2022 H2 Chemistry Preliminary Examination Paper 4

Suggested Answers

- 1 Investigation of the oxidising ability of substances
 - (a) (i) Table 1.1

Test		Observations		
1	To a 1 cm depth of FA 1 in a test-tube, add 1 cm depth of FA 4 , then gradually add FA 2 till 1 drop in excess.	Purple FA 2 <u>decolourised</u> . <u>Pale green/colourless</u> FA 1 turned pale <u>yellow</u> and finally <u>orange/ pink</u> .		
2	To a 1 cm depth of FA 3 in a test-tube, add 1 cm depth of FA 2 .	 Purple KMnO₄ decolourised. A brown solution/ppt formed. Effervescence/ bubbles of gas evolved rapidly. Colourless, odourless gas evolved relight a glowing splint. The gas is oxygen. 		
3	To a 1 cm depth of FA 1 in a test-tube, add about 1 cm depth of FA 4 , followed by 1 cm depth of FA 3 . To a portion of resulting solution, add aqueous sodium hydroxide till excess.	Pale green/colourless FA 1 turned <u>yellow</u> . Red-brown ppt formed is insoluble in excess NaOH(aq). Effervescence/ bubbles of gas evolved (rapidly).		

(ii) Purple MnO₄⁻ oxidised (pale green) iron(II) to (yellow) iron(III) ions.

Itself is reduced to colourless Mn²⁺. (reject pale Mn2+)

(iii) $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^{-}$

 $Fe^{3+}(aq) + 3OH^{-}(aq) \rightarrow Fe(OH)_{3}(s)$

(iv) Compound A / FA 3

(b) (i) Titration results

Titration number	1	2
Final burette reading /cm ³	24.20	24.25
Initial burette reading /cm ³	0.00	1.00

(ii) average volume of FA 2 (added) /cm³ 24.20 24.25
(ii) average volume of FA 2 used =
$$\frac{24.20 + 24.25}{2}$$

= 24.23 cm³
(c) (i) [KMnO₄] = $\frac{0.750}{39.1 + 54.9 + (4 \times 16.0)} \times \frac{1000}{250} = 0.01899 \text{ mol dm}^{-3}$

amount of MnO₄⁻ =
$$0.01899 \times \frac{V_{FA2}}{1000}$$
 mol

(ii) amount of Fe²⁺ in 25.0 cm³ = (c)(i)
$$\times \frac{5}{1}$$
 mol

$$[Fe^{2+}] = (C)(i) \times \frac{5}{1} \times \frac{1000}{25.0} \mod dm^{-3}$$
$$= 0.0920 \mod dm^{-3}$$

(d) Identify the cause: Chloride is oxidised by/ reacts with MnO₄-

And any one of the following modification : M16

- The titration needs to be carried out in the fumehood. Chloride is oxidised by MnO₄⁻ to give toxic chlorine gas.
- Iron(II) chloride needs to be diluted prior to titration. The titre will exceed 50.00 cm³ if iron(II) chloride is not diluted.
- Prepare higher concentration of MnO₄⁻ for used. The titre will exceed 50.00 cm³ if **FA 2** with original concentration is used.
- Using a smaller pipette/ burette, measure a smaller volume of iron(II) chloride for titration, so that the titre will not exceed 50.00 cm³.

 $(5FeCl_2(aq) + 3MnO_4^{-}(aq) + 24H^{+}(aq) \rightarrow 5Fe^{3+}(aq) + 5Cl_2(g) + 3Mn^{2+}(aq) + 12H_2O(I))$

- (e) (i) As V_{FA3} increases, more compound A/FA 3 was added to oxidise Fe^{2+} in FA 1. This leaves less Fe^{2+} to be oxidised by MnO_4^- in FA 2.
 - (ii) Not an anomaly.
 - (Compound A in FA 3 is both an oxidising and reducing agent.)
 - In experiment 5, compound **A** is in <u>excess</u>/ Fe²⁺ is <u>limiting</u>.
 - The (excess) compound **A** is <u>oxidised by MnO₄-</u>.

(iii) percentage uncertainty =
$$\frac{2 \times 0.05}{1.25} \times 100 = 8.0$$
 %

2 Results

Expt	V _{FA 5} / cm ³	$V_{\rm H_{2}O}/{\rm cm^{3}}$	Reaction time, t /s	lg(V _{FA 5})	lg (rate)
1	20.00	0.00	15.1	1.30	2.38
2	10.00	10.00	56.5	1.00	1.80
3	15.00	5.00	26.9	1.18	2.13
4	6.00	14.00	144.5	0.778	1.40



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(c) (i) Gradient of line =
$$\frac{1.40 - 2.20}{0.78 - 1.21}$$

= 1.86 (3 s.f.)
m = 2 (nearest integer)
(ii) From graph, when lg(7.9) = 0.898,
lg($\frac{3600}{\text{reaction time}}$) = 1.62

reaction time =
$$\frac{3600}{10^{1.62}}$$
 = 86.4 s

(d) (i) Experiment 1: [KI] =
$$0.0500 \times \frac{20.00}{60.00} = 0.016667 \text{ mol dm}^{-3}$$

Experiment 2: [KI] =
$$0.0500 \times \frac{10.00}{60.00} = 0.008333 \text{ mol dm}^{-3}$$

$$\frac{20.00}{10.00} = \frac{0.016667}{0.008333} = 2$$

(ii) Using results of experiment 1 and 2,

$$\frac{\text{rate in experiment 1}}{\text{rate in experiment 2}} = \frac{\frac{3600}{t_1}}{\frac{3600}{t_2}} = \frac{56.5}{15.1} = 3.74 \approx 4$$

When [KI] doubled, rate of experiment 2 is 4 times that of experiment 1.

(e) (i)
$$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(aq/g) + H_2O(l)$$

(ii) Not as good as that in (a). With any of the following reasons:

- There is <u>less thiosulfate left</u> in the reaction mixture <u>to react with</u> <u>iodine formed/ so shorter time recorded</u>. (or words to the effect)
- More time is needed to transfer the content in measuring cylinder/ 20.00 cm³ of solution into the beaker for mixing

Or

As good as that in (a). With any of the following reasons:

- $[S_2O_3^{2-}]$ is very small, so reaction with iron(III) ions/H⁺/acid will be very slow and negligible.
- $[S_2O_3^{2-}]$ decrease by similar extent for each experiment, the relative rate of experiments is not affected.

3 (a)

Test		Observations	
1	Place a test-tube containing 2 cm depth of FA 9 in an almost boiling water bath for a few minutes.	Blue/ bluish-green FA 9 turned green.	
2	To a 2 cm depth of FA 9 in a test-tube, add gradually add 2 cm depth of FA 10 . Pour half of this mixture into another test- tube and place it in the almost boiling water bath for a few minutes for comparison	 (Blue/ bluish-green) FA 9 turned green upon adding FA 10. The resultant solution turned yellowish-green/ brighter green after warming. 	
3	To a 1 cm depth of FA 9 in a boiling-tube, gradually add 3 cm depth of aqueous sodium hydroxide. Filter the resultant mixture and collect the filtrate. Keep the filtrate for Test 4.	<u>Pale blue/ Blue-green/greenish-blue</u> <u>ppt_</u> formed is <u>insoluble in excess</u> NaOH(aq). The residue is dark <u>blue</u> . The filtrate is a <u>colourless</u> solution.	
4	To a 1 cm depth of filtrate in a test-tube, add 1 cm depth of nitric acid, followed by AgNO ₃ (aq). To a portion of the resultant mixture, add NH ₃ (aq).	White ppt formed with AgNO ₃ (aq) is soluble in aqueous ammonia to give a colourless solution.	

- (b) (i) Cation Copper(II) ion/Cu²⁺
 - (ii) Either one of the following:
 - Colour of the white ppt cannot be seen clearly in dark-coloured **FA 9** solution.
 - Addition of NH₃(aq) could precipitate/form dark blue complex with Cu²⁺ if present.

(c) (i) $[CuCl_4]^{2-}$

In Test 2, when **FA 10**/ saturated NaY/Y⁻ is added to **FA 9**, a yellow complex is formed.

The solution is green due to presence of both blue and yellow complexes/ The solution turned green due to more yellow complex formed.

(ii) The conversion of blue to yellow complex is an <u>endothermic</u> process.

Upon warming, the <u>formation of yellow complex is favoured</u>/ <u>POE of</u> <u>Equation 1 shift to the right</u> to <u>absorb</u> some of the added <u>heat</u>.

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4 (a) (i) $H^+(aq) + OH^-(aq) \rightarrow H_2O(I)$

(ii)

Amount of OH⁻ in 25.0 cm³ = $2 \times 1.00 \times \frac{25.00}{1000}$

= 0.0500 mol

Volume of HC*l* required for complete neutralisation = $\frac{0.0500}{1.50} \times 1000$ = 33.33 cm³

Heat evolved = 57 000 \times 0.0500 = (25.0 + 33.33) \times 4.18 \times ΔT ΔT = 11.7 °C

(b) Procedure

- 1. Fill a 50.00 cm³ burette to 0.00 cm³ mark with 1.50 mol dm⁻³ HC*l*(aq).
- 2. Place a Styrofoam cup in a 250 cm³ beaker to prevent it from toppling.
- 3. Pipette 25.0 cm³ Ba(OH)₂ into the Styrofoam cup.
- 4. Using a thermometer, measure and record the initial temperature of the Ba(OH)₂, **T**_{initial}.
- 5. Place a lid on the Styrofoam cup to minimise heat loss to the surroundings.
- 6. Run 5.00 cm³ of HC*l*(aq) from the burette into the cup though an opening in the lid, stir the solution carefully with the thermometer and record the highest temperature reached, T.
- 7. Immediately run a further 5.00 cm^3 of HC*l*(aq) from the burette into the cup, stir and record the highest temperature reached, T.
- 8. Continue the addition of HC*l*(aq), in 5.00 cm³ portions, until 50.00 cm³ have been run from the burette.

Recognition of Equivalence Point

After equivalence point, highest temperature reached will be lower for each portion of HCl(aq) added.

- M47 Appropriate apparatus for volumes measurement
- M48 Details for measurement of volumes using burette
- M49 Measurement of temperatures
- M50 Ensuring accuracy
- M51 Recognition of equivalence point

(c) (i)



(ii) M53 – Explain T rise due to more reaction occurs.

Initially as V_{HCl} increases, larger amount of Ba(OH)₂ is neutralised to produce more heat. Therefore, T increases.

M54 – Explain T fall

(After equivalence point, Ba(OH)₂ is completely neutralised.)

Either one of the following:

- Same amount of heat is distributed over an increasingly larger total volume of solution, causing T to fall.
- <u>Excess</u> HC*l* <u>at lower temperature/ room temperature</u> cools down the mixture.