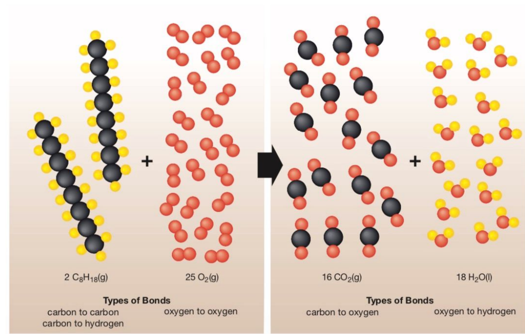
Science 30	Unit D: Energy and the Environment
Lesson 6 - Energy of Combustion	84 mins

Energy of Combustion

combustion: a chemical reaction that occurs in the presence of oxygen and results in the release of energy Energy from combustion - Radiant (em radiation) - Kinetic (temperature of moving particles)	Combustion of Octane 

Heat of Combustion

Temperature: a measure of the average kinetic energy of the atoms or molecules of a substance **Heat:** the ability to transfer of energy from molecules or atoms at a higher temperature to those at a lower temperature (TOTAL ENERGY OF AN OBJECT) **heat of combustion ($\Delta_c H°$):** the amount of heat released when a substance undergoes combustion	Draw

Science 30 - Lesson 42 - Unit D - Energy of Combustion

Name: ______________________________________

Determining Heat of Combustion

Purpose
You will determine and compare the amount of heat released by the combustion of three different fuels.

Experimental Design
During the experiment you will measure the mass of each fuel required to raise the temperature of 20.0 mL of water 20.0°C. The data you collect will be used to calculate an experimental value for the heat of combustion of each fuel tested.
Procedure

step 1: Use a graduated cylinder to fill each of the three test tubes with 20.0 mL of distilled water. Once you have filled the test tubes, place them in a test tube rack for later.

step 2: Use the electronic balance to measure the initial masses of each of the following: ethanol burner with ethanol inside, butane lighter, and candle plus candle holder. Record these values in the data table given in the handout.

step 3: Assemble the apparatus as shown in the handout. The bulb of the thermometer should not be touching the bottom or walls of the test tube. Measure the initial temperature of the water in the first test tube, and record it in the data table.

step 4: Determine the desired final temperature by adding 20.0°C to the initial temperature, and record it in the data table.

step 5: Ignite the ethanol burner, and quickly place it under the test tube so that the upper tip of the flame just touches the bottom of the test tube. Carefully monitor the rising temperature of the water. Once it reaches the final desired temperature, quickly remove the ethanol burner and extinguish the flame.

step 6: Replace the first test tube with another test tube from the test tube rack, and repeat steps 4 and 5 with the butane lighter.

step 7: Replace the test tube with the last test tube in the rack, and repeat steps 4 and 5 to test the paraffin (candle) wax.

step 8: Use the electronic balance to measure the final masses of each of the following: the alcohol burner containing the ethanol, the lighter containing the butane, and the candle. Record these values in the data table given in the handout.

step 9: Disassemble and clean the apparatus, and return all materials to their appropriate places. Make sure your work area is also clean.

Observations

Fuel	Water			Fuel	
	Initial Temperature (°C)	Final Temperature (°C)	Change in Temperature (°C)	Initial Mass of Fuel, m_i (g)	Final Mass of Fuel, m_f (g)
ethanol			20.0		
butane			20.0		
paraffin wax			20.0		

Analysis

Fuel	Mass of Fuel Combusted, $m_i - m_f$ (g)	Molar Mass, M (g/mol)	Quantity of Fuel (mol) $n = \frac{m}{M}$	Experimental Value for Heat of Combustion Per Mole, $\Delta_c H = \frac{Q^*}{n}$ (kJ/mol)
ethanol		46.08		
butane		58.14		
paraffin wax		284.42		
* Q = −1.68 kJ				

Note: Energy change for a substance undergoing a temperature change is calculated using the formula $Q = mc\Delta T$, where

m = mass of water (volume of water x density of water)
c = specific heat capacity of water, 4.19 J/g°C
ΔT = temperature change of water

Therefore,

$$Q = mc\Delta T$$
$$= (20.0 \text{ mL} \times 1 \text{ g/mL})(4.19 \text{ J/g°C})(20.0\text{°C})$$
$$= 1.68 \times 10^3 \text{ J}$$
$$= 1.68 \text{ kJ}$$

The energy required to raise 20.0 mL of water 20.0°C is 1.68 kJ. The energy released by the fuel during its combustion equals the energy gained by the water. As a result, the energy released by the fuel is also 1.68 kJ, which can be expressed as –1.68 kJ. The negative sign indicates that energy is released by the combustion of the fuel.

1) Identify the manipulated and responding variables in this experiment.

2) List three variables that were controlled during this experiment. Describe the actions you took to maintain consistency between trials.

3) Since the energy change for each trial was identical, use the mass of fuel combusted to rank the three fuels from most energetic to least energetic.

4) Use the calculated values for heat of combustion from your table to rank the fuels from highest heat of combustion per mole to the lowest.

5) Describe the relationship between the molar mass of the molecule tested and the heat of combustion per mole of each fuel tested.

6) Compare the rankings listed in your answers to questions 3 and 4. Account for any differences between the two answers.

7) Identify one major flaw in the design of this experiment. Hypothesize how this flaw may have affected your results.

8) Suggest improvements to the apparatus that might minimize the flaw indicated in question 8. If possible, include a diagram of your improvements to the apparatus used in the experiment.