GOVERNOR'S OFFICE OF ENERGY DEVELOPMENT

Advancing Utah's Energy Future

Combustion Process

Grade/Subject: Chemistry

Strand/Standard CHEM.2.3 Plan and carry out an investigation to observe the change in properties of substances in a chemical reaction, and relate the macroscopically observed properties to the molecular level changes in bonds and the symbolic notation used in chemistry. Emphasize that the visible macroscopic changes in chemical reactions are a result of changes on the molecular level. Examples of observable properties could include changes in color or the production of a solid or gaseous product. (PS1.B)

Lesson Performance Expectations: Students investigate the products of a combustion reaction. Students will learn tests to identify gases.

Materials:

1 candle per group

- 1 pint mason jar per group
- matches or lighter
- wood splint
- safety goggles

For demos

- 5 mL 1M HCl
- small piece of Magnesium ribbon
- 5ml 3% hydrogen peroxide
- .5 grams Manganese dioxide
- Vinegar
- baking soda
- wood splint
- 3 medium test tubes and holder for test tubes
- Matches
- safety goggles

Time: 1 period

Teacher Background Information:

- During chemical reactions, chemical bonds are broken and formed, and energy is either absorbed into the environment (endothermic reaction) or released into the environment (exothermic reaction).
- Bond making is an exothermic process, while bond breaking is an endothermic process. During these reactions, bonds are broken in the reactants and new ones are formed in the products. Combustion is a chemical reaction in which hydrocarbons (fossil fuels) are burned, and the heat released is used to create different forms of energy, such as electricity, transportation fuel, and heat. The generic formula for combustion looks like this, with differing hydrocarbons having differing amounts of carbon and hydrogen atoms per molecule:

- $C_XH_Y + O_2 \Longrightarrow H_2O + CO_2$

- The hydrocarbons most commonly used in our daily lives are coal, petroleum, and natural gas. The chemical reaction that takes place when these resources are combusted results in carbon dioxide (CO2), water (H2O), and energy (in the form of heat). In addition, any impurities in the hydrocarbon will be burned and emitted. Because of the chemical makeup of certain hydrocarbons, not all hydrocarbons release the same amount of CO2. For example, methane (CH4), the natural gas we use to heat our homes and cook with, has the lowest CO2 emissions and most is efficient natural gas, as its chemical makeup contains only one carbon atom for every four hydrogen atoms, thereby releasing fewer carbon atoms during combustion. Propane (C3H8), which is commonly used to power gas grills, has three carbon atoms for every eight hydrogen atoms, so it releases more CO2 during combustion than methane.

- All combustion reactions require oxygen. Fossil fuels are composed primarily of hydrocarbons, which are converted into carbon dioxide and water during a combustion reaction. If there is not enough oxygen (O2) available during combustion, the carbon atoms have fewer oxygen atoms with which to bond, this releases a poisonous gas called carbon monoxide (CO). This is why ventilation is so important for spaces that burn fuel and wood. Natural gas is a fossil fuel that burns cleaner than other hydrocarbons, meaning that the release of CO2 and other emissions is lower during combustion relative to other fossil fuel sources. New technologies such as chemical looping and carbon sequestration significantly reduce CO2 emissions.

- A burning candle is an example of combustion. Candle wax, which is made from carbon-based materials like petroleum, reacts with oxygen in the air to make carbon dioxide. Wax never burns perfectly clean so smoke is produced. Water is also produced in the form of steam. Each part represents different aspects of burning hydrocarbons: the candle wax represents hydrocarbons ; the oxygen stays the same; and the water converts into steam, the smoke represents what other substances are also being burned during the process of combustion.

Student Background Knowledge:
Students should have a working understanding of products and reactants.

Teacher Step by Step: A 3-d lesson should insist students do the thinking. Provide time and space for the students to experience phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. **Introduce *Phenomenon:*** This can demonstrated or students can perform the tests. Make sure all tests are performed in a well ventilated room by students dressed in appropriate laboratory clothing. If students are unfamiliar with this type of lab work, the tests should be demonstrated by the teacher.
   Flame Tests:
2. Place test tubes into rack add acid into #1 tube and to test tube #2 add the peroxide. #3 add the vinegar.
3. Now add magnesium ribbon to acid(it bubbles making Hydrogen gas) after a few seconds place a burning wood splint over the mouth of the tube (should make a barking sound as the hydrogen gas burns). Students will record their observations.
4. Add the manganese oxide to tube #2 (this should also bubble producing oxygen gas) have students write down observations. Now test the gas by placing a glowing wood splint into the tube (this should ignite the splint). Students record their observations.
5. Now add baking soda to tube #3 (this should also bubble producing carbon dioxide) and record the results. Now place a burning wood splint into the tube (this should extinguish the flame). Have students record their observations.
6. Ask students for questions that they have about the phenomenon. Students record them on their student sheet.
7. Give the student groups a candle and a jar and have them design their own test to find the products of combustion. Check their procedures for safety. Hopefully they will light the candle and place it in a closed

upright jar**,** wait for the flame to extinguish from lack of oxygen and then test for carbon dioxide by using a burning splint into the jar. They should also observe some condensation on the sides or lid of the jar. Other tests they might try include inverting the jar over the candle in a pool or water or trying a glowing splint instead of a flaming one. Students will complete the worksheet.

Answers to analysis questions:

1. Which gases were produced? CO2, water How did you know? The CO2 put the burning splint out. The water could be seen on the sides of the jar.
2. What is the chemical formula for combustion of a candle? (The candle can be considered a Hydrocarbon C_XH_Y)

$C_XH_Y + O_2 \longrightarrow H_2O + CO_2$

Assessment of Student Learning.

The claim should state that the reactants of chemical combustion are a carbon compound and oxygen which combine to release heat, light, carbon dioxide and water.

The evidence should include the reaction of the wooden splint which went out in the carbon dioxide and the appearance of water in the jar. The heat can be felt and the light can be seen.

The reasoning should a discussion of the original substances which was the candle as a carbon compound and oxygen in the air, which is invisible but other tests have shown it to be necessary. The heat and light given off are greater than the heat needed to start the reaction. The blackened wick on the candle is evidence that some of the carbon was present but not consumed in the reaction.

Standardized Test Preparation:

Combustion Processes

Properties of Gasses

Gas	**Density**	**Reaction with splint**	**Molar mass**
H_2 Hydrogen	.088	Burns rapidly-popping sound	2
He Helium	.1761	Non-reactive	4
Air Mixture	1.27	Allows splint to continue burning	29
O_2 Oxygen	1.40	Allows splint to increase the rate of burning	32
CO_2 Carbon Dioxide	1.935	Extinguishes flame	44

SF_6 Sulfur Hexaflouride	6.17	Non-reactive	148

1. A student creates a gas during a reaction and wishes to know what it is. The reaction bubbles for several minutes and fills a balloon. The balloon is tied off. What are two tests the student could do to test the gas?
    a. Place the balloon under water and bubble the gas through the water.
    b. Place a burning splint near the balloon and see what happens when it burns.*
    c. Measure the molar mass with a balance.
    d. Tie off the balloon, let it go and see if it rises or falls.*

2. The student determined that the tied-off balloon would rise through the air when let go and did burn. What gas was most likely formed?
    a. Hydrogen*
    b. Helium
    c. Oxygen
    d. Carbon dioxide

3. A candle burning in an upturned jar goes out when the jar is covered. What evidence shows that carbon dioxide has formed in the jar?
    a. A burning splint goes out when placed in the jar.*
    b. Moisture condenses on the inside of the jar.
    c. A loud popping sound occurs when a burning splint is placed in the jar.
    d. A glowing splint quickly relights.

Combustion reaction for any hydrocarbon:

4. What substances are "X" and "Y"?

    a. X = H_2 Y = O_2
    b. X = H_2O Y = O_2
    c. X = O_2 Y = H_2O*
    d. X = H_2O Y = CO_2

Extension of lesson and Career Connections: Explore how we use combustion in our society. Consider how combustion processes impacts our environment and economy.

Combustion Process

Name_____

Phenomenon: Watch as your teacher adds the amounts of each chemical and fill in the data table.

Test tube #1: Acid plus magnesium
Test tube #2: Peroxide and manganese oxide
Test Tube #3: Baking soda and vinegar

Results of Flame Test	What gas formed (see the chart below)
#1	
#2	
#3	

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Question: What gases are produced when a candle burns?

Materials: candle, fire, jar, matches or lighter and wooden splint

Lab procedure: What will you do?

1.

2.

3.

4.

5.

Data:

Analysis:

1. Which gases were produced? How did you know?
2. What is the chemical formula for combustion of a candle? (The candle can be considered a Hydrocarbon C_XH_Y)

Summary

Make a **claim** about the reactants and products of combustion.

What **evidence** supports your claim?

What **reasoning** did you use?