**Stoichiometry Brown LeMay chapters 3 and part of 4**

**Lesson 1: The atom and determination of average atomic mass**

Brief History of Atom

Law of Conservation of Mass

Law of constant composition

Atomic theory

Atom as we know it:

What is meant by a “representative” atom of an element?

What I need to know:

Ins and Outs of Mass Spectrometer

What I need to know:

Summary of Atom Basics:

**Lesson 2: Composition Stoichiometry**

Introduction to Chemistry

Definition

Problem

Just how small is the atom?

Solution

Stoichiometry a “larger” mathematical model that allows us to unequivocally quantify what is happening at the “smaller” particle level

Mole

Based on

When do we have the same number of particles?

Different ways of expressing same Idea:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Particle | Example | Type of “molar mass” | Value of mass | Number of units in molar mass | Additional numbers (if applicable) |
| Atom | Ne |  |  |  |  |
| Molecule  | C2H4O2 |  |  |  |  |
| Formula unit  | Al2Cl3 |  |  |  |  |

Pictorial Representation

Understanding the relationship between moles, mass, and number of particles (and how to estimate without calculator)

Using factor label to show unit conversions in stoich—worth points on free response portion of exam!

231 g Ni comprise how many moles of Ni?

5.2 moles H2O contain how many grams of H­2­O

2.8 x 1019 atoms of He are contained in how many moles of He?

59.3 g CO2 contain how many grams of oxygen? How many atoms of carbon?

5.2 moles C2H6 contains how many atoms of hydrogen? Grams of carbon?

**Lesson 3: Percent composition, empirical formula, molecular formula and hydrates**

Percent Composition (mass composition) not atom composition ie LiF is not 50% Li and 50% Fluoride because there are 1 one of each

Determine the percent composition of magnesium phosphide

Limitations of percent composition and formula of a compound

Variety of applications most useful is determination of an empirical formula

Calculating an empirical formula from percent composition

What is the empirical formula of a compound that is 68.4% chromium and 31% oxygen?

We can deduce the molecular formula from an empirical formula, if the molar mass is given. (Because the mfm will always be a multiple of the efm.)

A compound containing only carbon, hydrogen, and oxygen is 63.16% carbon and 8.77% hydrogen. It has a molar mass of 114 g/mol. Determine the empirical and molecular formulas.

A classic application of percent composition and empirical formula is determining the amount of water in a hydrate. Using CuSO4.5H2O as an example, let’s get our requisite knowledge of “hydrates”

Lab technique in Chemistry: separation of a mixture

A hydrate has the following percent composition: 75.5% calcium chloride and 24.5% water. What is the formula?

5.00 gram sample of hydrated barium chloride, BaCl2 . *x*H2O, is heated leaving 4.26 grams anhydrous BaCl2. What is the value of *x*

Another estimation problem: A 5.00 g sample of a compound that is found to contain 2.28 g oxygen, 0.13 g hydrogen, and the rest nitrogen. How many grams of nitrogen would you expect to find in a 2.00 g sample of the compound?

(a) 2.0 g (b) 1.0 g (c) 0.5 g (D) .25 g

*(Activity 2: hydrate determination)*

**Lesson 4: Balancing chemical equations**

What are the general types of reactions we will study in AP chem?

Some tips on balancing equations:

“make the odd even”

\_\_\_\_Fe2O3 →\_\_\_\_ Fe + \_\_\_\_O2

 “Use fractions”

\_\_\_\_\_MgS2 + \_\_\_\_\_O2 → \_\_\_\_\_Mg2O3 + \_\_\_\_\_SO2

”MINOH”

\_\_\_\_\_H3PO4 + \_\_\_\_\_ Mg(OH)2 → \_\_\_\_\_ Mg3(PO4)2 + \_\_\_\_\_ H2O

Application of MINOH—save element alone for last!!!

\_\_\_\_CaO + Si → CaSi2 + SiO2

**Lesson 5: Reaction Stoichiometry**

What is the difference between composition stoich and reaction stoich?

Write the balanced equation for the formation of water. What are two different ways you could read this information?

Remember our original model of the mole!!!

3H2 + N2 → 2NH3

How many moles of ammonia will form from .350 moles of nitrogen reacting with *excess* hydrogen?

5.4 grams of hydrogen will react *completely* with how many moles of nitrogen?

6.7 grams of hydrogen will react *fully* with how many grams of nitrogen?

A 3.489 gram sample of a compound containing C, H, and O yields 7.832 g of carbon dioxide, and 1.922 grams of water upon full combustion. What is the simplest formula of the compound?

Limiting Reactant: sometimes we are given amounts of all the reactants, we must understand that once any of the reactants are gone—the reaction stops and no more product is formed. The objective is to find out which reactant LIMITS the amount of product formed.

Must compare equivalent amount of reactants

20 boys and 25 girls ? couples

Write equation to form couple

What is the LR? How much “product” if formed based on amount of LR? What is “excess reactant”? how much excess is left over?

Try a ham & pepperoni sandwich comparison (slices: 2 bread, 3 pepperoni, 1 ham)

Try the same with pictures

There are four things that you need to know regarding limiting reactant questions:

6 moles of Hydrogen gas and 4 moles of oxygen gas combine to form how much water?

Math:

Particulate level drawing:

5.6 grams of hydrogen and 33.6 grams of nitrogen are placed in a closed container at low temp and pressure. The formation of ammonia goes to completion. Determine: limiting reactant, grams of ammonia formed, grams of excess reactant consumed, grams of excess reactant left over.

Define theoretical yield, actual yield, and percent yield. What is relationship between percent yield and percent error?

In the above example, 26.5 grams of ammonia were actually recovered. What is the percent yield?

(activity 3-decompostion of NHCO3)

**Lesson 6: Reaction Stoichiometry con’t—particulate level representation**

Consider the following mixture of SO2(g) and O2(g).

If SO2 and O2 react to form SO3 draw a representation of the product mixture assuming the reaction goes to completion. What is the LR in the reaction? If 96.0 g of SO2 react with 32.0 g O2, what mass of product will form?

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Nitrogen gas (N2) and hydrogen gas (H2) react to form ammonia gas (NH3) consider the mix of nitrogen and hydrogen in a closed container. Assuming the reaction goes to completion, draw a representation of the product mixture. Write BCE that reflects your drawing

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The reaction of element X with element Y is represented in the following diagram. Write the equation that best describes the reaction

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Bonus: Atoms of three different elements are represented by O, □, and, ∆. Which compound is left over when three molecules of O∆ and three molecules of □□∆ react to form O□ ∆ and O∆∆

**Lesson 7: Mixtures and impure samples**

The label on a bottle of NaOH states the substance is 98.2% pure. If I need 45.2 g for an experiment, how many grams of NaOH do I actually have, and how many grams of impurities? How will this affect my results?

Phosphorus can be prepared from calcium phosphate by the following reaction:

2Ca3(PO4)2(s) + 6SiO2(s) + 10C(s) → 6CaSiO3(s) + P4(s) + 10 CO(g)

Phosphorite is a mineral that contains Ca3(PO4)2 plus other non-phosphorus—containing compounds. What is the maximum amount of P4 that can be produced from 1.0 kg of phosphorite if the sample is 75%Ca3(PO4)2 by mass? Assume an excess of the other reactants.

(come back after next lesson)

Why do I have to standardize solutions of some reactive substances, ie NaOH?

**Lesson 8: Solution stoichiometry**

Solutions (qualitative and conceptual)

Definitions:

Solute: part of mix that is dissolved (or if not an aqueous solution—part that is the least)

Solvent: part of mix that does dissolving (or if not an aqueous solution—part that is the most)

Homogenous: mixed equally

Heterogeneous: mixed unequally

Alloy: mix of two metals

Amalgam: mix of a metal with mercury

Saturation: solvent has dissolved maximum amount of solute—the addition of more

Solute will simply settle to the bottom of solution.

Solubility: a mathematical measure of saturation in grams of solute/ 100 grams of solvent

Concentration: ratio of solute to solvent (generally speaking—careful of units!!)

Molarity (M): moles of solute/L of soln

Density: grams solution/mL of solution (not technically a concentration per definition)

Titration: using a special piece of equipment, buret, in attempt to combine two solutions to a precise equivalence point (no limiting reactant)

Stock solution: A solution that has been made in advance for an experiment that everyone uses

Standardized solution: a solution that has its concentration verified by titration with stable substance of known concentration.

Write the dissolution equation for any ionic compound dissolving in water. Relate that to concentration of ions in solution if 1.0 mole of each of the following is placed in 600 mL of water.

NaCl→

PbI2 →

Ca3(PO4)2 →

What happens to a saturated/unsaturated solution’s concentration as it evaporates?

What is a dilution? What is changing and what stays the same? What are the implications of this?

**Lesson 9: Solution stoichiometry**

Solutions (quantitative)

What is the molarity of a solution that contains 34 grams of silver nitrate in a total volume of 55 mL?

How many moles are there in 46 mL of a 5.2 M solution of lithium chlorate?

What volume is needed to hold 6.3 moles of 3.2 M sodium chloride solution?

How do you prepare 50 mL 2.0M solution of HNO3 from a 18 M solution?

How many grams of solid sodium hydroxide are needed to neutralize 20.0 mL of 1.8M hydrochloric acid? (Products: sodium chloride and water) Error analysis if NaOH mass was off because of absorption of water.

A solution of ethanol (C2H5OH) in water is prepared by dissolving 75.0 mL of ethanol (density = 0.79g/cm3) in enough water to make 250.0 mL of solution. Calculate the concentration of sol’n.

When 25.0 mL of a solution of 0.200 M NaIO3 was added to acidified iodide ions, the iodine produced reacted with 20.3 mL of sodium thiosulfate (Na2S2O3). Calculate the concentration of sodium thiosulfate solution given the REDOX equations:

IO3- + 5I- + 6H+🡪 3I2 + 3H2O

I2 + 2 S2O32- 🡪 2I- + S4O62-

*(Activity 4: gravimetric analysis)*