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Chemistry Paper 3A WASSCE (SC), 2023

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Question 1A

A is 0.100 *mol dm-3* of HCl.
B is 0.030 *mol dm-3* of a trioxocarbonate (IV) salt.
(a) Put **A** into the burette and titrate it with 20.0 cm3 **or** 25.0 cm3 portion of **B** using methyl orange as indicator.
Repeat the titration to obtain **concordant** titre values.
Tabulate your results and calculate the average volume of **A** used.
Put **A** into the burette and titrate it with 20.0 cm3 or 25.0 cm3 portion of **B** using methyl orange as Indicator.
Repeat the titration to obtain concordant titre values.
Tabulate your results and calculate the average volume of **A** used.

(b) From your results and the information provided, calculate the mole ratio of the acid to the trioxocarbonate (IV) in the reaction.

(c) Given that **B** contains 5.0 *g dm-3* of the hydrated trioxocarbonate (IV) salt, calculate the:
(i) concentration of anhydrous salt in **B** in *g dm-3*,
(ii) percentage of water hydration in **B**;
(iii) number of moles of hydrogen ions in the average titre value.
[Molar mass of an anhydrous salt in **B** = 106 g mol-1]

Observation

This question was based on acid-base titration, and was attempted by the majority of the candidates.

In part (a), majority of the candidates correctly calculated the average volume of **A** used.

In part (b), majority of the candidates were unable to calculate the mole ratio of the acid to the trioxocarbonate (IV) in the reaction.

In part (c), few candidates were able to calculate the concentration of anhydrous salt in **B** in *g dm-3*. Also, percentage of water of hydration in **B** was correctly calculated by few candidates.

The expected answers include:

(a) Two concordant titres
Averaging

(b) Amount of acid in A = 0.1 x $\frac{VA}{1000}$
= say a mol
Amount of CO_3^{2-} in B = 0.030 x $\frac{VB}{1000}$
=Say b mol
Mole ratio = a: b
Simpler whole number ratio = A : B

(c) (i) Conc. of anhydrous salt in g dm-3
= molar conc. x molar mass
= 0.030 x 106
= 3.18 g dm-3
(correct to 3 sig. fig to score, wrong unit no score)

(ii) % of water of hydration
$\frac{\text{mass of water of hydration in dm3}}{\text{mass of hydrated salt in dm3}} \times 100$
Mass of water of hydration = 5.0 g dm-3 – 3.18 g dm-3
= 1.82 g
% of water of hydration = $\frac{1.82}{5.0} \times 100$
= 36.4%

(iii) 1 mole of HCl contain 1 mole of H^+
1000 cm3 of A contain 0.1 moles H^+
VAcm3 will contain $\frac{VA \times 0.1}{1000}$
No. of moles of H^+ = 0.0001 VA
Say Q mol

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Candidate's Strength

Question 1B

E is a solution containing 2.92 *g* of HCl per dm3.
F is a solution obtained by diluting 20.0 cm3 of a saturated solution of Y(OH)2 at 25 ºC
per *dm3* of solution.

a. Put **E** into the burette and titrate it against 20.0 cm3 or 25.0 cm3 portion of **F** using phenolphthalein as indicator.

Repeat the titration to obtain **concordan**t titre values.

Tabulate your results and calculate the average volume of acid used.

The equation for the reaction is:
Y(OH)2 + 2HCl -> YCl2 + 2H2O

b. From your results and the information provided, calculate the:

(i) Concentration of HCl in E *mol dm-3*;
(ii) concentration of Y(OH)2 in **F** in *mol dm-3-;*
(iii) solubility of the substance Y(OH)2 in mol dm-3;
(iv) mass of Y(OH)2 that would be deposited if 1 dm3 of saturated solution is evaporated to dryness.

[H=1.0; O =16.0; Cl = 35.5; Y(OH)2 = 74.0]

Observation

This question was on titration experiment. Majority of the candidates that responded to this question performed above average.

In part (a), majority of the candidates obtained concordant values from the titration experiment;

In part (b), majority of the candidates were able to calculate the concentration of HCl in **E** in *mol dm-3* However, they could not calculate the solubility of the substance Y(OH)2 in *mol dm-3*.

The expected answers include:

(a) Two concordant titres
Averaging

(b) (i) Molar mass of HCl = 1 + 35.5
= 36.5 g mol--1
Concentration of **E** = $\frac{2.92}{36.5 \times 1}$
= 0.080 mol dm-3

(ii) From the equation

$$\frac{CEVE}{CFVF} = \frac{2}{1}$$

$$\frac{0.080 \times VE}{CF \times VF} = \frac{2}{1}$$

$$CF = \frac{0.080 \times VE}{2 \times VF}$$

= Say W mol dm-3

(iii) C1V1(Saturated solution) = C2V2 (dilute solution)
C1 x 20 = W x1000

$$C1 = \frac{W \times 1000}{20}$$

= Say X *mold m-3*

Alternative
20cm3 of saturated solution contains W moles
Hence 1000 cm3 of saturated solution = $\frac{W \times 1000}{20}$
= Say X *mol dm-3*

(iv) Mass of Y(OH)2 deposited
= X x molar mass (Y(OH)2)
= X x 74 g
= Z g say

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Question 2A

C is an Inorganic Compound.
D is an inorganic compound.
Carry out the following exercises on **C** and **D**.
Record your observations and identify any gas(es) evolved. State the conclusions you draw from the results of **each** test.

(a) Put **C** Into a test tube and add about 5 cm3 of distilled water and shake well. Divide the solution into **two** portions.
(i) Test the **first** portion with a litmus paper.
(ii) To the **second** portion, add about 1 cm of Fehling's solution, **A** and **B** and heat.

(b) Divide **D** into two portions.
(i) Put the **first** portion into a dry boiling tube and heat and then allow to cool.
(ii) Add about 5 *cm3* of dilute HCl to the second portion and heat, allow it to cool and filter necessary. Divide the resulting solution into **two** portions.
(ii) To the first portion from 2*(b)*(ii), add NaOH(aq) in drops and then in excess.
(iii) To the **second** portion from 2*(b)*(ii), add aqueous NH3 in drops and then in excess.

Observation

This question was attempted by majority of the candidates and their performance was above average.

In part (a), majority of the candidates tested the find portion of the solution with litmus paper, but some of them did not write the correct inference.

In part (b), majority of the candidates did not adhere to the instructions, and made them to lose marks.

The expected answers include:

C= Glucose D =ZnO

	TEST	OBSERVATION	INFERENCE
(a)	**C** + distilled water	Dissolved to form colourless solution	C is a soluble compound
(i)	C(aq) + litmus paper	No effect on litmus papers (red/blue)	Solution of C is neutral
(ii)	C(aq) + Fehling's solution + heat	A brick-red precipitate is formed	Reducing sugar/ reducing agent is present
b(i)	D + heat + cool	Solid turned yellow when hot, and turned white when cool	ZnO present
(ii)	**D** + HCl(aq) + heat	**D** dissolved to form a colourless solution	**D** is a base/basic oxide
(iii)	1st portion from b(ii) + NaOH(aq) in drops then in excess	A white gelatinous precipitate formed, Dissolves	Zn^{2+}, Al^{3+} may be present Al^{3+}, Zn^{2+} **(both ions must be present to score)**
(iv)	2nd portion from b(ii) + NH_3(aq) in drops then in excess	White gelatinous precipitate formed precipitate dissolved	Zn^{2+}, Al^{3+} Zn^{2+} is present

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Question 2B

G is an inorganic salt. Carry out the following exercises on G

Record your observations and identify any gas(es) evolved.
State the conclusions you draw from the results of **each** test.

(a) Dissolve all of **G** in about 10 cm3 of distilled water in a boiling tube

(b) (i) Test the resulting solution with litmus paper.
(ii) To about 2 cm3 portion of the solution in a test tube, add NaOH(aq). Then warm the resulting mixture gently.
(iii) To another 2 *cm3* portion of the solution, add dilute HNO3.
(Iv) To 2*cm3* portion of the solution, add BaCl2(aq) followed by excess dilute HNO3.

Observation

The performance of the candidates was below average in this question.

In part (a), majority of the candidates dissolved G in about 10 cm3 of distilled water in a boiling tube.

In part (b), majority of the candidates did not adhere to the instructions, and this affected their performance.

The expected answers include:

	TEST	OBSERVATION	INFERENCE
(a)	G + distilled water	Colourless solution obtained	
(b)	Solution of G + litmus papers	Turn red litmus blue	G(aq) is alkaline/ basic

(c)	Solution of G + NaOH(aq) Mixture warmed	No precipitate formed / no visible reaction Colourless gas with pungent /chocking / irritating smell evolved Gas turned red litmus paper to blue / formed dense white fumes with conc HCl	Gas is NH3 from NH4+
(i)	Solution of G + HNO3(aq)	Effervescence, gas evolved colourless, odourless Gas turned lime water milky	Gas is CO2 from CO32-/ HCO3- present
(ii)	Solution of G + BaCl2(aq) + HNO3(aq)	White (Chalky) precipitate formed Precipitate dissolved (with rapid effervescence)	CO32- SO32- SO42- CO32- present

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Question 3A

a. State what would be observed if few drops of NaOH solution is added to 2 cm3 c solutions of **each** of the following salts:
   i. Pb(NO3)2;
   ii. Fe2(SO4)2.

[2 marks]

b. Describe **briefly** how the melting point of benzoic acid could be determined in th laboratory.

[6 marks]

Observation

This question was based on the knowledge of Test of Practical, and was poorly answered by the candidates.

In part (a), majority of the candidates could not state what would be observed if few drops of NaOH solution is added to 2 cm3 of solutions of Pb(NO3)2 and Fe2(SO4)2.

In part (b), majority of the candidates could not describe how the melting point of benzoic acid could be determined in the laboratory.

The expected answers include:

a. (i) White (chalky) precipitate is formed
   ii. (Reddish) brown (gelatinous) precipitate is formed

(b) A small quantity of benzoic acid crystals is placed into a capillary tube sealed at one end the filled capillary tube is tied to a thermometer**.**
The set-up is clamped and lowered into a beaker half filled with liquid paraffin**.**
The beaker is heated gently over Bunsen flame and the rise in temperature observed
The temperature at which the crystal begins to liquefy (ti) and also the temperature at which it is completely liquefied (t2) are noted**.** The melting point is the range (t1 –t2) °C.

Alternatives

- Place a small quantity of the powdered benzoic acid into a capillary tube sealed at one end**.** Tie it to the thermometer such that the bulb of the thermometer is completely

immersed in the beaker, that is half filled with liquid paraffin and placed on a tripod stand with wire gauze.
- Heat the content of the beaker gently with constant stirring of the liquid paraffin
- Note the temperature at which the benzoic acid melts**.**
- Repeat the process using a fresh/ new benzoic acid until the readings agree within 2.0°C.

For candidates using melting point apparatus:

Grind the benzoic acid into powder
Fill the capillary tube with the powder and insert into the melting point apparatus
Heat the set up gradually and note the temperature at which the benzoic acid just melts
Read/record the temperature of the thermometer
Repeat the process using fresh powder until two melting points agree within 2.0oC

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Question 3B

(a) Determine the volume of water that should be added to 100 cm3 of 0.5 *mol dm3* HCl in order to obtain 0.3 *mol dm*-3 HCl. [5 marks]

(b) Describe briefly a chemical test to distinguish between dilute HCl and dilute HNO3. Support the test with relevant equation. [6 marks]

Observation

Majority of the candidates responded to this question but their performance was below average.

In part (a), majority of the candidates could not solve this question.

In part (b), majority of the candidates could not describe a chemical test to distinguish between HCl and dilute HNO3.

The expected answers include:

(a) C1VI = C2V2
0.5 x 100 = 0.3 x V2
V2 = $\frac{0.5 \times 100}{0.3}$
= 166.67 cm3
(accept 166.7 / 167)
Volume of water = 166.67 – 100
= 66.67 cm3

(b) Add AgNO3(aq) to each of the solutions in a test tube. Formation of a white precipitate
indicates that the solution is HCl, if no precipitate is formed then the solution is HNO3
AgNO3 + HCl → AgCl + HNO3

OR

Heat each sample in a test tube
Brown gas/ fumes indicates HNO3, no brown gas / fumes indicate HCl

$4HNO_3 \rightarrow 2H_2O + 4NO_2 + O_2$

OR

To each sample in a test tube, add fresh $FeSO_4(aq)$, followed by conc. H_2SO_4 along the
side of the test tube: brown ring indicates HNO_3, no brown ring indicates HCl
$FeSO_4 + NO \rightarrow FeSO_4.NO$

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