###### Stoichiometry Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*AP Chemistry Lecture Outline*

**Chemical Equations**

In a reaction: AND

**Balancing Chemical Equations**

Hint: Start with most complicated substances first and leave simplest substances for last.

EX. Solid lithium reacts w/oxygen to form solid lithium oxide.

EX. Aqueous aluminum sulfate reacts w/aqueous calcium chloride to form a white

precipitate of calcium sulfate. The other compound remains in solution.

EX. Methane gas (CH4) reacts with oxygen to form carbon dioxide gas and water vapor.

EX. CaC2(s) + H2O(l) 🡪 C2H2(g) + CaO(s)

CaSi2 + SbI3 🡪 Si + Sb + CaI2

Al + CH3OH 🡪 Al(CH3O)3 + H2

C2H2(g) + O2(g) 🡪 CO2(g) + H2O(l)

C3H8 + O2 🡪 CO2 + H2O

C4H10 + O2 🡪 CO2 + H2O

Complete combustion of a hydrocarbon, or of a compound containing C, H, and O

(e.g., methanol, CH3OH) yields CO2 and H2O.

Another pattern of reactivity: alkali metal + water metal hydroxide + hydrogen gas

e.g.,

**Two (of the several) Types of Reactions**

combination (synthesis): simpler substances combine to form more complex substances

-- form:

EX. sodium + chlorine gas 🡪 sodium chloride

decomposition: complex substances are broken down into simpler ones

-- form:

EX. lithium chlorate 🡪 lithium chloride + oxygen

EX. water 🡪 hydrogen gas + oxygen gas

formula weight: the mass of all of the atoms in a chemical formula (unit is amu)

-- If the substance is a molecular substance (e.g., C3H8), then the term

molecular weight is also used.

molar mass: the mass of one mole of a substance (unit is usually grams)

-- recall that 1 mole of any substance = 6.02 x 1023 particles of that substance

EX. Find the molar mass and formula weight of ammonium phosphate.

percentage composition: the mass % of each element in a compound

-- equation:

EX. Find the percentage of oxygen, by mass, in calcium nitrate.

**Empirical Formula and Molecular Formula**

|  |  |  |
| --- | --- | --- |
| **Compound** | **Molecular Formula** | **Empirical**  **Formula** |
| glucose | C6H12O6 |  |
| propane | C3H8 |  |
| butane | C4H10 |  |
| naphthalene | C10H8 |  |
| sucrose | C12H22O11 |  |
| octane | C8H18 |  |

Finding an Empirical Formula from Experimental Data

1. Find # of g of each element.

2. Convert each g to mol.

3. Divide each “# of mol” by the smallest “# of mol.”

4. Use ratio to find formula.

EX. A ruthenium/sulfur compound is 67.7% Ru. Find its empirical formula.

EX. A sample of a compound contains 4.63 g lead, 1.25 g nitrogen, and 2.87 g oxygen.

Name the compound.

To find molecular formula… A. Find empirical formula.

B. Find molar mass of empirical formula.

C. Find n = mm molecular

mm empirical

D. Multiply all parts of empirical formula by n.

EX. A sample of a compound has 26.33 g nitrogen, 60.20 g oxygen, and molar mass

92 g. Find molecular formula.

**Hydrates and Anhydrous Salts**

anhydrous salt: an ionic compound (i.e., a salt) that attracts water molecules and forms weak

chemical bonds with them; symbolized by MN

“anhydrous” =

Same idea as with…

hydrate: an anhydrous salt with the water attached

-- symbolized by MN **.** ? H2O

Examples:

###### MN

**H2O**

**H2O**

**H2O**

**H2O**

**H2O**

**H2O**

###### MN

**H2O**

**H2O**

**H2O**

**H2O**

**H2O**

**H2O**

**HEAT**

**+**

Finding the Formula of a Hydrate 1. Find the # of g of MN and # of g of H2O.

2. Convert g to mol.

3. Divide each “# of mol” by the smallest “# of mol.”

4. Use the ratio to find the hydrate’s formula.

EX. Strontium chloride is an anhydrous salt beaker = 65.2 g

on which the following data were beaker + sample before heating = 187.9 g

collected. Find formula of hydrate. beaker + sample after heating = 138.2 g

**MOLE**

**(mol)**

Mass

**(g)**

Particle

**(at. or m’c)**

Volume

**(L or dm3)**

1 mol = 22.4 L

1 mol = 6.02 x 1023 particles

1 mol = molar mass (in g)

1 mol = 22.4 dm3

**Converting Between Various Units**

“Volume Island”: for gases only

1 mol @ STP = 22.4 L = 22.4 dm3

EX. What mass is 6.29 x 1024 m’cules

aluminum sulfate?

EX. At STP, how many g is 87.3 dm3 of nitrogen gas?

***When going from moles of one substance to moles of another,***

***use the coefficients from the balanced equation.***

**“Straight”**

**Stoichiometry**

Use coefficients from balanced equation

**SUBSTANCE “A”**

**SUBSTANCE “B”**

**Stoichiometry Island Diagram**

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**(mol)**

Mass

**(g)**

Particle

**(at. or m’c)**

Volume

**(L or dm3)**

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**(L or dm3)**

1 mol = 22.4 L

1 mol = 6.02 x 1023 particles

1 mol = molar mass (in g)

1 mol = 22.4 dm3

EX. How many moles oxygen will react with 16.8 moles sodium?

EX. At STP, how many molecules of oxygen react with 632 dm3 of butane (C4H10)?

EX. How many grams potassium will react with 465 grams nickel(II) phosphide?

**Limiting Reactants (a.k.a., Limiting Reagents)**

limiting reactant (LR): the reactant that runs out first

--

Any reactant you don’t run out of is an excess reactant (ER).

***How to Find the Limiting Reactant***

For the generic reaction RA + RB 🡪 P, assume that the amounts of RA

and RB are given. Should you use RA or RB in your calculations?

1. Calc. # of mol of RA and RB you have.

2. Divide by the respective coefficients in balanced equation.

3. Reactant having the smaller result is the LR.

EX. 2 H2(g) + O2(g) 🡪 2 H2O(g)

13 g H2 80. g O2 How many g H2O are formed?

EX. 2 Fe(s) + 3 Cl2(g) 🡪 2 FeCl3(s)

223 g Fe 179 L Cl2

At STP, what is the limiting reactant?

What mass of FeCl3 is produced?

**Theoretical Yield, Actual Yield, and Percent Yield**

The amount of product we get if the reaction is perfect is called the theoretical yield.

--

If we ACTUALLY DO the reaction and measure the actual yield, we will find that this amount

is less than the theoretical yield (i.e., % yield can never be > 100%).

EX. ZnS + O2 🡪 ZnO + SO2

100. g 100. g X g

Assume 81% yield.

EX. Automobile air bags inflate with nitrogen via the decomposition of sodium azide:

**2 NaN3(s) 🡪 3 N2(g) + 2 Na(s)**

At STP and a % yield of 85%, what mass sodium azide is needed to yield 74 L nitrogen?