Stoichiometry Part II

Name____Section______________

1. Given an equation

$$2C_2H_6(g) + 7O_2(g) \xrightarrow{\Delta} 4CO_2(g) + 6H_2O(g)$$

How many mol of CO_2 will be formed by the complete combustion of 6.6 mol C_2H_6?

The question can be interpreted into the ICE Table as we are looking for the Ending amount of CO_2 given 6.6 mol C_2H_6 and an excess of O_2. The amounts of $CO_2(g)$ and $H_2O(g)$ are assumed to be 0 initially.

	$2C_2H_6(g)$	$+ 7O_2(g)$	→	$4CO_2(g)$	$+ 6H_2O(g)$
Initial	**6.6 mol**	**excess**		**0**	**0**
Change					
Ending					

The question states that the 6.6 mol C_2H_6 are completely combusted then we know that 6.6 moles C_2H_6 will completely react. This places 6.6 mol in the Change row for C_2H_6. Once we have an entry in the Change row we can use the stoichiometric coefficients to determine the other entries.

	$2C_2H_6(g)$	$+ 7O_2(g)$	→	$4CO_2(g)$	$+ 6H_2O(g)$
Initial	**6.6 mol**	**excess**		**0**	**0**
Change	**-6.6 mol**				
Ending					

Calculate the moles of CO_2 formed

$$6.6 \text{ mol } C_2H_6\left(\frac{4 \text{ mol } CO_2}{2 \text{ mol } C_2H_6}\right) = 13.2 \text{ mol } CO_2$$

	$2C_2H_6(g)$	$+ 7O_2(g)$	→	$4CO_2(g)$	$+ 6H_2O(g)$
Initial	**6.6 mol**	**excess**		**0**	**0**
Change	**-6.6 mol**			**13.2 mol**	
Ending				**13.2 mol**	

Since there were no mol of CO_2 initially,then the Ending amount of CO_2 is 0 + 13.2 mol = 13.2 mol

We can also determine the remaining entries in the Change row as

$$6.6 \text{ mol } C_2H_6\left(\frac{6 \text{ mol } H_2O}{2 \text{ mol } C_2H_6}\right) = 19.8 \text{ mol } H_2O$$

$$6.6 \text{ mol } C_2H_6\left(\frac{7 \text{ mol } O_2}{2 \text{ mol } C_2H_6}\right) = 23.1 \text{ mol } O_2$$

	$2C_2H_6(g)$	$+ 7O_2(g)$	→	$4CO_2(g)$	$+ 6H_2O(g)$
Initial	**6.6 mol**	**excess**		**0**	**0**
Change	**-6.6 mol**	***–23.1 mol***		**13.2 mol**	***19.8 mol***
Ending	***0 mol***	**excess**		**13.2 mol**	***19.8 mol***

How many moles of C_2H_6, assuming excess oxygen, are required to form 3.7 mol H_2O?

The question can be interpreted into the ICE Table as we are looking for the Initial amount of C_2H_6 given 3.7 mol H_2O are formed (Ending amount) and an excess of O_2. The amounts of $CO_2(g)$ and $H_2O(g)$ are assumed to be 0 initially.

	$2C_2H_6(g)$	$+ 7O_2(g)$	→	$4CO_2(g)$	$+ 6H_2O(g)$
Initial		**excess**		**0**	**0**
Change					
Ending					**3.7 mol**

Since there was no H_2O present initially (and no CO_2) we can determine that 3.7 mol H_2O should be in the Change row.

	$2C_2H_6(g)$	$+ 7O_2(g)$	→	$4CO_2(g)$	$+ 6H_2O(g)$
Initial		**excess**		**0**	**0**
Change					**+3.7 mol**
Ending					**3.7 mol**

Once we have an entry in the Change row we can use the stoichiometric coefficients to determine the other entries.

$$\mathbf{3.7\ mol\ H_2O\left(\frac{2\ mol\ C_2H_6}{6\ mol\ H_2O}\right) = 1.2\ mol\ C_2H_6}$$

	$2C_2H_6(g)$	$+ 7O_2(g)$	→	$4CO_2(g)$	$+ 6H_2O(g)$
Initial		**excess**		**0**	**0**
Change	**-1.2 mol**				**+3.7 mol**
Ending					**3.7 mol**

So there must be 1.2 mol C_2H_6 present initially for that much to react. Again we can use the stoichiometric coefficients to determine the other entries in the Change row and the Ending row.

$$\mathbf{3.7\ mol\ H_2O\left(\frac{4\ mol\ CO_2}{6\ mol\ H_2O}\right) = 2.47\ mol\ C_2H_6}$$

$$3.7 \text{ mol } H_2O\left(\frac{7 \text{ mol } O_2}{6 \text{ mol } H_2O}\right) = 4.32 \text{ mol } C_2H_6$$

	$2C_2H_6(g)$	$+ 7O_2(g)$	→	$4CO_2(g)$	$+ 6H_2O(g)$
Initial	**1.2 mol**	**excess**		**0**	**0**
Change	**-1.2 mol**	***-4.32 mol***		***+2.47 mol***	**+3.7 mol**
Ending	***0 mol***	***excess***		***2.47 mol***	**3.7 mol**

2. Determine the amount of iodine produced when 145 g of KI react with excess copper (II) chloride.

$$2CuCl_2(s) + 4KI(s) \rightarrow 2CuI(s) + 4KCl(s) + I_2(s)$$

The question can be interpreted into the ICE Table as we are looking for the Ending amount of I_2 given 145 g KI and an excess of $CuCl_2$. The amounts of CuI, KCl and $I_2(g)$ are assumed to be 0 initially. The ICE Table entries must be in moles so we must first convert grams of KI to moles of KI using the molar mass of KI.

$$145 \text{ g KI}\left(\frac{1 \text{ mol KI}}{166 \text{ g}}\right) = 0.873 \text{ mol KI reacting}$$

	$2CuCl_2(s)$	$+ 4KI(s)$	→	$2CuI(s)$	$+ 4KCl(s)$	$+ I_2(s)$
Initial	**excess**	**0.873 mol**		**0**	**0**	**0**
Change		**-0.873 mol**				
Ending						

So we know that 0.873 mol of KI are reacting we can use the stoichiometric coefficients to calculate how much I_2 forms

$$0.873 \text{ mol KI}\left(\frac{1 \text{ mol } I_2}{4 \text{ mol KI}}\right) = 0.218 \text{ mol } I_2 \text{ formed}$$

	$2CuCl_2(s)$	$+ 4KI(s)$	→	$2CuI(s)$	$+ 4KCl(s)$	$+ I_2(s)$
Initial	**excess**	**0.873 mol**		**0**	**0**	**0**
Change		**-0.873 mol**				**+0.218 mol**
Ending						**+0.218 mol**

Since there was no I_2 initially there is 0.218 mol in the Ending amount. If we want the grams of I_2 formed we need the molar mass of I_2.

$$0.218 \text{ mol } I_2 \left(\frac{254 \text{ g } I_2}{1 \text{ mol } I_2} \right) = 55.5 \text{ g } I_2 \text{ formed}$$

3. List the general steps required to solve any problem in which you are given the mass of each reactant and asked to calculate the mass of one or more products formed as the result of a complete reaction.

1. Balance the chemical equation which describes the chemical reaction and setup the ICE Table.
2. Use the molar mass of each substance to convert the grams of the substance to moles.
3. Enter the initial amounts into the ICE Table.
4. Find the entry (a reactant or product) for the Change row.
5. Use the unit conversion (mole ratio) from the balanced chemical equation to determine the number of moles of the other substances (reactants and products) in the Change row. Conclude which reactant is in excess and which is limiting.
5. Use the molar mass to convert from moles to grams.

4. In the formation reaction

$$2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$$

Calculate the number of moles of SO_3 formed when

a) 2.0 moles of SO_2 are reacted with 5.0 moles of O_2

From the problem we can complete the Initial row.

	$2SO_{2(g)}$	$+ O_{2(g)}$	$\rightarrow$	$2SO_{3(g)}$
Initial	**2.0 mol**	**5.00 mol**		**0**
Change				
Ending				

But this questions does not tell us which reactant is in excess, so we must determine that ourselve. So we'll assume that all of SO_2 reacts and see what happens in the Change row of the ICE Table.

	$2SO_{2(g)}$	$+ O_{2(g)}$	$\rightarrow$	$2SO_{3(g)}$
Initial	**2.0 mol**	**5.00 mol**		**0**
Change	**-2.0 mol**			
Ending				

Assuming that 2.00 mol SO_2 reacts we will use the stoichiometric coefficients to determine how much O_2 reacts;

$$2.0 \text{ mol } SO_2 \left(\frac{1 \text{ mol } O_2}{2 \text{ mol } SO_2} \right) = 1.00 \text{ mol } O_2 \text{ reacts}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	$\rightarrow$	$2SO_{3(g)}$
Initial	**2.0 mol**	**5.00 mol**		**0**

Change	**-2.0 mol**	**-1.00 mol**		
Ending				

Since 1.00 mol O_2 reacts and there are 5.00 mol O_2 initially O_2 is in excess and SO_2 is the limiting reagent. We can now calculate how much SO_3 is formed and finish out the ICE table.

$$2.0 \text{ mol } SO_2\left(\frac{2 \text{ mol } SO_3}{2 \text{ mol } SO_2}\right) = 2.00 \text{ mol } SO_3 \text{ formed}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	$\rightarrow$	$2SO_{3(g)}$
Initial	**2.0 mol**	**5.00 mol**		**0**
Change	**-2.0 mol**	**-1.00 mol**		**2.00 mol**
Ending	**0 mol**	**4.00 mol**		**2.00 mol**

b) 6.0 moles of O_2 are reacted with 4.0 moles SO_2

From the problem we can complete the Initial row.

	$2SO_{2(g)}$	$+ O_{2(g)}$	$\rightarrow$	$2SO_{3(g)}$
Initial	**4.0 mol**	**6.00 mol**		**0**
Change				
Ending				

But this question does not tell us which reactant is in excess, so we must determine that ourselve. So we'll assume that all of SO_2 reacts and see what happens in the Change row of the ICE Table.

	$2SO_{2(g)}$	$+ O_{2(g)}$	$\rightarrow$	$2SO_{3(g)}$
Initial	**4.0 mol**	**6.00 mol**		**0**
Change	**-4.0 mol**			
Ending				

Assuming that 4.00 mol SO_2 reacts we will use the stoichiometric coefficients to determine how much O_2 reacts;

$$4.0 \text{ mol } SO_2\left(\frac{1 \text{ mol } O_2}{2 \text{ mol } SO_2}\right) = 2.00 \text{ mol } O_2 \text{ reacts}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	$\rightarrow$	$2SO_{3(g)}$
Initial	**4.0 mol**	**6.00 mol**		**0**
Change	**-4.0 mol**	**-2.00 mol**		
Ending				

Since 2.00 mol O_2 reacts and there are 6.00 mol O_2 initially O_2 is in excess and SO_2 is the limiting reagent. We can now calculate how much SO_3 is formed and finish out the ICE table.

$$4.0 \text{ mol } SO_2\left(\frac{2 \text{ mol } SO_3}{2 \text{ mol } SO_2}\right) = 4.00 \text{ mol } SO_3 \text{ formed}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**4.0 mol**	**6.00 mol**		**0**
Change	**-4.0 mol**	**-2.00 mol**		**4.00 mol**
Ending	**0 mol**	**4.00 mol**		**4.00 mol**

c) 9.0 moles of O_2 are reacted with 5.0 moles of SO_2

From the problem we can complete the Initial row.

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**5.0 mol**	**9.00 mol**		**0**
Change				
Ending				

But this questions does not tell us which reactant is in excess, so we must determine that ourselve. So we'll assume that all of SO_2 reacts and see what happens in the Change row of the ICE Table.

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**5.0 mol**	**9.00 mol**		**0**
Change	**-5.0 mol**			
Ending				

Assuming that 5.00 mol SO_2 reacts we will use the stoichiometric coefficients to determine how much O_2 reacts;

$$5.0 \text{ mol } SO_2\left(\frac{1 \text{ mol } O_2}{2 \text{ mol } SO_2}\right) = 2.50 \text{ mol } O_2 \text{ reacts}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**5.0 mol**	**9.00 mol**		**0**
Change	**-5.0 mol**	**-2.50 mol**		
Ending				

Since 2.50 mol O_2 reacts and there are 9.00 mol O_2 initially O_2 is in excess and SO_2 is the limiting reagent. We can now calculate how much SO_3 is formed and finish out the ICE table.

$$5.0 \text{ mol } SO_2\left(\frac{2 \text{ mol } SO_3}{2 \text{ mol } SO_2}\right) = 5.00 \text{ mol } SO_3 \text{ formed}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**5.0 mol**	**9.00 mol**		**0**
Change	**-5.0 mol**	**-2.50 mol**		**5.00 mol**

Ending	**0 mol**	**6.50 mol**		**5.00 mol**

d)0.0812 moles of SO_2 react with 0.125 moles of O_2

From the problem we can complete the Initial row.

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**0.0812 mol**	**0.125 mol**		**0**
Change				
Ending				

But this questions does not tell us which reactant is in excess, so we must determine that ourselve. So we'll assume that all of SO_2 reacts and see what happens in the Change row of the ICE Table.

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**0.0812 mol**	**0.125 mol**		**0**
Change	**-0.0812 mol**			
Ending				

Assuming that 0.0812 mol SO_2 reacts we will use the stoichiometric coefficients to determine how much O_2 reacts;

$$\mathbf{0.0812\ mol\ SO_2\left(\frac{1\ mol\ O_2}{2\ mol\ SO_2}\right) = 0.0406\ mol\ O_2\ reacts}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**0.0812 mol**	**0.125 mol**		**0**
Change	**-0.0812 mol**	**-0.0406 mol**		
Ending				

Since 0.0406 mol O_2 reacts and there are 0.125 mol O_2 initially O_2 is in excess and SO_2 is the limiting reagent. We can now calculate how much SO_3 is formed and finish out the ICE table.

$$\mathbf{0.0812\ mol\ SO_2\left(\frac{2\ mol\ SO_3}{2\ mol\ SO_2}\right) = 0.0812\ mol\ SO_3\ formed}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**0.0812 mol**	**0.125 mol**		**0**
Change	**-0.0812 mol**	**-0.0406 mol**		**0.0812 mol**
Ending	**0 mol**	**0.0844 mol**		**0.0812 mol**

e)20.0 g SO_2 react with 15.0 g of O_2

The amounts provided are in grams, so we need to convert those to moles before inserting into the ICE table;

$$\mathbf{20.0\ g\ SO_2\left(\frac{1\ mol\ SO_2}{64.0\ g}\right) = 0.313\ mol\ SO_2\ reacting}$$

$$\mathbf{15.0\ g\ O_2\left(\frac{1\ mol\ O_2}{32.0\ g}\right) = 0.469\ mol\ O_2\ reacting}$$

From the problem we can complete the Initial row.

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**0.313 mol**	**0.469 mol**		**0**
Change				
Ending				

But this questions does not tell us which reactant is in excess, so we must determine that ourselves. So we'll assume that all of SO_2 reacts and see what happens in the Change row of the ICE Table.

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**0.313 mol**	**0.469 mol**		**0**
Change	**-0.313 mol**			
Ending				

Assuming that 0.313 mol SO_2 reacts we will use the stoichiometric coefficients to determine how much O_2 reacts;

$$\mathbf{0.313\ mol\ SO_2\left(\frac{1\ mol\ O_2}{2\ mol\ SO_2}\right) = 0.157\ mol\ O_2\ reacts}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**0.313 mol**	**0.469 mol**		**0**
Change	**-0.313 mol**	**-0.157 mol**		
Ending				

Since 0.157 mol O_2 reacts and there are 0.469 mol O_2 initially O_2 is in excess and SO_2 is the limiting reagent. We can now calculate how much SO_3 is formed and finish out the ICE table.

$$\mathbf{0.313\ mol\ SO_2\left(\frac{2\ mol\ SO_3}{2\ mol\ SO_2}\right) = 0.313\ mol\ SO_3\ formed}$$

	$2SO_{2(g)}$	$+ O_{2(g)}$	→	$2SO_{3(g)}$
Initial	**0.313 mol**	**0.469 mol**		**0**
Change	**-0.313 mol**	**-0.157 mol**		
Ending	**0 mol**	**0.312 mol**		**0.313 mol**

Now we'll convert the moles of SO_3 to grams

$$0.313 \text{ mol } SO_3 \left(\frac{80.0 \text{ g } SO_3}{1 \text{ mol } SO_3} \right) = 25.0 \text{ g } SO_3 \text{ formed}$$