Name _____ Block _____

As you've probably already discovered in your chemistry class, there are about a bazillion types of stoichiometric calculation out there. The good news, however, is that none of them are all that difficult. Seriously.

Section 12.2: Doing Stoichiometry

Before I show you some examples of stoichiometry, let me show you a handy picture that you'll be using a lot:[2]

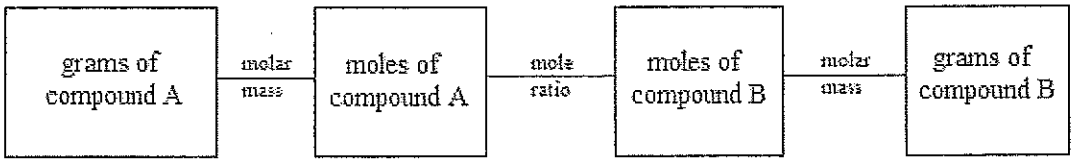


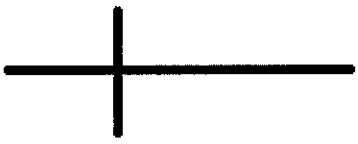
Figure 12.2: *A handy picture that you'll be using a lot.*

The best way to teach you how to use this picture to do stoichiometry is to simply give you a stoichiometry problem and solve it:

Problem: Given the equation $2\ H_2 + O_2 \rightarrow 2\ H_2O$, how many grams of water can be made with 50.0 grams of oxygen and an excess of hydrogen?[3]

Answer: Let's go through the following steps to solve this problem:

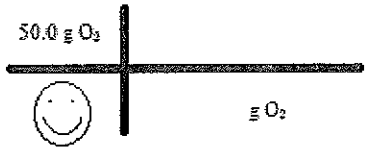
1. **Determine what you're trying to figure out, and what you've been given:** In this problem, you've been given the value "50.0 grams of oxygen", so we'll call O_2 "compound A." The problem tells you that you're trying to find the "grams of water", so we'll call H_2O "compound B."[4]
2. **Figure out where you are on this table, and where you're trying to get:** Since we're given "50.0 grams of oxygen", we start in the "grams of compound A" box. Because we're trying to find out how many grams of water we'll be making, we end in the "grams of compound B" box.
3. **Make a "t":** You'll recognize the following steps from the mole calculation chapter (chapter 11).



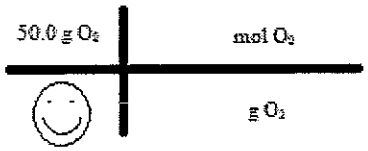
[2] That's my subtle way of saying "memorize this."
[3] When one of these problems refers to an "excess of [something]" what that really means is that there's so much of that compound hanging around that you really don't need to worry about it. Focus on the other reactant instead.
[4] It doesn't really matter which compound is A and which is B as long as you follow the steps in this guide.

4. **Put the thing that you were given in the problem in the top left of the t.** Since you were given the value "50.0 grams of oxygen" in the problem, put that in the top left of the t:[5]

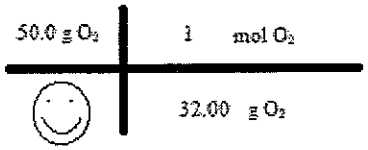
5. **Put the units of the thing that's in the top left in the space on the bottom right.** The units in the top left are "g O_2", so put "g O_2" in the bottom right:



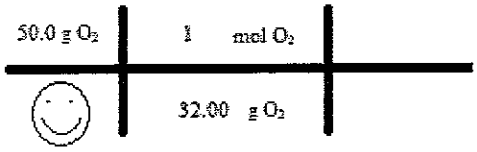
6. **Put the units of what you're trying to find in the top right.** Now, this one is a little more challenging. Obviously, we ultimately want to find the number of grams of water that can be formed. However, an examination of the table above tells us that we have to do several unit conversions to make that happen. As a result, our first conversion will simply be from grams of O_2 to moles of O_2:



7. **Put in the conversion factor between the things on the right.** The handy diagram says "molar mass", and molar mass is given to us in units of "grams in 1 mole", so we'll put a "1" in front of "mol O_2" and the molar mass of O_2 (32.00 g) in front of "g O_2":

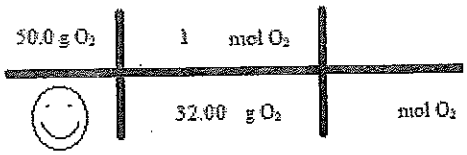


8. Clearly, we're not done. In fact, all we've done is to do the same type of mole calculation that you learned about in Chapter 11. In order to get all the way to grams of H_2O, we'll have to do two more calculations. Let's extend the t-chart a little:

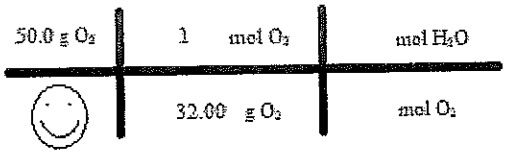


[5] The smiley face is put in the bottom left to make stoichiometry a happy and cheerful experience.

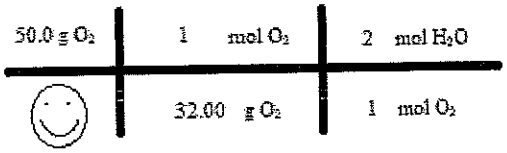
9. Move the units of the thing in the top left (mol O_2) to the bottom right. This is the same as step 5 above:



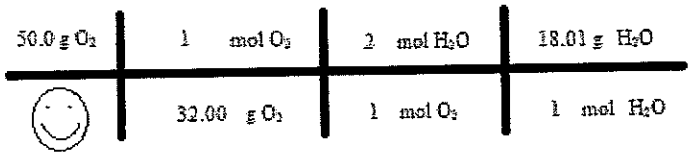
10. Put the units of what you're trying to find in the top right (same as step 6 above). Since we can't go directly to grams of water, we'll go to moles of water, as that's the next step on our handy chart:



11. Put in the conversion factors (same as step 7 above). In this step, the conversion factors are called the "mole ratio" because the conversion is from moles of one compound to moles of another compound. The conversion factors in the mole ratio step are the coefficients in front of each compound in the balanced equation:



12. Since we're not at grams of water yet, we need to go through the steps of extending the t-chart, writing the units from the top left in the bottom, and so forth (steps 4-7 again):



13. In this, the last step, we multiply this stuff together like a series of fractions, where the stuff on the top is multiplied together and divided by the product of the stuff on the bottom multiplied together. This gives us an answer of 56.3 g H_2O.[6]

Made-up Fun Fact

Fractions were invented in 1875 by Patrick L. Fraction, a British accountant. Prior to that time, whenever somebody would cut a pie in two, they'd refer to each piece as "the product of a pie that hath been cleaved in twain." Because the many variations on that were annoying to say every time somebody took a piece of pie, Fraction came up with the convenient "fractions" that we use today.

[6] The significant figures in this calculation are determined by the value "50.0 g O_2". Though it might seem that the numbers of moles would give us only one significant figure, they're exact values (i.e. there are approximately 18.01 grams of water in *exactly* one mole of water), so we treat them as if they have infinite significant figures.

Worksheet: Mole/Mole Problems Name_____

Answer each of the following questions using the equation provided. BE SURE TO BALANCE EACH EQUATION BEFORE SOLVING ANY PROBLEMS. SHOW ALL WORK.

1. ___NO + ___O_2 → ___NO_2

a. 2 moles of NO will react with _____ mole(s) of O_2 to produce _____ mole(s) of NO_2.

b. ? moles NO_2 = 3.6 moles O_2 × $\frac{\text{moles } NO_2}{\text{moles } O_2}$ =

c. How many moles of NO must react to form 4.67 moles of NO_2?

2. ___NH_3 + ___O_2 → ___N_2 + ___H_2O

a. 20 moles of NH_3 are needed to produce _____ moles of H_2O.

b. How many moles of N_2 will be produced if 3.5 moles of O_2 react?

3. ___AlF_3 + ___O_2 → ___Al_2O_3 + ___F_2

a. 20 moles of AlF_3 will produce _____ moles of F_2.

b. _____ moles of AlF_3 will react with 0.6 moles of O_2.

4. ___C_3H_8 + ___O_2 → ___CO_2 + ___H_2O

a. How many moles of oxygen react with 11 moles of C_3H_8?

b. How many moles of CO_2 are produced if 3.5 moles of water are produced?

5. ___O_2 + ___Fe → ___Fe_2O_3

a. Fill in the following word equation--_____ moles of oxygen gas react with _____ moles of iron to produce _____ moles of iron (III) oxide.

b. _____ moles of O_2 are required to produce 3.0 moles of iron (III) oxide.

Worksheet: Mole/Mass Problems Name_____

Answer each of the following questions using the equation provided. BE SURE TO BALANCE EACH EQUATION BEFORE SOLVING ANY PROBLEMS. SHOW ALL WORK.

1. In a reaction between the elements aluminum and chlorine, aluminum chloride is produced.

$$\_\_\_Al + \_\_\_Cl_2 \rightarrow \_\_\_AlCl_3$$

a. 2 moles of Al will react with _____ mole(s) of Cl_2 to produce _____ mole(s) of $AlCl_3$.

b. How many grams of $AlCl_3$ will be produced if 2.50 moles of Al react?

c. How many moles of Cl_2 must react to produce 12.3 g of $AlCl_3$?

d. How many grams of aluminum will react with 3.4 moles of chlorine?

e. If 17 grams of aluminum react, how many moles of aluminum chloride will be produced?

2. The ammonia (NH_3) used to make fertilizers for lawns and gardens is made by reacting nitrogen and hydrogen according to the following reaction.

$$\_\_\_N_2 + \_\_\_H_2 \rightarrow \_\_\_NH_3$$

a. Determine the mass in grams of NH_3 formed from 1.34 moles of nitrogen.

b. What is the mass in grams of hydrogen required to react with 1.34 moles of nitrogen?

c. How many moles of nitrogen are required to produce 11.7 moles of NH_3?

d. How many moles of nitrogen are required to produce 11.7 grams of NH_3?

e. How many grams of hydrogen are required to form 3.5 moles of NH_3?

Worksheet: Mixed Problems—Mole/Mole and Mole/Mass Name_____

Answer each of the following questions using the equation provided. BE SURE TO BALANCE EACH EQUATION BEFORE SOLVING ANY PROBLEMS. SHOW ALL WORK.

1. ___Cu + ___O_2 → ___CuO

   a. If 101 grams of copper is used, how many moles of copper (II) oxide will be formed?

   b. If 5.25 moles of copper are used, how many moles of oxygen must also be used?

   c. If 78.2 grams of oxygen react with copper, how many moles of copper (II) oxide will be produced?

2. ___C_4H_{10} + ___O_2 → ___CO_2 + ___H_2O

   a. How many moles of butane, C_4H_{10}, are needed to react with 5.5 moles of oxygen?

   b. How many grams of carbon dioxide will be produced if 3.5 moles of O_2 react?

3. ___Mg + ___HCl → ___$MgCl_2$ + ___H_2

a. What mass of HCl is consumed by the reaction of 2.50 moles of magnesium?

b. What mass of $MgCl_2$ is produced if 3.67 moles of HCl react?

c. How many moles of hydrogen gas are produced when 3.0 moles of magnesium react?

4. ___NH_3 + ___O_2 → ___N_2 + ___H_2O

a. How many moles of oxygen react with 0.23 moles of NH_3?

b. How many grams of water will be produced if 0.55 moles of oxygen react?

c. How many moles of nitrogen gas will be produced if 12.6 grams of ammonia react?

Worksheet: Mass/Mass Problems Name_____

1. Nitrogen and hydrogen react to form ammonia gas according to the following equation.

$$\_\_\_N_2 + \_\_\_H_2 \rightarrow \_\_\_NH_3$$

   a. If 56.0 grams of nitrogen are used up by the reaction, how many grams of ammonia will be produced?

   b. How many grams of hydrogen must react if the reaction needs to produce 63.5 grams of ammonia?

2. Aluminum metal reacts with zinc chloride to produce zinc metal and aluminum chloride.

$$\_\_\_Al + \_\_\_ZnCl_2 \rightarrow \_\_\_Zn + \_\_\_AlCl_3$$

   a. A mass of 45.0 grams of aluminum will react with how many grams of zinc chloride?

   b. What mass of aluminum chloride will be produced if 22.6 grams of zinc chloride are used up in the reaction?

3. For the reaction whose balanced equation is as follows, find the number of grams of I_2 that will be formed when 300.0 g of bromine react.

$$2\ KI + Br_2 \rightarrow 2\ KBr + I_2$$

4. For the reaction whose balanced equation is as follows, find the number of grams of sodium that must react to produce 42.0 grams of sodium oxide.

$$4\ Na + O_2 \rightarrow 2\ Na_2O$$

5. For the reaction whose balanced equation is as follows, find how many grams of zinc phosphate will be produced by the reaction of 5.00 grams of ammonium phosphate.

$$3\ ZnCl_2 + 2\ (NH_4)_3PO_4 \rightarrow Zn_3(PO_4)_2 + 6\ NH_4Cl$$

Mixed Stoichiometry Practice

NAME _____

Potassium Chlorate decomposes into potassium chloride and oxygen gas.

Balanced Equation: ___$KClO_4$ → ___KCl + ____O_2

How many grams of oxygen are produced when 3.0 moles of potassium chlorate decompose completely?

Butane (C_4H_{10}) undergoes combustion.

Balanced Equation: ___ $C_4H_{10}(l)$ + ___ $O_2(g)$ → ____ $CO_2(g)$ + _____ $H_2O(l)$

How many molecules of CO_2 are produced when 88 g of O_2 are reacted with an excess of butane?

Balanced Equation: ___H_2 + ___O_2 → ___H_2O

How many grams of hydrogen will be required to react with 6.00×10^{25} molecules of oxygen?

How many grams of water can be produced using 9.00 moles of hydrogen

Cobalt(II) chloride reacts with fluorine in a single replacement reaction to produce cobalt(II) fluoride and chlorine gas.

Balanced Equation: _____ $CoCl_2$ + _____ F_2 → _____ CoF_2 + _____ Cl_2

How many molecules of fluorine are required to produce 290.8 g of cobalt(II)fluoride?

Balance the following equation.

_____ $SrCl_2(aq)$ + _____ $H_2SO_4(aq)$ →_____$HCl(aq)$ + ____$SrSO_4(s)$

What is the mass of strontium chloride that reacts with 300.0 g of sulfuric acid?

Solid iron(III) oxide (Fe_2O_3) reacts with hydrogen gas (H_2) to form iron and water.

Balanced Equation:

How many grams of iron are produced when 450 grams of iron(III) oxide are reacted?

How many grams of water will be produced when 0.0155 moles of hydrogen gas react completely with iron(III) oxide?

Worksheet: Writing Equations

Write equations for the following reactions: WATCH OUT FOR DIATOMICS!!!

1) Aluminum fluoride breaks down into an atom of aluminum and a molecule of Fluorine.

A) If 85.0 grams of aluminum fluoride are used, how many moles of fluorine will be produced?

B) How many grams of aluminum will be produced if 2.5 moles of aluminum fluoride react?

2) Potassium combines with Chlorine to yield Potassium Chloride.

A) How many grams of chlorine will be produced if you start with 35.0 grams of potassium?

B) Determine the number of moles of potassium necessary to produce 3.5 moles of potassium chloride.

3) Silver (II) phosphide reacts with oxygen to produce Silver (II) oxide and an atom of Phosphorus.

A) 56.0 grams of oxygen will produce how many moles of silver (II) oxide?

B) 150.0 grams of silver (II) phosphide will produce how many grams of silver (II) oxide?

4) The complete combustion of tetracarbon decahydride in oxygen.

A) 6.0 moles of oxygen will produce how many moles of each of the products?

B) 135.0 grams of tetracarbon decahydride will produce how many moles of carbon dioxide

5) The reaction of $AlBr_3$ with $Mg(OH)_2$

A) 1.05 moles of aluminum bromide produces how many moles of magnesium bromide

B) 2.75 moles of magnesium hydroxide would yield how many grams of aluminum hydroxide

6) The decomposition of hydrogen peroxide (H_2O_2) to form water and oxygen.

A) 25.0 grams of oxygen gas would be produced from how many grams of hydrogen peroxide?

B) 2.5 moles of hydrogen peroxide would produce how many moles of oxygen gas?

7) The reaction of nitric acid with potassium hydroxide to form postassium nitrate and water.

A) 35.0 grams of nitric acid would produce how many moles of water?

B) 70.0 grams of potassium hydroxide will produce how many grams of potassium nitrate?