Chemical Reactions
Unit plan
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UNIT PLAN CONTEXT AND GOALS

Context:

This lesson plan includes the following topics:

- Physical versus Chemical changes
- Overview of energy in a chemical reaction
- Balanced chemical equations
- Quantity relationships between reactants/products
- Limiting reagent concept
- Types of chemical reactions

These topics deal with an overview of how molecules and atoms chemically interact with each other. Therefore, the student should have a strong knowledge base of individual molecules and atoms. The following topics should precede this unit plan:

- Matter and energy
- Periodic table/trends
- Chemical nomenclature
- Properties of matter
- Overview of gases/liquids/solids
- Chemical bonding/shape

Once the student has foundational knowledge of chemical change/equations and the concept of quantity relationships in chemical reactions, the student may proceed to learn more complex calculations and concepts involving chemical reactions. For example, this unit plan provides foundational knowledge and understanding for the following topics:

- Stoichiometry/mole (should directly follow this unit)
- Equilibrium
- Kinetics
- Acids/Bases
- Redox Reactions

Goals:

This unit plan stresses the concepts of chemical reactions using particulate level representations. These pictures help students understand the difference between subscripts and coefficients in a chemical equation. They also help develop a knowledge base for quantity relationships between reactants and coefficients (as seen in the technology lesson plan). This understanding is crucial for the stoichiometry/mole unit.

Another goal of this unit is to have students predict what will happen in a chemical reaction. The student should have a broad sense of how to predict products of a chemical reaction based on the starting materials. The three day laboratory lesson plan helps students to make these predictions and identify types of reactions.

Lastly, students should know how to write a chemical equation when given a sentence format or macroscopic representation of a reaction. This includes identifying the reactants and products and assigning states of matter to each species. The students should also be able to take a chemical equation and explain it using complete sentences.
Lesson 1: Lecture Lesson Plan

Overview: This lecture lesson plan introduces physical versus chemical change, evidence that a chemical reaction has occurred, and the bond energy involved in chemical reactions. The students will take a short pre-assessment quiz (no longer than 10 minutes) that the teacher will not grade but will look to see where the class stands in their understanding of chemical reactions/ equations and the prerequisite knowledge. The students will then use a note outline to take notes during the lecture. This lesson will take up one class period. The teacher may assign textbook problems regarding identifying physical versus chemical changes, evidence of a chemical change, and simple bond energy questions.

HSCES:

C5.2B Distinguish between chemical and physical changes in terms of the properties of the reactants and products.
C5.2C Draw pictures to distinguish between the relationships between atoms in physical and chemical changes.
C3.4A Explain why it is necessary for a molecule to absorb energy in order to break a bond.
C2.1a Explain the changes in potential energy (due to electrostatic interactions) as a chemical bond forms and use this to explain why bond breaking always requires energy.
C2.1b Describe energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).

Learning Objectives:

✓ TLW distinguish between a chemical change and a physical change
✓ TLW identify evidence of a chemical change.
✓ TLW explain energy changes that occur during a chemical reaction.

Misconception:

Several misconceptions from students (ages 11-14) were identified in Johnson (2000). One misconception was that a chemical reaction involves a change in appearance with no change in substance. This lecture will attempt to overcome this misconception by stating that products have properties that are different from the reactants.

References:


Pre-Assessment:

1. What is energy?

2. What is the lowest common denominator of these numbers: 6, 2, 8?

3. Balance the following reaction:
   
   \[\text{___NaCl + ___MgBr}_2 \rightarrow \text{___MgCl}_2 + \text{___NaBr}\]

4. Looking back at question 3, if three molecules of NaCl reacts, how many molecules of MgCl_2 will form?

5. Draw MgCl_2 using a circle for a magnesium atom and a square for a chlorine atom.
CHEMICAL REACTIONS NOTES

Physical change:

- Are ice and water the same material?

- Is condensation a physical or chemical change?

Chemical change:

Chemical and physical change examples:

Bread toasting:

Dissolving sugar in water:
Evidence of a chemical change:
- 
- 
- 
- 

Bonds:
  Definition:
  Types:
  - 
  - 

Energy:
  Definition:
  - 
  - 
  - 

Bonds, Energy, and Chemical Reactions:
  Bond breaking:
  Bond forming:
  Atoms:
Law of Conservation of Energy:
Lesson 2: Demonstration: An Introduction to Writing Chemical Equations

Overview: The students are expected to have general knowledge about chemical change and the energy involved in a chemical reaction. The demo presented in this lesson will begin students’ exploration of balanced chemical equations. The teacher will first perform the demo while students make observations (8 points). The students will then complete a worksheet that will introduce balancing chemical equations at the particulate level (10 points). For homework, the students will find a ‘real-life’ chemical reaction (6 points).

HSCE:

C5.2A Balance simple chemical equations applying the conservation of matter.
C1.1E Describe a reason for a given conclusion using evidence from an investigation.
C5.2B Distinguish between chemical and physical changes in terms of the properties of the reactants and products.

Learning Objective:  

TLW provide evidence that a chemical change has occurred.  
TLW apply the law of the conservation of matter by balancing chemical equations at the symbolic and particulate level.  
TLW identify the gas produced in a chemical reaction using evidence from the demonstration.

Misconception:  
When drawing the particulate level representation of a balanced chemical equation, the student may confuse the relationship between the coefficient and the subscripts in the equation. For instance, students in Yarroch (1985) illustrated $2 \text{H}_2\text{O}$ as $\text{H}_4\text{O}_2$. The hand-out with corresponding to this demonstration has the students draw the chemical equation at the particulate level in order to stress the difference between how subscripts and coefficients at the symbolic level relate to pictorial representations at the particulate level.

Materials and set-up:

- 600 mL beaker
- 2 medium size test tubes
- stopper to fit test tube
- phenolphthalein indicator solution
- matches
- small pieces of sodium in mineral oil
- forceps
- knife
- wood splints
- source of tap water
- paper towels
- safety glasses
- gloves

Safety:

- **Sodium**: A flammable, corrosive solid; dangerous when exposed to heat or flame; dangerous by reaction with moist air, water or any oxidizer. Spontaneously flammable when heated in air; reacts violently with water, producing very
dangerous hydrogen gas and a solution of corrosive sodium hydroxide. Technical Note: As you handle sodium be particularly attentive to the use of dry utensils and an entirely dry work surface.

- **Phenolphthalein**: Possible carcinogen. Acts as a laxative upon ingestion. Irritating to body tissues. Avoid body tissue contact.
- **Hydrogen gas**: Colorless, odorless gas. Asphyxiation if in high concentrations. Extremely flammable gas, severe fire hazard.
- **Sodium hydroxide**: Colorless, odorless liquid. Highly toxic by ingestion, inhalation, or skin absorption. Extremely corrosive to body tissues. Causes severe eye burns. Avoid all body tissue contact.
- **Fire**: This demonstration requires a flame test to identify the gas formed in the reaction (hydrogen). Only the teacher should handle the matches and wood splints. A container for used matches should be nearby for proper match disposal.
- Due to the above hazards, only the teacher will handle the reagents and products of the reaction. The teacher should wear safety goggles and gloves. The students should wear safety goggles during the demonstration. The use of sodium metal in this reaction requires caution. Use only small pieces of sodium metal. Using paper towels, dab any mineral oil or kerosene from the sodium before using. Do not handle the sodium; use forceps. Larger lumps of sodium can easily be cut with a knife.
- The solution remaining at the end of the reaction may be safely rinsed down the drain with excess water. Use caution in cleaning up to make sure that all the sodium metal has reacted.

**Requisite Knowledge:**

- Students should know and understand the law of the conservation of matter and how to represent a molecule symbolically. The student should also know the difference between a chemical and physical change, and the evidence that a chemical reaction occurred. This information is required to balance a chemical reaction at both the symbolic and particulate level.

**Engage:**

Ask: *What do you think will happen when I put table salt in water?* Allow the students to verbally give their hypotheses. After the students predict what will happen, stir some table salt into a beaker of water. *Ask: Based on what you just observed, was adding table salt to water a physical change or a chemical change? Why?* Guide the students towards the answer that sodium chloride is the identity of table salt, and that when it dissolves in water, a physical change occurs. There are no signs of a chemical reaction.

**Total Time:** 5 minutes
Exploration:

For teacher reference:

Procedure of Demonstration:
   a. Fill the 600 mL beaker about 3/4 full with tap water.
   b. Fill the test tube with water. Using the stopper, invert the test tube in the beaker using care that no water escapes.
   c. Add phenolphthalein indicator to the water.
   c. Raise the test tube with one hand and use the forceps to place a small (match head size) piece of sodium metal under the test tube. This must be done quickly!
   d. Allow the reaction to run to completion.
      1) Use a match to test the combustibility of the gas produced. The gas burns. It is hydrogen gas.
      2) Use the phenolphthalein to show that the solution in the beaker is basic. This identifies a second product as sodium hydroxide.
      3) Show that tap water is not basic by testing a few mL of tap water with phenolphthalein solution (this can either be done before the sodium is added or in a separate beaker with only water).

Say: Record your observations of the water when I add phenolphthalein indicator. Add the phenolphthalein indicator.

Ask: Do you think the same thing will happen when I put solid sodium in the water? Allow students to verbally discuss their ideas. Instruct the students to write their individual hypotheses down on a piece of paper. Students will record their own observations. Tell the students that as you do the demonstration, record their observations on the sheet of paper. Perform the demonstration as outlined in the demonstration procedure. Do not do the flame test or indicator test to identify the products yet!

Ask: What observations did you make when I added the sodium to the water? Allow the students to discuss their observations. They should include the formation of bubbles, the ‘disappearance’ of sodium, and the sound of fizzing.

Ask: Why did I trap the piece of sodium in the test tube? This question will be answered verbally by the students. The students should conclude that the test tube was used to collect a gas.

Tell: Explain that you will do a flame test to identify the gas inside the test tube. Tell them to write down their observations as the flame test is performed. Do not give away the identity of the gas! Do not tell them what the color change indicates, because this will be explored in the worksheet.

Ask: Based on your observations, was adding the solid sodium to water a physical or chemical change? Why? This question will also be answered verbally by the students. The students should come to the conclusion that a chemical change occurred because a gas formed and there was a color change (as indicated by the phenolphthalein indicator).

Total Time: 10 minutes

Explain:

Tell the students to return to their seats and form groups of three. Hand out the worksheet (see attached) for this demonstration. This worksheet guides the students through the process of writing a complete balanced chemical equation. They will turn this worksheet in for participation points. As the students work in groups, walk around the room and assist student learning when needed.
Elaboration:
Even though students just wrote a balanced chemical equation, the student may not fully understand what it means. The questions are listed below. Ask the students the first question. Have the students take a couple of minutes to discuss their answers in a group, and then lead a class discussion for that specific question. Repeat this process with the next questions.

Ask:  *Why do we use chemical equations?*

Possible Answers: Chemists use chemical equations to represent a chemical reaction. The equations save time and space and provide the information in an easy to read form.

Ask:  *How does a chemical equation follow the law of the conservation of mass?*

Possible answers: The Law of Conservation of Matter says that matter can neither be created or destroyed, but can be changed in form. In other words, the total mass of the material(s) before the reaction is the same as the total mass of material(s) after the reaction.

Ask:  *What does a chemical equation tell us?*

Possible answers: A chemical equation is a symbolic representation of all of the substances involved in a chemical reaction. We use the chemical formulas of substance to represent each chemical species involved in the reaction. We also use the notation (g), (l), (s), or (aq) following the chemical formula to identify the phase of the substances in the equation.

**Total Time:** 15 minutes
Evaluation:

❖ **To be collected/graded:**
  1) Student hypotheses and observations of the demonstration (individual, 8 points)
  2) Balancing Chemical Equations worksheet (individual per group, 10 points)
  3) Homework: ‘Real-life’ Reaction

❖ **Non-graded:**
  The group discussion during the elaboration step will be used to gage how well the students understand the use of chemical equations and what they represent.

References:

“An Introduction to Writing Chemical Equations.” *Grand Valley State University, Chemistry Department*. Web.<http://mybb.gvsu.edu/webapps/portal/frameset.jsp?tab_group=courses&url=%2Fwebapps%2Fblackboard%2Fcontent%2FcontentWrapper.jsp%3Fcontent_id%3D_1695423_1%26displayName%3DLinked%2BFile%26course_id%3D_121785_1%26navItem%3Dcontent%26attachment%3Dtrue%26href%3Dhttp%253A%252F%252Ffaculty.gvsu.edu%252Ftanisd%252F>.


Name__________________________________

Sodium and Water Demonstration
8 points total

What do you think will happen when solid sodium is put into water? Why?

Hypothesis:

What did you observe when the sodium was put into the water?

Observations:

In the spaces below, describe the tests that your teacher performed. Include what she did and why she did it. Also include the results of the test (observations).

Description of Test:

Observation:

Description of Test:

Observations:
Sodium and Water Demonstration

8 points total

What do you think will happen when solid sodium is put into water? Why?

(2) Hypothesis: Answers will vary, but student must clearly state what he or she thinks will happen based on scientific reasoning.

What did you observe when the sodium was put into the water?

(2) Observations: Two of the following must be present for full points.

- bubbles formed
- there was no sodium left over after a few seconds
- gas formed in the test tube/ you can see some cloudiness in the test tube where water used to be

In the spaces below, describe the tests that your teacher performed. Include what she did and why she did it. Also include the results of the test (observations).

(1) Description of Test: Student must describe what the teacher did and why she did it. Example: The teacher held a flame near the bottom of the test tube to test for gas. This is known as a flame test.

(1) Observation: Student must describe the results of the flame test: There was a popping or fizzing sound.

(1) Description of Test: Student does not need to use the term phenolphthalein, but must say that the indicator was added to both water and the solution in which sodium was added.

(1) Observations: Student must describe the colors seen in the water and in the solution that the sodium was added to. Example: There was no change to the color of the water, but the solution that sodium was added to went from colorless to pink.
Names:

Balancing Chemical Equations

This worksheet will be a guide to writing a complete balanced chemical equation for the demonstration that you observed. This worksheet will be turned in for 10 points total.

1. The substances initially mixed together by the teacher are the ‘reactants’ of the reaction. Identify the reactants in this demonstration.

Reactants: ___________________________ and ___________________________

2. Your teacher performed a flame test that allows you to identify the gas formed in the upside-down test tube. This gas is one of the ‘products’ of the reaction. Compare your observations with the following information to identify the gas product.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Odor</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>None</td>
<td>Relights a glowing splint</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>None</td>
<td>Makes a ‘popping’ sound with a flame test</td>
</tr>
<tr>
<td>Ammonia</td>
<td>Strong</td>
<td>Turns red litmus paper blue</td>
</tr>
</tbody>
</table>

Identity of the gas product: ___________________________

3. Your teacher added phenolphthalein indicator to both water and the reaction solution. Phenolphthalein makes a basic solution pink. Bases typically have hydroxide (OH) in them. Compare your observations to this information to identify the other product of this reaction.

Identity of the other product: ___________________________
4. Write a word equation for the reaction that took place in the demonstration. Word equations are typically written like this:

\[
\text{Reactant A + Reactant B} \rightarrow \text{Product C + Product D}
\]

Word Equation: ________________________________

5. Write the correct chemical formula for each reactant and product in the chemical reaction.

Chemical Formulas of Reactants: ____________________ and ____________________

Chemical Formulas of Products: ____________________ and ____________________

6. Write an equation for the chemical reaction that replaces the words (#4) with the chemical formulas you made in #5.

    + \rightarrow +

7. We are not done yet! A complete chemical equation that represents a chemical reaction needs to be balanced. To help you balance your chemical equation, we will represent the following elements at the level of a single particle:

   - Sodium □
   - Hydrogen ○
   - Oxygen ●

   Write your chemical equation by representing each compound/element with these particles.

    + + \rightarrow 

8. Do you notice that you don’t have the same number of sodium, hydrogen, and oxygen particles on the reactant side as the product side? Try to see if you can ‘balance’ the number of each particle on both sides of the equation by adding more of the appropriate reactants and products.
9. Count up the number of each reactant and product you drew in #8. These numbers are the ‘coefficients’ in the balanced chemical equation. Coefficients represent the numerical ratio between each species involved in a chemical equation. The coefficient is written before its matching chemical formula of each reactant and product. Write the balanced chemical equation using coefficients and the chemical formulas in the space provided below.

Parentheses are written after the chemical formula for you to indicate the state of matter that each reactant and product was in. In this case, a state of matter is the physical ‘phase’ that a substance is in at room temperature. The state of matter can either be a solid (s), liquid (l), gas (g), or aqueous (aq). Indicate the state of matter of each reactant and product in the provided parentheses. (Hint: aqueous means that the chemical is dissolved in water).
Balancing Chemical Equations

RUBRIC

0.5 points  1. Sodium and water

0.5 points  2. Hydrogen

0.5 points  3. Sodium hydroxide

0.5 points  4. Sodium + water $\rightarrow$ sodium hydroxide + hydrogen

1 point  5. Na and H₂O

NaOH and H₂

1 point  6. Na + H₂O $\rightarrow$ NaOH + H₂

2 points  7. $\Box + \bigcirc \rightarrow \Box \bigcirc + \bigcirc$

2 points  8. $\Box \Box + \bigcirc \bigcirc \rightarrow \Box \bigcirc \Box \bigcirc + \bigcirc$

2 points  9. 2 Na(s) + 2 H₂O(l) $\rightarrow$ 2 NaOH (aq) + H₂ (g)

10 points total
Homework Assignment

Name:

Try to think of a chemical reaction you might see in everyday life or in an industry. Describe the reaction in words, including states of matter, the reactants and products, and where the reaction typically takes place. Draw the chemical reaction at the particulate level. Write a complete balanced chemical equation for the reaction. List any sources you used to obtain the information.

Reaction Description:

Balanced Particulate Drawing:

Balanced Chemical Equation:

Sources:
Homework Assignment Rubric

**Reaction Description:** Student accurately listed all of the reactants and products and their states of matter. The student described the reaction using sentences, including where it occurs or what it is used for. 2 points

**Particulate Representation:** The student accurately drew the balanced chemical reaction at the particulate level. One point for accurately representing each reactant and product at the particulate level. One point for accurately balancing the representation. 2 points

**Balanced Chemical Equation:** 0.5 point for accurately writing the symbolic form of each reactant and product. One point for accurately balancing the equation. 0.5 for accurate states of matter. 2 points
Lesson 3: POGIL: Balancing Chemical Equations

HSCES:

C1.2D Evaluate scientific explanations in a peer review process or discussion format.
C5.2A Balance Simple chemical equations applying the conservation of matter.

Learning Objective:

- TLW actively participate in a group to solve chemical reaction questions.
- TLW identify balanced and unbalanced chemical reactions.
- TLW balance simple chemical reactions using both particulate and symbolic representations.
- TLW write balanced chemical reactions based on word problems.
- TLW predict products of a chemical reaction (homework).

Overview: This lesson plan is designed to give students a deeper understanding of the coefficients in a balanced chemical reaction. It uses a lot of particulate level representations that will help decipher the difference between subscripts and coefficients. The group work also allows students to practice writing balanced equations from word problems. This lesson proceeds after the demonstration lesson plan. It will last two class sessions (one of group work, one for discussion). A reading assignment from the textbook covering the prediction of chemical reactions should be assigned after the discussion of the worksheet. The student will take notes on the reading assignment to be turned in for 6 points.

Lesson: The teacher will inform the students that they will be taking a closer look at balancing chemical equations by working in groups. The teacher will divide students into groups of three to four. The teacher will walk around to each group with the following group member assignments in a hat: manager, strategy analyst, spokesperson, and recorder. In groups of three, the recorder and spokesperson assume the same role. After each group has their assigned roles, the teacher will read the description for each role. These descriptions can also be passed out or listed on an overhead projector so the students can follow along.

Manager: actively participates and keeps the team focused and on the task, distribute work and responsibilities, resolves disputes, and assures that all members participate and understand. Only the manager can ask the instructor a question.

Strategy analyst: actively participates, manages time, identifies strategies and methods for problem solving, and identifies what the team is doing well and what needs improvement in consultation with the others.

Spokesperson: actively participates and reports to the class.

Recorder: actively participates, keeps a record of the assignment and what the team has done.

The teacher will then inform the students that they will have X minutes to complete the worksheet as a group. If the students are not finished, tell them to only do a couple questions from Model 2 Exercise 2. The teacher can walk around and direct student thinking, but should not give students direct answers to their questions. The next day, the spokesperson will report the group findings. The teacher can lead group discussions based on what the spokespeople come up with. The teacher will assign the homework at the end of class. The students will have one night to complete the homework assignment.

Please see attached for the POGIL worksheet and Rubric.

Please see attached for the homework assignment and Rubric.
Assessment:
- If a group worksheet was submitted, it will receive 15 points.
- Reading assignment notes 6 points

Sources:

Balancing Chemical Equations

Why?

Atoms are neither created nor destroyed in a chemical reaction, they are just rearranged. In other words, in a chemical reaction, what goes into the reaction must come out of the reaction. Using this knowledge and some bookkeeping skills, all unbalanced chemical equations can be balanced.

Learning Objective

• Learn the steps to balancing a chemical equation.

Success Criteria

• Demonstrate the ability to balance a chemical reaction.

Prerequisites

• Writing chemical formulas, chemical reaction nomenclature

New Concepts

• Coefficient
• Balanced reaction

Definitions

• In your own words, write definitions of the terms in the New Concepts section.
Model 1

The following figures show the combination of hydrogen and oxygen to produce water.

Illustrations from: http://wps.prenhall.com/wps/media/objects/439/449969/Media_Portfolio/ch10.html

**Figure 1**
1 molecule of hydrogen + 1 molecule of oxygen → 1 molecule of water

**Figure 2**
2 molecules of reactants → 2 molecules of product

**Figure 3**
4 H atoms in reactants → 4 H atoms in products
2 O atoms in reactants → 2 O atoms in products

**Key Questions**

1. In Figure 1 there is one molecule of $\text{H}_2$ and one molecule of $\text{O}_2$ on the left side of the equation and one molecule of $\text{H}_2\text{O}$ on the right. Even though there is 1 of everything, why is this reaction not balanced?

2. In Figure 2 there are two molecules on the left and two molecules on the right. Even though there are 2 on the left and 2 on the right, why is this reaction not balanced?

3. In Figure 3, how many reactant molecules and product molecules are shown in the model?

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4. Does Figure 3 represent a balanced equation? Explain your answer.
5. What condition must be met in order for there to be a balance between reactants and products?

**Exercises:**

1. Write the balanced equation to show the reaction between hydrogen gas and oxygen gas to form water. (Hint: look at the model for guidance.)

2. Identify whether the following is a balanced chemical equation. Explain why or why not. If not, write the balanced equation. \( \text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{O}_2 \)

3. If mercury (Hg) and oxygen \( (\text{O}_2) \) were reacted to form mercury (II) oxide \( (\text{HgO}) \), how many molecules of each reactant and product would be needed to balance the equation?
**Information:**

Figure 4 below illustrates the Haber process, a method (reaction) used to produce ammonia that was developed during World War I. When the Allies blocked off all trade routes going to and from Germany, the Germans lost access to their source of sodium nitrate and potassium nitrate which were needed to make explosives. In response to the need for a source of nitrates, chemist Fritz Haber developed what is now known as the Haber Process, which combines molecular nitrogen from the air with molecular hydrogen to form ammonia gas. (Note: air is 78% nitrogen, so this synthesis is very clever because air is free and abundant.). Using the Haber Process the Germans had an uninterrupted source of nitrogen in a form that could be used to make the nitrates needed for explosives. ([http://haberchemistry.tripod.com/](http://haberchemistry.tripod.com/))

**Model 2**

![Figure 4 showing the reaction between hydrogen and nitrogen to produce ammonia.](image)

*Fig. 4*

*Figure 4* shows the reaction between hydrogen and nitrogen to produce ammonia.

**Key Questions**

1. Describe what is depicted in the first diagram shown at the top of Figure 4.

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2. Does the first diagram at the top of Figure 4 represent a balanced chemical equation? Why or why not? Explain your reasoning in terms the type and number of each atom present.

3. Describe what is depicted in the second diagram shown in the middle of Figure 4.

4. Does the second diagram in the middle of Figure 4 represent a balanced chemical equation? Why or why not? Explain your reasoning in terms the number and type of each atom present.

5. Describe what is depicted in the third diagram shown at the bottom of Figure 4.

6. Does the third diagram at the bottom of Figure 4 represent a balanced chemical equation? Why or why not? Explain your reasoning in terms the number and type of each atom present.

**Exercises:**

1. Write a balance reaction equation for hydrogen reacting with nitrogen to produce ammonia.

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2. Using the smallest whole number coefficients, balance the following reactions. Draw diagrams like those in Figure 4 for Equations a, b, and f.

a. \( \_ \text{HgO} \rightarrow \_ \text{Hg} + \_ \text{O}_2 \)

b. \( \_ \text{Fe} + \_ \text{O}_2 \rightarrow \_ \text{Fe}_2\text{O}_3 \)

c. \( \_ \text{KClO}_3 \rightarrow \_ \text{KCl} + \_ \text{O}_2 \)

d. \( \_ \text{Ca(OH)}_2 + \_ \text{H}_2\text{SO}_4 \rightarrow \_ \text{HOH} + \_ \text{CaSO}_4 \)

e. \( \_ \text{Cu} + \_ \text{AgNO}_3 \rightarrow \_ \text{Cu(NO}_3\text{)}_2 + \_ \text{Ag} \)

f. \( \_ \text{C}_6\text{H}_6 + \_ \text{O}_2 \rightarrow \_ \text{CO}_2 + \_ \text{H}_2\text{O} \)

Problems
Write the formulas for the components in each reaction and, using the smallest whole number coefficients, balance each equation.

1. Zinc metal reacts with hydrochloric acid to produce hydrogen gas and aqueous zinc chloride.

2. Solid carbon reacts with oxygen gas to produce carbon dioxide gas.

3. Solid sodium chloride is broken down into its elements.
Balancing Chemical Equations

Why?
Atoms are neither created nor destroyed in a chemical reaction, they are just rearranged. In other words, in a chemical reaction, what goes into the reaction must come out of the reaction. Using this knowledge and some bookkeeping skills, all unbalanced chemical equations can be balanced.

Learning Objective
• Learn the steps to balancing a chemical equation.

Success Criteria
• Demonstrate the ability to balance a chemical reaction.

Prerequisites
• Writing chemical formulas, chemical reaction nomenclature

New Concepts
• Coefficient
• Balanced reaction

Definitions
• In your own words, write definitions of the terms in the New Concepts section.

Coefficient - The smallest number that can be placed in front of a reactant or product in a chemical reaction to ensure the total number and type of atom is balanced (equal) across the chemical change.

Balanced Reaction: Symbolic method of expressing a chemical change using formulas and coefficients to ensure matter is conserved across the change.

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Written by Bryan Horan
Edited by Linda Padwa and David Hanson, Stony Brook University
Model 1

The following figures show the combination of hydrogen and oxygen to produce water.
Illustrations from: http://wps.prenhall.com/wps/media/objects/439/449969/Media_Portfolio/ch10.html

\[
\begin{array}{c|c}
\text{H} & \text{O} \\
\text{H} & \text{O} \\
\end{array}
\]

**Figure 1**

1 molecule of hydrogen + 1 molecule of oxygen \(\rightarrow\) 1 molecule of water

\[
\begin{array}{c|c}
\text{H} & \text{O} \\
\text{H} & \text{O} \\
\end{array}
\]

**Figure 2**

2 molecules of reactants \(\rightarrow\) 2 molecules of product

\[
\begin{array}{c|c}
\text{H} & \text{O} \\
\text{H} & \text{O} \\
\end{array}
\]

**Figure 3**

4 H atoms in reactants \(\rightarrow\) 4 H atoms in products
2 O atoms in reactants \(\rightarrow\) 2 O atoms in products

**Key Questions**

1. In Figure 1 there is one molecule of \(\text{H}_2\) and one molecule of \(\text{O}_2\) on the left side of the equation and one molecule of \(\text{H}_2\text{O}\) on the right. Even though there is 1 of everything, why is this reaction not balanced?
   
   \[\text{The number of atoms is not conserved.}\]

2. In Figure 2 there are two molecules on the left and two molecules on the right. Even though there are 2 on the left and 2 on the right, why is this reaction not balanced?
   
   \[\text{The number of atoms is not conserved.}\]

3. In Figure 3, how many reactant molecules and product molecules are shown in the model?
   
   3 reactant molecules, 1 product molecule

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2/6
4. Does Figure 3 represent a balanced equation? Explain your answer.

Yes because the total # of atoms is conserved.

5. What condition must be met in order for there to be a balance between reactants and products?

The total number and type of atoms must be conserved.

Exercises:

1. Write the balanced equation to show the reaction between hydrogen gas and oxygen gas to form water. (Hint: look at the model for guidance.)

\[ 2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{g}) \]

2. Identify whether the following is a balanced chemical equation. Explain why or why not. If not, write the balanced equation.

\[ \text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{O}_2 \]

No: Because total # atoms not conserved.

\[ 2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2 \]

3. If mercury (Hg) and oxygen (O₂) were reacted to form mercury (II) oxide (HgO), how many molecules of each reactant and product would be needed to balance the equation?

\[ \frac{2 \text{ Hg}}{2 \text{ O}} \rightarrow 2 \text{HgO} \]

Two atoms of Hg, one molecule of O₂.

Yield two formula unit of HgO.
**Information:**

*Figure 4* below illustrates the Haber process, a method (reaction) used to produce ammonia that was developed during World War I. When the Allies blocked off all trade routes going to and from Germany, the Germans lost access to their source of sodium nitrate and potassium nitrate which were needed to make explosives. In response to the need for a source of nitrates, chemist Fritz Haber developed what is now known as the Haber Process, which combines molecular nitrogen from the air with molecular hydrogen to form ammonia gas. (Note: air is 78% nitrogen, so this synthesis is very clever because air is free and abundant.) Using the Haber Process the Germans had an uninterrupted source of nitrogen in a form that could be used to make the nitrates needed for explosives. ([http://haberchemistry.tripod.com/](http://haberchemistry.tripod.com/))

**Model 2**

*Figure 4* shows the reaction between hydrogen and nitrogen to produce ammonia.

![Diagram of Haber process](image)

**Key Questions**

1. Describe what is depicted in the first diagram shown at the top of Figure 4.

   One molecule of hydrogen and one molecule of nitrogen are reactants. The product is one molecule of ammonia.
2. Does the first diagram at the top of Figure 4 represent a balanced chemical equation? Why or why not? Explain your reasoning in terms the type and number of each atom present.

No - Because the number and type of atoms are not conserved.

3. Describe what is depicted in the second diagram shown in the middle of Figure 4.

Reactant: 2 molecules of N₂ and 1 molecule of H₂.
Product: 2 molecules of NH₃

4. Does the second diagram in the middle of Figure 4 represent a balanced chemical equation? Why or why not? Explain your reasoning in terms the number and type of each atom present.

No. The type of atom is conserved, but the number is not. There are only 2 atoms of H and 2 atoms of N on left. While there are 2 atoms of N on right.

5. Describe what is depicted in the third diagram shown at the bottom of Figure 4.

3 H₂, 1 N₂ and 2 NH₃

The reaction has been balanced.

6. Does the third diagram at the bottom of Figure 4 represent a balanced chemical equation? Why or why not? Explain your reasoning in terms the number and type of each atom present.

Yes, because the number and type of atom are conserved.

Exercises:

1. Write a balance reaction equation for hydrogen reacting with nitrogen to produce ammonia.

\[ 3 \text{H}_2 + \text{N}_2 \rightarrow 2 \text{NH}_3 \]
2. Using the smallest whole number coefficients, balance the following reactions. Draw diagrams like those in Figure 4 for Equations a, b, and f.

a. $2\, \text{HgO} \rightarrow 2\, \text{Hg} + 1\, \text{O}_2$

b. $\frac{1}{4}\, \text{Fe} + \frac{3}{2}\, \text{O}_2 \rightarrow 2\, \text{Fe}_2\text{O}_3$

d. $\frac{1}{2}\, \text{Ca(OH)}_2 + \frac{1}{2}\, \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O}$

e. $\frac{1}{2}\, \text{Cu} + 2\, \text{AgNO}_3 \rightarrow \frac{1}{2}\, \text{Cu(NO}_3)_2 + 2\, \text{Ag}$

f. $2\, \text{C}_2\text{H}_6 + 7\, \text{O}_2 \rightarrow 4\, \text{CO}_2 + 6\, \text{H}_2\text{O}$

---

Problems

Write the formulas for the components in each reaction and, using the smallest whole number coefficients, balance each equation.

1. Zinc metal reacts with hydrochloric acid to produce hydrogen gas and aqueous zinc chloride.

   $\text{Zn(s)} + 2\, \text{HCl(aq)} \rightarrow \text{H}_2(g) + \text{ZnCl}_2$

2. Solid carbon reacts with oxygen gas to produce carbon dioxide gas.

   $\text{C(s)} + \text{O}_2(g) \rightarrow \text{CO}_2(g)$

3. Solid sodium chloride is broken down into its elements.

   $2\, \text{NaCl(s)} \rightarrow 2\, \text{Na}(s) + \text{Cl}_2(g)$
Homework Rubric

6 points total

The teacher should assign a part of the textbook covering predicting chemical reactions. The students will take notes and submit these notes for review. The notes will be graded on:

Completion 2 points: the notes summarize the main ideas of the text

Examples 2 points: the notes include examples to add to the text’s summary

Organization 2 points: the organization of the notes is easy to follow
Lesson 4: Technology Lesson Plan: Reactants, Products, and Leftovers

OVERVIEW: This lesson aims to help students understand the roles of coefficients in a balanced chemical equation as ratios that dictate the quantitative relationships of reactants and products in a reaction. It acts as a prelude to molar ratios, stoichiometry, and limiting/excess reagents. This lesson takes about one class period.

This lesson plan requires the use of laptops/computers. The teacher should set a strict rule for those who abuse their computer privileges. The worksheet will guide the students through the simulation, but the teacher needs to walk around and answer questions/monitor online activity. Each student will submit a worksheet, but the students may discuss their thoughts and answers with one another. After the worksheet is finished, the students are instructed to play a game. If students reach a certain point quota, they get a prize (such as candy). The teacher should make sure the student really reached this score. For homework, the student will need to complete the pre-lab assignment (see the Laboratory Lesson Plan for this assignment).

HSCES:

P5.p1 Conservation of Matter
C5.2e Identify the limiting reagent when given the masses of more than one reactant.

The students will learn the concept of limiting reagent, but calculations will not be performed yet.

LEARNING OBJECTIVES:

✓ TLW demonstrate the Law of Conservation of Matter through a balanced chemical equation.
✓ TLW define a limiting and excess reagent
✓ TLW identify the limiting reagent and the excess reagent in a given chemical equation.
✓ TLW explain why a chemical equation does not change based on how many reactants are available.
✓ TLW report the number of product molecules that can be made from a given number of reactant molecules.

MATERIALS: Each student needs to have a laptop or computer. Students may work in pairs if not enough computers are available. The teacher also needs prizes (such as candy).

MISCONCEPTIONS: Both reactants turn completely into product regardless of the proportions (Gauchon and Méheut, 2007), using a molar ratio equal to one regardless of the chemical equation (Coll et al. 2007), and claiming the limiting reactant is the compound with the smallest coefficient in the balanced equation (Chandrasegaran et al. 2009).

REFERENCES:


Reactants, Products, and Leftovers
20 points

Go to: http://phet.colorado.edu/en/simulation/reactants-products-and-leftovers
Click Run Now! You should see something like this:

Answer the following questions using this simulation. You may work with others, but you will be submitting your own worksheet.

1. Your friends are coming over after school, and they are STARVING! Luckily, you just went grocery shopping and have cheese, meat, and bread available for sandwiches. Your friends request a sandwich with one slice of cheese and two slices of meat. Use the boxes next to the ingredients on the top of the simulation to balance your ‘sandwich reaction.’ Write your balanced reaction below.

2. You, Mariah, Lee want sandwiches. You open up all of the ingredients packages and see you have 6 slices of bread, 9 meat slices, and 4 cheese slices. How many sandwiches can you make? Will everyone get a sandwich?
3. As you are making your sandwiches, Jack comes over. He asks for a sandwich. Explain why he cannot have a sandwich. Identify the amount and identity of ingredients you still have and the ingredients you don’t have. (Poor Jack!)

4. Look up ‘limiting reagent’ and ‘excess reagent’ using Google or your textbook. Define these terms below IN YOUR OWN WORDS.

5. Identify the limiting reagent(s) and excess reagent(s) from your sandwich ‘reaction.’ Explain how you identified these reagents.

---

Now click the Real Reaction tab. You should be making water. Answer the following questions:

1. How many molecules of water and oxygen are needed to form 2 molecules of water?
   
   ____ molecules of water _____ molecules of oxygen

2. If you have 6 molecules of hydrogen, how many molecules of water can you make? How many molecules of oxygen does this require?

   6 molecules of hydrogen REQUIRES _____ molecules of oxygen TO MAKE _______ molecules of water

3. If you only have 2 molecules of oxygen and 6 molecules of hydrogen, how many molecules of water can be made?

   _____ molecules of water
4. Do you have a limiting and/or excess reagent? If so, identify them and explain why you chose them.

5. Based on your answers to questions 3 and 4, does your chemical equation change? Why or why not?

6. Your friend leans in and says the limiting reagent in question 3 is oxygen because it has the smallest coefficient in the balanced equation. How do you respond? Explain.

When you are finished, click the Game tab. If you can get 10 points on the first level, come up and get a prize! If you get 10 points on level 2, come up and get an even better prize!

DISCLAIMER: To redeem your prize, I must see your total score.
Reactants, Products, and Leftovers Rubric
20 points

1. Your friends are coming over after school, and they are STARVING! Luckily, you just went grocery shopping and have cheese, meat, and bread available for sandwiches. Your friends request a sandwich with one slice of cheese and two slices of meat. Use the boxes next to the ingredients on the top of the simulation to balance your ‘sandwich reaction.’ Write your balanced reaction below.1 point

\[ 2 \text{ bread slices} + 2 \text{ meat slices} + 1 \text{ cheese slice} \rightarrow 1 \text{ sandwich} \]

2. You, Mariah, Lee want sandwiches. You open up all of the ingredients packages and see you have 6 slices of bread, 9 meat slices, and 4 cheese slices. How many sandwiches can you make? Will everyone get a sandwich?1 point

Yes, three sandwiches.

3. As you are making your sandwiches, Jack comes over. He asks for a sandwich. Explain why he cannot have a sandwich. Identify the amount and identity of ingredients you still have and the ingredients you don’t have. (Poor Jack!)1 point

There is not enough bread or cheese to make another sandwich. I have two slices of meat and one slice of cheese, but I don’t have any bread left.

4. Google ‘limiting reagent’ and ‘excess reagent.’ Define these terms below IN YOUR OWN WORDS.1 point

Limiting reagent: is completely consumed in a chemical reaction. Limits how much product can form. Excess reagent: is not completely consumed in a chemical reaction. There is still some left over after the reaction is done.

5. Identify the limiting reagent(s) and excess reagent(s) from your sandwich ‘reaction.’ Explain how you identified these reagents.2 points

The bread is the limiting reagent because we used it all to make those three sandwiches. The excess reagents were the cheese and meat slices because there is some left over after we made sandwiches.

Now click the Real Reaction tab. You should not be making water. Answer the following questions:

1. How many molecules of hydrogen and oxygen are needed to form 2 molecules of water?1 point

\[ \_\_2\_ \text{ molecules of water} \hspace{1cm} \_\_1\_ \text{ molecule of oxygen} \]

2. If you have 6 molecules of hydrogen, how many molecules of water can you make? How many molecules of oxygen does this require?2 points

\[ 6 \text{ molecules of hydrogen REQUIRES } \_\_3\_ \text{ molecules of oxygen TO MAKE } \_\_6\_ \text{ molecules of water} \]
3. If you only have 2 molecules of oxygen and 6 molecules of hydrogen, how many molecules of water can be made?  

   __4__ molecules of water

4. Do you have a limiting and/or excess reagent? If so, identify them and explain why you chose them.  

   The oxygen is the limiting reagent because it was completely used to make 4 molecules of water. Because there are two molecules of hydrogen left over, hydrogen is the limiting reagent.

5. Based on your answers to questions 3 and 4, does your chemical equation change? Why or why not?  

   The chemical equation does not change because it tells us the ratios of how many reactants are needed to make a certain amount of product. These ratios are in their simplest form and do not change no matter how many reactants are available.

6. Your friend leans in and says the limiting reagent in question 3 is oxygen because it has the smallest coefficient in the balanced equation. How do you respond? Explain.  

   I tell him that he is wrong because it depends on both the coefficients in the chemical equation and the amount of reagents available.
Lesson 5: Experiment: Exploring Chemical Reactions

Overview: In this lesson, students will design procedures to run specific chemical reactions, observe/collect evidence that a chemical reaction has occurred, identify products of a chemical reaction, balance chemical equations, and to identify the type of reaction. This laboratory lesson may take place over the course of three days (depends on how long class periods are and student abilities).

Students should know what the evidence is that a reaction has occurred and how to balance chemical equations. The students will have a broad sense of how to identify acids and bases from the demonstration lesson plan (using indicator). The newest material to the students should be identifying what type of reaction has occurred. This lesson is designed to introduce this topic. This lesson follows the POGIL worksheet.

Before the students start the lab, they need to have completed the pre-lab questions. This will jump start their ideas on how to go about designing the procedure. This pre-lab worksheet should be done as homework and handed in for an individual grade.

The students should be arranged in groups of three to four. Stations should already be set up for the students (see materials). The teacher should explain what the lab is about and the tasks the students must complete. The teacher will then demonstrate station 5 for the students, so the students have a better understanding of how to go about designing procedures. They must decide on the steps to run the reaction and what evidence to collect to provide evidence that a reaction has occurred. They must identify the species in the reaction using evidence. The students will then balance equations based on the reactions and classify the reactions (single replacement, combustion, etc.). Each group will then come up with a short presentation on their procedure, results, and conclusions for one station (they will be assigned this station so each station will be reported on). The students will also give another group feedback. It is advised that the presentations come the lesson after the laboratory lesson to allow students time to prepare.

HSCEs:

- C1.1D Identify patterns in data and relate them to theoretical models.
- C1.1E Describe a reason for a given conclusion using evidence from an investigation.
- C1.1h Design and conduct a systematic scientific investigation that tests a hypotheses.
- C1.2D Evaluate scientific explanations in a peer review process or discussion format.
- C5.2A Balance simple chemical equations applying the conservation of matter.
- C5.2B Distinguish between chemical and physical changes in terms of the properties of the reactants and products.

Learning Objectives:

- TLW design a procedure to run a chemical reaction in order to identify the species in the reaction.
- TLW determine if a chemical change has occurred based on evidence.
- TLW predict products of a chemical reaction based on evidence from a chemical reaction.
- TLW balance simple chemical equations.
- TLW identify types of reactions.
- TLW develop chemical equation patterns based on the type of reaction.

Misconception: Students fail to consider the role of ‘invisible gases’ as reactants (or possibly products) in a chemical reaction (Hesse et al., 1992). An example of this will be considered in the reaction of iron (steel wool) and oxygen.
**Materials/ Safety:** Solid calcium, tap water, steel wool (iron), 1M HCl, 1M NaOH, copper (II) sulfate, sodium chloride, iron (III) sulfate, sodium phosphate, solid ammonium carbonate, Bunsen burners, tongs, petri dishes, matches, test tubes, bromothymol blue indicator, lab scale

The lab will be set up in five different stations (for five different types of chemical reactions). All disposal techniques follow Flinn.

**Supplies of Station 1:**
Solid calcium: contact with water or moisture evolved flammable hydrogen. Flammable in finely divided form. Avoid contact with oxidizers. Skin irritant. Disposal #3 *(Students will put the contents of this station into a waste container labeled ‘Station 1 Calcium Waste.’)*
Test tubes
*Matches: dispose of in match container*

**Reagent/ supplies for Station 2:**
Iron (steel wool): disposal in trash.
Bunsen burner/ Tongs/ Matches: *dispose of in match container.*

**Reagent and indicators of Station 3A:**
Hydrochloric acid solution: toxic by ingestion of inhalation. Severely corrosive to skin and eyes.
Sodium hydroxide solution: corrosive liquid. Skin burns are possible; very dangerous to eyes. Wear gloves.
Bromthymol blue indicator solution:
*Substances can go down the drain.*
Prepare these solutions into drop bottles.

**Reagents* and products of station 3B.** All (except copper (II) phosphate) will be disposed of according to #26B (Flynn).
Petri dishes
*Copper (II) sulfate solution: skin and respiratory irritant, moderately toxic by ingestion and inhalation. Disposal #26b
Copper (II) phosphate: product of station 3B; disposal #26a
Iron (III) chloride solution: may be skin and body tissue irritant. Disposal #26b
Iron (III) phosphate: solid product of station 3B, disposal #26b
*Sodium chloride solution: slightly toxic by ingestion. Disposal #26b
Sodium sulfate: product of station 3B: #26b
*Sodium phosphate monobasic solution: disposal #26B
*Prepare all these solutions into drop bottles.
*Students will dispose of the contents of the Petri dishes into a waste container labeled ‘Station 3, iron & copper waste.’*

**Reagents and materials for Station 4:**
Ammonium carbonate (solid): disposal #26a
Bunsen burner
*Matches (dispose of in match container)*
Lab scale
*Students should not have any ammonium carbonate left (decomposition).*

**Materials for station 5 (teacher demonstration):**
Bunsen burner
*Matches (dispose of in match container)*
Beaker
Cold water

References:
1. List the possible signs (at least 3) that a chemical reaction has occurred.

2. What five molecules is air mostly composed of? (It is okay to look this up).

3. You just made a gas in the lab, but you are unsure what gas it is. What test might you perform to identify this gas? Construct a table of how you would identify carbon dioxide, oxygen, hydrogen, and ammonia gas.

4. How can you identify an acidic or basic solution?
Station 5 Teacher Demonstration Instructions

Say: What do you think will happen when methane gas and oxygen gas burn? What do you think the products will be? Why do you think this? Write down your answers.

Say: How would you run this reaction with the materials listed? Guide their thinking to say that you have a source of methane gas and that oxygen is in the atmosphere. Ask them how the reaction may get started (using a match). Light the Bunsen burner. Say: How do I know a chemical reaction is occurring? Guide the students to think that heat is being produced. Say: What can I do to identify the products of the reaction? Think about what you predicted to be the products. Guide the students to think that water is being formed. But it is a gas. Guide them to think that the gas can be condensed using a beaker of cold water. Wave the flame near the outside of the cold beaker. Say: what do you notice when I do this? Students should say condensation. Go through balancing the reaction with the students, classifying it, and coming up with a pattern.
Exploring Types of Chemical Reactions

In this lab, you will be performing various chemical reactions. Your goal is to write and classify chemical equations that represent each chemical reaction you do. You will then assign a reaction type to each equation. Each group will be assigned one station (or substation) on which you will be presenting to the class. This lab will take three days.

These are the reactions that you will be performing:

Station 1: calcium + water →
Station 2: iron (steel wool) + air → iron (III) oxide
Station 3a: hydrochloric acid + sodium hydroxide →
Station 3b: copper (II) sulfate + sodium chloride → iron (III) sulfate + sodium chloride →
Station 3b: copper (II) sulfate + sodium phosphate →
Station 3b: iron (III) sulfate + sodium phosphate →
Station 4: ammonium carbonate →
*Station 5: methane + air →
*Station 5 is a teacher demonstration. We will do this together.

Day One: For each station, you must design a procedure to do the following:
- Perform the chemical reaction
- Collect evidence that a chemical reaction took place (if it really does take place)
- Identify the products (or reactants) of the chemical reaction and their states of matter
*Don’t neglect to make predictions about the products of the reactions.

Day Two: With this gathered information you will do the following:
- Perform the experiment.
- Write complete balanced chemical equations for each reaction
- Classify each reaction according to its type (use your textbook as a reference)
- Create a general pattern for each reaction type

Day Three:
- Present to the class your predictions, brief procedure, results, conclusions for one assigned station
- Evaluate another group’s presentation.

You may work in groups of three to four. Hand in one report for the entire group. Write in pencil only. Make sure to answer all questions/sections thoroughly. If you run out of room, you may use an extra piece of loose leaf. Wear goggles at all times. If you use matches, dispose of them in the proper container. Your teacher will discuss proper disposal of materials from certain stations. Keep in mind that you will have access to a laboratory scale. It will be wise to design your procedures first, and then check with the teacher before continuing.
**Points:** 5 from pre-lab worksheet, 6 points per station, 10 points for presentation, 5 points for presentation feedback
Station 1: calcium + water → ?

Prediction: What do you think will happen when you mix calcium and water? What products do you think you will make if a chemical reaction has occurred?

Supplies: tap water, test tubes, small pieces of calcium metal, matches

Procedure: (Include how you will perform the chemical reaction, what data you will collect and when, and how you will identify the products (or reactants) of the chemical reaction.

Data and Observations:

Did your results match your prediction? Explain any differences.

Complete chemical equation:

Reaction Type:

Reaction type pattern:
Station 2: \( \text{iron} + \text{air} \rightarrow \text{iron (III) oxide} \)

**Prediction:** What do you think will happen when you iron reacts with air? What compound in the air do you think iron is reacting with?

**Supplies:** steel wool (iron), Bunsen burner, tongs, matches

**Procedure:** (Include how you will perform the chemical reaction and what data you will collect and when. You do not need to perform an identification test for this station, but you will need to make a guess as to what that reactant from air is).

**Data and Observations:**

Did your results match your prediction? Explain.

**Complete chemical equation:**

**Reaction Type:**

**Reaction type pattern:**
Station 3a:  hydrochloric acid  +  sodium hydroxide  \rightarrow  ?

**Prediction:** What do you think will happen when you mix hydrochloric acid and sodium hydroxide? What do you think the products are?

**Supplies:** 1 M hydrochloric acid, 1 M sodium hydroxide, test tubes, bromothymol blue

**Procedure:** (Include how you will perform the chemical reaction and what data you will collect and when. To identify the products, consider the types of reactions you wrote about in your prelab).

**Data and Observations:**

Did your results match your prediction? Explain.

**Complete chemical equation:**

**Reaction Type:**

**Reaction type pattern:**
Station 3b:

- Copper (II) sulfate + sodium chloride
- Iron (III) sulfate + sodium chloride
- Copper (II) sulfate + sodium phosphate
- Iron (III) sulfate + sodium phosphate

**Prediction:** In general, what do you think will be the result of each of these reactions?

**Supplies:** petri dish, sodium phosphate, sodium chloride, copper (II) sulfate, iron (III) sulfate

**Procedure:** (Include how you will perform the chemical reaction and what data you will collect and when. To identify the products and their states of matter, use the attached table. If you are unsure on how to use the table, please see the teacher!)

**Data and Observations:**
Did your results match your prediction? Explain.
Complete chemical equations:

Reaction Type:

Reaction type pattern:
Station 4: ammonium carbonate

**Prediction:** In general, what do you think will happen when you perform this reaction? What do you think the products will be?

**Supplies:** solid ammonium carbonate, test tube, Bunsen burner, tongs

**Procedure:** (Include how you will perform the chemical reaction and what data you will collect and when. Also include how you plan on identifying the products formed. Hint: Carbon dioxide gas is one of the products).

**Data and Observations:**

**Did your results match your prediction? Explain.**

**Complete chemical equation:**

**Reaction Type:**

**Reaction type pattern:**
Station 5: methane + air → ?

WE WILL DO THIS TOGETHER!

Prediction: In general, what do you think will be the result of reach of these reactions? What might the products be?

Supplies: Bunsen burner, match, beaker, cold water

Procedure: (Include how you will perform the chemical reaction and what data you will collect and when. Hint: this reaction makes the flame that comes from the Bunsen burner. Include how you will identify one of the products of this reaction).

Did your results match your prediction? Explain.

Complete chemical equation:

Reaction Type:

Reaction type pattern:
Group Presentation

Assigned Station_______

10 points total: You will report to the class your procedure, results, and conclusions of the station to which you were assigned. This presentation should be around 5 minutes. Each group member must speak during the presentation. You will be graded on the following:

- Including all of the relevant information
  - Procedure:
    - steps taken to perform the reaction
    - evidence you collected to confirm a reaction occurred
    - Steps you took to identify the products (when applicable)
  - Results:
    - Did a reaction occur?
    - Identify all species in the chemical reaction
    - Balanced chemical equation
    - Type of reaction
  - Conclusions:
    - What pattern did you come up with to describe this type of chemical reaction?
    - Give an example of this type of chemical reaction in everyday life or industry.

- Oral clarity/presentation skills
  - Did you talk loud enough, clear enough, slow enough?

- Organization
  - Was your presentation easy to follow?

5 points total: You will also be reviewing another group’s presentation using the same rubric as above. The quality of your feedback to your fellow classmates will be evaluated for a grade. Point out the parts you liked and the parts that needed work (using constructive criticism). Your feedback will be given to the group, but you will remain anonymous. That means only I will know who wrote what.

Assigned group to review ________
Group Presenting: __________________________

• Including all of the relevant information:
  o Procedure:
    ▪ steps taken to perform the reaction
    ▪ evidence you collected to confirm a reaction occurred
    ▪ Steps you took to identify the products (when applicable)

Comments:

  o Results:
    ▪ Did a reaction occur?
    ▪ Identify all species in the chemical reaction
    ▪ Balanced chemical equation
    ▪ Type of reaction

Comments:

  o Conclusions:
    ▪ What pattern did you come up with to describe this type of chemical reaction?
    ▪ Give an example of this type of chemical reaction in everyday life or industry.

Comments:

• Oral clarity/ presentation skills
  o Did you talk loud enough, clear enough, slow enough?

Comments:

• Organization
  o Was your presentation easy to follow?

Comments:
Name: Rubric

Pre-lab Questions
Suggested Total Number of Points: 5

1. List the possible signs that a chemical reaction has occurred. **One point**

   Must list at least three examples. Examples include gas formation, color change, precipitation, change in temperature.

2. What five molecules is air mostly composed of? (It is okay to look this up). **One point**

   Nitrogen, oxygen, argon, carbon dioxide, helium

3. You just made a gas in the lab, but you are unsure what gas it is. What test might you perform to identify this gas? Construct a table of how you would identify carbon dioxide, oxygen, hydrogen, and ammonia gas. **Two points**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Odor</th>
<th>Flame Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>None</td>
<td>Flame goes out and makes a whistling ‘pop’ sound</td>
</tr>
<tr>
<td>Oxygen</td>
<td>None</td>
<td>Flame grows brighter</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>None</td>
<td>Flame goes out</td>
</tr>
<tr>
<td>Ammonia</td>
<td>Strong</td>
<td>Flame goes out</td>
</tr>
</tbody>
</table>

4. How can you identify an acidic or basic solution? **One point**

   You can use an indicator to see if the color changes.
Exploring Chemistry Equations Lab Hand-In Rubric

Suggested: Each station is worth 6 points

Station One:

Prediction: Students made a logical prediction (including what products would form) based on previous experiences or scientific reasoning.

Procedure: Students designed a procedure to perform the reaction (amounts of reagents, what lab utensils they will use, etc.) included what data to collect and when, and steps were taken to identify the products of the reaction (flame test). The student was detailed enough so someone else in the class could follow the procedure. The procedure followed a chronological order.

Data: Students collected data needed to confirm a chemical reaction occurred (formation of gas, the calcium was gone by the end) and to identify the products of the reaction as hydrogen gas and calcium hydroxide.

Did your results match your prediction? Explain. Students explain how their predictions may or may not have matched their results. If they did not match, they explained why their prediction was wrong with scientific reasoning.

Complete chemical equation: Ca (s) + 2 H₂O (l) → >Ca(OH)₂ (aq) + H₂ (g)

Reaction type: single replacement

Reaction type pattern. A single element reacts with a compound to form another element (in this case it was diatomic hydrogen gas) and a compound. X + YZ → XZ + Y

Station 2:

Prediction: Students made a logical prediction (including what products would form) based on previous experiences or scientific reasoning. The student predicted what gas might be reacting with iron.

Procedure: Students designed a procedure to perform the reaction (amounts of reagents, what lab utensils they will use, etc.) included what data to collect and when. Student was detailed enough so someone else in the class could follow the procedure. The procedure followed a chronological order.

Data: Students collected data needed to confirm a chemical reaction occurred (color change, change in strength of steel wool).

Did your results match your prediction? Explain. Students explain how their predictions may or may not have matched their results. If they did not match, they explained why their prediction was wrong with scientific reasoning.

Complete chemical equation: 4Fe (s) + 3 O₂ (g) → 2 Fe₂O₃ (s)

Reaction type: synthesis or combination

Reaction type pattern. Multiple reactants combine to form one product. X + Y → XY
Station 3A:

**Prediction:** Students made a logical prediction (including what products would form) based on previous experiences or scientific reasoning. Students guessed what the products might be.

**Procedure:** Students designed a procedure to perform the reaction (amounts of reagents, what lab utensils they will use, etc.) included what data to collect and when, and steps were taken to identify the products of the reaction. The student must have included the use of an indicator. The student was detailed enough so someone else in the class could follow the procedure. The procedure followed a chronological order.

**Data:** Students collected data needed to confirm a chemical reaction occurred (color change based on the indicator) and to identify the products of the reaction as sodium chloride and water.

**Did your results match your prediction? Explain.** Students explain how their predictions may or may not have matched their results. If they did not match, they explained why their prediction was wrong with scientific reasoning.

**Complete chemical equation:** \( \text{HCl (aq)} + \text{NaOH (aq)} \rightarrow \text{H}_2\text{O (l)} + \text{NaCl (aq)} \)

**Reaction type:** double replacement neutralization

**Reaction type pattern.** An acid reacts with a base to form a salt and water.

\[ \text{HA} + \text{BOH} \rightarrow \text{H}_2\text{O} + \text{AB} \]

---

Station 3B:

**Prediction:** Students made a logical prediction (including what products would form) based on previous experiences or scientific reasoning. They included what they thought would result when mixing the two reactants together.

**Procedure:** Students designed a procedure to perform the reaction (amounts of reagents, what lab utensils they will use, etc.) included what data to collect and when, and steps were taken to identify the products of the reaction (use of the table). The student was detailed enough so someone else in the class could follow the procedure. The procedure followed a chronological order.

**Data:** Students collected data needed to confirm a chemical reaction occurred (precipitate formed, cloudiness) and to identify the products of the reactions as solid copper (II) phosphate, sodium sulfate, sodium chloride, solid iron (III) phosphate. The student identified that nothing occurred in the first two reactions.

**Did your results match your prediction? Explain.** Students explain how their predictions may or may not have matched their results. If they did not match, they explained why their prediction was wrong with scientific reasoning.

\[ 3 \text{CuSO}_4\text{aq} + 2 \text{Na}_3\text{PO}_4\text{aq} \rightarrow \text{Cu}_3(\text{PO}_4)_2(\text{s}) + 3 \text{Na}_2\text{SO}_4(\text{aq}) \]

**Complete chemical equations:**

\[ \text{FeCl}_3\text{aq} + \text{Na}_3\text{PO}_4\text{aq} \rightarrow \text{FePO}_4(\text{s}) + 3 \text{NaCl (aq)} \]

**Reaction type:** double replacement precipitation

**Reaction type pattern.** Two water soluble compounds make at least one insoluble ionic compound. \( \text{XD (aq)} + \text{YZ (aq)} \rightarrow \text{XZ} + \text{YD (s)} \)

---

Station 4:
Prediction: Students made a logical prediction (including what products would form) based on previous experiences or scientific reasoning. They included what they thought the products would be.

Procedure: Students designed a procedure to perform the reaction (amounts of reagents, what lab utensils they will use, etc.) included what data to collect and when, and steps were taken to identify the products of the reaction. The student was detailed enough so someone else in the class could follow the procedure. The procedure followed a chronological order.

Data: Students collected data needed to confirm a chemical reaction occurred (gas formation) and to identify the products of the reaction (flame test, noted condensation, smelly odor, maybe a loss of mass).

Did your results match your prediction? Explain. Students explain how their predictions may or may not have matched their results. If they did not match, they explained why their prediction was wrong with scientific reasoning.

Complete chemical equations: \((\text{NH}_3)_2\text{CO}_3 (s) \rightarrow 2\text{NH}_3 (g) + \text{H}_2\text{O} (g) + \text{CO}_2 (g)\)

Reaction type: decomposition

Reaction type pattern. One compound breaks apart into many different compounds. 

\(\text{XYZ} \rightarrow \text{X} + \text{YZ}\) or something similar

Station 5:

Teacher demonstration:

Prediction: Students made a logical prediction (including what products would form) based on previous experiences or scientific reasoning. They included what they thought the products would be.

Procedure: Students designed a procedure to perform the reaction (this should just include hooking the burner to a methane gas outlet, lighting the bunsen burner) included what data to collect and when, and steps were taken to identify the products of the reaction (wave the fire near a beaker of cold water). The student was detailed enough so someone else in the class could follow the procedure. The procedure followed a chronological order.

Data: Students collected data needed to confirm a chemical reaction occurred (heat) and to identify the products of the reaction (noted condensation for water formation).

Did your results match your prediction? Explain. Students explain how their predictions may or may not have matched their results. If they did not match, they explained why their prediction was wrong with scientific reasoning.

\(\frac{\text{CH}_4 (g)}{2} + \frac{2 \text{O}_2 (g)}{2} \rightarrow \frac{\text{CO}_2 (g)}{2} + \frac{2 \text{H}_2\text{O} (g)}{2}\)

Complete chemical equations:

Reaction type: combustion

Reaction type pattern. A hydrocarbon burns in the presence of oxygen to form carbon dioxide and water. 
\(\text{C}_x\text{H}_y + \text{O}_2 \rightarrow \text{CO}_2 (g) + \text{H}_2\text{O} (g)\)
Student Presentation: 10 points total

- Including all of the relevant information **3 Points**
  - Procedure:
    - steps taken to perform the reaction
    - evidence you collected to confirm a reaction occurred
    - Steps you took to identify the products (when applicable)
  - Results:
    - Did a reaction occur?
    - Identify all species in the chemical reaction
    - Balanced chemical equation
    - Type of reaction
  - Conclusions:
    - What pattern did you come up with to describe this type of chemical reaction?
    - Give an example of this type of chemical reaction in everyday life or industry.

- Oral clarity/ presentation skills **4 Points**
  - Did you talk loud enough, clear enough, slow enough to follow?

- Organization **3 Points**
  - Was your presentation easy to follow?

Student Feedback: 5 points total

5-4 points: The student identified both strengths and weaknesses of the presentation.

4-3 points: The student was vague about the strengths and weaknesses of the presentation.

3-2 points: The student did not identify either a strength or weakness of the presentation.

2-0 points: The student did not supply either a strength or weakness of the presentation.
Lesson 6: Group Activity: Jeopardy Lesson Plan

Overview: This lesson plan is designed to act as a review to the chemical equations unit exam. The lesson can take a whole class period. The students will be playing a game of jeopardy, which can be accessed at the following website address:

http://www.superteachertools.com/jeopardy/usergames/Apr201314/game1365113060.php

The class will self assemble so each student is in 1 of 5 teams. Each team will sit in one row. The person at the front of the row will receive a piece of paper on which the answer may be written. No one else can write on the piece of paper except for the person in the front row. When the person in the front row answered the question, the student will pass the paper to the next person, who can choose to check the person’s answer or pass it back to the next person. This check/pass process will continue until the person at the end of the row receives the paper. The end student may raise the paper in the air for the teacher to check. The first row/group to answer correctly receives the points. If the paper is passed to a student, and that student finds a mistake, the paper must be passed back to the person in the front of the row. This is the only person who may make any changes.

The group who answered correctly picks the new question. A new student will sit in the front row for the next question. Everyone should have an opportunity to sit in the front row.

During the last 10 minutes of class, the final question will be asked. The whole group may work on this problem together. Anyone may write the answer on the paper. The students will be given 4 minutes for this question.

The teacher can provide a prize for the winning team (candy, an extra half-point on the exam, etc.)

Below is a copy of the questions and answers for the teacher to use. Please note that subscripts could not be inserted into the jeopardy program.

| Chemical versus Physical Change |
|-------------------------------|---------------------------------|
| #1 A chemical change is this. | A change in which the end material has different properties compared to the starting material. |
| #2 Roasting a marshmallow is an example of this kind of change. | chemical |
| #3 Pure copper can be heated until it melts just below 2000oF. The liquid copper can be poured into molds. Using copper to make a mold is an example of this kind of change. | physical |
| #4 Sally takes a solution of Sample A and combines it with a solution of Sample B. After mixing and stirring, she returns to find residue on the side of the test tube. The evidence that a chemical change occurred is this. | precipitate |
| #5 Two parts: In a chemical change, the total number of end molecules can or cannot differ from the total number of beginning. In a physical change, the total number of end molecules can or cannot differ from the total number of molecules at the beginning. | can/cannot |
### Bond Energy

| #1 | Energy is this. | The ability to do work. |
| #2 | This law states that energy cannot be created or destroyed in a chemical reaction. | Law of conservation of energy. |
| #3 | A bond must do this with energy in order to break. | Absorb energy |
| #4 | Instead of being destroyed, energy does this during a chemical reaction. | Transform |
| #5 | A bond that forms releases energy because of this. | Stability of the molecule/attraction between molecules |

### Balancing Chemical Equations

| #1 | This is the name for the number of molecules/atoms that are involved in a chemical reaction. | Coefficients |
| #2 | The sum of the coefficients in the balanced chemical equation is this. Mg + HBr → H₂ + MgBr₂ | 5 |
| #3 | The sum of the coefficients in the balanced chemical equation is this. As₂O₃ + C → CO + As | 9 |
| #4 | The sum of the coefficients in the balanced chemical equations is this. C₂H₄O₂ + O₂ → CO₂ + H₂O | 7 |
| #5 | The sum of the coefficients in the balanced chemical equations is this. C₂H₃F + O₂ → CO + H₂O + HF | 13 |

### Interpreting Chemical Equations

| #1 | The reactant that limits how much product can form is this. | Limiting reactant |
| #2 | The following reaction, 2 N₂O (g) → 2 N₂ (g) + O₂ (g), is of this reaction type. | Decomposition |
| #3 | A copper penny is combined in a beaker with a solution of nitric acid. The nitric acid oxidizes the penny, resulting in a mixture of aqueous copper nitrate, dinitrogen monoxide, and water. The complete balanced chemical equation to represent the preceding story is this. | Cu (s) + 4 HNO₃ → Cu(NO₃)₂ (aq) + 2 NO₂ (aq) + 2 H₂O (l) |
| #4 | In the following reaction, Pb(NO₃)₂ (aq) + 2 NaCl (aq) → PbCl₂ (s) + 2NaNO₃ (aq) | 5, 6 |
| #5 | Draw a particulate representation of the following chemical reaction: NiBr₂ + 2 KOH → 2 KBr + Ni(OH)₂ | See teacher's notes. |

### Final Question

5 molecules of liquid methanol, CH₃OH, is burned with 6 molecules of oxygen. Write the complete balanced chemical equation, draw a particulate representation, and identify the limiting reagent.

See teacher's notes.

### Teacher Notes:

**Interpreting Chemical Change, #5:**

Draw a particulate representation of the following chemical reaction: NiBr₂ + 2 KOH → 2 KBr + Ni(OH)₂

Reactant Mixture:

![Reactant Mixture](image)

Product Mixture:

![Product Mixture](image)
**Final Question:**

5 molecules of liquid methanol, CH₃OH, is burned with 6 molecules of oxygen. Write the complete balanced chemical equation, draw a particulate representation, and identify the limiting reagent.

2 CH₃OH (l) + 3 O₂ (g) → 2 CO₂ (g) + 4 H₂O (g)

Reactant mixture:

Product Mixture:

Limiting reagent: oxygen
Overview: All lesson plans in the chemical equations unit should be completed prior to this assessment lesson plan. The students should be allowed a full period for completion. The assessment should be completed individually. Calculators are not needed. It is preferred that the assessment be printed in color so the students can see the macroscopic picture. The assessment consists of 5 multiple choice questions, 2 short answer questions, and 2 particulate level questions (50 points total).

<table>
<thead>
<tr>
<th>Question</th>
<th>Knowledge</th>
<th>Understanding</th>
<th>Application</th>
<th>Analysis</th>
<th>Synthesis</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bond energy</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Chemical change identification</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Balance chemical equation</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Writing a chemical equation (with phases) from a sentence.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Write a chemical equation from a limiting reagent particulate mixture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6. Draw product mixture with limiting reagent</td>
<td></td>
<td></td>
<td></td>
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<td>1</td>
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</tr>
<tr>
<td>7. Difference between a coefficient and subscript</td>
<td></td>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>8. Write/ Balance chemical reaction and type</td>
<td></td>
<td></td>
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<td>1</td>
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</tr>
<tr>
<td>9. Draw particulate representation from macroscopic and symbolic</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Point Distribution
Multiple Choice = 20 points total
Question 6 = 6 points
Question 7 = 6 points
Question 8 = 9 points
Question 9 = 9 points

References:

Name: _________________________  

**Chemical Equations Assessment**

1. Which of the following is true regarding a chemical reaction?  
   a. Heat always forms during a chemical reaction.  
   b. The properties of the reactants are the same as the products.  
   c. Energy is required to break the bonds of the reactants.  
   d. All of the above.

2. Which of the following are chemical changes?  
   a. Clay is molded into a new shape.  
   b. Your body digests food.  
   c. Milk goes sour.  
   d. Clay is molded into a new shape and your body digests food.  
   e. Your body digests food and milk goes sour.

3. Balance the following reaction:  
   \[ \text{____ COCl}_2 + \text{____ NaOH} \rightarrow \text{____ NaCl} + \text{____ H}_2\text{O} + \text{____ CO}_2 \]  
   a. \[ \text{COCl}_2 + 2 \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2 \]  
   b. \[ \text{COCl}_2 + 2 \text{NaOH} \rightarrow 2 \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2 \]  
   c. \[ 2 \text{COCl}_2 + 2 \text{NaOH} \rightarrow 2 \text{NaCl} + \text{H}_2\text{O} + 2\text{CO}_2 \]  
   d. \[ \text{COCl}_2 + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2 \]

4. Solid iron(III) oxide reacts with gaseous carbon monoxide to produce iron and carbon dioxide. Which chemical equation best describes this reaction?  
   a. \[ \text{FeO}_3 + 3 \text{CO} \rightarrow 2 \text{Fe} + 3 \text{CO}_2 \]  
   b. \[ \text{Fe}_2\text{O}_3 + \text{CO (g)} \rightarrow \text{Fe} + \text{CO}_2\text{(g)} \]  
   c. \[ \text{FeO}_3\text{(s)} + 3 \text{CO (g)} \rightarrow 2 \text{Fe (s)} + 3 \text{CO}_2\text{(g)} \]  
   d. \[ 2 \text{Fe (s)} + 3 \text{CO}_2 \rightarrow \text{Fe}_2\text{O}_3\text{(s)} + 3 \text{CO (g)} \]

5. The reaction of element X (○) with element Y (□) is represented in the following diagram.  
   ![Diagram showing the reaction of X with Y]  
   Which equation best describes this reaction?  
   a. \[ 3\text{X} + 8\text{Y} \rightarrow \text{X}_3\text{Y}_8 \]  
   b. \[ 3\text{X} + 6\text{Y} \rightarrow \text{X}_3\text{Y}_6 \]  
   c. \[ \text{X} + 2\text{Y} \rightarrow \text{XY}_2 \]  
   d. \[ 3\text{X} + 8\text{Y} \rightarrow 3\text{XY}_2 + 2\text{Y} \]  
   e. \[ \text{X} + 4\text{Y} \rightarrow \text{XY}_2 \]
6. The following particulate drawing shows the reactants for the chemical reaction written below. Draw the mixture of product. What is the limiting reagent?

\[
\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})
\]

7. In your own words, both define and state the difference between a coefficient and a subscript in a chemical equation.
Consider the picture above for questions 7 and 8. Four trials of a reaction between varying amounts of magnesium metal and a constant volume of aqueous hydrochloric acid were performed. A balloon was placed over the flasks to catch the hydrogen gas that is being formed. Each flask had the same amount of acid, but more metal was used in each subsequent reaction (going from left to right). Note that the 3rd and 4th balloons are the same size.

8. Write a balanced chemical equation that represents this reaction. Identify the type of reaction.

9. Draw a particulate level picture of the reactant and product mixture. Use
   
   Mg = ●
   Cl = □
   H = ○

   (HINT: There are many different ways to answer this question, but keep in mind that the 3rd and 4th balloons are the same size).
Chemical Equations Assessment

1. Which of the following is/are true regarding a chemical reaction?
   a. Heat always forms during a chemical reaction.
   b. The properties of the reactants are the same as the products.
   c. **Energy is required to break the bonds of the reactants.**
   d. All of the above.

2. Which of the following are chemical changes?
   a. Clay is molded into a new shape.
   b. Your body digests food.
   c. Milk goes sour.
   d. Clay is molded into a new shape and your body digests food.
   e. **Your body digests food and milk goes sour.**

3. Balance the following reaction:
   
   \[
   \_\_\_\text{COCl}_2 + \_\_\_ \text{NaOH} \rightarrow \_\_\_ \text{NaCl} + \_\_\_ \text{H}_2\text{O} + \_\_\_ \text{CO}_2
   \]

   a. \text{COCl}_2 + 2 \text{NaOH} \rightarrow \text{NaCl}_2 + \text{H}_2\text{O} + \text{CO}_2
   b. \text{COCl}_2 + 2 \text{NaOH} \rightarrow 2 \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2
   c. 2 \text{COCl}_2 + 2 \text{NaOH} \rightarrow 2 \text{NaCl} + \text{H}_2\text{O} + 2\text{CO}_2
   d. \text{COCl}_2 + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2

4. Solid iron(III) oxide reacts with gaseous carbon monoxide to produce iron and carbon dioxide. Which chemical equation best describes this reaction?

   a. \text{FeO}_3 + 3 \text{CO} \rightarrow 2 \text{Fe} + 3 \text{CO}_2
   b. \text{Fe}_2\text{O}_3 + \text{CO}_{(g)} \rightarrow \text{Fe} + \text{CO}_{2(g)}
   c. \text{Fe}_2\text{O}_3 + 3 \text{CO}_{(g)} \rightarrow 2 \text{Fe}_{(s)} + 3 \text{CO}_2_{(g)}
   d. 2 \text{Fe}_{(s)} + 3 \text{CO}_2 \rightarrow \text{Fe}_2\text{O}_3_{(s)} + 3 \text{CO}_{(g)}

5. The reaction of element X (●) with element Y (□) is represented in the following diagram.

Which equation best describes this reaction?

   a. \text{3X} + 8\text{Y} \rightarrow \text{X}_3\text{Y}_8
   b. \text{3X} + 6\text{Y} \rightarrow \text{X}_3\text{Y}_6
   c. \text{X} + 2\text{Y} \rightarrow \text{XY}_2
   d. \text{3X} + 8\text{Y} \rightarrow 3\text{XY}_2 + 2\text{Y}
6. The following particulate drawing shows the reactants for the chemical reaction written below. Draw the mixture of product. What is the limiting reagent?

\[ \text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \]

Methane (CH\(_4\)) is the limiting reagent.

7. In your own words, define the difference between a coefficient and a subscript in a chemical equation. What is the difference between the two?

*A coefficient is used to balance a chemical reaction, because it determines the number of molecules involved in a chemical reaction. A subscript dictates the number of a particular atom that is present in one molecule. Subscripts cannot be changed when balancing a chemical reaction, but is considered when assigning coefficients to balance the chemical equation.*
Consider the picture above for questions 7 and 8. Four trials of a reaction between varying amounts of magnesium metal and a constant volume of aqueous hydrochloric acid were performed. A balloon was placed over the flasks to catch the hydrogen gas that is being formed. Each flask had the same amount of acid, but more metal was used in each subsequent reaction (going from left to right). Note that the 3rd and 4th balloons are the same size.

8. Write a balanced chemical equation that represents this reaction. Identify the type of reaction.

\[
\text{Mg} \ (s) + 2 \ \text{HCl} \ (aq) \rightarrow \text{MgCl}_2 \ (aq) + \text{H}_2 \ (g)
\]

Single Replacement

9. Draw a particulate level picture of the reactant and product mixture. Use

Mg = ●
Cl = □
H = ○

(HINT: There are many different ways to answer this question, but keep in mind that the 3rd and 4th balloons are the same size).