Activity: Evaluating Fuels

FOR THE TEACHER

Summary
In this activity, students measure the heats of combustion of four fuels and compare them as potential replacements for gasoline. They also design an experiment based on prior experience, analyze the data and present their findings orally and in a lab report.

Resource Type  Activity
Grade Level  High school

Objectives
By the end of this lesson, students will
- Understand heat of combustion.
- Evaluate a fuel that could replace gasoline.
- Share their conclusions after careful analysis with classmates.

Chemistry Topics
This lesson supports students’ understanding of
- Heat of combustion
- Combustion
- Thermodynamics

Time
Teacher Preparation: 2 hours
Lesson: 1 week

Materials
To be placed on lab bench and cart/table near fume hood
For each group:
- Alcohol burners
- Methanol
- Ethanol
- 1-Butanol
- Paraffin candles (votive or food warming)
- Tin cans or aluminum soda cans with wire bails
- Balances
- Thermometers
- Graduated cylinders
- Water
- Ice
- Matches
- Ring stands
- Rings and/or clamps

Safety
- Always wear safety goggles when working in a chemistry lab.
- Warn students the chemicals they are working with are highly combustible. They should be closely supervised when working with these chemicals in the presence of fire sources.
• Always be aware of an open flame. Do not reach over it, tie back hair, and secure lose clothing.
• Students should wash their hands thoroughly before leaving the lab.
• When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.

Teacher Notes
• It is fun, easy to set up, and requires the students to work together in experimental design, execution, and analysis.
• This experiment was used to introduce the last unit of the year, thermochemistry. It was deliberately given as a class challenge without any prior learning of calorimetry or energy changes. Thus, it was presented at the beginning of the unit to generate student enthusiasm for both the project and the need to acquire a body of material about energy and calorimetry prior to undertaking the project itself.

FOR THE STUDENT
Student Activity Sheet: Evaluating Fuels for the Department of Energy

Lesson
Background
As the 21st Century pushes on, the availability of fossil fuels, particularly petroleum, will decline. You can expect gasoline to become scarce and expensive. Where and how you will obtain energy in the future will become an increasingly greater concern.

The U.S. Department of Energy (DOE) is looking for a team of scientists that can best conduct research to determine the suitability and efficiency of different fuels. The team that best demonstrates its ability to work together, designs experiments, and produces valid results will be awarded a contract to study potential future fuels.

In this precontract competition, you will be asked to compare four fuels that can undergo combustion. The specific heat of combustion is the heat released per gram of fuel burned, ΔH/g. Your task is to determine and compare the specific heats of combustion for
• methyl alcohol (methanol)
• ethyl alcohol (ethanol)
• 1-butyl alcohol (1-butanol)
• paraffin (wax). Paraffin will be used as a stand-in for gasoline
  o Paraffin is a straight-chain alkane with the formula CₙH₂ₙ₊₂. A typical value for n is 25.

As a class, you are expected to
• Design an experiment to accomplish this task
• Collect data (at least three similar and reliable measurements for each fuel)
• Compile data and calculations using a spreadsheet that shows averages and deviations

In addition, each group will be expected to submit a typed report that describes and explains your whole experiment. You will have to do some additional research
Your typed report should include:

- **Introduction**
  - Background information, statement of purpose (goals and objectives)

- **Procedure**
  - Description of what your group actually did, described so someone can replicate what you did

- **Data** (from the whole class)
  - Presented in a logical, easy to read format (spreadsheet)

- **Calculations** (best done using a spreadsheet, such as Excel)
  - Needs to include descriptions and explanations of the calculations

- **Results**
  - Summarize the results of the calculations (J/g for each of the four fuels).
  - Percent deviation spreads: did you make multiple attempts to reduce the percent deviation and eliminate results that had more than ±5% deviation from the average?
  - Sources of error in the experiment. Compare to commonly accepted values.
  - Make sure you understand the difference between % deviation and % error.

- **Conclusion**
  - Explain what the results mean
    - how does the presence of oxygen in a fuel affects its heat of combustion?
    - compare the molecular structure and elemental compositions of the fuels and how they relate to the results.
  - Provide pictures of each fuel molecule
    - A table of O:C and O:H ratios for each fuel would help you organize your thoughts and help explain the results.
  - Most suitable replacement for gasoline, with explanation.

Your whole class will present its findings to a scientist from DOE on *** using PowerPoint (or another presentation program you’re comfortable using). This presentation should include

- **Introduction**
- **Procedures**
- **Data**, presented in a spreadsheet
- **Results**, summarize the results of the calculations
- **Conclusions**, explain what the results mean

Each member of your team should be prepared for specific questions about your experimental procedures, results and conclusions.

Experimental Details
For supplies and equipment, you will be limited to the materials on the cart in front of the fume hood plus the supplies set out for you on the lab bench.