Class | Adm No

Class	Adm No

Candidate Name: ____________________

H

millennia institute

Shift
Laboratory

2020 Preliminary Examinations
Pre-University 3

H2 CHEMISTRY **9729/04**

Paper 4 Practical **31 Aug 2020**

2 hour 30 mins

Candidates answer on the Question paper.

READ THESE INSTRUCTIONS FIRST

Do not turn over this question paper until you are told to do so

Write your name, class and admission number on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

Qualitative Analysis Notes are printed at the back of the Question Paper.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

Question	**1**	**2**	**3**	Total
Marks	/ **27**	/ **13**	/ **15**	/ **55**

For Examiners' Use

1 Determination of the order of reaction with respect to H_2O_2

Hydrogen peroxide, H_2O_2, reacts with iodide ions, $I^-(aq)$, to form iodine, $I_2(aq)$.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \longrightarrow 2H_2O(l) + I_2(aq)$$

The rate of this reaction can be measured by adding acidified hydrogen peroxide, H_2O_2, to a mixture of iodide ions, I^-, thiosulfate ions, $S_2O_3^{2-}$, and starch indicator. The iodine, I_2, produced from the reaction between acidified H_2O_2 and I^- can be reacted immediately with thiosulfate ions, $S_2O_3^{2-}$.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

When all the thiosulfate has reacted, the iodine produced will then turn the starch indicator blue-black. The rate of the reaction can therefore be measured by the time taken for the reaction mixture to turn blue-black colour.

FA 1 is 0.180 mol dm^{-3} hydrogen peroxide, H_2O_2.
FA 2 is 0.200 mol dm^{-3} aqueous potassium iodide, KI.
FA 3 is 0.0100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FA 4 is 0.500 mol dm^{-3} aqueous sulfuric acid, H_2SO_4.
starch indicator

(a) Procedure

Experiment 1

1. Fill a burette with **FA 1**.
2. Run 20.00 cm^3 of **FA 1** from the burette into a 100 cm^3 beaker.
3. Using a suitable measuring cylinder, measure 10 cm^3 of **FA 4** and transfer into the same 100 cm^3 beaker.
4. Using suitable measuring cylinders, transfer the following into another 100 cm^3 beaker.
   - 10 cm^3 **FA 2**
   - 20 cm^3 **FA 3**
   - 5 cm^3 of starch indicator
5. Add the contents of the second beaker to the first beaker and start the stopwatch.
6. Place the beaker on a white tile and stir the mixture once using a glass rod.
7. Observe the solution and stop the stopwatch when the solution turns blue-black.
8. Record the time taken to the **nearest second**.
9. Wash both beakers thoroughly with water and drain.

Experiment 2

10. Fill the other burette with distilled water.

11. Run 6.00 cm^3 of **FA 1** into a 100 cm^3 beaker.

12. Run 14.00 cm^3 of distilled water into the same beaker.

13. Add 10 cm^3 of **FA 4** into the same beaker.

14. Using suitable measuring cylinders, transfer the following into another 100 cm^3 beaker.

- 10 cm^3 **FA 2**
- 20 cm^3 **FA 3**
- 5 cm^3 of starch indicator

15. Add the contents of the first beaker to the second beaker and start the stopwatch.

16. Place the beaker on a white tile and stir the mixture once using a glass rod.

17. Observe the solution and stop the stopwatch when the solution turns blue-black.

18. Record the time taken to the **nearest second**.

19. Wash both beakers thoroughly with water and drain.

Experiment 3 – 5

Carry out three further experiments to investigate how the reaction time changes with different volumes of **FA 1**, keeping the volumes of **FA 2**, **FA 3**, **FA 4** and starch indicator constant. Do not use a volume of **FA 1** that is less than 6.00 cm^3 and the total volume of the reaction mixture must always be kept at 65 cm^3 by adding distilled water.

For each **Experiments 1 – 5**, you are to record all your results in a single table. You should include the volume of **FA 1** used, the volume of distilled water used and the time taken for the blue-black colour to appear.

Results

M1

M2

M3

M4

M5

(b) **(i)** Calculate the amount of thiosulfate ions, $S_2O_3^{2-}$ used in each experiment.

Amount of $S_2O_3^{2-}$ =……………………… **M6**

(ii) Calculate the amount of H_2O_2 that were used to produce the amount of iodine that reacted with the amount of $S_2O_3^{2-}$ in **(i)**.

Amount of H_2O_2 =……………………… **M7**

(iii) Using your answer to **(ii)**, calculate the change in concentration of H_2O_2 up to the time of appearance of the blue-black colour using the following formula:

$$\text{Change in concentration of } H_2O_2 = \frac{\text{amount of } H_2O_2 \text{ reacted}}{\text{total volume of reaction mixture, in dm}^3}$$

M8

Change in concentration of H_2O_2 =………………………

(iv) The following formula can be used as a measure of the 'rate of reaction'.

$$\text{'rate of reaction'} = \frac{\text{change in concentration of } H_2O_2}{\text{time taken for solution to turn blue-black}} \times 10^5$$

Complete the table in **(a)** to include the rate in **Experiments 1 – 5**. **M9**

(c) On the grid, plot the rate against the volume of **FA 1**. Draw a line of best fit through the points.

M10

M11

M12

(d) Deduce the order of reaction with respect to H_2O_2.

Order of reaction with respect to H_2O_2 =…………………….. **M13**

(e) Explain why a fixed amount of sodium thiosulfate is required.

………………………………………………………………………………………………

……………………………………………………………………………………………… **M14**

(f) Instead of washing and draining the conical flask as required in **step 9** of **(a)**, another student simply just poured away the reaction mixture. There was some leftover reaction mixture in the flask when he continued using it for **Experiment 2**.

State and explain the effect on time, **t**, in his **Experiment 2**.

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……………………………………………………………………………………………… **M15**

(g) Planning

The concentration of a coloured chemical species can be determined by spectrometry where a small volume of the solution is placed inside a machine called spectrophotometer. This machine measures the amount of light that is absorbed when a specific wavelength of visible light is shone through a coloured solution, held in a glass sample holder called a cuvette.

The amount of light absorbed is expressed as an absorbance value. The more concentrated the solution, the higher the absorbance value.

Based on Beer-Lambert's Law, the absorbance values, A, is directly proportional to the concentration of absorbing species, c.

The general Beer-Lambert's Law is usually written as $A = \varepsilon c l$

where ε is the molar extinction coefficient and l is the path length, which is usually 1.0 cm.

This equation can be used to calculate the absorbance value when the concentration of iodine solution is known.

You may assume that you are provided with the following in the subsequent parts of the question.

- Iodine solid
- **FA 5**: unknown concentration of aqueous iodine
- access to a spectrometer
- the apparatus and chemicals normally found in a school or college laboratory.

This technique can be used to determine the concentration of a solution of aqueous iodine. A series, of known, but different concentrations of aqueous iodine is prepared. A spectrometer is used to measure the absorbance of each solution. A graph of absorbance against concentration is then plotted. This graph is known as the calibration line.

The experiment is then repeated using a solution of unknown concentration. By comparing the absorbance of this solution with the calibration line, the concentration of iodine in the unknown solution can be determined.

Devise a plan on how you would prepare:

- 100 cm^3 of 1.00 mol dm^{-3} standard aqueous iodine
- A suitable range of diluted solutions of accurate concentrations

You are to show detailed calculations and suitable tables (where appropriate) in your answer.

(i) Prepare 100 cm^3 of 1.00 mol dm^{-3} standard aqueous iodine.

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…………………………………………………………………………………………………… **M16**

…………………………………………………………………………………………………… **M17**

…………………………………………………………………………………………………… **M18**

(ii) A suitable range of diluted solutions of accurate concentrations, keeping the total volume of each solution constant at 20.00cm^3.

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.... **M19**

.... **M20**

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(iii) Using the solutions prepared in **(g)(ii)**, the absorbance value of each aqueous iodine solution can be determined and hence a calibration line can be obtained.

Describe a plan to determine the concentration of **FA 5**.

Your plan should include details of:

- calculation of the absorbance value for each aqueous iodine solution prepared in **(g)(ii)**, given **ε** of I_2(aq) is 1.96×10^4 $mol^{-1}\,dm^3\,cm^{-1}$.
- a sketch of the calibration line you would expect to obtain;
- a brief outline of how the results would be obtained.
- how the calibration line would be used to determine the concentration of aqueous iodine in **FA 5**.

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.... **M21**

.... **M22**

.... **M23**

.... **M24**

(h) Given that the absorbance for **FA 5** is 3000, calculate the concentration of **FA 5**.

concentration of **FA 5** = …………………………………… M25

(i) State the safety hazard involved in the experiment described in **(g)** and suggest the precaution to overcome it.

………

……… M26

……… M27

[Total: 27]

2 Determining the identity of halogen X in CH_2XCO_2H

For Examiners' Use

You will determine the identity of the halogen in compound **P**. Compound **P** is the halogenoethanoic acid CH_2XCO_2H, where X is a halogen.

4.50 g of **P** were heated with 250 cm^3 of 0.400 mol dm^{-3} aqueous potassium hydroxide. Some of the potassium hydroxide reacted with compound **P**. The remaining solution after the reaction is labelled as **FA 6**.

By titrating **FA 6** with hydrochloric acid, you will determine how much of the potassium hydroxide remained after reaction with **P**. You will them calculate how much potassium hydroxide had reacted and use this to determine the identity of X in CH_2XCO_2H.

FA 6 is aqueous potassium hydroxide after reaction with **P**.

FA 7 is 0.100 mol dm^{-3} dilute hydrochloric acid.

Thymolphthalein indicator

(a) Procedure:

1. Fill the burette with **FA 7**.
2. Pipette 25.0 cm^3 of **FA 6** into a conical flask.
3. Add about 5 drops of thymolphthalein indicator.
4. Titrate **FA 6** with **FA 7**.
5. Repeat the titration as many times as you think necessary to obtain consistent results.
6. Record in the space below, all of your burette readings and the volume of **FA 7** added.

Results

M28

M29

M30

(b) From your titration results, obtain a suitable value for the volume of **FA 7** to be used in your calculations. Show clearly how you obtained this value.

volume of **FA 7** used = ………………… **M31**

(c) A halogenoethanoic acid reacts with aqueous potassium hydroxide in two reactions.

$$KOH + CH_2XCO_2H \rightarrow CH_2XCO_2K + H_2O$$

and

$$KOH + CH_2XCO_2K \rightarrow CH_2(OH)CO_2K + KX$$

(i) Name the two types of reaction shown in the equations above.

……………………………………. and ……………………………….. **M32**

(ii) Calculate the amount of hydrochloric acid, present in the volume of **FA 7** calculated in **(b)**.

amount of HC*l* = ………………………… mol

Hence deduce the amount of potassium hydroxide present in 25.0 cm^3 of **FA 6**.

amount of KOH in 25.0 cm^3 of **FA 6** = ………………………… mol **M33**

(iii) Calculate the amount of KOH added to the 4.50 g of **P**.

amount of KOH added to 4.50 g of **P** = …………………………. mol **M34**

(iv) Calculate the amount of potassium hydroxide that **remained after** the reaction with compound **P**.

M35

amount of KOH remaining after reaction with **P** = ………………………….. mol

(v) Calculate the amount of potassium hydroxide that reacted with 4.50 g of **P**.

amount of KOH reacted with 4.50 g of **P** = ………………………….. mol

Hence calculate the amount of **P** in the 4.50 g sample.

M36

amount of **P** in 4.50 g = …………………………… mol

(vi) Use your answer to **(v)** to calculate the molar mass of **P**.

M37

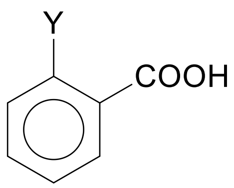
molar mass of **P** = ………………………….. g mol^{-1}

(vii) Deduce the atomic mass of X and determine the identity of X.

atomic mass of X = ……………. g mol^{-1} **M38**

identity of X = …………………….. **M39**

(d) Another halogen-containing compound, **Q**, has the structure shown below. Y is a halogen.



Q

Explain why the method used in this experiment is unable to determine the identity of Y.

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………………………………………………………………………………………………… **M40**

[Total: 13]

For Examiners' Use

3 Qualitative Analysis

Before you carry out the tests below, you are to half fill the 250 cm^3 beaker with water. Heat to approximately 70 °C, then turn off the hot plate. This will be used as a water bath.

(a) **FA 8** is an aqueous solution of an organic compound. Carry out the following tests on **FA 8** and record your observations in the table.

(i)

Test	Observations	
To a 1 cm depth of **FA 8** in a test-tube, add a small spatula of sodium carbonate.		**M41**
To a 1 cm depth of **FA 8** in a test-tube, add two drops of acidified potassium manganate(VII). Leave to stand in the water bath.		**M42**
To a 1 cm depth of **FA 8** in a test-tube, add a few drops of aqueous silver nitrate.		**M43**
To a 1 cm depth of aqueous silver nitrate in a test-tube, add a few drops of aqueous sodium hydroxide and then add aqueous ammonia slowly until the grey precipitate that forms **just** dissolves. This is Tollens' reagent. To this solution, add a 1cm depth of **FA 8** and leave to stand in the water bath.		**M44**

[4]

(ii) Suggest **two** functional groups that could be present in **FA 8**.

………………………………………. and ………………..……………………… [1] **M45**

(b) **(i)** **FA 9** is a solution of an unknown ionic compound containing either aluminium(III) ions, Al^{3+}(aq), or zinc(II) ions, Zn^{2+}(aq).

With reference to the Qualitative Analysis Notes, plan a simple chemical test to determine the identity of the cation in **FA 9**. Carry out the test and record your observations.

Hence state the identity of the cation in **FA 9**.

Procedure	**Observations**

[2] **M46** **M47**

Identity of cation in **FA 9**: ……………………… [1] **M48**

(ii) **FA 10** is a solution of a potassium compound. The anions in **FA 9** and **FA 10** are different and are listed in the Qualitative Analysis Notes.

Carry out the following tests on **FA 9** and **FA 10** and record your observations in the table.

Test	Observations with **FA 9**	Observations with **FA 10**
To a 1 cm depth in a test-tube, add a few drops of acidified potassium manganate(VII).		
To a 1 cm depth in a test-tube, add a few drops of aqueous barium nitrate.		

M49

M50

To a 1cm depth in a boiling tube, add an equal volume of aqueous sodium hydroxide. Warm **carefully** using the water bath.		
Then, add aluminium foil.		

M51

M52

[4]

(iii) From your observations, suggest the anions present in **FA 9** and **FA 10**.

Anion in **FA 9** ……………………………………… M53

Anion in **FA 10** ……..……………………………… [2] M54

(iv) Give the ionic equation, with state symbols, for any reaction observed in **(b)(ii)**.

………………………………………………………………………………………… [1] M55

[Total: 15]

END OF PAPER

Qualitative Analysis Notes

[ppt. = precipitate]

(a) Reactions of aqueous cations

cation	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq),	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. insoluble in excess	green ppt. insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. insoluble in excess	off-white ppt. insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

(b) Reactions of anions

ions	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives pale cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq))
nitrate, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-}(aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in dilute strong acids)

(c) Test for gases

ions	*reaction*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns aqueous acidified potassium manganate(VII) from purple to colourless

(d) Colour of halogens

halogen	*colour of element*	*colour in aqueous solution*	*colour in hexane*
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange	orange-red
iodine, I_2	black solid / purple gas	brown	purple

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Key

atomic number atomic symbol name relative atomic mass

Group																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3											13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –