Matter & Energy Unit – Week 2

Score
□ Above & Beyond
□ Fully Complete
□ Mostly Complete
□ Incomplete – *fix the following pages*:

Name: _____ Hour_____Date: _____

Date Packet is due: *after Part 5* Why late? _____
If your work was late, describe why

Driving Question: What happens to molecules during combustion?

Anchoring Phenomenon: When something burns (or is *combusted*), it seems like that substance disappears. We now know that all matter is made from tiny particles called atoms, and that these form molecules. How do these molecules change during combustion? And how do these changes relate to the flame's energy (heat, light, and motion)?

Deeper Questions

1. What happens to the atoms in molecules during combustion?
2. What happens to energy in molecules during combustion?
3. How does what we can observe during combustion (e.g., heat & light) relate to the changes happening at the molecular level?

Weekly Schedule

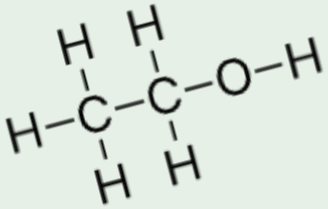
Part 1: Introduction
- Initial Ideas – What is combustion?
- Data Dive – Changing O_2 & CO_2
- Discussion & Developing Explanations

Part 2: Core Ideas
- Core Ideas
- Revisions of Part 1 Explanations

Part 3: Investigation
- Molecular Modeling
- Revisions of Part 1 Explanations

Part 4: Review & Assessment
- Ranking Your Readiness
- Assessment

Part 5: Life Connections
- Weekly Recap
- Life Connections – Combustion in Our State



NGSS Standards:
HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Semester Schedule

Matter & Energy
Week 1: What happens when something burns?
Week 2: What happens to molecules during combustion?
Week 3: Unit Assessment

Animals
Week 1: What are animal cells made from?
Week 2: What happens to food when it is consumed?
Week 3: What happens inside animal cells?
Week 4: Unit Assessment

Plants
Week 1: How do plant cells differ from animal cells?
Week 2: How do plants get their food and gain mass?
Week 3: How do plants get other needed molecules?
Week 4: Unit Assessment

Ecosystems
Week 1: Why do some places have more species than others?
Week 2: How does human activity affect living species?
Week 3: Unit Assessment

Part 1: Introduction – Changing O_2 & CO_2

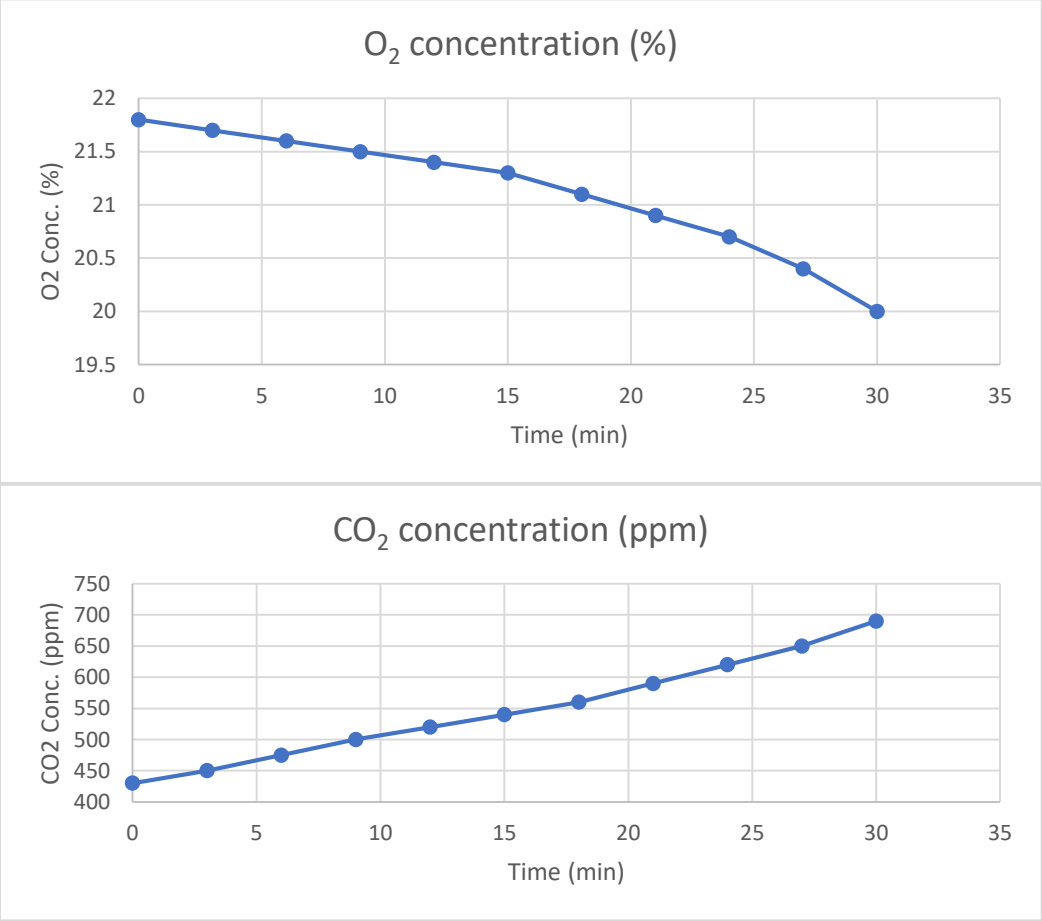
Overview: In this activity, you will begin by discussing your initial ideas about what happens to the matter and energy in molecules when a substance is combusted.

Initial Ideas:

1. A group of students are asked to explain happens to wood when it combusts. Read the following responses from students. **Do you agree or disagree with each student's claim**?
    a. Daryll: "Some of the oxygen atoms were turned into carbon atoms to make CO_2."
    b. Nina: "The oxygen atoms were destroyed in the fire; CO_2 came from the ethanol."
    c. Oscar: "The atoms in oxygen and ethanol were rearranged to make CO_2."

2. **Work in your small groups to discuss your ideas.** How are your ideas similar or different? Decide as a group whether each statement is correct (and why). Be prepared to present your ideas to the class.

Introduction: A class is conducting an experiment. They ignited a petri dish of ethanol inside of a sealed box. The box contained sensors that recorded changes in the amount of oxygen (O_2) and carbon dioxide (CO_2) in the air within the box. These changes were recorded in 3-minute intervals. The data is shown below.



How to read these graphs: The top graph shows changes in the oxygen (O_2). The bottom graph shows changes in carbon dioxide (CO_2).

The horizontal x-axis for each graph shows the change in time. The vertical y-axis for each graph shows the change in the amount of each gas (% O_2 and ppm of CO_2).

To determine trends in each graph, match each point on each line with where it lines up on the x- and y-axis. For example, at three minutes, O_2 was at 21.7% and CO_2 was at 450 ppm. At 6 minutes, O_2% was lower and CO_2 ppm was higher.

1. **Begin by individually attempting to make sense of this image**. What trends or patterns do you notice? How does this relate to any prior knowledge or experience that you have?

2. **Next, work in your teams to discuss your ideas**. Where do you agree? Where do you disagree? Can you use this data to reach agreement? Do others have prior knowledge or experience that could help?

3. **Based on this data, what is one conclusion that would be supported by this data?**
    a. How is this conclusion supported by this data?
    b. What specifically suggests that your claim is accurate?

4. **Based on this data, what is a second conclusion that would be supported by this data?**
    a. How is this conclusion supported by this data?
    b. What specifically suggests that your claim is accurate?

5. **Why do you think that levels of O_2 and CO_2 changed in these ways during combustion**? How can we explain these outcomes using what we know about combustion?

6. Eventually the flame inside the sealed container will go out even if some ethanol remains. **Why does the ethanol eventually stop burning in sealed container even if fuel remains?**

7. **Both ethanol and water are clear liquids. Why does ethanol burn but water does not?**

Be prepared to discuss your ideas with other groups and/or as a class. If you have prior experiences or knowledge that can be helpful, please share this with when you are discussing your ideas.

Discussion & Developing Ideas

1. As a class, discuss your ideas about this data. What are ideas that most agreed on? Where did your ideas differ as a class? Record your ideas in the spaces below.

We all agree that…	We disagreed or are unsure about…

2. **What happens to the matter and energy in molecules when a substance is combusted?** Write down your initial explanation in the space below. Don't worry if you aren't completely sure about your answer! You will come back and revise this explanation as you gain more information during this unit.

Part 2: Core Ideas

Overview: In this activity, you will begin with a short slideshow presentation. This will provide you with core ideas that will help you clarify your initial ideas. Your instructor will decide on how to implement this portion depending on your previous experience and capabilities with this content.

You will then work in small teams to answer the questions listed below. You should take notes in a notebook, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. *Note: your instructor may assign specific questions to your group if time is limited.*

Core Ideas Presentation: https://bit.ly/WUHS-Bio-Matter&EnergyW2

Driving Questions:

1. What is a chemical bond? If we look at a model of a molecule, what represents a chemical bond?
2. How can molecules contain energy if matter and energy are separate things?
3. What is a high energy bond? How would we know if something contains high energy bonds?
4. What makes something a "fuel"? What determines the amount of energy contained within a molecule?
5. Gasoline, ethanol, and sugar are examples of "high energy" molecules. Why?
6. What must happen to molecules with high energy bonds to transform its chemical energy into other forms of energy (such as light, heat, and motion)?
7. Where does the heat, light, and motion energy of a flame come from?
8. "Combustion reactions are rearrangement reactions." What does this mean? Explain in your own words.
9. Both ethanol and water are clear liquids. Why does ethanol burn but water does not?
10. True or false: the amount of atoms and the amount of energy that exists after combustion ends is the same as before combustion occurs. Explain.
11. Explain combustion in a way that specifically addresses our "three rules" of matter and energy:
    1) All matter is made of atoms. 2) Atoms lasts forever. 3) Energy lasts for forever.
12. Why is a spark needed to start a fire? Isn't a flame just "leftover energy" when molecules are rearranged?
13. **Revising Explanations**: Return to your original explanation that you created at the end of Part 1. Based on this new information, how would you now respond to this question?

What happens to the matter and energy in molecules when a substance is combusted?

Remember the following "rules" for energy and matter:

- **All solids, liquids, and gases are made of tiny particles called atoms**. Atoms can bond together to form molecules (*e.g., water molecules consist of 1 oxygen atom & 2 hydrogen atoms*).
- In biology, **atoms last forever**. Atoms cannot be created or destroyed or turned into energy (*e.g., a carbon atom is always a carbon atom*). If something gains mass, it gains atoms. If it loses mass, it loses atoms. Atoms found in molecules can be rearranged to form new molecules.
- In biology, **energy lasts forever**. Energy cannot be created or destroyed. Energy can exist as light, heat, motion, or as chemical energy stored in the bonds of molecules. Energy in one form can be transferred into a different form (*e.g., light energy can be transformed into heat energy*).

Part 3 Investigation: Molecular Modeling

Adapted from materials by Carbon TIME

Overview: In this investigation, you will use modeling clay to create physical models to explain how matter and energy change when a substance is combusted.

Materials Needed (per group): modeling clay (such as Playdoh), toothpicks, tape or twist ties, paper towel.

Pre-Investigation Questions: Work as a group to determine the best response to each question. Be prepared to provide verbal responses for these questions for your instructor before you complete the investigation.

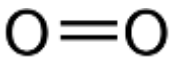
1. *How can molecules contain energy if matter and energy are separate things?*
2. *What makes something a "fuel"? What determines the amount of energy contained within a molecule?*
3. *Both ethanol and water are clear liquids. Why does ethanol burn but water does not?*
4. *What happens to the matter and energy in molecules when a substance is combusted?*

When you think you are ready, **raise your hand**. Your instructor will listen to your verbal responses.

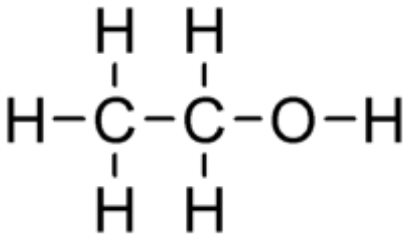
This activity was completed _____ (*instructor signature*)

Directions: In this investigation, you will create molecular molecules to explore what happens to matter and energy during combustion. *Scientific models* are tools that help us clarify our thinking and make more accurate predictions. Models can be pictures, examples, scale models, or anything that helps us reason more accurately about a concept. Use the following instructions to create each of your molecules.

1. **Using the modeling clay provided, create three molecules of oxygen gas (O_2).**
   a. You will need six balls of one color to represent oxygen atoms.
   b. Using this image as a guide, connect two oxygen atoms using two toothpicks.
   c. Repeat these instructions until you have three molecules of oxygen (O_2).



2. **Using the modeling clay provided, create one molecule of ethanol (C_2H_5OH).**
   a. Using the same color as you used previously for oxygen, create one ball of that color for the oxygen atom.
   b. Using a different color, create two balls of that color for the carbon atoms.
   c. Using a third color, create six balls of that color for the hydrogen atoms.
   d. Mark any high energy bonds (C-C and C-H) with a twist tie, piece of tape, or any other physical marker that your instructor has provided.
   e. Using the image at the right as a guide, connect these atoms (*one toothpick between each atom*).

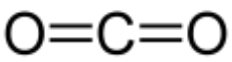


3. **When you think you are finished, raise your hand and show your instructor.**

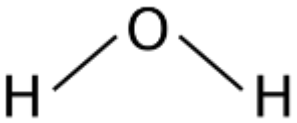
This activity was completed _____ (*instructor signature*)

4. **Disassemble your O_2 and ethanol molecules. Using the same clay atoms you used to create the oxygen gas and ethanol molecules, create CO_2 and H_2O using the following instructions:**

a. **To create <u>two</u> molecules of carbon dioxide (CO_2):** Using the image at the right as a guide, connect a carbon atom to two oxygen atoms using four toothpicks (two toothpicks for each oxygen atom). Repeat for a second molecule.



b. **To create <u>three</u> molecules of water (H_2O):** Using this image as a guide, connect a carbon atom to two oxygen atoms using two toothpicks (one toothpicks for each hydrogen atom). Repeat until you have 3 molecules.



c. **Mark any high energy bonds** (C-C and C-H) with a twist tie, piece of tape, or any other physical marker you received. Make a separate pile for any unused high energy bonds.

5. **Based on the core ideas from this week, explain how each of these molecules relates to what happens when ethanol is combusted.** When you think you are finished, **<u>raise your hand and show your instructor</u>**. While you are waiting for their approval and after they give their approval, complete the post-investigation questions on the next page. Disassemble your molecules *after* you get approval.

This activity was successfully completed _____ (*instructor signature*)

Post-Investigation Questions:

1. **How do atoms in ethanol and O_2 relate to the atoms in CO_2 and H_2O? Are they the same atoms?**

_____

_____

2. **Are there any high-energy bonds (C-C or C-H) in ethanol (C_2H_5OH) and/or oxygen (O_2)?** _____

   Are there any high-energy bonds (C-C or C-H) in carbon dioxide (CO_2) or water (H_2O)? _____

   How does this relate to the flames we observe during combustion?

_____

_____

3. **What do you think happens to the atoms in fuel when it is combusted?**

_____

_____

4. **What do you think happens to the chemical energy in fuel when it is combusted?**

_____

_____

Be prepared to discuss and defend your ideas in small groups and as a class.

Part 4: Review & Assessment

Overview: Rank each Driving Question in Part 2 as a 1 (*completely unsure*), 2 (*somewhat unsure*), or 3 (*completely sure*) based on your comprehension. Then work in teams to review each item and prepare a response. Next, write a final explanation below. You will conclude by completing a formative assessment.

What happens to the matter and energy in molecules when a substance is combusted?

Part 5: Life Connections – Combustion in Our State

Adopted with permission from Carbon TIME.

Background: Natural gas is a mixture of gases found underground in places where ancient plants and animals have decayed. It is a fossil fuel. It is about 95% methane (CH_4) with small amounts of other gases such as ethane (C_2H_6) and propane (C_3H_8) mixed in. It is commonly used in home heating and cooking. It can also be used to heat dryers and water in homes. Your school labs may be equipped with natural gas outlets for Bunsen burners. Some power plants burn natural gas to produce electricity.

The main component in natural gas is methane, CH_4. Like ethanol, it undergoes combustion.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Pre-Investigation Questions: Work as a group to determine the best response to each question. Be prepared to provide verbal responses for these questions for your instructor before you complete the investigation.

1. Explain the energy transformations involved in the combustion of methane. Why does this reaction and the combustion of other fossil fuels generate heat?
2. How is natural gas used in your home or school?
3. Are any other fuels burned in your home or school? List the fuel(s) and their uses.

Be prepared to discuss and defend your ideas in small groups and as a class.

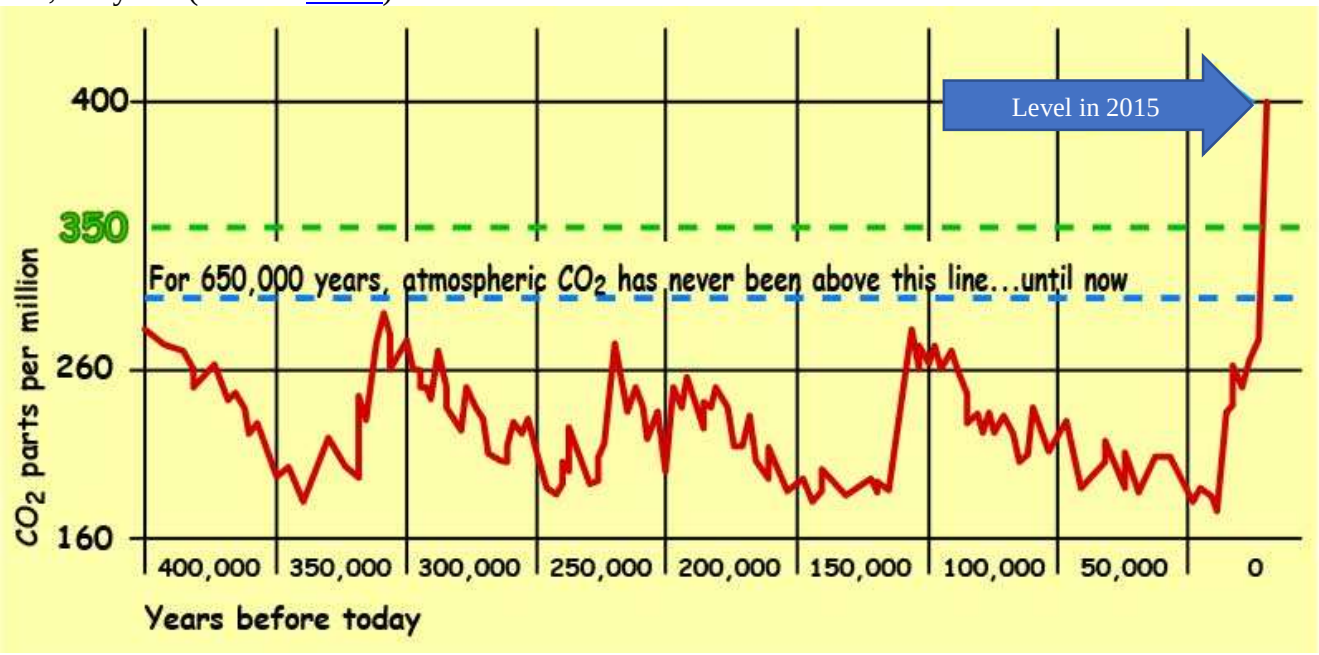
Digging Deeper: Most of the electricity used in this country is generated by burning a fossil fuel like coal or natural gas. The heat produced is used to turn water into steam that turns a turbine. The energy sources used to generate electricity vary widely from state to state.

What fuels and sources of energy are used in your state? Use the Energy Information Association website (https://www.eia.gov/state/) to complete the questions below.

1. **Based on this website, what are the top 4 energy sources for your state?**

2. **Do any of these energy sources involve combustion? <u>Circle</u> any above that do.**

The graph below is from NASA. This graph shows how carbon dioxide concentrations have changed over the past 500,000 years (*Source: NASA*).



3. **Based on this data, what are <u>two</u> conclusions that would be supported by this data?**
    a. How is these conclusions supported by this data? What suggests that your claims are accurate?

4. **How might the energy sources used in our state relate to recent changes in CO_2 concentrations?**
    a. How is this conclusion supported by this data? What suggests that your claim is accurate?

5. **What are the advantages and disadvantages of using these energy sources?** Work in small groups to develop as many ideas as you can. Be prepared to discuss your ideas as a class. Use the space below to record similarities and differences across your ideas as a class.

Advantages	Disadvantages

6. **If time allows, you can learn more about how electricity is generated from steam produced by combustion at the following web sites:**
    https://www.youtube.com/watch?v=ouWOhk1INjo
    https://en.wikipedia.org/wiki/Thermal_power_station

Matter & Energy Unit, Week 2 Formative Assessment

Name: _____ Hour_____ Date:_____ Score:_____ /____

Directions: A 3x5 notecard with *handwritten* notes can be used to guide your answers. Your instructor may allow you to work in assigned groups. If so, have a different person write each response while others assist.

Background: A class was trying to determine what happens to ethanol when it combusts. The teacher asks, "What happens to the molecules in the ethanol as it is combusting?" Three students shared their ideas.

1. **Circle "Agree" or "Disagree" for each of the three claims below.**

a) Daryll: "The atoms in the molecules of ethanol are being destroyed." Agree / Disagree

b) Marisol: "The ethanol and oxygen molecules are being converted into energy." Agree / Disagree

c) Bai: "The atoms in ethanol & oxygen are reorganized into different kinds of molecules." Agree / Disagree

2. **Provide an explanation. Why did you agree or disagree with each student's claim?**

a) _____

b) _____

c) _____

The teacher then asks, "What happens to the energy in the ethanol as it is combusting?"

3. **Circle "Agree" or "Disagree" for each of the three claims below.**

a) Daryll: "The chemical energy in the bonds of ethanol is changed to heat and light energy." Agree / Disagree

b) Marisol: "The ethanol and oxygen molecules are being converted into energy." Agree / Disagree

c) Bai: " Ethanol cannot contain energy because matter and energy are different things." Agree / Disagree

4. **Provide an explanation. Why did you agree or disagree with each student's claim?**

a) _____

b) _____

c) _____

5. **The teacher then asks, "Why does ethanol burn but water does not?" Provide an explanation:**

_____

_____

Remember the following "rules" for energy and matter:

- **All solids, liquids, and gases are made of tiny particles called atoms**. Atoms can bond together to form molecules (*e.g., water molecules consist of 1 oxygen atom & 2 hydrogen atoms*).
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