Chemistry 11 - Week 2: April 20 – 24

Anticipated time required: 3 hours

New learning objective: **solving concentrations and dilutions of solutions**

Goals to be completed:

1. Review how to solve multi step mole conversions
2. Review how to solve molarity problems
3. **New this week**: Applying the concept of molarity to practical applications such as creating diluted solutions from more concentrated stock solutions

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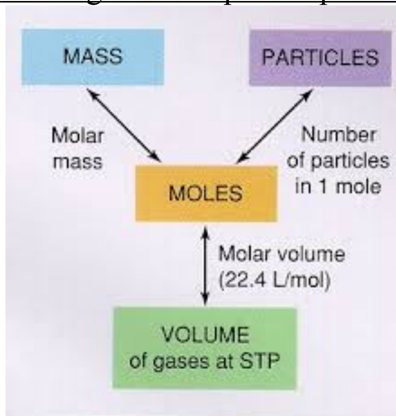
This PDF package contains several notes, examples and practice problems. The only formal portion that you are required to submit is the section titled "Formal Assignment to be Submitted". This can be sent to Charlie.feht@yesnet.yk.ca either as a scanned and uploaded PDF attachment to email, or as a jpeg image file. Midterm assignments will be scored and sent back to you as I receive them.

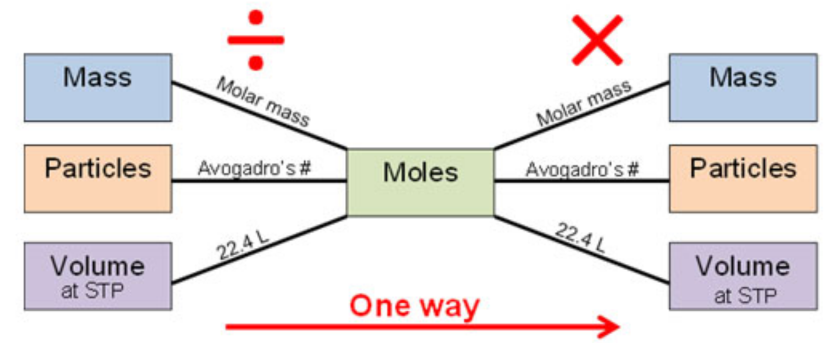
Upcoming next week:

Percent Composition and Empirical Formula of Compounds

Section 1: Solving multi-step mole problems review



Recall from the images above and below, that we are aware of three ways to solve mole related problems right now. Molar mass will vary depending on the type of molecule you have, avagadro's number (6.02×10^{23}) will solve number of particles, and 22.4L/mol will help us to solve a gas at STP (standard temperature and pressure).



Sample problem #1

What volume of H_2O gas at STP can be evaporated from 50g of liquid water?

Solution #1

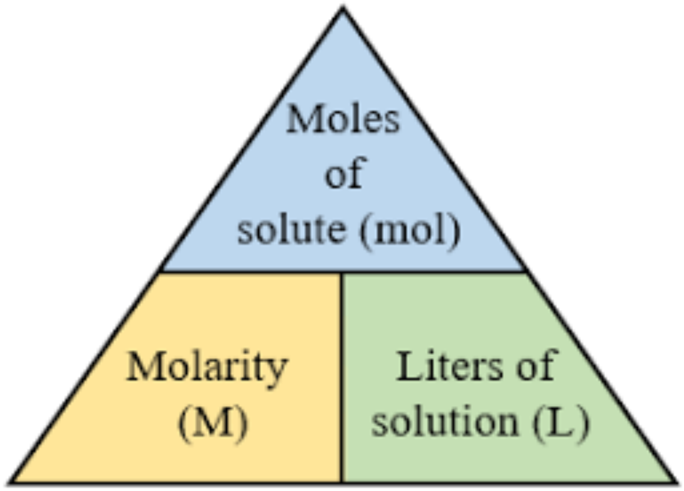
$$\frac{50\text{g H2O}}{1} \times \frac{1\text{ mol H2O}}{18g\text{ H2O}} \times \frac{22.4L\text{ H2O}}{1\text{ mol H2O}} = 62\text{ L } H_2O$$

Here we can see that the units "g H_2O" and "mol H_2O" cancel each other out, leaving us with our desired units of L H_2O. Simply multiple all of the numerators across the top (50 x 1 x 22.4 = 1120) and all the denominators along the bottom (1 x 18 x 1 = 18). Then divide the two to get your final answer (1120/18 = 62.2 ….round for sigfigs).

Helpful youtube video for further clarification:

https://www.youtube.com/watch?v=LSZhlNB94DA

Section 2: Solving Molarity Problems Review



We have used molarity in previous lessons to solve the concentration of a substance. Molarity is defined as the amount moles of a solute dissolved in a specific volume of solvent to form a specifically concentrated solution.

Concentration of solutions can be represented in several ways:

1. Concentration; C
2. Molarity; M
3. Units; mol/L
4. Square brackets; []
5. "Molar"

The formula for molarity contains three variables. Therefore, as long as we know two of them, we can manipulate the formula to solve the remaining variable.

Ex 1. M = mol/L
Ex 2. Mol = M x L
Ex 3. L = mol/M

Sample Problem # 2

For a lab you are required to prepare 300 ml of 0.5 M calcium chloride solution. How many grams of calcium chloride do you need in order to prepare this solution?

Solution #2

What we know: Volume of 300ml corresponds to 0.3L, required concentration of [0.5] $CaCl_2$
Need to solve: number of moles

Step 1. Use the formula mol = M x L to solve how many moles of $CaCl_2$ are required

$$mol = [0.5] \times 0.3\ L$$
$$mol = 0.15\ mol\ of\ CaCl_2$$

Step 2. Solve the specific mass using the molar mass formula for $CaCl_2$

Molar mass of $CaCl_2$ = 40 g/mol (Calcium) + 2 x 35.5 g/mol (two Chlorines) = 111 g/mol

Step 3. Solve the specific mass required for this solution.

$$0.15\ mol\ CaCl_2 \times 111 g/mol\ CaCl_2 = 16.65\ g\ CaCl_2$$

Play around with the following simulation to see how volume and solute can impact concentration:

https://phet.colorado.edu/sims/html/concentration/latest/concentration_en.html

Review practice problems (answers to be posted Thursday):

1. How many molecules of carbon dioxide are present in 15 litres of gas at STP?

2. How many atoms of hydrogen are present in 15 g of NH_3?

3. If you have 13 moles of NaCl and want to use all of it to prepare a 0.25 M solution, how much water do you need as your solvent?

4. What is the concentration of a solution that has 50g of $CuSO_4$ dissolved in 250 ml of water?

5. How many grams of Iodine are required to prepare a 500 ml, 0.2 molar solution?

Section 3: Dilutions

Introduction video:

https://www.youtube.com/watch?v=QYK3Aj-IUIs

Diluting Solutions

Experiments often require a solution that is more dilute than what is on hand in the stockroom. In this case, a more concentrated stock solution must be diluted to obtain the desired concentration. To carry out a dilution, the following equation is used:
$\text{Molarity}_{\text{concentrated soln}} \text{ X volume}_{\text{concentrated soln}} = \text{Molarity}_{\text{dilute soln}} \text{ X volume}_{\text{dilute soln}}$

In this equation, $\text{Molarity}_{\text{concentrated soln}}$ is the concentration of the stock solution, $\text{volume}_{\text{concentrated soln}}$ is the volume of the stock solution required to prepare the dilute solution, $\text{Molarity}_{\text{dilute soln}}$ is the concentration of the desired dilute solution, and $\text{volume}_{\text{dilute soln}}$ is the volume of the dilute solution needed. The dilution equation is commonly written as shown in Equation 2. The subscripts 1 and 2 refer to the concentrated solution and the dilute solution, respectively.

$$M_1V_1=M_2V_2 \qquad \text{Equation 2}$$

This equation is derived from the idea that Molarity is given as mol/L, or M =n/L, but when rearranged, the formula appears as n = M x L. This means that the moles present is determined by the concentration multiplied by the volume. The number of moles present will never change, only the volume and concentration will change. So if the initial amount of moles must equal the final amount of moles, then n_1 (initial stock) = n_2 (final dilute).

When we substitute Molarity x Litres in for n, we get: $M_1V_1=M_2V_2$

For example, assume that the 0.80M sodium chloride solution prepared in the example above is in the stockroom, but for another experiment, 100mL of a 0.20M sodium chloride solution is needed. In performing a dilution calculation, M_1, M_2, and V_2 are generally known and Equation 2 is rearranged to solve for the unknown V_1. Substituting the known values for this example into Equation 2 allows us to solve for the volume of the concentrated solution required to prepare the dilute solution.

$$V_1=\frac{M_2V_2}{M_1} \qquad V_1=\frac{0.20M * 100mL}{0.80M} = V_1=25mL$$

The following video summarizes how this is done:

https://www.youtube.com/watch?v=MG86IFZi_XM

FYI: Often times you may see the equation $M_1V_1=M_2V_2$ written as $C_1V_1=C_2V_2$ These two equations are synonymous and represent the exact same thing, one just uses the M variable for molarity, the other uses the C variable for concentration

Sample problem #3

You have a stock solution of [18] HCl. For a lab that you are about to perform, you only require 50 ml of 6 Molar HCl. How much HCl from the stock solution is reuired?

Solution #3

What we know:

→initial concentrated stock solution = 18 Molar	M_1 value
→final dilute solution concentration = 6 Molar	M_2 value
→Final dilute solution volume = 50 ml	V_2 value

Missing:

→ initial volume required of HCl…. V_1

Step 1. Substitute known value into equation $M_1V_1=M_2V_2$

$$18 \times V_1 = 6 \times 0.050L$$

Step 2. Rearrange to solve for V_1

$$V_1=\frac{M_2V_2}{M_1} \qquad V_1=\frac{6M * 0.050L}{18M} \qquad = V_1= 0.01666\ L = 16.7\ ml \text{ of stock solution required}$$

Question: If the final solution needs to be 50 ml, but we only take 16.7 ml of the stock solution, where does the difference come from?

Answer: The 16.7 ml of 18M solution is diluted to 6 M solution by adding 33.3 ml of water, thus reaching our final volume of 50 ml.

Sample problem #4

If I add 25 ml of water to 125 ml of 0.15 M NaOH solution, what will the molarity of the dilute solution be?

Solution #4

V_2 value is the final volume, so when 25 ml is added to 125 ml, the final volume becomes 150 ml

$$M_1V_1=M_2V_2$$

$$0.15\ M \times 0.125\ L = M_2 \times 0.150\ L$$

$$\frac{0.15\ M \times 0.125\ L}{0.150\ L} = M_2$$

$$0.125\ M = M_2$$

The final concentration of the dilute solution is 0.125 M

This video is a helpful tutorial on dilutions: https://www.youtube.com/watch?v=v6dnEp58mVk

Practice Problems on Dilutions – Not for Marks

Chemistry 11

Name:

Molarity/Dilutions Worksheet

Date:

1. **Molarity Problems** – Find the missing value.

Chemical	*Mass*	*Volume*	*Molarity*
(a) Na_2SO_4	16.0g	50.0mL	____
(b) HCl	143.28g	____	4.25M
(c) $Pb(NO_3)_2$	____	150.0mL	3.00M

2. Dilution Problems

(a) 110.0mL of 3.00M sulfuric acid has 25.0mL of water added to it. What is the resulting concentration of the solution?

(b) How much water must be added to 50.0mL sample of 18.0M nitric acid to give a resulting concentration of 0.250M?

(c) Barium nitrate is purchased as a 17.0M concentration. Explain how you would prepare 500.0mL of a 5.00M solution.

(d) If 25.0mL of 4.0M HNO_3 solution is diluted to a volume of 600.0mL, what will be the molarity of the diluted solution?

(e) What initial volume of 18M hydrochloric acid is required to make 2.0L of 0.50M hydrochloric acid solution?

(f) 250.0mL of 0.20M phosphoric acid is added to 1.00L of water. What is the molarity of the resulting solution?

Formal Assignment to be Submitted

1. If 20 ml of 0.75 M HBr is diluted to a total volume of 90.0 ml, what is the molar concentration of the HBr in the resulting solution?

2. Concentrated HNO_3 is 15.4 M. How would you prepare 2.50 L of 0.375 M HNO_3?

3. A 400 ml solution contains 35 g of LiOH. It is then diluted with 250 ml of water. What is the resulting concentration?

4. A 750 ml solution of NaCl with unknown molarity is diluted down to create a 2L batch of new solution. The new solution is tested and has its molarity determined to be 1.2 M. What was the initial concentration of the NaCl solution?

5. You are trying to prepare a standard 0.5 M solution of HCl, from a 12 M stock solution. If you have 750 ml of stock solution and plan to use all of it, how much water do you need to add to properly dilute the stock to the desired concentration?

Challenge Questions! (Still part of the assignment)

1. If 0.5 M NaCl in a 250 ml bottle is mixed with 1.2 L of 0.9 M NaCl. What is the resulting amount and concentration of the new NaCl solution?

2. If 300 ml of solution A contains 25 g of KCl and 250 ml of solution B contains 60 g of KCl, what is the molarity of the KCl solution resulting from mixing solutions A and B?