Name: Date: Class/Hour:

COMBUSTION

INTRODUCTION

In a science lab, you may have heated a test tube over the flame of a Bunsen burner fueled by natural gas. At home, perhaps you have charred vegetables, fish, or meat on a propane grill. You've seen candles burning on a dinner table or perhaps oak logs burning in a wood stove. On a daily basis, cars and motorbikes drive around on streets, most running on gasoline.

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Have you ever wondered how these fuels compare in terms of their energy content? Is one fuel "better" or more efficient than the others? On what basis might you compare different fuels? In this investigation, you will answer questions such as these.

Fuels burn to give off energy. They do so by combining with oxygen to form compounds of lower energy, typically carbon dioxide and water. For example, below is a chemical equation that represents the complete combustion of methane, CH_4, to produce CO_2 and H_2O:

$$CH_4 + 2O_2 \text{ -> } CO_2 + 2H_2O$$

Methane burns cleanly. We call this complete combustion because the two products, CO_2 and H_2O, are not flammable. That is, they cannot burn any further.

Other fuels, however, may burn incompletely unless supplied with plenty of oxygen. In addition to carbon dioxide, the combustion products also include carbon monoxide and/or soot, including black carbon. For example, some hydrocarbons when burned, including candles, burn with a sooty flame. Below is the chemical reaction in which hexane (a hydrocarbon, C_6H_{14}) burns to produce carbon monoxide:

$$C_6H_{14} + 2O_2 \text{ -> } 6CO + 7H_2O$$

When either soot or carbon monoxide or both are formed as products, this is called incomplete combustion.

The energy when fuels are burned is given off primarily in the form of heat, with some light as well. Although sometimes quite bright, the light emitted by a flame or fire is hard to quantify. In contrast, it is straightforward to measure the heat released when a fuel burns. For these two reasons, you will evaluate the energy content of fuels in this experiment by the heat they give off rather than by the light.

So how do you measure the heat? Rather than doing this directly, we will use the heat released to increase the temperature of a known quantity of water. From this, we can estimate the heat released by burning a particular fuel.

With these measurements, you can calculate the heat (q) absorbed by the water:

q = mass of water (g) × 4.184 joules/g-°C × temp change (°C)

$q = m \times 4.184$ joules/g-°C $\times \Delta T$

Finally, a reality check. In theory, the amount of heat liberated by the burning fuel is all absorbed by the water. But this doesn't happen. As part of this experiment, think about what happens to the heat that is lost.

PROCEDURE

- Safety glasses must be worn at all times.
- Only perform experiments in a well ventilated area (best done in a hood).
- A fire extinguisher should be present, but a box of baking soda or sand to pour on any excessive flames works best.
- Combustion apparatus will be hot after combustion. Heat resistant gloves or tongs should be used to handle samples.

1. Weigh your biomass and then suspend it above an evaporating dish using a wire mesh. Try to get at least 1g of biomass. Record in data table.

2. Measure the mass of the biomass with evaporating dish/ wire mesh setup prior to burning it. Record in data table.

3. Using a graduated cylinder, measure ~15mL of distilled water and pour it into a test tube. Record the mass of H_2O in the data table (1mL of H_2O = 1g). Alternatively, you may weigh the H_2O directly, less the mass of the test tube.

4. Place the biomass setup at the base of the ring stand. Adjust the test tube height so that it will be directly above the chip. Insert a thermometer into the water and secure.

5. Measure and record the initial temperature of the water.

6. Momentarily move the test tube. Use a lighter to ignite the bottom of the chip and then put the test tube back over the burning biomass. The idea is to get as much of the heat from the burning biomass to rise up and heat the water in the test tube.

7. With a stirring rod, stir the water in the test tube while the chip burns. Measure the highest temperature of the water and record it in the data table. Re-light biomass if it goes out.

8. Measure the final mass of the ash in the evaporating dish after burning. Record data.

9. Repeat steps 1-8 using a different biomass item each time.

NOTES