PLEASE NOTE: If ANY of the above information is UNCLEAR or not provided, your grade will NOT be recorded!!

Lab Day (circle):

Lab Week (circle):

Laboratory Report Form

Experiment 1.

Determination of the Composition of an Alloy

<u>Checklist:</u>

- o Raw Data Sheet written in pen, signed by TA and attached
- o Report Form completed in pen (or typed) and attached

Student's Initials

Data Tables

Table 1. Pure Metal

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Data	Trial 1	Trial 2
Identity of Metal	Zinc	Zinc
Mass of metal (g)	0.0500g	0.0460g
Uncalibrated volume of eudiometer (mL)	0.00mL	0.00mL
Volume of hydrogen gas (mL)	20.25mL	18.80mL
Height of water column (cm)	29.85cm	33.45cm
Density of water (kg/m^3)	1000 kg/m^3	1000 kg/m^3
Acceleration due to gravity (m/s^2)	9.80 $\frac{m}{s^2}$	9.80 $\frac{m}{s^2}$
Pressure of water column (Pa)	2930 Pa	3280 Pa
Water Temperature (°C)	23.3°C	23.5°C
Water Vapour pressure (Pa)	2810 Pa	2810 Pa
Atmospheric Pressure (Torr)	744.0 Torr	744.0 Torr
Pressure of Hydrogen	93.5 kPa	93.1 kPa
Room Temperature	20.5°C	20.5°C
Ideal Gas Constant, R	8.3144621 $\frac{kPa \cdot L}{K mol}$	8.3144621 $\frac{kPa \cdot L}{K mol}$
Actual Moles of Hydrogen (mol)	7.75×10^{-4} mol	7.17×10^{-4} mol
Theoretical moles of Hydrogen (mol)	7.64×10^{-4} mol	7.03×10^{-4} mol
Percent Yield (%)	101 %	102 %

Observations (Part 1): 1.5/2

The reaction occured fairly rapidly once the $HCl_{(aq)}$ came into contact with the zinc sample. Bubbles of $H_{2(g)}$ formed rapidly until all zinc was reacted.

→ Describe metal

Table 2. Alloy

3/3

Data	Trial 1	Trial 2
Unknown Number	3183	3183
Mass of alloy (g)	0.0452g	0.0423g
Uncalibrated volume of eudiometer (mL)	0.00mL	0.00mL
Volume of hydrogen gas (mL)	28.35mL	26.90mL
Height of water column (cm)	22.85cm	22.00cm
Density of water (kg/m³)	1000. kg/m³	1000 kg/m³
Acceleration due to gravity (m/s²)	9.80 m/s²	9.80 m/s²
Pressure of water column (Pa)	2240 Pa	2160 Pa
Water Temperature (°C)	23.3°C	23.5°C
Water Vapour pressure (kPa)	2810 Pa	2810 Pa
Atmospheric Pressure (Torr)	744.0 Torr	744.0 Torr
Pressure of Hydrogen	94.1 kPa	94.2 kPa
Room Temperature	20.5°C	20.5°C
Ideal Gas Constant, R	8.3144621 kPa·L/K·mol	8.3144621 kPa·L/K·mol
Moles of Hydrogen (mol)	1.09×10^{-3} mol	1.04×10^{-3} mol
Mass of Zinc (g)	3.52×10^{-2} g	3.26×10^{-2} g
Mass of Aluminum (g)	9.97×10^{-3} g	9.71×10^{-3} g
Percent Zinc (%)	77.9%	77.0%
Percent Aluminum (%)	22.1%	23.0%
Average Percent	Zinc = 77.5%	Aluminium = 22.5%

Observations (Part 2): 2/2

Again, the reaction occured fairly rapidly once the HCl (aq) came into contact with the alloy sample. During the reaction, lots of H_2 (g) was produced, and as the bubbles of gas rose up the eudiometer they often carried with them small chunks of the alloy, until we had a grey cloud near the top of the solution in the eudiometer. After tapping the eudiometer repeatedly, all the alloy reacted and the gray cloud dissappeared.

Sample Calculation : Trial 2 Pure Metal : Zinc

1. Uncalibrated Volume of the Eudiometer:

$$\text{Uncalibrated Volume} = V_{\text{Graduated Cylinder}} - V_{\text{Eudiometer}}$$
$$= 5.00\,mL - 5.00\,mL$$
$$= 0.00\,mL$$

Trial 1: Uncalibrated Volume = 0.00 mL

2. Volume of Hydrogen gas:

$$V_{H_2(g)} = V_{\text{measured}} + V_{\text{uncalibrated}}$$
$$= 18.80\,mL + 0.00\,mL$$
$$= 0.01880\,L$$

Trial 1: $V_{H_2(g)} = 0.02025\,L$

3. Pressure exerted by the water column:

0.5/1

$$P_{\text{water column}} = dgh$$
$$= (1000.\,\tfrac{kg}{m^3})(9.80\,\tfrac{m}{s^2})(0.3345\,m)$$
$$= 3278\,\tfrac{kg}{m\,s^2}$$
$$\doteq 3.278\,kPa$$

Sig figs

Trial 1: $P_{\text{WATER COLUMN}} =$ ~~2925.3 kg/m s²~~ $\doteq 2.925\,kPa$

4. Pressure of hydrogen gas:

$$P_{H_2(g)} = P_{\text{Atmospheric}} - P_{\text{water column}} - P_{\text{water vapour}}$$
$$= \left(744.0\,mmHg \times \frac{101.325\,kPa}{760.0\,mmHg}\right) - (3.2781\,kPa) - (2.81\,kPa)$$
$$\doteq 93.10\text{~~3746211~~}\,kPa$$

~~≐ 93.10 kPa~~

Trial 1: ~~$P_{H_2(g)}$ ≐ 93.4665421 kPa~~ ~~≐ 93.5 kPa~~ ~~≐ 93.46 kPa~~ $P_{H_2(g)} \doteq 93.46\,kPa$

5. Moles of hydrogen gas (experimental):

$PV = nRT$

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

$n_{H_2(g)} = \frac{(93.10~~374211~~ \text{ kPa})(0.01880 \text{ L})}{(8.3144621 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}})(293.65 \text{ K})}$

6/

$\doteq 7.169~~037015~~ \times 10^{-4}$ mol

~~$\doteq 7.17 \times 10^{-4}$ mol~~

~~$\doteq 7.169 \times 10^{-4}$ mol~~

should be 3 sig figs

Trial 1: $n_{H_2(g)} \doteq 7.751~~224059~~ \times 10^{-4}$ mol

~~$\doteq 7.751 \times 10^{-4}$ mol~~

6. Moles of hydrogen gas (theoretical):

$Zn_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$

$Mm(Zn) = 65.409 \frac{g}{mol}$

$n_{H_2(g)} = m_{Zn} \div Mm_{Zn} \times \frac{1 \text{ mol } H_2}{1 \text{ mol } Zn}$

$= (0.0460 g)\left(\frac{1 \text{ mol } Zn}{65.409 g}\right)\left(\frac{1 \text{ mol } H_2}{1 \text{ mol } Zn}\right)$

~~$\doteq 7.032671345 \times 10^{-4}$ mol H_2~~

~~$\doteq 7.03 \times 10^{-4}$ mol H_2~~

$\doteq 7.03 \times 10^{-4}$ mol H_2

✓

Trial 1: $n_{H_2(g)} \doteq 7.64~~4207984~~ \times 10^{-4}$ mol H_2

~~$\doteq 7.64 \times 10^{-4}$ mol H_2~~

7. Percentage Purity of metal:

$\% \text{ Purity} = \frac{n_{H_2(g)} \text{ experimental}}{n_{H_2(g)} \text{ theoretical}} \times 100\%$

$= \frac{7.169~~037015~~ \times 10^{-4} \text{ mol}}{7.03~~2671345~~ \times 10^{-4} \text{ mol}} \times 100\%$

~~$\doteq 101.939031\%$~~

$\doteq 102\%$

✓

Trial 1

% Purity $\doteq$ ~~101.4000986%~~

$\doteq 101\%$

8. Average Percent Purity:

Average % Purity = ~~101.439031 % + 101.9000000 %~~ / ~~2~~ $\frac{102\% + 101.\%}{2}$

~~≐ 101.6695298 %~~

≐ 102 % ✓

Sample Calculation : Trial 2 Alloy : 3183

1. Pressure of water column and hydrogen gas:

$P_{water\ column} = dgh$

$= (1000.\ \frac{kg}{m^3})(9.80\ \frac{m}{s^2})(0.2200 m)$

$= 2156\ \frac{kg}{m\ s^2}$

~~≐ 2.16 kPa~~ ≐ 2156 kPa   sig figs

Trial 1

$P_{water\ column}$ = ~~2239.5 $\frac{kg}{m\ s^2}$~~

~~≐ 2.24 kPa~~

≐ 2.239 kPa

$P_{H_2(g)} = P_{atmospheric} - P_{water\ column} - P_{water\ vapor}$

$= [(744.0 mmHg)(\frac{101.325 kPa}{760.0 mmHg})] - (2.156 kPa) - (2.81 kPa)$

~~≐ 94.2258421 kPa~~

≐ 94.23 kPa ✓

Trial 1

$P_{H_2(g)}$ ≐ ~~94.1425421 kPa~~

≐ 94.14 kPa

2. Moles of hydrogen gas:

$PV = nRT$

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

$n_{H_2(g)} = \frac{(94.2~~258421~~ kPa)(0.02690 L)}{(8.3144621 \frac{kPa \cdot L}{K \cdot mol})(273.15 K + 20.5 K)}$

~~≐ 1.038146305 × 10⁻³ mol~~

~~≐ 1.04 × 10⁻³ mol~~

≐ 1.038×10^{-3} mol ✓

Trial 1

$n_{H_2(g)}$ ≐ ~~1.093137571 × 10⁻³ mol~~

≐ 1.093×10^{-3} mol

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3. Masses of Zinc and Aluminum in the alloy:

$$n_{H_2\,Total} = n_{H_2\text{ from }Zn} + n_{H_2\text{ from }Al}$$

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

$$= \frac{m_{Zn}}{Mm(Zn)} + \frac{3m_{Al}}{2Mm(Al)} \quad \text{— ①}$$

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

$$m_{Zn} = m_{alloy} - m_{Al} \quad \text{— ②}$$

Sub ② into ①

$$n_{H_2\,Total} = \frac{m_{alloy} - m_{Al}}{Mm(Zn)} + \frac{3m_{Al}}{2Mm(Al)}$$

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

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

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

$$m_{Al} = \frac{\left(1.038\sout{45305} \times 10^{-3}\,mol - \frac{0.0423\,g}{65.39\,\frac{g}{mol}}\right)}{\left(\frac{3}{2(26.982\frac{g}{mol})} - \frac{1}{(65.39\frac{g}{mol})}\right)}$$

$m_{Al} \doteq$ ~~$9.708678432 \times 10^{-3}$ g~~

$m_{Al} \doteq 9.71 \times 10^{-3}$ g

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

$= 0.0423\,g - 9.71 \times 10^{-3}\,g$

~~$9.708678432 \times 10^{-3}$ g~~

~~$\doteq 3.259132157 \times 10^{-3}$ g~~

$\doteq 3.26 \times 10^{-2}$ g

Trial 1

$m_{Al} \doteq$ ~~$9.97277736 \times 10^{-3}$ g~~

$\doteq 9.97 \times 10^{-3}$ g

$m_{Zn} \doteq$ ~~$3.522720626 \times 10^{-2}$ g~~

$\doteq 3.52 \times 10^{-2}$ g

4. Percent composition of the alloy:

$$\%\text{ Composition Al} = \frac{m_{Al}}{m_{Alloy}}$$

$$= \frac{9.7\sout{086784\,32} \times 10^{-3}\,g}{0.0423\,g} \times 100\%$$

$\doteq$ ~~22.95195847 %~~

$\doteq 23.0\%$

$$\%\text{ Composition Zn} = \left(\frac{m_{Zn}}{m_{Alloy}}\right)100\%$$

$= 100\left(\frac{3.26\ldots}{0.0423\,g}\right)$

$\doteq$ ~~77.0480454%~~

$\doteq 77.0\%$

Trial 1 : % Composition Al $\doteq$ ~~22.0636581~~ % $\doteq 22.1\%$; % Composition Zn $\doteq$ ~~77.9363419~~ % $\doteq 77.9\%$

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

Average Percent composition of Al = ~~$\frac{22.95195847\% + 22.0636581\%}{2}$~~ $\frac{23.0\% + 22.1\%}{2}$

$\doteq$ ~~22.50780854 %~~

$\doteq 22.5\%$

Avg. % composition Zn = $\frac{77.0\sout{480454}\% + 77.9\sout{363419}\%}{2}$

$\doteq$ ~~77.49219146~~ % $\doteq 77.5\%$

3.5/4 27.5/30 = 92%

Discussion:

In this lab, we calculated the purity of a sample of zinc and the percent composition of an alloy of zinc and aluminium. We did this by reacting the zinc sample and the alloy with hydrochloric acid, and recording the amount of hydrogen gas produced. With the alloy, we were able to use the ideal gas laws and basic stoichiometry to determine the percent composition of the alloy; however, we were not given the actual percent composition of the alloy in order to compare our results and calculate the percent error. With the zinc sample, again we used the ideal gas laws and stoichiometry, this time in order to determine the experimental and theoretical yields of hydrogen gas and find the percent purity of the sample, which came out to approximately 101% for trial 1 and 102% for trial 2. There are two main sources of error in this experiment which could have led us to these results.

One experimental source of error could have occurred during the step in which the eudiometer was turned upside down and placed under water. We may have incorrectly inverted the eudiometer, allowing for a small amount of air to enter the eudiometer while covering the top with our thumb, thus adding a small amount of air to our volume of hydrogen gas. This gave us a greater value for the volume of hydrogen gas produced and caused us to have an experimental yield of hydrogen gas greater than the theoretical yield, giving us a result of over 100% for the purity of the metal. Good!

More importantly, an inherit source of error in this procedure could have come from an assumption we made when using the ideal gas laws to calculate the moles of hydrogen gas produced. The assumption was that the temperature of the hydrogen gas inside the eudiometer was the same as the room temperature (20.5°C). However, the temperature of the water in which the reaction occurred was greater than room temperature (23.3°C for trial 1 and 23.5°C for trial 2), and it is possible that as the hydrogen gas bubbled through the water its temperature was raised above room temperature. According to the ideal gas laws, an increase in the temperature of a gas results in a decrease of the number of moles of the gas, if pressure and volume remain the same. However, we used room temperature for the temperature of the hydrogen gas, which resulted in us calculating a greater experimental number of moles of hydrogen gas than actually present, and thus causing us to have a percent purity for the reacting metal (zinc) greater than 100%. Overall, however, our results were extremely close to the desired results and this experiment is an excellent way to determine the percent purity of a metal sample and the percent composition of an alloy.

Don't know if temp would affect the results in this particular exp.

Conclusion:

1.25/2

The average percent purity of the zinc sample was approximately 102%. The average percent composition of the alloy was approximately 22.5% aluminium and 77.5% zinc.

→ unknown #