Stoichiometry in Combustion of Acetylene

Stoichiometry in Combustion Reactions

Introduction

The reaction of calcium carbide and water to produce acetylene gas is fairly common in many chemistry curriculums. Use this demonstration in a new way to teach your students about stoichiometry and limiting reagents. Collect varying amounts of acetylene gas and air in test tubes and note the difference in reactivity and intensity of the combustion reaction for different ratios of acetylene and oxygen (air).

Concepts

- Chemical reactions
- Combustion
- Stoichiometry
- Limiting reagent

Materials

Calcium carbide, CaC_2, pellets
Distilled water
Matches
Pie dish, Pyrex®
Spatula
Test tubes, borosilicate glass, 25 × 200, 4–5
Wood splints

Safety Precautions

Calcium carbide is corrosive to eyes and skin and generates flammable acetylene gas when exposed to water or moisture. Perform this demonstration in a well-ventilated area only. Make sure there are no flames in the area. Use only borosilicate glass test tubes and check the tubes for cracks and chips before performing the demonstration. Avoid contact of all chemicals with eyes and skin. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Fill Pyrex® dish with water.
2. Fill several large test tubes with varying amounts of water and invert them in the dish. Be sure to include at least one tube that is completely filled.
3. Using a spatula, place one or two pieces of calcium carbide under each test tube and allow the reaction to proceed, collecting the acetylene gas in the tubes.
4. Let at least one test tube fill completely with acetylene gas. Remove a second test tube from over the calcium carbide pellet before the reaction can go to completion, filling the tube only partially with acetylene gas.
5. Remove each test tube from the dish individually and invert it over a burning splint to light the acetylene gas. Observe the intensity of the resulting "pop" as well as the cleanliness of the tube following the combustion.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The reaction of calcium carbide and water produced a basic solution, which may be neutralized with 3 M hydrochloric acid and rinsed down the drain with excess water according to Flinn Suggested Disposal Method #10. If a precipitate was formed, the final solution may be filtered, and the solid may be disposed of according to Flinn Suggested Disposal Method #26a.

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Tip

- The tubes can be filled with varying amounts of water in order to achieve the correct 5:2 stoichiometric ratio of oxygen to acetylene. Ask students to predict which of the tubes will produce the most intense combustion reaction when ignited. Students are often surprised that the tube filled only slightly with acetylene will emit a more satisfying "pop" than the tube filled completely with acetylene!

Discussion

Calcium carbide reacts with water to produce acetylene gas and calcium hydroxide according to the following reaction (Equation 1):

$$CaC_2(s) + 2H_2O(l) \rightarrow C_2H_2(g) + Ca(OH)_2(s) \qquad \textit{Equation 1}$$

Acetylene consists of two hydrogen atoms and two carbon atoms connected by a triple bond. It is often used as a fuel in torches because it burns brilliantly in air with a sooty flame. Like any hydrocarbon, complete combustion of acetylene produces carbon dioxide and water according to the following reaction (Equation 2):

$$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l) \qquad \textit{Equation 2}$$

A test tube filled completely with acetylene with no oxygen will burn slowly and quietly only at the mouth of the tube where oxygen is present in the air, since there is no air present anywhere else in the tube. In addition, test tubes containing all or mostly acetylene with little oxygen will be very "dirty" due to the soot (carbon) produced by the incomplete combustion of the acetylene. These observations, combined with information gathered from the chemical equation, indicate that oxygen is the limiting reagent. That is, the acetylene gas will only undergo complete combustion with the proper amount of oxygen. Any mole ratio of oxygen to acetylene lower than 5:2 will result in incomplete combustion. Finally, when the correct stoichiometric ratio is achieved, with plenty of oxygen to react completely with the acetylene, the ignition of the gases will produce a loud "pop" and leave behind no unburned hydrocarbon.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Stoichiometry in Combustion of Acetylene* activity, presented by Annis Hapkiewicz, is available in *Stoichiometry in Combustion Reactions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Stoichiometry in Combustion of Acetylene* are available from Flinn Scientific, Inc.

Catalog No.	Description
C0346	Calcium Carbide, 100 g
GP6040	Test Tubes with Rims, 25 × 200

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.