Determining the Molar Volume of a Gas

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1. Calculate the theoretical number of moles of hydrogen gas produced:

$$P_{total} = P_{H_2} + P_{H_2O}$$
$$766.6\,\text{mmHg} = P_{H_2} + 19.8\,\text{mmHg}$$
$$P_{H_2} = 746.8\,\text{mmHg}$$
$$PV = nRT$$
$$746.8\,\text{mmHg} \cdot 49.4\,\text{mL} = n \cdot 62\,363.8\,\frac{\text{ml mmHg}}{\text{mol K}} \cdot 295\,\text{K}$$
$$n = 2.01 \cdot 10^{-3}\text{mol}$$

2. Find the vapor pressure of water at the temperature of the water bath in this experiment. Calculate the partial pressure of hydrogen gas produced:

$$P_{total} = P_{H_2} + P_{H_2O}$$
$$766.6\,\text{mmHg} = P_{H_2} + 19.8\,\text{mmHg}$$
$$P_{H_2} = 746.8\,\text{mmHg}$$

3. Use the combined gas law to convert the measured volume of hydrogen to the ideal volume the hydrogen gas would occupy at STP:

$$\frac{P_1 \cdot V_1}{T_1} = \frac{P_2 \cdot V_2}{T_2}$$
$$\frac{1.009\,\text{atm} \cdot 49.4\,\text{ml}}{295\,\text{K}} = \frac{1\,\text{atm} \cdot V_2}{295\,\text{K}}$$
$$V_2 = 49.8\,\text{ml}$$

4. Divide the volume of hydrogen gas at STP by the theoretical number of moles of hydrogen to calculate the molar volume of hydrogen:

$$V_{mol} = \frac{V_2}{n} \rightarrow 24.6\,\frac{\text{L}}{\text{mol}}$$

5. Calculate the percent error in your experimental determination of the molar volume of hydrogen:

$$\delta_{V_{mol}} = \frac{\left|V_{mol} - 22.4\,\frac{\text{L}}{\text{mol}}\right|}{22.4\,\frac{\text{L}}{\text{mol}}} \cdot 100\% \rightarrow 9.82\%$$

6. Calculate the density of hydrogen gas and determine the percent error of your measurements:

$$mol_V = V_{mol}^{-1} \to 0.0407$$

$$\rho = mol_V \cdot 2.02 \,\frac{\text{g}}{\text{mol}} \to 0.0822 \,\frac{\text{g}}{\text{L}}$$

$$\delta_\rho = \frac{\left|\rho - 0.0899 \,\frac{\text{g}}{\text{L}}\right|}{0.0899 \,\frac{\text{g}}{\text{L}}} \cdot 100\% \to 8.57\%$$

7. If a bubble leaked into the eudiometer during the experiment, what effect would the bubble have on the measured volume of hydrogen gas, and would the calculated molar volume of hydrogen be too high or too low as a result:
   The measured volume of hydrogen gas would be higher, meaning that the molar volume of hydrogen would also seem higher. This would occur because the molar volume of hydrogen has a direct relationship with the measured volume of hydrogen, meaning that if the measured volume of hydrogen increases, the molar volume of hydrogen also increases.

8. If the magnesium ribbon was oxidized before the experiment, what effect would that have on the measured volume of hydrogen gas, and would the calculated molar volume of hydrogen be too high or too low as a result:
   The measured volume of hydrogen gas would be lower, meaning that the molar volume of hydrogen would also seem lower. This would occur because magnesium which would have otherwise reacted with the HCl would react with oxygen in the air, creating a dull coating of MgO on the magnesium strip. The reaction between MgO and HCl would then produce $MgCl_2$ and H_2O, not $MgCl_2$ and H_2 as the reaction between Mg and HCl would. The molar volume, which has a direct relationship with the measured volume, would then decrease, because the measured volume of hydrogen would be lower.

Question	**Response**
1	$2.01 \cdot 10^{-3}\text{mol}$
2	$P_{H_2} = 746.8\,\text{mmHg}$
3	$V_2 = 49.8\,\text{ml}$
4	$V_{mol} = 24.6 \,\frac{\text{L}}{\text{mol}}$
5	$\delta_{V_{mol}} = 9.82\%$
6	$\delta_\rho = 8.57\%$