Data Tables

Table 1. Pure Metal

Data	Trial 1	Trial 2
Identity of Metal	Zinc	Zinc
Mass of metal (g)	0.0502	0.0322
Uncalibrated volume of eudiometer (mL)	N/A	N/A
Volume of hydrogen gas (mL)	20.25	13.10
Height of water column (cm)	31.2	37.8
Density of water (kg/m^3)	1000	1000
Acceleration due to gravity (m/s^2)	9.8	9.8
Pressure of water column (Pa)	3060	1280
Water Temperature (°C)	21.2	21.1
Water Vapour pressure (Pa)	2510	2500
Atmospheric Pressure (Torr)	758.3	758.3
Pressure of Hydrogen	95.5kPa	97.3kPa
Room Temperature	22.0°C (295.15°K)	22.0°C (295.15°K)
Ideal Gas Constant, R	8.3145	8.3145
Actual Moles of Hydrogen (mol)	0.000788	0.000519
Theoretical moles of Hydrogen (mol)	0.000768	0.000493
Percent Yield (%)	103	105

Observations (Part 1):

True for both trials:

Room Pressure: 101.1kPa

- Took a couple minutes for reaction between zinc and HCl to occur
- Slowly and steadily the reaction sped up (the whole piece of metal was entirely surrounded by bubbles)
- Bubbles abruptly stopped being produced
- All of the zinc sample was used up

Table 2. Alloy

Data	Trial 1	Trial 2
Unknown Number	2038	2038
Mass of alloy (g)	0.0381	0.0413
Uncalibrated volume of eudiometer (mL)	N/A	N/A
Volume of hydrogen gas (mL)	24.13	25.62
Height of water column (cm)	26.40	23.29
Density of water (kg/m^3)	1000	1000
Acceleration due to gravity (m/s^2)	9.8	9.8
Pressure of water column (Pa)	1280	2280
Water Temperature (°C)	23.7	24.2°C
Water Vapour pressure (kPa)	2.90	3.00
Atmospheric Pressure (Torr)	758.3	758.3
Pressure of Hydrogen	96.9kPa	95.8kPa
Room Temperature	22.0°C	22.0°C
Ideal Gas Constant, R	8.3145	8.3145
Moles of Hydrogen (mol)	0.000953	0.00100
Mass of Zinc (g)	0.0289	0.0322
Mass of Aluminum (g)	0.00918	0.00913
Percent Zinc (%)	75.9	77.9
Percent Aluminum (%)	24.1	22.1
Average Percent	Zinc: 76.9%	Aluminum: 23.1%

Observations (Part 2):

True for both trials:

Room Pressure: 101.1kPa

- Reaction between zinc and HCl began immediately
- Tiny but abundant bubbles: almost made the solution look white in colour
- Sample pieces were very light and kept floating to the top of the solution
    - As the pieces floated up they turned into a grey precipitate that sank back to the bottom and reacted with the HCl

Sample Calculation : Zinc – Trial 1 Pure Metal

1. Uncalibrated Volume of the Eudiometer:

N/A

2. Volume of Hydrogen gas:

$$20.25ml = \frac{1L}{1000mL} x\ 20.25ml$$

$=0.02025L$

3. Pressure exerted by the water column:

$P_{H2O(l)}=d*g*h$

$=(1000kg/m^3)(9.8m/s^2)(0.1310m)$

$=1280Pa$

$$1280Pa = \frac{1kPa}{1000Pa} x\ 1280Pa$$

$=1.28kPa$

4. Pressure of hydrogen gas:

As calculated by values given at a table in the manual, the pressure of water vapour at 21.1°C is:

$$\frac{2.49kPa}{21°C} = \frac{P}{21.1°C}$$

$$P = \frac{2.49kPa(21.1°C)}{21°C}$$

$= 2.51kPa$

$P_{H2}= P_{atm} - P_{H2O(v)} - P_{H2O(l)}$

$= 101.1kPa – 2.51kPa – 3.06kPa$

$= 95.5kPa$

5. Moles of hydrogen gas (experimental):

$$n = \frac{PV}{RT}$$

$$= \frac{(95.5kPa)(0.02025L)}{(8.3145L * kPa * K^{-1} * mol^{-1})(295.15K)}$$

$= 0.000788mol$

6. Moles of hydrogen gas (theoretical):

Working with a 0.0502g Zinc sample
M_{zinc}= 65.38g/mol

$$n_{zinc} = \frac{m}{M}$$
$$= \frac{0.0502g}{65.38g/mol}$$
$$= 0.000768mol$$

According to the equation given in the manual [$Zn_{(s)}+2H^{+}_{(aq)} \rightarrow Zn_{2}^{+}{}_{(aq)}+H_{2(g)}$] the mol ratio of zinc to hydrogen gas is 1:1.

Therefore the theoretical yield of hydrogen gas is 0.000768mol

7. Percentage Purity of metal (percentage yield of hydrogen):

$$Percent\ yield\ of\ hydrogen = \frac{Actual\ yield}{Theoretical\ yield} x100\%$$
$$= \frac{0.000788mol}{0.000768mol} x100\%$$
$$= 103\%$$

8. Average Percent Purity:

$$Average\ Percent\ Purity = \frac{(Percent\ Purity\ of\ Trial\ 1) + (Percent\ Purity\ of\ Trial\ 2)}{2}$$
$$= \frac{103\% + 105\%}{2}$$
= 104% Purity

<u>Sample Calculation : 2038 – Trial 1 Alloy</u>

1. Pressure of water column and hydrogen gas:

Water column:

$P_{H2O(l)}$=d*g*h
=(1000kg/m^3)(9.8m/s^2)(0.2640m)
=2590Pa

$$1280Pa = \frac{1kPa}{1000Pa} x\ 1280Pa$$

=1.28kPa

Pressure of hydrogen gas:

As calculated by values given at a table in the manual, the pressure of water vapour at 21.1°C is:

$$\frac{2.81kPa}{23°C} = \frac{P}{23.7°C}$$

$$P = \frac{2.81kPa(23.7°C)}{23°C}$$

= 2.90kPa

$P_{H2}= P_{atm} - P_{H2O(v)} - P_{H2O(l)}$

= 101.1kPa – 2.90kPa – 1.28kPa

= 96.9kPa

2. Moles of hydrogen gas:

$$n = \frac{PV}{RT}$$

$$= \frac{(96.9kPa)(0.02413L)}{(8.3145L * kPa * K^{-1} * mol^{-1})(295.15K)}$$

$$= 0.000953\text{mol}$$

3. Masses of Zinc and Aluminum in the alloy:

Molar mass of Zinc= 65.38g/mol

Molar mass of Aluminum= 26.98g/mol

Given equations [7] and [8] in the manual:

$$m_{alloy} = m_{Zn} + m_{Al}$$

$$m_{Zn} = m_{alloy} - m_{Al}$$

And $n_{H_2} = \frac{m_{Zn}}{M_{Zn}} + \frac{3m_{Al}}{2M_{Al}}$ then $n_{H_2} = \frac{m_{alloy} - m_{Al}}{M_{Zn}} + \frac{3m_{Al}}{2M_{Al}}$

$$n_{H_2} = \frac{m_{alloy}}{M_{Zn}} + m_{Al}\left(\frac{-1}{M_{Zn}} + \frac{3}{2M_{Al}}\right)$$

$$0.000953mol = \frac{0.0381g}{65.38\ g/mol} + m_{Al}\left(\frac{-1}{65.38\ g/mol} + \frac{3}{2*26.98\ g/mol}\right)$$

$$0.000953mol = 0.000583mol + m_{Al}(0.0403mol/g)$$

$$\frac{0.000370mol}{0.0403mol/g} = m_{Al}$$

$$m_{Al} = 0.00918g$$

Then: $m_{Zn} = m_{alloy} - m_{Al}$

$m_{Zn} = 0.0381g - 0.00918g$

= 0.0289g

4. **Percent composition of the alloy:**

Zinc:

$$Percent\ composition\ of\ zinc = \frac{m_{Zn}}{m_{alloy}} x100\%$$

$$= \frac{0.0289g}{0.0381g} x100\%$$

= 75.9 %

Aluminum:

$$Percent\ composition\ of\ aluminum = \frac{m_{Al}}{m_{alloy}} x100\%$$

$$= \frac{0.00918g}{0.0381} x100\%$$

= 24.1 %

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

$$\%\ Composition\ Zn_{average} = \frac{\%\ Composition_{Trial1} + \%\ Composition_{Tria}}{2}$$

$$= \frac{75.9\% + 77.9\%}{2}$$

= 76.9%

$$\%\ Composition\ Al_{average} = \frac{\%\ Composition_{Trial} + \%\ Composition_{Tri}}{2}$$

$$= \frac{24.1\% + 22.1\%}{2}$$

= 23.1%

Discussion:

- Though not applicable to the experiment this report is specifically based on, whether the eudiometer was calibrated makes a significant difference on the experiment results. (Note: when tested for this experiment, the eudiometer was calibrated.) Should the experiment proceed without a calibrated eudiometer the experimental values will naturally be flawed, hence yielding wrong answers when used in calculations and not matching the expected results and theoretical values.
- Special care was taken throughout the experience as to not allow any air in the eudiometer when it was being placed in the large beaker. With air already in the eudiometer, the yielded result for volume of hydrogen gas would be measured as higher than that actually obtained; this means that the calculated value for mols of hydrogen gas would be higher and the pressure exerted by the water column would be less than expected, throwing off the rest of the experiment's calculation.
  However, even though this special care was taken not to allow air in the eudiometer, the % Yield calculated on both trials of Part 1) was higher than 100%, meaning the amount of hydrogen gas mols obtained in the experiment was higher than the amount that should have been obtained from the metal sample reacted (according to stoichiometric calculations). This could mean that a portion of the volume calculated for hydrogen was water vapour or oxygen gas from the water in the beaker, contributing to a higher measurement of hydrogen volume than should have been obtained according to later calculations.
- Depending on the mol:mol ratio of each metal to hydrogen, the amount of hydrogen gas being produced by each metal should vary. For example, zinc produces less mols of hydrogen gas per mol than aluminum. Therefore it can be assumed that if in a reaction a sample produces hydrogen gas at a greater rate and yields more than the pure metal (zinc) per mol, then the sample must contain aluminum as well.
- In any given experiment trials that uses the same metal or alloy it is of course expected that the percent yields and compositions should be very close, if not the same. This is because chemical composition of the samples used does not differ, even if measurement like does. Therefore after calculations have been done, results should be similar.
- There are many applications for this form of experiment, some as simple as having to determine the percent composition of a common pop can. Since pop is such a popular product of consumption, it is expected from mass manufacturers and big corporations to give customers access to the information concerning what the container they are using is made of.

Conclusion:

Based on calculations done using values obtained in this experiment, it is determined that the Alloy 2038 is composed 76.9% of Zinc and 23.1% of Aluminum.

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Data Tables

Table 1. Pure Metal (zinc)

Data	Trial 1	Trial 2
Identity of Metal	Zinc	Zinc.
Mass of metal (g)	0.0502g	0.0322g
Uncalibrated volume of eudiometer (mL)	—	—
Volume of hydrogen gas (mL)	20.25 mL	13.10 mL
Height of water column (cm)	31.2 cm.	37.8 cm
Density of water (kg/m³)		
Acceleration due to gravity (m/s²)		
Pressure of water column (Pa)		
Water Temperature (°C)	21.2°C	21.1°C
Water Vapour pressure (Pa)	.	
Atmospheric Pressure (Torr)		
Pressure of Hydrogen		
Room Temperature	22.0°C	22.0°C
Ideal Gas Constant, R		
Actual Moles of Hydrogen (mol)		
Theoretical moles of Hydrogen (mol)		
Percent Yield (%)		

Observations (Part 1): Rm P: 101.1 kPa

20mL HCl. 16

- In both cases: took a couple minutes for zinc to start reacti[ng]
  - ↳ slowly & steadily sped up (all of piece (metal) surrou[nded] by bubbles
  - ↳ Bubbles stopped being produced abruptly

Trial 1: All of zinc used up.
& 2

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Table 2. Alloy

Data	Trial 1	Trial 2
Unknown Number	2038	2038
Mass of alloy (g)	0.03819	0.0413g
Uncalibrated volume of eudiometer (mL)	—	—
Volume of hydrogen gas (mL)	24.13mL	25.62mL
Height of water column (cm)	26.40 cm	23.29cm
Density of water (kg/m³)		
Acceleration due to gravity (m/s²)		
Pressure of water column (Pa)		
Water Temperature (°C)	23.7°C	24.2°C
Water Vapour pressure (kPa)		
Atmospheric Pressure (Torr)		
Pressure of Hydrogen		
Room Temperature	22.0°C	22.0°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):

Room Pressure: 101.1 KPa

≈ 10.05 mL HCl

.00mL HCL

Trial 1 & 2: Started reaction right away (imidiet[e]

↳ A LOT of bubbles

↳ Tiny but abundant. (Almost made liquid seem 'white')

↳ Some pieces kept floating up (very light)

↳ Pieces float up ⇒ turn into grey precip that sinks bac[k] to the bottom & reacts to form $H_{2(g)}$