Class | Adm No

Candidate Name: _____

H

millennia institute

Shift
Laboratory

2022 Preliminary Examinations
Pre-University 3

H2 CHEMISTRY **9729/04**

Paper 4 Practical **31 Aug 2022**

2 hours 30 min

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	4	Total
Marks	/13	/17	/12	/13	/55

1 Determination of amount of water of crystallization in $CuSO_4 \cdot nH_2O$

Copper is a transition metal capable of exhibiting variable oxidation states. Compounds containing Cu^{2+} ions tend to be relatively stable.

Cu^{2+} ions react with excess potassium iodide, KI, to produce iodine, I_2, and a stable precipitate, CuI. To determine the concentration of Cu^{2+} via iodometric titration, all the Cu^{2+} ions are reduced to Cu^{+} ions. A brown suspension, made up of an off-white precipitate of CuI in a brown solution of I_2, will be produced.

equation 1 $\quad 2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$

I_2 has a relatively low solubility in water. However, the presence of an excess of I^{-} ions in the reaction mixture allows the soluble tri-iodide ion, I_3^{-}, to form as shown by equation 2. This ensures that the I_2 formed as shown in equation 1 is fully dissolved.

equation 2 $\quad I_2 + I^{-} \rightarrow I_3^{-}$

The I_3^{-} ions formed may be titrated against a standard solution of $Na_2S_2O_3$ as shown in equation 3.

equation 3 $\quad I_3^{-} + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 3I^{-}$

The solution should be titrated immediately after addition of KI because the I_2 may be adsorbed onto the CuI precipitate, rendering the end-point less sharp.

You are provided with:

FA 1 is solid hydrated copper(II) sulfate, $CuSO_4 \cdot nH_2O$, where *n* is an integer

FA 2 is 0.10 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$

FA 3 is 1.00 mol dm^{-3} potassium iodide, KI

FA 4 is 10% potassium thiocyanate, KSCN

Starch indicator

The presence of thiocyanate ion, SCN^{-}, in the titration mixture near to the end-point will have an impact on the accuracy of the results. The procedure described is designed to improve on the accuracy.

In this experiment, you will determine the amount of water of crystallisation in 1 mol of $CuSO_4 \cdot nH_2O$. You will titrate **FA 1** against **FA 2**.

(a) Procedure

Preparation of solution of FA 1

1. Weigh accurately about 5.0 g of **FA 1** in a weighing bottle. Record your readings in an appropriate manner in the space provided below.
2. Transfer all the solid into a 250 cm^3 beaker. Dissolve this solid in about 100 cm^3 of deionised water.
3. Transfer the solution to a 250 cm^3 volumetric flask. Rinse the beaker with deionised water several times, adding each rinsing to the volumetric flask.
4. Make up the solution to 250 cm^3 with deionised water. Stopper, invert and shake well to obtain a homogenous solution. Label this solution as **FA 1 solution**.

Results

Mass of empty weighing bottle /g	**4.10**
Mass of weighing bottle + FA1 /g	**9.11**
Mass of weighing bottle + residual FA1 /g	**4.11**
Mass of FA1 /g	**5.00**

[2]

M1: All masses consistently recorded to 2 (or 3) decimal places and correct mass headers **M1**
M2: Mass of FA 1 used correctly calculated and Mass of FA 1 used 5.00 ±0.05 **M2**

(b) Titration

1. Fill the burette with **FA 2**.
2. Use a pipette to transfer 25.0 cm^3 of **FA 1** solution into a 250 cm^3 conical flask.
3. Use a measuring cylinder to add about 15 cm^3 of **FA 3** into this flask.
4. Titrate **FA 1** against **FA 2**. Near the end-point, when the brown suspension becomes pale yellow, add about 10 drops of starch solution.
5. Continue adding **FA 2** until the blue-black colour **just** disappears. Add 10 cm^3 of **FA 4** using a measuring cylinder.
6. Continue adding **FA 2** slowly. The end-point is reached when the **solution** first becomes colourless. The white precipitate remains.
7. Record your titration results in the space provided on page **4**. Make certain that your recorded results show the precision of your working.
8. Repeat the titration as many times as you think necessary to obtain consistent results.

(i) Results

Initial burette reading / cm^3	0.00	0.00
Final burette reading / cm^3	21.00	21.00
Volume of FA2 added / cm^3	21.00	21.00
	✓	✓

M3
M4
M5

M3: A table including the appropriate header and units for:

- Initial burette readings
- Final burette readings
- volume added

M4: All accurate burette readings are recorded to the nearest 0.05 cm^3.
Do not award this mark if: 50.00cm^3 is used as an initial burette reading

M5: Accuracy: Titre/mass ratio: 4.05 ± 0.50

[3]

(ii) From your titres, obtain a suitable volume of **FA 2** to be used in your calculations.
Show clearly how you obtained this volume.

Volume of FA2 = $\frac{21.00+21.00}{2}$ = 21.00 cm^3

M6: Correct calculation of the average of two consistent readings within 0.10 cm^3 difference

M6

Volume of **FA 2** = …… [1]

(c) Calculations

(i) Calculate the amount of iodine, I_2, liberated from 25.0 cm^3 of **FA 1** solution.

amount of $S_2O_3^{2-}$ = $\frac{21.00}{1000}$ x 0.10 = 0.00210 mol
amount of I_2 = ½ x 0.00210 = 0.00105 mol

amount of I_2 liberated from 25.0 cm^3 of **FA 1** solution =……..[1]

M7

(ii) Hence, calculate the amount of copper(II) ions, Cu^{2+}, in 25.0 cm^3 of **FA 1** solution.

Amount of Cu^{2+} in 25.0 cm^3 = 2 x 0.00105 = 0.00210 mol

amount of Cu^{2+} in 25.0 cm^3 of **FA 1** solution = ...[1] **M8**

(iii) Determine the amount of $CuSO_4 \cdot nH_2O$ in 250 cm^3 of **FA 1** solution.

Amount of Cu^{2+} in 250 cm^3 = 10 x 0.00210 = 0.0210 mol = Amount of $CuSO_4 \cdot nH_2O$

amount of $CuSO_4 \cdot nH_2O$ in 250 cm^3 of **FA 1** solution = ...[1] **M9**

(iv) Calculate the M_r of $CuSO_4 \cdot nH_2O$, and hence the value of n.
[A_r: H, 1.0; O, 16.0; S, 32.1; Cu, 63.5]

$M_r = \frac{5.00}{0.0210} = 238.1$

$n = \frac{238.1 - 63.5 - 32.1 - 16.0 \times 4}{1.0 \times 2 + 16.0} = 4.36 \approx 4$ (nearest integer)

M_r of $CuSO_4 \cdot nH_2O$ = ... **M10**

value of n = ... [2] **M11**

(d) Starch forms a dark blue-black complex with the tri-iodide ion, I_3^-. The starch indicator is not added at the beginning of the titration as the resulting complex at high I_3^- concentration is relatively stable, dissociating only slowly.

Predict and explain the effect of adding the starch indicator at the start of the titration on the M_r of $CuSO_4 \cdot nH_2O$ determined in **(c)(iv)**.

Due to the slow release of I_3^- from the starch-I_3^- complex, the **end point would have exceeded the equivalence point**, resulting in a **larger titre value**. **M12**
This leads to larger amount of $CuSO_4.nH_2O$ hence the **Mr would have been smaller than the actual value**. **M13**
[2]

[Total: 13]

2 Investigation of the effect of concentration changes on the rate of a reaction

Iodate(V) ions, IO_3^-, also react with sulfite ions, SO_3^{2-}, in the presence of acid to produce iodine:

$$IO_3^-(aq) + SO_3^{2-}(aq) + H^+(aq) \rightarrow I_2(aq) + \text{other products}$$

The rate of this reaction is affected by the concentration of acid present in the reaction mixture. In the presence of starch, the iodine produced will give a dark blue colour. Therefore, the effect of the concentration of the acid on the initial rate of the reaction can be studied by measuring the time taken for a fixed amount of iodine to be produced.

You are also provided with:

FA 5 is 0.0500 mol dm^{-3} dilute sulfuric acid, H_2SO_4

FA 6 is 0.0400 mol dm^{-3} sodium sulfite, Na_2SO_3

FA 7 is 3.50 g dm^{-3} aqueous potassium iodate(V), KIO_3

Starch solution (from **Question 1**)

(a) You are required to perform a series of five 'iodine clock' experiments, by varying the concentration of acid and measuring the time, t, taken for the dark blue colour to appear.

- For each experiment, **solution 1** will contain the same volume of **FA 6** but a different volume of **FA 5**. You will need to ensure that the total volume of **solution 1** is kept constant at 50 cm^3 by adding deionised water as required.
- For each experiment, prepare **solution 2** as described in **(a)(i)**.

Note: Use separate measuring apparatus to prepare **solutions 1** and **2**.

For each experiment, you will note the volume of **FA 5**, $V_{\mathbf{FA\ 5}}$, and the time taken, t, for the reaction mixture to turn dark blue.

You will then calculate the following values to 3 significant figures:

- 1/t,
- lg(1/t),
- lg($V_{\mathbf{FA\ 5}}$).

In the space provided on page 9, prepare a table in which to record, to an appropriate level of precision:

- all volumes used to prepare **solution 1**,
- all values of t,
- all calculated values of 1/t, lg(1/t) and lg($V_{\mathbf{FA\ 5}}$).

(i) Experiment 1

Solution 1

- Pour 10.0 cm^3 of **FA 6** to a 50 cm^3 measuring cylinder and make up the volume to 50.0 cm^3 by adding **FA 5**.

Solution 2

- Pour 10.0 cm^3 of **FA 7** to a 10 cm^3 measuring cylinder.

1. Transfer **solution 1** into a 100 cm^3 beaker placed on a white tile.
2. Using a 10 cm^3 measuring cylinder, add 5.0 cm^3 of the starch indicator to the beaker.
3. Pour **solution 2** from the measuring cylinder **rapidly but carefully** into the beaker containing **solution 1**. Start the stopwatch immediately.
4. Stir the mixture using a glass rod.
5. Stop the stopwatch when the dark blue colour first appears.
6. Record the time taken, *t*, to the nearest second in your table.
7. Wash the beaker thoroughly with water and dry it.

(ii) Experiment 2

8. Prepare a different **solution 1** using 10.0 cm^3 of **FA 6** and 10.0 cm^3 of **FA 5**. Make up the volume to 50.0 cm^3 by adding deionised water.
9. Prepare **solution 2** as described in **experiment 1** above.
10. Repeat steps 1 to 7.

(iii) Experiment 3 to **5**

Choose **three** other suitable volumes of **FA 5**, between 10.0 cm^3 and 40.0 cm^3, for use in the remaining three experiments.

In each case,

- Use 10.0 cm^3 of **FA 6**, together with your selected volume of **FA 5** and deionised water to prepare 50.0 cm^3 of **solution 1**.
- Prepare **solution 2** as described in **experiment 1**.
- Determine the time taken, *t*, for the solution to turn dark blue.

Record all required volumes, time taken and calculated values in your table.

Results

Volume of FA5 / cm^3	Volume of FA6 / cm^3	Volume of deionised water / cm^3	time /s	$\frac{1}{t}$ / s^{-1}	lg $\frac{1}{t}$	lg (V_{FA5})
40.0	10.0	0.0	4	0.250	-0.602	1.60
10.0	10.0	30.0	28	0.0357	-1.45	1.00
20.0	10.0	20.0	15	0.0667	-1.18	1.30
25.0	10.0	15.0	12	0.0833	-1.08	1.40
30.0	10.0	10.0	9	0.111	-0.954	1.48

M14: Table with correct headers and units
- volumes of **FA 5**, **FA 6** and deionised water
- time
- 1/t
- lg (1/t)
- lg ($V_{FA\,5}$)

M15: Record all data with correct precision
- volumes to 0.5 cm^3
- t to nearest second
- calculated values to 3 sf

M16: Complete set of volume of **FA 5** and time readings for 5 experiments and all values of t increase as volume of **FA 5** decreases. Data for experiments 1 and 2 must be included

M17: Choose 3 other well-spaced values for the volume of **FA 5**. All volumes must differ by at least 5 cm^3

M18: Correctly calculate 1/t, lg (1/t) and lg ($V_{FA\,5}$) values for all stated experiments.

[5]

M14
M15
M16
M17
M18

Graphical determination of order of reaction

In a series of experiments, where the same end-point (i.e. appearance of dark blue colour) is timed, while changing the concentration of one of the reactants and keeping the total volume of the mixture constant,

- 1/t can provide a measure of its initial rate,
- volume of the reactant that is changed in each experiment, can be used as a measure of its initial concentration.

Since the total volume of the reaction mixture is kept constant and only the concentration of **FA 5** has been changed, the rate equation, where ***m*** is the order of reaction with respect to H^+, can be simplified to

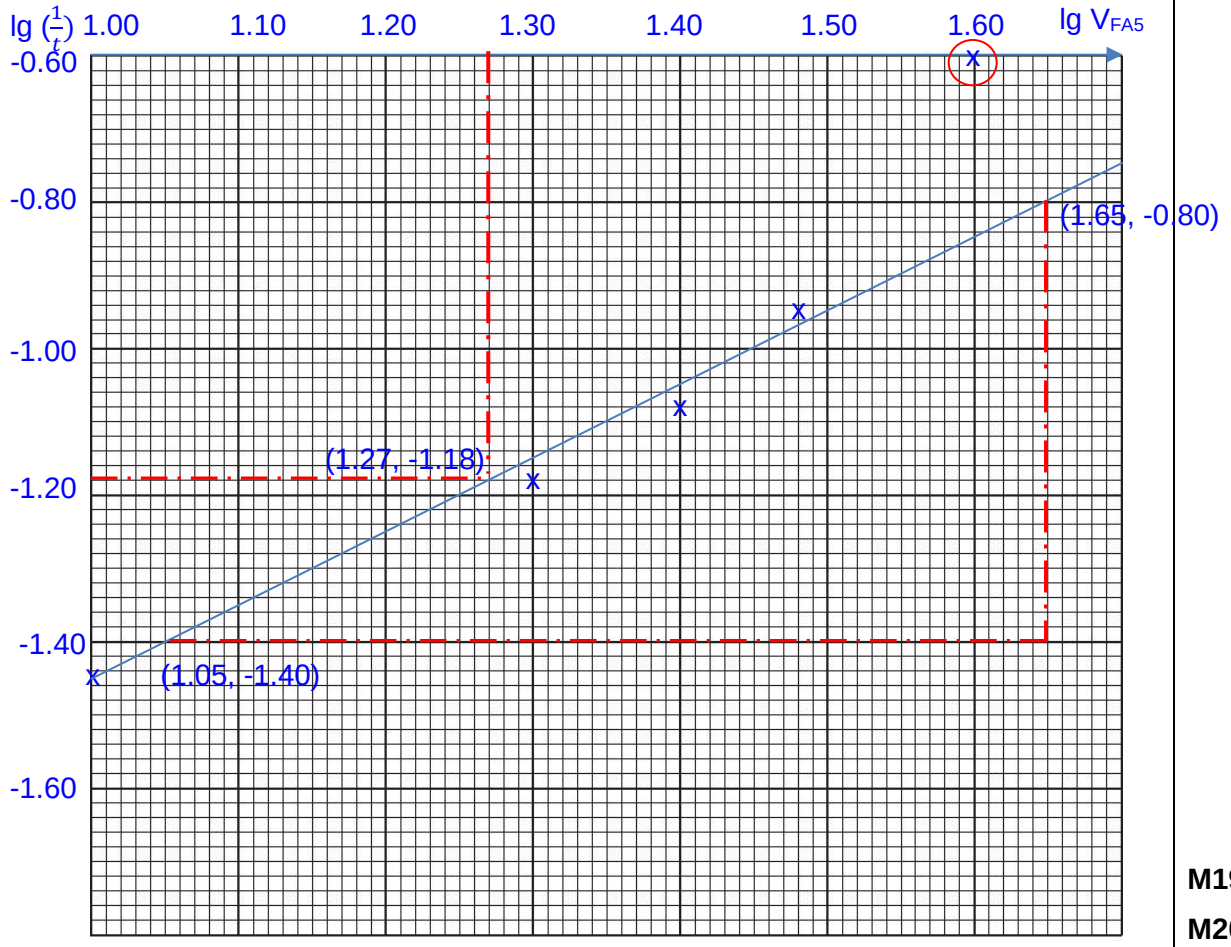
$$\text{rate} = k[H^+]^{\boldsymbol{m}}$$

By taking logarithms of the factors in this equation and by substituting 1/t for rate and $V_{FA\,4}$ for concentration respectively,

$$\lg(1/t) = \boldsymbol{m} \times \lg(V_{FA\,5}) + \lg k$$

Therefore, by plotting a graph of lg(1/t) against $\lg(V_{FA\,5})$, you will be able to draw a straight line of best-fit graph, where ***m*** is the gradient of the line.

(b) Plot a graph of lg(1/t) on the *y*-axis against $\lg(V_{FA\,5})$ on the *x*-axis. Draw the best-fit straight line, taking into account all of your plotted points.



M19
M20
M21

[3]

M19: Axes correct way round, with correct labels and appropriate scale. Scale must be chosen so that plotted points occupy at least half the graph grid in both x and y directions
M20: All plotted points correct to within ± ½ small square
M21: A best fit line is drawn with anomalous points excluded

(ii) From your graph, determine the value of ***m***, showing clearly all your working. Give your answer to 3 significant figures and hence state the order of reaction with respect to $[H^+]$.

Gradient = $\frac{(-0.80-(-1.40))}{1.65-1.05}$ = 1.00 = ***m***

Correct calculation of gradient of the graph with working shown. The ***m*** value is equal to the gradient of the line
Must show accurate coordinates falling on the line with triangle

M22

m = ...

order of reaction with respect to $[H^+]$ = ...[1]

(c) This experiment is known to be very reliable. When it is performed carefully, it is possible to make a reaction mixture that changes colour after a specified time interval.

Use your graph to determine the volume of **FA 5** which would need to be added in **solution 1** so that the reaction mixture turns dark blue at **15 seconds**.

Show your working clearly.

When t= 15 s, lg (1/t) = lg(1/15) = –1.18

From the graph, lg V_{FA5} = 1.27

V_{FA5} = 18.6 cm^3 (3s.f)

volume of **FA 5** required = ... [2]

- Correct calculation of lg(1/15) = –1.18 **M23**
- Correct reading of lg($V_{FA\ 5}$) value from graph to within ±½ small square. **M24**
- Correct calculation of volume of **FA 5** using value for lg($V_{FA\ 5}$)

[2] for all 3 points correct
[1] for 2 points correct

(d) State and explain which experiment, from **experiments 1** to **5**, is likely to have the greatest error.

Experiment 1 as time, t, is smallest value and so has greatest % error

OR
Selects Experiment 2 and explains that volume of **FA 5** used (20 cm^3) is smallest and so has greatest % error

[1] **M25**

(e) Calculate the concentration of hydrogen ions, $[H^+]$, in mol dm^{-3}, that is present in the reaction mixture for **experiment 1** at time t = 0 s.

You may assume that the solutions are perfectly mixed and that the reaction has **not** started at t = 0 s.

amount of $H^+ = 0.05 \times 2 \times 40 \times 10^{-3} = 0.00400$ mol **M26**

$[H^+] = 0.00400 / (65/1000) = 0.0615$ mol dm^{-3} **M27**

M28

$[H^+]$ = ... mol dm^{-3} [3]

M26: correct value

M27: Show correct units and appropriate significant figures in all final answers in **1(c)**, **2(e)**

M28: Show all relevant workings in **1(c)**, **2(e)**

M28 deducted for any blank questions

(f) Suppose that the following mistake was made in the preparation of **solution 1** for **experiment 2**:

Kaleyn added 10.0 cm^3 of **FA 6** to the 50.0 cm^3 measuring cylinder and added **FA 5** up to the 30.0 cm^3 mark, instead of 20.0 cm^3 mark, on the measuring cylinder. After that, she made up the volume to 50.0 cm^3 by adding deionised water.

(i) State and explain how the value of t is affected for **experiment 2** described above.

The value of t will be lower. This is because the $[H^+]$ is higher than expected, so rate of reaction is faster. [1] **M29**

(ii) Suggest a modification to the experimental procedure to avoid this error.

Measuring volumes of **FA 5**, **FA 6** and deionized water using separate measuring cylinders to make solution 1. [1] **M30**

[Total: 17]

3 Planning

Like iodine solution, many transition metal complex ions are coloured. It is possible to use this property to determine the concentration of a solution of a coloured complex ion. A few cm^3 of the solution is placed inside a machine, known as a spectrometer. This machine measures the amount of light that is absorbed when a specific wavelength of visible light is shone through a coloured solution. It does this by comparing the amount of light passing through the sample with the amount of light passing through the pure solvent. The amount of light absorbed is expressed as an *absorbance value.* The higher the concentration of the solution, the higher the absorbance value, i.e., the absorbance value is directly proportional to the concentration of the solution.

This technique can be used to determine the concentration of a solution of aqueous $[Ni(en)_3]^{2+}$. A series of known concentration of solution containing $[Ni(en)_3]^{2+}$ 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 a 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 $[Ni(en)_3]^{2+}$ in the unknown solution can be determined.

(a) Explain why transition metal compounds are often coloured.

- As the ligands approach the central metal ions, it results in interelectronic repulsion and splits the d orbitals into 2 energy levels with a small energy gap, ΔE
- As the d orbitals are partially filled, when electrons absorb energy from the visible light region of the electromagnetic spectrum corresponding to ΔE, they are promoted from the lower energy d orbital to be promoted to higher energy d orbital. **M31** **M32**
- The colour of the complex is the complementary colour of the light absorbed. [2]

(c) Given that $[Ni(en)_3]^{2+}$ absorbs radiation of a wavelength of about 570 nm, use the information below to predict the colour of $[Ni(en)_3]^{2+}$.

Wavelength range (nm)	Colour	Complementary colour
400 - 450	Violet	Yellow
450 - 490	Blue	Orange
490 - 550	Green	Red
550 - 580	Yellow	Violet
580 - 650	Orange	Blue
650 - 700	Red	Green

violet [1] **M33**

(a) Using the information given above, you are required to write a plan to determine the concentration of $[Ni(en)_3]^{2+}$ in a solution of **X**.

You may assume that you are provided with:

- solution **X**, of unknown $[Ni(en)_3]^{2+}$ concentration less than 2 mol dm^{-3};
- a stock solution containing 5.00 mol dm^{-3} of $[Ni(en)_3]^{2+}$;
- access to a spectrometer and instructions for its use;
- graph paper;
- the apparatus and chemicals normally found in a school laboratory.

Your plan should include details of:

- the preparation of 100.0 cm^3 of 2.00 mol dm^{-3} aqueous $[Ni(en)_3]^{2+}$ from the stock solution;
- the preparation of a suitable range of diluted solutions of accurate concentrations;
- an outline of how the results would be obtained;
- a sketch of the calibration line you would expect to obtain;
- how the calibration line would be used to determine the concentration of $[Ni(en)_3]^{2+}$ in solution **X**.

- Calculation of vol of stock solution needed:
  Vol of stock solution needed = $\frac{100\times2}{5} = 40$ cm^3

- Procedure for preparation of standard solution of 2.00 mol dm^{-3}
  1. Fill the 50.00 cm^3 burette with the stock solution of 5.00 mol dm^{-3} $[Ni(en)3]^{2+}$
  2. Run 40.00 cm^3 of the solution into a 100 cm^3 volumetric flask
  3. Top up to the mark with deionised water
  4. Stopper, invert and shake the volumetric flask to obtain a homogeneous solution. Label this solution **P**.

- Preparation of a suitable range of diluted solutions
  1. Fill the 50.00 cm^3 burette with solution **P**
  2. Run 15.00 cm^3 of **P** into a 100 cm^3 beaker.
  3. Using another 50.00 cm^3 burette, transfer 5.00 cm^3 of deionised water into the same beaker. Stir the solution with a glass rod to obtain a homogeneous solution.
  4. Repeat steps 2 and 3 with different volumes of solution **P** and deionised water as shown in the table below (Expt 3 to 5).

Expt	Volume of solution **P**/ cm^3	Volume of deionised water /cm^3	Conc of $[Ni(en)_3]^{2+}$ prepared / mol dm^{-3}	Absorbance / A
1	20.00	0.00	2.00	
2	15.00	5.00	1.50	
3	10.00	10.00	1.00	
4	5.00	15.00	0.50	
5	0.00	20.00	0.00	

- Outline of how the results would be obtained
    1. Use the spectrometer to measure the absorbance of each of the solutions of different concentrations prepared and record the absorbance value.
    2. Plot a graph of the absorbance against concentration and draw a best-fit line. This is the calibration line.

- Determining concentration of solution **X**
    1. Use the spectrometer to measure and record the absorbance of $[Ni(en)_3]^{2+}$ in solution **X**
    2. Using the calibration line drawn, read off the concentration of $[Ni(en)_3]^{2+}$ corresponding to the absorbance.

[9]

[Total: 12]

1. correct volume of stock solution used to prepare the standard solution.	M34
2. correct procedure for preparing the standard solution, including top up to the mark, stopper and shake	M35
3. use of suitable apparatus with stated capacity for the preparation of standard solution ○ burette for measuring out 40.00 cm^3 stock solution ○ 100 cm^3 volumetric flask	M36
4. correct dilution concept for preparation of range of diluted solutions using 2.00 mol dm^{-3} solution	M37
5. select a suitable range of concentrations for the diluted solutions (at least 3 more solutions with concentrations not less than 0.3 mol dm^{-3} apart)	M38
6. measurement of absorbance value using the diluted solutions	M39
7. plotting of graph (mention axis)	M40
8. sketch of the calibration line graph (straight line graph passing through the origin) (if sketch is correct and with appropriate axes, M40+M41)	M41
9. description of use of calibration line to determine concentration of $[Ni(en)_3]^{2+}$ in solution **X**	M42

M34
M35
M36
M37
M38
M39
M40
M41
M42

4 Qualitative Analysis

You are provided with two ionic solids, **FA 8** and **FA 9**.

Perform the tests described in the table below and record your observations in the table. In all the tests, the reagent should be added gradually until no further change is observed, with shaking after each addition. No additional or confirmatory tests for ions present should be attempted.

		observations with **FA 8**	observations with **FA 9**
(a)(i)	Add 1 cm^3 of dilute hydrochloric acid to ½ spatula of the solid sample in a test tube.	Blue / Blue-green / green **solution** is observed.	Cream / Off-white ppt is observed. Yellow ppt / solid is formed on warming. (No need to test for SO_2) FYI: $Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + S + SO_2 + H_2O$
(ii)	Add 2 cm^3 of silver nitrate solution to ½ spatula of the solid sample in a test tube. If need be, filter the resultant mixtures.	White ppt in blue solution formed.	A white / yellow ppt and eventually forms black / brown ppt. Do not accept red-brown ppt Do not accept brown solution Can accept eventually brown ppt
(iii)	Add 1 cm^3 of potassium iodide solution to ½ spatula of the solid sample in a test tube. If need be, filter the resultant mixtures.	A white / cream ppt is formed in brown solution. FYI: $2CuCl_2 + 4KI \rightarrow 2CuI + I_2 + 2KCl$	A colourless solution is formed.
(iv)	Add 1 cm^3 of aqueous iodine to ½ spatula of the solid sample in a test tube.	[redacted]	Brown solution decolourises.
(v)	Add 1 cm^3 of deionised water to ½ spatula of the solid sample in a test tube. To this resultant solution, add aqueous ammonia slowly, with shaking, until no further change is seen.	Blue solution is formed when DI water is added. Blue ppt formed when $NH_3(aq)$ is added dropwise. Ppt soluble in excess $NH_3(aq)$ forming a dark blue solution	[redacted]

[8]

(b) Suggest the identity of the cation and anion present in **FA 8**. Hence, write a balanced equation for the reaction occurring with **FA 8** in **(a)(ii)**.

cation: Cu^{2+} anion: Cl^- **M51**

M52

equation: $2AgNO_3(aq) + CuCl_2(aq) \rightarrow Cu(NO_3)_2(aq) + 2AgCl(s)$ [3] **M53**

(c) Based on your observation in **(a)(iii)**, state the type of reaction undergone between potassium iodide and **FA 8**.

Redox [1] **M54**

(d) Based on your observation in **(a)(iv)**, state the role of **FA 9** in the reaction.

reducing agent [1] **M55**

[Total: 13]

END OF PAPER

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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