Outline

- Solutions
- Factors Affecting Solubility
- Concentration Units
- Solution Stoichiometry

Solutions

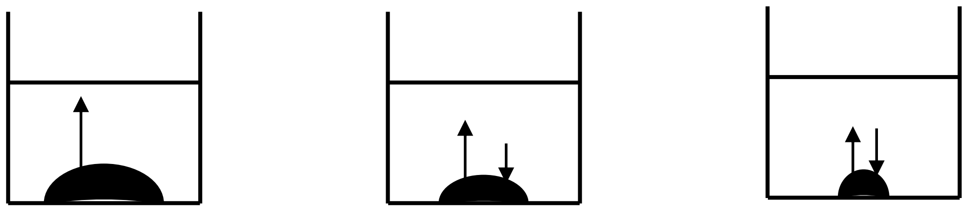
Solution	A homogeneous mixture
Solvent	The major component of the solution
Solute	The minor component of a solution

Solubility describes amount of solute that will dissolve in a solvent

Aqueous solutions are those in which water is the dissolving medium

- Ability of water to dissolve substances results from its unequal charge distribution

- "Charged ends" of water molecule interact with solute molecules (ions)



When the maximum amount of solute has been dissolved, the solution is saturated

Dissolving and crystallizing rates equal in a saturated solutions

If less than the maximum amount of solute is dissolved, the solution is undersaturated

If more than the maximum amount of solute is dissolved, the solution is supersaturated

Factors Affecting Solubility

1. Like Dissolve Like

    nonpolar substances dissolve in nonpolar substances

    polar / ionic substances dissolve in polar substances

2. Pressure

    No effect on solid and liquid solubility

    Increasing the pressure increases gas solubility

3. Temperature

    Increasing the temperature generally increases the solid's solubility

    Increasing the temperature decreases gas solubility

Concentration Units

Concentration is the amount of solute dissolved in a given quantity of solvent or solution

1. mass-mass percent, $$\% \, (m/m) = \frac{\text{g solute}}{\text{g solution}} \times 100$$

2. volume-volume percent, $$\% \, (v/v) = \frac{\text{mL solute}}{\text{mL solution}} \times 100$$

3. mass-volume percent, $$\% \, (m/v) = \frac{\text{g solute}}{\text{mL solution}} \times 100$$

What is concentration, % (m/m), of a sodium chloride solution made by dissolving 5.4 g NaCl in 75.0 g of water?

solute : 5.4 g NaCl

solvent : 75.0 g H_2O

solution : 5.4 g NaCl + 75.0 g H_2O

$$\%\,(m/m) = \frac{\text{g solute}}{\text{g solution}} \text{ x } 100$$

$$= \frac{5.4\text{ g}}{5.4\text{ g} + 75.0\text{ g}} \text{ x } 100 = \underline{6.7\,\%\,(m/m)\text{ NaCl}}$$

What is concentration, % (v/v), of an alcohol solution made by dissolving 15 mL alcohol in water, if the total volume is 375 mL?

solute : 15 mL alcohol

solvent : water

solution : 375 mL of alcohol and water

$$\% \text{ (v/v)} = \frac{\text{mL solute}}{\text{mL solution}} \times 100$$

$$= \frac{15 \text{ mL}}{375 \text{ mL}} \times 100 = \underline{4.0 \% \text{ (v/v) alcohol}}$$

How many grams of sodium hydroxide are present in 85 g of 15 % (m/m) NaOH solution?

$$85\text{ g solution x } \frac{15\text{ g NaOH}}{100\text{ g solution}} = \underline{13\text{ g NaOH}}$$

What masses of sodium hydroxide and water are needed to produce 355 g of 15 % (m/m) NaOH solution

$$355\text{ g solution x } \frac{15\text{ g NaOH}}{100\text{ g solution}} = \underline{53\text{ g NaOH}}$$

$$355\text{ g solution - 53 g NaOH} = \underline{302\text{ g } H_2O}$$

Percent represents parts-per-hundred (x 100)...

Parts-per-million (x 1,000,000), $\text{ppm (m/m)} = \dfrac{\text{g solute}}{\text{g solution}} \times 10^6$

<u>Molarity</u> (M) is the number of moles of solute per liter of solution

Determine the molarity of a 875 mL solution containing 14.5 g KBr.

$$14.5\ \text{g KBr} \times \frac{1\ \text{mol KBr}}{119.00\ \text{g KBr}} = 0.12\underline{1}8\ \text{mol KBr}$$

$$M = \frac{\text{mol solute}}{\text{L solution}} = \frac{0.12\underline{1}8\ \text{mol KBr}}{0.875\ \text{L}} = \underline{0.139\ \text{M KBr}}$$

A 40.00 % (m/m) aqueous solution of formic acid (CH_2O_2) has a density of 1.098 g/mL. What is the molarity of this solution?

$$100\text{ g solution} \times \frac{1\text{ mL}}{1.098\text{ g solution}} \times \frac{1\text{ L}}{1000\text{ mL}} = 0.09107\text{ L}$$

$$100\text{ g solution} \times \frac{40.00\text{ g } CH_2O_2}{100\text{ g solution}} = 40.00\text{ g } CH_2O_2$$

$$40.00\text{ g } CH_2O_2 \times \frac{1\text{ mol } CH_2O_2}{46.03\text{ g } CH_2O_2} = 0.8690\text{ mol } CH_2O_2$$

$$\frac{0.8690\text{ mol } CH_2O_2}{0.09107\text{ L}} = \underline{9.542\text{ M}}$$

What is the mass-mass percent of a 18.0 M H_2SO_4 solution, given that its density is 1.84 g/mL?

$$1\ \text{L} \times \frac{1000\ \text{mL}}{1\ \text{L}} \times \frac{1.84\ \text{g}}{\text{mL}} = 1840\ \text{g solution}$$

$$1\ \text{L} \times \frac{18.0\ \text{mol}\ H_2SO_4}{1\ \text{L}} = 18.0\ \text{mol}\ H_2SO_4$$

$$18.0\ \text{mol}\ H_2SO_4 \times \frac{98.08\ \text{g}\ H_2SO_4}{1\ \text{mol}} = 17\underline{6}5\ \text{g}\ H_2SO_4$$

$$\frac{17\underline{6}5\ \text{g}\ H_2SO_4}{1840\ \text{g solution}} \times 100 = \underline{95.9\ \%\ (\text{m/m})}$$

Solution Stoichiometry

Dilution is when more solvent is added to lower the concentration of the solution

number of moles of solute does not change

$$\text{moles solute (conc.)} = \text{moles solute (diluted)}$$

$$M_c \times V_c = M_d \times V_d$$

What's molarity of solution prepared by mixing 65 mL of 0.95 M HNO_3 with 135 mL of water?

$$M_d = \frac{M_c \times V_c}{V_d} = \frac{(0.95\,\text{M})(65\,\text{mL})}{(65\,\text{ml} + 135\,\text{mL})} = \underline{0.31\,\text{M}\,HNO_3}$$

Consider the following reaction…

$$3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \rightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$$

Calculate the volume of 0.25 M Na_3PO_4 needed to react with 15.0 mL of 0.50 M $Ca(NO_3)_2$.

$$15.0\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} \times \frac{0.50\ \text{M}\ Ca(NO_3)_2}{\text{L}} = 0.0075\ \text{mol}\ Ca(NO_3)_2$$

$$0.0075\ \text{mol}\ Ca(NO_3)_2 \times \frac{2\ Na_3PO_4}{3\ Ca(NO_3)_2} = 0.0050\ \text{mol}\ Na_3PO_4$$

$$0.0050\ \text{mol}\ Na_3PO_4 \times \frac{1\ \text{L}}{0.25\ \text{mol}\ Na_3PO_4} = \underline{0.020\ \text{L}}\quad (20\ \text{mL})$$

Consider the following reaction…

$$3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \rightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$$

How many grams of $Ca_3(PO_4)_2$ are produced from reaction of 25.0 mL of 0.50 M Na_3PO_4 with 25.0 mL of 0.50 M $Ca(NO_3)_2$?

$$0.0250\ \text{L} \times \frac{0.50\ \text{mol}\ Ca(NO_3)_2}{1\ \text{L}} = 0.01\underline{2}5\ \text{mol}\ Ca(NO_3)_2$$

$$0.0250\ \text{L} \times \frac{0.50\ \text{mol}\ Na_3PO_4}{1\ \text{L}} = 0.01\underline{2}5\ \text{mol}\ Na_3PO_4$$

Consider the following reaction…

$$3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \rightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$$

Problem Continued…

$$0.01\underline{2}5 \text{ mol } Ca(NO_3)_2 \text{ x } \frac{1 \text{ mol } Ca_3(PO_4)_2}{3 \text{ mol } Ca(NO_3)_2} = 0.004\underline{1}6 \text{ mol } Ca_3(PO_4)_2$$

$$0.01\underline{2}5 \text{ mol } Na_3PO_4 \text{ x } \frac{1 \text{ mol } Ca_3(PO_4)_2}{2 \text{ mol } Na_3PO_4} = 0.006\underline{2}5 \text{ mol } Ca_3(PO_4)_2$$

$$0.004\underline{1}6 \text{ mol } Ca_3(PO_4)_2 \text{ x } \frac{310.18 \text{ g } Ca_3(PO_4)_2}{1 \text{ mol}} = \underline{1.3 \text{ g } Ca_3(PO_4)_2}$$