  

Combustion and Fuels: Efficient Use

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Description

Fuels are any materials that store potential energy in forms that can be practicably released and used as heat energy. Learning about fuel burning is relevant during these times of fuel shortage and the need to save on gas and heating costs. Another important area is the search for alternative fuels that will help protect the planet and fight against the harmful effects of global climate change associated with the emission of fuel by-products.

Fuel is used to power anything, from lawn mowers to generator engines, to cars and airplanes, and toy motor boats. It is the lifeblood of our transportation system. Fuel is also one of the main heating sources for our buildings and residential areas. As our technology advances, society is able to use several natural and man-made sources of fuel.

Fuels can be classified in to several categories. For this lesson we will classify fuels as either gas, liquid or solid.

General types of chemical fuels

	Primary (natural)	**Secondary (artificial)**
Solid fuels	wood, coal, peat, dung, etc.	coke, charcoal
Liquid fuels	petroleum	diesel, gasoline, kerosene, LPG, coal tar, naptha, ethanol
Gaseous fuels	natural gas	hydrogen, propane, coal gas, water gas, blast furnace gas, coke oven gas, CNG

Performing experiments to test fuel burning and indirectly measure their efficiency can provide an interesting learning experience on the environmental value of different fuel types. It is generally agreed that the ideal fuel is a chemical material that releases the greatest amount energy and produces the least amount of waste or by-products.

Objectives

- Students will be able to identify the basic types of fuels.
- Students will be able to predict the environmental consequences of choosing different types of fuels.
- Students will use indirect methods to measure and determine fuel efficiency.
- Students will be able to conduct basic tests to measure composite fuel quality.

North Dakota State Standards

9-10.1.1	Explain how models can be used to illustrate scientific principles
9-10.2.1	Explain how scientific investigations can result in new ideas
9-10.2.6	Design and conduct a guided investigation
9-10.2.7	Maintain clear and accurate records of scientific investigations
9-10.2.8	Analyze data found in tables, charts, and graphs to formula conclusions
9-10.6.3	Explain how emerging technologies may impact society and the environment
11-12.1.2	Identify structure, organization, and dynamics of components within a system
11-12.8.1	Identify the criteria that scientific explanations must meet to be considered valid

Schedule

09:00-09:30	General Organization and Cultural Connection
09:30-10:00	PowerPoint Presentation
10:00-10:30	Activity 1
10:30-11:15	Activity 2
11:15-12:00	Activity 3
12:00-12:45	Lunch
12:45-01:45	Activity 4
01:45-02:30	Activity 5
02:30-02:50	Activity 6
02:50-03:00	Wrap-up and Reflection questions

Cultural Connection: Heating Up the Sweat Lodge

Terminology to Note:

Combustion:
Heat:
Flammability:
Calorie:
Oxidizer:
Turbulence:
Density:
Exothermic reaction:
Endothermic reaction:
Flame:

Smoke:
Viscosity:
Flash point:
Pour point:
Specific heat:
Moisture content:
Energy conversion:
Primary fuels:
Secondary fuels:



Activity 1 – Know Your Fuels

Objective

Identify the different types of fuels, their sources, and their usage

Materials

Internet access, computer, pencils and spreadsheet

Data collection

Fuel	Source	Usage	Heat Content
Wood			
Petroleum			
Natural gas			
Coal			
Peat			
Dung			
Coke			
Charcoal			
Diesel			
Gasoline			
Kerosene			
Coal tar			
Naptha			
Ethanol			
Hydrogen			
Propane			
Coal gas			
Water gas			
Blast furnace gas			
Coke oven gas			

Fire Safety Warning!

Fire Safety (Source: McGill University Lab Safety Excerpts)

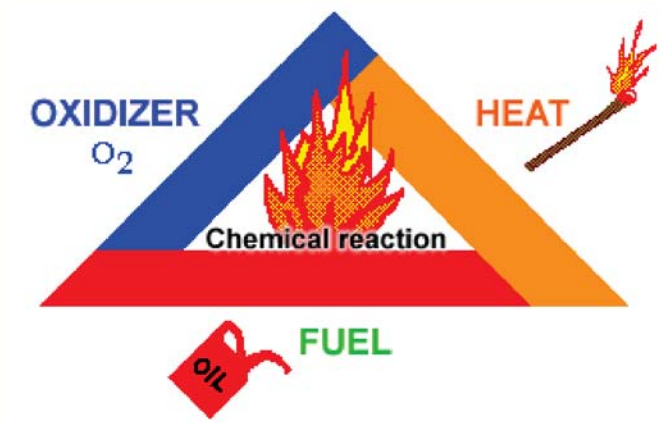
Laboratory fires can by caused by Bunsen burners, runaway chemical reactions, electrical heating units, failure of unattended or defective equipment, or overloaded electrical circuits.

Familiarize yourself with the operation of the fire extinguishers and the location of pull stations, emergency exits and evacuation routes where you work. In the event that the general alarm is sounded use the evacuation routes established for your area and follow the instructions of the Evacuation Monitors. Once outside of the building, move away from the doors to enable others to exit.

The fire triangle

Fire cannot occur without an ignition source, fuel and an oxidizing atmosphere (usually air), the three elements that comprise what is called the "fire triangle":



Fire will not be initiated if any one of these elements is absent, and will not be sustained if one of these elements is removed. This concept is useful in understanding prevention and control of fires.

Classes of fire

The National Fire Protection Association (NFPA) has defined four classes of fire, according to the type of fuel involved. These are:

- *Class A* fires involve combustibles such as paper, wood, cloth, rubber and many plastics.
- *Class B* fires entail burning of liquid fuels like oil-based paints, greases, solvents, oil and gasoline.
- *Class C* fires are of electrical origin (fuse boxes, electric motors, wiring).
- *Class D* fires encompass combustible metals such as magnesium, sodium, potassium and phosphorus.

Activity 2 – Cleanest Burning Fuels

Objective

Conduct an experiment to determine the cleanest burning fuel source.

Materials

1. Procure samples of the fuels you want to test (at least 5 samples)
   - Methanol (Heet)
   - Ethanol
   - Vegetable oil
   - Mineral oil
   - Canola oil
   - Kerosene
   - Unleaded gas
   - Diesel
2. Cotton clothesline or wick
3. Droppers
4. Paperclips
5. Lighter for ignition
6. Timer

Procedure

- Use a dropper to place 20 drops of each kind of fuel onto separate pieces of clothesline.
- To be safe, suspend the clothesline pieces on bent paperclips so that they do not touch the surface you are working on.
- Burn each clothesline sample until the flame goes out on its own.
- While each type is burning, observe the fumes that emanate from the sample.
- Do they appear sooty or oily or do they burn cleanly?
- Record the results.

Fuel Type	**Time to burn out**	**Fume color**	**Smell**
- Methanol			
- Ethanol			
- Vegetable oil			
- Mineral oil			
- Canola oil			
- Kerosene			
- Unleaded gas			
- Diesel			

Activity 3 – Bio-fuel Efficiency

Objective

Measuring fuel heat output as a proxy for fuel efficiency. This experiment will reveal whether bio-fuels or gasoline have a better energy output

Materials

1. 400 ml beakers (3) or container that can withstand burning fuel
2. Large test tubes (3)
3. Fuels types including:
    - Bio-ethanol (E-85)
    - Alcohol
    - Gasoline
4. Thermometers (3)
5. Thermal mat or hot plate
6. Water
7. Timer
8. Ignition source
9. Rolled up newspaper
10. Fire extinguisher

Procedure

- Measure 200 ml of bio-ethanol, 200 ml of alcohol, and 200 ml of gasoline into separate beakers.
- Fill a test tube on a stand with 50 ml of water.
- Place a thermometer in the test tube and measure the exact temperature of the water. Leave the thermometer in the test tube.
- Position the bio-ethanol beneath the test tube and place it on a hot plate or thermal mat.
- Use rolled-up newspaper and a lighter to ignite the fuel.
- Record the time it takes to stop burning and the temperature of the water after burning.
- Repeat this process, using alcohol and gasoline in place of the bio-ethanol.

Fuel type	**Water Temperature before heating**	**Water temperature after heating**	**Burn out time**
Bio-ethanol			
Alcohol			
Gasoline			

Activity 4 – Efficiency of Different Types of Wood

Objective

Wood has been a source of fuel since man first discovered fire. We use wood for heating our houses and it is a renewable fuel. Different types of wood products have different abilities to burn and generate adequate heat as fuel. Nowadays, manmade composites have been developed that have the potential of producing better output of heat at the longest possible time. Which of the many different types of wood and composite products burns for the longest amount of time and at the highest temperature?

Materials

1. Procure a few types of wood, such as: (any 2 will do)
    - Pine
    - Oak
    - Birch
    - 5 composite log products that you can buy at a hardware store:(any 3 will do)
        i. Duraflame
        ii. Pine Mountain
        iii. Enviro-log
        iv. Cotton stem log (Provided by NDSU)
        v. Pine dust log (Provided by NDSU)
2. Fireplace or fire pit or fume hood
3. Container or beaker
4. Rack and stand,
5. A grate made out of any metal mesh to suspend the wood product
6. Thermometer
7. Scale
8. Collection pan made of metal
9. Ignition source and flame starter (Duraflame fire starter)
10. Water
11. Drill with a core bit about 2 inches in diameter

Procedure

- Cut the different wood samples into uniform pucks (2 x 1 inches) using a drill with a core bit. The small size will enable it to easily burn in a controlled space such as a fireplace or fire pit or fume hood.
- Weigh the puck of wood and record its mass. Place the puck on the grate and use the flame starter to start burning the wood.
- Measure a set amount of tap water into a container and place above the fire area on a rack. Make sure to record the beginning temperature of the water.



- Light a fire containing one type of wood beneath the water.
- Record the amount of time it takes for the fire to burn out and then record the ending temperature of the water.
- Collect the ash left after burning and weigh this to determine the amount of residue or waste left by the burning.
- Repeat the process for the other sample products.
- Record you observations

Fuel type	**Mass of puck**	**Mass of residue**	**Water temp before heating**	**Water temp after heating**	**Burn out time**
Pine					
Oak					
Birch					
Duraflame					
Pine Mountain					
Enviro-Log					
Cotton stem					
Pine dust					

Activity 5 – Effect of Alcohol Percentage in Gasoline

Objective

Test how the alcohol percentage in gasoline affects how long an engine runs.

Materials

1. Small generator engine or lawn mower can be used
2. Fuels including
   - Ethanol
   - Gasoline
3. 200 ml beakers (5)
4. 100ml measuring cylinder (2)
5. Graphing paper

Procedure:

We can test how the percentage of alcohol in gas affects how long an engine runs by mixing different amounts of ethanol with gasoline and separating them into marked beakers.

- The mixture amounts should be:



  - 10 percent: 10 ml of ethanol and 90 ml of gasoline,
  - 15 percent: 15 ml of ethanol and 85 ml of gasoline,
  - 20 percent: 20 ml of ethanol and 80 ml of gasoline,
  - 25 percent: 25 ml of ethanol and 75 ml of gasoline,
  - 30 percent: 30 ml of ethanol and 70 ml of gasoline.
- Pour one mixture into a generator engine and allow it to run until it is dry.
- Record the amount of time the generator takes before it stops running.
- Repeat with different gasoline mixtures.
- Note: you may need to proportionally reduce the amounts for faster results.
- Use caution when operating a generator and ask an experienced adult for help.
- Plot a graph of your results to show the optimal combination of ethanol and gasoline that will keep the engine running the longest time. Your Y-axis should be the engine operation duration, and your X-axis should be the percent ethanol added to the mixture

Fuel mixture	**Engine Duration run**
- 10 percent: 10 ml of ethanol and 90 ml of gasoline,	
- 15 percent: 15 ml of ethanol and 85 ml of gasoline,	
- 20 percent: 20 ml of ethanol and 80 ml of gasoline,	
- 25 percent: 25 ml of ethanol and 75 ml of gasoline,	
- 30 percent: 30 ml of ethanol and 70 ml of gasoline.	

Activity 6 – Testing fuels for alcohol content

Objective

Regular gasoline usually contains some alcohol, which can sometimes be as much as 10 percent. Alcohol, however, can be harmful to the engine and it is important to determine the amount that is present in the gasoline you use in your car or other engine.

There are many alcohol test kits you can purchase and use to test gasoline before using it in your car. However, a simple method that may be less costly will be shown today.

Materials

1. 100 ml graduated cylinder
2. Fuel sample
3. Tap water
4. Stopper

Procedure

- Collect a regular fuel sample from your fuel supply. Use a clean and dry container so you do not contaminate your sample.
- Pour 90 ml of your fuel sample into a 100 ml graduated cylinder.
- Add 10 ml of water to the cylinder and cover the top with your with a stopper or paraffin paper and shake.
- Let the fuel sample set for 10 to 15 minutes.
- The alcohol will combine with the water and separate from the fuel.
- Read the line where it separates.

Now, the calculations!

- Note that: 100 ml = 100%
- The water will settle to the bottom because water is heavier than gasoline
- Looking at the cylinder, if the line is on the 53 ml mark for example, we interpret this as 53%.
- Now we know 10 ml (10%) of the liquid in the cylinder was added as water.
- In order to get the amount or percent of alcohol, we will subtract 10 from 53, which is 43.
- This sample would have a 43% alcohol content
- This sample technically has way too much alcohol for a 10% blend and most cars (except those equipped to run with flex fuel) would run very poorly if they started.

Lesson Questions:

Activity 1 – Know Your Fuels

1. Which of these fuels are green renewable fuels?
2. Which of these fuels are nonrenewable fuels?
3. Which of these fuels is the cleanest fuel for the environment?

Activity 2 – Cleanest Burning Fuels

1. Which of these fuels burnt cleanest based on the fumes produced?
2. Which of these fuels burnt very sooty based on the fumes produced?
3. Which of these fuels had fumes with the strongest smell?
4. Which of these fuels had fumes with no smell or minimal smell?
5. How would you use the information above to make wise decisions on what type of fuel to use that benefit the environment?

Activity 3 – Bio-fuel Efficiency

1. Based on your results and observations, do bio-fuels produce a better heat output than gasoline?
2. Which of the fuels had a longer burn out time?
3. Which of the fuels had the shortest burn out time?
4. The highest temperature for water was observed by using which fluid?
5. How will this information influence your decision on which type of fuel to use based on environmental sustainability?

Activity 4 – Efficiency of Different Types of Wood

1. What is the difference between a composite log of wood and a natural log of wood?
2. Composite logs are made from a variety of materials and are usually designed to have a high heat output. Can you name some materials that could be combined to produce composite logs?
3. Which of these log products have the highest heat output?

4. Which of these log products have the lowest heat output?

5. Which log type, natural wood log or composite, produced the greatest output of heat on average?

6. Which log product produced the largest amount of residue by weight?

7. Which log product produced the least amount of residue by weight?

8. Which of these log products burnt longest?

9. Which of these log products burnt shortest?

10. As an environmentally conscious person, based on your results, which of these fire logs would you recommend for use in your home?

Activity 5 – Effect of Alcohol Percentage in Gasoline

1. If you use E-85 as fuel for your car to run, what does the acronym E-85 tell you about the alcoholic content of your fuel?

2. Based on our observed results, which of these fuel mixtures produced the longest run time for the motor?

3. Based on our observed results, which of these fuel mixtures produced the shortest run time for the motor?

4. Which of these will produce the best MPG for a vehicle?

5. The regular gasoline sold at most gas stations in the US, typically has a 10% alcohol added to it. Based on our observations, do you think this is the best fuel mixture that will give you the highest MPG?

Activity 6 – Testing fuels for alcohol content

1. The regular gasoline sold at most gas stations in the US, typically has a 10% alcohol added to it. Based on our observations, does the gas tested have more or less than 10% alcohol?

2. Is the labeling of 10% on commercially sold gasoline justified?