

Table 1. Pure Metal

Data	Trial 1	Trial 2
Identity of Metal	Magnesium	Magnesium
Mass of metal (g)	0.0220g	0.0195
Uncalibrated volume of eudiometer (mL)	0	0
Volume of hydrogen gas (mL)	23.85	21.05
Height of water column (cm)	28.10	21.40
Density of water (kg/m ³)	1000	1000
Acceleration due to gravity (m/s ²)	9.81	9.81
Pressure of water column (Pa)	2760	2100
Water Temperature (°C)	20	21
Water Vapour pressure (Pa)	2340	2490
Atmospheric Pressure (Torr)	760.6	760.6
Pressure of Hydrogen (kPa)	96.31	96.82
Room Temperature	20.2	20.2
Ideal Gas Constant, R	8.314 L kPa K ⁻¹ mol ⁻¹	8.314 L kPa K ⁻¹ mol ⁻¹
Actual Moles of Hydrogen (mol)	9.418x10 ⁻⁴	8.356x10 ⁻⁴
Theoretical moles of Hydrogen (mol)	9.05x10 ⁻⁴	8.02x10 ⁻⁴
Percent Yield (%)	104%	104%

Observations (Part 1):

The acid quickly dissolved the magnesium into hydrogen gas. There were large bubbles that quickly raised to top of the eudiometer.

Table 2. Alloy

Data	Trial 1	Trial 2
Unknown Number	2407	2407
Mass of alloy (g)	0.0373	0.0366
Uncalibrated volume of eudiometer (mL)	0	0
Volume of hydrogen gas (mL)	24.26	19.75
Height of water column (cm)	28.10	32.70
Density of water (kg/m ³)	1000	1000
Acceleration due to gravity (m/s ²)	9.81	9.81
Pressure of water column (Pa)	2760	3210
Water Temperature (°C)	20	19
Water Vapour pressure (kPa)	2.34	2.20
Atmospheric Pressure (Torr)	760.6	760.6
Pressure of Hydrogen (kPa)	96.31	95.99
Room Temperature (°C)	20.2	20.2
Ideal Gas Constant, R	8.314 L kPa K ⁻¹ mol ⁻¹	8.314 L kPa K ⁻¹ mol ⁻¹
Moles of Hydrogen (mol)	9.580x10 ⁻⁴	7.773x10 ⁻⁴
Mass of Zinc (g)	0.0195	0.0266
Mass of Aluminum (g)	0.0178	0.0100
Percent Zinc (%)	52.3	72.7
Percent Aluminum (%)	47.7	27.3
Average Percent (%)	62.5	37.5

Observations (Part 2):

The acid was a lot slower at dissolving the alloy than the last time. There were many more bubbles as well, although, the bubbles were much smaller. The reaction took a lot longer to finish.

Sample Calculation : Pure Metal

1. Uncalibrated Volume of the Eudiometer:

The eudiometer did not need calibration. Therefore the uncalibrated volume of the eudiometer was 0.

2. Volume of Hydrogen gas:

Volume of H = 23.85 mL

Uncalibrated volume of eudiometer = 0

Actual volume of H = Volume of H - Uncalibrated volume of eudiometer
= 23.85 mL - 0
= 23.85 mL

3. Pressure exerted by the water column:

$$d = 1000 \text{ kg/m}^3$$

$$g = 9.81 \text{ m/s}^2$$

$$h = 28.10 \text{ cm} = 0.2810 \text{ m}$$

$$P = dgh$$

$$= (1000 \text{ kg/m}^3)(9.81 \text{ m/s}^2)(0.281 \text{ m})$$

$$= 2760 \text{ Pa}$$

4. Pressure of hydrogen gas:

$$P \text{ of atmosphere} = 760.6 \text{ Torr} = 101405 \text{ Pa}$$

$$P \text{ of water column} = 2760 \text{ Pa}$$

$$P \text{ of water vapour} = 2340 \text{ Pa}$$

$$P \text{ of hydrogen} = P \text{ of atmosphere} - P \text{ of water column} - P \text{ of water vapour}$$

$$= 101405 \text{ Pa} - 2760 \text{ Pa} - 2340 \text{ Pa}$$

$$= 96305 \text{ Pa} = 96.31 \text{ kPa}$$

5. Moles of hydrogen gas (experimental):

$$P = 96.31 \text{ kPa}$$

$$V = 23.85 \text{ mL} = 0.02385 \text{ L}$$

$$R = 8.314 \text{ L kPa K}^{-1} \text{ mol}^{-1}$$

$$T = 20.2^\circ\text{C} = 293.35 \text{ K}$$

$$PV = nRT$$

$$n = PV/RT$$

$$= [(96.31 \text{ kPa})(0.02385)]/[(8.314 \text{ L kPa K}^{-1} \text{ mol}^{-1})(293.35 \text{ K})]$$

$$= 9.418 \times 10^{-4} \text{ mol}$$

6. Moles of hydrogen gas (theoretical):

$$m \text{ of Mg} = 0.0220 \text{ g}$$

$$\text{MM of Mg} = 24.305 \text{ g/mol}$$

$$\text{Ratio} = 1 \text{ mol Mg} / 1 \text{ mol O}_2$$

$$n = m/\text{MM}$$

$$= (0.0220 \text{ g}) / 24.305 \text{ g/mol}$$

$$= 9.05 \times 10^{-4}$$

$$\text{Mol of O}_2 = 9.05 \times 10^{-4} \text{ mol Mg} \times (1 \text{ mol O}_2 / 1 \text{ mol Mg})$$

$$= 9.05 \times 10^{-4}$$

7. Percentage Purity of metal:

$$\text{Actual mol of H} = 9.418 \times 10^{-4}$$

$$\text{Ratio} = 1:1$$

$$\text{Actual mol of Mg} = 9.418 \times 10^{-4}$$

$$m \text{ of Mg} = 0.0220 \text{ g}$$

$$\text{MM of Mg} = 24.305 \text{ g/mol}$$

$$n = m/\text{MM}$$

$$= 0.0220 \text{ g} / 24.305 \text{ g/mol}$$

$$= 9.05 \times 10^{-4}$$

$$\text{Percentage Purity} = 9.418 \times 10^{-4} / 9.05 \times 10^{-4}$$

$$= 104\%$$

8. Average Percent Purity:

$$(104\%+104\%)/2 = 104\%$$

Sample Calculation : Alloy

1. Pressure of water column and hydrogen gas:

$$d = 1000 \text{ kg/m}^3$$

$$g = 9.81 \text{ m/s}^2$$

$$h = 28.10 \text{ cm} = 0.2810 \text{ m}$$

$$P = dgh$$

$$= (1000 \text{ kg/m}^3)(9.81 \text{ m/s}^2)(0.281 \text{ m})$$

$$= 2760 \text{ Pa}$$

$$P \text{ of atmosphere} = 760.6 \text{ Torr} = 101405 \text{ Pa}$$

$$P \text{ of water column} = 2760 \text{ Pa}$$

$$P \text{ of water vapour} = 2340 \text{ Pa}$$

$$P \text{ of hydrogen} = P \text{ of atmosphere} - P \text{ of water column} - P \text{ of water vapour}$$

$$= 101405 \text{ Pa} - 2760 \text{ Pa} - 2340 \text{ Pa}$$

$$= 96305 \text{ Pa} = 96.31 \text{ kPa}$$

2. Moles of hydrogen gas:

$$P = 96.31 \text{ kPa}$$

$$V = 24.26 \text{ mL} = 0.02426 \text{ L}$$

$$R = 8.314 \text{ L kPa K}^{-1} \text{ mol}^{-1}$$

$$T = 20.2^\circ\text{C} = 293.35 \text{ K}$$

$$PV = nRT$$

$$n = PV/RT$$

$$= [(96.31 \text{ kPa})(0.02426 \text{ L})]/[(8.314 \text{ L kPa K}^{-1} \text{ mol}^{-1})(293.35 \text{ K})]$$

$$= 9.580 \times 10^{-4} \text{ mol}$$

3. Masses of Zinc and Aluminum in the alloy:

$$\begin{aligned}n \text{ of hydrogen} &= (m \text{ zinc}/MM \text{ of zinc}) + 3/2(m \text{ total} - m \text{ zinc}/MM \text{ Al}) \\9.58 \times 10^{-4} \text{ mol} &= (m \text{ zinc}/65.39 \text{ g/mol}) + 3/2(0.0373 \text{ g} - m \text{ zinc}/26.982 \text{ g/mol}) \\m \text{ of zinc} &= 0.01950 \text{ g}\end{aligned}$$

$$\begin{aligned}m \text{ of Al} &= m \text{ total} - m \text{ of zinc} \\&= 0.0373 \text{ g} - 0.01950 \text{ g} \\&= 0.0178 \text{ g}\end{aligned}$$

4. Percent composition of the alloy:

$$\begin{aligned}\% \text{ composition of zinc} &= (m \text{ of zinc}/m \text{ of total}) \times 100\% \\&= (0.0195/0.0373) \times 100\% \\&= 52.3\%\end{aligned}$$

$$\begin{aligned}\% \text{ composition of Al} &= (m \text{ of Al}/m \text{ of total}) \times 100\% \\&= (0.0178/0.0373) \times 100\% \\&= 47.7\%\end{aligned}$$

5. Average Percent composition of the alloy (average of zinc values and average of aluminum values):

$$\begin{aligned}\text{Average \% Comp. of alloy (zinc)} &= (\% \text{ zinc } 1 + \% \text{ zinc } 2)/2 \\&= (52.3\% + 72.7\%)/2 \\&= 62.5\%\end{aligned}$$

$$\begin{aligned}\text{Average \% Comp. of alloy (Al)} &= (\% \text{ Al } 1 + \% \text{ Al } 2)/2 \\&= (47.7\% + 27.3\%)/2 \\&= 37.5\%\end{aligned}$$

Discussion: (within space provided)

Some sources of error that affected the results consisted of:

- 1) When flipping the eudiometer and placing it into the beaker where the metal/alloy was located, air could have gotten into the eudiometer. This would have affected the volume of hydrogen observed in all of the reactions, and therefore affecting the results of the calculations. Using the "Ideal Gas Law" equation, the volume is used to calculate the number of moles, which means the number of moles were also affected by this error. This would go on to affect the yield.
- 2) The metal/alloy could have been dirty, even after cleaning it with sandpaper. This would have affected the mass of the metal/alloy because it changes the measured mass, but it doesn't mean that the metal/alloy was exactly that mass. Therefore, it would have changed the theoretical amount of hydrogen that would be produced from that metal/alloy. Thus, affecting the yield.

These two errors caused the percent yield to be 104%. Obviously, this is not possible because it goes against the law of conservation of mass, which states that mass cannot be created nor destroyed in an ordinary chemical reaction.

Conclusion: (no more than two lines)

The purity of the metal, magnesium, was found to be 104% both times. The alloy sample #2407 was found to be 52.3% zinc, 47.7% aluminum and 72.7% zinc, 27.3% aluminum, with an average of 62.5% zinc and a 37.5% aluminum.