

Investigating Chemical Reactions

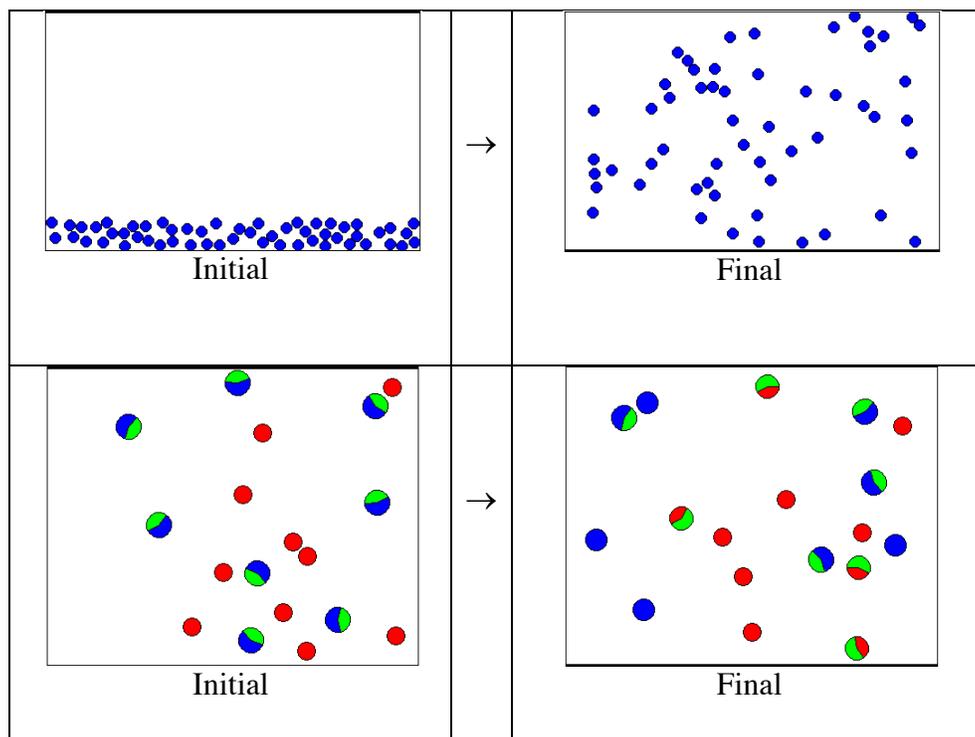
Name _____ Section (CRN) _____

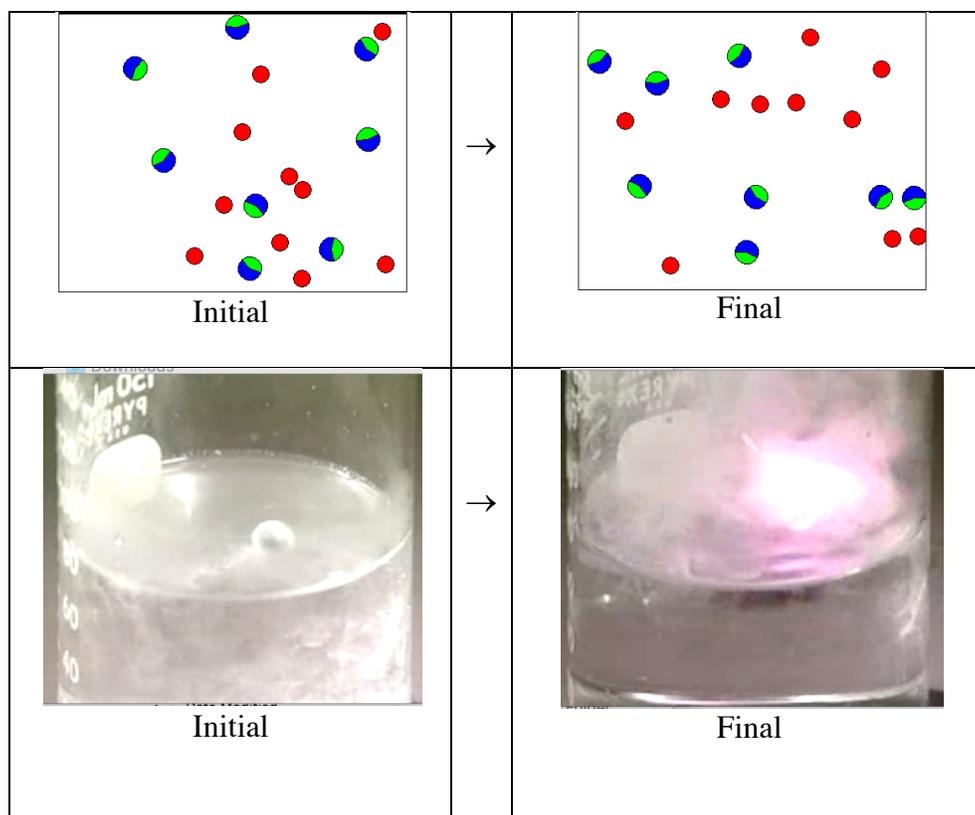
Problem Statement: How are masses of reactants and products related in a chemical reaction?

I. Preliminary Information

A. Using your textbook or an online source define/describe a chemical reaction. (Cite your source.)

B. For each of the following changes indicate which represents a chemical change and which represents a physical change. For each provide a brief explanation to support your claim.





C. Answer the questions below regarding the reaction between hydrogen and oxygen to form water.

- i) Write the formula for the element, hydrogen.

- ii) Write the formula for the element oxygen.

- iii) Write the formula for the compound water.

- iv) Write the balanced chemical equation (using the smallest whole number coefficients) that describes the reaction of hydrogen plus oxygen to form water.

- v) In the chemical equation you wrote in C iv) above, if you multiplied each of the coefficients by 2 does that change anything about the chemical equation? Provide a brief explanation to support your yes or no answer.

D. Figure I. below depicts the particulate level (submicroscopic) representation of a container (the box on the left) with a mixture of hydrogen and oxygen molecules before a reaction occurs, and the same container (the box on the right) after a reaction occurs.

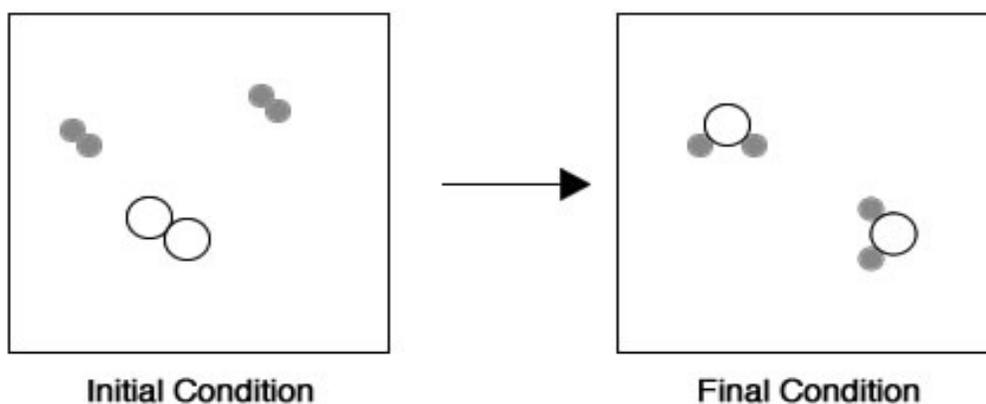
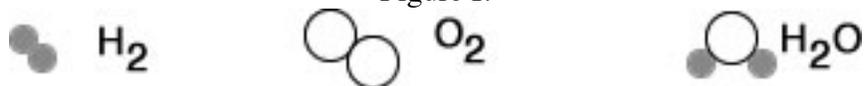


Figure I.



Write the balanced chemical equation (using whole number coefficients) that describes the reaction of hydrogen plus oxygen to form water.

E. Figure II. below depicts the particulate level (submicroscopic) representation of a container (the box on the left) with a mixture of hydrogen and oxygen molecules before a reaction occurs, and the same container (the box on the right) after a reaction occurs.

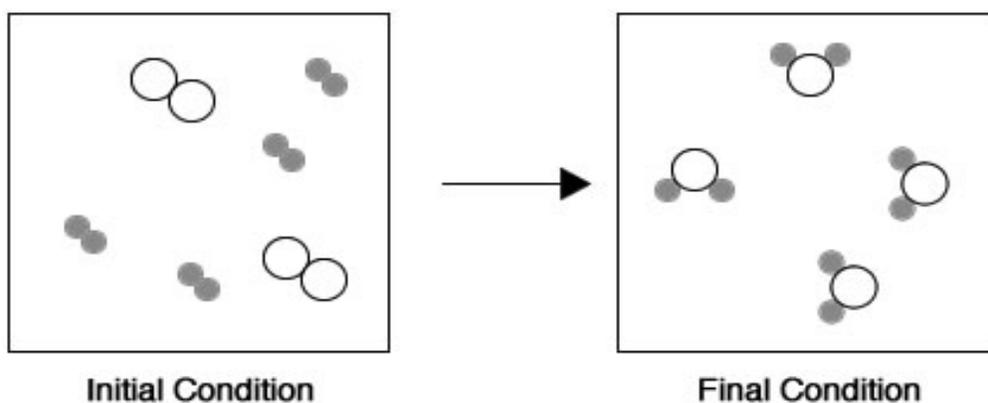
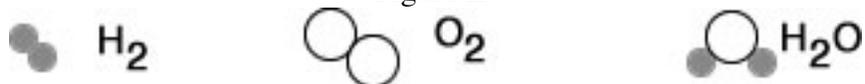


Figure II.



Write the balanced chemical equation (using whole number coefficients) that describes the reaction of hydrogen plus oxygen to form water.

F. The Figure III. below depicts the particulate level (submicroscopic) representation of a container (the box on the left) with a mixture of hydrogen and oxygen molecules before a reaction occurs, and the same container (the box on the right) after a reaction occurs.

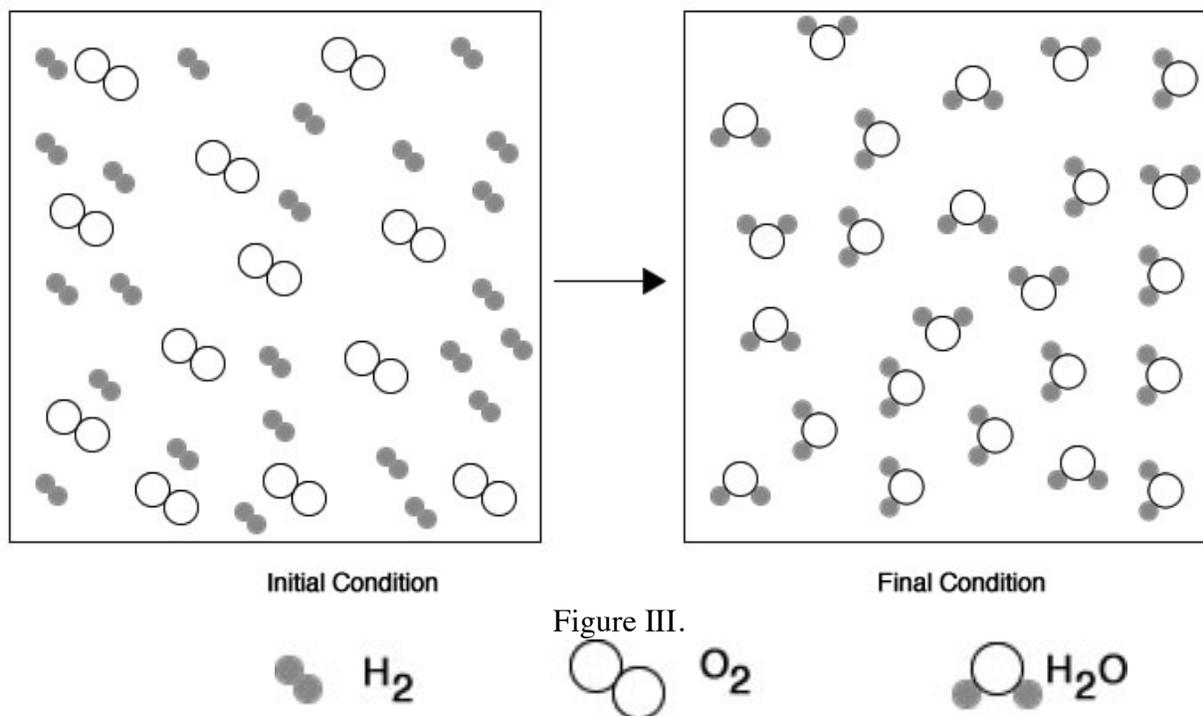


Figure III.

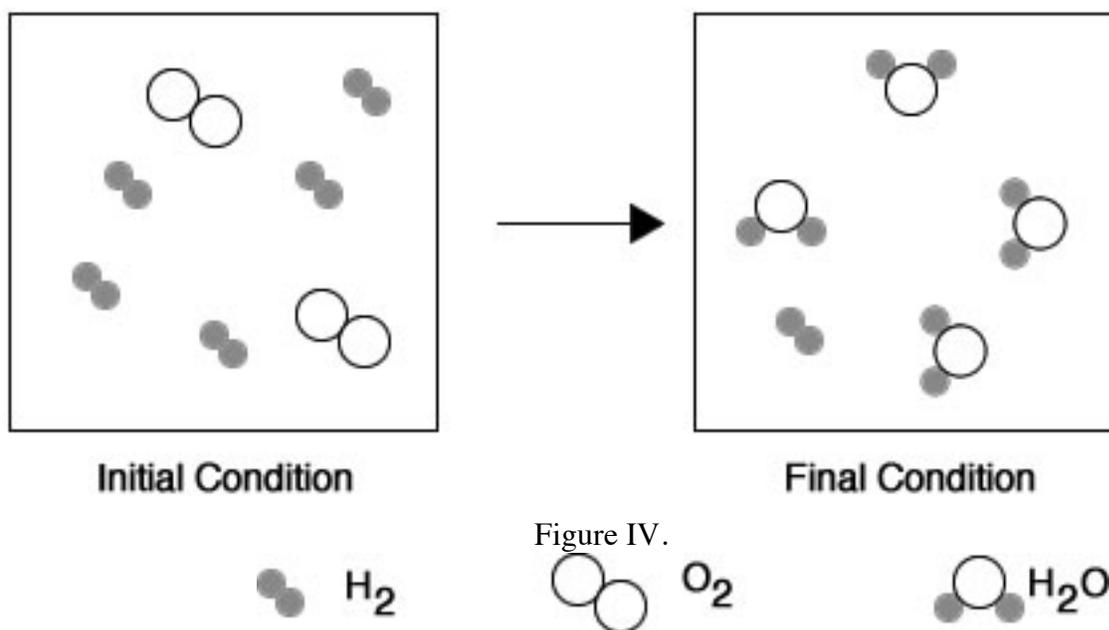
Write the balanced chemical equation (using whole number coefficients) that describes the reaction of hydrogen plus oxygen to form water.

G. Summarizing parts D – F.

i) What is different about Figures I - III shown above?

ii) What is the same about Figures I - III shown above?

H. The Figure IV. below depicts the particulate level (submicroscopic) representation of a container (the box on the left) with a mixture of hydrogen and oxygen molecules before a reaction occurs, and the same container (the box on the right) after a reaction occurs.



- i) Write the balanced chemical equation (using whole number coefficients) that describes the reaction of hydrogen plus oxygen to form water.

I. What is different about the Initial condition in Figure IV compared to Figures I - III?

J. Consider Figure V below and complete the contents of the Initial Conditions, before the reaction begins.

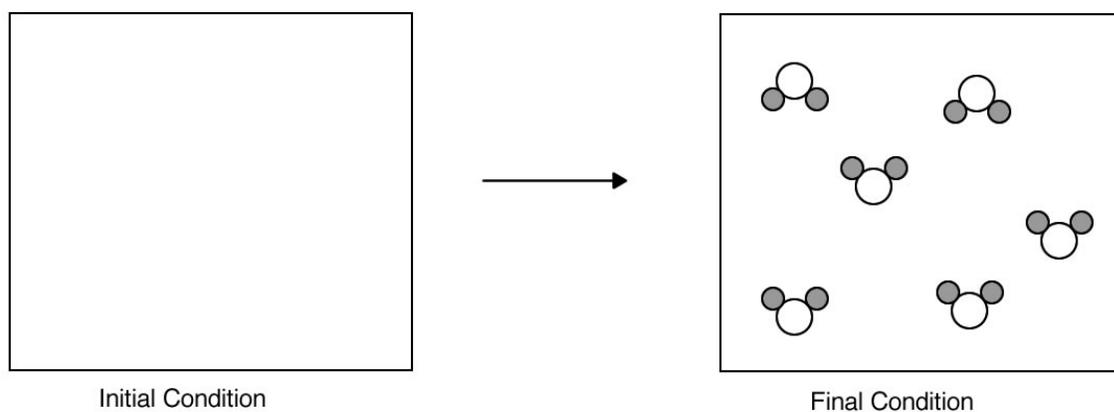


Figure V.

K. One way to summarize the amounts of reactants and products in a chemical reaction is to use a table that shows the Initial amounts of reactants and products, the Final amounts of reactants and products and the Change in the amounts of reactants and products.

Returning to Figure I in part D above, the table that summarizes the amounts of reactants and products in the chemical reaction would look like the following;

Looking at the Initial Conditions

	$2\text{H}_2(g)$ +	$\text{O}_2(g)$	\rightarrow	$2\text{H}_2\text{O}(g)$
Initial	2 molecules	1 molecule		0 molecules
Change				
Final				

Looking at the Final Conditions

	$2\text{H}_2(g)$ +	$\text{O}_2(g)$	\rightarrow	$2\text{H}_2\text{O}(g)$
Initial	2 molecules	1 molecule		0 molecules
Change				
Final	0 molecules	0 molecules		2 molecules

Determine the Change amounts

	$2\text{H}_2(g)$ +	$\text{O}_2(g)$	\rightarrow	$2\text{H}_2\text{O}(g)$
Initial	2 molecules	1 molecule		0 molecules
Change	-2 molecules	-1 molecules		+2 molecules
Final	0 molecules	0 molecules		2 molecules

Complete the tables below for Figures II, III, IV and V.

Figure II:

	$2\text{H}_2(g) +$	$\text{O}_2(g)$	\rightarrow	$2\text{H}_2\text{O}(g)$
Initial				
Change				
Final				

Figure III:

	$2\text{H}_2(g) +$	$\text{O}_2(g)$	\rightarrow	$2\text{H}_2\text{O}(g)$
Initial				
Change				
Final				

Figure IV:

	$2\text{H}_2(g) +$	$\text{O}_2(g)$	\rightarrow	$2\text{H}_2\text{O}(g)$
Initial				
Change				
Final				

Figure V:

	$2\text{H}_2(g) +$	$\text{O}_2(g)$	\rightarrow	$2\text{H}_2\text{O}(g)$
Initial				
Change				
Final				

L. Consider the Change amounts for each of the tables above. What is interesting about the ratios of the numbers in the Change row for all four examples.

M. Now we will investigate another chemical reaction as viewed at the particulate level. In Table V below are links to an experiment that you are to perform using a simulation of a chemical reaction. The first link will load a Java applet. If this link does not work you are welcome to click on the second link which will play a movie of the reaction simulation, or you can review instructions in the Appendix on how to download and accessorize your computer so it will play java applets. Click on the link for Exp #1. Note the number and kind of reacting particles, then click on the Enable Reaction button and then the Resume button; (Note you may want to reduce the volume of the container if the reaction is too slow.)

Table V.

Experiment	Reactant1 (R)	Reactant2 (GB)
Exp#1 http://introchem.chem.okstate.edu/DCICLA/CRRGBM1.htm Or (http://genchem1.chem.okstate.edu/BDA/Exp1.mp4)	4	4

- i) Briefly describe what you observed happening in the reaction container Before and then After clicking on the Enable Reaction button. (NOTE: If you are watching the movie describe what you observe before starting the movie and what happens during the movie.)

To summarize what happens in the simulation for Exp #1 look at Table VI. which has been completed as an example.

Table VI: Summary Results for Experiment #1.

	REACTANTS	REACTANTS		PRODUCTS	PRODUCTS
Exp. #1	Reactant(1)	Reactant(2)		Product(1)	Product(2)
Formula	R	BG	→	RG	B
Initial Amount	4	4		0	0
Change Amount	-4	-4		+4	+4
Final Amount	0	0		4	4

- ii) How many Red atoms were present initially, before the reaction started?
- iii) How many Red atoms reacted?
- iv) How many RG molecules were formed?

N. Now perform Experiment #2 and #3: Use the link for the appropriate experiment (applet or movie) below. Complete Table VII for Exp#2 and #3 in the same way as Table VI for Exp #1 above.

Experiment	Reactant1 (R)	Reactant2 (GB)
Exp#2 (http://introchem.chem.okstate.edu/DCICLA/CRRGBM2.htm)		
Or (http://genchem1.chem.okstate.edu/BDA/Exp2.mp4)	4	2
Exp#2 (http://introchem.chem.okstate.edu/DCICLA/CRRGBM3.htm)	2	4

Or		
(http://genchem1.chem.okstate.edu/BDA/Exp3.mp4)		

- i) *Reminder Instructions:* Enter the formula for each reactant (recommend using the capitalized first letter for the color(s) of the particle as its formula, for example R and BG) and the initial amount of each reactant in Table VII: Experiment #2 or #3. After recording this information for the particular experiment (#2 or #3) in the appropriate table, click on the Resume Button and then click on the Enable Reaction button and then observe what takes place in the reaction container. After the reaction is 'complete' enter the formula(s) of the product(s) of the reaction in the table. Also enter the final amounts of the reactants and the product(s) in the table. (NOTE: After you watch the movie complete Table VII. You may wish to rewind a movie and watch it more than once.)

Table VII: Experiment #2

	REACTANTS	REACTANTS		PRODUCTS	PRODUCTS
Exp. #1	Reactant(1)	Reactant(2)		Product(1)	Product(2)
Formula	R	BG	→	RG	B
Initial Amount					
Change Amount					
Final Amount					

Table VII: Experiment #3.

	REACTANTS	REACTANTS		PRODUCTS	PRODUCTS
Exp. #1	Reactant(1)	Reactant(2)		Product(1)	Product(2)
Formula	R	BG	→	RG	B
Initial Amount					
Change Amount					
Final Amount					

- ii) Write a balanced chemical equation describing the reaction you observed in each experiment. (Use a format similar to $R1 + R2 \rightarrow P1 + P2$ when writing the equation for the reactions observed. Use a single space to separate reactants, products, plus sign and the reaction arrow.)

Exp. #1:

Exp. #2:

Exp. #3:

O. A reagent in excess is a reactant that is not completely used up in a chemical reaction, a limiting reagent is a reactant that limits the amount of product formed in a chemical reaction. Look back at Tables VI and VII Exp#1, #2 and #3 and select one of the statements below that best fits the assignment of the excess reagent and the limiting reagent.

- i) In Exp #1:

R is the excess reagent and BG is the limiting reagent:

BG is the excess reagent and R is the limiting reagent:

both R and BG are excess reagents:

both R and BG are limiting reagents

- ii) In Exp #2:

R is the excess reagent and BG is the limiting reagent:

BG is the excess reagent and R is the limiting reagent:

both R and BG are excess reagents:

both R and BG are limiting reagents

iii) In Exp #3:

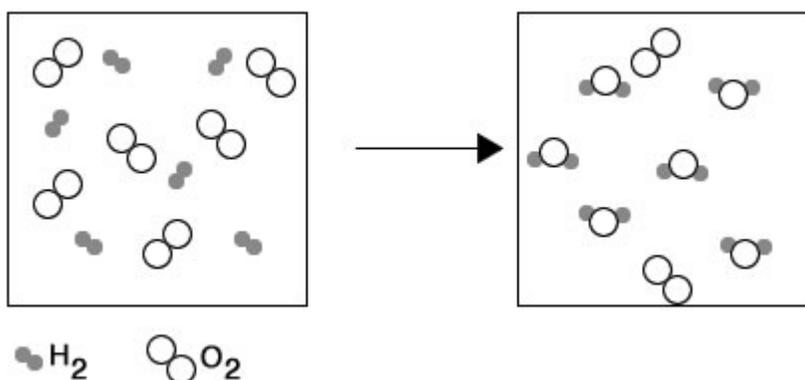
R is the excess reagent and BG is the limiting reagent:

BG is the excess reagent and R is the limiting reagent:

both R and BG are excess reagents:

both R and BG are limiting reagents

iv) Consider the figure below representing a chemical reaction between $\text{H}_2(\text{g})$ and $\text{O}_2(\text{g})$ forming $\text{H}_2\text{O}(\text{g})$



v) Which reactant, $\text{H}_2(\text{g})$ or $\text{O}_2(\text{g})$, is the limiting reagent?

Explain:

vi) Write the balanced chemical equation that represents the reaction that occurs in the figure.

P Data Collection

In this next portion of this activity you will use a simulation accessible at the following link;

https://media.pearsoncmg.com/bc/bc_0media_chem/chem_sim/html5/stoich/Stoich.php

Open the link to the simulation . There are three tabs near the top of the window: Overview; Learner Outcomes; and Experiment. Review the Overview tab and the Learner Outcomes tab, and then click on the Experiment tab. In the new screen there are three buttons. Two are for Demo modes and the third is 'Run Experiment'. You are welcome to run the Demos, however the instructions below are for 'Run Experiment' mode.

ATTENTION: Be sure to read the instructions as they will guide you.

Use the following steps in 'Run Experiment'.

1. Select a reaction:

Click in the 'Choose two gases to react' dropdown menu. You are welcome to explore any reaction, but for this activity you should select methane and oxygen. Click the Next button.

2. Balance the equation:

Enter a whole number coefficient (enter 1 where needed) to balance the equation then click on the Check Balance button. Click the Next button.

3. On the right side of the screen showing the ICF table in the lower right corner is a button that reads Moles. Click on it and select Moles and Grams

4. In the Initial Row, or above the gas tanks add 20.0 grams of oxygen, O₂, and 10.0 grams of methane, CH₄ in the cells identified as grams (watch the tank values open to add the gases to the reaction container.). The initial amounts of the products have already been entered.

5. You will next be asked to enter amounts for the change for the reactants and the products. You may do that in units of Moles or Grams. If you choose to enter Change amounts in Moles, Grams will be calculated for you as you enter each amount. When you have entered values for all substances click on the Change button to see if the amounts you have entered are acceptable. You can correct any errors that are identified with a Red 'X'.

6. Once all of the Change amounts are correct you can click on the React button to see a short animations of the reaction.

5. You will next enter the Final/Ending amounts. Once all values are entered click the Final button to check your entries. You will be able to correct any errors of entry.

Refer to the simulation, to complete the following reaction table.

Complete Table VIII and IX below with the information from the ICF table in the simulation

Table VIII: Use units of moles

	REACTANTS	REACTANTS		PRODUCTS	PRODUCTS
Exp. #1	Reactant(1)	Reactant(2)		Product(1)	Product(2)
Formula	CH ₄	2O ₂	→	CO ₂	2H ₂ O
Initial Amount					
Change Amount					
Final Amount					

Table IX: Use units of grams

	REACTANTS	REACTANTS		PRODUCTS	PRODUCTS
Exp. #1	Reactant(1)	Reactant(2)		Product(1)	Product(2)
Formula	CH ₄	2O ₂	→	CO ₂	2H ₂ O
Initial Amount					
Change Amount					
Final Amount					

Q. Using Tables VIII and/or IX, answer the following questions.

i) Which units moles or grams is the most appropriate for the ICF table? Explain.

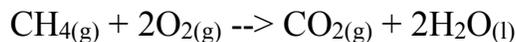
ii) In your experiment who is the limiting reagent and who is the reagent in excess?

limiting reagent is _____

reagent in excess is _____

Try answering these questions.

1. The balanced reaction for the combustion of methane;



Consider mixing 1.50 mol of methane with 1.80 mol of oxygen. Assume there is no carbon dioxide or water present in the initial mixture.

2. Which of the following ICF Tables (X or XI) make sense assuming the initial amounts above and that the reaction goes to completion.

Table X: Based on assuming all the CH_4 reacts

	REACTANTS	REACTANTS		PRODUCTS	PRODUCTS
Equation	CH_4	2O_2	\rightarrow	CO_2	$2\text{H}_2\text{O}$
Initial Amount	1.50 mol	1.80 mol		0 mol	0 mol
Change Amount	-1.50 mol	-3.00 mol		+1.50 mol	+3.00 mol
Final Amount	0 mol	-1.20 mol		+1.50 mol	+3.00 mol

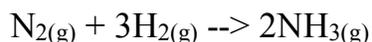
Table XI: Based on assuming all the O_2 reacts

	REACTANTS	REACTANTS		PRODUCTS	PRODUCTS
Equation	CH_4	2O_2	\rightarrow	CO_2	$2\text{H}_2\text{O}$
Initial Amount	1.50 mol	1.80 mol		0 mol	0 mol
Change Amount	-0.90 mol	-1.80 mol		+0.90 mol	+1.80 mol
Final Amount	+0.60 mol	0 mol		+0.90 mol	+1.80 mol

The Table that makes the most sense is; _____

Briefly explain your reasoning.

3. The balanced reaction for the synthesis of ammonia;



Consider mixing 0.50 mol of nitrogen with 2.10 mol of hydrogen. Assume there is no ammonia present in the initial mixture.

4. Which of the following ICF Tables (XII or XIII) make sense assuming the initial amounts above and that the reaction goes to completion.

Table III: Based on assuming all the N_2 reacts

	REACTANTS	REACTANTS		PRODUCTS
Equation	N_2	3H_2	\rightarrow	2NH_3
Initial Amount	0.50 mol	2.10 mol		0 mol
Change Amount	-0.50 mol	-1.50 mol		+1.00 mol
Final Amount	0 mol	+0.60 mol		+1.00 mo

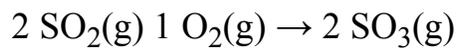
Table IV: Based on assuming all the H_2 reacts

	REACTANTS	REACTANTS		PRODUCTS
Equation	N_2	3H_2	\rightarrow	2NH_3
Initial Amount	0.50 mol	2.10 mol		0 mol
Change Amount	-0.70 mol	-2.10 mol		+1.40 mol
Final Amount	-0.20 mol	0 mol		+1.40 mol

The Table that makes the most sense is; _____

Briefly explain your reasoning.

5. In the synthesis reaction



Calculate the number of moles of SO_3 formed when:

a. 2.0 moles of SO_2 are mixed with 5.0 moles of O_2 and allowed to react.

b. 4.0 moles of SO_2 are mixed with 6.0 moles of O_2 and allowed to react.

c. 5.0 moles of SO_2 are mixed with 9.0 moles of O_2 and allowed to react.

d. 0.812 moles of SO_2 are mixed with 0.125 moles of O_2 and allowed to react.

e. 20.0 grams of SO_2 are mixed with 15.0 grams of O_2 and allowed to react.

Appendix Instructions for using Java Applets

This activity use Java applets which can be a little funky at time. Please follow the instructions below to insure the computer you are using is setup properly to access both of these simulations.

Download Java at <http://java.com/en/> and follow the instructions.

Continue for a PC

- 1) Search for Java on the computer by typing java into the search feature. Do not search for Java using a browser, simply search on the computer itself. In the list of items that are provided, open Configure Java and in the window that appears click on the security tab. Near the bottom of the page click 'edit site list'. A new window will appear. Click the Add button and enter <http://introchem.chem.okstate.edu> in the exception list and then click the Add button then click the OK button, then click the next OK button. (NOTE: If you are interested what this is doing is indicating to the Security feature on the computer that any future software being downloaded from <http://introchem.chem.okstate.edu> can be trusted.
- 2) Now open up an Explorer window or a Firefox browser window. (Do not attempt to us Chrome!) Chrome is not equipped to run this particular Java applet (any Java applet?)
- 3) Copy and paste the link to the java applet into your browser. There maybe a few windoids that appear that you must respond properly to for the software to load. Here are possible windoids and how to respond to the questions.
 - a. A screen with what might appear to be a battery icon with the words 'activate Java' below: click on the activate Java link then,
 - b. A windoid may appear in the upper left corner with two buttons (Allow and Allow and Remember), click on the Allow and Remember button,
 - c. A windoid indicating the version of Java on the computer is out-of-date. Buttons at the bottom of this windoid include, Remind Me Later, Stop/Quit, and Update Java. Click the Remind Me Later button,
 - d. A windoid asking you if it is okay to run the software. In this windoid, click Run.
 - e. This should result in the simulation working.
- 4) On a Mac: Assuming you have Java installed, go to System Preferences. Near the bottom you will see a Java icon. Open the Control Panel. Go to the Security tab. In the Exceptions Site List select the Edit Site list button. Click on the Add button and enter '<http://introchem.chem.okstate.edu>', then click the OK button. Click OK to exit the Control Panel. You should be able to access the simulation after following these instructions. It is possible you may have to quit your browser and re-open the web site.
- 5) If you continue to have problems contact please contact me at john.gelder@okstate.edu.