The Balanced Equation is a Recipe
Stoichiometry (Stoy-key-aw-met-tree)

Name____________________

Chemists spend a lot of time and effort making things. Just like a chef spends lots of time and effort making food, a chemist spends lots of time making chemicals. Chefs use recipes to make food, and chemists use recipes to make chemicals.

This my recipe for one batch of home-made brownies to be cooked in a 9 in x 13 in pan.

- 2 sticks margarine (M)
- 4 eggs (E)
- 1.67 cups sugar (S) (which is 1 & 2/3 cups)
- 1.5 cups flour (F)
- 1 tsp salt
- 2 tsp vanilla
- 4 squares unsweetened chocolate
- ¼ tsp baking powder
- 1 ¾ tsp baking soda

So the recipe goes like this: 2M + 4E + 1.67 S + 1.5F (+ more) = 1 batch

1. If you had 8 eggs, (and everything else you need) how many batches of brownies could you make?

2. Using the 8 eggs, how many sticks of margarine would you need to take out of the fridge?

3. If you had 4.5 cups of flour and wanted to make as many brownies as possible, how many eggs would you need to go with your 4.5 cups of flour?

4. What if you had 3 eggs, and you were really hungry and wanted to make the most brownies that you could, how many cups of sugar would you need to go with those eggs?

5. What if you wanted to make 3 batches of brownies, how many cups of flour (and of course all the other necessary ingredients) would you need? Use the flour to batch ratio to calculate.

6. What if you had 2.5 cups of sugar and you wanted to know how much flour you would need to go with that sugar if you wanted to use it all up?

You see, deciding how much of each ingredient, how many pans you need (or batches you can make) is nothing more than manipulating the ratios or proportions that exist between the ingredients. If you didn't maintain those set proportions, it is likely that your brownies would not taste very good.

7. Write the balanced equation for the synthesis of ammonia (nitrogen trihydride) from nitrogen gas and hydrogen gas.
   (Use this balanced equation to solve problems 8 – 11)

8. Given 7 moles of nitrogen gas, how many moles of hydrogen gas do you need to go with it?

9. Given 7 moles of nitrogen gas, how many moles of ammonia can you make?
   Would your answer be the same if you started with 21 moles of hydrogen?

Using mass measurements in the problem

Since in the lab we have no method to directly measure moles, we usually measure quantities in mass. Before using the balanced equation (mole ratios – stoichiometric link) to do any problems, you must first change any information given in grams to moles.

10. Given 19.6 g of nitrogen gas, how many grams of hydrogen gas would you need to go with it?

11. Given 19.6 g of nitrogen gas, determine the mass of ammonia that you can make.
    Would your answer be the same if you had started with 4.24 g of hydrogen, the amount of gas that would also be required to do this reaction.

Two more practice problems to see if you understand all the steps:

12. Write a balanced equation that represents the reaction between magnesium and aluminum sulfate.

    a. If you had 8.40 g of magnesium, what mass of aluminum sulfate would you need to completely react with it.

    b. From this combination in part a, what mass of aluminum could you produce?

    c. Suppose you actually did this experiment with the quantities described above, and in the lab experiment you were able to produce 5.10 g of aluminum. Calculate the % yield of aluminum.

13. Write an overall balanced equation that represents the reaction between a solution of aluminum chloride and sodium carbonate.

    a. If you had 5.00 g of aluminum chloride, (and an excess of sodium carbonate) what mass of precipitate would you expect to produce?

    b. What would be the minimum mass of sodium carbonate we would need?

    c. Suppose you actually did this experiment with the quantities described above, and you were able to produce 4.20 g of aluminum carbonate. Calculate the % yield of precipitate.

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ANSWERS

1. 8 egg * $\left(\frac{1 batch}{4 eggs}\right)$ = 2 batches

2. 8 eggs $\left(\frac{2 margarine}{4 eggs}\right)$ = 4 sticks margarine

3. 4.5 cups flour $\left(\frac{4 eggs}{1.5 CupsFlour}\right)$ = 12 eggs

4. 3 eggs $\left(\frac{1.67 CupsSugar}{4 eggs}\right)$ = 1.25 cups sugar

5. 3 batches $\left(\frac{1.5 CupsFlour}{1 batch}\right)$ = 4.5 cups flour

6. 2.5 cups sugar $\left(\frac{1.5 CupsFlour}{1.67 CupsSugar}\right)$ = 2.25 cups flour

7. $N_2 + 3 H_2 \rightarrow 2 NH_3$

8. 7 mol N_2 $\left(\frac{3H_2}{1N_2}\right)$ = 21 mol H_2

9. 7 mol N_2 $\left(\frac{2NH_3}{1N_2}\right)$ = 14 mol NH_3 can be produced,

   and of course its the same even when starting with 21 mol H_2 $\left(\frac{2NH_3}{3H_2}\right)$ = 14 mol NH_3 can be produced

10. 19.6 g N_2 $\left(\frac{1 mol N_2}{28 g N_2}\right)\left(\frac{3H_2}{1N_2}\right)\left(\frac{2 g H_2}{1 mol H_2}\right)$ = 4.24 g of H_2 needed to go with the nitrogen

11. 19.6 g of N_2 $\left(\frac{1 mol N_2}{28 g N_2}\right)\left(\frac{2NH_3}{1N_2}\right)\left(\frac{17 g NH_3}{1 mol NH_3}\right)$ = 23.8 g of NH_3 can be produced,

    and of course its the same even when starting with 4.25 g of H_2* $\left(\frac{1 mol H_2}{2 g H_2}\right)\left(\frac{2NH_3}{3H_2}\right)\left(\frac{17 g NH_3}{1 mol NH_3}\right)$ = 23.8 g of NH_3 can be produced

12. $3 Mg + Al_2(SO_4)_3 \rightarrow 3 MgSO_4 + 2 Al$

    a. 8.4 g $\left(\frac{1 mol Mg}{24.3 g Mg}\right)\left(\frac{1 Al_2(SO_4)_3}{3Mg}\right)\left(\frac{342.17 g Al_2(SO_4)_3}{1 mol Al_2(SO_4)_3}\right)$ = 39.4 g of $Al_2(SO_4)_3$ needed to go with the Mg

    b. 8.4 g $\left(\frac{1 mol Mg}{24.3 g Mg}\right)\left(\frac{1 Al}{3 Mg}\right)\left(\frac{27 g Al}{1 mol Al}\right)$ = 6.22 g of Al can be produced,

    and of course its the same even when starting with 39.4 g of $Al_2(SO_4)_3$

    c. $\left(\frac{5.10 g Experimental}{6.22 g Theoretical}\right) \times 100$ = 82 % yield

13. $2AlCl_3 + 3Na_2CO_3 \rightarrow Al_2(CO_3)_3 + 6NaCl$

    a. 5.0 g $\left(\frac{1 mol AlCl_2}{133.33 g AlCl_2}\right)\left(\frac{1 Al_2(CO_3)_3}{2 AlCl_3}\right)\left(\frac{234 g Al_2(CO_3)_3}{1 mol Al_2(CO_3)_3}\right)$ = 4.39 g of $Al_2(CO_3)_3$ precipitate can be formed

    b. 5.0 g $\left(\frac{1 mol AlCl_2}{133.33 g AlCl_2}\right)\left(\frac{3 Na_2CO_3}{2 AlCl_3}\right)\left(\frac{106 g Na_2CO_3}{1 mol Na_2CO_3}\right)$ = 5.96 g of Na_2CO_3 is required

    c. $\left(\frac{4.20 g Experimental}{4.39 g Theoretical}\right) \times 100$ = 95.7% yield