Christ Church Grammar School

Year 12 Chemistry

Volumetric Analysis Validation Test 2019

Time allowed: 45 minutes

Name: ANSWERS

Marks: ____________ / 46

Question 1 **(14 marks)**

In an investigation a group of students set out to analyse the percentage of Vitamin C (ascorbic acid) in Vitamin C tablets. Ascorbic acid ($C_6H_8O_6$) is a monoprotic acid.

A 14.14g tablet is crushed and dissolved in 4.88 x 10^{-1} $molL^{-1}$ NaOH solution in a 500.0 mL volumetric flask. 20.00 mL aliquots of this solution with the excess NaOH are titrated with 0.122 $molL^{-1}$ H_2SO_4 . The results of the titrations are in the table below .

	Titration 1	Titration 2	Titration 3	Titration 4
Final volume	36.28	37.22	36.28	37.29
Initial volume	1.30	1.77	1.24	2.28
Titre				

(a) Calculate the % by mass of the ascorbic acid

	Titration 1	Titration 2	Titration 3	Titration 4
Final volume	36.28	37.22	36.28	37.29
Initial volume	1.30	1.77	1.24	2.28
Titre	34.98	35.45	35.04	35.01

Omitting the outlier the average titre is 35.01 ml (1)

Vav = 34.98 + 35.04 + 35.01 /3 = 35.01 mL

- Work out how many moles of NaOH were left unreacted.

Equation 2 NaOH + H_2SO_4 → Na_2SO_4 + 2 H_2O (1)

20.00 ml 35.01 ml

? 0.122M

n (NaOH) = 2 x 35.01 x 10^{-3} x 0.122 = 0.00854 moles in 20.00 ml (2)

n (NaOH) = 0.00854 x (500/20) = 0.2135 moles unreacted in the 500 ml. (1)

- Work out how much NaOH was present at the beginning.

n (NaOH) = 0.5 x 4.88 x 10^{-1} = 0.244 moles present before the tablet was added. (1)

- Work out how much NaOH reacted with the ascorbic acid in the original reaction with the tablet.

Difference = 0.244 – 0.2135 = 0.0305 moles of NaOH reacted with the Ascorbic acid. (1)

- Find number of moles of Ascorbic acid and hence the mass.

From the 1:1 mole relationship.

n (Asc. Acid) = n (NaOH) = 0.0305 M($C_6H_8O_6$) = 176.124 (1)

m (Asc. Acid) = n x M = 0.0305 x 176.124 = 5.36 g (1)

- Give the percentage composition.

Percentage Composition = (5.36/14.14) x 100 = 37.9% (1)

(10 marks)

(b) One pair of students in the group decided to dissolve the crushed tablet in a small quantity of distilled water before they added it to the volumetric flask. They then added the NaOH up to the 500.0 mL mark.

Explain the effect would this have on:

(i) The concentration of the NaOH after the reaction in the volumetric flask?

The n(NaOH) added to the flask would be less. (1)

The n(NaOH) reacted is the same so the [NaOH] would be less. (1)

(2 marks)

(ii) The calculated % by mass of ascorbic acid?

The n(NaOH) remaining would be less. (1)

The n(Vitamin C) calculated would be more, thus calculated % composition would be more then it actually is. (1)

(2 marks)

Question 2 **(19 marks)**

In a procedure to determine the exact acid concentration in a commercial brand of hydrochloric acid, the following steps were used.

Step 1: A primary standard was prepared

A sample of sodium carbonate is placed in an oven at 110.0 ^{O}C and left for a day.

A 4.850 (± 0.005) g sample of the sodium carbonate was dissolved and transferred quantitatively into a 500.0 (± 0.25) mL volumetric flask and made up to the mark with distilled water, in order to prepare a **standard** solution.

(a) Determine the concentration of the **standard** sodium carbonate.

$n(Na_2CO_3)$ = 4.85/106.99 = 0.04576 mole (1)

$[Na_2CO_3]$ = 0.04576/0.5 = 0.0915 $molL^{-1}$ (1)

(2 marks)

(b) Give two reasons why sodium carbonate is a suitable compound to be used as a primary standard.

chemically stable/ no reactive with air

high molar mass

Known purity
2 out of 3

(2 marks)

(c) Why did the sodium carbonate need to be heated?

Water of crystallisation needs to be removed

(1 mark)

Step 2: The commercial brand of HCl was analysed to determine its exact concentration.

A 5.500 (± 0.005) mL sample of the commercial strength acid was delivered into a 250.00 (± 0.15) mL volumetric flask and made up to the mark.

25.00 (± 0.03) mL aliquots of the previously prepared **standard** sodium carbonate solution were titrated against the HCl solution. After a series of titrations, 3 concordant results were obtained. The average titre was 19.85 mL.

(d) Find the concentration of HCl in the commercial acid.

$n(Na_2CO_3)$ = 0.025 x 0.0915 = 0.0022075 moles (1)

$Na_2CO_3 + 2H^+ \rightarrow 2Na^+ + H_2O + CO_2$ (1)

$n(H^+)$ = $2n(Na_2CO_3)$ = 0.004575 moles in 19.85 mL (1)

$n(H^+)$ in 250 mL = 0.004575 x 250/19.85 = 0.05762 mol (1)

$n(H^+)$ in the 5.500 mL sample = 0.05762 mol (1)

$[H^+]$ in the commercial acid = 0.05762/0.0055 = 10.48 $molL^{-1}$ (1)

(6 marks)

(e) What effect would it have on the concentration of the sodium carbonate if it was not heated initially? Explain why.

Mass of Na_2CO_3 in the weighed sample would less (1)

The $[Na_2CO_3]$ would be less (1)

(2 marks)

(f) What effect would it have on the calculated concentration of the hydrochloric acid if the sodium carbonate was not heated initially? Explain why.

The $[Na_2CO_3]$ would be less, so

The volume of HCl titrated would be less (1)

The calculated $[H^+]$ would be greater (1)

(2 marks)

(g) Using the measurement uncertainties in the equipment, calculate the error in the concentration of the commercial hydrochloric acid. Express your answer to the correct number of significant figures.

% error in m(Na2CO3) = 0.005/4.85 x 100 = 0.103%

% error in the 500 volumetric flask = 0.25/500 x 100 = 0.05%

% error in volume of acid = 0.005/5.500 x 100 = 0.091%

% error in the 250mL volumetric flask = 0.15/250 x 100 = 0.06%

% error in the pipette = 0.03/25 x 100 = 0.12%

% error in titre volume = 0.1/19.85 x 100 = 0.5038%

total % error = 0.9309% (1)

error in the calculated concentration of commercial HCl = 10.48 x 0.0309%

= 0.09756 $molL^{-1}$ (1)

[HCl] = 10.48 +/- 0.10 $molL^{-1}$ (1)

(3 marks)

Question 3 **(13 marks)**

Malic acid is a naturally occurring compound found in many fruits and vegetables, and is largely responsible for the sour taste found in apples and pears. Malic acid is an organic compound with the molecular formula $\mathbf{C_4H_6O_5}$. It is a **diprotic acid.**

The **acidity of apple juice** is largely due to **malic acid.** Citric acid is a minor organic acid also found in apple juice.

The mean value for the malic acid content of apple juice is normally in the range 45.0 - 60.0 gL^{-1}.

The malic acid content of apple juice was determined by titration of 20.00mL aliquots of apple juice (dilution to be determined) against 0.1070 $molL^{-1}$ NaOH in a burette.

(a) Using a calculation, determine whether the apple juice needs to be diluted to achieve approximately the same titre volume as the aliquot of apple juice. If so, by what factor does it need to be diluted?

Assuming 60 gL^{-1} malic acid

In 20 mL of apple juice, m(malic acid) = 60 x 20/1000 = 1.2 g (1)

n(malic acid) = 1.2/134.064 = 0.00895 mol (1)

$C_4H_6O_5 + 2OH^- \rightarrow C_4H_4O_5^{2-} + 2H_2O$ (1)

n(OH^-) = 2n(moles of acid)

= 0.0179 mol (1)

V(OH-) required = n/c = 0.0179/0.1070 = 0.1673 L = 167.3 mL (1)

Dilution needed = 167.3/20 = 8.4 (1)

(6 marks)

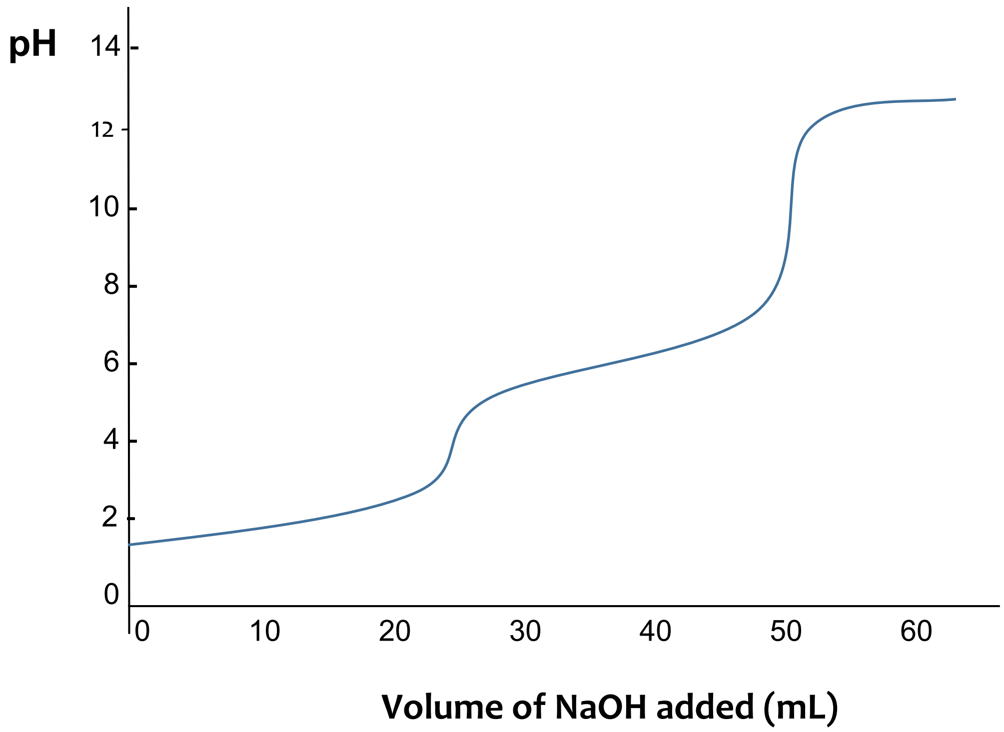
(b) Comment on any assumptions made in this investigation and their effect on the validity of the procedure.

Malic acid is not the only acid present. Other acids are in wine such as citric acid which is triprotic.

This reduces validity.

(2 marks)

The titration curve below is for the titration of 25.00 mL of 0.1 $molL^{-1}$ malic acid (H_2M) with 0.1 $molL^{-1}$ NaOH. There are two equivalence points because malic acid is a diprotic weak acid.



(c) The equation for the neutralisation at the second end point is:

$$HM^- + OH^- \rightarrow H_2O + M^{2-}$$

Write the equation for the neutralisation at the first equivalence point

$$H_2M + OH^- \rightarrow H_2O + HM^-$$

(2 marks)

You have 3 indicators to choose from in your titration.

Indicator	**pH range**	**Colour (lower pH – higher pH)**
Methyl orange	3.1– 4.4	red –yellow
Methyl red	4.4–6.2	pink – yellow
Phenolphthalein	8.3–10.0	colourless – pink

(d) (i) Which indicator would you choose to identify each equivalence point

Equivalence point 1 methyl orange

Equivalence point 2 phenolphthalein

(2 marks)

(ii) Would it matter which equivalence point was identified to calculate the moles of malic acid in the aliquot. Explain your answer.

It would not matter (1)

The $n(HM^-)$ at equivalence point 1 = $n(M^{2-})$ at equivalence point 2 (1)

(2 marks)

END OF TEST