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

Lab Day (T/W/Th/F): Thursday

Lab Week (even/odd): Odd (7)

Lab time (10:00, 2:30, 6:30): 6:30-9:30

## **Laboratory Report Form**

### **Experiment 1.**

#### Determination of the Composition of an Alloy

#### Checklist:

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

Student's Initials MK

## Data Tables

**Table 1. Pure Metal**

Data	Trial 1	Trial 2
Identity of Metal	Zinc	Zinc
Mass of metal (g)	0.0555	0.0596
Uncalibrated volume of eudiometer (mL)	6.00	6.00
Volume of hydrogen gas (mL)	16.2	18.1
Height of water column (cm)	33.0	31.0
Density of water (kg/m <sup>3</sup> )	1.00 x10 <sup>3</sup>	1.00 x10 <sup>3</sup>
Acceleration due to gravity (m/s <sup>2</sup> )	9.80	9.80
Pressure of water column (Pa)	3.23	3.04
Water Temperature (°C)	24.0 °C	24.0 °C
Water Vapour pressure (Pa)	2.64	2.64
Atmospheric Pressure (Torr)	(101.6 kPa) = 7.26 x10 <sup>2</sup>	(101.6 kPa) = 7.26 x10 <sup>2</sup>
Pressure of Hydrogen	9.83 x 10 <sup>1</sup> kPa	9.83 x 10 <sup>1</sup> kPa
Room Temperature	22.1 °C	22.1 °C
Ideal Gas Constant, R	8.314 kPa·L/mol·K	8.314 kPa·L/mol·K
Actual Moles of Hydrogen (mol)	6.49 x 10 <sup>-4</sup>	7.25 x 10 <sup>-4</sup>
Theoretical moles of Hydrogen (mol)	8.48 x 10 <sup>-4</sup>	9.11 x 10 <sup>-4</sup>
Percent Yield (%)	76.5 %	79.6%

### Observations (Part 1):

Zinc is a shiny, malleable flat solid that is in a one long piece.

HCl is transparent, with tingly smelled fumes.

The reaction did not take place immediately, however the eudiometer was warm when touched, after few minutes, hydrogen gas bubbles started to rise to the top, forcing the mixture of the hydrochloric acid and water level to decrease. After the reaction, zinc was completely consumed. No colour change happened during the reaction.

**Table 2. Alloy**

Data	Trial 1	Trial 2
Unknown Number	#5092	#5092
Mass of alloy (g)	$4.00 \times 10^{-2}$ g	$4.00 \times 10^{-2}$ g
Uncalibrated volume of eudiometer (mL)	6.30 mL	6.30 mL
Volume of hydrogen gas (mL)	19.9 mL	18.0 mL
Height of water column (cm)	29.1 cm	31.5 cm
Density of water (kg/m <sup>3</sup> )	$1.00 \times 10^3$ kg/m <sup>3</sup>	$1.00 \times 10^3$ kg/m <sup>3</sup>
Acceleration due to gravity (m/s <sup>2</sup> )	9.80 m/s <sup>2</sup>	9.80 m/s <sup>2</sup>
Pressure of water column (Pa)	2.85 Pa	3.09 Pa
Water Temperature (°C)	24.0 °C	23.0 °C
Water Vapour pressure (kPa)	$2.64 \times 10^3$ kPa	$2.64 \times 10^3$ kPa
Atmospheric Pressure (Torr)	(101.6 kPa) = $7.26 \times 10^2$ Torr	(101.6 kPa) = $7.26 \times 10^2$ Torr
Pressure of Hydrogen	95.8 kPa	95.5 kPa
Room Temperature	22.1 °C	22.1 °C
Ideal Gas Constant, R	8.314 kPa·L/mol·K	8.314 kPa·L/mol·K
Moles of Hydrogen (mol)	$7.76 \times 10^{-4}$ mol	$7.01 \times 10^{-4}$ mol
Mass of Zinc (g)	$1.37 \times 10^{-2}$ g	$1.82 \times 10^{-2}$ g
Mass of Aluminum (g)	$2.63 \times 10^{-2}$ g	$2.18 \times 10^{-2}$ g
Percent Zinc (%)	34.2%	45.5%
Percent Aluminum (%)	65.8%	54.5%
Average Percent	Zn = 39.8%	Al = 60.2%

**Observations (Part 2):**

Alloy is shiny crumbles with different sizes.

HCl is transparent, with tingly smelled fumes.

The reaction took place almost immediately, however the eudiometer was not warm as the experiment carried previously with zinc. More activity involving hydrogen gas bubbles rising to the top, forcing the mixture of the hydrochloric acid and water level to decrease. During the reaction, almost all of particles floated, forming opaque, dark gray clouds near the surface of the mixture in eudiometer. After the reaction, the alloy was completely consumed.

## Sample Calculation : ( Zinc ) Pure Metal

1. Uncalibrated Volume of the Eudiometer:

$$10\text{mL} - 4\text{mL} = 6\text{mL}$$

2. Volume of Hydrogen gas:

$$\begin{aligned} 1^{\text{st}} \text{ Trial: } 16.2 \text{ mL} &= 0.0162 \text{ L} \\ 2^{\text{nd}} \text{ Trial: } 18.1 \text{ mL} &= 0.0181 \text{ L} \end{aligned}$$

3. Pressure exerted by the water column:

$$\begin{aligned} 1^{\text{st}} \text{ Trial: } \text{ Pressure} &= (\text{density}) \times (\text{gravity}) \times (\text{height}) \\ d &= 1000 \text{ kg/h}, g = 9.8 \text{ m/s}^2, h = 33 \text{ cm} = 0.033 \text{ m} \end{aligned}$$

$$\begin{aligned} P &= (1000 \text{ kg/h}) \times (9.8 \text{ m/s}^2) \times (0.033 \text{ m}) \\ P &= 323.4 \text{ Pa} = 0.3234 \text{ kPa} = 3.23 \times 10^{-1} \text{ kPa} \end{aligned}$$

2<sup>nd</sup> Trial:

$$d = 1000 \text{ kg/h}, g = 9.8 \text{ m/s}^2, h = 31 \text{ cm} = 0.031 \text{ m}$$

$$\begin{aligned} P &= (1000 \text{ kg/h}) \times (9.8 \text{ m/s}^2) \times (0.031 \text{ m}) \\ P &= 303.8 \text{ Pa} = 0.3038 \text{ kPa} = 3.04 \times 10^{-1} \text{ kPa} \end{aligned}$$

4. Pressure of hydrogen gas:

$$\begin{aligned} P_{\text{H}_2} &= P_{\text{atm}} - P_{\text{water vapour}} - P_{\text{water column}} \\ P_{\text{atm}} &= 101.6 \text{ kPa}, P_{\text{H}_2\text{O vapour}} = 2.98 \text{ kPa}, \\ P_{\text{H}_2\text{O column}} &= 0.3234 \text{ and } 0.3038 \text{ kPa} \end{aligned}$$

$$\begin{aligned} 1^{\text{st}} \text{ Trial: } P_{\text{H}_2} &= 101.6 \text{ kPa} - 2.98 \text{ kPa} - 0.3234 \text{ kPa} \\ &= 98.2966 \text{ kPa} = 9.83 \times 10^1 \text{ kPa} \end{aligned}$$

$$\begin{aligned} 2^{\text{nd}} \text{ Trial: } P_{\text{H}_2} &= 101.6 \text{ kPa} - 2.98 \text{ kPa} - 0.3038 \text{ kPa} \\ &= 98.3162 \text{ kPa} = 9.83 \times 10^1 \text{ kPa} \end{aligned}$$

5. Moles of hydrogen gas (experimental):

$$\begin{aligned} n_{\text{H}_2} &= \frac{PV}{RT} & P &= 98.2966 \text{ kPa}, 98.3162 \text{ kPa} \\ & & V &= 0.0162 \text{ L}, 0.0181 \text{ L} \\ & & R &= 8.314 \text{ kPa}\cdot\text{L/mol}\cdot\text{K} \quad T = 22.1^\circ\text{C} = 295.25 \text{ K} \end{aligned}$$

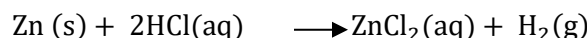
1<sup>st</sup> Trial:

$$n_{\text{H}_2} = \frac{(98.2966 \text{ kPa}) \times (0.0162 \text{ L})}{(8.314 \text{ kPa}\cdot\text{L}/\text{mol}\cdot\text{K}) \times (295.25 \text{ K})} = 0.000648714 \text{ mol}$$
$$= 6.49 \times 10^{-4} \text{ mol}$$

2<sup>nd</sup> Trial:

$$n_{\text{H}_2} = \frac{(98.3162 \text{ kPa}) \times (0.0181 \text{ L})}{(8.314 \text{ kPa}\cdot\text{L}/\text{mol}\cdot\text{K}) \times (295.25 \text{ K})} = 0.000724942 \text{ mol}$$
$$= 7.25 \times 10^{-4} \text{ mol}$$

6. Moles of hydrogen gas (theoretical):



$$\text{Mass of Zn} = 0.0555 \text{ g}, 0.0596 \text{ g} \quad n_{\text{Zn}} = \frac{\text{mass}}{\text{Molar mass}}$$
$$\text{Molar mass} = 65.41 \text{ g/mol}$$

$$\text{For 1}^{\text{st}} \text{ trial, } n_{\text{Zn}} = \frac{0.0555 \text{ g}}{65.41 \text{ g/mol}} = 0.000848494 \text{ mol}$$

$$\text{For 2}^{\text{nd}} \text{ trial, } n_{\text{Zn}} = \frac{0.0596 \text{ g}}{65.41 \text{ g/mol}} = 0.000911175 \text{ mol}$$

The ratio of the amount of mole between Zn and H<sub>2</sub> is 1:1

Therefore,  $n_{\text{H}_2} = 0.000848494 = 8.48 \times 10^{-4} \text{ mol}$  for 1<sup>st</sup> trial and  
 $n_{\text{H}_2} = 0.000911175 = 9.11 \times 10^{-4} \text{ mol}$  for 2<sup>nd</sup> trial.

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

$$\text{Percentage purity of metal} = \frac{\text{actual moles of H}_2}{\text{theoretical moles of H}_2} \times 100\%$$

Actual moles of H<sub>2</sub> = 0.000648714 mol, 0.000724942 mol  
Theoretical moles of H<sub>2</sub> = 0.000848494 mol, 0.000911175 mol

$$\text{1}^{\text{st}} \text{ Trial, \% purity of metal} = \frac{0.000648714 \text{ mol}}{0.000848494 \text{ mol}} \times 100\% = 76.4547539 = 76.5 \%$$

$$\text{2}^{\text{nd}} \text{ Trial, \% purity of metal} = \frac{0.000724942 \text{ mol}}{0.000911175 \text{ mol}} \times 100\% = 79.5612258 = 79.6 \%$$

8. Average Percent Purity:

$$\text{Average \% purity} = \frac{(\text{1st \% purity of metal}) + (\text{2nd \% purity of metal})}{2}$$
$$= \frac{(76.4547539) + (79.5612258)}{2} = 78.00798985 = 78.0 \%$$

## Sample Calculation : ( #5092 ) Alloy

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

$$P_{\text{water column}} = (\text{density}) \times (\text{gravity}) \times (\text{height})$$

$$P_{\text{H}_2} = P_{\text{atm}} - P_{\text{water vapour}} - P_{\text{water column}}$$

$$\text{Density} = 1000 \text{ kg/m}^3 \quad \text{Gravity} = 9.8 \text{ m/s}^2$$

$$\text{Height} = 29.1 \text{ cm} = 0.291 \text{ m}, 31.5 \text{ cm} = 0.315 \text{ m}$$

$$\begin{aligned} 1^{\text{st}} \text{ trial, } P_{\text{water column}} &= (1000 \text{ kg/m}^3) \times (9.8 \text{ m/s}^2) \times (0.291 \text{ m}) \\ &= 2851.8 \text{ Pa} = 2.8518 \text{ kPa} = 2.85 \times 10^{-3} \text{ kPa} \end{aligned}$$

$$\begin{aligned} 2^{\text{nd}} \text{ trial, } P_{\text{water column}} &= (1000 \text{ kg/m}^3) \times (9.8 \text{ m/s}^2) \times (0.315 \text{ m}) \\ &= 3087 \text{ Pa} = 3.087 \text{ kPa} = 3.09 \times 10^{-3} \text{ kPa} \end{aligned}$$

$$P_{\text{atm}} = 101.6 \text{ kPa} \quad P_{\text{H}_2\text{O vapour}} = 2.98 \text{ kPa}$$

$$\begin{aligned} 1^{\text{st}} \text{ trial, } P_{\text{H}_2} &= 101.6 \text{ kPa} - 2.98 \text{ kPa} - 2.8518 \text{ kPa} \\ &= 95.7682 \text{ kPa} = 95.8 \text{ kPa} \end{aligned}$$

$$\begin{aligned} 2^{\text{nd}} \text{ trial, } P_{\text{H}_2} &= 101.6 \text{ kPa} - 2.98 \text{ kPa} - 3.087 \text{ kPa} \\ &= 95.533 \text{ kPa} = 95.5 \text{ kPa} \end{aligned}$$

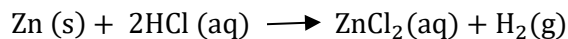
### 2. Moles of hydrogen gas:

$$n_{\text{H}_2} = \frac{PV}{RT} \quad \begin{array}{l} P=95.7682 \text{ kPa}, 95.533 \text{ kPa} \\ V = 0.0199 \text{ L}, 0.0180 \text{ L} \\ R = 8.314 \text{ kPa}\cdot\text{L/mol}\cdot\text{K} \\ T = 22.1^\circ \text{C} = 295.25 \text{ K} \end{array}$$

$$\begin{aligned} 1^{\text{st}} \text{ trial: } n_{\text{H}_2} &= \frac{(95.7682 \text{ kPa})(0.0199 \text{ L})}{(8.314 \text{ kPa}\cdot\text{L/mol}\cdot\text{K})(295.25 \text{ K})} \\ &= 0.00077638 \text{ mol} = 7.76 \times 10^{-4} \text{ mol} \end{aligned}$$

$$\begin{aligned} 2^{\text{nd}} \text{ trial: } n_{\text{H}_2} &= \frac{(95.533 \text{ kPa})(0.0180 \text{ L})}{(8.314 \text{ kPa}\cdot\text{L/mol}\cdot\text{K})(295.25 \text{ K})} \\ &= 0.000700528 \text{ mol} = 7.01 \times 10^{-4} \text{ mol} \end{aligned}$$

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



- ratio of amount of mole between Zn and H<sub>2</sub> is 1:1



- ratio of amount of mole between Al and H<sub>2</sub> is 2:3

$$n_{\text{H}_2} = n_{\text{H}_2 \text{ Zn}} + n_{\text{H}_2 \text{ Al}} = n_{\text{Zn}} + \frac{3}{2}n_{\text{Al}} = \frac{\text{mass Zn}}{\text{molar mass Zn}} + \left(\frac{3}{2}\right) \frac{\text{mass Al}}{\text{molar mass Al}}$$

$$\text{mass}_{\text{Alloy}} = \text{mass}_{\text{Zn in alloy}} + \text{mass}_{\text{Al in alloy}}$$

$$\therefore \text{mass}_{\text{Zn in alloy}} = \text{mass}_{\text{Alloy}} - \text{mass}_{\text{Al in alloy}}$$

$$\therefore n_{\text{H}_2} = \frac{\text{mass}_{\text{Zn}}}{\text{molar mass Zn}} + \left(\frac{3}{2}\right) \frac{\text{mass}_{\text{Al}}}{\text{molar mass Al}} = \frac{(\text{mass}_{\text{Alloy}} - \text{mass}_{\text{Al in alloy}}) + 3(\text{mass}_{\text{Al in alloy}})}{(\text{molar mass Zn}) + 2(\text{molar mass Al})}$$

$$n_{\text{H}_2} = 0.00077638 \text{ mol}, 0.000700528 \text{ mol}$$

$$\text{mass}_{\text{Alloy}} = 0.04 \text{ g (for both trials)}$$

$$\text{molar mass Zn} = 65.41 \quad \text{molar mass Al} = 26.98$$

$$\begin{aligned} \text{1st trial: } n_{\text{H}_2} &= \frac{(\text{mass}_{\text{Alloy}} - \text{mass}_{\text{Al in alloy}}) + 3(\text{mass}_{\text{Al in alloy}})}{(\text{molar mass Zn}) + 2(\text{molar mass Al})} \\ 0.00077638 &= \frac{0.04 \text{ g} + 2\text{mass}_{\text{Al in alloy}}}{65.41 + 2(26.98) \text{ g/mol}} \\ 0.00077638 (119.37) - 0.04 &= 2\text{mass}_{\text{Al in alloy}} \\ \frac{0.05267648}{2} &= \text{mass}_{\text{Al in alloy}} \end{aligned}$$

$$\text{mass}_{\text{Al in alloy}} = 0.02633824 \text{ g}$$

$$\text{mass}_{\text{Zn in alloy}} = 0.04 \text{ g} - 0.02633824 \text{ g} = 0.01366176 \text{ g}$$

$$\therefore 2.63 \times 10^{-2} \text{ g of Al and } 1.37 \times 10^{-2} \text{ g of Zn in the alloy used for 1st trial.}$$

$$\begin{aligned} \text{2nd trial: } n_{\text{H}_2} &= \frac{(\text{mass}_{\text{Alloy}} - \text{mass}_{\text{Al in alloy}}) + 3(\text{mass}_{\text{Al in alloy}})}{(\text{molar mass Zn}) + 2(\text{molar mass Al})} \\ 0.000700528 &= \frac{0.04 \text{ g} + 2\text{mass}_{\text{Al in alloy}}}{65.41 + 2(26.98) \text{ g/mol}} \\ 0.000700528 (119.37) - 0.04 &= 2\text{mass}_{\text{Al in alloy}} \\ \frac{0.043622027}{2} &= \text{mass}_{\text{Al in alloy}} \end{aligned}$$

$$\text{mass}_{\text{Al in alloy}} = 0.021811013 \text{ g}$$

$$\text{mass}_{\text{Zn in alloy}} = 0.04 \text{ g} - 0.021811013 \text{ g} = 0.018188987 \text{ g}$$

$$\therefore 2.18 \times 10^{-2} \text{ g of Al and } 1.82 \times 10^{-2} \text{ g of Zn in the alloy used for 2nd trial.}$$

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

$$\% \text{ composition} = \frac{\text{mass}_{\text{metal}}}{\text{mass}_{\text{alloy}}} \times 100\% \quad \text{mass}_{\text{alloy}} = 0.04 \text{ g}$$

$$\text{mass}_{\text{Al}} = 0.02633824 \text{ g}, 0.021811013 \text{ g}$$

$$\text{mass}_{\text{Zn}} = 0.01366176 \text{ g}, 0.018188987 \text{ g}$$

$$\begin{aligned} \text{1st trial: } \% \text{ composition of Al} &= \frac{0.02633824}{0.04} \times 100\% \\ &= 65.8456\% = 65.8\% \text{ Al} \end{aligned}$$

$$\begin{aligned} \% \text{ composition of Zn} &= \frac{0.01366176}{0.04} \times 100\% \\ &= 34.1544\% = 34.2\% \text{ Zn} \end{aligned}$$

$$\begin{aligned} \text{2nd trial: } \% \text{ composition of Al} &= \frac{0.021811013}{0.04} \times 100\% \\ &= 54.5275325\% = 54.5\% \text{ Al} \end{aligned}$$

$$\begin{aligned} \% \text{ composition of Zn} &= \frac{0.018188987}{0.04} \times 100\% \\ &= 45.4724675\% = 45.5\% \text{ Zn} \end{aligned}$$

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

$$\text{Avg. \% composition of metal} = \frac{1\text{st \% composition} + 2\text{nd \% composition}}{2}$$

% composition of Al = 65.8456%, 54.5275325%

% composition of Zn = 34.1544%, 45.4724675%

$$\text{Avg. \% composition of Al} = \frac{65.8456\% + 54.5275325\%}{2} = 60.18656625\% = 60.2\% \text{ Al}$$

$$\text{Avg. \% composition of Zn} = \frac{34.1544\% + 45.4724675\%}{2} = 39.81343375\% = 39.8\% \text{ Zn}$$

∴ The alloy #5092 is made up of average of 60.2% Al and 39.8% Zn.

### **Discussion: (within space provided)**

The main object of this experiment was to determine the purity of metal (zinc) and the composition of the unknown alloy #5092. As each material reacts with the hydrochloric acid, it is consumed completely, forming hydrogen gas as a by-product of the reaction. The volume of hydrogen gas plays an important role in figuring out for both objectives of this lab. By calibrating the eudiometer before carrying on the procedure, it provide more accurate volume of hydrogen gas, thus making the results to be as more accurate. For both components of this lab, different records such as height and pressure of water column, is used to determine the number of moles of hydrogen gas present after the reaction had taken place. Then, moles of hydrogen gas is subbed in several equations to determine the purity of the metal (percentage yield of hydrogen gas), and in equations [6], [7], and [8] to determine the percentage composition of the alloy.

Following these procedures, the results show acceptable values. The first part, zinc had 78% purity, meaning that the actual amount of hydrogen gas produced is not that far off from the theoretical hydrogen gas' value; differing only 22%. The next part, using the unknown alloy, it turns out that the alloy had average compositions of 60.2% aluminum and 39.8% zinc. The result is reasonable, since the composition percentages add up to be  $60.2 + 39.8 = 100$ .

However, there are some sources of error during the experiment that might result in the different experimental values compared to corresponding theoretical values. Most evidential one would be the fact that the step where the eudiometer had to be flipped, while the HCl-water mixture in it. Although it was blocked, it is impossible to stop the mixture from leaking through little gaps between the mouth of the eudiometer and the thumb as it was flipped (gravity would act on it) and as it was put in the water-filled beaker. Another error that might have happened in the lab is that the acid was in fact diluted, both in eudiometer and in the beaker with a sample of metal/alloy. Since the eudiometer was not immediately put into the vial, the hydrochloric acid would have been diluted by water. Also, because the mouth of the eudiometer was kept open in an attempt (or several) to place it directly on the sample holder and vial. Both errors might have led the acid being not as reactive, which would result in smaller reaction: lower volume of hydrogen gas and higher water column- leading to bigger difference in the experimental value and the theoretical value.

In order to improve the accuracy of results and to avoid any possible errors, more of the trials should be carried out for each part, since only one or two trials are insufficient to ensure the accuracy of results.

**Conclusion: (no more than two lines)**

The alloy #5092 had an average composition of 60.2% aluminum and 39.8% zinc, while the average purity of zinc (percent yield of hydrogen gas) was 78%. The by-product of both parts of the lab, hydrogen gas, played a key factor in determining the composition of the alloy, used in a series of equations given by the manual.

pure metal 1st

metal = Zn

V HCl = 20 mL

pre-d

mass = 0.055g

= one long piece

water V for uncalibrated = 6 mL

shiny

water V for calibrated = 10 mL

piece

water column 33 cm

flat

Volume of  $H_2$  = 16.2 mL

malleable

- endio. is hot when touched

water temp 24°C

no colour change

- lots of bubbles going of Zn after few mins.

Alloy 5092

mass 0.04g

uncalibrated = 6.3 mL

water V = 3.7 mL

shiny, in pieces.

- opaque at the top of endio  
V HCl = 10 mL

- lots of small gas bubble

- faster reaction

- dark gray or ~~the~~ in endio.

- temp = 24°C

- water column = 15 cm + 14.1 cm

= 29.1 cm

- V of  $H_2$  = 19.9 mL

2nd pure metal

Zn.

0.0596 g

HCl = 20 mL

V H<sub>2</sub> = 18.1 mL

water column = 31 cm

water temp = 24°C

Rm 22.1°C

101.6 kPa

$g = 9.8 \text{ m/s}^2$

density = 1000 kg/m<sup>3</sup>

R = 8.314 kPa·L/mol·K

2nd Alloy

#5092

V HCl = 10 mL

mass = 0.04 g

°C = 23°C

H<sub>2</sub> 18 mL

water C = 31.5 cm

during reaction

~~opaque at the~~

HCl → clear, transparent, fumes, pungently smell,  
denser than water (sits at the bottom  
of the eudiometer when water is squeezed  
in)