_2 for part **b** is about $\frac{1}{2}$ V_2 for part **a**, and c_2 for part **b** is about 2 times that for part **a**. Similarly, V_2 for part **c** is about 9 times V_2 for part **a**, and c_2 for part **c** is about $\frac{1}{9}$ times that for part **a**. The answers seem reasonable.

Substitution to solve for V_2:

$$V_2 = \frac{c_1 V_1}{c_2}$$

$$= \frac{3.00\ \cancel{\text{mol/L}} \times 0.125\ \text{L}}{1.25\ \cancel{\text{mol/L}}}$$

$$= 0.300\ \text{L}$$

The final volume of potassium iodide solution that you can make is 0.300 L.

Check Your Solution
The final volume, V_2, is about 2.5 times the initial volume, V_1. The final concentration, c_2, is about 0.4 times the initial concentration, c_1. The answer seems reasonable and correctly shows three significant digits.

58. Practice Problem (page 386)
Hydrochloric acid is available as a stock solution with a concentration of 10 mol/L. If you need 1.0 L of 5.0 mol/L hydrochloric acid, what volume of stock solution should you measure out? Approximately how much distilled water will you need to make the dilution?

What Is Required?
You need to calculate the initial volume, V_1, of hydrochloric acid, HCl(aq), stock solution required to prepare a dilute solution.

What Is Given?
You know the initial concentration of the hydrochloric acid stock solution:
$c_1 = 10$ mol/L
You know the final volume and concentration of the dilute solution:
$V_2 = 1.0$ L
$c_2 = 5.0$ mol/L

Plan Your Strategy
Write the dilution equation.
Rearrange the equation to solve for V_1.
Substitute the numbers and units for the known variables in the formula and solve for V_1.
Calculate the volume of distilled water required by subtracting the initial volume from the final volume.

Act on Your Strategy

Dilution equation:

$$c_1V_1 = c_2V_2$$

Rearranged equation to solve for V_1:

$$c_1V_1 = c_2V_2$$

$$\frac{\cancel{c_1}V_1}{\cancel{c_1}} = \frac{c_2V_2}{c_1}$$

$$V_1 = \frac{c_2V_2}{c_1}$$

Substitution to solve for V_1:

$$\begin{aligned} V_1 &= \frac{c_2V_2}{c_1} \\ &= \frac{5.0\ \cancel{\text{mol/L}} \times 1.0\ \text{L}}{10\ \cancel{\text{mol/L}}} \\ &= 0.50\ \text{L} \end{aligned}$$

The initial volume of hydrochloric acid stock solution required is 0.50 L.

$$\begin{aligned} \text{Amount of distilled water required } &= V_2 - V_1 \\ &= 1.0\ \text{L} - 0.50\ \text{L} \\ &= 0.50\ \text{L} \end{aligned}$$

To prepare the dilute HCl solution, add 0.50 L of acid slowly to 0.50 L of water.

Check Your Solution

The final concentration, c_2, is $\frac{1}{2}$ the initial concentration, c_1. The final volume, V_2, is 2 times the initial volume, V_1. The answer seems reasonable and correctly shows two significant digits.