Australian Islamic College 2020

ATAR Chemistry Units 3 and 4

Task 4 (Weighting: 3%)

Volumetric Analysis Test

Test Time: 35 minutes

Please do not turn this page until instructed to do so.

First Name	Surname
ANSWERS	

Teacher

Mark / 30	Percentage

Equipment allowed: Pens, pencils, erasers, whiteout, rulers and non-programmable calculators permitted by the Schools Curriculum and Standards Authority.

Special condition: 2 marks will be deducted for failing to write your full name on this test paper.

Teacher help: Your teacher cannot help you during the test. Do not ask the teacher questions about the questions.

Questions must be answered in this booklet, in the spaces provided.

For all questions involving calculations:

- State your answer to the appropriate number of significant figures.
- Show your calculations. Calculations must be presented in a logical sequence that can be easily followed and understood by the marker.
- Follow-on marks will not be awarded.

All chemical and ionic equations must be balanced and have state symbols, unless otherwise stated.

Total marks: 30

1. Here is a description of a titration conducted by two Year 12 ATAR Chemistry students.

   The titration was conducted to determine the concentration of ethanoic acid in vinegar. A secondary standard solution of sodium hydroxide had previously been prepared. The titration had already been conducted correctly once to determine the approximate titre.

   A 20 mL volumetric pipette was rinsed with distilled water and it was then used to transfer a 20.0 mL aliquot of vinegar into the conical flask. The conical flask had previously also been rinsed with distilled water. Two drops of methyl orange were added to the conical flask. The burette was washed with distilled water and then rinsed a final time with a small amount of the sodium hydroxide standard solution. A funnel was placed in the top of the burette and the burette filled almost to the top graduation with standard solution. Leaving the funnel in place for next time, the stop cock was opened and then closed again to clear the air bubble under the stopcock. The volume of standard solution in the burette was read from the top of the meniscus. Standard solution was then allowed to flow slowly through the open stopcock into the conical flask while the conical flask was constantly shaken. When flashes of colour indicated that the endpoint was close, the stopcock was partially closed and the standard solution was added dropwise until a permanent colour change was noted. The stopcock was then closed and the final volume in the burette read from the top of the meniscus.
   This process was repeated two more times and the concordant titres averaged.

   Five errors were made during this titration. Each may have been mentioned in the text above, or it may be something not mentioned that should have been included. Note: Having the base in the burette is NOT one of the errors.

The question continues over the page.

For each of the five errors made during the titration, identify the error, state what the students should have done instead and state whether the error will cause the calculated value of ethanoic acid concentration to be too high, too low or unchanged, assuming that error was the only error made.

(15 marks)

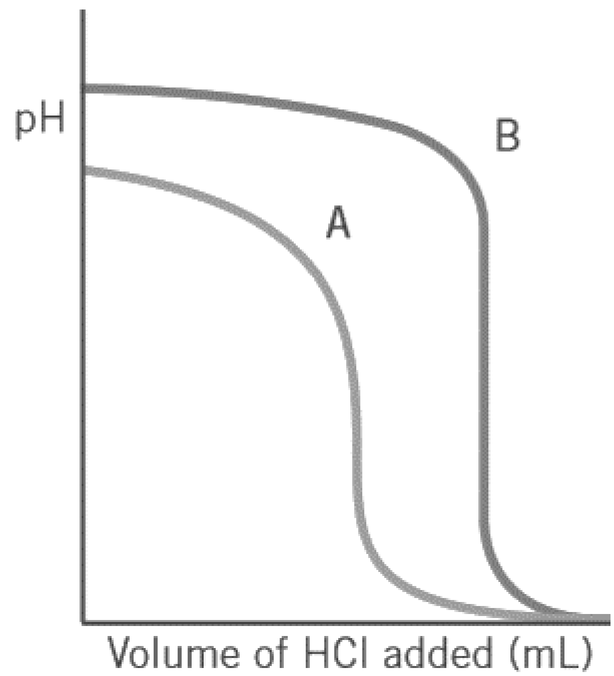
Description of Error	**What the Students Should Have Done Instead? Be as specific as possible.**	**Will the calculated concentration of the ethanoic acid be too high, too low or unchanged?**
Volumetric pipette was (final) rinsed with distilled water.	**Volumetric pipette should have been rinsed with vinegar.**	**Too low.**
The wrong indicator was used.	**The indicator <u>phenolphthalein</u> should have been used.**	**Too low.**
The funnel was left in place during the titration.	**The funnel should have been removed during the titration.**	**Too low.**
The volume of liquid in the burette was read (both times) from the top of the meniscus.	**The volume of liquid in the burette should have been read from the bottom of the meniscus.**	**No change.**
As the endpoint was approached the tip of the burette was not rinsed with distilled water after every drop.	**As the endpoint was approached the tip of the burette should have been rinsed with distilled water after every drop.**	**Too high.**

Other answers may be correct at the teacher's discretion. The box in columns 2 and 3 can only be marked correct if they follow on from a correct answer in column 1.

The point about reading the burette from the top of the meniscus can instead be done as two separate points but the effect on calculated concentration of ethanoic acid must assume that was the only error made.

Initial volume in the burette read from the top of the meniscus	Initial volume in the burette should be read from bottom of meniscus.	Too high
Final volume in the burette read from the top of the meniscus	Final volume in the burette should be read from bottom of meniscus.	Too low

2. The graph below shows the titration curve for the reaction of two different bases with a standard solution of hydrochloric acid.



a. Which of these curves is with the strong base?

(1 mark)

B

b. If 20.0 mL of each of the bases A and B was present at the beginning of the titration, provide two possible reasons for the difference between the volume of acid required to reach the equivalence point in each titration.

(2 marks)

Base B may be more concentrated that Base A (1).
Base B may have more hydroxide ions per formula unit than Base A.

3. Vitamin C tablets contain ascorbic acid, $C_6H_4O_2(OH)_4$. A tablet with a mass of 320 mg is crushed and dissolved in 30.0 mL of water in a conical flask. The contents of the flask are titrated with a 0.0458 mol L^{-1} solution of iodine. Ascorbic acid reacts with iodine according to the unbalanced equation:

$$C_6H_4O_2(OH)_{4(aq)} + I_{2(aq)} \rightarrow C_6H_4O_4(OH)_{2(aq)} + I^-_{(aq)} + H^+_{(aq)}$$

Starch indicator is added to the titration mixture as it turns a deep blue colour when iodine is in excess. The starch indicator changes colour after 24.6 mL of iodine solution has been added. Determine the mass of ascorbic acid in the tablet and hence the percentage by mass of ascorbic acid in the vitamin C tablet.

(3 marks)

$$\mathbf{C_6H_4O_2(OH)_{4(aq)} + I_{2(aq)} \rightarrow C_6H_4O_4(OH)_{2(aq)} + 2I^-_{(aq)} + 2H^+_{(aq)}}$$

$n(I_2) = cV = 0.0458 \times 0.0246 = 1.12668 \times 10^{-3}$ mol
$n(C_6H_4O_2(OH)_4) = n(I_2) = 1.12668 \times 10^{-3}$ mol **(1)**
$m(C_6H_4O_2(OH)_4) = n\,M = 1.12668 \times 10^{-3} \times 176.124$
$= 1.98435 \times 10^{-1}$ g **(1)**
% composition ascorbic acid in Vitamin C tablet
$= \frac{1.98435 \, x \, 10^{-1}}{0.320}$ x 100 = 62 % **(1)**

1 mark off for wrong number of significant figures and/or wrong or missing unit in final answer.

4. A mixture of sodium chloride and anhydrous potassium carbonate with a mass of 0.260 g was made up to 25.00 mL with deionised water. This solution required 13.2 mL of 0.0995 mol L^{-1} hydrochloric acid to reach the equivalence point. What volume of 0.0500 mol L^{-1} $AgNO_3$ solution would be required to precipitate all of the chloride ions (including any chloride ions introduced with the hydrochloric acid) from the resulting solution?

(4 marks)

$2HCl_{(aq)} + K_2CO_{3(aq)} \rightarrow 2KCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$
$n(HCl) = c\ V = 0.0995 \times 0.0132 = 1.3134 \times 10^{-3}$ mol
$n(K_2CO_3) = ½ \times 1.3134 \times 10^{-3} = 6.567 \times 10^{-4}$ mol
$m(K_2CO_3) = n\ M = 6.567 \times 10^{-4} \times 138.21 = 9.07625 \times 10^{-2}$ g

(1)

$m(NaCl) = 0.260 - 9.07625 \times 10^{-2} = 1.69237 \times 10^{-1}$ g

(1)

$n(NaCl) = n(Cl^- \text{ in NaCl}) = \frac{m}{M} = \frac{1.69237 \times 10^{-1}}{58.44}$
$= 2.8959 \times 10^{-3}$ mol
$n(\text{HCl used in titration}) = n(Cl^- \text{ in HCl}) = 1.3134 \times 10^{-3}$ mol
Total $Cl^- = 2.8959 \times 10^{-3} + 1.3134 \times 10^{-3} = 4.20931 \times 10^{-3}$ mol

(1)

$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$
$n(Ag^+ \text{ required}) = n(AgNO_3) = n(Cl^-) = 4.20931 \times 10^{-3}$ mol
$V(AgNO_3 \text{ required}) = \frac{n}{c} = \frac{4.20931 \times 10^{-3}}{0.0500}$
$= 8.4186 \times 10^{-2}$ L OR 84.2 mL

(1)

1 mark off for wrong number of significant figures and/or wrong or missing unit in final answer.

5. Lindane, $C_6H_6Cl_6$, is an insecticide that has been used in the treatment of head lice. On combustion, lindane produces carbon dioxide and hydrogen chloride gases. An impure sample of lindane having a mass of 1.200 g was burnt in oxygen. The hydrogen chloride produced was bubbled through 50.00 mL of 0.946 mol L^{-1} lithium hydroxide. The resulting solution was titrated with a standard solution of 0.500 mol L^{-1} sulfuric acid and a titre of 26.55 mL was required. Calculate the percentage, by mass, of lindane in the impure sample.

(4 marks)

$2LiOH_{(aq)} + H_2SO_{4(aq)} \rightarrow Li_2SO_{4(aq)} + 2H_2O_{(l)}$

$n(H_2SO_4) = c\ V = 0.500 \times 0.02655 = 1.3275 \times 10^{-2}$ mol

n(LiOH after reaction with HCl) = $2 \times 1.3275 \times 10^{-2}$

$= 2.655 \times 10^{-2}$ mol (1)

n(LiOH before reaction with HCl) = c V = 0.946×0.0500
$= 4.7300 \times 10^{-2}$ mol

n(LiOH that reacted with HCl) = $4.7300 \times 10^{-2} - 2.655 \times 10^{-2}$ =
2.0750×10^{-2} mol (1)

$LiOH_{(aq)} + HCl_{(g)} \rightarrow LiCl_{(aq)} + H_2O_{(l)}$

n(HCl) = n(LiOH) = 2.0750×10^{-2} mol

$C_6H_6Cl_6 + 6O_{2(g)} \rightarrow 6HCl_{(g)} + 6CO_{2(g)}$

$n(C_6H_6Cl_6) = \frac{2.0750 \times 10^{-2}}{6} = 3.4583 \times 10^{-3}$ mol (1)

$m(C_6H_6Cl_6) = n\ M = 3.4583 \times 10^{-3} \times 290.808 = 1.00570$ g

Percentage composition = $\frac{1.00570}{1.200} \times 100 = 83.8$ % (1)

1 mark off for wrong number of significant figures and/or wrong or missing unit in final answer.

6. Copying down a single number from the equipment used during a titration usually results in a random error. Give an example where copying down a single number wrong may result in a systematic error.

(1 mark)

Writing down the wrong mass of solid when making up the standard solution.

Other answers may be accepted at the teacher's discretion.

END OF TEST