Comparing Auto Racing Fuels
Student Guide - Secondary

The objective of this guide is to compare racing fuels based on their properties, use knowledge of organic chemistry in a practical application, apply the principles of racing technology to passenger vehicles, and assess the positive and negative attributes of varying racing fuels.

Vocabulary

- chemical energy
- combustion
- distilled
- efficiency
- emissions
- energy
- energy density
- enthalpy
- ethanol
- exothermic
- fermentation
- gasoline
- glucose
- greenhouse gas
- hydrocarbon
- methanol
- nonrenewable
- octane
- performance
- renewable
- surroundings
- suspension
- system
- thermal energy
- transmission
- viscous
- volatile

Student Background Information

Since Henry Ford began building his Model T, the automotive and petroleum industries have been working to improve **performance** and **efficiency** of passenger and freight vehicles. Did you know that many of the features seen in today's passenger vehicles were developed first in the racing industry? It's true! Virtually every system in your car has been influenced by progress made in racing. Lightweight materials, tire, brake, and **suspension** technology, new **transmission** and engine developments, and even the rear view mirror all first appeared on a race track somewhere. Oftentimes, technology appearing in today's racing vehicles shows up in tomorrow's passenger vehicles. The same is true with racing fuel and fuel blends.

Racing vehicles are built primarily for performance and safety. Therefore, the fuel used must be capable of delivering a sufficient amount of **energy** to the vehicle without being too **volatile**, too heavy, or too **viscous** to transfer it quickly from tank to vehicle. **Gasoline** was the fuel of choice for years, and continues to be used in Formula 1 racing. However, **methanol** has been used in the past, and **ethanol** blends with gasoline are currently being used in both NASCAR (E15) and Indycar (E85) racing.

Gasoline is a **nonrenewable** fuel. **Distilled** from petroleum, gasoline contains a mixture of **hydrocarbon** compounds ranging in size from four carbon atoms to twelve carbon atoms. Because it is a mixture, and its composition varies somewhat, it is difficult to pinpoint the **energy density** of gasoline. However, by looking at an average-sized molecule, **octane**, we can determine its energy density and compare it to other fuels.

Ethanol is a **renewable** fuel that is the product of the **fermentation** of **glucose**. Ethanol's properties are slightly different from gasoline. However, if ethanol is combined with gasoline, the combination can improve how completely gasoline burns and also how clean burning it is. Vehicles using fuel blends with very high ethanol content get slightly less miles per gallon of fuel, but produce less air pollution.

One factor in choosing a fuel is the **emissions** released by the fuel. Fuel or fuel blends that produce high amounts of air pollution are undesirable. Both ethanol and gasoline produce carbon dioxide and water vapor when they burn. These gases are **greenhouse gases.**

In chemistry, the process of burning a fuel is called combustion. **Combustion** is a chemical reaction with oxygen gas as one of the reactants. In the case of hydrocarbons or alcohols, the products are carbon dioxide and water. Both ethanol and gasoline release energy when they burn, which is the energy that is used to power the race car. The **chemical energy** stored in the fuel is transformed into **thermal energy** and motion inside the engine.

If a chemical reaction is **exothermic**, it will release energy. Almost all combustion reactions are exothermic. The energy released by a chemical reaction is called **enthalpy**, and is represented by the letter 'H'. If a reaction, like combustion, is exothermic, the numerical value of the change in enthalpy (ΔH) for the reaction will be negative. Because the **system** of reactants and products is transferring energy to its surroundings, the value for ΔH is negative. The energy gained by the surroundings is lost by the system.

If one fuel is going to be substituted for another, its properties must be similar. The table below gives some of the properties for gasoline and ethanol.

PROPERTY	GASOLINE	ETHANOL
Enthalpy of combustion	-5330 kJ/mol	-1371 kJ/mol
Specific gravity	0.739 kg/L	0.787 kg/L
Color	Clear yellowish liquid	Clear colorless liquid
Boiling point	37 to 204 °C	77 °C
Freezing point	-60 to -40 °C	-114 °C
Energy density	Approximately 35 MJ/L	23-26 MJ/L
Viscosity	0.40 – 0.88 cSt	1.2 – 1.52 cSt
Solubility in water	Not soluble	Soluble
Biodegradable	No	Yes

Activities

1. Write chemical reaction equations for the combustion of ethanol and octane, and balance the equations.

2. How many moles of ethanol must be burned to obtain the same amount of energy released by burning one mole of octane?

3. Use a molecular modeling kit to build the molecules in the ethanol and octane combustion reactions in the proper proportions. Combine kits with a partner or two if necessary. Visually compare the combustion reactions. Make a sketch of each molecule present in each reaction in the space below. Which reaction releases more energy? Which produces more carbon dioxide?

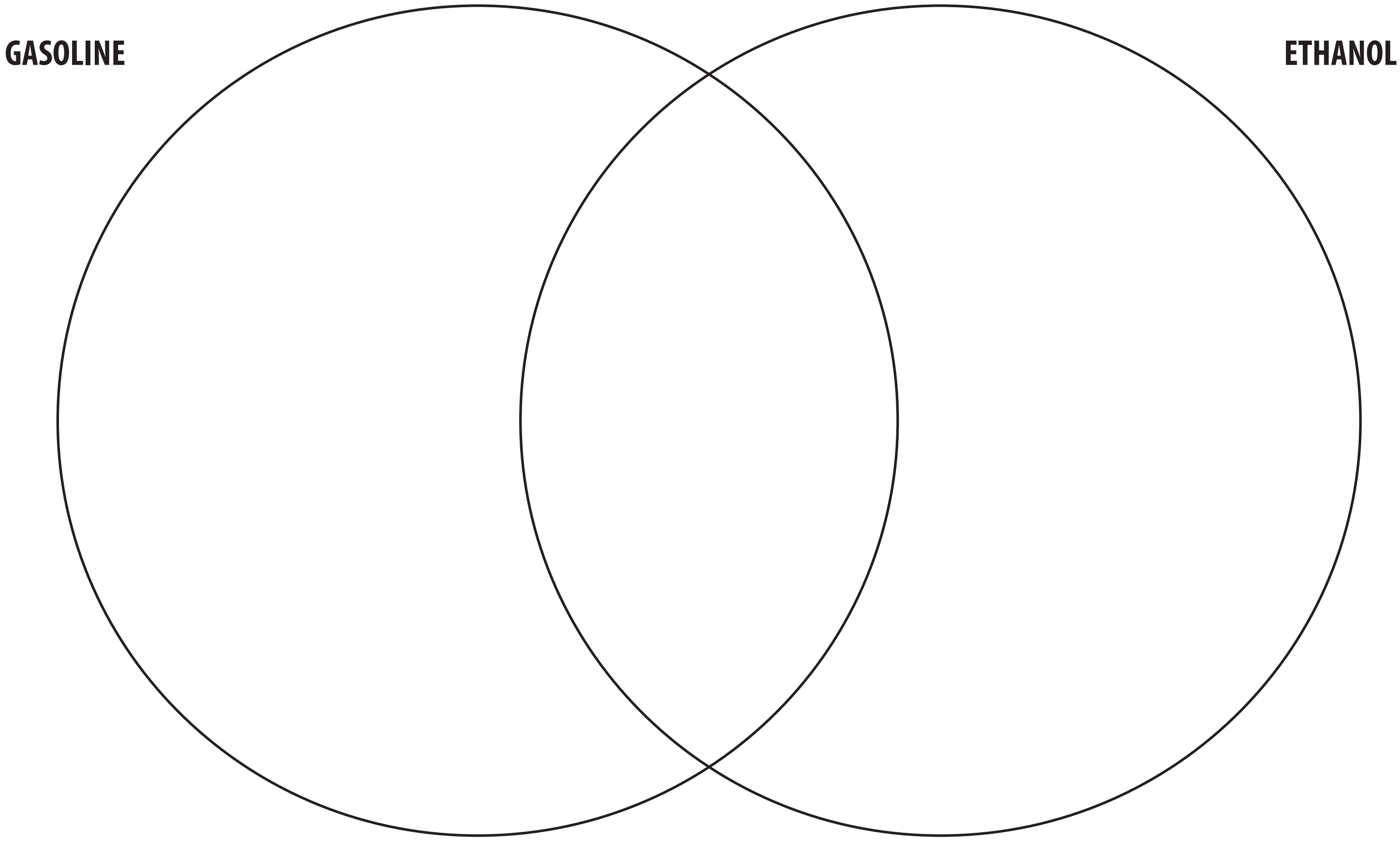
ETHANOL COMBUSTION

OCTANE COMBUSTION

4. Research the processes required to manufacture gasoline and ethanol. Fill in the chart below with information you find.

	GASOLINE	ETHANOL
Which substance(s) produce the fuel?		
Renewable or nonrenewable? How do you know?		
What type of facility is needed to produce the fuel?		
How many production facilities are located around the U.S.?		
How is the fuel distributed to the consumer?		
Average cost per gallon of the fuel, and the date you obtained the data.		
Health and environmental hazards of the fuel.		

5. Complete the Venn diagram below using the properties of ethanol and octane discussed in this activity.



6. Write a short essay comparing and contrasting ethanol and gasoline.

7. Which fuel, in your opinion, is better, ethanol or gasoline? Use the evidence from this activity to justify your decision.