Molarity

Molarity (M) is a unit of concentration used when making up aqueous solutions of chemicals. M means one mole per liter or mole/liter.

<u>Molarity of solutions</u>

Since chemical reactions occur according to mole ratios, molarity is usually used to express the concentration of solutions.

To find molarity of a solution:

1. Express the volume in liters
2. Convert any amounts in grams into moles
3. Then use:

$$M = \frac{\text{moles solute}}{\text{Liters of solution}}$$

Example:

How would you find the molarity of a solution with a volume of 300ml that contains 25g of KOH?

1. 300 ml = .3 liters
2. 25 g KOH = 25g/56.1g = .44 moles
3. Molarity = .44moles/.3 liters = 1.46M

What is the molarity of a solution in which 25.0 grams of NaCl is dissolved in 100.0 mL of water?

Dilution Problems

Suppose that you have 350 mL of a .2M solution of KNO_3. What would the concentration become if 100mL of water was added?

Use molarity equation $$M = \frac{\text{moles solute}}{\text{Liters of solution}}$$

2.0 = x/.350

X = .7 moles KNO_3

So there must also be .7 moles in the final solution. Adding water does not alter the amount of KNO_3 in the soulution!

Now use molarity equation for your final solultion

$$M = \frac{\text{moles solute}}{\text{Liters of solution}}$$

X = .7moles/.450 liters

= 1.55 M

The .450 liters is from 350 mL of original solution plus 100 mL of water we added.

Example:

Suppose that you have 300 mL of a .25M solution of HNO_3. What would the concentration of this solution be if 150 mL of water were added to it?

Quite often we may need to dilute a concentrated acid to make a more dilute solution. These problems are similar to the last example. Just remember **adding water to a solution does not alter the amount of solute in the solution.**

We want to end up with 250 mL of a .05M solution of HCl. How much 12M HCl would be needed to prepare 250 mL of a .05 M solution?

1. Use molarity equation for the solution you want to make

   $$M = \frac{\text{moles solute}}{\text{Liters of solution}}$$ .05 = x/.250

   X= .0125 moles

   So we need .0125 moles of HCl

2. Now use molarity equation for your starting HCl solution

   $$M = \frac{\text{moles solute}}{\text{Liters of solution}}$$ 12=.0125/x

   X= .001 liters or 1mL

These problems can also be set up as:

$M_1 \times V_1 = M_2 \times V_2$

M_1 = is the most concentrated molarity

V_1 = is the volume of the most concentrated species

M_2 = is the dilute concentration

V_2 = is the TOTAL volume. It includes V_1 AND the water needed for dilution.

To find the volume of water needed in a dilution, simply subtract V_1 from V_2.

Example:

How would you prepare 100.0 mL of 0.10 M NaOH from 0.50 M NaOH

(0.50 M) (X mL) = (0.10M) (100.0 mL)

X = 20mL NaOH with 80.0 mL of water

Practice Problems

1. What is the molarity of a solution if 15.0 grams of NaOH are dissolved in 1400 mL of solution.

2. What is the molarity of a solution containing 5.00 grams of NaCl in 150.0 mL of solution?

3. How many grams of $HgCl_2$ are needed to prepare 200.0 mL of 0.450 M solution?

4. How many milliliters of a 0.050 M solution can be prepared form 16.5 g of NaCl?

5. How many grams of $Ca(OH)_2$ are needed to prepare 300.0 mL of a 0.115 M solution?

6. How many milliliters of a 0.650 M solution can be prepared from 5.12 grams of $Mg(OH)_2$?

7. How many moles of solute are in 250.0 mL of a 0.500 M solution?

8. What is the molarity of a solution containing 5.00 grams of NaCl in 150.0 mL of solution?

9. 2.0 moles of salt are diluted in 5.0 L of solution. What is the molarity of the solution?

10. What is the final volume of 2.0 L of a 1.0 M solution that has been diluted to a concentration of 0.10 M?

11. How much water must be added to 20.0 mL of a 1.0 M solution to make a 0.10 M solution?

What's the Concentration of Kool-Aid???

Purpose: Determine the concentration (molarity) of properly made Kool-Aid.

Method: Make three solutions of Kool-Aid with different concentrations and taste them to decide which is the correct concentration. <u>You will prepare 0.1 L of each of the following Kool-Aid solutions: 0.1 M, 0.4 M, and 0.7 M.</u>

Materials:

Kool-Aid Powder	Popsicle sticks (to stir solutions)
Water	Balance
Plastic cups	Ruler

Procedure:

1. Calculate how much solid Kool-Aid you will need to make 0.1 L of each solution. (**Hint 1: Kool-Aid is mostly sugar ($C_6H_{12}O_6$), so you can assume that the "molar mass" of Kool-Aid is the same as the molar mass of sugar.) (Hint 2: "What you know" is the volume – 0.1 L)**

Show all of your calculations below. *<u>Circle or box the answer for each part.</u>*

The "molar mass" of Kool-Aid:

Mass of Kool-Aid needed for 0.1 M solution:

Mass of Kool-Aid needed for 0.4 M solution:

Mass of Kool-Aid needed for 0.7 M solution:

2. Mark the 0.1 L mark on a plastic cup by measuring 3.5 cm from the bottom of the cup and drawing a line. (Usually we would use more accurate measuring techniques, but we can't drink out of lab equipment.)

3. Mass out the correct amount of solid Kool-Aid in each cup by putting your cup on the balance, setting the mass to zero, and putting the correct mass of Kool-Aid in the cup.

4. Add water to the cup until you have 0.1 L of solution (fill it up to the line you drew). Stir with a popsicle stick.

5. Observe and taste the solutions you have made. You can have one "designated taster" or you can pour a little into separate cups for each group member to taste. Record how each solution looked, smelled, and tasted:

Observations of the 0.1 M solution:

Observations of the 0.4 M solution:

Observations of the 0.7 M solution:

6. Compare the solutions, and decide which one is closest to the correct concentration. If you have extra time, you can try to make one more solution with the exactly perfect concentration based upon your observations.

7. Dump leftovers in the sink and throw away used cups.

<u>Questions:</u>

1. Which concentration that you tested was closest to the ideal concentration of Kool-Aid? What was wrong with each of the other solutions that you made?

2. How is taste related to concentration? Why are they related in this way?

Molarity

Information: Molarity

Concentration is a term that describes the amount of solute that is dissolved in a solution. Concentrated solutions contain a lot of dissolved solute, but dilute solutions contain only a little.

Questions

1. Consider the terms "concentrated" and "dilute". Are these qualitative or quantitative terms?

2. One way of quantitatively measuring solution concentration is with units of molarity, symbolized by M. You see 1.7 liters (L) of a sodium chloride and water solution. The label on the bottle reads "1.5 M NaCl". You don't know what molarity is, but you decide to find out. After evaporating the water out of the solution you discover that there are about 149 grams of salt. Using this information, which of the following formulas is/are correct for finding molarity?

   A) $\text{Molarity} = \dfrac{\text{grams of solute}}{\text{moles of solute}}$ B) $\text{Molarity} = \dfrac{\text{moles of solute}}{\text{liters of solution}}$

3. Using the equation you discovered in question two, calculate the molarity of each of the following solutions.
   A) A solution is prepared by dissolving 24.9 g of $CaCl_2$ in 210 mL (which 0.210 L) of solution.

   B) A solution contains 12.9 g of Na_2SO_4 in 325 mL of solution.

4. Verify that I need 2.15 moles of $Ca(NO_3)_2$ to make 358 mL of a 6.00 molar solution.

5. Verify that it takes 80.8 g of sodium chloride to make 425 mL of a 3.25 M solution.

6. Consider 670 mL of a 4.10 M solution of $Mg(NO_3)_2$ setting in a beaker. If you evaporate all 670 mL of the solution, how many grams of solute would be left in the beaker?

Disparities about your *molarities*?

When a substance (solute) is dissolved in a solvent, a solution is formed. A chemist often needs to know how much solute is present in a given volume of solution. In this activity you will learn how to determine the amount of solute that is dissolved in a given quantity of solvent by calculating the concentration of a solution.

VOCABULARY

Solute
Solution
Solvent
Concentrated
Concentration
Saturated
Dilute
Aqueous
Molarity

MODEL 1: What does concentration mean?

INFORMATION

The most common measure of concentration used by chemists is molarity (M). Molarity is defined as the number of moles of solute (mol) divided by the total volume (V) of the solution in liters (L).

Molarity = moles of solute per liter of solution (M = mol / L).

Molarity also is called molar concentration. When the symbol M is accompanied by a numerical value, it is read as "molar". For example, a solution labeled ***3.0M NaCl*** is read as "***three molar sodium chloride solution".***

EXCERCISES

1. In a problem, a student is given the amount of solute in grams and the volume of the solution in milliliters. What must be done with the information before the molarity can be calculated?

2. Calculate the molarity of a solution in which 0.50 moles of $MgCl_2$ are dissolved to produce 1.5 liters of solution.

3. Intravenous (IV) saline solutions are often administered to patients in the hospital. Normal saline solution contains 0.90g NaCl in exactly 100 ml of solution. Calculate the molarity of this solution.

4. Calculate the molarity of the following solutions.

a. 1.0 mole of $NaNO_3$ in 500 ml of H_2O

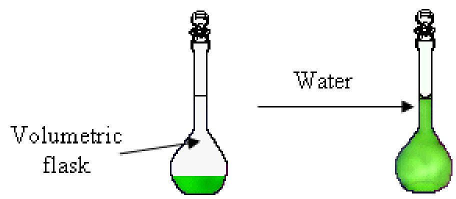
b. 85.0 g of $NaNO_3$ in 250. ml of H_2O

c. Which of the solutions, 4a or 4b, is more concentrated? Explain your answer.

MODEL 2

Part I- Demonstration and discussion:

When preparing one liter of a ***1.0 molar solution***, one should pour some solvent (water) into a 1.0 liter volumetric flask. The measured amount of solute (1.0 mole) is added to the volumetric flask. The flask is stirred to dissolve the solute, and the additional solvent is added to bring the volume to the 1.0 liter mark.



Part II- Demonstration and discussion:

Fill a 1.0 liter volumetric flask with water up to the 1.0 liter mark and then add measured amount of solute (1.0 mole).

KEY QUESTIONS

1. In demonstration 1, why is the solute added to some of the solvent and dissolved before solvent is added to bring the volume to the 1.0 liter mark on the volumetric flask?

2. Which of the solutions prepared in Model 2 contains one liter of solvent? Explain.

3. Which of the solutions prepared in this demonstration contains a 1.0 M solution? Explain your answer.

PROBLEMS

1. What volume of 0.25 M solution can be prepared using 0.50 mole of KCl?

2. What volume of 0.10 M solution can be prepared using 11.6 g of NaCl?

Activity: Comparing the molarities and densities of 4 Sucrose solutions

1. Label each flask with the following molarities: 0.0625 M, 0.125 M, 0.250 M, and 0.500 M. Then, determine the mass of each of the four 100mL volumetric flasks and record in the data table.

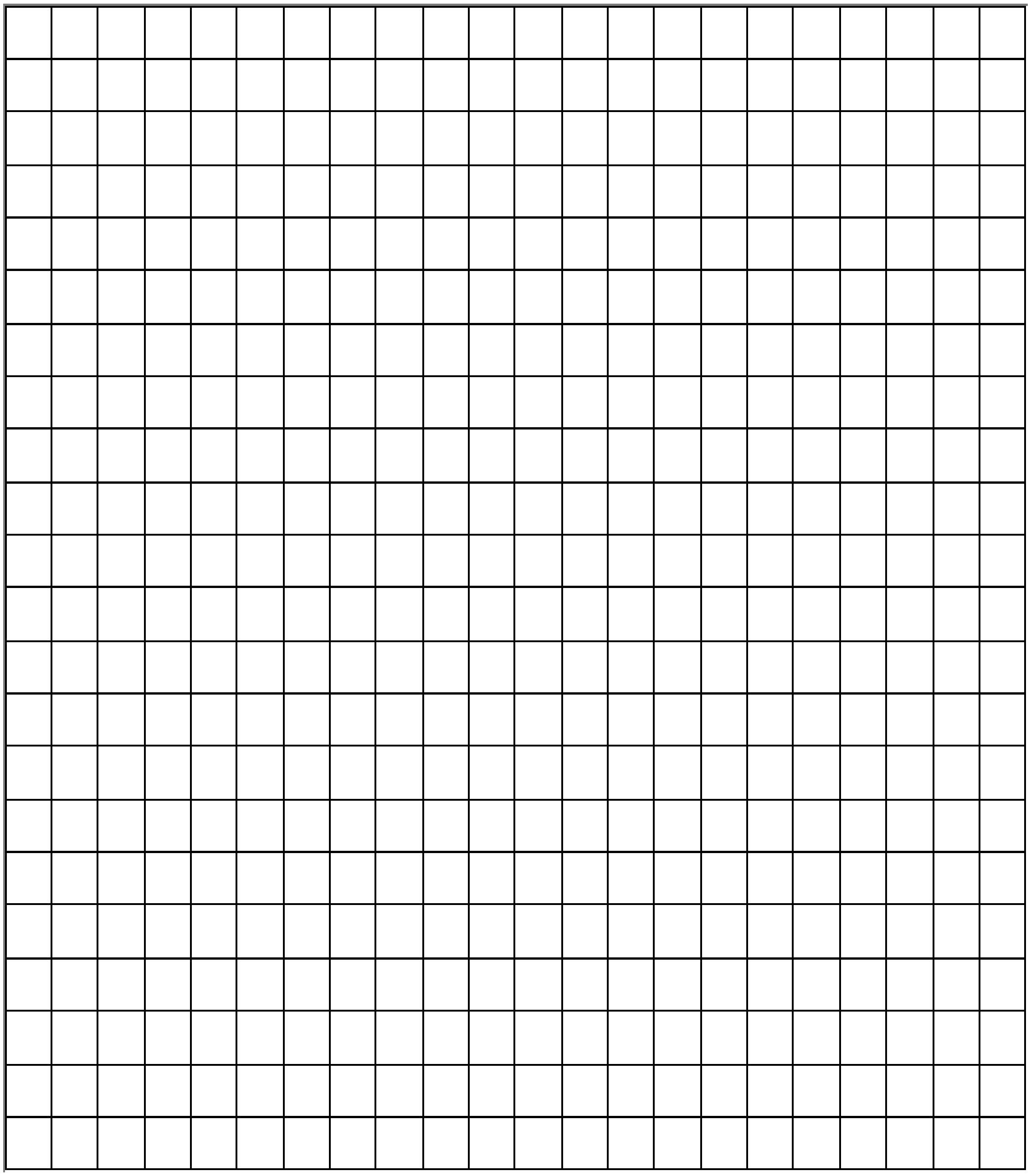
2. In each flask, prepare one of the following sucrose solutions: 0.0625 M, 0.125 M, 0.250 M, and 0.500 M.

Show your calculations in the space below!! Hint: You are making 100mL of each solution! Record massof sucrose needed in your data table.

3. Find the mass of your solution and flask. Then, determine the **mass** of your **solution**. Next, calculate the **density** of your **solution**. Record all data in the data table.

4. Prepare a graph of density versus concentration for sucrose using your data and your table's data. You must include the molarity and density of each solution. Also, *include the density of pure water on the graph, using the value 1.00g/ml.* Use the graph paper on the back of this page.

DATA TABLE					
Molarity	**Mass of sucrose needed**	**Mass of Flask**	**Mass of Flask and Solution**	**Mass of Solution**	**Density of Sucrose Solution**
0.0625 M					
0.125 M					
0.250 M					
0.500 M					



Name ____________________

THE DILUTIONAL DEBACLE PROBLEMS

1. Given a 12.00 *M* solution of HCl, how would you prepare 150 ml of a 1.0 *M* solution? Your answer should include how much hydrochloric acid is needed and how much water is needed.

2. Starting with a 18.0 *M* stock solution of sulfuric acid, how would you prepare 500.0 ml of 2.00 *M* solution? Your answer should include how much sulfuric acid is needed and how much water is needed.

3. Starting with 16 M stock solution of HNO_3, how would you prepare 225 ml of 0.50 M HNO_3?

4. Calculate the new molarity that results when 250 ml of water is added to each of the following solutions.

   a. 125 ml of 6.0 M HCl

   b. 750 ml of 1.0 M HNO_3

   c. 250 ml of 1.0 M $CuSO_4$

5. A chemistry student needs 125 ml of 0.15 M NaOH solution for her experiment, but the only solution available in the lab is 3.0 M NaOH. Describe how the student could prepare the solution she needs.

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7. How much water must be added to 500 ml of 0.20 M HCl to produce a 0.150 M solution of HCl? (Assume the volumes are additive.)

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6. Given the following molarities of the concentrated acids, determine how many ml of each concentrated acid would be required to prepare 225 ml of a 3.0 M solution of the acid.

12.0 M HCl

16.0 M HNO_3

18.0 M H_2SO_4

14.9 M H_3PO_4

Name ____________________
Hour______

The Solution Side of the Stoichiometric Shuffle

Procedure:

1. Write the **balanced equation** and the **net ionic equation** between aqueous lead(II) nitrate and aqueous potassium iodide.

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2. What, if any, precipitate will be formed? (use your solubility chart) ppt formed_________

3. Determine the amount of lead (II) nitrate needed to prepare 20 ml of a 0.2 *M* solution of lead (II) nitrate.

Mass $_{\text{lead (II) nitrate}}$ ________________

4. Determine the amount of potassium iodide needed to prepare 20 ml of a 0.1 *M* solution of potassium iodide.

Mass $_{\text{potassium iodide}}$ __________________

5. Using **stoichiometric calculations**, determine the amount of precipitate that could be formed(theoretical yield) from the 20 ml of lead (II) nitrate.

Mass $_{\text{Precipitate}}$ ______________________

6. Using **stoichiometric calculations**, determine the amount of precipitate that could be formed (theoretical yield) from the 20 ml of potassium iodide.

Mass $_{\text{Precipitate}}$ _______________________

7. What is the **limiting reacant**? LR __________

8. What is the **theoretical yield** of the precipitate? Yield of ppt __________

9. Prepare the two solutions making sure that the entire solute is dissolved.
10. Mix the two solutions in a 100 ml beaker.
11. Find the mass of a dry piece of filter paper.
12. Place the filter paper in a funnel and pour the solution into the funnel trapping the precipitate in the filter paper.
13. You may have to wash the inside of the beaker with distilled water to make sure all of the precipitate ends up in the filter paper.
14. **Carefully** pull out the filter paper and unfold so that the precipitate can dry overnight.
15. Weigh the filter paper and determine the mass of the precipitate. Determine the experimental error. **Show your work for the experimental error!!!**

Mass of filter paper ________________ Filter paper with precipitate ____________

Mass of precipitate _______________ Experimental Error _______________