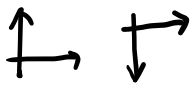
2022 PU3 H2 Chemistry EOY Paper 4 Mark Scheme

Question	Answer	Marks
1 (a)	All masses consistently recorded to 2 (or 3) decimal places. and correct mass headers Mass of bottle + FA 1 Mass of bottle + residual of FA 1 Mass of FA 1 Mass of empty bottle Mass of bottle + FA 1 Mass of FA 1 *Inform students to be always reminded to weigh residual mass	M1
	Mass of FA 1 used correctly calculated Mass of FA 1 used 5.00 ±0.05	M2
(b)(i)	A table including the appropriate header and units for: • Initial burette readings • Final burette readings • volume added	M3
	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	M4
	Accuracy Titre/mass ratio: 4.05 ± 0.50	M5
(b)(ii)	Correct calculation of the average of two consistent readings within 0.10 cm^3 difference	M6
(c)(i)	amount of I_2 = 0.5 (ans from b(ii)/1000) x 0.10 = A mol	M7
(ii)	amount of Cu^{2+} in 25.0 cm^3 = A × 2 = B mol	M8
(iii)	amount of $CuSO_4.nH_2O$ in 250 cm^3 = 10 × B = C mol	M9
(iv)	Mr = mass of **FA 1** / C = D Must be 1dp, will affect M27	M10
	n = (D -159.6) / 18.0 n must be an integer	M11
(d)	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**. This leads to larger amount of $CuSO_4.nH_2O$ hence the **Mr would have been smaller than the actual value**. OR The **I_2 is trapped by the starch complex** and hence resulting in less I_3^- a smaller titre value This leads to a smaller amount of $CuSO_4$ and hence **Mr will be larger**	M12 M13

Question	Answer	Marks
2(a)	Table with correct headers and units • volumes of **FA 5**, **FA 6** and deionised water • time • 1/t • lg (1/t) • lg ($V_{FA\ 5}$)	M14
	Record all data with correct precision • volumes to 0.5 cm^3 • t to nearest second • calculated values to 3 sf	M15
	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	M16
	Choose 3 other well-spaced values for the volume of **FA 5**. All volumes must differ by at least 5 cm^3	M17
	Correctly calculate 1/t, lg (1/t) and lg ($V_{FA\ 5}$) values for all stated experiments.	M18
(b)(i)	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  Both accepted, must be in logical numerical sense	M19
	All plotted points correct to within ± ½ small square	M20
	A best fit line is drawn with anomalous points excluded	M21
(b)(ii)	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 or triangle or best both	M22
(c)	• Correct calculation of lg(1/15) = –1.18 • Correct reading of lg($V_{FA\ 5}$) value from graph to within ±½ small square. • 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	M23 M24
(d)	Selects Experiment 1 and explains that time, t, is smallest value and so has greatest % error Says that reaction time is fastest and hence it is the most significant OR	M25

	Selects Experiment 2 and explains that volume of **FA 5** used (20 cm^3) is smallest and so has greatest % error	
(e)	amount of $H^+ = 0.05 \times 2 \times 40 \times 10^{-3} = 0.00400$ mol $[H^+] = 0.00400 / (65/1000) = 0.0615$ mol dm^{-3}	M26
	Show correct units and appropriate significant figures in all final answers in **1(c)**, **2(e)** **Penalise only if answer is correct**	M27
	Show all relevant workings in **1(c)**, **2(e)** **M28 deducted for any blank questions**	M28
(f)(i)	The value of t will be lower. This is because the $[H^+]$ is higher than expected, so rate of reaction is faster.	M29
(ii)	Measuring volumes of **FA 4**, **FA 6** and deionized water separately and mixing to make solution 1	M30

Question	Answer	Marks
3(a)	• presence of partially filled d-orbitals • splitting of d orbitals into 2 groups with a small energy gap • absorbs light energy for electrons from lower energy d orbital to be promoted to higher energy d orbital • light not absorbed is seen as the colour of the complex 2m - all 3 points 1m – any correct 2 points	M31 M32
(b)	violet	M33
(c)	• 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 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. Make up to the mark with deionised water 4. Stopper 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 burette with solution **P** 2. Run 15.00 cm^3 of **P** into a 100 cm^3 beaker. 3. Using another 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	Volume of	Conc of $[Ni(en)_3]^{2+}$	Absorbance / A

	<table><tr><td></td><td>solution **P**/ cm^3</td><td>deionised water /cm^3</td><td>prepared / mol dm^{-3}</td><td></td></tr><tr><td>1</td><td>20.00</td><td>0.00</td><td>2.00</td><td></td></tr><tr><td>2</td><td>15.00</td><td>5.00</td><td>1.50</td><td></td></tr><tr><td>3</td><td>10.00</td><td>10.00</td><td>1.00</td><td></td></tr><tr><td>4</td><td>5.00</td><td>15.00</td><td>0.50</td><td></td></tr><tr><td>5</td><td>0.00</td><td>20.00</td><td>0.00</td><td></td></tr></table> • 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.	
	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

4		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 (optional) 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. Something to the extent of decolourisation
(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. Blue ppt formed. Ppt soluble in excess $NH_3(aq)$ forming a dark blue solution	[redacted]

Question	Answer	Marks
4(a)	1m for each box	M43 to M50
(b)	cation: Cu^{2+}	M51
	anion: Cl^- or SO_4^{2-}	M52
	equation: $2AgNO_3(aq) + CuCl_2(aq) \rightarrow Cu(NO_3)_2(aq) + 2AgCl(s)$ OR $2AgNO_3(aq) + CuSO_4(aq) \rightarrow Cu(NO_3)_2 + Ag_2SO_4(s)$ Can accept ionic equation	M53
(c)	Redox Not displacement	M54
(d)	reducing agent	M55