

Data Tables

Table 1. Pure Metal

Data	Trial 1	Trial 2
Identity of Metal	Mg	
Mass of metal (g)	0.0274g	0.0236g
Uncalibrated volume of eudiometer (mL)	0, calibrated eudiometer	
Volume of hydrogen gas (mL)	35.2mL	24.5mL
Height of water column (cm)	15.7 cm	25.5cm
Density of water (kg/m ³)	1000kg/m ³	
Volume of HCl used	9.2mL	9.4mL
Acceleration due to gravity (m/s ²)	9.81m/s ²	
Pressure of water column (Pa)	3.45Pa	2.40Pa
Water Temperature (°C)	20°C	21°C
Water Vapour pressure (Pa)	2.34 KPa	2.49 KPa
Atmospheric Pressure (Torr)	760.56 Torr (1.014 bar)	
Pressure of Hydrogen	97.519kPa	96.509kPa
Room Temperature	19.6 °C	
Ideal Gas Constant, R	8.314 kPa L/Mol K	
Actual Moles of Hydrogen (mol)	1.408x10 ⁻³ mols	9.6684x10 ⁻⁴ mols
Theoretical moles of Hydrogen (mol)	0.001127 mols H ₂	0.001013 moles H ₂
Percent Yield (%)	123.9% yield	95.4%

Observations (Part 1):

Table 2. Alloy

Data	Trial 1	Trial 2
Unknown Number	2484	
Mass of alloy (g)	0.0412 g	0.0424g
Uncalibrated volume of eudiometer (mL)	0, Calibrated Eudiometer	
Volume of hydrogen gas (mL)	25.0mL	25.4mL
<i>Volume of HCl used</i>	9.5mL	9.0mL
Height of water column (cm)	24.8 cm	25.4cm
Density of water (kg/m ³)		
Acceleration due to gravity (m/s ²)	9.81m/s ²	
Pressure of water column (Pa)	2.43kPa	2.49kPa
Water Temperature (°C)	21 °C	21 °C
Water Vapour pressure (kPa)	2.49kPa	2.49 kPa
Atmospheric Pressure (Torr)	760.56 Torr (1.014 bar)	
Pressure of Hydrogen	96.479 kPa	96.419 kPa
Room Temperature	19.6 °C	
Ideal Gas Constant, R	8.314 kPa L/Mol K	
Moles of Hydrogen (mol)	9.862x10 ⁻⁴ moles hydrogen gas	9.857x10 ⁻⁴ moles of hydrogen gas
Mass of Zinc (g)	0.032367g	0.03403g
Mass of Aluminum (g)	0.008834g	0.008367g
Percent Zinc (%)	78.56% zinc	80.26% Zinc
Percent Aluminum (%)	21.44% Al	19.74% Al
Average Percent	79.41% Zinc, 20.59% Al	

Observations (Part 2):

Sample Calculation : Pure Metal

1. Uncalibrated Volume of the Eudiometer:

0ml, eudiometer was calibrated.

2. Volume of Hydrogen gas:

Trial #1	Trial #2
35.2mL	24.5mL

3. Pressure exerted by the water column:

Trial #1	Trial #2
<p>P=dgh Pressure =? density H₂O = 1.0g/cm³, 1000kg/m³ h = 0.157m g=9.81m/s²</p> $P = dgh$ $P = \frac{1000kg}{m^3} \times \frac{9.81m}{s^2} \times 0.157m$ $P = \frac{1538.6kg}{m \ s^2} = 1540.17 \text{ Pa}$ <p>=1.54kPa</p>	<p>H=0.245m</p> $P = dgh$ $P = \frac{1000kg}{m^3} \times \frac{9.81m}{s^2} \times 0.245m$ $P = \frac{3.45kg}{m \ s^2} = 2404.45 \text{ Pa}$ <p>=2.40kPa</p>

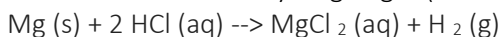
4. Pressure of hydrogen gas:

Trial 1	Trial 2
<p>$P_{hydrogen} = P_{Atmospheric} - P_{Water \text{ Column}} - P_{Water \text{ Vapor}}$</p> <p>$P_{hydrogen}=?$ $P_{Atmospheric} = 760.56 \text{ Torr} = 101.399 \text{ kPa}$ $P_{Water \text{ Column}} = 1.54kPa$ $P_{Water \text{ Vapor}} = 2.34KPa$</p> <p>$P_{hydrogen} = 101.399kPa - 1.54kPa - 2.34kPa$ $= 97.519kPa$</p>	<p>$P_{hydrogen} = P_{Atmospheric} - P_{Water \text{ Column}} - P_{Water \text{ Vapor}}$</p> <p>$P_{hydrogen}=?$ $P_{Atmospheric} = 760.56 \text{ Torr} = 101.399 \text{ kPa}$ $P_{Water \text{ Column}} = 2.40kPa$ $P_{Water \text{ Vapor}} = 2.49KPa$</p> <p>$P_{hydrogen} = 101.399kPa - 2.4kPa - 2.49kPa$ $= 96.509kPa$</p>

5. Moles of hydrogen gas (experimental):

Trial 1	Trial 2
<p>pV=nRT p=97.519kPa V=35.2mL=> 0.0352L R=8.314 kPa L/Mol K T=20°C => 293.15</p> $n = \frac{pV}{RT}$ $n = \frac{(97.519\text{kPa})(0.0352\text{L})}{(8.314 \frac{\text{kPa L}}{\text{Mol K}}) 293.15\text{K}}$ <p>n= 1.408x10⁻³ mols</p>	<p>pV=nRT p=96.509kPa V=24.5mL=0.0245L R=8.314 kPa L/Mol K T=21 °C =>294.15</p> $n = \frac{pV}{RT}$ $n = \frac{(96.509\text{Pa})(0.0245\text{L})}{(8.314 \frac{\text{kPa L}}{\text{Mol K}}) 294.15\text{K}}$ <p>n=9.6684x10⁻⁴ mols</p>

6. Moles of hydrogen gas (theoretical):



Trial 1	Trial 2
<p>Finding limiting reagent Mg was fully consumed in the reaction, therefore it must be the limiting reagent</p> $0.0274\text{g Mg} \times \frac{1\text{mol}}{24.305\text{g Mg}} \times \frac{1\text{mol H}_2}{1\text{mol Mg}}$ <p>=0.001127 mols H₂</p>	$0.0236\text{g Mg} \times \frac{1\text{mol}}{24.305\text{g Mg}} \times \frac{1\text{mol H}_2}{1\text{mol Mg}}$ <p>=0.001013 moles H₂</p>

7. Percentage Purity of metal:

<p>%yield = Mols actual/mols theoretical = 1.408x10⁻³ mols / 1.127x10⁻³ mols 123.9% yield</p> <p>Therefore, according to our experiments, the metal was 123.9% pure. This cannot be the case because you cannot have a purity over 100%. The errors associated with this will be discussed in the discussion section of the report.</p>	$= 1.408 \times 10^{-3} \text{ mols} / 1.127 \times 10^{-3}$ $= 9.6684 \times 10^{-4} \text{ mols} / 0.001013 \text{ mols H}_2$ <p>= 95.4% yield</p> <p>Therefore, the percent purity of the metal was 95.4%</p>
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8. Average Percent Purity:
$$\frac{(\text{Percent purity of trial 1})(\text{Percent purity of trial 2})}{2}$$

=109.65% pure.

This answer cannot be accurate, as it is a purity over 100%

Sample Calculation : Alloy

1. Pressure of water column and hydrogen gas:

Trial 1	Trial 2
<p>P=dgh Pressure =? density H₂O = 1.0g/cm³, 1000kg/m³ h = 0.248m g=9.81m/s²</p> $P = dgh$ $P = \frac{1000kg}{m^3} \times \frac{9.81m}{s^2} \times 0.248$ $P = \frac{1538.6kg}{m \ s^2} = 2432.88 \text{ Pa}$ <p>=2.43288 kPa => 2.43kPa</p>	<p>h = 0.254m</p> $P = dgh$ $P = \frac{1000kg}{m^3} \times \frac{9.81m}{s^2} \times 0.254$ $P = \frac{1538.6kg}{m \ s^2} = 2491.71$ <p>=2.49171 kPa=>2.49kPa</p>
<p>$P_{hydrogen} = P_{Atmospheric} - P_{Water \text{ Column}} - P_{Water \text{ Vapor}}$</p> <p>$P_{hydrogen} = ?$ $P_{Atmospheric} = 760.56 \text{ Torr} = 101.399 \text{ kPa}$ $P_{Water \text{ Column}} = 2.43 \text{ kPa}$ $P_{Water \text{ Vapor}} = 2.49 \text{ kPa}$</p> <p>$P_{hydrogen} = 101.399 \text{ kPa} - 2.43 \text{ kPa} - 2.49 \text{ kPa}$ = 96.479 kPa</p>	<p>$P_{hydrogen} = P_{Atmospheric} - P_{Water \text{ Column}} - P_{Water \text{ Vapor}}$</p> <p>$P_{hydrogen} = ?$ $P_{Atmospheric} = 760.56 \text{ Torr} = 101.399 \text{ kPa}$ $P_{Water \text{ Column}} = 2.49 \text{ kPa}$ $P_{Water \text{ Vapor}} = 2.49 \text{ kPa}$</p> <p>$P_{hydrogen} = 101.399 \text{ kPa} - 2.49 \text{ kPa} - 2.49 \text{ kPa}$ = 96.419 kPa</p>

2. Moles of hydrogen gas:

Trail 1	Trial 2
<p>pV=nRT $n = \frac{pV}{RT}$ $n = ?$ $p = 96.479 \text{ kPa}$ $V = 25.0 \text{ mL}$ $R = 8.314 \text{ J/Mol K}$ $T = 21 \text{ degrees celcius} = 294.15 \text{ Kelvin}$ $n = \frac{(96.479)(0.0250L)}{(8.314 \frac{kPa \cdot L}{Mol \cdot K}) 294.15k}$</p> <p>= 9.862x10⁻⁴ moles hydrogen gas</p>	<p>pV=nRT $n = \frac{pV}{RT}$ $n = ?$ $p = 96.419 \text{ kPa}$ $V = 25.4 \text{ mL}$ $R = 8.314 \text{ J/Mol K}$ $T = 21 \text{ degrees celcius} = 294.15 \text{ Kelvin}$ $n = \frac{(96.419)(0.0250L)}{(8.314 \frac{kPa \cdot L}{Mol \cdot K}) 294.15k}$</p> <p>= 9.857x10⁻⁴ moles of hydrogen gas</p>

3. Masses of Zinc and Aluminum in the alloy:

Let:

N_H = Number of moles of Hydrogen

$M_{\text{tot Alloy}}$ = mass total of alloy

M_{Al} = Mass of aluminium

M_{Zn} = Mass of zinc

mm_{Al} = Molar mass aluminum

mm_{zn} = Molar mass of zinc

getting the equation

Equation 1

$$N_H = \frac{M_{\text{Zn}}}{mm_{\text{zn}}} + \frac{3 M_{\text{Al}}}{2 mm_{\text{Al}}}$$

Equation 2

$$M_{\text{tot Alloy}} = M_{\text{Zn}} + M_{\text{Al}}$$

$$M_{\text{Zn}} = M_{\text{tot Alloy}} - M_{\text{Al}}$$

Sub equation 2 into equation 1

$$N_H = \frac{M_{\text{tot alloy}} - M_{\text{Al}}}{mm_{\text{zn}}} + \frac{3 M_{\text{Al}}}{2 mm_{\text{Al}}}$$

$$N_H = \frac{M_{\text{tot alloy}}}{mm_{\text{zn}}} - \frac{M_{\text{Al}}}{mm_{\text{zn}}} + \frac{3 M_{\text{Al}}}{2 mm_{\text{Al}}}$$

$$N_H - \frac{M_{\text{tot alloy}}}{mm_{\text{zn}}} = -\frac{M_{\text{Al}}}{mm_{\text{zn}}} + \frac{3 M_{\text{Al}}}{2 mm_{\text{Al}}}$$

$$N_H - \frac{M_{\text{tot alloy}}}{mm_{\text{zn}}} = (M_{\text{Al}}) \left(\frac{-1}{mm_{\text{zn}}} + \frac{3}{2} \times \frac{1}{mm_{\text{Al}}} \right)$$

$$\frac{N_H - \frac{M_{\text{tot alloy}}}{mm_{\text{zn}}}}{\left(\frac{-1}{mm_{\text{zn}}} + \frac{3}{2} \times \frac{1}{mm_{\text{Al}}} \right)} = (M_{\text{Al}})$$

Trial 1	Trial 2
$N_H = 9.862 \times 10^{-4}$ moles hydrogen gas $M_{\text{tot Alloy}} = 0.0412$ g $M_{\text{Al}} = ?$ $M_{\text{Zn}} = ?$ $mm_{\text{Al}} = 26.98$ grams per mole $mm_{\text{zn}} = 65.38$ grams per mole	$N_H = 9.857 \times 10^{-4}$ moles hydrogen gas $M_{\text{tot Alloy}} = 0.0424$ g $M_{\text{Al}} = ?$ $M_{\text{Zn}} = ?$ $mm_{\text{Al}} = 26.98$ grams per mole $mm_{\text{zn}} = 65.38$ grams per mole
$\frac{9.862 \times 10^{-4} - \frac{0.0412 \text{ g}}{65.38 \text{ g}}}{\left(\frac{-1}{65.38 \text{ g}} + \frac{3}{2} \times \frac{1}{26.98 \text{ g}} \right)} = (M_{\text{Al}})$	$\frac{9.857 \times 10^{-4} - \frac{0.0424 \text{ g}}{65.38 \text{ g}}}{\left(\frac{-1}{65.38 \text{ g}} + \frac{3}{2} \times \frac{1}{26.98 \text{ g}} \right)} = (M_{\text{Al}})$
$M_{\text{Al}} = 0.008834$ g $M_{\text{Zn}} = M_{\text{tot Alloy}} - M_{\text{Al}}$ $= 0.0412 \text{ g} - 0.008834$ $= 0.03237$ g of Zn	$M_{\text{Al}} = 0.008367$ g $M_{\text{Zn}} = M_{\text{tot Alloy}} - M_{\text{Al}}$ $= 0.0424 \text{ g} - 0.008367$ g

	=0.03403g of Zn
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4. Percent composition of the alloy:

Trial 1	Trial 2
Mass alloy = 0.0412g Mass zinc = 0.032367g Mass aluminium = 0.008834g $\%Zinc = (Mass\ zinc)/Mass\ Alloy * 100\%$ $= (0.032367g)/(0.0412g)$ $= 78.56\% \text{ zinc}$ $\%Aluminium = (Mass\ Aluminium)/Mass\ Alloy$ $* 100\%$ $= 21.44\% \text{ Al}$	Mass alloy = 0.0424g Mass zinc 0.03403g Mass aluminum = 0.008367g $\%Zinc = (Mass\ zinc)/Mass\ Alloy * 100\%$ $= 0.03403g/0.0424g$ $= 80.26\% \text{ Zinc}$ $\%Aluminium = (Mass\ Aluminium)/Mass\ Alloy$ $* 100\%$ $= 19.74\% \text{ Al}$

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

Average zinc = $(78.56\% \text{ zinc} + 80.26\% \text{ Zinc})/2 = 79.41\%$

Average Al = $(21.44\% \text{ Al} + 19.74\% \text{ Al})/2 = 20.59\%$

Discussion: (within space provided)

During this experiment, there were a few sources of error which could have significantly changed the quality of the data we collected. In particular, the first trial for the pure Mg yielded us with a volume that was noticeably higher than those around us conducting the experiment, as well as our 2nd trial. This is confirmed to be an erroneous result, because when the experimental moles of Hydrogen gas was calculated (based on this volume) we received a value that was greater than the theoretical. As such, we ended up with a yield greater than 100%. This would have been likely caused by incorrect procedures, such as breaking the vacuum in the eudiometer and allowing the water level to artificially fall; resulting in a higher perceived volume of hydrogen gas, and therefore a higher number of moles of hydrogen gas.

The 2nd set of trials with the alloy provided results that were more consistent, and within 2% of each other. While ideally the same percentage composition of the alloys should be calculated, a 2% difference is acceptable. The percent composition should not be affected by the mass of the samples chosen though, as the composition is a ratio of the mass of one metal and another in an alloy, and is therefore the same for any mass of the alloy.

For both experiments, sources of error could be due to contamination of the metals from our hands, or being left uncovered for an extended period of time. The concentration of the HCl could have also decreased due to being uncovered inside of the beakers or test tubes. Fumes were visible escaping from the HCl that was waiting to be used in between tests, and as a result later tests could have less concentrated hydrochloric acid.

Conclusion: (no more than two lines)

This lab used the various techniques to find the composition of pure metals and alloys. Sample 2484 had ~79%Zn and ~21%Al, while the pure Mg sample gave an incorrect yield of >100%.

Data Tables

Table 1. Pure Metal

Data	Trial 1	Trial 2
Identity of Metal	mg	
Mass of metal (g)	0.0233g + 18.6 mg	0.0221g 0.0236g
Uncalibrated volume of eudiometer (mL)	∅	∅
Volume of hydrogen gas (mL)	35.2	24.5 mL
Height of water column (cm)	18.7 cm	23.5
Density of water (kg/m ³)		
Acceleration due to gravity (m/s ²)		
Pressure of water column (Pa)		
Water Temperature (°C)	20°C	21°C
Water Vapour pressure (Pa)		
Atmospheric Pressure (Torr)		
Pressure of Hydrogen		
Room Temperature	18°C 19.6°	18°C 19.6°
Ideal Gas Constant, R		
Actual Moles of Hydrogen (mol)		
Theoretical moles of Hydrogen (mol)		
Percent Yield (%)		

HCl mL
Observations (Part 1):

9.5 mL
9.2 mL
1.014 bar

9.8 mL
9.4 mL
1.014 bar

Yixin Zhang

Table 2. Alloy

Data	Trial 1	Trial 2
Unknown Number	2484	2484
Mass of alloy (g)	0.0412	0.0424
Uncalibrated volume of eudiometer (mL)	∅	∅
Volume of hydrogen gas (mL)	25.0 25.0 mL	25.0 25.4 mL
Height of water column (cm)	24.9 cm	25.4 mL
Density of water (kg/m ³)		
Acceleration due to gravity (m/s ²)		
Pressure of water column (Pa)		
Water Temperature (°C)	21°C	21°C
Water Vapour pressure (kPa)		
Atmospheric Pressure (Torr)		
Pressure of Hydrogen		
Room Temperature	19.5°C	19.5°C
Ideal Gas Constant, R		
Moles of Hydrogen (mol)		
Mass of Zinc (g)		
Mass of Aluminum (g)		
Percent Zinc (%)		
Percent Aluminum (%)		
Average Percent		

Observations (Part 2):

9.5 mL H ₂	9.0 mL H ₂
1.014 bar	Yixin Zhang