Announcements

Monday, March 23, 2009

Exam 2 is next Monday, Mar 30

- Similar format to exam 1
- Ch 5 - Ch 9 (tonight's lecture's material)
- Study guide will be up tomorrow morning.
- Polyatomic ions need to be memorized (will be used in naming and writing formulas for compounds)

Question/review session: This Wednesday 6pm - 7pm in lab.

Practice for the exam:

- Polyatomic ion naming worksheet
- General naming worksheet
- Chemical equations worksheet
- Precipitation worksheet
- Mole conversions worksheet
- End-of-chapter problems (odd # answers in back of book)
- Rework MasteringChemistry tutorials and problems for practice
- Practice multiple choice exams from U of M

Lecture 7 post assignment due March 30. Lecture 8 pre assignment due April 6 (will be available next week).

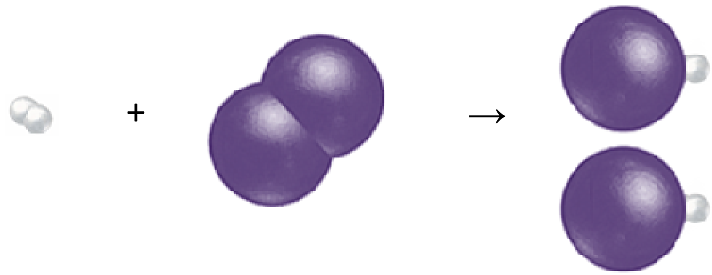
Exp 4 tonight, Exp 14 on Mar 30.

Disc assignment 2 will be in D2L tomorrow morning. You have 2 weeks to choose a topic.

Stoichiometry: study of mass and amounts in chemical reactions

What masses of H_2 and I_2 are required to make 10.0 g HI?

(1) H_2 + (1) I_2 → 2 HI



1 H_2 molecule + 1 I_2 molecule → 2 HI molecules

1 dozen H_2 molecules + 1 dozen I_2 molecules → 2 dozen HI molecules

1 mol H_2 + 1 mol I_2 → 2 mol HI

A **mole ratio** can be created with coefficients in balanced chemical equation

$$\frac{1 \text{ mol } H_2}{2 \text{ mol } HI} \qquad \frac{1 \text{ mol } H_2}{1 \text{ mol } I_2} \quad \text{etc.}$$

In the balanced chemical equation on the previous page, how many moles H_2 are required to form 5.3 mol HI?

$H_2 + I_2 \rightarrow 2HI$

$$5.3 \text{ mol HI} \times \frac{1 \text{ mol } H_2}{2 \text{ mol HI}} = 2.7 \text{ mol } H_2$$

mol ratio

$Cu + 2\ AgNO_3 \rightarrow 2\ Ag + Cu(NO_3)_2$

If 2.3 mol Cu react, how many mol $AgNO_3$ will react?

$$2.3 \text{ mol Cu} \times \frac{2 \text{ mol } AgNO_3}{1 \text{ mol Cu}} = 4.6 \text{ mol } AgNO_3$$

How many grams H_2 are required to form 10.0 g HI?

g → mol → mol → g

$(1) H_2 + I_2 \rightarrow 2\ HI$

? g H_2 ... 10.0 g HI

10.0 g HI ↓ molar mass HI 127.908 g/mol → mol HI

mol HI → mol H_2 (mole ratio from coefficients)

mol H_2 ↑ Molar mass H_2 (2.016 g/mol) → ? g H_2

coeff.

$$10.0 \text{ g HI} \times \frac{1 \text{ mol HI}}{127.908 \text{ g HI}} \times \frac{1 \text{ mol } H_2}{2 \text{ mol HI}} \times \frac{2.016 \text{ g } H_2}{1 \text{ mol } H_2} = 0.0788 \text{ g } H_2$$

MM always per 1 mol

Stoichiometry problems

$2\ C_8H_{18} + 25\ O_2 \longrightarrow 16\ CO_2 + 18\ H_2O$

How many grams CO_2 are produced from combustion of 100. g octane (C_8H_{18})?

$$100.\ g\ C_8H_{18} \times \frac{1\ mol\ C_8H_{18}}{114.224\ g\ C_8H_{18}} \times \frac{16\ mol\ CO_2}{2\ mol\ C_8H_{18}} \times \frac{44.01\ g\ CO_2}{1\ mol\ CO_2} = \boxed{308\ g\ CO_2}$$

MM C_8H_{18} — mol ratio — MM CO_2

How many grams CO_2 are produced from combustion of 100. g propane, C_3H_8?

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

$$100.\ g\ C_3H_8 \times \frac{mol\ C_3H_8}{g\ C_3H_8} \times \frac{mol\ CO_2}{mol\ C_3H_8} \times \frac{g\ CO_2}{mol\ CO_2} = \boxed{299\ g\ CO_2}$$

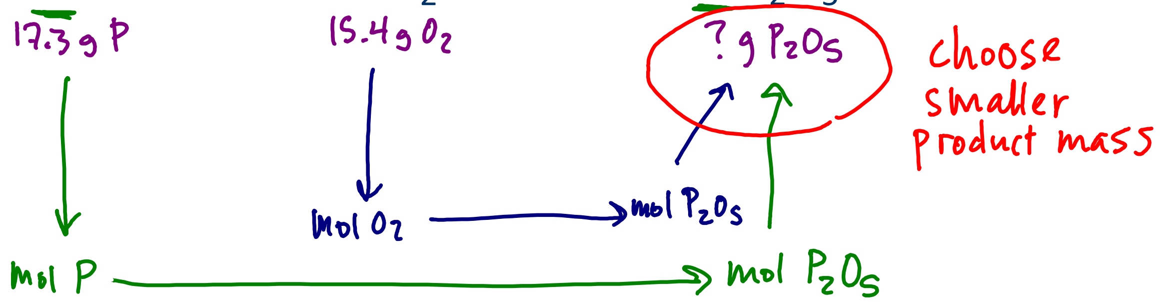
There is **no direct route** from mass to mass. (Use the mol ratio in the middle of a g → mol → mol → g calculation)

Only use the coefficients in the mol ratio, **not** in molar masses!

What if you're given masses of two reactants and are asked for product mass?

17.3 g P are reacted with 15.4 g O_2. How many grams P_2O_5 can be produced?

$$4\,P + 5\,O_2 \rightarrow 2\,P_2O_5$$



This is a **limiting reactant** problem:

- One reactant is consumed before the other
- Once one reactant is consumed, the reaction stops.
- The reactant that's consumed first is the limiting reactant

$$17.3\,g\,P \times \frac{1\,mol\,P}{30.97\,g\,P} \times \frac{2\,mol\,P_2O_5}{4\,mol\,P} \times \frac{141.94\,g\,P_2O_5}{1\,mol\,P_2O_5} = \text{~~39.6 g~~}\,P_2O_5$$

$$15.4\,g\,O_2 \times \frac{1\,mol\,O_2}{32.00\,g\,O_2} \times \frac{2\,mol\,P_2O_5}{5\,mol\,O_2} \times \frac{141.94\,g\,P_2O_5}{1\,mol\,P_2O_5} = \boxed{27.3\,g\,P_2O_5}$$

limiting reactant ($15.4\,g\,O_2$); theoretical yield ($27.3\,g\,P_2O_5$)

Reaction stops when 27.3 g product are formed (O_2 runs out - the limiting reactant is O_2.)

Yield calculations

Theoretical yield: product mass from a stoichiometry calculation. Maximum amount of product that can be formed under ideal conditions.

27.3 g P_2O_5 from last page

Actual yield: isolated product mass from real reaction in a real lab. Always smaller than theoretical yield.

will be given in question

Percent yield: $\frac{\text{actual}}{\text{theoretical}} \times 100\%$

Say the actual yield of the previous reaction was 25.2 g P_2O_5. What was the percent yield?

$$\frac{25.2\text{ g}}{27.3\text{ g}} \times 100\% = \boxed{92.3\%}$$

Limiting reactant practice

If 4.20 g Ca reacted with 2.80 g O_2, what is the theoretical yield of CaO? Which is the limiting reactant? What was the % yield if 4.93 g CaO were produced?

$$2\,Ca(s) + O_2(g) \longrightarrow 2\,CaO(s)$$

$$4.20\text{ g Ca} \times \frac{1\text{ mol Ca}}{40.08\text{ g Ca}} \times \frac{2\text{ mol CaO}}{2\text{ mol Ca}} \times \frac{56.08\text{ g CaO}}{1\text{ mol CaO}} = \boxed{5.88\text{ g CaO}}$$

lim. reactant (Ca); theoretical yield (5.88 g CaO)

$$2.80\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32.00\text{ g } O_2} \times \frac{2\text{ mol CaO}}{1\text{ mol } O_2} \times \frac{56.08\text{ g CaO}}{1\text{ mol CaO}} = \text{~~9.81 g~~ CaO}$$

$$\%\text{ yield} = \frac{4.93\text{ g}}{5.88\text{ g}} \times 100\% = \boxed{83.8\%}$$

If 12.3 g Na react with 0.750 g H_2, what is the theoretical yield of NaH? Which is the limiting reactant? If 8.24 g NaH were produced, what was the % yield?

$$2\,Na + H_2 \longrightarrow 2\,NaH$$

$$12.3\text{ g Na} \times \frac{1\text{ mol Na}}{22.99\text{ g Na}} \times \frac{2\text{ mol NaH}}{2\text{ mol Na}} \times \frac{23.998\text{ g NaH}}{1\text{ mol NaH}} = \boxed{12.8\text{ g NaH}}$$

limiting reactant (Na); theoretical yield (12.8 g NaH)

$$0.750\text{ g } H_2 \times \frac{1\text{ mol } H_2}{2.016\text{ g } H_2} \times \frac{2\text{ mol NaH}}{1\text{ mol } H_2} \times \frac{23.998\text{ g NaH}}{1\text{ mol NaH}} = \text{~~17.9 g NaH~~}$$

not produced

$$\%\text{ yield} = \frac{8.24\text{ g}}{12.8\text{ g}} \times 100\% = \boxed{64.4\%}$$