



River Valley High School
9729 H2 Chemistry
Preliminary Examination Paper 4
Suggested solution

1 (a) (i) Results

Titration number	1	2
Final burette reading /cm ³	23.75	23.75
Initial burette reading /cm ³	0.00	0.00
V _{FA2} /cm ³	23.75	23.75

Subject supervisor's reading: 23.75 cm³

2 marks if difference ≤ 0.20 cm³, 1 mark if difference ≤ 0.30 cm³

[5]

(ii) average volume of **FA 2** used = $\frac{23.75 + 23.75}{2}$

= 23.75 cm³

[1]

(iii) $[Ag^+(aq)] = \frac{23.75}{1000} \times 0.01 \div \frac{10}{1000}$

= 0.02375

= 0.0238 mol dm⁻³

[1]



I/ mol dm⁻³ (0.1)/2 (0.1)/2 0 -

C -x -x +x

E 0.02375 0.02375 x

Initial $[Fe^{2+}]$ or initial $[Ag^+] = 0.1 / 2 = 0.05$ mol dm⁻³

$[Fe^{3+}(aq)] = 0.05 - 0.02375 = 0.02625 = 0.0263$ mol dm⁻³

OR

Initial amount of Fe^{2+} or initial amount of Ag^+

= $0.1 \times \frac{100}{1000} = 0.01$ mol

[2]

$$[\text{Fe}^{3+}] = \frac{0.01 - \frac{200}{1000} \times 0.02375}{\frac{200}{1000}}$$

$$= 0.02625 = 0.0263 \text{ mol dm}^{-3}$$

(v) $K_c = \frac{0.0263}{(0.0237)^2} = 46.8 \text{ mol}^{-1} \text{ dm}^3$

[2]

(b) Disagree.

Either of the following:

- The equilibrium is established in 4 hours and thus the position of equilibrium does not shift within minutes of titration.
- Titration is carried out very quickly such that it will not shift the position of equilibrium/ no time to establish new equilibrium.
- The value of K_c implies that position of equilibrium lies far right, the impact of titration does not affect position significantly.
- FA 1 is left to stand for 4h, all Ag would have aggregated as solid at the bottom, which was left undisturbed. There is no Ag in the aliquot, so backward reaction will not occur, shifting of position of equilibrium will not occur.

[1]

(c) Use a lower concentration of FA1/ FA2, increase volume used, lower percentage uncertainty.

Use higher volume of FA 1 used, lower percentage uncertainty of K_c .

Conduct the experiment in a thermostatically controlled water bath OR controlled at constant temperature.

Filter the equilibrium mixture prior to titration to remove the solid so that the backward reaction will not occur during titration to affect the titre and value of K_c .

[1]

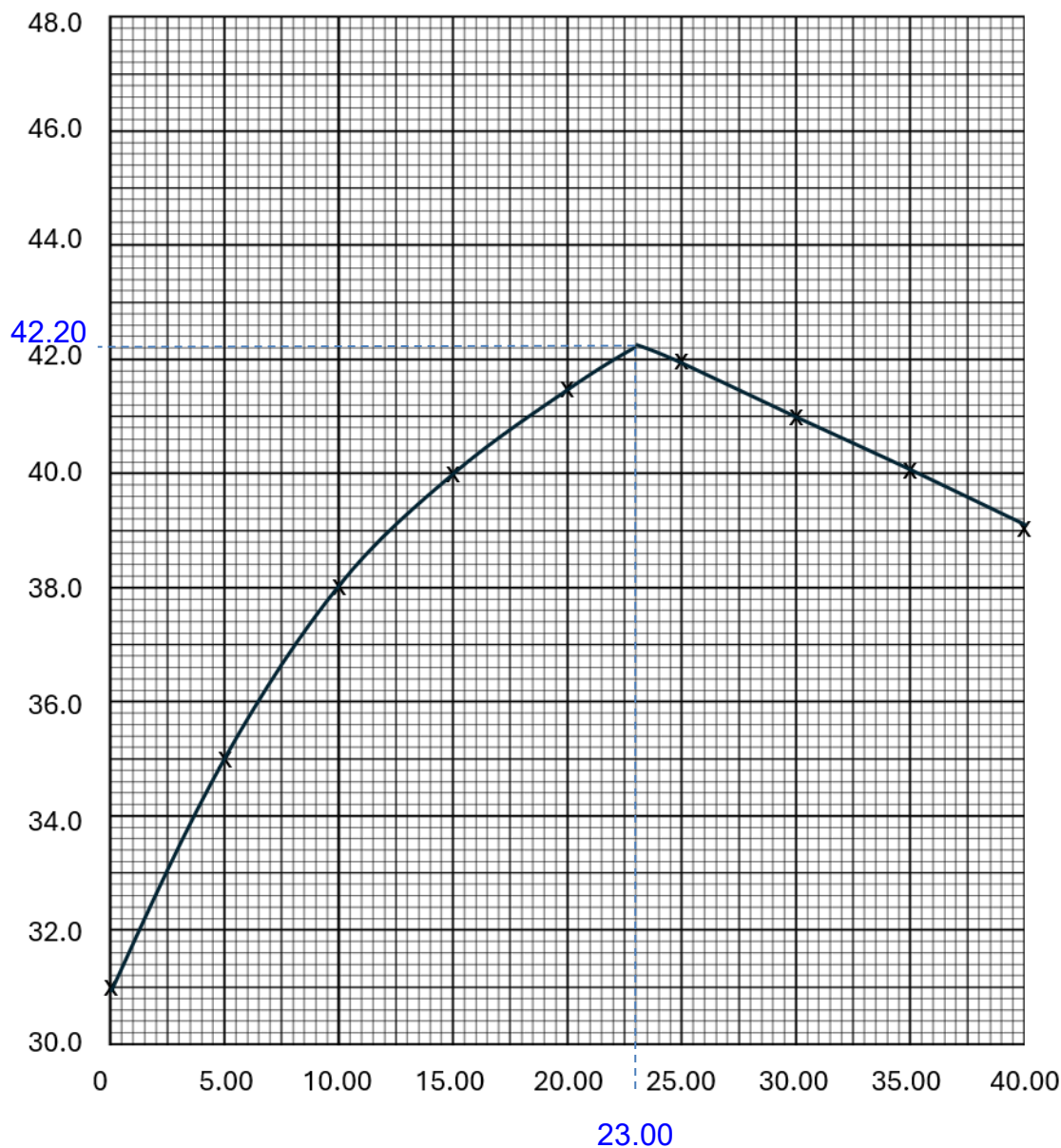
[Total: 13]



2 (a) Results

V/cm ³	0.00	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
T/ °C	31.0	35.0	38.0	40.0	41.5	42.0	41.0	40.0	39.0

(b) (i)



[3]

(ii) volume of FA 4 used = 23.00cm³ [1]

(iii) Energy change = (25.0 + 23.0) (4.18) (42.20 – 31.0)
= 2247.2 J
= 2250 J [1]

(iv) Amount of $\text{Ba}(\text{OH})_2 = 0.95 (0.025) = 0.02375 = 0.0238 \text{ mol}$ [1]

(v) $\Delta H_{\text{neut}} = (-2247.2 \text{ J} / 1000) / 2(0.02375) = -47.3 \text{ kJ mol}^{-1}$ [1]

[1] Accuracy $-43 \leq \Delta H_{\text{neut}} \leq -53$ [2]

(vi) $[\text{CHX}(\text{COOH})_2] = 0.02375 \text{ mol} / 0.023 = 1.033 \text{ mol dm}^{-3}$

Molar mass = $141.3 / 1.033 = 136.8 \text{ g mol}^{-1}$

$M_r = 137$ (3sf) [1]

(vii) Acid is $\text{CHCl}(\text{COOH})_2$ [1]

(viii) percentage error = $(138.5 - 136.8) / 138.5 \times 100\% = 1.20\%$ [1]

M2: 3sf for Q1 (except (a)(ii) and Q2 (except (b)(ii))

M3: units for Q1 and Q2 (except (b)(vi)) [3]

(c) In a conventional titration, the V_{neut} was determined directly by a colour change which produces a sharper and more reliable end-point.

In a thermometric titration, V_{neut} was determined indirectly from the maximum temperature rise determined graphically, and subject to errors e.g. heat loss.

Improvement: $V\Delta T$ should be used to determine the V_{neut} , which would have taken into account the increasing volume of the reaction system. [1]

[Total: 16]



3 (a)

Table 3.1

	test	observations
(i)	To a 1cm depth of FA 5 in a test-tube add a 1 cm depth of sodium hydroxide,	FA 5 is colourless. With NaOH: Pale or light brown/ off white ppt formed and insoluble in excess. Ppt rapidly turn brown (on contact with air).
	then add several drops of hydrogen peroxide.	With H ₂ O ₂ , Brown ppt turned dark brown/ black. Effervescence. Colourless, odourless gas evolved that relight a glowing splint. Gas is oxygen.
(ii)	To a 1 cm depth of FA 6 in a test tube add aqueous sodium hydroxide.	FA 6 contains yellow solution with orange ppt. Green ppt is insoluble in excess. Green ppt turned brown on contact with air
(iii)	To a 1 cm depth of FA 6 in a test-tube add several drops of hydrogen peroxide and	FA 6 turned brown Effervescence. Colourless, odourless gas evolved that relight a glowing splint. Gas is oxygen.
	then add aqueous sodium hydroxide.	Red-brown ppt formed insoluble in excess.
(iv)	To a 1 cm depth of FA 6 in a test-tube add a 1 cm depth of sulfuric acid and then add a few drops of FA 7 .	Purple FA 7 turned colourless/ decolourised Allow purple to (pale) yellow/ pale orange
(v)	To a 1 cm depth of aqueous potassium iodide in a test-tube add a few drops of FA 7	With KI, Brown/ black ppt in brown solution.

then add a few drops of aqueous starch.	With starch, Brown solution turned dark blue/ blue-black
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[5]

(b)		FA 5	FA 6	FA 7
	Metal ions	Mn^{2+} / $Mn(II)$	Fe^{2+} / $Fe(II)$	MnO_4^- / $Mn(VII)$

[3]

(c)	(i)	Test	Observation
		Add $AgNO_3(aq)$	No observable change/ no ppt/ solution remain (pale) yellow/ orange
		Add $Ba(NO_3)_2(aq)$, followed by nitric acid	White ppt formed with Ba^{2+} insoluble in HNO_3 / White ppt formed with Ba^{2+} , no gas evolved

[2]

OR

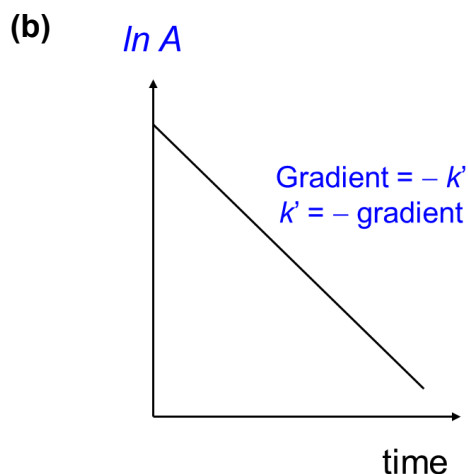
Test	Observation
Add $HNO_3(aq)$	No gas evolved/ no observable change
Add $Ba(NO_3)_2(aq)$	White ppt formed.

(ii)	Anion	Evidence
	SO_4^{2-}	(White ppt of Ag_2SO_4) <u>White ppt</u> of <u>$BaSO_4$</u> formed which is <u>insoluble</u> in nitric acid.
	Or	
	SO_4^{2-}	<u>No SO_2</u> evolved with HNO_3 . <u>White ppt</u> of <u>$BaSO_4$</u> .

[Total: 12]



- 4 (a) In case some of the light is absorbed/ blocked (allow reflect) by fingerprints / dirt/ oil/ contaminant. [1]



- (c) (i) Mass of CV = $0.25 \times 1.80 \times 10^{-3} \times (407.5) = 0.18338 = 0.183 \text{ g}$ [2]
(ii) Mass of crystal violet (0.0018 g) is too small to be measured directly. [1]
Percentage uncertainty/ error of mass measurement is (too) big. [1]

- (d) (i)
1. Using a 10 cm^3 pipette, add 10 cm^3 of $1.80 \times 10^{-5} \text{ mol dm}^{-3}$ crystal violet into a clean and dry 250 cm^3 / 100 cm^3 conical flask/ 100 cm^3 beaker.
 2. Using a 10 cm^3 measuring cylinder, add 10 cm^3 of $0.200 \text{ mol dm}^{-3}$ NaOH to the conical flask. Start the stopwatch immediately. Swirl the reaction mixture.
 3. At 20s, using a dropper, quickly transfer some of the mixture from the conical flask to a cuvette and place the cuvette in the colorimeter.
 4. Measure the absorbance of the mixture in a clean and dry cuvette at 565 nm every 30s until the solution decolourises.
 5. Plot $\ln [A]$ against t , gradient = $-k'$
 6. Using a burette, add 8.00 cm^3 of NaOH into a 10 cm^3 volumetric flask. Make to the mark using deionised water, adding dropwise near the mark. Shake to ensure a homogeneous solution.
 7. Repeat step 1.
 8. Transfer the diluted NaOH(aq) from the volumetric flask into a clean and dry 100 cm^3 conical flask directly. Start the stopwatch immediately. Swirl the reaction mixture.
 9. Repeat steps 3 to 5.



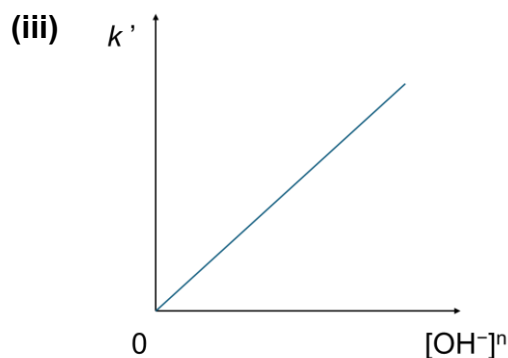
10. Repeat step 6 - 9 using 6.00 cm³, 4.00 cm³ and 2.00 cm³ of NaOH, topping up to the 10 cm³ mark using deionised water each time.

(ii) For each experiment, calculate $[\text{OH}^-]_{\text{rxn mixture}} = \frac{V_{\text{NaOH}} \times 0.2}{V_{\text{total}} \text{ or } \frac{20}{1000}}$

Since k' of each experiment = gradient of $\ln A$ against t
(Choose two pairs of experimental data)

$$\frac{(k')_{\text{expt 1}}}{(k')_{\text{expt 2}}} = \frac{k[\text{OH}^-]_{\text{expt 1}}^n}{k[\text{OH}^-]_{\text{expt 2}}^n}$$

$$n = \ln \left(\frac{(k')_{\text{expt 1}}}{(k')_{\text{expt 2}}} \right) \div \ln \left(\frac{[\text{OH}^-]_{\text{expt 1}}}{[\text{OH}^-]_{\text{expt 2}}} \right) \text{ (or using lg)}$$



Gradient = k .

[Total: 15]