

Acetylene Lab 2006 Honors Chemistry

Write up and record this lab completely in a full, formal lab report. You are to include a brief, fully cited background on: 1. The historical uses and production of acetylene and 2. a section on the chemical principle behind this lab describing the generation of a gas and basic combustion reactions.

Be sure to show all calculations, observations and data in appropriately labeled tables. Include *all* questions detailed below in a Discussion Section and complete this lab with a written Conclusion statement. Please refer to the formal lab write-up handout for details concerning documentation and write-up requirements.

Purpose:

To experimentally determine the mixture of acetylene to air that produces a **complete** combustion reaction.¹

Equipment:

Acetylene gas generator set up with syringe, Erlenmeyer Flask, tubing, clamp, ring stand, water trough, 70 mL ignition tube, matches, #6 rubber stopper, graduated cylinder, goggles.

Reagents: calcium carbide, water

PreLab:

Before you begin the experiment, calculate the amount of water you need to add to the ignition tube for each of 5 trials with the ratios of air to acetylene outlined below. The amount of water you add will be equal to the amount of acetylene that will fill the ignition tube by displacement. Please note that the ignition tubes utilized are 70 mL in volume. Show the following calculations on your paper and construct a data table to include this information. The data table should include, Volume of acetylene, Volume of air, (*Calculated*) Volume of Oxygen, and Reaction Observation for each of six Trials. (Note: The sea-level composition of air (in percent by volume at 15 °C and 101325 Pa) contains 20.9476% oxygen².)

Trial 1: 100% acetylene and 0% air

Trial 4: 10% acetylene and 90% air

Trial 2: 50% acetylene and 50% air

Trial 5: 5% acetylene and 95% air

Trial 3: 25% acetylene and 75% air

Trial 6: Repeat and confirm the most successful ratio

Directions: Safety goggles are required at all times.

1. Make sure all of the tubes are connected securely and the water trough is filled.
2. Place two to three crystals of calcium carbide into the small Erlenmeyer flask.
3. Remove the syringe from the gas generator set-up and fill the syringe half way with water.
4. Squeeze one to two drops of water from the syringe into the Erlenmeyer flask and wait for the gas to begin to bubble from the bottom of the trough. (Add water *only* when the bubbling stops.)
6. Fill the ignition tube with the volume of water measured in the graduated cylinder that equals the volume of *acetylene* you calculated for each trial.
7. Place a stopper over the ignition tube, invert and place in the water trough being careful not to let any of the water out of the ignition tube. Once it is below the water line, remove the stopper.
8. Position the mouth of the ignition tube over the hole in the bottom of the trough where the bubbles are being generated to capture the gas being generated.
9. Hold the ignition tube over the hole until all of the water has been displaced by the acetylene and *one* bubble of acetylene comes out from the bottom of the ignition tube.
10. Keeping the tube under water, place it on top of a stopper then pick up both the tube and the stopper holding them tightly together to keep from releasing the gas.
11. *With your goggles on*, take the tube and matches outside to combust the gas.
12. Mix the gas with the air in the tube with a gentle rocking motion, then with the tube pointing away from *all* other life forms, light the match, remove the stopper, and place the lit match over the opening.
13. After the fire has died, use the brush to clean out the ignition tube discarding dirty water into the appropriately marked container.
14. Record carefully detailed observations of each trial in your Data Table once you get back inside. Repeat the procedure until you have completed each of the volumes originally calculated and for confirmation, repeated the ratio that produced the most complete reaction.

Discussion Questions:

1. Acetylene gas, C_2H_2 , is produced by the reaction of liquid water and solid calcium carbide, CaC_2 . The other product of this reaction is solid calcium hydroxide, $Ca(OH)_2$. Write a balanced chemical equation for this reaction including the phases of each reactant and product.
2. When acetylene gas reacts with the oxygen in the air, O_2 , carbon dioxide and water in the gas phase are produced. Write a balanced chemical equation for this combustion reaction and include all phases of reactants and products.
3. What type of reaction did you perform to generate the gas?
4. What type of reaction did you perform to react the acetylene gas?
5. Which of the mixtures gave you the most amount of ash? What were the products (byproducts) of this reaction? Write the balanced equation for incomplete combustion.
6. What mixture of air and acetylene appeared to give the most complete reaction? What was the observable evidence of a complete reaction?
7. What errors contributed to this lab that may have affected your data? Would these errors cause your determined ratio of air to acetylene to be too high or too low?

Calculations:

The sea-level composition of air (in percent by volume at 15 °C and 101325 Pa) is 20.9476 % oxygen².

1. Based on the *balanced equation for complete combustion of acetylene*, and the fact that the ignition tube has a maximum volume of 70 mL, construct an algebraic equation to determine the volume of air and the volume of acetylene that would give a perfect stoichiometrically balanced volume of air and volume of acetylene for complete combustion. (*Hint: Assign x to the volume of air and y to the volume of acetylene. If $x = \text{volume of air}$, then $\frac{y}{x} = \text{volume of } O_2$.)*)
2. Calculate the percent difference between this theoretical volume of oxygen and that volume actually consumed in the most complete combustion trial.
3. Discuss any discrepancies in these values.

$\frac{ \text{theoretical-experimental} }{\text{theoretical}} \times 100\% = \% \text{ difference}$

Extension:

1. The products of a complete combustion reaction are always the same. Write and balance the combustion reactions for (a) methane gas, CH_4 , (b) propane gas, C_3H_8 , and (c) butane gas, C_4H_{10} . Show the phases of each reactant and product.
2. Provide at least one example for the **use** of each of the three gases.
3. Discuss the possible by-products of incomplete combustion of methane gas and relate this to the hazards and uses in the home.

Conclusion: Restate your experimental findings.

¹A complete combustion reaction is one that leaves no ash. This reaction will appear invisible with little flame and a great amount of force. Your goal is to find the best mixture (ratio of gas to air) that leaves the least amount of ash (byproducts) and gives the loudest "pop."

² Source: CRC Handbook of Chemistry and Physics, by David R. Lide, Editor-in-Chief, 1997 Edition