1. Phosphoric acid, \( \text{H}_3\text{PO}_4 \), reacts with sodium hydroxide. Write the balanced equation below.

\[ \text{H}_3\text{PO}_4 + 3\text{NaOH} \rightarrow \text{Na}_3\text{PO}_4 + 3\text{H}_2\text{O} \]

What volume of 0.20 M \( \text{H}_3\text{PO}_4 \) is needed to react with 100 mL of 0.10 M \( \text{NaOH} \)?

**Step 1: Label your equation:**

\[ \text{H}_3\text{PO}_4 + 3\text{NaOH} \rightarrow \text{Na}_3\text{PO}_4 + 3\text{H}_2\text{O} \]

0.20 M \quad 100 mL

? L \quad 0.10 M

**Step 2: Use the equation for molarity to determine how many moles of \( \text{NaOH} \) are present:**

\[ M = \frac{\text{mol solute}}{\text{L solution}} \]

\[ 0.10 \, M = \frac{\text{mol NaOH}}{0.100 \, \text{L}} \]

\[ = 0.010 \, \text{mol NaOH} \]

**Step 3: Convert from moles of \( \text{NaOH} \) to moles of \( \text{H}_3\text{PO}_4 \) using stoichiometry (mole ratio):**

\[ 0.010 \, \text{mol NaOH} \times \frac{1 \, \text{mol H}_3\text{PO}_4}{3 \, \text{mol NaOH}} = 0.0030 \, \text{mol H}_3\text{PO}_4 \]

**Step 4: Now use the molarity equation again to calculate the volume of \( \text{H}_3\text{PO}_4 \) used:**

\[ M = \frac{\text{mol solute}}{\text{L solution}} \]

\[ 0.20 \, M = \frac{0.0030 \, \text{mol H}_3\text{PO}_4}{\text{L solution}} \]

\[ = 0.017 \, \text{L} \]

\[ = 17 \, \text{mL} \]
Unit 11—Solutions

2. Hydrochloric acid reacts with zinc to produce zinc chloride and hydrogen gas. Write a balanced chemical equation in the space below.

How many grams of zinc will be reacted when you use 25 mL of 4.0 M HCl to produce H₂ gas?

Answer 3.3 g

3. Calcium carbonate reacts with hydrochloric acid to produce calcium chloride, water and carbon dioxide. Write a balanced chemical equation in the space provided below.

What volume of a 0.80 M HCl solution would be needed to dissolve a CaCO₃ pearl weighing 4.0 grams?

Answer 0.10 L

4. Iron reacts with gold (III) nitrate and one of the products is iron (II) nitrate. Write a balanced chemical equation in the space provided below.

Throwing some crap iron in a gold nitrate solution causes the gold metal to precipitate. What volume of a 0.50 M gold nitrate solution would produce 224 grams of gold metal?

Answer 2.3 L
5. Sea water is about 0.50 M NaCl. To produce Cl₂ gas, a company evaporates sea water, melts the NaCl, and then runs electricity through it:

\[ 2 \text{NaCl} \rightarrow 2 \text{Na} + \text{Cl}_2 \]

What volume of sea water is needed to fill a car tank with 1,120.00 L of chlorine gas at 25°C and 0.85 atm?

Answer \(1.6 \times 10^5\) L

6. Phosphoric acid is reacted with sodium hydroxide. Write a balanced equation in the space provided below.

How many grams of sodium phosphate will be produced if 36.0 mL of 0.500 M H₃PO₄ react with 80.0 mL of 0.500 M NaOH?

Answer \(2.13\) g