S.5 CHEM 2 SCORING GUIDE

X/40

ITEM 1

A local pharmaceutical manufacturer produces a Vitmin C supplement which relies on high –Purity of Citric acid ($C_6H_8O_7$) as a key stabilizing agent. For effectiveness, the percentage purity of citric acid should be at least **95%** . To ensure the quality of the raw material, the company's quality control laboratory needs to determine the exact purity of a supplement.

Direct titration of the solid citric acid with **a standard sodium hydroxide solution** is often deemed insufficient due to potential surface impurities that interfere with the end point. The pharmaceutical laboratory assistant has decided to perform a back –titration procedure to verify the purity of a sample of citric acid crystal delivered **but** first standardizing sodium hydroxide using hydrochloric acid using phenolphthalein indicator.

In his procedure **0.5g** of citric acid is to be measured and dissolved in exactly **100.0 cm3** (excess) of the available sodium hydroxide solution (BA1) and the resulting solution made upto 250.0cm3 using distilled water .By titrating a fixed volume of the resultant solution with BA2 ,the technician hopes to obtain information that help with the investigation but is not sure of the entire process and has contacted you for help.

You are provided with:

- Solid Q which is citric acid.
- BA1 which is available sodium hydroxide solution which had been stored in plastic can for along time.
- BA2 which is **0.2 M hydrochloric acid solution which is freshly prepared**

- Phenolphthalein indicator.
- Distilled water.

Citric acid reacts with sodium hydroxide in the ratio of **1:3 Task**

:

As a chemistry learner carryout an investigation to determine the percentage purity of the citric acid provided.

In your design include, aim of the experiment, Hypothesis and variables, mitigated risks, results, analysis and conclusion Aim of the experiment

Aim: An experiment to determine **percentage purity of citric acid** through back titration by measuring the volume of **hydrochloric acid solution** ✓A **(or BA2)** required to neutralize **a fixed volume of unreacted sodium hydroxide solution** ✓A obtained by reacting **fixed mass of solid Q**✓A with excess sodium hydroxide solution in order to **ensure the quality of the raw material** ✓A

Dependent variabl,A- Indepent variable,A,controlled variable,A and purpose ,A=4A

(3 scores for all the 4A) ,Less than 4A =00

Hypothesis:

The **percentage purity of citric acid** is **at least 95%** (or is above 95%) ✓H through back titration by measuring the volume of **hydrochloric acid solution** ✓H **(BA2)** required to neutralize **a fixed volume of unreacted sodium hydroxide** ✓H obtained by reacting a fixed mass of solid Q with excess sodium hydroxide solution .

Predication ,H -Dependent variable,H - independent variable, H =3H

(4 Scores for all the 3H) , **Less than 3H =00**

Variables:

Independent variable: volume of Unreacted sodium hydroxide solution ✓Vi pipetted (or volume of BA1 **)**

(Or volume of a mixture of solutions of BA1 and Solid Q pipetted **)**

Dependent variable: volume of Hydrochloric acid solution ✓Vi from the burette required to reach end –point (volume of BA2)

Controlled variable: mass of solid Q made fixed ✓Vc

Or Volume of unreacted sodium hydroxide solution pipetted kept constant at 20.0cm3 **For all the 3V = O3 scores , Less than 3v =00**

Summary 3V+4A+3H= level 3 = 10scores

3V+4A=level 2 = 06 scores

3V =level 1 = 03 scores

Mitigated Risks

1. Hydrochloric acid ,

Danger: Chemical burns to the skin and eyes.
Explanation: hydrochloric acid is highly corrosive and can damage body tissues upon contact. **Mitigation:** Wear safety goggles, gloves, and a laboratory coat to prevent contact of the acid with the body ✓Rm.

2. Glassware

Danger: Cuts and injuries from broken glass.
Explanation: Glassware can crack or break if mishandled, producing sharp edges.
Mitigation: Handle all glassware carefully, check for cracks before use, and dispose of broken glass safely in the designated container ✓Rm .

3) Swallowing of the solution during pipetting causing irritation of the throat or mouth burns.

This is mitigated by using a pipette filler to avoid direct contact of the chemical with the mouth. 2Rm

Procedure I; Standardization of sodium hydroxide (or BA2) using hydrochloric acid (or BA1)

a) **20.0cm^3** ✓Pr of BA1 was pipetted in **a clean conical flask** ✓Pr and 2 (or 3) drops of phenolphthalein indicator were then added using a dropper. Initial burette reading was recorded in the table 1 below.

b) The content in a conical flask (mixture) was titrated against BA2✓Pr from the burette until the purple solution changed to colourless . ✓Pr The final burette was recorded was also recorded.

c)The titration was repeated several times to obtain consistent results. ✓Pr

d) The results were recorded in the table 1 below.

Procedure II: Titration of BA2 with BA3

a)0.5g ✓Pr of solid Q was weighed using a weighing balance ✓Pr into a beaker✓Pr About 100.0cm3 of sodium hydroxide solution(BA1) was measured using a measuring cylinder ✓Pr and then added into a beaker while stirring with a glass rod until it was completely dissolved✓Pr.

b)The solution was transferred into a 250cm^3 volumetric flask ✓Pr .The beaker was rinsed with distilled water, and the washings were transferred into the volumetric flask. More distilled water was added upto the 250cm^3 mark. This solution was labeled BA3. ✓Pr

c) 20.0cm^3✓Pr of **BA3** was pipetted into a clean conical flask ,2 drops of phenolphthalein indicate were then added using a dropper.

d) The mixture was titrated against BA2 from the burette until the purple solution changed to colourless ✓Pr e)The titres were recorded in a table 3

f) The titration was repeated several times to obtain consistent values. ✓Pr

g)The results were recorded in table 3 below.

15Pr +2Rm =level 3 (7 scores)
15Pr =level 2 (5scores)
(7-14)Pr =level 1 (3 scores)

(c) Data Presentation and Recording Data recording and presentation

Standardisation of BA 2Sodium hydroxide using BA1

Table1

Volume of pipette used = **20.0cm^3 ✓ Dr**

Final burette readings (cm3)	30.80	40.50	45.50
Initial burette readings (cm3)	0.00	10.00	15.00
Volume of BA2 used (cm3)	30.80	30.50	30.50

Centre range (25.50 - 35.50)

✓ **Ds** ✓ **Dc** ✓ **Dc**

Table 2

Mass beaker(dish) + solid Q (g)	**31.5**
Mass of beaker (dish) only (g)	**31.0**
Mass of solid Q (g) ✓ **Dr**	**0.5** ✓ **Dc**

(allow 2dps)

Table 3

Volume of pipette used = 20.0cm3

Final burette readings (cm3) ✓ **Dr**	9.30	19.00	29.00
Initial burette readings (cm^3)	0.00	10.00	20.00
Volume of BA1 used (cm3)	9.30	9.00	9.00

Centre range (5 .00 - 14.0)

✓ **Ds** ✓ **Dc** ✓ **Dc**

3Dr + 2Ds + 5 Dc = level 3 (10 scores)

3Dr + 2Ds = level 2 (8 scores)

3Dr = level 1 (5 scores)

Note: Variables with units = Dr,

Data sets (2/3of required) = D s ,

Accuracy within centre range =Dc

Number of decimal places(d.ps) = Dc ie mass 1or 2dps,burette vol 2dps, pipette,1dp

c) **Analyze the data, make conclusion and recommendation**

Interpretation of data

Table 1: Titre values for calculating average are **30.50 and 30.50** cm3

Average volume of BA1 used $\frac{30.50+30.50}{2}$ = **30.50 cm^3** ✓Da **(range 29.5-31.0)**

Table 3: Titre values for calculating average are **9.00 and 9.00** cm3 **cm^3** ✓

Average volume of FA1used $\frac{9.00+9.00}{2}$ = **9.00** cm^3 ✓Da **(range 8.5-9.5)**

1000.0cm3 of BA2 contain 0.2 moles of hydrochloric acid

30.50cm3 of BA2 contain $\frac{(0.2 \times 30.50)}{1000.0}$ moles of HCl

= 0.0061 moles ✓Da

$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$ ✓Da

1mole of NaOH reacts with 1 mole of HCl

0.0061 moles of H Cl react with (1x0.0061) moles of NaOH

= 0.0061 **moles** ✓Da

20.00 cm3 of BA1 contain 0.0061 **moles of NaOH**

1000cm3 of BA1 contain $\frac{(0.0061 \times 1000)}{20.00}$ moles of NaOH

= 0.305 M

Molarity of NaOH is Approximately **0.3 moldm^{-3}** ✓Di

Original moles of Sodium hydroxide

1000cm3 of BA 1 contain 0.3 moles of NaOH

100cm3 of BA1 contain $\frac{(0.3x100)}{1000}$ moles of NaOH✓

= **0.03** moles of NaOH ✓Da

Moles of NaOH in 250 cm^3 = **0.03 moles**

Unreacted moles of Sodium hydroxide that reacted with hydrochloric acid solution.

1000 cm3 of BA2 contain 0.2 moles of Hydrochloric acid

9.00 cm3 of BA 2 contain (0.2x9.00) moles of hydrochloric acid

1000

= 0.0018 moles ✓Da

$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$ ✓Da

Imole of HCl reacts with 1 moles of NaOH

0.0014 moles of HCl react with (1x00.0018) NaOH moles

= **0.0018 moles** ✓Da

20.00cm3 of BA3 contain **0.0018** moles of excess NaOH

250cm3 of BA3 contain (0.0018 x 250) moles of excess NaOH

20.0

= **0.0225 moles** ✓Da

Moles of NaOH that reacted with citric acid

= Original moles of NaOH –moles of excess NaOH

= (O.03-0.0225) moles

= 0.0075 moles ✓Da

Moles of acidic ingredient **,(citric acid**)

3 moles of NaOH reacted with 1 mole of Citric acid

0.0075 moles of NaOH reacted with (1x**0.0075**) moles of Citric acid

3

= 0.0025 moles of Citric acid ✓Da

Molar molar mass of citric acid , $C_6H_8O_7$ = (6x12)+ (8x1) +(7x16) =**192g** ✓Da

Reject Rmm with units

1 mole of citric acid weighs 192g

0.0025 moles of citric acid weigh (192x**0.0025**) g

= 0.48g ✓Da

Percentage purity of zinc = $\frac{0.48 \times 100}{0.5}$

= 96.0% ✓Da

Interpretation of data: the percentage purity of citric acid is **96.0%** ✓Di

15Da + 2Di = level 3 (18 scores)
15 Da =level 2 (15 scores)
(7-14) Da =level 1 (10 scores)

Conclusion and advise/recommendation

Since the percentage purity of citric acid is **96.0%** which is above **95.0%** ✓C . The sample meets the pharmaceutical quality requirement and is suitable for use in vitamin C manufacture. ✓R

C+ R =level 2 (2 scores)
C = level 1 (1 score)

Note : ALLOW PERCENTAGE RANGING FROM 90.0% TO 99.9%
Ie between 90% to 94 % do not recommend and 95% and above recommend

Total scores = 40