CHEMICAL REACTIONS:
Combustion Engines and Atmospheric Chemistry

Georgia Performance Standards: SCSh1, 3, 5, 6, 7, 8, 9, SC2 a, b
National Science Standards: Content Standards A, B: chemical reactions, E, F: natural resources, environmental quality, science in local, national, and global challenges

Objective: Students will create a website that explains internal combustion engines, chemical equations involved in emissions in the atmosphere, and how biodiesel compares to petroleum diesel fuel.

Essential Questions:

- How do internal combustion engines work?
- How does a diesel engine differ from a gasoline engine?
- What happens in the atmosphere after combustion?
- How does biodiesel improve emissions?

Background:

Engines:

Chances are that you got to school this morning with a vehicle running with an internal combustion engine. Almost all car engines use a four-stroke combustion cycle in order for the fuel to run the engine. The four strokes are: intake stroke, compression stroke, combustion stroke and exhaust stroke. Imagine a piston moving up and down in an engine. As the piston moves down, air and fuel are brought into the cylinder through a valve at the top. The piston moves back up compressing the air/fuel mixture, and then the combustion reaction occurs forcing the piston back down. On the way back up the last time, the piston pushes the exhaust gas out of another valve at the top of the cylinder. The up and down of the pistons is converted to rotational motion with the crankshaft and that motion later turns the wheels in your car.

In the case of the internal combustion engine, the combustion reaction occurs between the fuel and oxygen in the air. Engine fuels are made up of hydrocarbons, hence the general equation:

$$\text{Hydrocarbon} + O_{2\,(g)} \rightarrow CO_{2\,(g)} + H_2O_{\,(l)}$$

This is generally and exothermic reaction and the energy given off results in rapidly expanding gas which is what forces the piston in a downward motion. Heat is also given off as a result.

Diesel fuel is not as volatile as gasoline and that is due to the fact that diesel fuel hydrocarbons are much heavier molecules. You may know that gasoline engines contain something called a sparkplug – it provides a spark that ignites the fuel/air mixture and triggers the combustion. For that reason gasoline engines are sometimes called *spark-ignition* engines. A spark will not ignite diesel/air mixtures. In diesel engines, as the piston moves up in the cylinder, it compresses just air to the point that the temperature is very high. The fuel is injected into the hot air and that is what ignites the fuel. For this reason diesel engines are sometimes called *compression-ignition* engines. With gasoline engines, the amount of air and fuel injected into the cylinder is in a fixed ratio. Diesel engines can sense the amount of oxygen in the cylinder before injecting fuel and therefore the amount of fuel can change slightly each time. This is what makes diesel engines more efficient than gasoline engines resulting in better mileage.

Reactions:
In an ideal situation, fuel would combust completely (reaction would go to completion) and therefore the only products coming out of the tailpipe would be carbon dioxide and water. Because fuel doesn't always completely combust, sometimes the carbon atoms (from the hydrocarbon) only combine with one oxygen atom forming poisonous carbon monoxide. Sometimes the carbon and hydrogen atoms continue to stick together in different ratios causing uncombusted hydrocarbons to escape from the tailpipe. These along with hydrocarbons that evaporate directly from the fuel without entering into the combustion cylinder can be toxic. The heat from the engine and combustion reaction can also cause nitrogen and oxygen molecules from the atmosphere to combine outside the engine producing harmful nitrogen oxides. The unburned hydrocarbons can combine with nitrogen oxides and can produce photochemical smog. Carbon atoms from the combustion can also remain unburned and stick together forming carbon deposits in your engine or soot from the tailpipe.

Fuels like biodiesel contain smaller molecules and tend to combust more completely in an engine. Therefore they are much cleaner for the environment. The amounts of soot, unburned hydrocarbons, carbon monoxide, and sulfur oxides released from combusting biodiesel are much less than petroleum diesel fuel.

Materials:

1. two Oil lamps
2. Biodiesel, Petroleum diesel
3. two watch glasses
4. crucible tongs
5. electronic balance
6. matches or lighters
7. time keeping device
8. Computer Access
9. Web design software

10. Internet/Library access

Procedure:

Part I: Combustion Measurements

In the lab you will need to perform one set of measurements.

1. Obtain three oil lamps, three watch glasses and a pair of tongs
2. Put biodiesel into one oil lamp and petroleum diesel into another
3. Weigh each watch glass and record the mass
4. Light each lamp and let it burn for 2 minutes – be careful!
5. Using the tongs, hold one watch glass 6 inches above the flame of the biodiesel lamp.
6. Time yourself holding the watch glass for exactly 2.0 minutes.
7. Weigh the watch glass again and calculate how much soot was accumulated.
8. Repeat steps 5-7 for the petroleum lamp.

Did you notice any difference in the soot given off from each fuel? If so, why do you think there was a difference?

Part II: Website

Your task is to create a website that illustrates the concepts of engines and emissions. You will need to use the internet and library to do research. You will need to use sources other than howstuffworks.com.

Your website will need to contain the following information:

- Thorough explanation of how the diesel engine works
- How the diesel engine is different than a gasoline engine
- An overview of the differences in diesel fuel and gasoline
- Explanation and equations involved in the combustion of fuel
- Any and all equations (with explanation) involved in the atmosphere that result from hydrocarbon combustion in the engine. How do we get harmful emissions in the atmosphere? How do compounds react? How is acid rain or smog or ozone formed?
- Include statistical and other information on emissions: photochemical smog, ozone formation, NOx, SOx, hydrocarbons, carbon

monoxide and carbon dioxide. You should have one set of numbers/info for petroleum diesel and one set for biodiesel
- Explain the benefits of using biodiesel in terms of combustion and emissions (environmental benefits). How is using biodiesel good in the long run or for the "big picture"?
- You should report the results of your lab experiment and you should provide an explanation of what the results mean.

If you use pictures or illustrations from another source be sure to cite that source. Be sure to have a separate page for your bibliography of information/picture sources.

MAKE SURE YOU ARE BACKING UP YOUR WORK. You should be saving your work in more than one place EVERY TIME. You never know what might happen and if you lose your work before you turn in the assignment, you will not receive a passing grade.

Assessment: Website rubric

Web Site Design : Combustion Engines and Atmospheric Reactions

Teacher Name:

Student Name: _____

CATEGORY	5	3	2	1
Content Accuracy	All information provided by the student on the Web site is accurate and all the requirements of the assignment have been met.	Almost all the information provided by the student on the Web site is accurate and all requirements of the assignment have been met.	Almost all of the information provided by the student on the Web site is accurate and almost all of the requirements have been met.	There are several inaccuracies in the content provided by the students OR many of the requirements were not met.
Content	The site has a well-stated clear purpose and theme that is carried out throughout the site.	The site has a clearly stated purpose and theme, but may have one or two elements that do not seem to be related to it.	The purpose and theme of the site is somewhat muddy or vague.	The site lacks a purpose and theme.
Layout	The Web site has an exceptionally attractive and usable layout. It is easy to locate all important elements. White space, graphic elements and/or alignment are used effectively to organize material.	The Web pages have an attractive and usable layout. It is easy to locate all important elements.	The Web pages have a usable layout, but may appear busy or boring. It is easy to locate most of the important elements.	The Web pages are cluttered looking or confusing. It is often difficult to locate important elements.
Navigation	Links for navigation are clearly labeled, consistently placed, allow the reader to easily move from a page to related pages (forward and back), and take the reader where s/he expects to go. A user does not become lost.	Links for navigation are clearly labeled, allow the reader to easily move from a page to related pages (forward and back), and internal links take the reader where s/he expects to go. A user rarely becomes lost.	Links for navigation take the reader where s/he expects to go, but some needed links seem to be missing. A user sometimes gets lost.	Some links do not take the reader to the sites described. A user typically feels lost.
Color Choices	Colors of background, fonts, unvisited and visited links form a pleasing palette, do not detract from the content, and are consistent across pages.	Colors of background, fonts, unvisited and visited links do not detract from the content, and are consistent across pages.	Colors of background, fonts, unvisited and visited links do not detract from the content.	Colors of background, fonts, unvisited and visited links make the content hard to read or otherwise distract the reader.

Graphics	Graphics are related to the theme/purpose of the site, are thoughtfully cropped, are of high quality and enhance reader interest or understanding.	Graphics are related to the theme/purpose of the site, are of good quality and enhance reader interest or understanding.	Graphics are related to the theme/purpose of the site, and are of good quality.	Graphics seem randomly chosen, are of low quality, OR distract the reader.
Spelling and Grammar	There are no errors in spelling, punctuation or grammar in the final draft of the Web site.	There are 1-3 errors in spelling, punctuation or grammar in the final draft of the Web site.	There are 4-5 errors in spelling, punctuation or grammar in the final draft of the Web site.	There are more than 5 errors in spelling, punctuation or grammar in the final draft of the Web site.
Interest	The author has made an exceptional attempt to make the content of this Web site interesting to the people for whom it is intended.	The author has tried to make the content of this Web site interesting to the people for whom it is intended.	The author has put lots of information in the Web site but there is little evidence that the person tried to present the information in an interesting way.	The author has provided only the minimum amount of information and has not transformed the information to make it more interesting to the audience (e.g., has only provided a list of links to the content of others).
Layout	The Web site has an exceptionally attractive and usable layout. It is easy to locate all important elements. White space, graphic elements and/or alignment are used effectively to organize material.	The Web pages have an attractive and usable layout. It is easy to locate all important elements.	The Web pages have a usable layout, but may appear busy or boring. It is easy to locate most of the important elements.	The Web pages are cluttered looking or confusing. It is often difficult to locate important elements.
Copyright	Fair use guidelines are followed with clear, easy-to-locate and accurate citations for all borrowed material. No material is included from Web sites that state that permission is required unless permission has been obtained.	Fair use guidelines are followed with clear, easy-to-locate and accurate citations for almost all borrowed material. No material is included from Web sites that state that permission is required unless permission has been obtained.	Fair use guidelines are followed with clear, easy-to-locate and accurate citations for most borrowed material. No material is included from Web sites that state that permission is required unless permission has been obtained.	Borrowed materials are not properly documented OR material was borrowed without permission from a site that requires permission

CHEMICAL REACTIONS:
Instructor Notes

Use the website: http://www.howstuffworks.com.
Search terms to consider:

- "diesel engines" – how they work and the difference between gasoline and diesel
- "gasoline engines" – how they work
- "internal combustion engines"
- "oil refining"

Consider publishing the websites and telling the students that you will. They will put more effort into it if they know that people might actually be able to view them.

I usually DO NOTT let students use websites that let them create web pages such as MySpace, Wetpaint, etc. I have used MS FrontPage or Dream Weaver in the past and have encouraged them to make websites that contain several pages. You can have the students turn in the websites on a CD or on a common network drive at your school.