Lab: Determining the Value of the Ideal Gas Constant, R

When Charles’ Law, Boyle’s law, and Avogadro’s Principle are combined, the result is the ideal gas law, \( PV = nRT \). In this equation, pressure (\( P \)), Volume (\( V \)), Temperature (\( T \)), and number of moles (\( n \)) are variable; \( R \) is a constant called the ideal gas constant. You can use the ideal gas law to calculate the value of \( R \) if you know the values of \( P, V, T, \) and \( n \) for a sample of gas.

Objectives:
1. Measure the volume, pressure and temperature of a sample of wet butane (\( C_{4}H_{10} \)) gas.
2. Determine the pressure of dry butane gas by correcting for the partial pressure of water.
3. Calculate the experimental value of the ideal gas constant, \( R \), and compare it with the accepted value.

Materials:

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<thead>
<tr>
<th>Apparatus</th>
<th>Reagent</th>
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<tr>
<td>centigram scale</td>
<td>butane lighter</td>
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<td>thermometer</td>
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<td>pneumatic trough</td>
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<td>barometer</td>
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<td>50-ml graduated cylinder</td>
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Procedure:
1. Fill a pneumatic trough will tap water about 3/4 full. Record the temperature of the water in the data table where it says temperature of water.
2. Completely fill a 50-ml graduated cylinder to the very top with tap water. Make sure there are no air bubbles.
3. Obtain a butane lighter from your teacher. Place the lighter under water for a minute. Remove the lighter and shake off excess water by tapping the lighter in the palm of your hand till dry. Keep count of how many times you tapped the lighter and with what force. It will be important to do the same at the end of the lab. Dry the outside of the lighter with a paper towel. Mass the lighter to the nearest 0.001 gram. Record the mass in your data table where it says initial mass of butane lighter.
4. While using your hand to keep all the water in the cylinder, flip the cylinder over into the pneumatic trough. Be careful to keep the opening of the cylinder below the level of the water in the pneumatic trough at all times. If you now have air bubble in the bottom (top) of the cylinder remember to subtract this volume of bubble from the amount of gas you collect.
5. As one partner holds the cylinder steady, the other should hold the butane lighter under the water just below the opening of the cylinder. Without trying to light the butane release the gas into the cylinder and displace between 50 and 60ml of water from the cylinder.

**Note:** If you run out of gas in your lighter. Obtain a second lighter. Add its starting mass to the original initial mass. Then at the end of the lab add the mass of both lighters together for your final mass of the lighter.

6. When you have collected enough gas, remove the lighter from the water and dry it. For a small % error it is important to make sure the lighter is dried in the same manner as it was at the beginning of the lab (One of the biggest error factors in this lab is the mass of the water on the lighter when it is not completely dry). When the lighter is completely dry find its new mass and record this mass in the data table where it says final mass of butane lighter.

7. Record the volume of gas collected.

8. Place your hand over the opening of the cylinder. Keep the cylinder covered and flip it out of the trough. Keep the cylinder covered and carry it to the hood or next to an open window so the butane can dissipate.

9. Using the barometer, record the barometric pressure of the room. If there is no barometer, look up the atmospheric pressure in Allendale on the Internet.
**Data**: Create table in your lab notebook.

A. Initial Mass of Butane Lighter  

B. Final Mass of Butane Lighter  

C. Barometric Pressure of Room  

D. Temperature of Water  

E. Volume of Gas Collected  

**Calculations**

1. Subtract the final mass of butane lighter from the initial mass to obtain the mass of butane used.
2. Using calculation #1 and the formula of butane, C₄H₁₀, calculate the number of moles of butane used.
3. Using the conversion factor 25.4 mm equals one inch, convert the pressure from inches of Hg to mm Hg and then to ATM.
4. Look up the vapor pressure of water at the temperature of the water in the pneumatic trough. Subtract this pressure from the room pressure reading and then convert the pressure to ATM.
5. Rearrange PV = nRT to solve for R. Plug your experimental numbers in and solve for experimental value of R. Remember that P must be in ATM, V must be in L, and T must be in K.
6. Calculate % error. (the accepted value for R is 0.0821 atm•L/mol•K)

**Conclusions**

1. What factors contributed your percent error?
2. What steps could be taken to decrease your percent error?
3. Why does the liquid in the disposable lighter become a gas when released from the lighter?
4. What effect would it be on your percent error if it is a sunny day with high atmospheric pressure or a cloudy day with low atmospheric pressure?
5. Would the value of R go up or down if you had not corrected the gas for partial pressure of water? Why?