Data Tables

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Table 1. Pure Metal

Data	Trial 1	Trial 2
Identity of Metal	Zinc	Zinc
Mass of metal (g)	0.0574g ± 0.0001g	0.0613g ± 0.0001g
Uncalibrated volume of eudiometer (mL)	0mL	0mL
Volume of hydrogen gas (mL)	23mL ± 1mL	24 mL ± 1mL
Height of water column (cm)	29.5cm ± 0.1cm	28.0cm ± 0.1cm
Density of water (kg/m^3)	1000kg/m^3	1000kg/m^3
Acceleration due to gravity (m/s^2)	9.8m/s^2	9.8m/s^2
Pressure of water column (Pa)	2.9 x 10^3 Pa	2.7x10^{3}Pa
Water Temperature (°C)	25°C ± 1°C	23°C ± 1°C
Water Vapour pressure (Pa)	2.64 X 10^{3}Pa	2.81x10^{3}Pa
Atmospheric Pressure (Torr)	760mmHg	760mmHg
Pressure of Hydrogen	25.79 kPa	95.77 kPa
Room Temperature	25°C ± 1°C	25°C ± 1°C
Ideal Gas Constant, R	8.3145Jmol^{-1}K^{-1}	8.3145Jmol^{-1}K^{-1}
Actual Moles of Hydrogen (mol)	8.9x10^{-4}mol	9.4x10^{-4}mol
Theoretical moles of Hydrogen (mol)	8.78x10^{-4}mol	9.4x10^{-4}mol
Percent Yield (%)	101.3%	99.5%

should not be over 100%

Observations (Part 1):

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Zinc
-solid
-metallic
-malleable

HCl
-Strong Odour
-Clear
-Liquid

-When exposing the zinc to the hydrochloric acid, you could see the acid and the metal reacting through the eudiometer in the form of swirling water.
-While the reaction was taking place you could see the H_2 bubbles forming and rising to the top of the eudiometer.
-This process was lengthy and usually took around 2minutes ± 1minute.

Table 2. Alloy

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Data	Trial 1	Trial 2
Unknown Number	2134	2134
Mass of alloy (g)	0.0456g ± 0.0001g	0.0492
Uncalibrated volume of eudiometer (mL)	0mL	0mL
Volume of hydrogen gas (mL)	28mL ± 1mL	28mL ± 1mL
Height of water column (cm)	27cm ± 0.1cm	23.6cm ± 0.1cm
Density of water (kg/m^3)	1000kg/m^3	1000kg/m^3
Acceleration due to gravity (m/s^2)	9.8m/s^2	9.8m/s^2
Pressure of water column (Pa)	2.6 x 10^{3}Pa	2.8 x10^{3}Pa
Water Temperature (°C)	25°C ± 1°C	22°C ± 1°C
Water Vapour pressure (kPa)	2.64 kPa	2.98 kPa
Atmospheric Pressure (Torr)	760mmHg	760mmHg
Pressure of Hydrogen	96.04 kPa	95.57 kPa
Room Temperature	25°C ± 1°C	25°C ± 1°C
Ideal Gas Constant, R	8.3145Jmol^{-1}K^{-1}	8.3145Jmol^{-1}K^{-1}
Moles of Hydrogen (mol)	1.10 x 10^{-3}mol	1.08x10^{-3}mol
Mass of Zinc (g)	3.57x10^{-2}g	4.13x10^{-2}g
Mass of Aluminum (g)	9.90x10^{-3}g	7.91x10^{-3}g
Percent Zinc (%)	78.3%	83.9%
Percent Aluminum (%)	21.7%	16.1%
Average Percent	(81.1% Zn) (18.9% Al)	(81.1% Zn) (18.9% Al)

Observations (Part 2):

2/2

Alloy
- Metallic
- Solid
- Malleable

HCl
- Strong Odour
- Clear
- Liquid

-When exposing the alloy to the hydrochloric acid, you could see the acid and the alloy reacting through the eudiometer in the form swirling water.

-While the reaction was taking place you could see the H_2 bubbles forming and rising to the top of the eudiometer.

-This process was lengthy and usually took around 2minutes ± 1minute.

Sample Calculation : Zinc Pure Metal

1. Uncalibrated Volume of the Eudiometer:

$V_{graduated\ cyl} = 6.3 mL \pm 0.1 mL$

$V_{eudiometer} = 6.3 mL \pm 0.1 mL$

$V_{uncalibrated} = V_{graduated\ cyl} - V_{eudiometer}$

$= 0 mL$

✓ (

2. Volume of Hydrogen gas:

$V_{H_2} = 23 mL \times \frac{1 L}{1000 mL} = 2.3 \times 10^{-2} L$

✓ (

3. Pressure exerted by the water column:

$p = dgh$

$p = (1000 kg/m^3)(9.8 m/s^2)(2.95 \times 10^{-1} m)$

$p = 2891 Pa$

$p = 2891 Pa \times \frac{1 kPa}{1000 Pa}$

$p = 2.891 kPa$

$p = 2.9 \times 10^3 Pa$

$d = 1000 kg/m^3$

$g = 9.8 m/s^2$

$h = 29.5 cm \times \frac{1 m}{100 cm}$

$= 2.95 \times 10^{-1} m$

p = pressure of water column

✓)

4. Pressure of hydrogen gas:

$P_{H_2} = P_{atm} - P - P_{water vapour}$

$= \left(760 mmHg \times \frac{101.325 kPa}{760 mmHg}\right) - (2.891 kPa) - (2.64 kPa)$

$= 95.794 kPa$

$= 95.79 kPa$

✓)

5. **Moles of hydrogen gas (experimental):**

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

$P = 95.794\,kPa$

$V = 23\,mL \times \frac{1\,L}{1000\,mL}$

$= 2.3 \times 10^{-2}\,L$

$= 2.3 \times 10^{-2}\,m^3$

$R = 8.3145\,J\,mol^{-1}\,K^{-1}$

$T = 25° + 273.15 = 298.15\,K$

$n = \frac{(95.794\,kPa)(2.3 \times 10^{-2}\,m^3)}{(8.3145\,J\,mol^{-1}K^{-1})(298.15\,K)}$

$= 8.8878 \times 10^{-4}\,mol\ H_2(g)$

$n = 8.9 \times 10^{-4}\,mol\ H_2(g)$

✓

6. **Moles of hydrogen gas (theoretical):**

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

(0.0574g) (20ml)

$mol\,Zn = 0.0574\,g \times \frac{1\,mol}{65.41\,g}$

$= 8.775 \times 10^{-4}\,mol$

$= 8.78 \times 10^{-4}\,mol$

✓

$mol\,H_2 = 8.775 \times 10^{-4}\,mol\,Zn \times \frac{1\,mol\,H_2}{1\,mol\,Zn}$

$= 8.775 \times 10^{-4}\,mol\ H_2$

$= 8.78 \times 10^{-4}\,mol$

Note: Zn has 1:1 ratio with hydrogen gas so mol of Zn = mol of H_2

7. **Percentage Purity of metal:**

$\%\,purity = \frac{actual\ yield}{theoretical\ yield} \times 100\%$

$= \frac{8.8878 \times 10^{-4}\,mol}{8.775 \times 10^{-4}\,mol}$

$= 101.3\%$

✓

8. Average Percent Purity:

$$Avg\%purity = \frac{\%purity_1 + \%purity_2}{2} = \frac{101.3\% + 99.5\%}{2} = 100\%$$

$\%purity_2 = 99.5\%$

✓ |

Sample Calculation : 2134 Alloy

1. Pressure of water column and hydrogen gas:

$P = dgh$

$= (1000\,kg/m^3)(9.8\,m/s^2)(0.27\,m)$

$= 2646\,Pa \times \frac{1\,kPa}{1000\,Pa}$

$= 2.646\,kPa$

$= 2.6\,kPa$

$h = 27\,cm \times \frac{1\,m}{100\,cm}$

$= 0.27\,m$

$P_{H_2} = P_{atm} - P - P_{H_2O}$

$= (101.325\,kPa) - (2.646\,kPa) - (2.64\,kPa)$

$= 96.039\,kPa$

$= 96.04\,kPa$

✓ |

2. Moles of hydrogen gas:

$PV = nRT$

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

$V = 28.3\,mL \times \frac{1\,L}{1000\,mL}$

$= 2.83 \times 10^{-2}\,L$

$T = 25°C + 273.15$

$= 298.15\,K$

✓ |

$$n = \frac{(96.039\,kPa)(2.83 \times 10^{-2}\,L)}{(8.3145\,J\,mol^{-1}\,K^{-1})(298.15\,K)}$$

$n = 1.0964 \times 10^{-3}\,mol$

$n_{H_2} = 1.10 \times 10^{-3}\,mol$

3. Masses of Zinc and Aluminum in the alloy:

$n_{H_2(g)} = 1.0964\times10^{-3}\,mol$

$m_{total} = 0.0456g$

$n_{H_2} = n_{Zn} + \frac{3}{2} n_{Al}$

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

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

$n_{H_2} = \frac{mass_{Zn}}{M_{Zn}} + \frac{3}{2}\frac{mass_{Al}}{M_{Al}}$

$n_{H_2} = \frac{(m_{total} - m_{Al})}{M_{Zn}} + \frac{3}{2}\frac{m_{Al}}{M_{Al}}$

$n_{H_2} = \frac{(m_{total} - m_{Al})2M_{Al} + (3m_{Al})M_{Zn}}{2(M_{Zn}M_{Al})}$

$n_{H_2} = \frac{(m_{total}\cdot 2M_{Al}) - (m_{Al}\cdot 2M_{Al}) + (3m_{Al}\cdot M_{Zn})}{2(M_{Zn}M_{Al})}$ ✓

$1.0964\times10^{-3}\,mol = \frac{(0.0456g\cdot 2(26.98\frac{g}{mol})) - (m_{Al}\cdot 2(26.98\frac{g}{mol})) + 3m_{Al}\cdot(65.4\frac{g}{mol})}{2(26.98\frac{g}{mol}\cdot 65.4\frac{g}{mol})}$ 2/2

$1.4086\frac{g^2}{mol} = 142.27\frac{g}{mol}(m_{Al})$

$9.9009\times10^{-3}g = m_{Al}$

$m_{Al} = 9.90\times10^{-3}g$

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

$= 0.0456g - 9.9009\times10^{-3}g$

$= 0.035699g$

$m_{Zn} = 0.0357g$

4. Percent composition of the alloy:

$\%Comp_{Zn} = \frac{m_{Zn}}{m_{total}}\times100\% = 78.3\%$

$\%Comp_{Al} = \frac{m_{Al}}{m_{total}}\times100\% = 21.7\%$ ✓ 1

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

$AvgComp_{Zn} = \frac{78.3\% + 83.9\%}{2} = 81.1\%$ $AvgComp_{Al} = \frac{21.7\% + 16.1\%}{2} = ~~29.75\%~~$ 18.9%

✓ 1

Discussion: (within space provided)

There were a few sources of error in the experiment. Some were experimental and some theoretical. ↷ Theoretical does not have sources of error!! – You can say some were systematic some were random

The ideal gas law proved very successful in calculating the moles of hydrogen gas, giving an almost perfect percent yield (101.3%), with a slight margin of error. This law was vital in the calculations as it gave the values which determined the percent purity of the zinc and the percent composition of the alloy. - Explain why over 100%

In the procedure the goal is to mix the water in with the HCl with the least amount of dilution as possible. However, it was very difficult to keep the two separate while mixing and some dilution was bound to occur. This could skew the results by creating a falsified end to the reaction and decreasing the volume of hydrogen gas created. This in turn would affect the final composition of the alloy by altering the calculation in which you solve the separate masses of the elements. Even the smallest amount of HCl left unreacted would leave a large margin of error in the amount of hydrogen gas created and thus change the final percent composition. ✓

In the experiment we used the ideal gas law to find the moles of hydrogen gas created from the reaction between the metals and the acid. This equation is used for that of ~~hypothetical~~ ideal gases. The gas we used may not necessarily perform in the way that an ideal gas would and could give an ✓ increased volume of hydrogen gas. This increased volume would lead to an increased mass of aluminum and therefore increase the percent of aluminum in the alloy. Also, when inverting the eudiometer tube into the beaker, some HCl may have been allowed to escape into the beaker, decreasing the final moles of hydrogen. 2.5/4

- other sources of error
- Metal stick to glass

Conclusion: (no more than two lines)

The value obtained for the purity of the metal was 101.3%.The percent composition of the metals was 78.3% zinc and 21.7% aluminum.

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