Properties of Matter, Physical/Chemical Changes, and Thermal Energy Transfer

Title: Fire!: UL Investigation
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Estimated Time: 5-7 days

Core Ideas (GSE Standards):

8th Grade Physical Science

S8P1. Obtain, evaluate, and communicate information about the structure and properties of matter.

b. Develop and use models to describe the movement of particles in solids, liquids, gases, and plasma states when thermal energy is added or removed.

c. Plan and carry out investigations to compare and contrast chemical (i.e., reactivity, combustibility) and physical (i.e., density, melting point, boiling point) properties of matter.

d. Construct an argument based on observational evidence to support the claim that when a change in a substance occurs, it can be classified as either chemical or physical.

f. Construct an explanation based on evidence to describe conservation of matter in a chemical reaction including the resulting differences between products and reactants.

S8P2. Obtain, evaluate, and communicate information about the law of conservation of energy to develop arguments that energy can transform from one form to another within a system.

d. Plan and carry out investigations on the effects of heat transfer on molecular motion as it relates to the collision of atoms (conduction), through space (radiation), or in currents in a liquid or a gas (convection).

High School Physical Science

SPS3. Obtain, evaluate, and communicate information to support the Law of Conservation of Matter.

a. Plan and carry out investigations to generate evidence supporting the claim that mass is conserved during a chemical reaction. (Clarification statement: Limited to synthesis, decomposition, single replacement, and double replacement reactions.)

SPS5. Obtain, evaluate, and communicate information to compare and contrast the phases of matter as they relate to atomic and molecular motion.

b. Plan and carry out investigations to identify the relationships among temperature, pressure, volume, and density of gases in closed systems. (Clarification statement: Using specific Gas laws to perform calculations is beyond the scope of this standard; emphasis should focus on the conceptual understanding of the behavior of gases rather than calculations.)

SPS7. Obtain, evaluate, and communicate information to explain transformations and flow of energy within a system.

b. Plan and carry out investigations to describe how molecular motion relates to thermal energy changes in terms of conduction, convection, and radiation.

Science and Engineering Practices:	**Crosscutting Concepts:**
Plan and carry out investigations Construct an argument	Cause and effect Matter and energy

5E Stage	Student Activities How will students engage actively in the three dimensions throughout the lesson?	Teacher Activities How will the teacher facilitate and monitor student learning throughout the lesson?

Phenomena/Authentic Scenarios

- Legacy homes vs modern homes burn differently: https://www.youtube.com/watch?v=IEOmSN2LRqo-
- Connecting this phenomena to the UL Kitchen scene to help students form an evidence based claim.
- **Guiding Questions:** How does the material burned effect a fire? How would the type of matter impact the behavior of the fire?

5E Stage	Student Activities How will students engage actively in the three dimensions throughout the lesson?	Teacher Activities How will the teacher facilitate and monitor student learning throughout the lesson?
Engage	Students presented with photograph of a house fire. Students prior knowledge about strength and magnitude of fires elicited through whole group discussion based on teacher prompts such as considering what factors may make a fire more severe (cover more area), spread more quickly, have higher flames, etc.  Students watch the UL Legacy vs Modern House burn. Students partner discuss observations from fires and make predictions about why the fires may behaved differently. From observations, students generate/list/share at least one question that can be tested in the classroom.	Teacher opens the lesson by showing a photograph of a house fire and then asking questions to access prior knowledge. Sample questions: • Are all house fires the same? • What makes a house fire stay in one or two rooms? • What might make a house fire spread? • What makes some house fires more damaging? Teacher Note: Allow students to partner share and then volunteer their thoughts. Teacher plays the UL Legacy vs Modern House burn. Resource: https://www.youtube.com/watch?v=IEOmSN2LRqo- As students compare the house burns, ensure that they use observations to support their comparisons. At this time you may also need to be explicit about the different types of materials used in the homes, construction techniques, used in modern homes and furnishings, etc. As students share their testable question you may need to model a testable v non-testable question. For example: How long did the fire burn? versus Would a fire burn longer if it was an insulated house or an uninsulated house? List students' questions on the board, and provide feedback for questions that are not testable. Once students' questions are listed, emphasize questions that address differences between the materials in each room. Synthesize the questions into one overarching question, such as: How does the material burned affect a fire?

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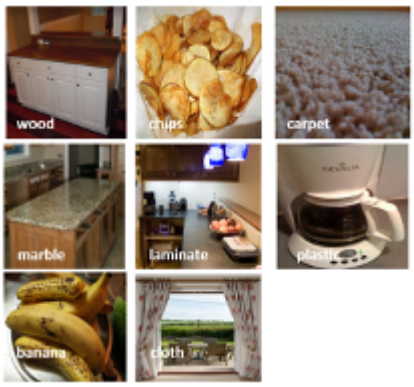
Explore	Students explore facts about different materials through an image based card sort. Students collaborate to organize the cards in a way that indicates how they think each substance would behave in a fire or affect a fire. Students support their categories with reasoning or a rule. Students record/write this initial thinking next to their organization that can be revised later.  Students preview/skim UL Investigation 3: Energy Transfer Background Information to infer what they will read about. Students engage in brief whole group discussion about the prior knowledge they have that may come into play during reading. Students read the text independently, responding to prompts found throughout the text Students pre-read procedures for investigation with a calorimeter. Students predict what they think will happen to each material if it is placed in the calorimeter set up, and why they believe this may be the case.	Provide students with image based cards showing common household materials and some of their properties. Instruct students to sort the cards in a way that gives information about how they think it would behave in a fire or affect a fire. As monitoring student progress, remind them that they must determine a reason/rule for their arrangement. For example, a student may say, "I put them in order from least flammable to most." This organizes the cards based on the chemical property of flammability. As a non-example, show students that sorting the cards into categories like edible and non-edible, though true, would not give information about how they would affect a fire. As students are sorting and discussing the cards you may need to give additional information about each material or guide their thinking. This activity serves as a way for you to pre-evaluate their knowledge. Provide UL Investigation 3: Energy Transfer Background Information, time for students to skim the sections titles and images, and briefly discuss how they initially see connections to their prior knowledge. Be sure to elicit the following prior knowledge: fire triangle components, examples of fuel, methods of heat transfer, etc. Provide independent reading and processing time. Facilitate discussion based on prompts embedded in the text. Teacher Note: Annotation may be useful for some of your students. Provide students with investigation procedures and set up. Demonstrate calorimeter set-up as shown in background information. Support students in making connections to the items being tested to the common household materials found at the scene in the previous case study investigation. Facilitate discussion that allows students to predict how they might observe each material burn while in the calorimeter.

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Explain	In teams of 3-4, students assign group roles for the investigation.	Display group roles and allow students time to determine which group member will fulfill each role.
	Students observe plastic being burned in the calorimeter and record data in table 1.	Model collecting data for sample 1 (plastic) using UL video. Emphasize that burning plastic requires appropriate ventilation and therefore should never be done by them at home, etc. As they watch the video, emphasize important aspects of the setup, what information to record, and the types of observations they will make. Observations could include: how long the sample burns, how charred it is, amount of smoke released, color of smoke released, etc. Support students in being successful at recording all data for plastic in table 1.
	Students observe the comparison of wood and chips burning (simultaneously) in the teacher set up and record observations only.	Next demonstrate the setup for the wood and potato chip. Light both samples from the bottom (as close to the same time as possible) and prompt students to record observations in table 1. This allows students to see how you set up the investigation, overcome the initial shock factor, and have a side by side view of each material. Safety Statement – table should be clear of all other materials, long hair should be tied back, loose clothing should be secured. If you cannot provide safe circumstances or the risk of such an experiment outweighs the benefit with your students then use a video or teacher led demo.
	Student groups will re-examine/ independently investigate samples 2 and 3 for additional data specific to that requested in table 1.	As students investigate sample 2: potato chips and sample 3: wood, monitor their actions closely. It is advised that this investigation be done under close supervision, and in partnership with local fire personnel.
	Students analyze data collected to complete requested calculations in data table 1. Students then transfer/analyze the necessary data in table 2 in order to find the H.O.C for the materials in the lab.	Support students as they calculate the H.O.C for each sample using table 2. If these calculations are beyond the students' expectations, consider using an excel table that will calculate H.O.C once they input the data; or even simply allow the observations about each substance during its burn to substantiate future claims.
	Students connect outcomes from the investigation to respond to the summarizing prompts.	Facilitate discussion (see conclusion questions for options) that allows students to articulate the relationship between synthetic fuels having a higher heat of combustion and a more violent flame with more char, soot, and smoke damage than natural fiber fuels.

Evaluate	Students revisit their organization and rationales of common household items from the engage phase. Students make revisions based on new understandings of specific heat.	As students modify their organization of the materials they should raise their hand for you to check. Provide feedback and extensions on their organization. Place emphasis on which materials are synthetic or natural and how these materials would look differently when burning based on observations from the investigation.

Evaluate	Students revisit their revised claim (from previous days) about the cause of the fire in the UL virtual lab academy. Students determine if they need to revise their claim based on their new understandings about the behavior of fire with synthetic and natural fuels.	Guide students back to the kitchen scene, and their initial/revised claim. Prompt students to consider their new data on how synthetic and natural fuels behave differently in fires, as well as, the new background knowledge. After consideration provide time for students to make final revisions/submissions of their UL claim. Teacher Note: This new information could help differentiate between the potato chips, coffee pot, and countertops as the ignition point due to the difference in composition.

Elaborate	Option 1: Students research which couch would be safer in a fire. Students support their decision with evidence from the investigation and supporting reasons. Option 2: Students take on the role of material scientists to design/ build a room that will withstand flashover. Students test prototypes in an actual fire.	Option 1: Give students images and details on different couches available at local retailers. Students should make a decision about which couch is safest based on their lab results. You may also choose to have students do this research on their own. Option 2: Students design a room that will withstand flashover as long as possible using different materials. Still working on this idea.

Teacher Notes:

- See notes within lesson plan.
- All ideas are adapted from UL Xplorlabs curriculum. Please see their website for videos, commentary, alternative labs, background knowledge and digital content. https://ulxplorlabs.org/fire-forensics-claims-and-evidence/.
- It is possible to complete investigation 3 using a video provided by UL (https://ulxplorlabs.org/experiments/energy-and-combustion/). In this video a marshmallow, cheeto, and wood are burned. You can have students make the observations about the different fuels and deduce which are more "natural" or "synthetic."
- Materials needed: See UL investigation 3 on Xplorlabs website https://ulxplorlabs.org/experiments/energy-and-combustion/
    - **Investigation 3 Lab paper (either one provided in UL Xplorlabs Instructors Manual linked above or the one adapted by Cobb County Teachers)**
    - **Common Materials in our Home cards (for sorting activity)**
    - **Can or Erlenmeyer flask**
    - **Digital thermometer**
    - **Water**
    - **Materials to burn in calorimeter**
    - **Ring stand**
    - **Cork**
    - **Paperclip**
    - **Fire blanket or extinguisher for safety**