Sample Problem 3.12

Calculating the Molarity of a Solution

PROBLEM: Glycine (H_2NCH_2COOH) is the simplest amino acid. What is the molarity of an aqueous solution that contains 0.715 mol of glycine in 495 mL?

PLAN: Molarity is the number of moles of solute per liter of solution.

mol of glycine

↓ divide by volume

concentration(mol/mL) glycine

↓ 10^3mL = 1L

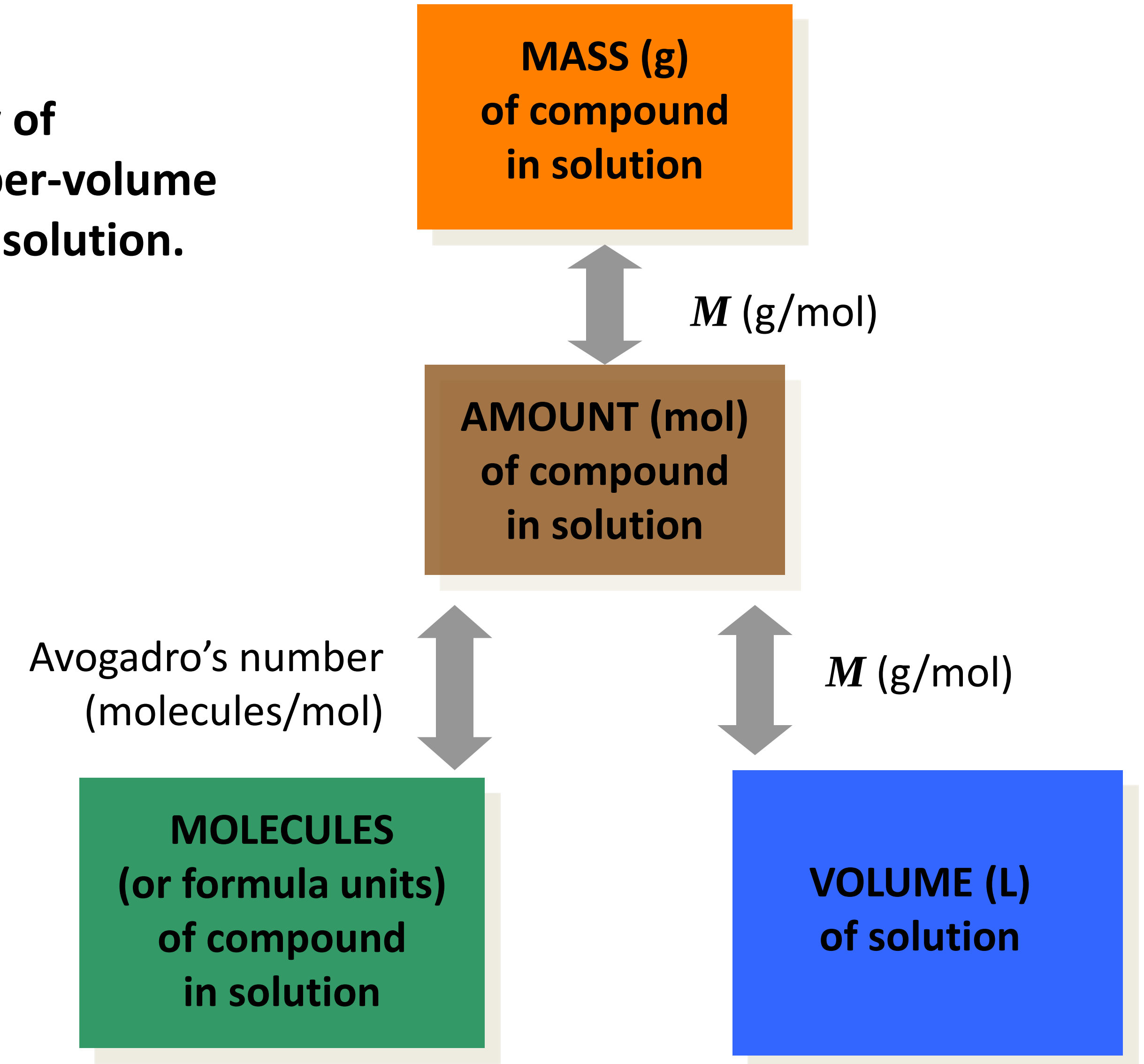
molarity(mol/L) glycine

SOLUTION:

$$\frac{0.715 \text{ mol glycine}}{495 \text{ mL soln}} \times \frac{1000\text{mL}}{1 \text{ L}} = 1.44 \text{ M glycine}$$

Figure 3.10

Summary of mass-mole-number-volume relationships in solution.



Sample Problem 3.13 Calculating Mass of Solute in a Given Volume of Solution

PROBLEM: A "buffered" solution maintains acidity as a reaction occurs. In living cells phosphate ions play a key buffering role, so biochemistry often study reactions in such solutions. How many grams of solute are in 1.75 L of 0.460 M sodium monohydrogen phosphate?

PLAN: Molarity is the number of moles of solute per liter of solution. Knowing the molarity and volume leaves us to find the # moles and then the # of grams of solute. The formula for the solute is Na_2HPO_4.

volume of soln

↓ multiply by M

moles of solute

↓ multiply by *M*

grams of solute

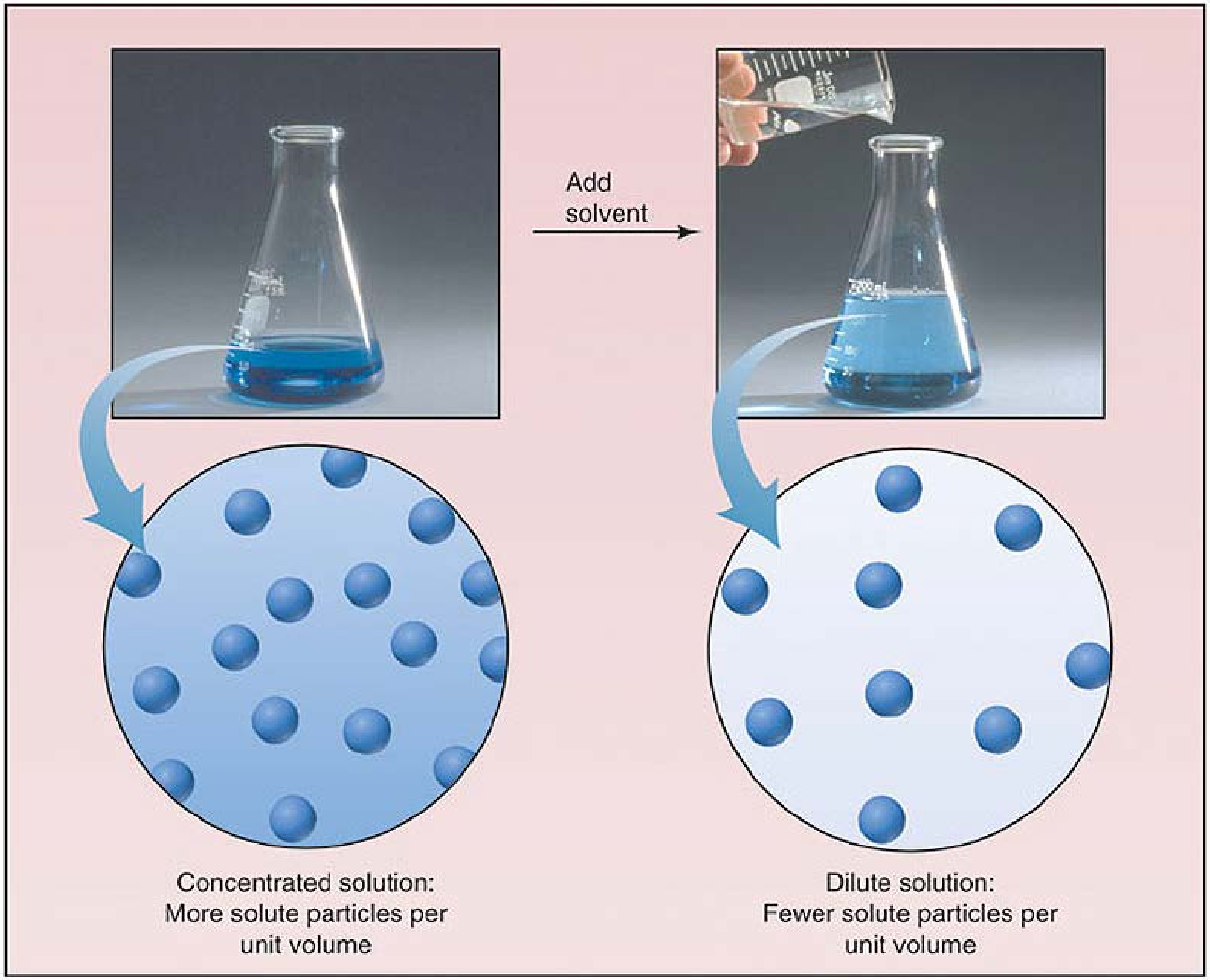
SOLUTION:

$$1.75\ \text{L} \times \frac{0.460\ \text{moles}}{1\ \text{L}} = 0.805\ \text{mol}\ Na_2HPO_4$$

$$0.805\ \text{mol}\ Na_2HPO_4 \times \frac{141.96\ \text{g}\ Na_2HPO_4}{\text{mol}\ Na_2HPO_4}$$

$$= 114\ \text{g}\ Na_2HPO_4$$

Figure 3.11 **Converting a concentrated solution to a dilute solution.**



Sample Problem 3.14

Preparing a Dilute Solution from a Concentrated Solution

PROBLEM: "Isotonic saline" is a 0.15 M aqueous solution of NaCl that simulates the total concentration of ions found in many cellular fluids. Its uses range from a cleaning rinse for contact lenses to a washing medium for red blood cells. How would you prepare 0.80 L of isotomic saline from a 6.0 M stock solution?

PLAN: It is important to realize the number of moles of solute does not change during the dilution but the volume does. The new volume will be the sum of the two volumes, that is, the total final volume.

$$M_{dil} x V_{dil} = \text{\#mol solute} = M_{conc} x V_{conc}$$

volume of dilute soln

↓ multiply by M of dilute solution

moles of NaCl in dilute soln = mol NaCl in concentrated soln

↓ divide by M of concentrated soln

L of concentrated soln

SOLUTION:

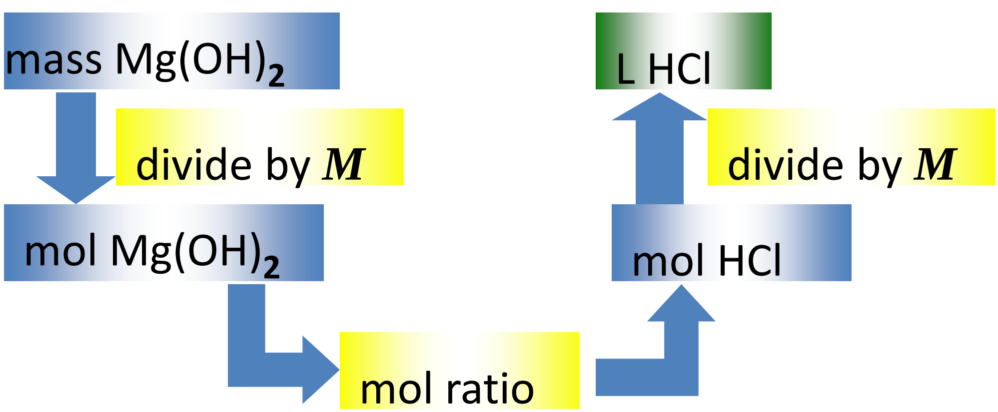
$$0.80 \text{ L soln} \times \frac{0.15 \text{ mol NaCl}}{\text{L soln}} = 0.12 \text{ mol NaCl}$$

$$0.12 \text{ mol NaCl} \times \frac{\text{L soln}_{conc}}{6 \text{ mol}} = 0.020 \text{ L soln}$$

Sample Problem 3.15 Calculating Amounts of Reactants and Products for a Reaction in Solution

PROBLEM: Specialized cells in the stomach release HCl to aid digestion. If they release too much, the excess can be neutralized with antacids. A common antacid contains magnesium hydroxide, which reacts with the acid to form water and magnesium chloride solution. As a government chemist testing commercial antacids, you use 0.10M HCl to simulate the acid concentration in the stomach. How many liters of "stomach acid" react with a tablet containing 0.10g of magnesium hydroxide?

PLAN: Write a balanced equation for the reaction; find the grams of $Mg(OH)_2$; determine the mol ratio of reactants and products; use mols to convert to molarity.



Sample Problem 3.15 — Calculating Amounts of Reactants and Products for a Reaction in Solution

continued

SOLUTION: $Mg(OH)_2(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + 2H_2O(l)$

$$0.10g\ Mg(OH)_2 \times \frac{mol\ Mg(OH)_2}{58.33g\ Mg(OH)_2} = 1.7x10^{-3}\ mol\ Mg(OH)_2$$

$$1.7x10^{-3}\ mol\ Mg(OH)_2 \times \frac{2\ mol\ HCl}{1\ mol\ Mg(OH)_2} = 3.4x10^{-3}\ mol\ HCl$$

$$3.4x10^{-3}\ mol\ HCl \times \frac{1L}{0.10mol\ HCl} = 3.4x10^{-2}\ L\ HCl$$

Sample Problem 3.16 Solving Limiting-Reactant Problems for Reactions in Solution

PROBLEM: Mercury and its compounds have many uses, from fillings for teeth (as an alloy with silver, copper, and tin) to the industrial production of chlorine. Because of their toxicity, however, soluble mercury compounds, such mercury(II) nitrate, must be removed from industrial wastewater. One removal method reacts the wastewater with sodium sulfide solution to produce solid mercury(II) sulfide and sodium nitrate solution. In a laboratory simulation, 0.050L of 0.010M mercury(II) nitrate reacts with 0.020L of 0.10M sodium sulfide. How many grams of mercury(II) sulfide form?

PLAN: As usual, write a balanced chemical reaction. Since this is a problem concerning a limiting reactant, we proceed as we would for a limiting reactant problem. Find the amount of product which would be made from each reactant. Then choose the reactant that gives the lesser amount of product.

Sample Problem 3.16 **Solving Limiting-Reactant Problems for Reactions in Solution**

continued

SOLUTION:

$$Hg(NO_3)_2(aq) + Na_2S(aq) \longrightarrow HgS(s) + 2NaNO_3(aq)$$

L of $Hg(NO_3)_2$	0.050L $Hg(NO_3)_2$		0.020L $Hg(NO_3)_2$	L of Na_2S
multiply by *M*	x 0.010 mol/L		x 0. 10 mol/L	multiply by *M*
mol $Hg(NO_3)_2$				mol Na_2S
mol ratio	$\times \frac{1\text{mol HgS}}{1\text{mol } Hg(NO_3)_2}$		$\times \frac{1\text{mol HgS}}{1\text{mol } Na_2S}$	mol ratio
mol HgS	$= 5.0\times10^{-4}$ mol HgS		$= 2.0\times10^{-3}$ mol HgS	mol HgS

$Hg(NO_3)_2$ is the limiting reagent.

$$5.0\times10^{-4}\text{ mol HgS} \times \frac{232.7\text{g HgS}}{1\text{ mol HgS}} = 0.12\text{g HgS}$$