**Molar Mass of a Metal**

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**ABSTRACT**

Gas laws explain the relationships between temperature, volume, pressure and number of moles of a gas. If we know any of these values, we can calculate an unknown value or even find out what is forming the gas. In this experiment, the Ideal Gas Law (PV = nRT) was used to determine the molar mass of an unknown metal. The reaction of an unknown metal with hydrochloric acid (HCl) will form a known amount of hydrogen gas (H2) and unknown amount of aqueous unknown metal chloride. The metal is a divalent metal cation and may be from the alkaline earth metal column or group 2 on the periodic table of elements.

1. **INTRODUCTION**

The purpose of this experiment was to use the ideal gas law to determine the molar mass of an unknown metal. The reaction that occurs is an oxidation reduction reaction. Oxidation reduction reactions change the oxidation states of the atoms involved and allow for a visible reaction to be observed and recorded. In this experiment, the observation to be recorded is the volume of hydrogen gas. A solid metal is reacted with an acid (12 M HCl) which produces a divalent metal cation and hydrogen gas. The hydrogen gas that is generated is converted to a number of moles. The number of moles of hydrogen gas is used to determine the molar mass of the unknown metal and that will mass number will tell us what metal it is. The metal will most likely be from group 2 or the alkaline earth metal column on the periodic table of elements

1. **EXPERIMENTAL**

The unknown metal used was obtained as a silver metal ribbon. The metal is the reducing agent in an oxidation reduction reaction. The hydronium ions, H+ (*aq*), from the aqueous acid 12 M HCl are the oxidizing agents. The metal ribbon was weighed using an electronic balance. About 7 mL of the 12 M HCl was placed into a eudiometer but some of the HCl was stuck on the walls of the eudiometer. Water was then poured into the eudiometer until it was full. The ribbon was bended into a V shape and placed at the mouth of the eudiometer with the mouth covered by a thumb. The eudiometer was inverted and placed into large evaporating dish filled with distilled water until all of the acid descended and hydrogen gas was forming. The eudiometer was moved to a large cylinder filled with water and the volume of hydrogen gas was measured. The temperature of the water was recorded and the barometric pressure was taken from the instructor. This process was repeated another time for a second trial.

The materials used in this experiment were: 12 M HCl solution, unknown metal ribbon, eudiometer, large evaporation dish, distilled water and large cylinder of water.

1. **RESULTS AND DISCUSSION**

The general balanced reaction that occurred was: M (*s*) + 2 HCl (*aq*) 🡪 MCl­2 (*aq*) + H2 (*g*). The goal was to find the volume of hydrogen gas produced during the reaction and that was done using the markings on the eudiometer. The only gas present in the eudiometer should be hydrogen gas if the experiment was done correctly since we only wanted to measure the volume of hydrogen gas produced from the oxidation reduction reaction. The value for pressure of hydrogen gas was given to us from the instructor. After the volume of hydrogen gas was determined, the number of moles of hydrogen gas was calculated using the ideal gas law formula (PV = nRT). For trial #1, the number of moles of hydrogen gas was 9.87 \* 10-4 mol. For trial #2, the number of moles of hydrogen gas was 9.05 \* 10-4 mol. The number of moles of hydrogen gas was used to determine the molar mass of the unknown metal by using the general equation to find how much metal reacts to form a specific amount of hydrogen gas. The measured mass of the metal ribbon was divided by the number of moles of hydrogen gas produced. For trial #1, the molar mass of the unknown metal is 17.21 g/mol. For trial #2, the molar mass of the unknown metal is 25.41 g/mol. If we take the average of the two trials, we get an average molar mass of 21.32 g/mol. Since the metal is a divalent cation, the metal that is closest in molar mass to 21.32 g is magnesium (Mg) which has a molar mass of 24.305 g/mol.

1. **CONCLUSION**

In this experiment, gas laws were used in conjunction with stoichiometric principles to determine an unknown value from known values. For gas laws to be useful, the values of pressure, temperature and volume of a sample of gas need to be known. If all of these values are known, we can determine the unknown reactant of any reaction that produces a gas. This experiment demonstrates clearly the relationships that are present in chemistry. These relationships force us to analyze why certain things occur and teach us to what extent we as humans can manipulate them.

Table I. Results for calculating the molar mass of an unknown metal; initial mass of metal ribbon, volume of hydrogen gas, barometric pressure and temperature of the room.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Trial # | Mass of metal ribbon | Volume of hydrogen gas | Barometric pressure | Temperature |
| 1 | 0.017 g | 24 mL | 1 atm | 23 degrees C |
| 2 | 0.023 g | 22 mL | 1 atm | 23 degrees C |