Unit 4 Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Types of Reactions & Date \_\_\_\_\_\_\_\_\_\_\_\_ Block \_\_\_\_

Solution Stoichiometry

Unit 4B – Solution Stoich

### Knowledge/Understanding Goals:

* What concentration means
* Know how stoichiometry can be applied to solution reactions.

### Skills:

1. Calculate concentration as molarity or ppm/ppb
2. Be able to identify what type of reaction will occur between reactants.
3. Predict the products of a reaction and their phases.
4. Apply stoichiometry to predict amounts of reagents needed and products formed in solution reactions.

###  Notes:

Concentration: how much of something (solute) is dissolved in something else (solvent).

There are as many possible ways expressing concentration as there are units for measuring the amount of solute and solvent; any quantitative relationship between the two is a unit of concentration.



Which concentration unit you use depends on which quantities you can measure (or which quantities you are given), and on what kind of answer you need.

Ex: moles, grams, liters, etc.

Some common ways of expressing concentration include:

 Molarity (M): a unit of concentration equal to  or .

 Molarity is almost always the concentration unit used in chemistry labs, because it is most efficient to measure different volumes when you want a specific number of moles.

 Molality (m): a unit of concentration equal to  or .

 Molality is sometimes used in large-scale processes in industry, because it is difficult to measure very large volumes precisely, but it is easy to precisely measure the mass of the solvent in a tank (using a strain gauge attached to the tank supports), and then add a specific mass of solute.

 Molality is also used to calculate properties of the *solvent* (as opposed to properties of the solute), such as colligative properties.

**colligative properties** are properties of solutions that depend upon the ratio of the number of solute particles to the number of solvent molecules in a solution, and not on the type of chemical species present.

Ex: Changing vapor pressure, boiling and freezing temperature, and osmotic pressure.

 Mole Fraction (χ): a unit of concentration that relates the moles of one component to the total moles. For example, the mole fraction of substance “A” in a mixture would be:



 Mole fraction is used to relate properties of one component of a mixture to the properties of the bulk mixture, such as when relating the partial pressure of a gas to the total pressure of the mixture.

 Parts Per Million (ppm) and parts per billion (ppb): a unit of concentration that relates the parts (usually by mass) of one component to one million (106) or one billion (109) parts (also by mass) of the total mixture.

Parts per million and parts per billion are often used to describe the concentration of a contaminant or impurity that is present only in a trace amount. One example is the concentration (level) of arsenic in drinking water, which is required to be less than 10 ppb.

As mentioned above, there are many other ways of describing concentration. For example, solubility is often expressed in . For this unit, be able to identify what different concentration measurements represent (ie know your units) and be able to manipulate the concentration values as conversion factors.

**Calculating Concentrations**:

As dimensional analysis would suggest, you can express concentration by dividing the top unit (describing the solute) by the bottom unit (describing the solvent). For example, you would express the molarity of a solution made by dissolving 0.25 mol of CuSO4 in enough water to make a total volume of 500 mL (0.5 L) of solution as follows:



\*\*\*NOTES \*\*\*

Your volume must be in liters!

The volume represents liters of ***solution***, not solvent! (final volume, not volume added)

**Properly Making Solutions**

One of the most common laboratorial tasks is solution preparation. Make sure you are familiar with how to calculate how much solute to dissolve in a given solvent to acquire the desired concentration.

Ex: How many grams of barium acetate would be required to produce 300.0mL of a 0.500M solution?

Once you have calculated the appropriate amount (g or mL) of solute to use, there are certain steps you should take in the lab to make a solution of desired concentration accurately. We will demonstrate this in the lab. Write down the steps below and include illustrations.

 How to make a solution:

 1)

2)

3)

**Dilution Problems:**

A dilution problem is simply a conservation of matter problem; the moles of solute before dilution must equal the moles of solute after dilution.

Note that dimensional analysis tells us that molarity times volume equals moles of solute (MV=mol). So if the moles of solute must stay constant through a dilution, initial (stock) molarity times initial (stock) volume will be equal to final (dilute) volume times final (dilute) molarity:

M1V1 = M2V2

Ex: 20.0mL of 1.5M HCl is diluted to a final volume of 100.0mL with diH2O. What is the concentration of the final solution?

 Ex2: How much 0.45M NaOH stock solution would be required to make 200.0mL of a 0.05M NaOH solution?

You should follow the same procedural steps highlighted earlier to make dilute solutions, the only change being that quantitative transfer is inferred through the use of volumetric pipettes, whereas graduated cylinders should be rinsed quantitatively

**Solution Stoich Problems**

Solution stoich problems should be treated the same as any other stoich problem, with the only difference generally being that you must use the molarity and volume of a solution to figure out how many moles of reactant/product you have rather than using a mass and molar mass.

General Solution Stoich Problems

 **Precipitation:** Mixing two aqueous solutions to form a precipitate per the solubility

 rules.

 Ex: 400.0mL of a 0.6M solution of Na3PO4 is mixed with 1.0M Ca(C2H3O2)2 in excess. How

 much precipitate would be formed?

 **Neutralization:** Combining acidic and basic solutions together to form a salt and water.

 Ex: 100.0mL of 0.86M H2SO4 is combined with 150mL of 0.95M NaOH. How much water was formed?

 **Titrations:** Combining acidic and basic solutions together in exact molar ratios to form a completely neutral product. Utilized as a tool for calculating the unknown molarity of an acid solution.

If the problem requires a calculation of pH, you will need to calculate the moles of H+ ions or OH− ions added to the solution of unknown molarity from an acid/base of given concentration. (Covered later)

However, to identify the unknown concentration of an acid or a base, all you need to do is apply the concept of neutralization. If an acid and base have perfectly neutralized one another, the perfect molar ratio of each reactant has been mixed (no limiting reagent).

For example, if you titrated 25.0 mL of a NaOH base of unknown concentration (to make it neutral in pH) with 50.0 mL of 0.10 M H2SO4:

1. Determine the neutralization reaction occurring (balanced equation).
2. Calculate the moles of acid needed to get to neutral.
3. Knowing that many moles of acid were needed to react all of the base, how many moles of base must have been in the unknown solution?
4. Convert the moles of unknown base present into a concentration.

Ex 1: What is the concentration of 110mL of a H2SO4 solution if it took 34mL of 1.2M Ca(OH)2 to neutralize it?

Ex 2: A 130.0 mL sample of KOH is spilled on a countertop. If 45.0 mL of 0.50M HCl is needed to neutralize the spill, what was the concentration of the KOH solution?