Factors that Effect the Rate of Solvation

Rate of Solvation

there are three ways to increase collisions between the solvent and the solute.

agitating the mixture

increasing the surface area of the solute

increasing the temperature of the mixture

Factors that Effect Solubility

Effect of temperature

Gas in water

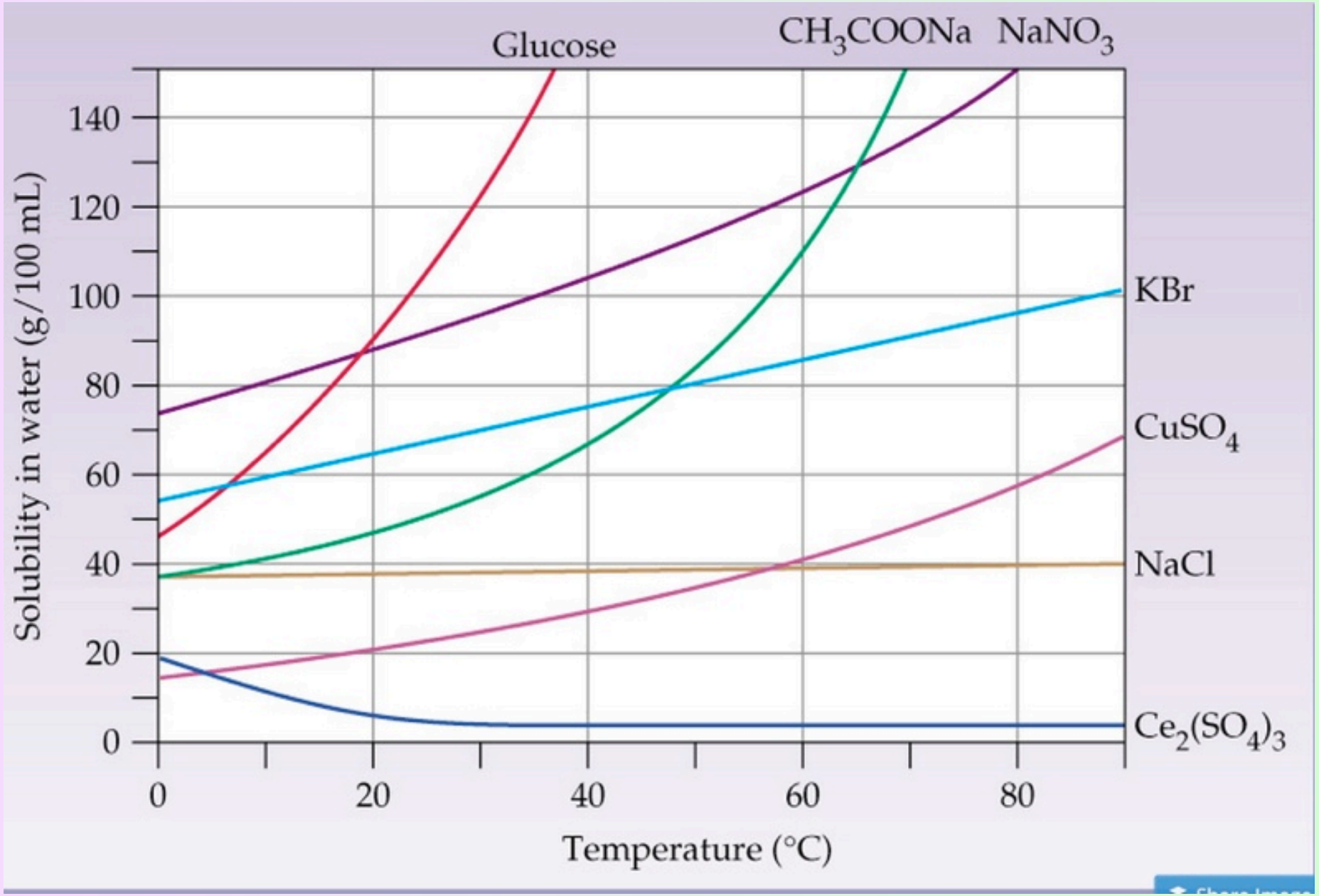
gases are almost always less soluble at higher temperatures than at lower temperatures

Solid in water

varies with substance

the solubility of some substances increases with temperature

the solubility of some substances decreases with temperature


Glucose
CH_3COONa
$NaNO_3$
KBr
$CuSO_4$
NaCl
$Ce_2(SO_4)_3$
Solubility in water (g/100 mL)
0
20
40
60
80
100
120
140
0
20
40
60
80
Temperature (°C)

Effect of temperature

The variation in solubility has some correlation with enthalpy of solution (ΔH_{soln})

If ΔH_{soln} is positive, the solubility increases with increases in temperature.

If ΔH_{soln} is negative, the solubility decreases with increases in temperature.

Effect of pressure

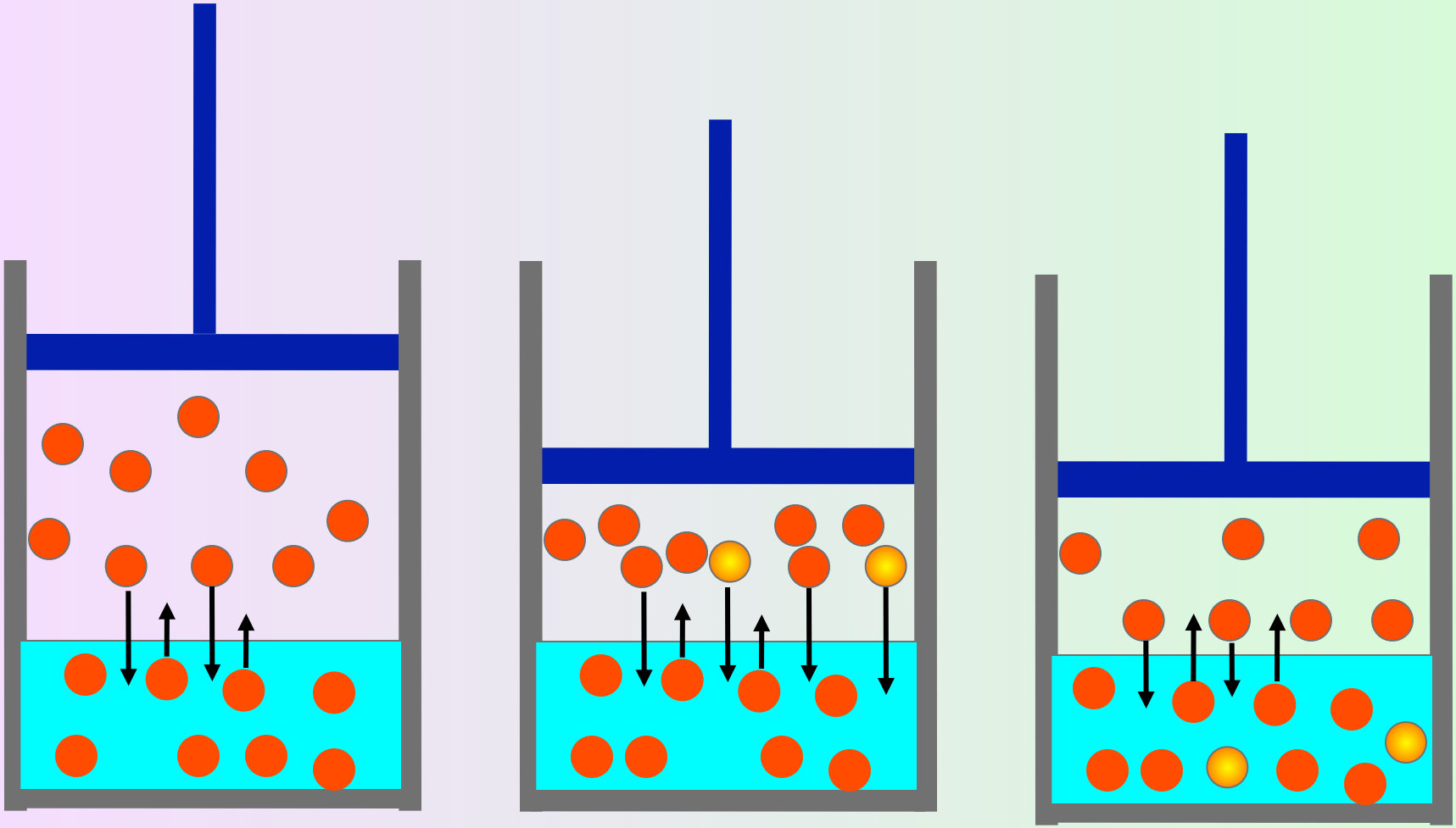
Pressure has little effect on solubility of solids or liquid in liquids

large effect on solubility of gas in liquid

Solubility of gas increases with increased pressure

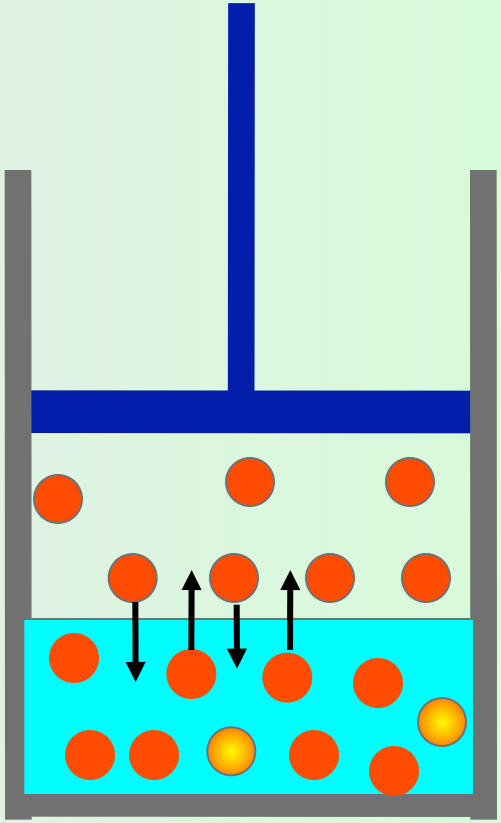
Example: carbonated beverages

Gas solubility versus Pressure



Gas solubility versus Pressure

more gas molecules are soluble at the higher pressure



Henry's Law

The amount of gas dissolved in a solution is directly proportional to the pressure of the gas above the solution.

$$S = k\,P$$

(holds only when there is no chemical reaction between the solute and the solvent)

Henry's Law

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$$S = k\,P$$

$$\frac{S}{P} = k$$

$$\frac{S_1}{P_1} = \frac{S_2}{P_2}$$

pg.461 problem 1

If 0.55 g of a gas dissolves in 1.0 L of water at 20.0 kPa of pressure, how much will dissolve at110.0 kPa of pressure?

$$\frac{0.55\ \text{g/L}}{20.0\ \text{kPa}} = \frac{S_2}{110.0\ \text{KPa}}$$

$$\frac{S_1}{P_1} = \frac{S_2}{P_2}$$

$$S_2 = \frac{(0.55\ \text{g/L})\ (110.0\ \cancel{\text{KPa}})}{(20.0\ \cancel{\text{kPa}})}$$

$$T_2 = 3.0\ \text{g/L}$$

Concentration units

Mole fraction **molarity** **molality**

Percentage by mass

Percentage by volume

Concentration

Percentage by mass

$$\text{Mass \%} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100\ \%$$

Determine the percentage by mass of 1.4g cane sugar in 50.0g of sugar syrup (sugar + water).

$$\text{Mass \% (sugar)} = \frac{1.4\ \text{g sugar}}{50.0\ \text{g (sugar + water)}} \times 100\ \%$$

$$= 2.8\ \%$$

pg.463 problem 9

You have 1500.0 g of a bleach solution. The percent by mass of the solute sodium hypochorite, NaOCl, is 3.62%. How many grams of NaOCl are in the solution?

$$\text{Mass \%} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100\ \%$$

$$3.62\% = \frac{\text{NaOCl g}}{1500.0\ \text{g}} \times 100\%$$

NaOCl g = 54.3 g

Concentration

Percentage by volume

$$\text{volume \%} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100\ \%$$

If you have 100.0 mL of 30.0% aqueous of ethanol, what volumes of ethanol and water are in the solution?

$$30.0\ \% = \frac{\text{mL ethanol}}{\text{100.0 mL (ethanol + water)}} \times 100\ \%$$

= 30.0 mL ethanol

100.0 mL - 30.0 mL

= 70.0 mL water

Concentration

Molarity (M)

moles of solute /1L of solution

What is the molarity of a solution made up by dissolving 9.52g of NaCl in enough H_2O to form 575 mL of solution?

$$M = n/L$$

$$9.52\text{g NaCl} \times \frac{1\text{ mol}}{58.4\text{g NaCl}} \times \frac{1}{575\text{ mL}} \times \frac{10^3\text{ mL}}{1\text{ L}}$$

$$= 0.284\text{ mol/L}$$

Important point about concentration

Given: Na_2SO_4 concentration = 0.683 M

What is the concentration of Na^+

What is the concentration of SO_4^{2-} ?

Na^+ = 2 x 0.683 M = 1.37 M

SO_4^{2-} = 0.683 M

pg.465 problem 14

What is the molarity of an aqueous solution containing 40.0 g of glucose ($C_6H_{12}O_6$) in 1.5 L of solution?

moles of solute /1L of solution

$$40.0\ \text{g}\ C_6H_{12}O_6 \times \frac{1\ \text{mol}\ C_6H_{12}O_6}{180\ \text{g}\ C_6H_{12}O_6} \times \frac{1}{1.5\ \text{L}}$$

= 0.128 mol/L

Concentration

Molality (m)

Moles of solute /kg solvent

Determine the molality of a solution made by adding 0.345 mol of C_2H_5OH to 168 g of H_2O

$$m = n_{sol} / (\text{kg solv})$$

$$m = \frac{0.345 \text{ mol } C_2H_5OH}{168 \text{ g } H_2O} \times \frac{10^3 \text{ g}}{1 \text{ kg}}$$

$$= 2.05 \text{ mol / kg}$$

pg.469 problem 25

What is the molality of a solution containing 30.0 g of naphaline ($C_{10}H_8$) dissolved in 500.0 g of toluene (C_7H_8)?

moles of solute /kg of solvent

$$\frac{30.0\ \text{g}\ C_{10}H_8}{500.0\ \text{g}\ C_7H_8} \times \frac{1\ \text{mol}\ C_{10}H_8}{128\ \text{g}\ C_{10}H_8} \times \frac{1000\ \text{g}}{1\ \text{kg}}$$

= 0.468 mol/kg

Concentration

Mole fraction (X_n)

Moles of substance / total moles of all materials

Mole fraction

moles of solute

$$X_A = \frac{n_A}{n_A + n_B + n_C \ldots}$$

total moles

Example

Calculate the mole fractions of benzene (X_B) and of toluene (X_T) in mixture of 0.884 mol of benzene and 1.657 mol of toluene.

$$X_B = \frac{n_B}{n_B + n_T} = \frac{0.884\ \text{mol}}{0.884\ \text{mol} + 1.657\ \text{mol}} = 0.348$$

$$X_T = \frac{n_T}{n_B + n_T} = \frac{1.657\ \text{mol}}{0.884\ \text{mol} + 1.657\ \text{mol}} = 0.652$$

Dilution of solutions

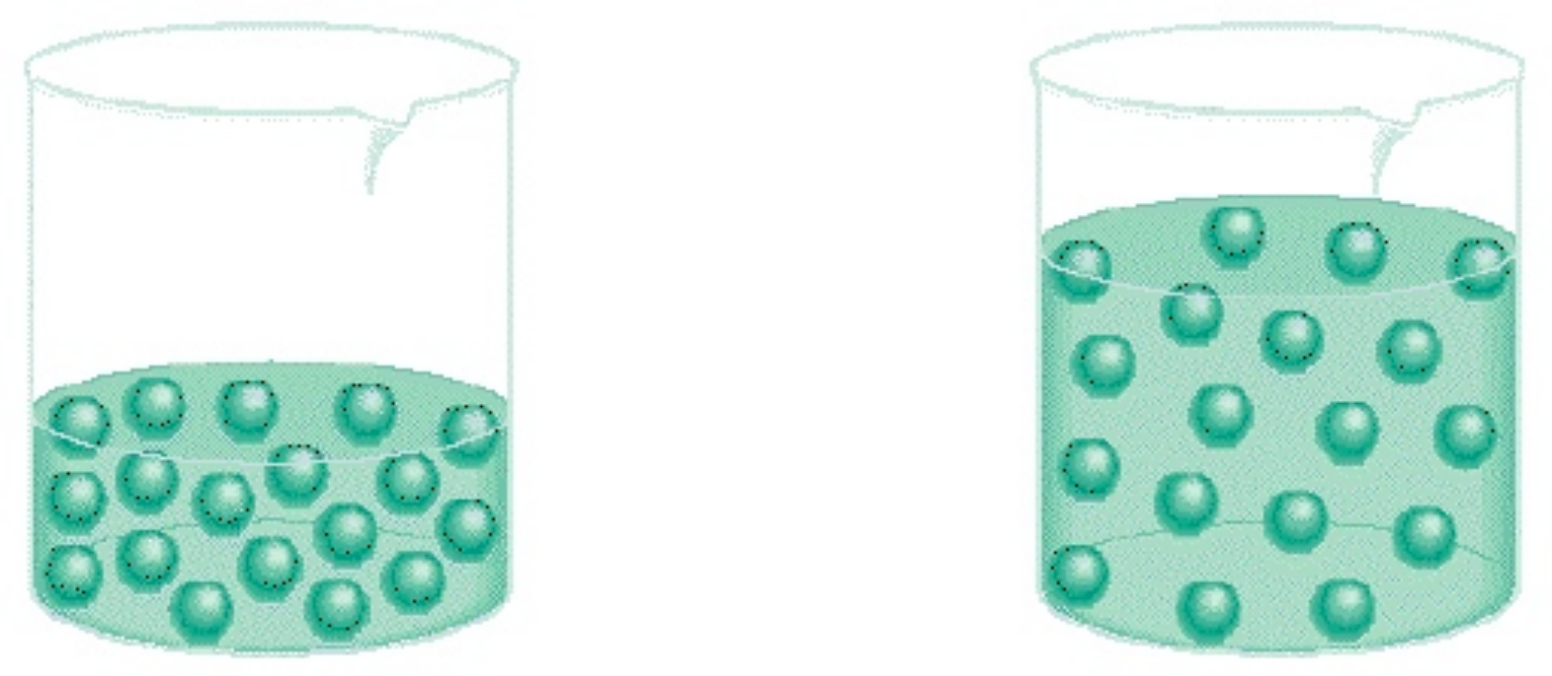
Dilution of solutions

Preparation of a less concentrated solution from a more concentrated one

$$M_{initial} \times V_{initial} = M_{final} \times V_{final}$$

$$\frac{mol_{(solute)}}{\cancel{L}} \times \cancel{L} = \frac{mol_{(solute)}}{\cancel{L}} \times \cancel{L}$$

$$\text{Moles of solute}_{initial} = \text{Moles of solute}_{final}$$



The dilution of a more concentrated solution to a less concentrated one does not change the number of moles of solute

Dilution of solutions

How much concentrated HCl (12.5 M) is required in order to prepare 1 L of a 1 M solution?

$$M_{initial} \times V_{initial} = M_{final} \times V_{final}$$

$$(12.5 \text{ mol / L}) V_{initial} = (1 \text{ mol / L})(1 \text{ L})$$

$$V_{initial} = \frac{(1 \text{ mol / L})(1 \text{ L})}{12.5 \text{ mol / L}}$$

$$V_{initial} = 0.080 \text{ L} = 80 \text{ ml}$$

pg.468 problem 22

How many milliliters of a 5.0 M H_2SO_4 stock solution would you need to prepare 100.0 ml of 0.25M H_2SO_4 .

$$M_{initial} \times V_{initial} = M_{final} \times V_{final}$$

$$(5.0\ M\ H_2SO_4)\ (V_{initial}) = (0.25\ M\ H_2SO_4)(0.1000\ L)$$

$$(V_{initial}) = \frac{(0.25\ M\ H_2SO_4)(0.1000\ L)}{(5.0\ M\ H_2SO_4)}$$

$$= 0.0050\ L \times \frac{1000\ ml}{1\ L} = 5.0\ mL$$