Slides from Mixture and Concentration Problems (Tutorial 16)

Mixture and Concentration Problems

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This handout contains selected slides to use when reviewing this tutorial topic with or without the video. To access al thumbnail link on the tutorial interface.

Objective

- To set up equations to solve mixture and concentration problems
- To use various mathematical techniques to solve the equations

Solving Mixture Problems

1. Read the problem carefully to determine what is known and what may be needed to answer the question posed
2. Choose variable(s) to represent the unknown(s)
3. Reread the problem and write equation(s) using the variable(s) to represent the problem situation
4. Solve the equation(s)
5. Verify solution

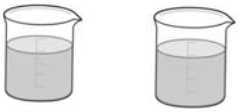
Read The Problem Carefully

A chemist has two chlorine solutions. One solution is 20% chlorine and the other one is 80% chlorine.

How much of each solution is needed to make 15 liters of solution that is 40% chlorine?

What Is Known

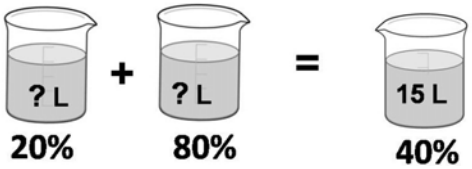
- Chemist has supplies of 20% solution and 80% solution.



- Chemist needs 15 liters of 40% solution.

What Is Unknown

- Amount of 20% solution and of 80% solution needed to make 15 L of 40% solution.



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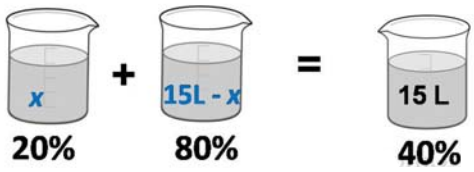
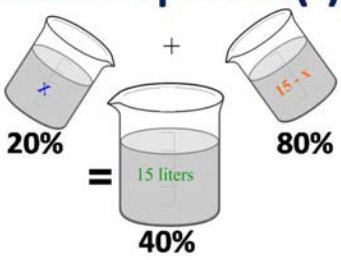
Use Variable(s) to Represent Unknown(s)

- Let x represent amount of 20% solution needed.
- Write an expression $15L - x$ for the amount of 80% solution needed.



Reread the Problem & Write Equation(s)



$$\underline{0.20}x + \underline{0.80}(15L - x) = \underline{0.40}(15L)$$

$20\% = 0.20$ $\quad 80\% = 0.80$ $\quad 40\% = 0.40$

Solve the Equation(s)

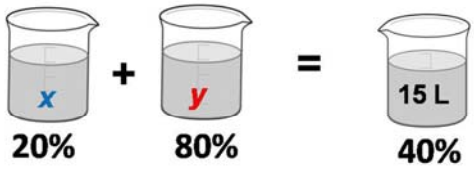
$$0.20x + 0.80(15L - x) = 0.40(15L)$$
$$0.20x + 12L - 0.80x = 6L$$
$$-0.60x = -6L$$
$$x = 10L$$

Verify Solution

The chemist needs 10 liters of the 20% solution and 5 liters of the 80% solution.

$$0.20(10L) + 0.80(5L) = 0.40(15L)$$
$$2L + 4L = 6L \checkmark$$

Solve by Using a System of Linear Equations with Substitution



$$x + y = 15L$$
$$0.20x + 0.80y = 0.40(15L)$$

Using Substitution

$$\begin{cases} x + y = 15L \longrightarrow x = 15L - y \\ 0.20x + 0.80y = 0.40(15L) \end{cases}$$

$$0.20(15L - y) + 0.80y = 0.40(15L)$$

Multiplied all terms by 100

$$20(15L - y) + 80y = 40(15L)$$
$$300L - 20y + 80y = 600L$$

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Using Substitution

$300L + 60y = 600L$

$60y = 300L$

$y = 5L$

To find x, substitute for y in the original equation

$x + y = 15L$

$x + 5L = 15L$

$x = 15L - 5L$

$x = 10L$

Using Substitution

$300L + 60y = 600L$

$60y = 300L$

$y = 5L$

The chemist needs 10 liters of the 20% solution and 5 liters of the 80% solution.

$x = 15L - 5L$

$x = 10L$

Concentration Terms

- **Molarity** (M) (a concentration unit) is the number of moles of solute per liter of solution. Expressed as mol/L and often stated as molar.
- **Solute** is the substance dissolved in a solution. In fluid solutions, the solvent is present in a greater amount than the solute.

Concentration Terms

- **Mole** (mol) (chemical mass unit) is the SI (Systeme International D'Unites) unit for the amount of substance.
- **Molar mass** of a substance is the mass per mole of its atoms, ions, molecules, or formula units. Also called molecular weight. Expressed as grams/mol.

Concentration Terms

$$\text{molarity } (M) = \frac{\text{moles of solute}}{\text{liter of solution}}$$

Solving Concentration Problems with Molarity and Volume Formula

$$M_1V_1 = M_2V_2$$

Solve for a missing value

Molarity of 1st solution × Volume of 1st solution = Molarity of 2nd solution × Volume of 2nd solution

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Problem 1: Basic Concepts

What mass of NaCl is required to prepare a 1 molar (*M*) NaCl solution?

First, find the molar mass of NaCl.

element	# of atoms		molar mass*	total
Na	1	x	23.0 g/mol	= 23.0
Cl	1	x	35.5 g/mol	= 35.5
				58.5 g/mol

The molar mass of NaCl is 58.5 g/mol.

*from the periodic table

Problem 2: *Step 1*

Calculate the molarity of a solution prepared by dissolving 4.09 g NaI (sodium iodide) solute in enough water to have 312 mL NaI solution.

1. Find the molar mass of NaI

element	# of atoms		molar mass*	total
Na	1	x	23.0 g/mol	= 23.0
I	1	x	127.0 g/mol	= 127.0
				150.0 g/mol

Molar mass of NaI is 150.0 g/mol

*from the periodic table

Problem 2: *Step 2*

2. Find the number of NaI moles

$$\text{moles (solute)} = \frac{\text{mass of solute}}{\text{molar mass of NaI}}$$

$$= 4.09 \text{ g (NaI)} \div 150.0 \text{ g/mol (NaI)}$$

$$= \frac{4.09 \text{ grams}}{1} \div \frac{150.0 \text{ grams/mol}}{1}$$

$$= \frac{4.09 \text{ g}}{1} \times \frac{1}{150.0 \text{ g/mol}} = \frac{4.09}{1} \times \frac{1 \text{ mol}}{150.0}$$

= 0.0273 moles of NaI

There are 0.0273 moles of NaI in the solute

Problem 2: *Step 3*

3. Convert milliliters to liters

312 mL = 0.312 L

Problem 2: *Alternative Step 4*

Solve by substituting in $M_1V_1 = M_2V_2$

M_1 = molarity solution 1 (0.0273 g/L)
V_1 = volume solution 1 (1 L)
M_2 = unknown molarity solution 2
V_2 = volume solution (0.312L)

$$0.0273(1 \text{ L}) = M_2(0.312\text{L})$$
$$0.0273/0.312 = M_2$$
$$0.0875 = M_2$$

The molarity of the NaI solution is 0.0875 moles per liter

Problem 2: *Preferred Step 4*

4. Calculate the molarity of the NaI solution using the definition of molarity

$$\text{molarity } (M) = \frac{\text{moles of solute}}{\text{liter of solution}}$$

$$= \frac{0.0273 \text{ moles}}{0.312 \text{ L}}$$

= 0.0875 mol/L

The molarity of the NaI solution is 0.0875 moles per liter

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Problem 3

A 20.0 g sample of HF (hydrofluoric acid) is dissolved in enough water to give 200 mL of solution. Find the concentration (molarity) of the HF solution.

1. Find the molar mass of HF

element	# of atoms		molar mass*	total
H	1	x	1.0 g/mol	= 1.0
F	1	x	19.0 g/mol	= 19.0

$$= \frac{19.0}{20.0\ \text{g/mol}}$$

Molar mass of HF is 20g/mol

Problem 3

2. Find the number of moles in the HF solute

$$\text{moles(solute)} = \frac{\text{mass of solute}}{\text{molar mass of solute}}$$

$$= \frac{20.0\ \text{grams}}{20\ \text{grams per mole}}$$

$$= \frac{20.0\ \text{g}}{1} \times \frac{1\ \text{mol}}{20\ \text{g}}$$

$$= 1\ \text{mol of HF}$$

3. Convert the given milliliters to liters

200 mL = 0.2 L

Problem 3

4. Calculate the molarity of the HF solution

$$\text{molarity } (M) = \frac{\text{moles of solute}}{\text{liter of solution}}$$

$$= \frac{1\ \text{mol}}{0.2\ \text{L}}$$

$$= 5\ \text{mols/L}$$

The molarity of the HF solution is 5 moles per liter

Summary

- Set up equations to solve mixture and concentration problems
- Use mathematical techniques to solve the equations

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