

\* Name : Aya Rae'd Ismail Hasan.

اية راشد اسمعيل حسن

\* Reg. No. : [REDACTED]

\* Section : "15"

\* Experiment No. : "1"

15

\* Experiment Name : Volumetric Glassware and Balances.

\* Instructor's Name : Prof. Mohammed Rasheed.

\* Date : 21<sup>th</sup> / Oct / 2021

**Experiment 1**  
**Data sheet and calculations**

Name: Aya Raed Hasan Section: 15  
Reg. No. [redacted] Date: 2<sup>nd</sup> / 10 / 2021

|                                  | Trial (1)              | Trial (2)              | Trial (3)              |
|----------------------------------|------------------------|------------------------|------------------------|
| Initial burette reading          | 20.00<br>$\pm 0.05$    | 25.00<br>$\pm 0.05$ ml | 30.10<br>$\pm 0.05$ ml |
| Final burette reading            | 25.00<br>$\pm 0.02$    | 30.10<br>$\pm 0.05$    | 35.00<br>$\pm 0.05$ ml |
| Apparent volume, ml              | 5.00<br>$\pm 0.02$     | 5.10<br>$\pm 0.07$     | 4.90<br>$\pm 0.07$     |
| Weight of empty flask            | 6.6567<br>$\pm 0.001$  | 6.6618<br>$\pm 0.001$  | 6.6800<br>$\pm 0.001$  |
| Weight of flask and water        | 11.7011<br>$\pm 0.001$ | 11.6395<br>$\pm 0.001$ | 11.6154<br>$\pm 0.001$ |
| Weight of water, g               | 5.0444<br>$\pm 0.001$  | 4.9777<br>$\pm 0.001$  | 4.9348<br>$\pm 0.001$  |
| Temperature, °C                  | 21.0°C<br>$\pm 0.5$    | 22.0°C<br>$\pm 0.5$    | 21.0°C<br>$\pm 0.25$   |
| Actual (experimental) volume, ml | 5.0595 ml              | 4.9936 ml              | 4.9496 ml              |
| Correction (ml)                  | 0.0595 ml              | -0.1064 ml             | 0.0496 ml              |

Calculate the volume of water contained in each 5 ml portion from the above data

Instructor's Signature: [Signature]

Instructor's Name: Hanex Adi  
21.10.2021

91

$V_i$   
Initial burette reading

$$10 \pm 0.05) = 5.00 \pm 0.05$$

$$0.05) = 5.10 \pm 0.07 \text{ ml}$$

$$) = 4.90 \pm 0.07 \text{ ml}$$

$$(0.05)^2 + (0.05)^2 = \pm 0.07$$

$w_i$   
Weight of empty flask

$$0.001) = 5.0444 \text{ g} \pm 0.001$$

$$1) = 4.9777 \text{ g} \pm 0.001$$

$$1) = 4.9348 \text{ g} \pm 0.001$$

$$1)^2 = \pm 0.0001$$

water, I found it equals

to  $21.0^\circ \text{C} \pm 0.25$  So: for 1g of water at  $21.0^\circ \text{C}$  the volume is 1.0030 ml

$$\Rightarrow \text{trial 1} = 1 \text{ g of water} \rightarrow 1.0030 \text{ ml}$$

$$5.0444 \text{ g} \rightarrow x$$

$$x = 1.0030 \times 5.0444$$

$$x = 5.0595 \text{ ml}$$

the actual volume

$$\Rightarrow \text{trial 3} = 1 \text{ g of water} \rightarrow 1.003$$

$$4.9348 \text{ g} \rightarrow x$$

$$x = 1.0030 \times 4.9348$$

$$x = 4.9496 \text{ ml}$$

the actual volume

Follow

## Calculations

\* Apparent volume "ml" = Final burette reading<sup>V<sub>2</sub></sup> - Initial burette reading<sup>V<sub>1</sub></sup>

$$\Rightarrow \text{trial 1} = V_2 - V_1 = (25.00 \pm 0.05) - (20.00 \pm 0.05) = 5.00 \pm 0.07$$

$$\Rightarrow \text{trial 2} = V_2 - V_1 = (30.10 \pm 0.05) - (25.00 \pm 0.05) = 5.10 \pm 0.07 \text{ ml}$$

$$\Rightarrow \text{trial 3} = V_2 - V_1 = (35.00 \pm 0.05) - (30.10 \pm 0.05) = 4.90 \pm 0.07 \text{ ml}$$

Uncertainty for the burette  $\rightarrow$  "apparent Volume" =  $\sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

\* Weight of water "g" = Weight of flask and water<sup>w<sub>2</sub></sup> - Weight of empty flask<sup>w<sub>1</sub></sup>

$$\Rightarrow \text{trial 1} = w_2 - w_1 = (11.7011 \pm 0.0001) - (6.6567 \pm 0.0001) = 5.0444 \text{ g} \pm 0.0001$$

$$\Rightarrow \text{trial 2} = w_2 - w_1 = (11.6395 \pm 0.0001) - (6.6618 \pm 0.0001) = 4.9777 \text{ g} \pm 0.0001$$

$$\Rightarrow \text{trial 3} = w_2 - w_1 = (11.6154 \pm 0.0001) - (6.6806 \pm 0.0001) = 4.9348 \text{ g} \pm 0.0001$$

Uncertainty for the weight of water =  $\sqrt{(0.0001)^2 + (0.0001)^2} = \pm 0.0001$

\* Actual (experimental) Volume "ml" :

In trial 1 and 3 when I measured the temperature of water, I found it equals

to  $21.0^\circ\text{C} \pm 0.25$  So : for 1g of water at  $21.0^\circ\text{C}$  the Volume is 1.0030 ml

$$\Rightarrow \text{trial 1} = 1 \text{ g of water} \rightarrow 1.0030 \text{ ml}$$

$$5.0444 \text{ g} \rightarrow x$$

$$x = 1.0030 \times 5.0444$$

$$x = 5.0595 \text{ ml}$$

the actual Volume

$$\Rightarrow \text{trial 3} = 1 \text{ g of water} \rightarrow 1.0030$$

$$4.9348 \text{ g} \rightarrow x$$

$$x = 1.0030 \times 4.9348$$

$$x = 4.9496 \text{ ml}$$

the actual Volume

Follow

In trial 2 when I measured the temperature of water, I found it equals to  $22.0^{\circ}\text{C}$   $\pm 0.25$  So: for 1g of water  $\rightarrow 1.0032 \text{ ml}$

$$4.9777 \text{ g} \rightarrow x$$

$$x = 4.9777 \times 1.0032 = 4.9936 \text{ ml}$$

the actual volume

\* Correction value "ml" = actual Volume "ml" - Apparent Volume "ml"

$$\Rightarrow \text{trial 1} = 5.0595 \text{ ml} - 5.00 \text{ ml} = 0.0595 \text{ ml}$$

$$\Rightarrow \text{trial 2} = 4.9936 \text{ ml} - 5.10 \text{ ml} = -0.1064 \text{ ml}$$

$$\Rightarrow \text{trial 3} = 4.9496 \text{ ml} - 4.90 \text{ ml} = 0.0496 \text{ ml}$$

### \* Source of errors

while I used the burette I notice, air bubbles appear so I removed them by quick closing and opening the stopcock until the bubbles disappeared. Also, errors in reading a scale the value of reading, depends on the position of the eye, it should be perpendicular to the scale.

### \* Conclusion

Finally in this experiment, I have learnt how to calibrate the glassware which is a burette. Also, depending on the correction, my data was accurate and precise because it close to the actual value in table (1): Tolerances in burettes.

## Question

A 25.00ml pipette was found to deliver 24.976 g of water

When Calibrated against Stainless Steel weights at 25°C. Use the

data in Table 2 to Calculate the volume delivered by the pipette

at this temperature and at 20°C.

$$\Rightarrow \text{at } 25^{\circ}\text{C} = 1 \text{ g of water} \rightarrow 1.0038 \text{ ml} \quad \begin{matrix} \text{at } 25^{\circ}\text{C} \\ \downarrow \end{matrix}$$

$$24.976 \text{ g} \rightarrow x$$

$$x = 1.0038 \times 24.976 = 25.071 \text{ ml}$$

the volume delivered by the pipette

$$\Rightarrow \text{at } 20^{\circ}\text{C} = 1 \text{ g of water} \rightarrow 1.0028 \text{ ml} \quad \begin{matrix} \text{at } 20^{\circ}\text{C} \\ \downarrow \end{matrix}$$

$$24.976 \text{ g} \rightarrow x$$

$$x = 1.0028 \times 24.976 = 25.046 \text{ ml}$$

the volume delivered by the pipette

very good :)

\* Name : Aya Rae'd Ismail Hasan.

اية رائد اسمعيل حسن

\* Reg. No. : [REDACTED]

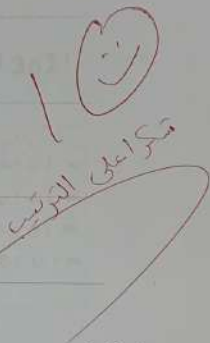
\* Section : "15"

\* Experiment No. : "2"

\* Experiment Name : Sampling and Statistical Treatment of Data.

\* Instructor's Name : Prof. Mohammed Rasheed.

\* Date : 28<sup>th</sup>/Oct/2021



## Experiment 2

### Data Sheet and Calculations

Name: Aya Raed Hasan.

Section: 15

Reg. No. [REDACTED]

Date: 28<sup>th</sup>/Oct/2021

#### A. Homogenous sample

| Result no. | $V_s$                       | $V_H$                      | $V_s - V_H$                |
|------------|-----------------------------|----------------------------|----------------------------|
| 1          | $11.90 \pm 0.07 \text{ ml}$ | $0.30 \pm 0.07 \text{ ml}$ | $11.60 \pm 0.1 \text{ ml}$ |
| 2          | $9.10 \pm 0.07 \text{ ml}$  | $0.30 \pm 0.07 \text{ ml}$ | $8.80 \pm 0.1 \text{ ml}$  |
| 3          | $9.00 \pm 0.07 \text{ ml}$  | $0.30 \pm 0.07 \text{ ml}$ | $8.70 \pm 0.1 \text{ ml}$  |
| 4          | $10.70 \pm 0.07 \text{ ml}$ | $0.30 \pm 0.07 \text{ ml}$ | $10.40 \pm 0.1 \text{ ml}$ |
| 5          |                             |                            |                            |

#### B. Non-homogenous sample

| Result no. | $V_s$                       | $V_H$                                           | $V_s - V_H$                |
|------------|-----------------------------|-------------------------------------------------|----------------------------|
| 1          | $9.70 \pm 0.07 \text{ ml}$  | <del><math>0.1 \pm 0.07 \text{ ml}</math></del> | $9.60 \pm 0.1 \text{ ml}$  |
| 2          | $8.50 \pm 0.07 \text{ ml}$  | $0.10 \pm 0.07 \text{ ml}$                      | $8.40 \pm 0.1 \text{ ml}$  |
| 3          | $13.90 \pm 0.07 \text{ ml}$ | $0.10 \pm 0.07 \text{ ml}$                      | $13.80 \pm 0.1 \text{ ml}$ |
| 4          | $10.00 \pm 0.07 \text{ ml}$ | $0.10 \pm 0.07 \text{ ml}$                      | $9.90 \pm 0.1 \text{ ml}$  |
| 5          | $11.70 \pm 0.07 \text{ ml}$ | $0.10 \pm 0.07 \text{ ml}$                      | $11.60 \pm 0.1 \text{ ml}$ |

Instructor's Signature: [Signature]

Instructor's Name: Manar Adh

28.10.2021

# Calculations

## \* A. Homogenous Sample

### 1) Calculation of $V_s - V_B$

trial

$$1 \rightarrow 11.90 - 0.30 = 11.60 \pm 0.1 \text{ ml}$$

$$2 \rightarrow 9.10 - 0.30 = 8.80 \pm 0.1 \text{ ml}$$

$$3 \rightarrow 9.00 - 0.30 = 8.70 \pm 0.1 \text{ ml}$$

$$4 \rightarrow 10.70 - 0.30 = 10.40 \pm 0.1 \text{ ml}$$

$$\text{Uncertainty for } V_s \rightarrow V_s = V_f - V_i = \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$$

$$V_B \rightarrow \text{Uncertainty for a burette} = \frac{0.1}{2} = \pm 0.05$$

$$\begin{aligned} &\text{Uncertainty for reading from a burette} \\ &= \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07 \end{aligned}$$

$$V_s - V_B \rightarrow \sqrt{(0.07)^2 + (0.07)^2} = 0.098 \approx \pm 0.1 = \pm 0.1$$

### 2) Apply the Q-test to the data in each group

- Homogenous Sample: <sup>the data</sup> [11.60, 8.80, 8.70, 10.40]

- Rearrange in increasing order: [8.70, 8.80, 10.40, 11.60]

- Calculate  $Q_{exp}$  for each:

$$\rightarrow Q_{exp} = \frac{|\text{suspected value} - \text{closest value}|}{\text{max. value} - \text{min. value}}$$

$$(11.6) \quad Q_{exp} = \frac{|11.60 - 10.40|}{11.60 - 8.70} = 0.41 < Q_{critical} \quad \therefore N=4 \quad \therefore Q_{critical} \text{ at confidence level } 90\% = 0.765 \quad \therefore \text{value retained}$$

$$(8.7) \quad Q_{exp} = \frac{|8.70 - 8.80|}{11.60 - 8.70} = 0.03 < 0.765 \quad \therefore \text{value retained}$$

Follow  $\rightarrow$

$\therefore$  All data accepted

4) Mean ( $\bar{x}$ ) :  $\bar{x} = \sum_{i=1}^N \frac{x_i}{N} \Rightarrow \bar{x} = \frac{8.70 + 8.80 + 10.40 + 11.60}{4} = \boxed{9.88}$

4) Median ( $\bar{y}$ ):  $8.70, 8.80, 10.40, 11.60 \Rightarrow \text{Median} = \frac{8.80 + 10.40}{2} = \boxed{9.60}$

5) Average deviation from the mean "ADV" :  $\sum_{i=1}^N |x_i - \bar{x}|$  <sup>Mean</sup>

①  $|8.70 - 9.88| = \boxed{1.18}$  ③  $|10.40 - 9.88| = \boxed{0.52}$

②  $|8.80 - 9.88| = \boxed{1.08}$  ④  $|11.60 - 9.88| = \boxed{1.72}$

$\Rightarrow \text{ADV} = \frac{1.18 + 1.08 + 0.52 + 1.72}{4} = \boxed{1.13}$

6) Relative average deviation from the mean "RDV" :  $\frac{\text{Average deviation } \bar{x}}{\bar{x}} \times 100\%$

$\frac{1.13}{9.88} \times 100\% = \boxed{11.4\%}$

7) Average deviation from the median :  $\sum_{i=1}^N |x_i - \bar{y}|$  <sup>Median</sup>

①  $|8.70 - 9.60| = 0.90$

③  $|10.40 - 9.60| = 0.80$

②  $|8.80 - 9.60| = 0.80$

④  $|11.60 - 9.60| = 2.00$

$\Rightarrow \text{ADV} = \frac{0.90 + 0.80 + 0.80 + 2.00}{4} = \boxed{1.13}$

8) Relative average deviation from the Median :  $\frac{\text{Average deviation from the median}}{\text{Median } (\bar{y})} \times 100\%$

$\Rightarrow \frac{1.13}{9.60} \times 100\% = \boxed{11.8\%}$

9) Standard deviation from the mean :  $S = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N-1}}$

①  $(8.70 - 9.88)^2 = 1.39$

③  $(10.40 - 9.88)^2 = 0.270$

②  $(8.80 - 9.88)^2 = 1.17$

④  $(11.60 - 9.88)^2 = 2.96$

$\Rightarrow \sum_{i=1}^N (x_i - \bar{x})^2 = 1.39 + 1.17 + 0.270 + 2.96 = 5.79$

$\Rightarrow S = \sqrt{\frac{5.79}{4-1}}$

$\boxed{S = 1.39}$

10) Relative standard deviation from the mean :  $\frac{S}{\bar{x}} \times 100\%$

$\Rightarrow \frac{1.39}{9.88} \times 100\% = \boxed{14.1\%}$

# Calculations

## \* B. Non-homogenous Sample

### 1) Calculation of $V_s - V_B$

trial

$$1 \rightarrow 9.70 - 0.10 = 9.60 \pm 0.1 \text{ ml}$$

$$2 \rightarrow 8.50 - 0.10 = 8.40 \pm 0.1 \text{ ml}$$

$$3 \rightarrow 13.90 - 0.10 = 13.80 \pm 0.1 \text{ ml}$$

$$4 \rightarrow 10.00 - 0.10 = 9.90 \pm 0.1 \text{ ml}$$

$$5 \rightarrow 11.70 - 0.10 = 11.60 \pm 0.1 \text{ ml}$$

$$\text{Uncertainty for } V_s \rightarrow V_s = V_f - V_i = \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$$

$$V_B \rightarrow \text{uncertainty for a burette} = \frac{0.1}{2} = \pm 0.05$$

• Uncertainty for reading from a burette

$$= \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$$

$$V_s - V_B \rightarrow \sqrt{(0.07)^2 + (0.07)^2} = 0.098 \approx \pm 0.1 = \pm 0.1$$

### 2) Apply the Q-test to the data in each group

- Non-homogenous Sample:  $\overset{\text{the data}}{[9.60, 8.40, 13.80, 9.90, 11.60]}$

- Rearrange in increasing order:  $[8.40, 9.60, 9.90, 11.60, 13.80]$

- Calculate  $Q_{\text{exp}}$  for each:

$$\rightarrow Q_{\text{exp}} = \frac{|\text{Suspected Value} - \text{Closest Value}|}{\text{max. value} - \text{min. value}}$$

$$(8.40) Q_{\text{exp}} = \frac{|8.40 - 9.60|}{13.80 - 8.40} = 0.22 < \overset{N=5}{Q_{\text{critical at Confidence Level 90\%}} = 0.642} \checkmark \therefore \text{value retained}$$

$$(13.80) Q_{\text{exp}} = \frac{|13.80 - 11.60|}{13.80 - 8.40} = 0.41 < 0.642 \checkmark \therefore \text{value retained}$$

$\therefore$  All data accepted

Follow

$$3) \text{ Mean } (\bar{x}) : \bar{x} = \frac{\sum_{i=1}^N x_i}{N} \Rightarrow \bar{x} = \frac{9.60 + 8.40 + 13.80 + 9.90 + 11.60}{5} = \boxed{10.66}$$

$$4) \text{ Median } (\bar{y}) : 8.40, 9.60, \underline{9.90}, 11.60, 13.80 \Rightarrow \boxed{\text{Median} = 9.90}$$

$$5) \text{ Average deviation from the mean "ADV"} : \frac{\sum_{i=1}^N |x_i - \bar{x}|}{N} \xrightarrow{\text{Mean}}$$

$$① |8.40 - 10.66| = 2.26$$

$$③ |9.90 - 10.66| = 0.76$$

$$⑤ |13.80 - 10.66|$$

$$② |9.60 - 10.66| = 1.06$$

$$④ |11.60 - 10.66| = 0.94$$

$$= 3.14$$

$$\Rightarrow \text{ADV} = \frac{2.26 + 1.06 + 0.76 + 0.94 + 3.14}{5} = \boxed{1.63}$$

$$6) \text{ Relative average deviation from the mean "RDV"} : \frac{\text{Average deviation } \bar{x}}{\bar{x}} \times 100\% \\ \frac{1.63}{10.66} \times 100\% = \boxed{15.31\%}$$

$$7) \text{ Average deviation from the median} : \frac{\sum_{i=1}^N |x_i - \bar{y}|}{N} \xrightarrow{\text{Median}}$$

$$① |8.40 - 9.90| = 1.50$$

$$③ |9.90 - 9.90| = 0$$

$$⑤ |13.80 - 9.90| = 3.90$$

$$② |9.60 - 9.90| = 0.30$$

$$④ |11.60 - 9.90| = 1.70$$

$$\Rightarrow \text{ADV} = \frac{1.50 + 0.30 + 0 + 1.70 + 3.90}{5} = \boxed{1.48}$$

$$8) \text{ Relative average deviation from the Median} : \frac{\text{Average deviation from the median}}{\text{Median } (\bar{y})} \times 100\% \\ \Rightarrow \frac{1.48}{9.90} \times 100\% = \boxed{14.91\%}$$

$$9) \text{ Standard deviation from the mean} : S = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N-1}}$$

$$① (8.40 - 10.66)^2 = 5.11$$

$$③ (9.90 - 10.66)^2 = 0.578$$

$$⑤ (13.80 - 10.66)^2 = 9.86$$

$$② (9.60 - 10.66)^2 = 1.12$$

$$④ (11.60 - 10.66)^2 = 0.88$$

$$\Rightarrow \sum_{i=1}^N (x_i - \bar{x})^2 = 5.11 + 1.12 + 0.578 + 0.88 + 9.86 = 17.55$$

$$\Rightarrow S = \sqrt{\frac{17.55}{5-1}} = \boxed{2.095}$$

$$10) \text{ Relative Standard deviation from the mean} : \frac{S}{\bar{x}} \times 100\% \\ \Rightarrow \frac{2.095}{10.66} \times 100\% = \boxed{19.65\%}$$

# Questions

1) Compare the results of the group in term of :

- a) Mean(x)    b) Standard deviation    c) Relative standard deviation

|                             | Homogenous Sample | Non-Homogenous Sample |
|-----------------------------|-------------------|-----------------------|
| Mean                        | 9.88              | 10.66                 |
| Standard deviation          | 1.39              | 2.095                 |
| Relative standard deviation | 14.1%             | 19.65%                |

Conclusion?

2) Calculate the molar concentration of acetic acid for both groups of results.

• Homogenous

$$(MV)_{\text{NaOH}} = (MV)_{\text{CH}_3\text{COOH}}$$

$$0.10 \times 9.88 = M \times 10.00$$

$$M = \frac{0.10 \times 9.88}{10.00} \Rightarrow M_{\text{CH}_3\text{COOH}} = 0.099 \text{ M}$$

~~dilution~~

• Non-Homogenous

$$(MV)_{\text{NaOH}} = (MV)_{\text{CH}_3\text{COOH}}$$

$$0.10 \times 10.66 = M \times 10.00$$

$$M = \frac{0.10 \times 10.66}{10.00} \Rightarrow M_{\text{CH}_3\text{COOH}} = 0.11 \text{ M}$$

3) Assume the true concentration of the acetic acid is 0.1 M; make comments on the results in terms of accuracy and precision.

• Accuracy  $\rightarrow$  Relative error =  $\frac{x_1 - x_2}{x_2} \times 100\%$

1) For homogenous

$$= \frac{0.099 - 0.1}{0.1} \times 100\% = -1\%$$

more accurate

2) For Non-Homogenous

$$= \frac{0.11 - 0.1}{0.1} \times 100\% = 10\%$$

• Precision

- Relative standard deviation  $\rightarrow$  Homogenous  $\rightarrow$  14.1%  $\rightarrow$  more precise  
 $\rightarrow$  Non-Homogenous  $\rightarrow$  19.65%

\* Name : Aya Rae'd Ismail Hasan

اير راءد اسماعيل حسن

\* Reg. No. : ~~XXXXXXXXXX~~

\* Section : "15"

10

Excellent

\* Experiment : "3"

\* Experiment Name : Neutralization Titration in Aqueous Medium.

\* Instructor's Name : Prof. Mohammed Rasheed.

\* Date : 4<sup>th</sup> / Nov / 2021.

### Experiment 3 Date Sheet and Calculations

Name: Aya Raed Hasan  
Reg. No.:                     

Section: 15  
Date: 4<sup>th</sup> / NOV / 2021

|                                                  |                                                 |                              |
|--------------------------------------------------|-------------------------------------------------|------------------------------|
| Mass of $\text{Na}_2\text{CO}_3$                 | <u><math>0.5094 \pm 0.0001 \text{ g}</math></u> |                              |
| (A) Vol. of $\text{Na}_2\text{CO}_3$             | Vol. of HCl                                     |                              |
| 1. <u><math>10.00 \pm 0.05 \text{ ml}</math></u> | <u><math>9.50 \pm 0.07 \text{ ml}</math></u>    |                              |
| 2. <u><math>10.00 \pm 0.05 \text{ ml}</math></u> | <u><math>9.60 \pm 0.07 \text{ ml}</math></u>    |                              |
| 3.                                               |                                                 |                              |
| (B) Vol. of NaOH                                 | Vol. of HCl                                     |                              |
| 1. <u><math>10.00 \pm 0.05 \text{ ml}</math></u> | <u><math>9.80 \pm 0.07 \text{ ml}</math></u>    |                              |
| 2. <u><math>10.00 \pm 0.05 \text{ ml}</math></u> | <u><math>10.10 \pm 0.07 \text{ ml}</math></u>   |                              |
| 3.                                               |                                                 |                              |
| #12 (C) Vol. of $\text{H}_3\text{PO}_4$          | Vol. of NaOH                                    | Indicator                    |
| 1. <u><math>10.00 \pm 0.05 \text{ ml}</math></u> | <u><math>5.60 \pm 0.07 \text{ ml}</math></u>    | <u>Bromocresol<br/>Green</u> |
| 2. <u><math>10.00 \pm 0.05 \text{ ml}</math></u> | <u><math>5.60 \pm 0.07 \text{ ml}</math></u>    |                              |

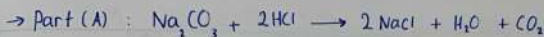
Calculate the molarity of  $\text{Na}_2\text{CO}_3$ , HCl and NaOH solutions, and calculate the concentration of  $\text{H}_3\text{PO}_4$  in the unknown solution in g/L.

Instructor's Signature: Hasan

Instructor's name: Manar Adi

| Vol. of $\text{H}_3\text{PO}_4$                  | Vol. of NaOH                                  | Indicator              |
|--------------------------------------------------|-----------------------------------------------|------------------------|
| 1. <u><math>10.00 \pm 0.05 \text{ ml}</math></u> | <u><math>10.60 \pm 0.07 \text{ ml}</math></u> | <u>Phenolphthalein</u> |
| 2. <u><math>10.00 \pm 0.05 \text{ ml}</math></u> | <u><math>10.50 \pm 0.07 \text{ ml}</math></u> |                        |

# Calculations



\* Indicator : we used Bromocresol green.

\* mass of  $\text{Na}_2\text{CO}_3 = 0.5094 \pm 0.0001 \text{ g}$ , \* Mw of  $\text{Na}_2\text{CO}_3 = 105.99 \text{ g/mol}$

\* Volume of  $\text{Na}_2\text{CO}_3 = 10.00 \pm 0.05 \text{ ml}$  (we use a pipette) in the 2 trials.

• Uncertainty  $\Rightarrow \frac{1}{2} \times 0.1 = \pm 0.05$

\* Volume of HCl

→ trial 1 :  $9.50 \pm 0.07 \text{ ml}$  → trial 2 :  $9.60 \pm 0.07 \text{ ml}$

$$\therefore \boxed{\text{average Volume}} = \frac{9.50 + 9.60}{2} = \boxed{9.55 \text{ ml}} \text{ of HCl}$$

• Uncertainty → (burette)  $\rightarrow \frac{1}{2} \times 0.1 = \pm 0.05$

$$V_{\text{HCl}} = V_f - V_i \rightarrow \text{uncertainty} = \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$$

$$\rightarrow \text{moles of } \text{Na}_2\text{CO}_3 = \frac{\text{mass}}{\text{Mw}} = \frac{0.5094}{105.99} = \boxed{4.806 \times 10^{-3} \text{ mol}}$$

$$\rightarrow M(\text{Na}_2\text{CO}_3) = \frac{\text{mole}}{\text{Volume (L)}} = \frac{4.806 \times 10^{-3}}{100.0 \times 10^{-3}} = \boxed{0.04806 \text{ M}}$$

$$M_{\text{HCl}} = \frac{(MV)_{\text{Na}_2\text{CO}_3}}{9.55} = \frac{(M \times \overbrace{V}^{\text{average Volume of HCl}})_{\text{HCl}}}{2} = \boxed{0.101 \text{ M HCl}}$$



\* Volume of NaOH =  $10.00 \pm 0.05 \text{ ml}$  (in 2 trials)

- Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

\* Volume of HCl

→ trial 1 :  $9.80 \pm 0.07 \text{ ml}$  → trial 2 :  $10.10 \pm 0.07 \text{ ml}$

• Uncertainty → (burette)  $\rightarrow \frac{1}{2} \times 0.1 = \pm 0.05$

$$V_{\text{HCl}} = V_f - V_i \rightarrow \text{uncertainty} = \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$$

$$\boxed{\text{average Volume of HCl}} = \frac{9.80 + 10.10}{2} = \boxed{9.95 \text{ ml}}$$

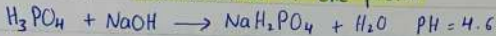
follow

\* Indicator : we used phenolphthalein of <sup>average volume of HCl</sup>

$$(MV)_{NaOH} = (MV)_{HCl}$$

$$M_{NaOH} = \frac{0.101 \times 9.95}{10.00} = 0.100 \text{ M of NaOH}$$

→ Part (c) : - Neutralization of one proton



\* Indicator → we used Bromocresol green.

\* Volume of  $H_3PO_4 = 10.00 \pm 0.05 \text{ ml}$  (in 2 trials)

- Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

\* Volume of NaOH

→ trial 1 + 2 (Both) :  $5.60 \pm 0.07 \text{ ml}$

Uncertainty → (burette) →  $\frac{1}{2} \times 0.1 = \pm 0.05$

$V_{NaOH} = V_f - V_i \rightarrow$  Uncertainty =  $\sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

Average volume of NaOH =  $\frac{5.60 + 5.60}{2} = \underline{5.60 \text{ ml}}$

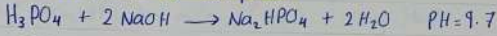
$(MV)_{H_3PO_4} = (MV)_{NaOH}$

$M_{H_3PO_4} = \frac{0.100 \times 5.60}{10.00} = 0.0560 \text{ M of } H_3PO_4$

- molar mass ( $H_3PO_4$ ) =  $97.97 \text{ g/mol}$

→  $0.0560 \frac{\text{mol}}{L} \times 97.97 \frac{\text{g}}{\text{mol}} = \underline{5.49 \text{ g/L}}$

- Neutralization of two proton



\* Indicator : we used phenolphthalein.

\* Volume of  $H_3PO_4 = 10.00 \pm 0.05 \text{ ml}$  (in 2 trials)

• Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

\* Volume of NaOH

→ trial 1 :  $10.60 \pm 0.07 \text{ ml}$  → trial 2 :  $10.50 \pm 0.07 \text{ ml}$

• Uncertainty → (burette) →  $\frac{1}{2} \times 0.1 = \pm 0.05$

$V_{NaOH} = V_f - V_i \rightarrow$  Uncertainty =  $\sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

Average volume of NaOH =  $\frac{10.60 + 10.50}{2} = \underline{10.55 \text{ ml}}$

$(MV)_{H_3PO_4} = (MV)_{NaOH}$

$M_{H_3PO_4} = \frac{1}{2} \left( \frac{0.100 \times 10.55}{10.00} \right) = 0.0528 \text{ M of } H_3PO_4$

• molar mass ( $H_3PO_4$ ) =  $97.97 \text{ g/mol}$

→  $0.0528 \frac{\text{mol}}{L} \times 97.97 \frac{\text{g}}{\text{mol}} = \underline{5.17 \text{ g/L}}$

→ follow

$$\therefore \text{Total Concentration} = \frac{5.49 + 5.17}{2} = 5.33 \text{ g/l}$$

## \* Questions

1] How do you determine the Solubility of Calcium hydroxide by a simple acid-base titration?

- prepare a Saturated Solution for  $\text{Ca(OH)}_2$ .
- allow the Undissolved  $\text{Ca(OH)}_2$  to settle down in the Saturated Solution.
- Pipette a certain Volume of Saturated Solution of  $\text{Ca(OH)}_2$ .
- $\text{Ca(OH)}_2 + 2\text{HCl} \rightarrow \text{CaCl}_2 + 2\text{H}_2\text{O}$
- Solubility of  $\text{Ca(OH)}_2 = [\text{Ca}^{2+}] = \frac{[\text{OH}^-]}{2}$

2] How do you determine the water of Crystallization of washing Soda?

- we take a certain amount of certain hydrous and dissolve it in a certain amount of water.
- add Suitable indicator. - Titrate with Suitable acid.
- Calculate the mass of  $\text{Na}_2\text{CO}_3$  (Using Mw).
- Calculate the mass of  $\text{H}_2\text{O} = \text{mass of } \text{Na}_2\text{CO}_3 \times \text{H}_2\text{O} - \text{mass } \text{Na}_2\text{CO}_3$
- Calculate the mole of  $\text{H}_2\text{O}$  (Using Mw).
- X water of Crystallization =  $\frac{\text{moles of } \text{H}_2\text{O}}{\text{moles of } \text{Na}_2\text{CO}_3}$

3] Why two indicators Can be used for the determination of phosphoric acid? Because,  $\text{H}_3\text{PO}_4$  has 3 protons in the titration with  $\text{NaOH}$  and each end point occurs at a certain pH.

4] Could you make titration for  $\text{NH}_3$  Solution with a Standard Solution of  $\text{CH}_3\text{COOH}$ ? why?

No, because  $\text{NH}_3$  is weak base and  $\text{CH}_3\text{COOH}$  is a weak acid-base, and there's no weak acid-base titration, because no sharp change in pH and we need a large amount of titrate for each equivalence point.

\* Name: Aya Rae'd Ismail Hasan.

آية رائد اسماعيل حسن

\* Reg. No. : 

C

\* Section : "15"

\* Experiment No. : "4"

\* Experiment Name: Precipitation Titrations (Argentometry).

\* Instructor's Name: Prof. Mohammed Rasheed.

\* Date : 11<sup>th</sup> / Nov / 2021

## Experiment 4 Data Sheet and Calculations

Name: Aya Raed Hasan  
Reg. No.:                     

Section: 15  
Date: 11<sup>th</sup>/Nov/2021

Mass of NaCl:  $0.6097 \pm 0.0001$  g

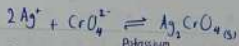
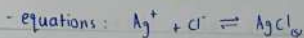
| (A) Mohr's method                | Trial (1)           | Trial (2)           |
|----------------------------------|---------------------|---------------------|
| Vol. of NaCl solution            | $10.00 \pm 0.05$ ml | $10.00 \pm 0.05$ ml |
| Vol. of $\text{AgNO}_3$ solution | $10.50 \pm 0.07$ ml | $10.20 \pm 0.07$ ml |
| (B) Fajan's method               |                     |                     |
| Vol. of NaCl solution            | $10.00 \pm 0.05$ ml | $10.00 \pm 0.05$ ml |
| Vol. of $\text{AgNO}_3$ solution | $10.20 \pm 0.07$ ml | $10.10 \pm 0.07$ ml |
| (C) Volhard's method             |                     |                     |
| Vol. of $\text{AgNO}_3$ solution | $10.00 \pm 0.05$ ml | $10.00 \pm 0.05$ ml |
| Vol. of KSCN solution            | $10.20 \pm 0.07$ ml | $10.00 \pm 0.07$ ml |

| Unknown mixture ID: <u># 74</u>         |                     |                                 |
|-----------------------------------------|---------------------|---------------------------------|
| (I) According to Mohr's method          | Trial 1             | Trial 2                         |
| Vol. of unknown solution                | $10.00 \pm 0.05$ ml | $10.00 \pm 0.05$ ml             |
| Vol. of $\text{AgNO}_3$ solution        | $9.70 \pm 0.07$ ml  | $10.10 \pm 0.07$ ml             |
| (II) According to Volhard's method      |                     |                                 |
| Volume of unknown solution              | $10.00 \pm 0.05$ ml | $10.00 \pm 0.05$ ml             |
| Vol. of KSCN solution                   | $6.40 \pm 0.07$ ml  | <del>                    </del> |
| Vol. of $\text{AgNO}_3$ added in excess | $15.00 \pm 0.05$ ml | <del>                    </del> |

Instructor's Signature:                       
Instructor's Name: Manar Ad  
11.11.2021

# Calculations

## Part (A) : Standardization of silver nitrate by Mohr's method



- Indicators : First trial  $\rightarrow \uparrow$  Chromate indicator.

Second trial  $\rightarrow$  mixed indicator (Potassium Chromate and potassium dichromate)

- Color Change in 2 trials From : Yellow  $\xrightarrow{+}$  red to brown.

- Mass of Sodium chloride "NaCl" =  $0.6097 \text{ g}$   $\rightarrow$  Using analytical balance.

• Uncertainty =  $\pm 0.0001$

- Volume of NaCl Solution  $\rightarrow$  trial 1 and 2  $\rightarrow 10.00 \text{ ml}$   $\rightarrow$  using a pipette

• Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of  $\text{AgNO}_3$  Solution  $\rightarrow$  using a burette  $\rightarrow$  Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

$\rightarrow$  trial 1 :  $10.50 \pm 0.07 \text{ ml}$

trial 2 :  $10.20 \pm 0.07 \text{ ml}$

• Uncertainty  $\rightarrow V_{\text{AgNO}_3} + V_f - V_i \rightarrow \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

- Average volume of  $\text{AgNO}_3$  Solution (" $\bar{V}$ ") =  $\frac{10.50 + 10.20}{2} = 10.35 \text{ ml}$

- No. of moles of NaCl =  $\frac{\text{mass of NaCl}}{\text{molar mass of NaCl}}$ ,  $M_r(\text{NaCl}) = 58.44 \text{ g/mol}$   
 $= \frac{0.6097}{58.44}$

$$n_{\text{NaCl}} = 0.01043 \text{ mole}$$

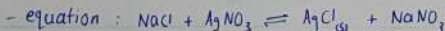
$$- M_{\text{NaCl}} = \frac{n}{V(\text{l})} = \frac{0.01043}{100 \times 10^{-3}} = 0.1043 \text{ mol/L}$$

$$\text{(?)} (M\bar{V})_{\text{AgNO}_3} = (M\bar{V})_{\text{NaCl}}$$

$$\text{(?)} M_{\text{AgNO}_3} = \frac{0.1043 \times 10.00}{10.35} = 0.1008 \text{ M of AgNO}_3$$

$$0.1008 \frac{\text{mol}}{\text{L}} \times 169.87 \frac{\text{g}}{\text{mol}} = 17.12 \text{ g/L} \quad (\text{molar mass of AgNO}_3 = 169.87 \text{ g/mol})$$

## Part (B) : Standardization of silver nitrate by Fajan's method



Follow  $\rightarrow$

- Indicator: dichlorofluoresceine indicator.

• Color Change from: pale green  $\xrightarrow{t_0}$  pink

- Volume of NaCl Solution  $\rightarrow$  trial 1 and 2  $\rightarrow$  10.00 ml  $\rightarrow$  using a pipette

• Uncertainty  $= \frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of  $\text{AgNO}_3$  Solution  $\rightarrow$  using a burette  $\rightarrow$  Uncertainty  $= \frac{1}{2} \times 0.1 = \pm 0.05$

$\rightarrow$  trial 1:  $10.20 \pm 0.07$  ml  $\rightarrow$  trial 2:  $10.10 \pm 0.07$  ml

• Uncertainty  $\rightarrow V_{\text{AgNO}_3} = V_f - V_i \rightarrow \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

- Average volume of  $\text{AgNO}_3$  Solution " $\bar{V}$ "  $= \frac{10.20 + 10.10}{2} = 10.15$  ml

$$(M\bar{V})_{\text{AgNO}_3} = (M\bar{V})_{\text{NaCl}}$$

$$\hookrightarrow M_{\text{AgNO}_3} = \frac{0.1043 \times 10.00}{10.15} = 0.1028 \text{ M of } \text{AgNO}_3$$

$$\boxed{0.1028 \frac{\text{mol}}{\text{L}} \times 169.87 \frac{\text{g}}{\text{mol}}} = 17.46 \text{ g/L}, \text{ molar mass of } \text{AgNO}_3 = 169.87 \text{ g/mol}$$

- Average of  $M(\text{mol/L})$  and  $M(\text{g/L})$  for  $\text{AgNO}_3$  from part (A+B)

$$\text{1) } \bar{M}(\text{mol/L}) = \frac{0.1008 + 0.1028}{2} = 0.1018 \text{ mol/L}$$

$$\text{2) } \bar{M}(\text{g/L}) = \frac{17.12 + 17.46}{2} = 17.29 \text{ g/L}$$

Part (c): Standardization of potassium Thiocyanate by Volhard's Method

- equations:  $\text{Ag}^+ + \text{SCN}^- \rightleftharpoons \text{AgSCN}_{(s)}$  (white precipitate)

$\text{Fe}^{3+} + \text{SCN}^- \rightleftharpoons [\text{Fe}(\text{SCN})]^{2+}$  (blood red solution)

- Indicator: Ferric indicator

• Color Change: Colorless  $\rightarrow$  red

- Volume of  $\text{AgNO}_3$  Solution  $\rightarrow$  trial 1 and 2  $\rightarrow$  10.00 ml  $\rightarrow$  using a pipette

• Uncertainty  $= \frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of KSCN Solution  $\rightarrow$  using a burette  $\rightarrow$  Uncertainty  $= \frac{1}{2} \times 0.1 = \pm 0.05$

$\hookrightarrow$  trial 1:  $10.20 \pm 0.07$  ml  $\rightarrow$  trial 2:  $10.00 \pm 0.07$  ml

• Uncertainty  $\rightarrow V_{\text{KSCN}} = V_f - V_i \rightarrow \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

- Average Volume of KSCN Solution " $\bar{V}$ "  $= \frac{10.20 + 10.00}{2} = 10.10$  ml

From part A+B  $\rightarrow M_{\text{AgNO}_3} = 0.1018 \frac{\text{mol}}{\text{L}}$

$$(M\bar{V})_{\text{AgNO}_3} = (M\bar{V})_{\text{KSCN}}$$

$$\hookrightarrow M_{\text{KSCN}} = \frac{0.1018 \times 10.00}{10.10} = 0.1008 \text{ M of KSCN}$$

$$\boxed{0.1008 \frac{\text{mol}}{\text{L}} \times 97.18 \frac{\text{g}}{\text{mol}}} = 9.796 \text{ g/L}, \text{ molar mass of KSCN} = 97.18 \text{ g/mol}$$

Follow

Part (D) : Determination of an unknown Mixture of Halides (NaCl + KCl)

I : According to Mohr's method

- Volume of unknown Solution  $\rightarrow$  trial 1 and 2  $\rightarrow$  10.00 ml  $\rightarrow$  using a pipette

• Uncertainty  $= \frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of  $\text{AgNO}_3$  Solution  $\rightarrow$  using a burette  $\rightarrow$  uncertainty  $= \frac{1}{2} \times 0.1 = \pm 0.05$

$\rightarrow$  trial 1 :  $9.70 \pm 0.07$  ml  $\rightarrow$  trial 2 :  $10.10 \pm 0.07$  ml

• Uncertainty  $\rightarrow V_{\text{AgNO}_3} = V_f - V_i \rightarrow \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

- average volume of  $\text{AgNO}_3$  Solution " $\bar{V}$ "  $= \frac{9.70 + 10.10}{2} = 9.90$  ml

- Indicator : potassium Chromate indicator, Color Change: yellow  $\rightarrow$  red to brown

Calculations:

moles of  $\text{AgNO}_3 = \text{moles of Cl}^-$

Suppose that X : mass of NaCl, Y : mass of KCl

Then  $X + Y = 0.065$  g  $\rightarrow$  (1)

moles  $\text{Cl}^- = \frac{X}{M_{\text{mass NaCl}} \times 58.5} + \frac{Y}{M_{\text{mass KCl}} \times 74.5}$

moles of  $\text{AgNO}_3 = \frac{X}{58.5} + \frac{Y}{74.5}$

(M  $\bar{V}$ )  $\text{AgNO}_3 = \frac{0.065 - Y}{58.5} + \frac{Y}{74.5}$

$0.1018 \times 9.90 \times 10^{-3} = \frac{74.5(0.065 - Y) + 58.5Y}{4358.3}$

$1.01 \times 10^{-3} = \frac{4.8 - 74.5Y + 58.5Y}{4358.3}$

$4.40 = 4.8 - 16Y$   
 $-4.8 = -16Y$

$-\frac{16Y}{-16} = \frac{-0.4}{-16} \rightarrow Y = 0.025$  g  
 mass of KCl

$\therefore X + Y = 0.065$

$\therefore X = 0.065 - 0.025$

$X = 0.040$  g  
 mass of NaCl

Note that  $\rightarrow$  X mass of NaCl found in 10 ml, Y mass of KCl found in 10 ml

Then : Conc. of NaCl in g/l  $= \frac{0.040 \times 1000}{10} = 4.0$  g/l

Conc. of KCl in g/l  $= \frac{0.025 \times 1000}{10} = 2.5$  g/l

Follow

Part (D) : II : According to Volhard's method

equations:  $\text{Ag}^+ + \text{SCN}^- \rightleftharpoons \text{AgSCN}_{(s)}$  "white precipitate"

$\text{Ag}^+ + \text{Cl}^- \rightleftharpoons \text{AgCl}_{(s)}$  "white"

- Volume of unknown Solution  $\rightarrow$  trial I  $\rightarrow$  10.00 ml  $\rightarrow$  using a pipette

• uncertainty  $= \frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of  $\text{AgNO}_3$  added in excess  $\rightarrow$  trial I  $\rightarrow$  15.00 ml  $\rightarrow$  using a pipette

- Volume of  $\text{KSCN}$  Solution  $\rightarrow$  using a burette  $\rightarrow$  uncertainty  $= \frac{1}{2} \times 0.1 = \pm 0.05$

$\rightarrow$  trial I : 6.40  $\pm 0.07$  ml

• Uncertainty  $\rightarrow V_{\text{KSCN}} = V_f - V_i \rightarrow [(0.05)^2 + (0.05)^2] = \pm 0.07$

- Indicator : Ferric ion Indicator, Color Change: Colorless  $\xrightarrow{\text{Fe}^{3+}}$  Red

Calculations:

$\rightarrow$  moles of  $\text{AgNO}_3 = MV = 0.1018 \times 15.00 \times 10^{-3} = 1.527 \times 10^{-3}$  mole

$\rightarrow$  wt. of mixture = 0.065 g ( $\text{SCN}^- + \text{Cl}^-$ )

$$x + y = 0.065 \text{ g}$$

moles of  $\text{AgNO}_3 = \text{moles Cl}^- + \text{moles SCN}^-$

$$(MV)_{\text{AgNO}_3} = \left( \frac{x}{58.5} + \frac{y}{74.5} \right) + (MV)_{\text{SCN}^-}$$

$$1.527 \times 10^{-3} = \left( \frac{0.065 - y}{58.5} + \frac{y}{74.5} \right) + (0.1008 \times 6.40 \times 10^{-3})$$

$$1.527 \times 10^{-3} = \frac{74.5(0.065 - y) + 58.5y}{4358.3} + 6.45 \times 10^{-4}$$

$$8.82 \times 10^{-4} = \frac{48 - 74.5y + 58.5y}{4358.3}$$

$$3.84 = 48 - 16y$$

$$\frac{-0.96}{-16} = \frac{-16y}{-16} \rightarrow y = 0.06 \text{ g}$$

mass of KCl

$$\therefore x + y = 0.065 \text{ g} \rightarrow x = 0.065 - 0.06 \rightarrow x = 0.005 \text{ g}$$

mass of NaCl

$$\Rightarrow \text{Conc. of NaCl in g/l} = \frac{0.005 \times 1000}{10} = 0.5 \text{ g/l}$$

$$\Rightarrow \text{Conc. of KCl in g/l} = \frac{0.06 \times 1000}{10} = 6 \text{ g/l}$$

$\Rightarrow$  Comparison between 2 results from Step I and II :

| Part | mass NaCl | mass KCl |
|------|-----------|----------|
| I    | 0.040 g   | 0.025 g  |
| II   | 0.005 g   | 0.06 g   |

Follow  $\rightarrow$

## Questions

① Why precipitation titrations by the Mohr's method requires a neutral solution?  
Because in basic media ( $\text{Ag}^+$ ) will react with ( $\text{OH}^-$ ) from the base producing ( $\text{AgOH}$ ) and this will increase the volume needed of  $\text{AgNO}_3$  to titrate  $\text{NaCl}$  solution, as well as in acidic media ( $\text{Cr}_2\text{O}_7^{2-}$ ) will be formed which means that active errors will occur. So the neutral media is the best media.

② What is the effect of using acidic solution in the Fajan's method?  
Because in Fajan's method we use Fluorescein indicator which in acidic media solution will react with ( $\text{H}^+$ ) from the acid to form ( $\text{HF}$ ), so the indicator will be consumed to form the acid, so we need to add more of the titrant which is " $\text{AgNO}_3$ " to reach the end point (until the solution became pink) so will have positive error.

③ What is the effect of using  $\text{K}_2\text{Cr}_2\text{O}_7$  instead of  $\text{K}_2\text{CrO}_4$  as an indicator on the titration results?

The  $K_{sp}$  of  $\text{K}_2\text{Cr}_2\text{O}_7$  is greater than  $K_{sp}$  for  $\text{K}_2\text{CrO}_4$  so it is more soluble. So reaching to the end point will need less volume of titrant, so the volume of  $\text{AgNO}_3$  would increase.

④ What is the effect of using basic solutions on the results in precipitation titration?  
the volume of  $\text{AgNO}_3$  will increase because of the reaction of  $\text{Ag}^+$  with  $\text{OH}^-$  from the base (in Mohr's and Fajan's methods). So  $\text{AgOH}_{(s)} \rightarrow \text{Ag}_2\text{O}_{(ppt)}$  (very large positive error). but in Volhard's method:  $\text{Fe}^{3+}$  will react with  $\text{OH}^-$  to form  $\text{Fe}(\text{OH})_3 \rightarrow \text{Fe}$ . So, we need more  $\text{Ag}^+$  so positive error.

⑤ Why nitrobenzene is added in case of titration of  $\text{Cl}^-$  by the Volhard's method?  
Because nitrobenzene will cover the surface of  $\text{AgCl}_{(ppt)}$ , and prevent the following reaction between  $\text{AgCl}$  and the titrant  $\text{SCN}^-$  and prevent the formation of  $\text{AgSCN}$ .



- $\text{AgCl}$  is more soluble than  $\text{AgSCN}$ .
- $K_{sp} \text{AgCl} > K_{sp} \text{AgSCN}$ .

\*Name : Aya Rae'd Ismail Hasan.

أية رائد اسماعيل حسن

\*Reg. No. : [REDACTED]

\*Section : "15"

8.5

\*Experiment No. : "5"

\*Experiment Name : Redox Titrations (Dichromate Titrations)

\*Instructor's Name : Prof. Mohammed Rasheed.

\*Date : 18 / Nov / 2021.

## Experiment 5 Data Sheet and Calculations

Name: Aya Raed Hasan  
Reg. No. [REDACTED]

Section: 15  
Date: 18<sup>th</sup> / Nov / 2021

|                                                       |                                           |
|-------------------------------------------------------|-------------------------------------------|
| Unknown ID No.: <u>60</u>                             |                                           |
| (A) Determination of $\text{Fe}^{2+}$ in a mixture    |                                           |
| Vol. of unknown solution                              | Vol. of $\text{K}_2\text{Cr}_2\text{O}_7$ |
| 1) $10.00 \pm 0.05 \text{ ml}$                        | $4.70 \pm 0.07 \text{ ml}$                |
| 2) $10.00 \pm 0.05 \text{ ml}$                        | $4.20 \pm 0.07 \text{ ml}$                |
| 3)                                                    |                                           |
| (B) Determination of $\text{Fe}^{3+}$ after reduction |                                           |
| Vol. of unknown solution                              | Vol. of $\text{K}_2\text{Cr}_2\text{O}_7$ |
| 1) $10.00 \pm 0.05 \text{ ml}$                        | $5.50 \pm 0.07 \text{ ml}$                |
| 2)                                                    |                                           |

Wt. of  $\text{Fe}^{2+}$  per liter = 2.98 g/L  
Wt. of  $\text{Fe}^{3+}$  per liter = 0.704 g/L

Instructor's signature: [Signature]

Instructor's Name: Dr. M. A. [Signature]

18-11-21

# Calculations

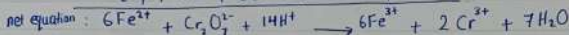
## Part A: Determination of $\text{Fe}^{2+}$ in a mixture

Note: No. of unknown 60

- Indicator: 2-4 drops of diphenylamine indicator.

• Color Change: Colorless  $\xrightarrow{\text{t}_0}$  violet-blue.

- equations:  $(\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + e^-) \times 6$



- Volume of unknown Solution =  $[10.00] \pm 0.05$  ml [using a pipette]  $\rightarrow$  in 2 trials.

• Uncertainty:  $\frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of  $\text{H}_2\text{SO}_4$  = 10.00 ml

- Volume of  $\text{H}_3\text{PO}_4$  = 5.00 ml (using a graduated cylinder)

• Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of  $\text{K}_2\text{Cr}_2\text{O}_7$  (titrant)  $\rightarrow$  (using a burette)

$\rightarrow$  trial 1 =  $[4.70] \pm 0.07$  ml

$\rightarrow$  trial 2 =  $[4.20] \pm 0.07$  ml

• Uncertainty  $\rightarrow V_{\text{K}_2\text{Cr}_2\text{O}_7} = V_f - V_i \rightarrow \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

- average volume of  $\text{K}_2\text{Cr}_2\text{O}_7$  ( $V_t$ ) =  $\frac{4.70 + 4.20}{2} = [4.45]$  ml

- Molarity of  $\text{K}_2\text{Cr}_2\text{O}_7$  = 0.02 M.

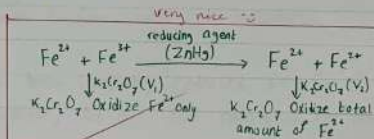
Calculations:

$$M V_t (\text{K}_2\text{Cr}_2\text{O}_7) \times 6 = M V (\text{Fe}^{2+})$$

$$0.02 \times 4.45 \times 6 = M \times 10.00$$

$$M_{\text{Fe}^{2+}} = \frac{0.534}{10.00} = [0.0534 \text{ M}]$$

$$0.0534 \frac{\text{mol}}{\text{L}} \times 55.85 \frac{\text{g}}{\text{mol}} = [2.98 \text{ g/L}]$$

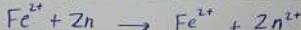


Mw of Fe = 55.85 g/mol

## Part B: Determination of $(\text{Fe}^{2+} + \text{Fe}^{3+})$ as $\text{Fe}^{2+}$

- Indicator: 2-4 drops of diphenylamine indicator (in titration)

- equations:  $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Fe}^{2+} \rightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$



- Volume of  $\text{K}_2\text{Cr}_2\text{O}_7 (V_t)$  =  $[5.50] \pm 0.07$  ml

• Uncertainty =  $V_{\text{K}_2\text{Cr}_2\text{O}_7} = V_f - V_i \rightarrow \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

- Volume of unknown Solution =  $[10.00] \pm 0.05$  ml (using a pipette)

follow  $\rightarrow$

Calculation:

$$\rightarrow M \times (V_2 - V_1) \times K_2Cr_2O_7 \times 6 = MV(Fe^{2+})$$

$$0.02 \times (5.50 - 4.45) \times 6 = M \times 10.00$$

$$M_{Fe^{2+}} = \frac{0.126}{10.00} = 0.0126 M$$

$$0.0126 \frac{mol}{L} \times 55.85 \frac{g}{mol} = 0.704 \frac{g}{L}$$

Solve it in two steps:-

1.  $M$  of  $Fe^{2+}$  total

2.  $M_{Fe^{2+}}^{total} - Fe^{2+}(part A)$

OK?

work!

$M_w$  of  $Fe = 55.85 g/mol$

## Questions

Q1] What is the role of  $H_3PO_4$  in determination of  $Fe^{2+}$  by titration with  $K_2Cr_2O_7$ ?  
 $H_3PO_4$  forms colorless mixture with  $Fe^{3+}$ , so the yellow color of  $Fe^{3+}$  will not appear in the solution, so while titration we will detect the end point easily. and also it has lower potential difference.

Q2] Can you determine iron in ores using  $K_2Cr_2O_7$ ?

Yes, because iron contains  $Fe_2O_3$  and  $Fe_3O_4$  which can be dissolved in acidic solutions to get  $Fe^{3+} \rightarrow Fe^{2+}$  by John's reductor, then titrate with  $K_2Cr_2O_7$  using  $H_3PO_4$  and diphenylamine sulfuric acid as indicator.

Q3] How could you check that  $Fe^{3+}$  has been completely reduced to  $Fe^{2+}$ ?

After preparing zinc amalgam (John's reductor) we add zinc amalgam to an erlenmeyer flask that contains (10.00 ml of the unknown) and  $H_2SO_4$  and boil it. we add a drop of this mixture and 1 drop of  $NH_4SCN$  on a palette; if the color is blood red so, the reduction is not complete and we need to boil more to ensure that the reaction is completed and watch it until the color becomes colorless.

\*Name: Aya Rae'd Ismail Hasan.

ايعه رائد اسماعيل حسن

\*Reg. No. : 

\*Section : "15"

\*Experiment No. : "6"

\*Experiment Name : Redox Titrations (Iodine Titrations)

Instructor's Name : Prof. Mohammed Rasheed.

\*Date : 25<sup>th</sup>/Nov/2021.



Experiment 6  
Data Sheet and Calculations

Name: Aya Raed Hasan  
Reg. No:                     

Section: 15  
Date: 25<sup>th</sup> / Nov / 2021

|                                                   |                             |                                             |
|---------------------------------------------------|-----------------------------|---------------------------------------------|
| <b>(A) Standardization of 0.1M thiosulfate</b>    |                             |                                             |
| Wt of $\text{KIO}_3 = 0.3364 \pm 0.001 \text{ g}$ |                             |                                             |
| Volume of $\text{KIO}_3$                          |                             | Volume of $\text{Na}_2\text{S}_2\text{O}_3$ |
| 1- $10.00 \pm 0.05$ ml                            |                             | $10.20 \pm 0.07$ ml                         |
| 2- $10.00 \pm 0.05$ ml                            |                             | $10.00 \pm 0.07$ ml                         |
| 3- ml                                             |                             | ml                                          |
| <b>(B) Standardization of 0.1M iodine:</b>        |                             |                                             |
| Volume of $\text{I}_2$                            |                             | Volume of $\text{Na}_2\text{S}_2\text{O}_3$ |
| 1- $10.00 \pm 0.05$ ml                            |                             | $18.00 \pm 0.07$ ml                         |
| 2- $10.00 \pm 0.05$ ml                            |                             | $17.90 \pm 0.07$ ml                         |
| 3- ml                                             |                             | ml                                          |
| <b>(C) Determination of tin in the unknown:</b>   |                             |                                             |
| Unknown ID #: <u>70</u>                           |                             |                                             |
| Volume of $\text{I}_2$                            | volume the unknown solution | Volume of $\text{Na}_2\text{S}_2\text{O}_3$ |
| 1- $15.00 \pm 0.05$ ml                            | $10.00 \pm 0.05$ ml         | $18.10 \pm 0.07$ ml                         |
| 2- $15.00 \pm 0.05$ ml                            | $10.00 \pm 0.05$ ml         | $15.70 \pm 0.07$ ml                         |
| 3- ml                                             | ml                          | ml                                          |

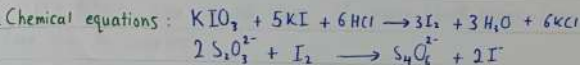
Instructor's Signature: Maass A.A.

Instructor's Name: Maass A.A.

25.11.2021

# Calculations

Part (A): Standardization of 0.1 M Sodium Thiosulfate



Indicator: iodine (acts as a self-indicator). Color will change from red-brown to yellow and then in back titration, we add Starch Solution the color will change from blue to colorless.

- Volume of  $\text{KIO}_3$  in 2 trials =  $10.00 \pm 0.05$  ml (using a pipette)

Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of  $\text{Na}_2\text{S}_2\text{O}_3$ :

Trial 1:  $10.20 \pm 0.07$  ml Trial 2:  $10.00 \pm 0.07$  ml

Uncertainty  $\rightarrow V_{\text{Na}_2\text{S}_2\text{O}_3} = V_f - V_i \rightarrow \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

- Average Volume of  $\text{Na}_2\text{S}_2\text{O}_3$  ( $\bar{V}$ ) =  $\frac{10.20 + 10.00}{2} = 10.10$  ml

- Wt of  $\text{KIO}_3$  =  $0.3364 \pm 0.0001$  g

- Mw of  $\text{KIO}_3$  =  $214.00$  g/mol

- Mw of  $\text{S}_2\text{O}_3^{2-}$  =  $158.11$  g/mol

No. of mol of  $\text{KIO}_3$  =  $\frac{m}{M_r} = \frac{0.3364}{214.00} = 1.572 \times 10^{-3}$  mol

M of  $\text{KIO}_3$  =  $\frac{n}{V(L)} = \frac{1.572 \times 10^{-3}}{100.00 \times 10^{-3}} = 0.01572$  mol/l

For each 1 mole of  $\text{KIO}_3$  there's 3 moles of  $\text{I}_2$

$$n_{\text{KIO}_3} = \frac{1}{3} n_{\text{I}_2}$$

$$n_{\text{I}_2} = 4.716 \times 10^{-3} \text{ mol I}_2$$

For each 1 mole of  $\text{I}_2$  there's 2 moles of  $\text{S}_2\text{O}_3^{2-}$

$$n_{\text{I}_2} = \frac{1}{2} n_{\text{S}_2\text{O}_3^{2-}}$$

$$n_{\text{S}_2\text{O}_3^{2-}} = 9.432 \times 10^{-3} \text{ mol S}_2\text{O}_3^{2-}$$

$$\therefore \text{So } n_{\text{KIO}_3} = \frac{n_{\text{S}_2\text{O}_3^{2-}}}{6}$$

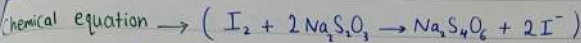
$$M_1 V_1 = \frac{M_2 V_2}{6}$$

$$0.01572 \times 10.00 = \frac{M_2 \times 10.10}{6} \rightarrow M_2(\text{S}_2\text{O}_3^{2-}) = 0.09339 \text{ mol/L}$$

$$0.09339 \frac{\text{mol}}{\text{L}} \times 158.11 \frac{\text{g}}{\text{mol}} = 14.77 \text{ g/L}$$

Follow

### Part B: Standardization of 0.1 M Iodine



Indicator: Iodine works as a self-indicator. (color will change from red-brown to pale yellow, then we add 2 ml of starch (back titration) the color will change from blue to colorless.

- Volume of  $I_2$  in 2 trials =  $10.00 \pm 0.05$  ml

• Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of  $Na_2S_2O_3$  =

Trial 1:  $18.00 \pm 0.07$  ml      Trial 2:  $17.90 \pm 0.07$  ml

• Uncertainty  $\rightarrow V_{Na_2S_2O_3} = V_f - V_i \rightarrow \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

- Average Volume of  $Na_2S_2O_3$  ( $\bar{V}$ ) =  $\frac{18.00 + 17.90}{2} = 17.95$  ml

- Mw  $I_2 = 253.81$  g/mol

• for each 1 mole of  $I_2$  there's 2 moles of  $S_2O_3^{2-}$

$$n_{I_2} = \frac{n_{S_2O_3^{2-}}}{2}$$

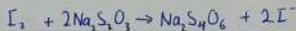
$$M_1 V_1 = \frac{M_2 V_2}{2} \rightarrow M_1 \times 10.00 = \frac{0.09339 \times 17.95}{2} \rightarrow M_1 = 0.08382 \text{ M of } I_2$$

$$0.08382 \frac{\text{mol}}{L} \times 253.81 \frac{g}{\text{mol}} = 21.27 \text{ g/L}$$

### Part C: Determination of Tin in an Unknown Sample

- Unknown ID#: 70

- Chemical equations:  $Sn^{2+} + I_2 \rightarrow Sn^{4+} + 2I^-$



- Indicator: Starch: at the beginning we will titrate until the color changes from red brown to pale yellow, then add 2 ml of starch and titrate (color change from blue to colorless).

- Volume of  $I_2$  in the 2 trials =  $15.00 \pm 0.05$  mL (using a pipette)

• Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of unknown solution in 2 trials =  $10.00 \pm 0.05$  mL (using a pipette)

• Uncertainty =  $\frac{1}{2} \times 0.1 = \pm 0.05$

- Volume of  $Na_2S_2O_3$  =

Trial 1:  $18.10 \pm 0.07$  ml      Trial 2:  $15.70 \pm 0.07$  ml

• Uncertainty  $\rightarrow V_{Na_2S_2O_3} = V_f - V_i \rightarrow \sqrt{(0.05)^2 + (0.05)^2} = \pm 0.07$

- Average Volume of  $Na_2S_2O_3$  ( $\bar{V}$ ) =  $\frac{18.10 + 15.70}{2} = 16.90$  ml

Follow  $\rightarrow$

$$M_w Sn^{2+} = 118.71 \text{ g/mol}$$

For each 1 mole of  $I_2$  there's 1 mole of  $Sn^{2+}$

$$n_{I_2} = n_{Sn^{2+}}$$

$$[n_{I_2, \text{total}} - n_{I_2, \text{react with } S_2O_3^{2-}}] = n_{Sn^{2+}}$$

$$\left[ M_{I_2} V_{I_2} - \frac{M_{S_2O_3^{2-}} V_{S_2O_3^{2-}}}{2} \right] = M_{Sn^{2+}} V_{Sn^{2+}}$$

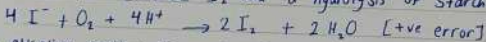
$$\left[ 0.08382 \times 15.00 - \frac{0.09339 \times 16.90}{2} \right] = M_{Sn^{2+}} \times 10.00 \rightarrow M_{Sn^{2+}} = 0.04682 \text{ M}$$

$$0.04682 \frac{\text{mol}}{\text{L}} \times 118.71 \frac{\text{g}}{\text{mol}} = 5.558 \text{ g/L}$$

## Questions:

1) Iodine titration, must be carried out in neutral, slightly acidic or slightly alkaline solution, what would happen if strong acidic or strong alkaline solutions are used?

In acidic media, air oxidize  $I_2$  and a hydrolysis of starch occurs:



In alkaline media:  $I_2 + 2 OH^- \rightarrow I^- + IO^- + H_2O$  [-ve error].

2)  $Na_2S_2O_3$  solution must be prepared in recently boiled distilled water, why?  
To be sure there are no bacteria or air that may oxidize  $Na_2S_2O_3$ .

3) In standardization of  $Na_2S_2O_3$  against  $KIO_3$ , the titration solution must be continuously stirred and the titration must be carried out immediately, why?

To: 1) prevent oxidation of  $I^-$  by  $O_2$ .

2) prevent loss of thiosulfate, because it's decomposed to produce  $Sulfate$ .

4) In Iodine titration, Sodium bicarbonate or dry ice must be added sometimes, why?  
It's from blanket of  $CO_2$  over the solution, which contains  $I^-$  to avoid oxidation.

\* Name : Aya Rae'd Ismail Hasan.

أية رائد السماعيل حسن

\* Reg. No. : 

حنينه

\* Section : "15"

\* Experiment No. : "7"

\* Experiment Name : Complexometric Titration using EDTA.

\* Instructor's Name : Prof. Mohammed Rasheed.

\* Date : 9<sup>th</sup>/Dec/2021.

# Experiment 7 Data Sheet and Calculations

Name: Aya Raed Hasan

Section: 15

Reg. No.                     

Date: 9<sup>th</sup> / Dec / 2021

## (A) Standardization of EDTA

| Mass of $ZnSO_4 \cdot 7H_2O$            | $0.3237 \pm 0.0001$ g  |                        |         |                        |
|-----------------------------------------|------------------------|------------------------|---------|------------------------|
| Data                                    | Trial 1                | Trial 2                | Trial 3 | Average                |
| Volume of $ZnSO_4 \cdot 7H_2O$ Solution | 10.00<br>$\pm 0.05$    | 10.00<br>$\pm 0.05$    |         | 10.00<br>$\pm 0.05$    |
| Volume of EDTA solution                 | 13.80<br>$\pm 0.07$    | 13.10<br>$\pm 0.07$    |         | 13.45<br>$\pm 0.07$    |
| Molarity of EDTA solution               | $8.372 \times 10^{-3}$ | $8.372 \times 10^{-3}$ |         | $8.372 \times 10^{-3}$ |

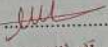
## (B) Determination of Water Hardness

| Data                                                               | Trial 1             | Trial 2             | Trial 3 | Average             |
|--------------------------------------------------------------------|---------------------|---------------------|---------|---------------------|
| 1- Vol. of tap water                                               | 50.00<br>$\pm 0.25$ | 50.00<br>$\pm 0.25$ |         | 50.00<br>$\pm 0.25$ |
| 2- Vol. of EDTA solution ( $V_1$ )<br>(corresponding to Ca and Mg) | 13.10<br>$\pm 0.07$ | 13.40<br>$\pm 0.07$ |         | 13.25<br>$\pm 0.07$ |
| 3- Vol. of tap water                                               | 50.00<br>$\pm 0.25$ | 50.00<br>$\pm 0.25$ |         | 50.00<br>$\pm 0.25$ |
| 4- Vol. of EDTA ( $V_2$ )<br>(corresponding to Ca)                 | 7.20<br>$\pm 0.07$  | 6.70<br>$\pm 0.07$  |         | 6.95<br>$\pm 0.07$  |

| Data                                          | Trial 1    | Trial 2    | Trial 3 | Average    |
|-----------------------------------------------|------------|------------|---------|------------|
| Volume of EDTA                                | 5.90       | 6.70       |         | 6.30       |
| Corresponding to Mg ( $V_1 \cdot V_2$ )       | $\pm 0.10$ | $\pm 0.10$ |         | $\pm 0.14$ |
| ppm Ca                                        | 46.65 ppm  | 46.65 ppm  |         | 46.65 ppm  |
| ppm Mg                                        | 25.5 ppm   | 25.5 ppm   |         | 25.5 ppm   |
| Water hardness (mg $\text{CaCO}_3/\text{L}$ ) | 222.1 mg/L | 222.1 mg/L |         | 222.1 mg/L |

(C) Unknown solution

| Unknown ID No.              | 19                  |                     |         |                                              |
|-----------------------------|---------------------|---------------------|---------|----------------------------------------------|
| Data                        | Trial 1             | Trial 2             | Trial 3 | Average                                      |
| 1. Vol. of unknown solution | 10.00<br>$\pm 0.05$ | 10.00<br>$\pm 0.05$ |         | 10.00<br>$\pm 0.05$                          |
| 2. Vol. of EDTA solution    | 26.80<br>$\pm 0.07$ | 27.20<br>$\pm 0.07$ |         | 27.05<br>$\pm 0.07$                          |
| 3. ppm Ca and Mg            | —                   | —                   |         | 626 mg $\text{Ca}^{2+}$ and $\text{Mg}^{2+}$ |
| 4. Vol. of unknown solution | 10.00<br>$\pm 0.05$ | 10.00<br>$\pm 0.05$ |         | 10.00<br>$\pm 0.05$                          |
| 5. Vol. of EDTA solution    | 26.80<br>$\pm 0.07$ | 27.20<br>$\pm 0.07$ |         | 27.05<br>$\pm 0.07$                          |
| 6. ppm Ca                   | —                   | —                   |         | 190 mg/L                                     |

Instructor's Signature: 

Instructor's Name: 

09-12-21

# Calculations

## part A: Standardization of 0.01M EDTA Solution with standard Zinc sulfate solution

- Weight of Zinc sulfate ( $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ ) =  $0.3237 \pm 0.0001 \text{ g}$

- No. of moles of ( $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ ) =  $\frac{m}{M_{\text{Mwt}}}$ , Molar mass of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  =  $287.55 \text{ g/mol}$   
 $= \frac{0.3237}{287.55}$

$$n = 1.126 \times 10^{-3} \text{ mole of } \text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$$

- Molarity of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  =  $\frac{n}{V(L)} = \frac{1.126 \times 10^{-3}}{100.00 \times 10^{-3}} = 0.01126 \text{ M}$

- Average volume of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  ( $\bar{V}$ ) =  $10.00 \pm 0.05 \text{ ml}$  <sup>in 2 trials</sup> "using a pipette"

$$\text{error} = \frac{1}{2} \times 0.1 = \pm 0.05$$

- Average volume of EDTA Solution ( $\bar{V}$ ) =  $\frac{13.80 + 13.10}{2} = 13.45 \pm 0.07 \text{ ml}$

$$\text{error} \rightarrow V_{\text{EDTA}} = V_1 - V_2 \rightarrow \pm 0.07$$

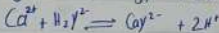
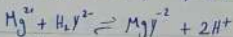
→ ( $M\bar{V}$ ) EDTA = ( $M\bar{V}$ )  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$

$$M \times 13.45 \times 10^{-3} = 0.01126 \times 10.00 \times 10^{-3}$$

$$M_{\text{EDTA}} = \frac{0.01126 \times 10.00 \times 10^{-3}}{13.45 \times 10^{-3}} = 8.372 \times 10^{-3} \text{ M of EDTA}$$

## part B: Determination of water hardness

- Chemical equations:  $\text{M}^{n+} + \text{H}_2\text{Y}^{2-} \rightleftharpoons \text{MY}^{n-4} + 2\text{H}^+$



- Molar mass ( $\text{Mg}^{2+}$ ) =  $24.31 \text{ g/mol}$

- Molar mass ( $\text{Ca}^{2+}$ ) =  $40.08 \text{ g/mol}$

- Molar mass ( $\text{CaCO}_3$ ) =  $100.09 \text{ g/mol}$

1. ppm of  $\text{Ca}^{2+}$  :  $\#V_1$  - volume of EDTA corresponding to  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$   $\#V_2$  = Volume of EDTA corresponding to  $\text{Ca}^{2+}$  only

- Average volume of EDTA Solution ( $\bar{V}_2$ ) =  $\frac{17.20 + 16.70}{2} = 16.95 \pm 0.07 \text{ ml}$

$$(M\bar{V}_2) \text{ EDTA} = (M\bar{V}) \text{ Ca}^{2+}$$

$$8.372 \times 10^{-3} \times 16.95 \times 10^{-3} = M \times 50.00 \times 10^{-3}$$

$$M_{\text{Ca}^{2+}} = 1.164 \times 10^{-3} \frac{\text{mol}}{\text{L}}$$

$$\text{ppm } \text{Ca}^{2+} = 1.164 \times 10^{-3} \frac{\text{mol}}{\text{L}} \times 40.08 \frac{\text{g}}{\text{mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 46.65 \frac{\text{mg}}{\text{L}}$$

follow

$$\text{ppm of } \text{Mg}^{2+} : V_1 - V_2 \Rightarrow \text{Corresponding to } \text{Mg}^{2+} \\ = 13.25 - 6.95 = 6.30 \pm 0.14 \text{ mL}$$

$$(M\bar{V}) \text{ EDTA} = (M\bar{V}) \text{ Mg}^{2+}$$

$$8.372 \times 10^{-3} \times 6.30 \times 10^{-3} = M \times 50.00 \times 10^{-3}$$

$$M_{\text{Mg}^{2+}} = 1.05 \times 10^{-3} \text{ M}$$

$$\text{ppm } \text{Mg}^{2+} = 1.05 \times 10^{-3} \frac{\text{mol}}{\text{L}} \times 24.31 \frac{\text{g}}{\text{mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \boxed{25.5} \text{ ppm}$$

### ③ water hardness

$$(M\bar{V}) \text{ EDTA} = (M\bar{V}) \text{ CaCO}_3$$

$$8.372 \times 10^{-3} \times 13.25 \times 10^{-3} \text{ M} \times 50.00 \times 10^{-3}$$

$$M_{\text{CaCO}_3} = 2.219 \times 10^{-3} \text{ M}$$

$$2.219 \times 10^{-3} \frac{\text{mol}}{\text{L}} \times 100.09 \frac{\text{g}}{\text{mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \boxed{222.1} \frac{\text{mg}}{\text{L}}$$

$$\left. \begin{array}{l} \text{Average Volume of EDTA Solution } (\bar{V}_1) \\ = \frac{13.10 + 13.40}{2} = 13.25 \text{ mL} \\ \pm 0.07 \end{array} \right\}$$

### ④ Part C : Determination of the concentration of Calcium and Magnesium in an Unknown Solution

#### ① water hardness

$$(M\bar{V}) \text{ EDTA} = (M\bar{V}) \text{ CaCO}_3$$

$$8.372 \times 10^{-3} \times 27.05 \times 10^{-3} = M \times 10.00 \times 10^{-3}$$

$$M_{\text{CaCO}_3} = 0.02265 \text{ M}$$

$$\text{ppm } \text{CaCO}_3 = 0.02265 \frac{\text{mol}}{\text{L}} \times 100.09 \frac{\text{g}}{\text{mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \boxed{2267} \frac{\text{mg}}{\text{L}}$$

$$\left. \begin{array}{l} \text{Average Volume of EDTA Solution} \\ = \frac{26.90 + 27.20}{2} = 27.05 \text{ mL} \\ \pm 0.07 \end{array} \right\}$$

#### ② ppm Ca<sup>2+</sup>

$$(M\bar{V}_2) \text{ EDTA} = (M\bar{V}) \text{ Ca}^{2+}$$

$$8.372 \times 10^{-3} \times 5.65 \times 10^{-3} = M \times 10.00 \times 10^{-3}$$

$$M_{\text{Ca}^{2+}} = 4.73 \times 10^{-3} \text{ M}$$

$$\text{ppm } \text{Ca}^{2+} = 4.73 \times 10^{-3} \frac{\text{mol}}{\text{L}} \times 40.08 \frac{\text{g}}{\text{mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 189.5 \approx \boxed{190} \frac{\text{mg}}{\text{L}}$$

$$\left. \begin{array}{l} \text{Average Volume of EDTA Solution } (\bar{V}_2) \\ = \frac{5.90 + 5.40}{2} = 5.65 \pm 0.07 \text{ mL} \end{array} \right\}$$

#### ③ ppm Mg<sup>2+</sup>

$$(\text{EDTA}) \bar{V} \text{ corresponding to } \text{Mg}^{2+} = 27.05 - 5.65 = 21.40 \pm 0.14 \text{ mL}$$

$$(M\bar{V}) \text{ EDTA} = (M\bar{V}) \text{ Mg}^{2+}$$

$$8.372 \times 10^{-3} \times 21.40 \times 10^{-3} = M \times 10.00 \times 10^{-3}$$

$$M_{\text{Mg}^{2+}} = 0.01792 \text{ M}$$

$$\text{ppm } \text{Mg}^{2+} = 0.01792 \frac{\text{mol}}{\text{L}} \times 24.31 \frac{\text{g}}{\text{mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \boxed{435.6} \frac{\text{mg}}{\text{L}}$$

$$\text{④ ppm Ca}^{2+} \text{ and } \text{Mg}^{2+} = 435.6 \text{ mg Mg}^{2+}/\text{L} + 190 \text{ mg Ca}^{2+}/\text{L} = \boxed{626} \text{ mg Ca}^{2+} \text{ and } \text{Mg}^{2+}$$

\* Name : Aya Rae'd Ismail Hasan.

اية رائد اسماعيل حسن

\* Reg.No. : [REDACTED]

\* Section : "15"

\* Experiment NO. : "8"

\* Experiment Name : Determination of Calcium by Quantitative precipitation and Titration.

\* Instructor's Name : prof. Mohammed Rasheed.

\* Date : 2<sup>th</sup> / Dec / 2021 .

Scanned with

**Experiment 8**  
**Data Sheet and Calculations**

Name: Ava Rae'd Hasan.

Section: 15

Reg. No.                     

Date: 2<sup>nd</sup> / Dec / 2021

Unknown ID No.:                     

(A) Standardization of  $\text{KMnO}_4$

Mass of Sodium oxalate  $0.6030 \pm 0.0001$  g per 100 mL

Molarity of sodium oxalate  $0.0450 \text{ M}$

| Vol. of $\text{Na}_2\text{C}_2\text{O}_4$ solution        | Vol. of $\text{KMnO}_4$ |
|-----------------------------------------------------------|-------------------------|
| 1) $10.00 \pm 0.05$                                       | $9.05 \pm 0.07$         |
| 2) $10.00 \pm 0.05$                                       | $9.00 \pm 0.07$         |
| 3) $10.00 \pm 0.05$                                       | $8.90 \pm 0.07$         |
| Molarity of $\text{KMnO}_4$ solution = $0.0200 \text{ M}$ |                         |

Concentration of  $\text{KMnO}_4$  in g/L:  $3.16 \text{ g/L}$

(B) Precipitation and Titration of  $\text{Ca}^{2+}$

| Vol. of $\text{Ca}^{2+}$ solution | Vol. of $\text{KMnO}_4$ |
|-----------------------------------|-------------------------|
| 1) $10.00 \pm 0.05$               | $29.40 \pm 0.07$        |
| 2)                                |                         |
| 3)                                |                         |

Concentration of  $\text{Ca}^{2+}$  solution in g/L =  $6.01 \text{ g/L}$

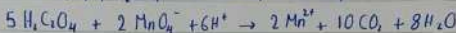
Instructor's Signature: .....

Instructor's Name: .....

# Calculations

## Part (A): Standardization of 0.1M $\text{KMnO}_4$

- Chemical equations:  $\text{Ca}^{2+} + \text{C}_2\text{O}_4^{2-} \rightleftharpoons \text{CaC}_2\text{O}_4 \downarrow$



- Calculations of part (A):

- Mass of Sodium Oxalate =  $0.6030 \pm 0.0001 \text{ g}$

- Mw of  $\text{Na}_2\text{C}_2\text{O}_4 = 134 \text{ g/mol}$

- Mw of  $\text{KMnO}_4 = 158.03 \text{ g/mol}$

- average Volume of  $\text{KMnO}_4 (\bar{V}) = \frac{9.05 + 9.00 + 8.90}{3} = 8.98 \text{ ml}$

- Volume of  $\text{Na}_2\text{C}_2\text{O}_4$  in 3 trials =  $10.00 \pm 0.05 \text{ ml}$

- n of moles of  $\text{Na}_2\text{C}_2\text{O}_4 = \frac{m}{M_r} = \frac{0.6030}{134} = 4.50 \times 10^{-3} \text{ mole}$

$\therefore M_{\text{Na}_2\text{C}_2\text{O}_4} = \frac{n}{V(l)} = \frac{4.50 \times 10^{-3}}{100.00 \times 10^{-3}} = 0.0450 \text{ M}$

$$\frac{M_{\text{KMnO}_4} V_{\text{KMnO}_4}}{2} = \frac{M_{\text{C}_2\text{O}_4^{2-}} V_{\text{C}_2\text{O}_4^{2-}}}{5} \rightarrow \frac{M_{\text{KMnO}_4} \times 8.98}{2} = \frac{0.0450 \times 10.00}{5} \rightarrow M_{\text{KMnO}_4} = 0.0200$$

$$0.0200 \frac{\text{mol}}{\text{L}} \times 158.03 \frac{\text{g}}{\text{mol}} = 3.16 \text{ g/l}$$

## Part (B): precipitation of calcium as calcium oxalate and titration with standard $\text{KMnO}_4$ Solution

- Chemical equations: Reduction equation:  $(8\text{H}^+ + \text{MnO}_4^- + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}) \times 2$

Oxidation equation:  $(\text{H}_2\text{C}_2\text{O}_4 \rightarrow 2\text{CO}_2 + 2\text{H}^+ + 2\text{e}^-) \times 5$

Net equation:  $6\text{H}^+ + 2\text{MnO}_4^- + 5\text{H}_2\text{C}_2\text{O}_4 \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 10\text{CO}_2$

- Mw of  $\text{Ca}^{2+} = 40.08 \text{ g/mol}$

- Volume of  $\text{KMnO}_4 = 29.90 \pm 0.07 \text{ ml}$

- Volume of  $\text{Ca}^{2+}$  Solution =  $10.00 \pm 0.05 \text{ ml}$

$$\frac{n(\text{Ca}^{2+})}{5} = \frac{n\text{CaC}_2\text{O}_4}{5} = \frac{n\text{H}_2\text{C}_2\text{O}_4}{5} = \frac{n\text{KMnO}_4}{2}$$

$$\therefore \frac{n(\text{Ca}^{2+})}{5} = \frac{n\text{KMnO}_4}{2}$$

$$\frac{(MV)_{\text{Ca}^{2+}}}{5} = \frac{(MV)_{\text{KMnO}_4}}{2} \rightarrow \frac{M_{\text{Ca}^{2+}} \times 10.00}{5} = \frac{0.0200 \times 29.90}{2} \rightarrow M_{\text{Ca}^{2+}} = 0.150 \text{ M}$$

$$0.150 \frac{\text{mol}}{\text{L}} \times 40.08 \frac{\text{g}}{\text{mol}} = 6.01 \text{ g/l}$$

follow

## Questions

1] Why methyl red is used ?

Because this indicator have pH between "4.5 - 6.2", the pH range of indicator is suitable for pH solution to precipitate  $\text{Ca}^{2+}$  as  $\text{CaC}_2\text{O}_4$  in neutral or slightly basic media.

2] Why the precipitate must be washed ?

1] To get rid of  $\text{Cl}^-$ , because  $\text{Cl}^-$  <sup>will</sup> react with  $\text{KMnO}_4$  to give  $\text{Cl}_2$ , and it will cause to have an (+ve) error.

2] To get rid of  $\text{C}_2\text{O}_4^{2-}$  (oxalate), because it react with  $\text{H}_2\text{SO}_4$  to give  $\text{H}_2\text{C}_2\text{O}_4$  which will consume more volume of the titrant ( $\text{KMnO}_4$ ) and be the cause of having positive error [(+ve) error].

3] What are the possible sources of error in carrying out this experiment ?

1. incomplete dissolving  $\text{CaC}_2\text{O}_4$  with  $\text{H}_2\text{SO}_4$ .
2. incomplete washing.
3. incomplete filtration.
4. incomplete precipitation of the solution.
5. There was free chloride ( $\text{Cl}^-$ ) or free oxalate ( $\text{C}_2\text{O}_4^{2-}$ ).

شعبة

\* Name: Aya Rae'd Ismail Hasan.

اية رائد اسماعيل حسن

يوم الخميس

\* Reg. No. : [REDACTED]

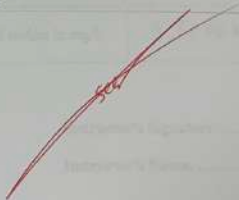
\* Section : "15"

\* Experiment No. : "9"

\* Experiment Name: Gravimetric Determination of Sulfate.

\* Instructor's Name: Prof. Mohammed Rasheed.

\* Date: 23<sup>th</sup>/Dec/2021.

A red ink signature, likely of the instructor, is written over the 'Instructor's Name' field.

**Experiment 9**  
**Data Sheet and Calculations**

Name: Aya Rae'd Hasan

Section: 15

Reg. No.:                     

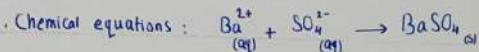
Date: 23<sup>rd</sup> Dec / 2021

|                                         |                                    |
|-----------------------------------------|------------------------------------|
| Unknown ID No.:                         |                                    |
| Vol. of unknown solution                | $10.00 \pm 0.05 \text{ mL}$        |
| Mass of empty crucible                  | $16.7334 \pm 0.0001 \text{ g}$     |
| Mass of crucible + precipitate          | $17.3425 \pm 0.0001 \text{ g}$     |
| Mass of precipitate ( $\text{BaSO}_4$ ) | $0.6091 \text{ g}$<br>$\pm 0.0001$ |
| Mass of sulfate                         | $0.2507 \text{ g}$                 |
| Concentration of sulfate in mg/L        | $2.5070 \times 10^4 \text{ mg/L}$  |

Instructor's Signature: .....

Instructor's Name: .....

# Calculations



- Volume of  $\text{SO}_4^{2-}$  in an unknown solution =  $10.00 \pm 0.05 \text{ ml}$

- Mass of empty crucible ( $m_1$ ) =  $16.7334 \pm 0.0001 \text{ g}$

- Mass of crucible + precipitate ( $m_2$ ) =  $17.3425 \pm 0.0001 \text{ g}$

- Mass of precipitate ( $\text{BaSO}_4$ ) =  $m_2 - m_1$   
 $= 17.3425 - 16.7334$

$$m_{\text{BaSO}_4} = 0.6091 \text{ g}$$

uncertainty =  $\sqrt{(0.0001)^2 + (0.0001)^2} = \pm 0.0001$

-  $M_w$  of  $\text{SO}_4^{2-} = 96.06 \text{ g/mol}$

-  $M_w$  of  $\text{BaSO}_4 = 233.38 \text{ g/mol}$

$$\therefore m_{\text{SO}_4^{2-}} = m_{\text{BaSO}_4} \times \frac{M_w \text{SO}_4^{2-}}{M_w \text{BaSO}_4}$$

$$= 0.6091 \text{ g} \times \frac{96.06 \text{ g/mol}}{233.38 \text{ g/mol}} = 0.2507 \text{ g of SO}_4^{2-}$$

$$\therefore \text{Concentration of SO}_4^{2-} = \frac{\text{mass SO}_4^{2-}}{10 \times 10^{-3}} \times 1000 \text{ mg}$$

$$= \frac{0.2507}{10 \times 10^{-3}} \times 1000 = 2.5070 \times 10^4 \text{ mg/L}$$

## Questions:

1) Why should the Sulfate precipitation be carried out in a slightly acidic solution?

to: 1) prevent co-precipitate of  $\text{Ba}^{2+}$  2) Force precipitate to form larger crystals and so making filtration easier.

3) prevent any crystals passing with filtrate through the filter paper.

2) Why the  $\text{BaCl}_2$  solution is added quickly to the sulfate containing solution?

to: 1) prevent inclusion and occlusion. 2) Ensure that only  $\text{BaSO}_4$  will precipitate.

3) Why filtration is carried out while the solution is still hot?

If the solution not filtered hot, the solution might crystallize quickly thus trapping the insoluble impurities (to prevent co-precipitation).

4) Why the filter paper should be charred without inflaming?

To prevent reduction of  $\text{BaSO}_4$  by carbon:



10

Section: 15

Date: 30<sup>th</sup> / Dec. / 2021

- Number of mmols of  $H^+$ : 0.322 mmole

- Concentration of  $\text{Ca}^{2+}$ :  $0.0161 \text{ mole/L}$

ppm:  $645.288 \text{ KIO}^8$   
645.288 ppm

Instructor's Signature: Hanan

Instructor's Name: Manar Ali

30.12.2024

\* Name : Aya Rae'd Ismail Hasan.

أية رائد اسماعيل حسن

\* Reg. No. : 

\* Section : "15"

\* Experiment No. : "12"

\* Experiment Name : paper Chromatography

\* Instructor's Name : prof. Mohammed Rasheed.

\* Date : 16<sup>th</sup> / Dec / 2021.

## Experiment 12

## Data Sheet and Calculations

Name: Aya Rae'd Hasan.Section: 15Reg. No.                     Date: 16<sup>th</sup> / Dec / 2021.

## A. PURE COMPONENTS

| Component        | $x_s$ | $x_c$ | $x_c/x_s = R_f$ |
|------------------|-------|-------|-----------------|
| Cargo red        | 5     | 1.5   | 0.3             |
| Phenyl red       | 5     | 4.2   | 0.84            |
| Bromothymol blue | 5     | 5     | 1               |
| Methyl orange    | 5     | 4.8   | 0.96            |

 $x_s$  = Distance of the solvent front,  $x_c$  = Distance of the component

## B. UNKNOWN SAMPLE

Distance of the solvent front

5cm ( $x_s$ )

| Spot Nr. | $x_c$ | $R_f = x_c/x_s$ | Spot Identification |
|----------|-------|-----------------|---------------------|
| 1        | 1.6   | 0.32            | Cargo red           |
| 2        | 4.1   | 0.82            | Phenyl red          |
| 3        |       |                 |                     |
| 4        |       |                 |                     |

Instructor's Signature: .....

Instructor's Name: .....