Intermediate/Secondary Activity: Chemical Models

Goals
- To construct models of the hydrocarbon gases that compose raw natural gas.
- To balance chemical equations of the combustion of hydrocarbon gases.

Concepts
- The gases that compose natural gas are hydrocarbons.
- When burned, hydrocarbons produce carbon dioxide and water.

Time
45 minutes

Materials
- Copies of student worksheets
- Science journals
- Molecular model set or three colors of clay and toothpicks for each group

Preparation
- Gather the needed materials.
- Divide the students into groups of two to three.
- Review with students the process for balancing chemical equations.

Procedure
1. Explain to the students that raw natural gas is typically a mixture of gases. These gases are hydrocarbons consisting of carbon and hydrogen atoms.
2. The gases found in raw natural gas are alkanes; the prefix of the alkane indicates the number of carbon atoms present. Review the background information with the students.
3. Distribute the worksheet and have students look at the list of alkane prefixes. Ask the students if they have any questions and give them time to complete the Molecular Formulas section of the worksheet.
4. Review the molecular formulas with the students. Allow students time to complete the Molecular Models and Balancing Equations sections of the worksheet.
5. Review the equations with the students. Allow students time to complete the Hydrocarbon Combustion section. Make the connection between the balanced equations and the combustion models.
6. Review and discuss in terms of the concepts listed above.

Extensions
- Have students explain what impact burning hydrocarbons has on the environment. Emphasize that carbon dioxide is the major greenhouse gas associated with global climate change.
- Have students determine the molecular formulas for gasoline and diesel. Discuss the environmental impact of using these fuels and possible alternatives to hydrocarbon fuels (biodiesel, ethanol).

Answer Keys
Molecular Formulas: Methane: CH_4 Ethane: C_2H_6 Propane: C_3H_8 Butane: C_4H_{10}

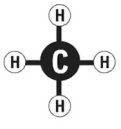
Balancing Equations & Models:

$1\ CH_4 + 2\ O_2 \longrightarrow 1\ CO_2 + 2\ H_2O$

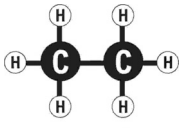
$2\ C_2H_6 + 7\ O_2 \longrightarrow 4\ CO_2 + 6\ H_2O$

$1\ C_3H_8 + 5\ O_2 \longrightarrow 3\ CO_2 + 4\ H_2O$

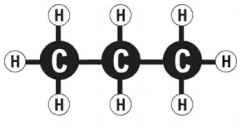
$2\ C_4H_{10} + 13\ O_2 \longrightarrow 8\ CO_2 + 10\ H_2O$



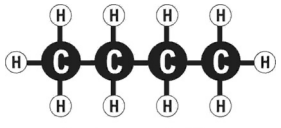
Methane: CH_4



Ethane: C_2H_6



Propane: C_3H_8



Butane: C_4H_{10}

HYDROCARBONS

Background

Hydrocarbons are molecules composed only of carbon and hydrogen atoms. Carbon atoms have four electrons available to bond. When one carbon atom bonds with hydrogen, it needs four hydrogen atoms. This hydrocarbon is known as methane.

When a hydrocarbon molecule has as many hydrogen atoms bonded as possible, it is considered saturated and is part of the alkane group. Alkanes are named for the number of carbon atoms present. The alkanes form a straight chain of carbon atoms with hydrogen atoms bonding with the remaining open electrons.

The generic formula for alkanes is C_nH_{2n+2}. This formula can be used to determine the molecular formula for the gases that typically compose raw natural gas.

Alkane Series Prefixes

meth- one carbon atom
eth- two carbon atoms
prop- three carbon atoms
but- four carbon atoms

In your science journal, write the answers to the following problems:

Molecular Formulas

Use the generic formula for alkanes to determine the molecular formula for the following gases: methane, ethane, propane, and butane.

Molecular Models

Use the model sets or colored clay to make three-dimensional models of the four alkanes. Use one color to represent hydrogen and another for carbon. Use the third color to make several oxygen molecules, which consist of two oxygen atoms bonded together (O_2). Draw a picture of each model (methane, ethane, propane, butane, oxygen) in your science journal.

Balancing Equations

When a hydrocarbon burns, it combines with oxygen to form carbon dioxide and water. Write and balance each chemical reaction equation for methane, ethane, propane and butane.

$$\text{alkane} + O_2 \xrightarrow{\text{heat}} CO_2 + H_2O$$

Hydrocarbon Combustion

Using the chemical models of methane and oxygen, determine the products of methane combustion. Draw models of the molecules formed in the reaction. Repeat this procedure for ethane, propane, and butane.