7.PS1.5 How Many Atoms?

Phenomenon-Based Instructional Task

Performance Expectation (PE) | 7.PS1.5

Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

Disciplinary Core Idea (DCI) | Chemical Reactions

Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change.

Possible Driving Phenomena

Student Observation or Initial Interaction:

Students observe the reaction between baking soda and vinegar in a bottle/balloon system in which bubbles form and the balloon expands capturing the gas being formed. By recording mass before and after the reaction, students see that the mass of the system does not change.

Phenomenon explanation for teachers:

A balloon containing baking soda is placed over the top of a bottle containing vinegar. The mass of the entire system (e.g. bottle, vinegar, balloon, baking soda, and any air trapped in the system) can be determined. Lifting the balloon to spill the baking soda into the vinegar causes a chemical reaction to occur inside the bottle and the balloon begins to inflate. The mass of the system after the reaction is the same as before the reaction. In this phenomenon, vinegar (acetic acid) and baking soda (sodium bicarbonate) react chemically. The atoms composing the original substances regroup to form sodium acetate, water, and carbon dioxide gas. There is no change in the mass of the system during the process, indicating that the total number of atoms remains the same. The balloon allows gas to remain trapped within the system.

Student observation or initial interaction:

Students observe a picture, video, or a model demonstration of a brush fire or forest fire. Fire is a natural phenomenon that occurs when a combustible fuel source, such as wood or other plant material, comes in contact with oxygen at a very high temperature.

Phenomenon explanation for teachers:

Three elements are required for a fire to occur: heat, fuel, and oxygen. The fuel in a forest fire is the fibrous, woody substance in trees and plants, structured from chains of glucose molecules produced through photosynthesis. Oxygen comes from the air. Heat comes from contact with an ignition source such as a spark, lightning, hot winds, or burning materials. In this phenomenon, oxygen (O2) combines with glucose (C6H12O6) in a chemical reaction resulting in the release of carbon dioxide (CO2) and water vapor (H2O). The atoms composing the original substances regroup in new ways to form different molecules as energy is released in the form of heat. However, the total number of atoms remains the same. The total mass of the products and reactants remains the same if considered as a closed system. The conservation of mass is not easily measured due to the apparent open nature of the system. It is important to define the gasses in the system in order to discuss conservation of mass in a combustion reaction.

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How Does the Phenomenon Connect to the DCI or PE?

During chemical reactions such as seen in the driving phenomena, the smallest units of that substance (atoms) rearrange and regroup to produce new substances that have different properties than the original substance. During this reaction and rearrangement all the atoms are accounted for and none are lost. The atoms are just in a new configuration and the total number of atoms present before the reaction is equal to the number of atoms after the reaction. In a system, atoms combine chemically with other atoms to regroup and form new molecules with different properties than each molecule's original properties. Since matter cannot be created or destroyed, when these chemical reactions occur, matter is conserved and the original number of atoms before a reaction occurs (reactant) is the same as the number of atoms after the reaction occurs (product). In **phenomenon 1**, the mass of the system (bottle, liquids, solids, gasses, and balloon) stays the same before and after the chemical reaction has occurred, even though the balloon has inflated, suggesting that a new substance has formed in the system. For **phenomenon 2**, students should ask questions and pose initial ideas about what is happening to the chemical elements in a wildfire. Students will observe that a new substance is formed and that the mass appears to be smaller after combustion. In both phenomena, the total number of atoms in the system remain the same, therefore the mass is conserved. Students conduct investigations in order to collect data that can be used to develop a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. The law of conservation of mass can be demonstrated using physical models or drawings, including digital forms that represent atoms in the reactants and the products. Simple balanced equations can be utilized to model the law of conservation of mass. The concept that the number of atoms entering a reaction equals the number of atoms at the end of a reaction should be the focus.

Gathering and Reasoning in Order to Construct and Refine Explanations:

How could students gather evidence using SEPs and CCCs that will help them construct/refine a supported explanation of the phenomenon?

1. Initial Engagement with the Phenomenon

Overarching Question: How does the mass of a system change in a chemical reaction?

For **phenomenon 1**, students observe the setup (baking soda still in balloon and not yet spilled into bottle), and find the mass. They make predictions about what will happen when baking soda is tipped into the bottle. Have students generate ideas about what will happen to the mass of the system after the baking soda and vinegar are combined. After students have recorded predictions, begin the investigation, and ask students to make and record observations. Students may also wish to release gas from the system and record this mass as well.

- Provide time for students to sketch the setup and use their prior knowledge to make sense of the phenomenon.
- Students can make predictions about the chemical reaction and discuss the reactants and products in terms of number of atoms.
- Physical models of atoms and molecules could also be utilized or created by students at this point.

For **phenomenon 2**, students should ask questions and pose initial ideas about what is happening to the chemical elements in a wildfire. Students may need to experience additional combustion reactions in closed systems in the laboratory setting where measurements can be made to show that there is no change in mass.

- Students should identify reactants and products of the combustion reaction in the phenomenon.
- Students can sketch models of the combustion system that include the air space into which gasses are released. Models should include energy inputs and outputs in addition to showing what happens to the reactants.
- Students can create physical models of the atoms and molecules of a basic combustion reaction to show how they are rearranged.

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2. CONTINUING EXPLORATION:
Challenge students to model and explain what they have observed by encouraging the use of evidence to support their claims.
• Review different types of models (e.g., conceptual, physical, numerical) and ask different groups of students to develop one of the types of models to explain the phenomena at the molecular level. The models should show that the number of atoms does not change during a chemical reaction and that matter and mass are conserved.
• Give each group time to share their model with the class, followed by a class discussion about each presentation.
• Provide time for each group to modify and revise their first attempt given new data or conceptual understanding based on the class discussion.

GUIDING QUESTIONS
• What do you notice happening in each phenomenon?
• What questions do you have about what is happening in each phenomenon?
• Define the system in each phenomenon.
• What evidence is there that new substances were formed?
• Describe the substances present before and after the chemical reaction in each phenomenon.
• If there is a new substance formed from the chemical reaction, how do you think the mass of the system will change?
• How are the atoms in the reactant molecules being rearranged?
• What evidence is there that matter is being conserved in these systems?
• If you were to draw a model of what is occurring in the system, what things might you include?

Communicate Final Explanation of the Phenomenon:

How might students communicate their understanding of the targeted DCI or PE in an explanation supported by evidence?

Possible formats for constructing explanations of this phenomenon:

• Students can develop and use models to describe how the total number of each type of atom is conserved in chemical reactions; the atoms are regrouped and rearranged to form new substances with properties that differ from the original substance.
• Students can construct a scientific explanation that supports the law of conservation of matter by developing different types of molecular models.
• Students can identify other types of reactions and explain or demonstrate through models how the atoms are rearranged in the reaction process to show conservation of matter.

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