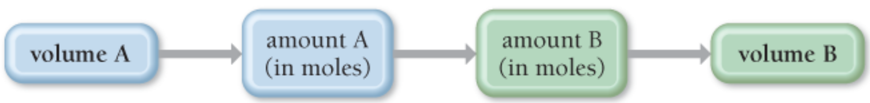
# 8.3: Solution Stoichiometry

In Section 7.4, we discussed how to use the coefficients in chemical equations as conversion factors between the amounts of reactants (in moles) and the amounts of products (in moles). In aqueous reactions, quantities of reactants and products are often specified in terms of volumes and concentrations. We can use the volume and concentration of a reactant or product to calculate its amount in moles. We can then use the stoichiometric coefficients in the chemical equation to convert to the amount in moles of another reactant or product. The general conceptual plan for these kinds of calculations begins with the volume of a reactant or product:




We make the conversions between solution volumes and amounts in moles of solute using the molarities of the solutions. We make the conversions between amounts in moles of A and B using the stoichiometric coefficients from the balanced chemical equation. Example 8.4 demonstrates solution stoichiometry.

## Example 8.4 Solution Stoichiometry

What volume (in L) of 0.150 M KCl solution will completely react with 0.150 L of a 0.175 M $Pb(NO_3)_2$ solution according to this balanced chemical equation?

$$2\ KCl\,(aq) + Pb(NO_3)_2\,(aq) \rightarrow PbCl_2\,(s) + 2\ KNO_3\,(aq)$$

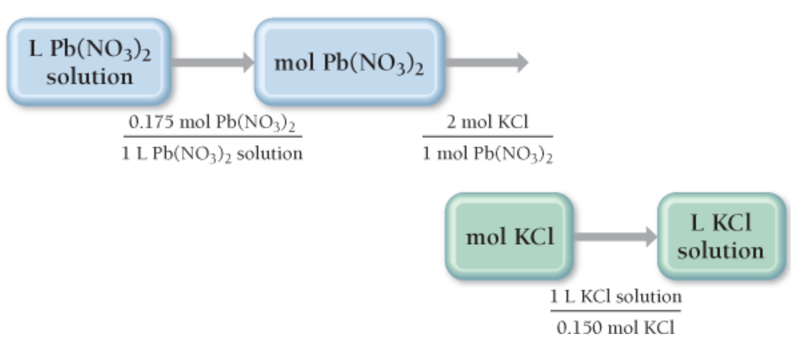
**SORT** You are given the volume and concentration of a $Pb(NO_3)_2$ solution. You are asked to find the volume of KCl solution (of a given concentration) required to react with it.

**GIVEN:** 0.150 L of $Pb(NO_3)_2$ solution, 0.175 M $Pb(NO_3)_2$ solution, 0.150 M KCl solution

**FIND:** volume KCl solution (in L)

**STRATEGIZE** The conceptual plan has the form: volume A → amount A (in moles) → amount B (in moles) → volume B. Use the molar concentrations of the KCl and $Pb(NO_3)_2$ solutions as conversion factors between the number of moles of reactants in these solutions and their volumes. Use the stoichiometric coefficients from the balanced equation to convert between number of moles of $Pb(NO_3)_2$ and number of moles of KCl.

**CONCEPTUAL PLAN**



**RELATIONSHIPS USED**

$$\text{M } [Pb(NO_3)_2] = \frac{0.175 \text{ mol } Pb(NO_3)_2}{1 \text{ L } Pb(NO_3)_2 \text{ solution}}$$

2 mol KCl : 1 mol $Pb(NO_3)_2$ (from chemical equation)

$$\text{M } [KCl] = \frac{0.150 \text{ mol KCl}}{1 \text{ L KCl solution}}$$

**SOLVE** Begin with L $Pb(NO_3)_2$ solution and follow the conceptual plan to arrive at L KCl solution.

**SOLUTION**

$$0.150 \text{ L } \cancel{Pb(NO_3)_2 \text{ solution}} \times \frac{0.175 \text{ mol } \cancel{Pb(NO_3)_2}}{1 \text{ L } \cancel{Pb(NO_3)_2 \text{ solution}}}$$

$$\times \frac{2 \cancel{\text{mol}} \text{ KCl}}{1 \text{ mol } \cancel{Pb(NO_3)_2}} \times \frac{1 \text{ L KCl solution}}{0.150 \cancel{\text{ mol KCl}}} = 0.350 \text{ L KCl solution}$$

**CHECK** The final units (L KCl solution) are correct. The magnitude (0.350 L) is reasonable because the reaction stoichiometry requires 2 mol of KCl per mole of $Pb(NO_3)_2$. Since the concentrations of the two solutions are not very different (0.150 M compared to 0.175 M), the volume of KCl required is roughly two times the 0.150 L of $Pb(NO_3)_2$ given in the problem.

**FOR PRACTICE 8.4** What volume (in mL) of a 0.150 M $HNO_3$ solution will completely react with 35.7 mL of a 0.108 M $Na_2CO_3$ solution according to this balanced chemical equation?

$$Na_2CO_3\,(aq) + 2\,HNO_3\,(aq) \rightarrow 2\,NaNO_3\,(aq) + CO_2\,(g) + H_2O\,(l)$$

**FOR MORE PRACTICE 8.4** In the reaction in For Practice 8.4, what mass (in grams) of carbon dioxide forms?

Interactive Worked Example 8.4 **Solution Stoichiometry**

Conceptual Connection 8.3 **Solution Stoichiometry**

Interactive