

Activity 5.4: Other Organic Materials Reading Octane, Gasoline, and Internal Combustion Engines

You probably know that car engines burn gasoline, but how do they do that? You can't see any flames.

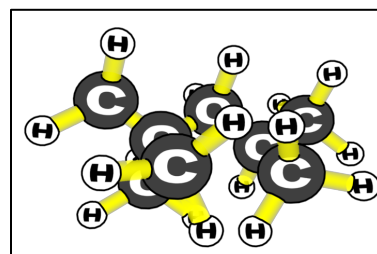
The energy that makes cars move starts out as chemical energy in gasoline. This reading answers two questions:

1. What is gasoline?
2. How does an engine get energy from gasoline?

What is gasoline?

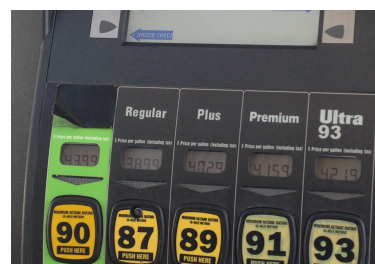
Gasoline is a mixture of liquid organic materials. You already know about one of these materials—ethanol. Most gasoline in the United States is about 10% ethanol. The other materials in gasoline are mostly *hydrocarbons*: organic molecules made of only hydrogen and carbon. Because ethanol has oxygen atoms it is not a hydrocarbon.

One hydrocarbon molecule in gasoline is *octane*: C_8H_{18} . Here is the structure of an octane molecule. All of the different hydrocarbon molecules in gasoline have about the same amount of energy. However, octane is different from some of the other organic molecules in gasoline because octane burns very smoothly.



At a gas pump, people can choose from types of gasoline with different octane ratings. All of the different grades have the same amount of energy, but high-octane gasoline burns more smoothly. The octane ratings on a gas pump indicate how smoothly the gasoline burns: an octane rating of 100 means that the gasoline burns as smoothly as pure octane.

(High-grade gasoline is more expensive. Most cars do not need gasoline that burns so smoothly, so for most cars it makes sense to get the less expensive lower-octane gasoline that has just as much energy.)



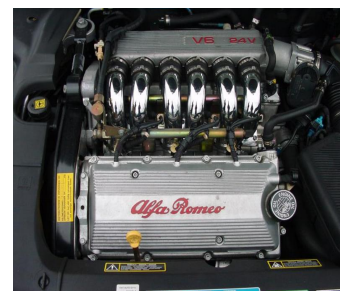
"Pump grades" by 127driver is licensed under CC BY 4.0

How does an engine get energy from gasoline?

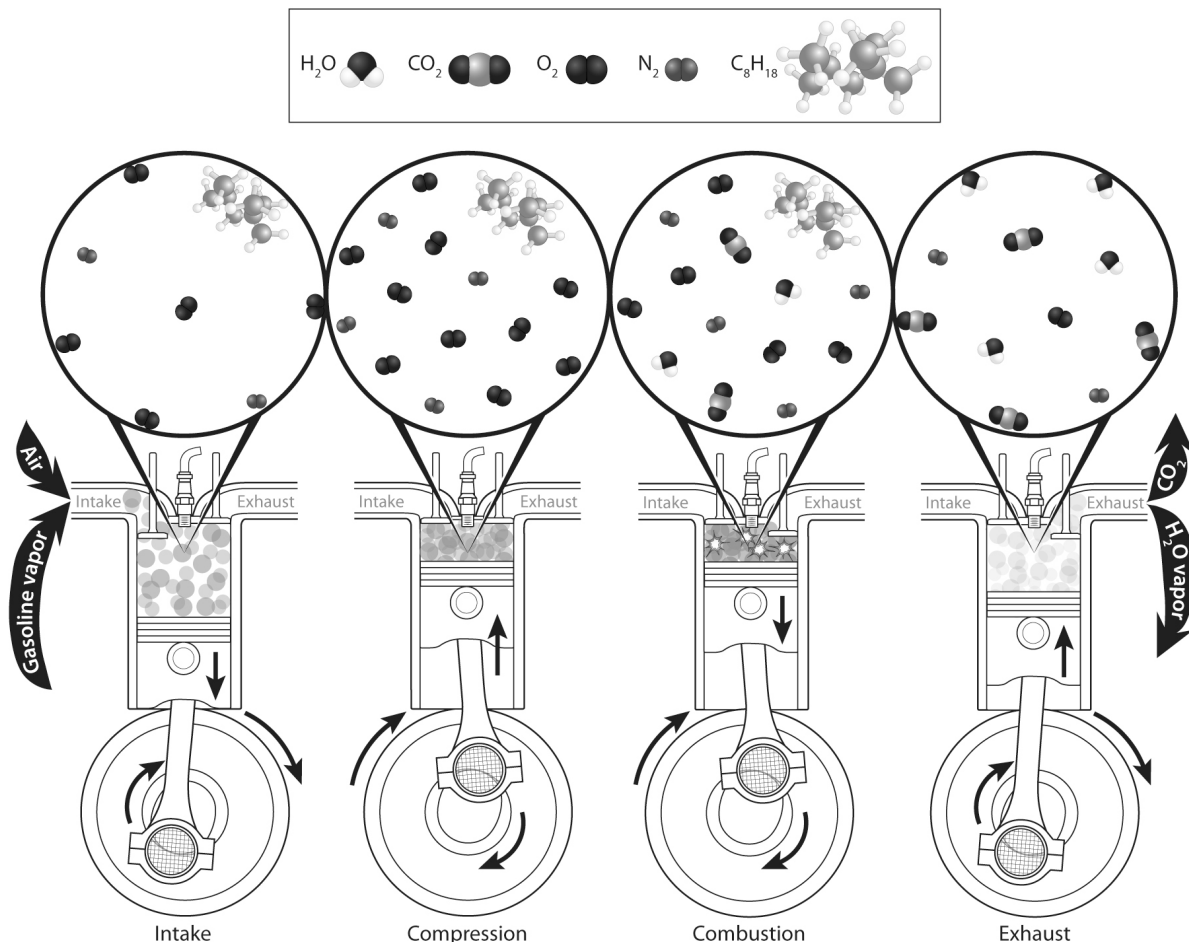
A gasoline engine is an *internal combustion* engine: The gasoline burns inside the engine. The places where gasoline burns are called cylinders, because of their shape. Small gasoline engines like lawnmowers have just one cylinder. Most cars have four-cylinder or six-cylinder engines.

In all gasoline engines, the burning gasoline pushes out a piston that provides power to turn the wheels or do other work. This is a four-step process.

Step 1: Intake. A mixture of air and gasoline vapor comes into the cylinder.



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Step 2: Compression. The piston moves into the cylinder, compressing the mixture of air and gasoline vapor.

Step 3: Combustion. A spark from the spark plug sets the gasoline vapor on fire. Octane and the other molecules in gasoline combine with oxygen in the air to produce CO_2 and H_2O —carbon dioxide and water vapor. When the gasoline burns, the chemical energy in its C-C and C-H bonds is released—a lot of heat! The hot air expands and pushes out the piston. This is the energy that makes the car move.

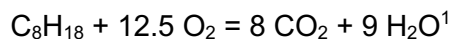
Step 4: Exhaust. The release valve opens to let the air with CO_2 and H_2O leave the cylinder. Now the cylinder is ready for more gasoline and air to come in, and the cycle starts over again.

What happens to octane when it burns?

Now let's look more closely at what happens when octane burns inside the cylinder. You already know some parts of the story of octane burning. It can help to think about how burning octane is *alike* and *different* from burning other organic materials that you have studied, such as ethanol or methane.

Alike: Like ethanol and methane, octane is an organic material, with lots of high-energy C-C and C-H bonds that can release energy when they are combined with oxygen (O_2). Octane, ethanol, and methane are also alike in that they begin combustion as gases (after evaporating from liquids in the case of ethanol and octane).

Different: Octane molecules have a different structure from ethanol and methane, C_8H_{18} . So, the chemical equation for burning propane looks something like this:



Use the worksheet to tell the story based on what you know about octane and about combustion of other organic materials.

Digging deeper

Here are some more places that you can go to learn about where gasoline comes from, what is in it, and how engines work:

- Read more about where gasoline comes from and what it is: [Nick's original gasoline reading.]
- Learn more about how gasoline engines work:
 - How fossil fuels form - <https://www.youtube.com/watch?v=pvH-h7TzSsE>
- Learn more about where petroleum comes from and how it is refined into gasoline:
 - How crude oil is extracted and refined - <https://www.youtube.com/watch?v=9Py8-Xy9MKo>
 - Fracking - <https://www.youtube.com/watch?v=Uti2niW2BRA>

¹ Chemists usually write equations that have only whole molecules, so they write an equation for two octane molecules burning: $2 \text{C}_8\text{H}_{18} + 25 \text{O}_2 = 16 \text{CO}_2 + 18 \text{H}_2\text{O}$.