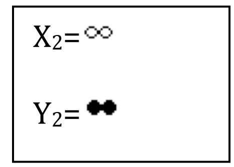
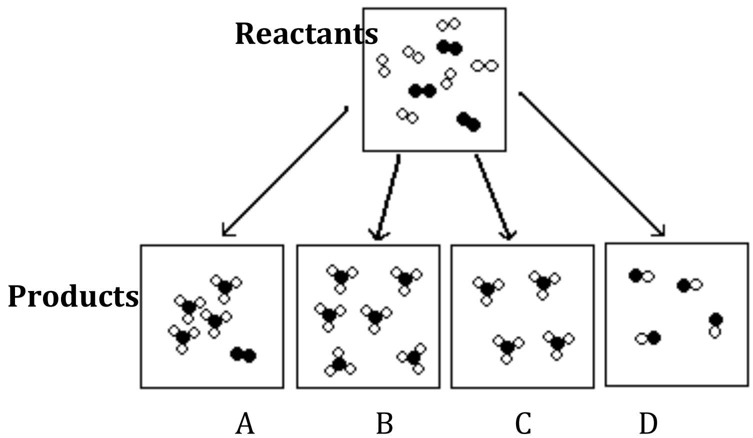
Limiting Reagent

Name____Section____________

1) Analyze the following chemical reaction:





a) Which box best represents what results when X_2 and Y_2 react?

The only container that reflects conservation of particles is Container B. All other containers do not have the same number of X and Y atoms.

b) Write a balanced equation that describes this reaction in terms of X_2 and Y_2.

$3X_2(g) + Y_2(g) \rightarrow 2YX_3(g)$

c) Is there a limiting reagent? Explain.

	$3X_2(g)$	+ $Y_2(g)$	$\rightarrow$ $2YX_3(g)$
Initial	**6 molecules**	**3 molecules**	**0 molecules**
Change	**-6 molecules**	**-3 molecules**	**+6 molecules**
Final	**0**	**0**	**6 molecules**

Yes, both $X_2(g)$ and $Y_2(g)$ are limiting reagents. Using either one we can predict the amount of product that can be formed.

2) Which equation, if any, accurately accounts for the reaction above?

a) $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

b) $H_2 + Cl_2 \rightarrow 2\ HCl$

c) $3\ N_2 + 6\ H_2 \rightarrow 4\ NH_3 + N_2$

d) $6\ H_2 + 3\ Cl_2 \rightarrow 6\ HCl + 3\ H_2$

Student 1: *None, because one nitrogen mixed with three hydrogen only gives us one NH_3.*

Student 2: *c or d, because there was an additional substance left over.*

Student 3: *a, because for every one molecule of N_2 and three molecules of H_2 there were two molecules of NH_3 created.*

Student 4: *a or b, because they are possible results when X_2 and Y_2 mix.*

Student 3 has the correct idea. Looking at the container depicting the products.

Discuss with your partners which, if any, of these statements you agree with. Explain.

3) What else would you need to know in order to decide which reaction is correct?

What the formula of the expected product should be.

4) If you were to double the amount of H_2 in the first box what would the result look like?

It would look like 'B' again, only there would be three unreacted molecules of H_2 remaining unreacted.

5. Propane, C_3H_8, is the fuel of choice in a gas barbecue. When propane burns, the reaction that occurs can be described by the following chemical equation:

$$\_\_\ C_3H_8 + \_\_\ O_2 \rightarrow \_\_\ CO_2 + \_\_\ H_2O$$

a) Balance the chemical equation.

$$\_\_\ C_3H_8 + \_5\ O_2 \rightarrow \_3\ CO_2 + \_4\ H_2O$$

b) What is the limiting reactant when cooking with a gas grill?

Would expect propane to be the limiting reagent since we have all the O_2 we could possibly want in the air.

c) If the grill will not light and you know that you have an ample flow of propane to the burner, what is the limiting reactant?

Would expect not enough oxygen was mixing with the propane.

6. Aspirin is produced by the reaction of salicylic acid and acetic anhydride.

$$\_\_\ C_7H_6O_3\ (s) + \_\_\ C_4H_6O_3\ (l) \rightarrow \_\_\ C_9H_8O_4\ (s) + \_\_\ H_2O\ (l)$$

salicylic acid — acetic anhydride — aspirin

a) Balance the chemical equation.

$$\_2\ C_7H_6O_3\ (s) + \_\_\ C_4H_6O_3\ (l) \rightarrow \_2\ C_9H_8O_4\ (s) + \_\_\ H_2O\ (l)$$

b) If you mix 200 g of each of the reactants, what is the maximum mass of aspirin that can be obtained?

$$200\text{ g } C_7H_6O_3\left(\frac{1\text{ mol } C_7H_6O_3}{138\text{ grams } C_7H_6O_3}\right) = 1.44\text{ moles } C_7H_6O_3$$

$$200\text{ g } C_4H_6O_3\left(\frac{1\text{ mol } C_4H_6O_3}{102\text{ grams } C_4H_6O_3}\right) = 1.96\text{ moles } C_4H_6O_3$$

	$\_2\ C_7H_6O_3\ (s)$ +	$\_\_\ C_4H_6O_3\ (l)$ →	$\_2\ C_9H_8O_4\ (s)$ +	$\_\_\ H_2O\ (l)$
Initial	**1.44 mol**	**1.96 mol**	**0**	**0**
Change				
Final				

We will begin by assuming one of the reactants has to be the limiting reagent. We will guess one of the reactants, $C_7H_6O_3$. Assuming $C_7H_6O_3$ is the LR we can calculate the amount of $C_4H_6O_3$ required to react with 1.44 mol $C_7H_6O_3$.

$$1.44\text{ moles } C_7H_6O_3\left(\frac{1\text{ mol } C_4H_6O_3}{2\text{ mol } C_7H_6O_3}\right) = 0.72\text{ moles } C_4H_6O_3$$

We can now add these to the ICE table,

	$\_2\ C_7H_6O_3\ (s)$ +	$\_\_\ C_4H_6O_3\ (l)$ →	$\_2\ C_9H_8O_4\ (s)$ +	$\_\_\ H_2O\ (l)$
Initial	**1.44 mol**	**1.96 mol**	**0**	**0**
Change	**-1.44 mol**	**-0.72 mol**		
Final	**0**	**1.24 mol**		

That was a good guess. $C_7H_6O_3$ is the LR as we can see there is excess $C_4H_6O_3$ remaining after the reaction is complete. We can also calculate the moles of $C_9H_8O_4$ and H_2O formed using the same approach. Remember the ratio that the products are formed must be the same as the ratio of the coefficients of the products in the balanced chemical equation. We must start with the LR to calculate the moles of products

$$1.44 \text{ moles } C_7H_6O_3\left(\frac{2 \text{ mol } C_9H_8O_4}{2 \text{ mol } C_7H_6O_3}\right) = 1.44 \text{ moles } C_9H_8O_4$$

$$1.44 \text{ moles } C_7H_6O_3\left(\frac{1 \text{ mol } H_2O}{2 \text{ mol } C_7H_6O_3}\right) = 0.72 \text{ moles } H_2O$$

Now back to the ICE table,

_2 $C_7H_6O_3$ (s) + __ $C_4H_6O_3$ (l) → _2 $C_9H_8O_4$ (s) + __ H_2O (l)

Initial	**1.44 mol**	**1.96 mol**	**0**	**0**
Change	**-1.44 mol**	**-0.72 mol**	**1.44 mol**	**0.72 mol**
Final	**0**	**1.24 mol**	**1.44 mol**	**0.72 mol**

We can now calculate the mass of aspirin that can be produced,

$$1.44 \text{ moles } C_9H_8O_4\left(\frac{180 \text{ grams } C_9H_8O_4}{1 \text{ mol } C_9H_8O_4}\right) = 259 \text{ grams } C_9H_8O_4$$