

Packet 1.2 - Matter & Energy Unit

First & Last Name: _____ Period/Hour: _____

NOTE: Check each page to be sure all blanks are completed.

<p>Driving Question: How does burning change matter & energy?</p>	<p>Semester Schedule</p> <p>1. Matter & Energy</p> <p>1.1: What happens when something burns?</p> <p>1.2: How does burning change matter & energy?</p> <p>1.3: Unit Assessment</p> <p>2. Animals</p> <p>2.1: How do animal cells use food?</p> <p>2.2: What happens to food when it is consumed?</p> <p>2.3: How do cells acquire atoms from food?</p> <p>2.4: Unit Assessment</p> <p>3. Plants</p> <p>3.1: How do plant cells differ from animal cells?</p> <p>3.2: How do plant cells obtain matter and energy?</p> <p>3.3: How can we investigate plant growth and function?</p> <p>3.4: Unit Assessment</p> <p>4. Ecosystems</p> <p>4.1: Why do different places have different amounts of species?</p> <p>4.2: How does human activity affect species?</p> <p>4.3: Unit Assessment</p> <p><i>These materials were partly developed with assistance from artificial intelligence.</i></p>
<p>Anchoring Phenomenon: Ethanol is a clear liquid that looks like water. However, unlike water, ethanol burns easily. Why does ethanol burn but water does not? And how do molecules of ethanol change when it is combusted? We'll explore how atoms and energy are changed by combustion reactions.</p> <p>Deeper Questions</p> <ol style="list-style-type: none"> 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? 	
<p style="text-align: center;">Schedule</p> <p>Part 1: Introduction</p> <ul style="list-style-type: none"> - Initial Ideas & Data Dive - Discussion & Developing Explanations <p>Part 2: Core Ideas</p> <ul style="list-style-type: none"> - Core Ideas - Revisions of Part 1 Explanations <p>Part 3: Investigation</p> <ul style="list-style-type: none"> - Molecular Modeling <p>Part 4: Review & Assessment</p> <ul style="list-style-type: none"> - Ranking Your Readiness - Formative Assessment & Mastery Check <p>Part 5: Life Connections</p> <ul style="list-style-type: none"> - Life Connections - Combustion in Our State 	
<p>NGSS Standards (<i>PEs & CCCs are summarized below. SEPs are noted throughout the packet.</i>)</p> <p>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</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> Patterns</div> <div style="text-align: center;"> Cause and Effect</div> <div style="text-align: center;"> Scale, Proportion, and Quantity</div> <div style="text-align: center;"> Systems and System Models</div> <div style="text-align: center;"> Energy and Matter</div> <div style="text-align: center;"> Structure and Function</div> <div style="text-align: center;"> Stability and Change</div> </div>	
<p>Resource Links: Class Website; Core Ideas; Summary Video; Practice Test; Part 5 EIA Data; Combustion Basics Poster; Part 5 - Video 1; Video 2</p>	

This work is licensed under a Creative Commons Attribution-NonCommercial 3.0 Unported License.

Part 1: Introduction – Changing Molecules (1.2.1)

Overview: In this activity, you will begin by discussing your initial ideas about why some things burn but others do not. You will then analyze data and work in teams to develop your initial explanations.

Initial Ideas - Record your ideas separately (e.g., on a white board or scratch paper).

SEP: Engaging in Argument from Evidence

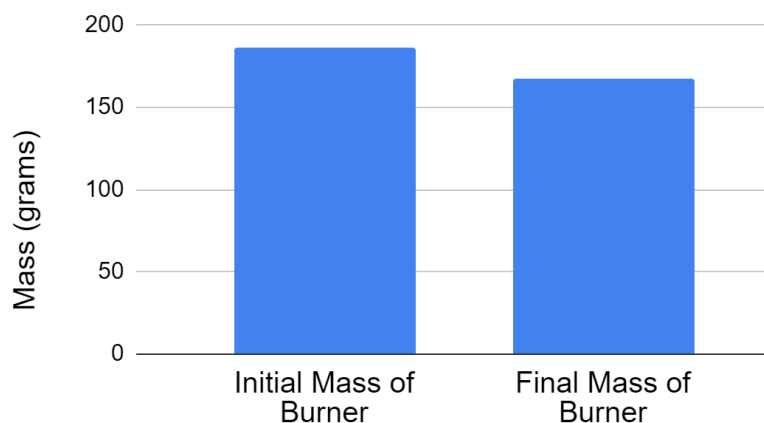
1. A group of students observe ethanol burning during a lab investigation. They notice that both ethanol and water are clear liquids. They debate why ethanol burns but water does not. **Do you agree or disagree with each student’s claim?**
 - a. Daryll: “Ethanol burns because it has carbon atoms. Anything that has carbon can burn”
 - b. Nina: “Water does not burn because it contains hydrogen atoms. This prevents combustion.”
 - c. Oscar: “Something must have at least three different elements to be combustible (like ethanol).”
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.

Data Dive - Complete the reading below. Annotate the text as you are reading. SEP: Analyzing & Interpreting Data

A group of students were trying to determine where the energy of fire comes from. They know that ethanol can be burned with oxygen to produce carbon dioxide (CO₂) and water (H₂O). This combustion reaction releases energy in the form of heat, light, and motion. Where does this energy come from?

Avery hypothesizes that the energy of a flame comes from the air surrounding the flame. Avery think this because if something is placed over the flame, the fire goes out. Bristol argues that a flame’s energy comes from chemical bonds in ethanol. Bristol thinks that substances that burn must have different kinds of bonds than substances that don’t burn.

The students measured the mass of an ethanol burner before and after combustion. They also looked at molecular models of the *reactants* (ethanol and oxygen) and the *products* (CO₂ and H₂O). They used these models to determine how many “high energy bonds” are found in each type of molecule. A high-energy bond (HEB) holds more energy than other chemical bonds. This energy is often released during reactions like combustion. Their data are shown below.



Molecule	No. of HEBs
Oxygen (reactant)	0
Ethanol (reactant)	6
CO ₂ (product)	0
H ₂ O (product)	0

1. What was their research question (what they were trying to figure out)? _____

2. What are the key trends in this data? What do they indicate? _____

3. Where does Avery think that the energy of the flame comes from?

- A) Air molecules in the surroundings
- B) Light emitted by the flame
- C) Chemical bonds within the products
- D) Energy absorbed from the reactants

4. How do the viewpoints differ regarding the source of energy for a flame?

- A) Avery argues that the energy comes from the air; Bristol argues it comes from ethanol molecules.
- B) Avery argues that the energy comes from the chemical bonds within the reactants, whereas Bristol suggests it originates from external sources like air molecules.
- C) Avery and Bristol both agree on the origin of flame energy. Their viewpoints do not differ.

5. What evidence would support the argument that the energy of a flame comes from the chemical bonds within the reactants (ethanol and/or oxygen)?

- A) The increase in mass of the reactants during combustion
- B) The decrease in mass of the reactants during combustion
- C) The difference in high energy bonds between the reactants and the products.
- D) The release of energy (light, heat) during combustion.

Discussion - Record your ideas in the spaces below. SEP: Asking Questions & Defining Problems

We generally agree that...

We disagreed or were unsure if...

Initial Explanations - Record your ideas in the spaces below. SEP: Constructing Explanations & Designing Solutions

Where does the energy of a flame (heat & light) come from? Record your initial explanation below.

Part 2: Core Ideas (1.2.2)

Overview: Use a [short presentation](#) to gain information needed to improve your initial ideas. Your instructor will decide on how to implement this portion. Then work in small teams to address the questions listed below.

Driving Questions - Record your ideas separately (e.g., on a white board or scratch paper).

SEP: Developing & Using Models

- | | |
|---|--|
| <ol style="list-style-type: none">1. What is a chemical bond? In a picture 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 do we know if a substance has high energy bonds?4. What determines if a molecule can be 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)? | <ol style="list-style-type: none">7. Where does the heat, light, and motion energy of a flame come from?8. “Combustion reactions are rearrangement reactions.” Explain this 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 began. Explain.11. Explain combustion in a way that specifically addresses our “three rules” of matter & energy: 1) All matter is made of atoms. 2) Atoms last forever. 3) Energy lasts for forever.12. Why is a spark needed to start a fire? |
|---|--|

1. How can molecules contain energy if matter and energy are separate things?

2. What is a high energy bond? What are examples of this? How does it relate to if something burns?

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?

Revising Explanations - Record your ideas in the spaces below. SEP: Constructing Explanations & Developing Solutions

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

Part 3: Molecular Modeling (1.2.3)

Pre-Investigation Questions - Work as a group to prepare verbal responses for these questions. When you think you are all ready to provide responses, raise your hand. Your instructor will listen to your explanations, provide feedback, and determine if you are ready to move on to the investigation.

SEP: Developing & Using Models

1. How can molecules contain energy if matter and energy are separate things?
2. What is a high energy bond? What are examples of this? How does it relate to if something burns?
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?

This activity was completed _____ (instructor signature)

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

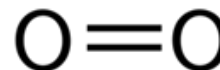
Materials needed for both investigations (per group): modeling clay (such as PlayDoh or [Plastilina](#)) with at least three different colors; toothpicks; [gold twist-ties](#) or tape; paper towel (to protect tabletops from residue).

Directions - Carefully read the directions below before beginning. Record info where prompted.

SEP: Developing & Using Models

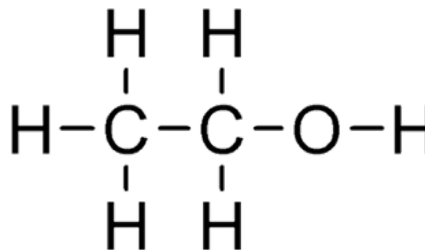
1. Using the modeling clay provided, create three molecules of oxygen gas (O₂).

- 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 (O₂).



2. Using the modeling clay provided, create one molecule of ethanol (C₂H₅OH).

- 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. Using this image, connect these atoms (one toothpick between each atom).
- e. 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.



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

This activity was completed _____ (instructor signature)

Directions - Carefully read the directions below before beginning. Record info where prompted.

4. **Disassemble your O₂ and ethanol molecules. Using the same clay atoms you used to create the oxygen gas and ethanol molecules, create CO₂ and H₂O using the following instructions.**

5. **Create two molecules of carbon dioxide (CO₂).**

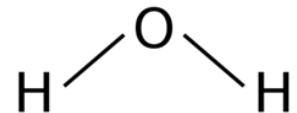
a. Using this image as a guide, connect a carbon atom to two oxygen atoms using four toothpicks (two toothpicks for each oxygen atom).



b. Repeat for a second molecule.

6. **Create three molecules of water (H₂O).**

a. Using this image as a guide, connect an oxygen atom to two hydrogen atoms using two toothpicks (one toothpick for each hydrogen atom).



b. Repeat until you have 3 molecules.

7. **Mark any high energy bonds (C-C and C-H) with a twist tie, piece of tape, or any other physical marker you received.**

a. Make a separate pile for any unused high energy bonds.

8. **Based on the core ideas from this week, explain how each of these molecules relates to what happens when ethanol is combusted.** Also explain what happens to any leftover high energy bonds.

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

a. While you are waiting for their approval and after they give their approval, complete the post-investigation questions in the next section.

b. Disassemble your molecules and put away materials only after you get approval.

This activity was completed _____ (instructor signature)

Post-Investigation Questions - Record your ideas in the spaces below.

SEP: Engaging in an Argument from Evidence. Constructing Explanations & Designing Solutions.

1. **How do atoms in ethanol and O₂ relate to the atoms in CO₂ and H₂O? Are they the same atoms?**

2. **Are there any high-energy bonds (C-C or C-H) in ethanol (C₂H₅OH) or oxygen (O₂)? Yes / No**
(circle one)

Are there any high-energy bonds (C-C or C-H) in carbon dioxide (CO₂) or water (H₂O)? Yes / No
(circle one)

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



3. Based on your results, what happens to the atoms in ethanol & oxygen during combustion?

4. Based on your results, where does the energy of the flame (heat, light, motion) come from?

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

Part 4: Review & Assessment (1.2.4)

Step 1: Rank each Driving Question in Part 2 based on your comprehension (you can rank them as 1,2,3 or green/yellow/red, or any other method). Then work in teams to review anything that is still unclear.

Step 2: Identify any remaining areas of confusion or concern. Then review these topics with your instructor.

Step 3: Complete the Formative Assessment. Your instructor will determine if you will work individually, in pairs, or in small groups. Then compare and evaluate your responses as a class.

Step 4: Individually complete a Mastery Check. If additional support is needed, your instructor will determine how to help you move forward.

Matter & Energy, Packet 1.2 Formative Assessment (1.2.4)

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) Nina: “The ethanol and oxygen molecules are being converted into energy.” Agree / Disagree
- c) Oscar: “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) _____



Background: A class was trying to determine what happens to ethanol when it combusts. The teacher next 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) Nina: “The atoms in ethanol and oxygen molecules are being converted into energy.” Agree / Disagree
- c) Oscar: “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:

Part 5: Life Connections – Combustion in Our State (1.2.5)

Adopted with permission from [Carbon TIME](#).

Background - Complete the reading before answering the questions below. Annotate the text as you are reading. SEP: Engaging in an Argument from Evidence. Constructing Explanations & Designing Solutions.

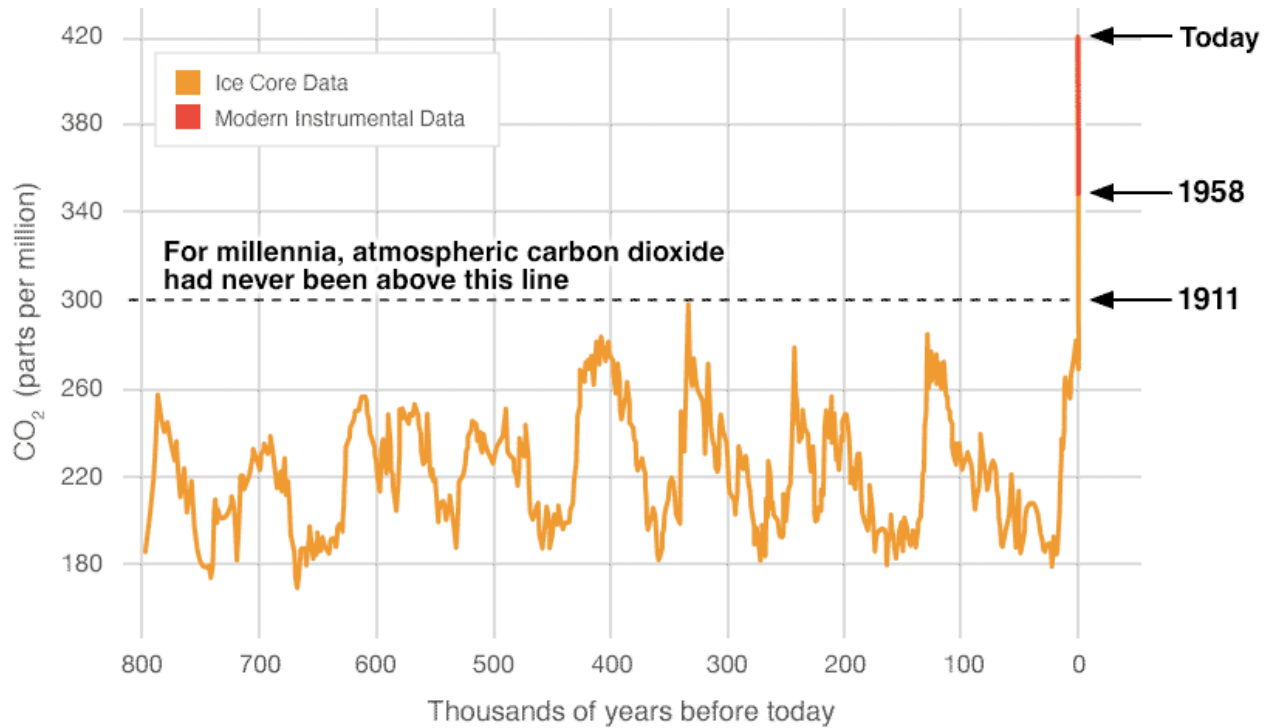
Background: Natural gas is a blend of gases formed from ancient plants and animals. The main component of natural gas is methane (CH₄). When methane molecules are combusted, they are rearranged with oxygen to form carbon dioxide (CO₂) and water (H₂O) molecules: CH₄ + 2O₂ → CO₂ + 2H₂O.

Natural gas is a fossil fuel and cannot be replaced as quickly as it is consumed. As such, it is limited in supply. In the US, a significant portion of the electricity is generated by burning fossil fuels. The heat produced during this burning process is used to convert water into steam. This steam powers a turbine to generate electricity. Natural gas is also commonly used for heating homes, to power stoves, and provides heat for dryers and water heaters. You might even notice natural gas outlets in your school labs for Bunsen burners.

Some states rely more on fossil fuels than others. Recently, there has been a growing emphasis on using renewable energy sources like wind and solar power. This shift is driven by both the rising costs of fossil fuels as well as the negative effects of increasing carbon dioxide levels in the atmosphere from combustion.

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

2. Do any of these energy sources involve combustion? Circle any above that do.



This [NASA](#) graph shows how carbon dioxide concentrations have changed over the past 500,000 years.

3. Based on this data, what are two conclusions that would be supported by this data?

Conclusion 1: _____

Conclusion 2: _____

4. How might the energy sources used in our state relate to recent changes in CO₂ concentrations?

5. What are the advantages & disadvantages of these energy sources? Discuss & record your ideas below.

<i>Advantages</i>	<i>Disadvantages</i>

6. If time allows, you can learn more about how electricity is generated from steam produced by combustion at the following web sites: [Video 1](#); [Video 2](#).

Packet Performance Evaluation

Summary of Expectations for Packets: Students should fully and accurately answer all required questions with detailed and precise responses that reflect their best effort and show improvement over time. Specifically:

- **Completion:** Full written responses should be provided for all questions with a blank, box, or line.
- **Accuracy & Precision:** Responses should be accurate and use precise language whenever feasible.
- **Effort:** This should reflect proper effort for your age/skill. It shouldn't be rushed, unclear, or gibberish. Packet readings should be annotated, and extra notes & reminders should be written in the margins.
- **Growth & Progress:** You should show evidence of improvement in your reasoning and sensemaking. Your revised explanations should improve in quality, precision, & accuracy with each attempt.

Packet Completion Rubric

Criteria	Above & Beyond	Meets Expectations	Below Expectations
Completion	Full responses are provided for all required questions.	Responses are provided for all required questions.	Multiple required questions do not have completed responses.
Accuracy & Precision	Responses are consistently accurate, detailed, & precise.	Responses demonstrate satisfactory comprehension.	Responses need improvement to show sufficient comprehension.
Effort	Effort exceeds what would be expected at this age/skill.	Effort reflects reasonable expectations for age & skill.	Shows minimal effort; multiple tasks are incomplete or rushed.
Growth & Progress	Responses clearly improve from beginning to end.	Evidence of some growth and improvement.	Shows little to no growth or improvement over time.

Overall Score: _____/20

- **Above & Beyond** (21): The student consistently exceeds expectations with high-quality work in all areas.
- **Meets Expectations** (20): The student shows a good level of quality and effort; minor areas need improvement.
- **Near Expectations** (16): The student meets basic requirements but responses need significant improvement.
- **Below Expectations** (0): The student falls short of meeting the basic requirements in most areas.

Students need a score of 16/20 or higher to be eligible for retakes on summative assessments & projects.

Comments: