Objective

By the end of this lesson, students will understand the concept of analogous chemical reactions, specifically comparing cellular respiration with combustion reactions. They will conduct hands-on experiments to observe exothermic reactions and analyze the properties of substances involved in these reactions.

Materials and Prep

- Candle
- Matches or lighter
- Instant heat pack
- Glow sticks
- Plastic cups (regular and insulated)
- Thermometer
- Timer or stopwatch
- Notebook for observations
- Access to a digital device for research (if needed)

Before starting the lesson, ensure that all safety precautions are in place for working with fire and chemicals. Discuss the importance of safety when conducting experiments.

Activities

- **Candle Experiment:**

  Light a candle and observe the flame. Discuss how the wax (a hydrocarbon) reacts with oxygen to produce carbon dioxide and water. Ask the student to note the heat and light produced as evidence of energy release.

- **Instant Heat Pack Reaction:**

  Activate an instant heat pack and feel the temperature change. Discuss the chemical reaction occurring inside the pack and how it relates to energy transfer in cellular respiration.

- **Glow Stick Investigation:**

  Activate a glow stick and observe the light produced. Explain the chemical reaction that occurs and how it demonstrates energy transformation from chemical to light energy.

- **Comparative Analysis:**

  Using the data collected from the candle, heat pack, and glow stick, have the student create a chart comparing the energy produced, the reactants involved, and the products formed in each reaction.

- **Heart Rate and Respiration Rate Measurement:**

  After engaging in physical activity (e.g., jumping jacks), measure the student's heart rate and respiration rate. Discuss how these rates change during exercise and relate them to cellular respiration.

Other Analogous Chemical Reactions This hands-on experience with a chemical reaction will help students understand the reaction involving oxygen and glucose in cells. You can also discuss other exothermic chemical reactions with which students are likely to have some experience. Burning a candle is a good example of an analogous chemical reaction to cellular respiration. The wax of the candle reacts with the oxygen in the air, producing new substances—for example, carbon dioxide, which is an invisible gas that rises with the smoke from the candle. The heat and light from the candle are evidence that energy is released. Other possible examples include instant heat packs or glow sticks. A [illegible] of human body [illegible] students (and family's) heartbeat and respiration rates after different activities. Every substance has characteristic properties that can be used to identify it (e.g., solubility, odor, melting point, boiling point, flammability, density, color). These do not change regardless of the amount of the substance. (7.2, 7.3) In a chemical reaction, 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. In a chemical reaction, the total number of each type of atom is conserved, and thus the mass does not change. Unit Abstract This unit on thermal energy transfer begins with students testing whether a new plastic cup sold by a store keeps a drink colder for longer than the regular plastic cup that comes free with the drink. Students find that the drink in the regular cup warms up more than the drink in the special cup. This prompts students to identify features of the cups that are different, such as the lid, walls, and hole for the straw, that might explain why one drink warms up more than the other. Students investigate the different cup features they conjecture to explain the phenomenon, starting with the lid. They model how matter can enter or exit the cup via evaporation. However, they find that in a completely closed system, the liquid inside the cup still changes temperature. This motivates the need to trace the transfer of energy into the drink as it warms up. Through a series of lab investigations and simulations, students find two ways to transfer energy into the drink: (1) the absorption of light and (2) thermal energy from the warmer air around the drink. They are then challenged to design their own drink container or [illegible] as well as the store-bought container, following a set of design criteria and constraints. Narrative In this unit, students will develop and use particle models of a pure substance (water) to explain energy transfer from light and thermal energy. Across the unit, students develop and refine models to explain how objects can change temperature both when matter moves out of a system, and when energy is transferred between objects. Students begin by encountering the anchoring phenomenon of an iced drink in a new (special) cup staying cooler than an iced drink in a regular cup. Students share their initial ideas about matter or energy moving into or out of the cups to explain how the drinks warm up over time. The purpose of the anchor is twofold. First, it is used to probe students' initial ideas of what it means for something to warm up and mechanisms for how this happens in the cup system context. Second, it prompts students to identify the key components of the cup system and how they function to keep the drink cold or allow it to warm up. Defining the system in this way sets students up for making principled decisions about how and why to modify components of the system in their engineering designs to slow energy transfer. Learning Targets Through these investigations students: build on what they know about the particle nature of matter from 5th grade to develop a particle model of solids, liquids, and gases that include both structure and movement of particles as it relates to the temperature of the substance. plan and carry out investigations to systematically test the different parts of the cup system, tracking the flow of matter and energy into or out of the cup system. develop a model of temperature as the average kinetic energy of a group of particles. model the transfer of energy from light to kinetic energy of particles when light is absorbed. model thermal energy transfer between substances through particle collisions, or conduction, to change the average particle motion in a substance. revise their models to include factors that minimize energy transfer by reducing the absorption of light and decreasing the opportunities for particle collisions. apply what they have learned about features that can slow energy transfer to design, build, test, and revise a cup system to keep a drink cold. Supplemental teaching of the nature of matter, so that students see matter as made of particles. Supplemental teaching of the foundations for chemical reactions in PEs MS-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures and MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. This unit is designed to come directly after two units involved in the foundations of chemical reactions and explicitly builds on those understandings. It is critical to note that students need the idea of chemical reactions and the idea that matter can be rearranged through these reactions yielding resultant materials with different properties to develop the explanations in this unit. Specific Differentiation Strategies for Students Who Need More Challenge Compare combustion and cellular respiration. Students who need additional challenge can consider another class of chemical reactions that release energy: combustion reactions. Explain that when most substances burn, a chemical reaction occurs between the substance and oxygen. For example, when a candle burns, the wax reacts with the oxygen in the air. A candle can't burn if it is somewhere with no oxygen. Gasoline in an engine reacts with air to burn. Vehicles have parts that pull in air from outside and mix them with the gasoline in the engine. Ask students to consider what they know about burning and what they have learned about cellular respiration and write three lists: 1. Ways the two reactions are similar [They both use oxygen, require two substances, release energy, can allow movement.] 2. Ways they are different [Burning produces more heat, cellular respiration happens inside living things.] 3. Questions students have about the two reactions Standards NGSS Statement Students engage in a hands-on of a also read a short article and respiration takes place. chemical reaction that releases energy (energy and matter) the parts of the cell where cellular • Practice 2: Developing and Using Models • Practice 3: Planning and Carrying Out Investigations • Practice 8: Obtaining, Evaluating, and Communicating Information Disciplinary Core Ideas Structure and Function: • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2) Structure and Function: • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS-LS1-3) Organization for Matter and Energy Flow in Organisms: • Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. (MS-LS1-7) Energy in Chemical Processes and Everyday Life: • Cellular respiration in plants and animals involve chemical reactions with oxygen that

release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary to MS-LS1-7) Crosscutting Concepts • Energy and Matter • Systems and System Models Common Core State Standards for English Language Arts Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. Draw on several [illegible] reflection, and research Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when encountering an unknown term important to comprehension or expression. Make sense of problems and persevere in solving them. Reason abstractly and quantitatively. Use appropriate tools strategically. Attend to precision. California English Language Development Standards Exchanging information and ideas: Contribute to class, group, and partner discussions by following turn-taking rules, asking relevant questions, affirming others, adding relevant information, and paraphrasing key ideas. Reading/viewing closely: a. Explain ideas, phenomena, processes, and text relationships (e.g., compare/contrast, cause/effect, problem/solution) based on close reading of a variety of grade-level texts and viewing of multimedia with light support. Reading/viewing closely: b. Express inferences and conclusions drawn based on close reading of grade-level texts and viewing of multimedia using a variety of precise academic verbs (e.g., indicates that, influences). Justifying/arguing: a. Justify opinions or persuade others by providing relevant textual evidence (e.g., quoting from the text or referring to what the text says) or relevant background knowledge with moderate support. Using nouns and noun phrases: Expand noun phrases in an increasing variety of ways (e.g., adding comparative/superlative and general academic adjectives to noun phrases or more complex clause embedding) in order to enrich the meaning of sentences and add details about ideas, people, things, and the like. Connecting ideas: Combine clauses in a wide variety of ways (e.g., creating compound and complex sentences) to make connections between and join ideas, for example, to express a reason (e.g., He stayed at home on Sunday to study for Monday's exam), to make a concession (e.g., She studied all night even though she wasn't feeling well), or to link two ideas that happen at the same time (e.g., The students worked in groups while their teacher walked around the room). Reading/viewing closely: c. Use knowledge of morphology (e.g., affixes, roots, and base words), context, reference materials, and visual cues to determine the meaning, including figurative and connotative meanings, of unknown and multiple-meaning words on a variety of new topics. / Lesson Planner / LearningCorner.co

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Talking Points

- "The candle demonstrates a combustion reaction, where the wax reacts with oxygen to release energy in the form of heat and light."
- "In cellular respiration, glucose and oxygen react to produce energy, carbon dioxide, and water, similar to how the candle burns."
- "Both reactions are exothermic, meaning they release energy, but they occur in different contexts—one in a living organism and the other in a non-living system."
- "When we activate the instant heat pack, a chemical reaction occurs that generates heat. This is similar to how our bodies generate heat through metabolism."
- "Glow sticks use a chemical reaction to produce light—this is an example of a reaction that transforms energy from one form to another."
- "The products of a chemical reaction have different properties from the reactants. For example, the wax and oxygen are different from the carbon dioxide and water produced."
- "Understanding these reactions helps us see how energy flows in both living and non-living systems."
- "When we measure our heart and respiration rates after exercise, we can see how our body responds to the need for more energy."
- "In both combustion and cellular respiration, oxygen is a key reactant. Without oxygen, these reactions cannot occur."
- "Let's think about how we can design a drink container that minimizes energy transfer, just like the insulated cup keeps drinks cold."
- "Chemical reactions involve the rearrangement of atoms, which means the total mass before and after the reaction stays the same."
- "When we compare combustion and cellular respiration, we can see similarities in energy release but also important differences in where these reactions take place."
- "It's fascinating to see how everyday items like candles and glow sticks can help us understand complex biological processes."
- "Remember, safety is crucial when conducting experiments, especially with fire and chemical reactions."
- "Let's keep track of our observations and data; it will help us make connections between the experiments and the concepts we've learned."

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