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Lab Day (T/W/Th/F): T
Lab Week (even/odd): Odd
Lab time (10:00, 2:30, 6:30): 2:30

Laboratory Report Form

Experiment 1.

Determination of the Composition of an Alloy

<u>Checklist:</u>

- **Raw Data Sheet written in pen, signed by TA and attached**
- **Report Form typed and attached**

Student's Initials *hjk*

DATA TABLES

TABLE 1. MAGNESIUM PURE METAL

Data	**Trial 1**	**Trial 2**
Identity of Metal	Magnesium	Magnesium
Mass of metal (g)	0.0287	0.0231
Uncalibrated volume of eudiometer (mL)	7.70	7.70
Volume of hydrogen gas (mL)	33.9	32.6
Height of water column (cm)	19.5	22.1
Density of water (kg/m^3)	1.00×10^3	1.00×10^3
Acceleration due to gravity (m/s^2)	9.80	9.80
Pressure of water column (Pa)	1.91×10^3	2.17×10^3
Water Temperature (°C)	24.1	23.9
Water Vapour pressure (Pa)	2980	2980
Atmospheric Pressure (Torr)	753.8	753.8
Pressure of Hydrogen	95.6kPa	95.4kPa
Room Temperature	22.0	22.0
Ideal Gas Constant, R	8.314	8.314
Actual Moles of Hydrogen (mol)	1.31×10^{-3}	1.26×10^{-3}
Theoretical moles of Hydrogen (mol)	1.18×10^{-3}	9.40×10^{-4}
Percent Yield (%)	111%	134%

OBSERVATION (PART 1):

BEFORE REACTION

Magnesium strip given is a silver and shiny solid. Hydrochloric acid is clear, transparent strong odoured liquid with fumes.

DURING REACTION

Magnesium strip begins to dissolve producing bubbles while the volume of the hydrochloric solution begins to decrease releasing clear hydrogen gas in the eudiometer.

AFTER REACTION

Magnesium strip is completely consumed. Hydrochloric acid solution still remains clear and transparent liquid. Hydrogen gas trapped in the eudiometer is a clear gas.

TABLE 2. ALLOY

Data	Trial 1	Trial 2
Unknown Number	2128	2128
Mass of alloy (g)	0.0400	0.0400
Uncalibrated volume of eudiometer (mL)	8.20	8.20
Volume of hydrogen gas (mL)	15.7	22.4
Height of water column (cm)	30.0	24.3
Density of water (kg/m^3)	1.00×10^3	1.00×10^3
Acceleration due to gravity (m/s^2)	9.80	9.80
Pressure of water column (Pa)	2.94×10^3	2.38×10^3
Water Temperature (°C)	24.1	23.7
Water Vapour pressure (kPa)	2.98	2.98
Atmospheric Pressure (Torr)	753.8	753.8
Pressure of Hydrogen	94.6	95.1
Room Temperature (°C)	22. 0	22.0
Ideal Gas Constant, R	8.314	8.314
Moles of Hydrogen (mol)	6.01×10^{-4}	8.63×10^{-4}
Mass of Zinc (g)	4.03×10^{-2}	3.37×10^{-2}
Mass of Aluminum (g)	-2.61×10^{-4}	6.24×10^{-4}
Percent Zinc (%)	101.0	84.4
Percent Aluminum (%)	-0.01	15.6
Average Percent Zinc (%)	92.2	
Average Percent Aluminum (%)	7.8	

OBSERVATION (PART 2):

BEFORE REACTION
Alloy given is small silver and shiny sediments. Hydrochloric acid is clear, transparent strong odoured liquid with fumes.

DURING REACTION
Alloy begins to dissolve and rise to the surface while producing bubbles. While dissolving, the alloy turns dark grey and the volume of the hydrochloric solution begins to decrease. The liberated hydrogen gas in the eudiometer is clear.

AFTER REACTION
Dissolved alloy remains but no bubble is produced and the volume of hydrochloric acid solution remains constant. The trapped hydrogen gas in the eudiometer still remains clear.

<u>SAMPLE CALCULATION:</u> <u>MAGNESIUM PURE METAL</u>

TRIAL 1

1. **Uncalibrated Volume of the Eudiometer:**
   EUDIOMETER #1
   10mL - 7.7mL = 2.3mL

2. **Volume of Hydrogen gas:**
   V_H = 13.9mL = 0.0139

3. **Pressure exerted by water column:**
   $p_{water\ column}$ = dgh = (1000 kg/m^3)(9.80m/s^2)(0.218m) = 2136.4 Pa

4. **Pressure of Hydrogen gas:**
   $p_H = p_{atmospheric} - p_{water\ column} - p_{water\ vapour}$ = 100.5kPa - 2.1364kPa - 2.98kPa = 95383.6Pa

5. **Moles of Hydrogen gas:**
   Pv = nRT
   n = PvRT= 95.6kPa ✕ .339mL8.314 ✕ 297.25K= 1.31 ✕ 10^{-3}

6. **Moles of Hydrogen (theoretical):**
   $Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$
   $n_{magnesium}$ = m/M= 0.0287g /24.31g/mol= 1.31 ✕ 10^{-3} mol
   1.18 ✕ 10^{-3} mol $Mg_{(s)}$✕ (1 mol $HCl_{(aq)}$ / 1 mol $Mg_{(s)}$) = 1.18 ✕10^{-3} mol $H_{2(g)}$

7. **Percentage Purity of metal (percentage yield of hydrogen):**
   Percentage Yield % = actual/theoretical✕ 100% = (1.31 ✕ 10^{-3} / 1.18 ✕ 10^{-3})✕ 100%
   111%

TRIAL 2

1. **Uncalibrated Volume of the Eudiometer:**
   EUDIOMETER #1
   10mL - 7.7mL = 2.3mL

2. **Volume of Hydrogen gas:**
   V_H = 32.6mL = 0.326L

3. **Pressure exerted by water column:**
   $p_{water\ column} = dgh = (1000\ kg/m^3)(9.80 m/s^2)(0.221 m) = 2.17 \times 10^3$

4. **Pressure of Hydrogen gas:**
   $p_H = p_{atmospheric} - p_{water\ column} - p_{water\ vapour}$ = 100.5kPa - 2.17kPa - 2.98kPa = 95.4kPa

5. **Moles of Hydrogen gas:**
   Pv = nRT
   n = Pv/RT= 95.4kPa $\times$ 0.326mL / 8.314 $\times$ 297.05K= 1.31×10^{-3}

6. **Moles of Hydrogen (theoretical):**
   $Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$
   $n_{magnesium}$ = m/M= (0.0231g)/(24.31g/mol)= 9.50×10^{-4} mol
   9.50×10^{-4} mol $Mg_{(s)}$ $\times$ (1 mol $HCl_{(aq)}$ / 1 mol $Mg_{(s)}$) = 9.50×10^{-4} mol $H_{2(g)}$

7. **Percentage Purity of metal (percentage yield of hydrogen):**
   Percentage Yield % = actual/theoretical $\times$ 100% = (1.31×10^{-3} / 9.50×10^{-4}) $\times$ 100%
   = 134%

8. **Average Percent Purity**
   Average Percent Purity % = Trial 2 Percent Purity / Trial 1 Percent Purity $\times$ 100%
   = 1.34/1.11 $\times$ 100% = 120%

SAMPLE CALCULATION: #2128 ALLOY

TRIAL 1

1. **Pressure of water column and hydrogen gas:**
   $p_{water\ column}$ = dgh = (1000 kg/m^3)(9.80m/s^2)(0.300m) = 2.94 × 10^3 Pa
   $p_H = p_{atmospheric} - p_{water\ column} - p_{water\ vapour}$ = 100.5kPa - 2.94kPa - 2.98kPa = 94.6kPa

2. **Moles of hydrogen gas:**
   Pv = nRT
   n = Pv/RT= (94.6kPa × 0.0157L) / (8.314 × 297.25K) = 6.01 × 10^{-3} mol

3. **Masses of Zinc and Aluminum in the alloy:**
   $n_H = \frac{mtotal\text{-}mAl}{MZn} + \frac{3mAl}{2MAl}$

   $n_H = \frac{(2MAlmtotal\text{-}2MAlmAl)+3mAl}{2MAlMZn}$

   $2M_{Zn}M_{Al}n_H = 2M_{Al}m_{total} - 2M_{Al}m_{Al} + 3M_{Zn}m_{Al}$

   2(65.41g/mol)(26.98g/mol)(6.01 × 10^{-4}mol) = 2(26.98g/mol)(0.0400g) –
   2(26.98g/mol)m_{Al} + 3(65.41g/mol)m_{Al}

   2.1212243684 = 2.1584 – 53.96m_{Al} – 196.23m_{Al}

   -0.037156316 = 142.27m_{Al}

   -2.26× 10^{-4}g= m_{Al}

   $m_{total} = m_{Zn} + m_{Al}$
   $m_{Zn} = m_{total} - m_{Al}$
   m_{Zn} = 0.0400g – (-2.26× 10^{-4}g)
   m_{Zn} = 4.03 × 10^{-2}g

4. **Percent composition of the alloy:**
   Mass % Zn = m_{zn}/m_{total} = (4.03 × 10^{-2}g/0.0400g) × 100% = 101%
   Mass % Zn = m_{Al}/m_{total} = (-2.26× 10^{-4}g/0.0400g) × 100% = -0.01%

TRIAL 2

1. **Pressure of water column and hydrogen gas:**

$p_{water\ column} = dgh = (1000\ kg/m^3)(9.80 m/s^2)(0.234 m) = 2.38 \times 10^3$ Pa

$p_H = p_{atmospheric} - p_{water\ column} - p_{water\ vapour}$ = 100.5kPa - 2.38kPa - 2.98kPa = 95.1kPa

2. **Moles of hydrogen gas:**

Pv = nRT

n = Pv/RT= (95.1kPa $\times$ 0.224L) / (8.314 $\times$ 296.85K) = 8.63 $\times 10^{-4}$ mol

3. **Masses of Zinc and Aluminum in the alloy:**

$n_H = \frac{mtotal\text{-}mAl}{MZn} + \frac{3mAl}{2MAl}$

$n_H = \frac{(2MAlmtotal\text{-}2MAlmAl)+3mAl}{2MAlMZn}$

$2M_{Zn}M_{Al}n_H = 2M_{Al}m_{total} - 2M_{Al}m_{Al} + 3M_{Zn}m_{Al}$

$2(65.41 g/mol)(26.98 g/mol)(8.63 \times 10^{-4} mol) = 2(26.98 g/mol)(0.0400 g) - 2(26.98 g/mol)m_{Al} + 3(65.41 g/mol)m_{Al}$

$3.045978867 = 2.1584 - 53.96m_{Al} - 196.23m_{Al}$

$0.887578867 = 142.27m_{Al}$

$6.24 \times 10^{-3} g = m_{Al}$

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

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

$m_{Zn} = 0.0400 g - (6.24 \times 10^{-3} g)$

$m_{Zn} = 3.37 \times 10^{-2} g$

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

Mass % Zn = $m_{zn}/m_{total} = (4.03 \times 10^{-2} g/0.0400 g) \times 100\%$ = 84.4%

Mass % Zn = $m_{Al}/m_{total} = (6.24 \times 10^{-3} g /0.0400 g) \times 100\%$ = 15.6%

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

Percent Average of Zinc % = $\frac{Zntrial\ 1+Zntrial\ 2}{2} = \frac{100\%+84.4\%}{2}$ = 92.2%

Percent Average of Aluminum % = $\frac{Altrial\ 1+AltriaL\ 2}{2} = \frac{-0.01\%+15.6\%}{2}$ = 7.8%

DISCUSSION: (WITHIN SPACE PROVIDED)

The main objective of this lab experiment was to determine the percentage purity and the composition of the unknown alloy. When magnesium metal/alloy undergoes a reaction with hydrochloric acid, hydrogen gas and metal ions are produced. During this lab, hydrogen gas was collected in order to determine the percentage purity of pure magnesium metal and the composition of the duralumin alloy. How this is achieved are through the ideal gas law to determine the actual yield of hydrogen gas and stoichiometric calculation to find the theoretical yield of hydrogen gas. By obtaining these two values, through theoretical concepts, the percentage yield of hydrogen could be found, which is then directly related to the percentage purity of the pure metal. For the second part of the experiment (determining the composition of the alloy), by using the actual number of moles of hydrogen produced during the reaction, the following formula could use to determine the composition of the alloy: $n_{hydrogen\ total} = n_{zinc\ total} + 3/2n_{aluminium\ total}$

During the experiment it was important to consider a couple of procedure concepts to avoid making experimental errors and affect the data. Before the experiment, the eudiometer first needed to be calibrated in order to record the accurate data since the measurement would always have been below the actual measurement. During the experiment it was important not to let any air inside the eudiometer since this could essentially affect the pressure of the water column as well as the volume of hydrogen gas collected. Another factor to consider during the experiment was to not let the metal float up to the surface of the solution and stick to the eudiometer before it was completely consumed. If this were to happen, the measurement of the of hydrogen gas would be inaccurate since the reaction hasn't fully completed therefore it would not produce the maximum yield of hydrogen.

After the experiment, the rest of the data collected through theoretical concepts and calculations. Based on the calculated data it was clear that the data collected during the experiment was inaccurate. For both trials of determining the percent purity of the metal, the percent yield/percent purity were both over a 100%. This suggests that actual yield of hydrogen was over the theoretical yield based on the mass of the metal. Some of the factors that could have concluded to this result was a small volume of air entering the eudiometer while inverting it. This procedural error also affected result of the first trial of the second part of the lab, when determining the composition of the alloy. The amount of hydrogen produced was not in ratio with the mass of the alloy, therefore mass of the aluminum was less than zero and mass of the zinc was higher than the alloy. Doing multiple trials was necessary, since it can potentially improve accuracy. Results between both trial should, in theory, be similar but due to procedural errors this is not expected.

Therefore, it is clear that the inaccuracy of the results was mainly due to procedural errors. To improve accuracy for this lab, it is necessary to make sure that there is no volume of air inside the eudiometer, to measure every single matter correctly and to be more precise when inverting the eudiometer to avoid leakage of hydrochloric acid in the beaker. To improve accuracy in any lab experiment, it is beneficial to always follow the procedure correctly to collect accurate results.

CONCLUSION: (NO MORE THAN TWO LINES)

In conclusion, the average percent purity for the two magnesium metal was 120% and the composition of the alloy #2128 was 92.2% zinc and 7.8% aluminum. The amount of hydrogen gas produced was to determine the percentage purity of the magnesium metal and composition of the alloy.

Data Tables

Table 1. Pure Metal

Data	Trial 1	Trial 2
Identity of Metal	Magnesium	Magnesium
Mass of metal (g)	0.028 [illegible] g	0.0230 g
Uncalibrated volume of eudiometer (mL)	[illegible]	27.7 mL
Volume of hydrogen gas (mL)	29.3	28 mL
Height of water column (cm)	19.5	22.1
Density of water (kg/m³)	1.0×10^{-2}	1.0×10^{-2}
Acceleration due to gravity (m/s²)	9.81	9.81
Pressure of water column (Pa)	0.019	0.022
Water Temperature (°C)	24.1	23.9
Water Vapour pressure (Pa)		
Atmospheric Pressure (Torr)	100.5 kPa	100.5
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):

gnesium: silver,

Table 2. Alloy

Data	Trial 1	Trial 2
Unknown Number	2126	2126
Mass of alloy (g)	0.040	0.040
Uncalibrated volume of eudiometer (mL)	31.8	31.8
Volume of hydrogen gas (mL)	13.9	20.6
Height of water column (cm)	30 cm	24.3cm
Density of water (kg/m³)	1.0×10^{3}	0.243
Acceleration due to gravity (m/s²)	9.81	9.81
Pressure of water column (Pa)	0.029	0.024
Water Temperature (°C)	24.1	23.7
Water Vapour pressure (kPa)		
Atmospheric Pressure (Torr)	100.5	100.5
Pressure of Hydrogen		
Room Temperature	22.0	22.0
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):

Alloy: chunks, silver, sediment, shiny heterogeneous

4/4

Report Form...Page 3