



HWA CHONG INSTITUTION
2026 C2 H2 CHEMISTRY PRELIMINARY EXAMINATION
PAPER 4 MARK SCHEME

1	(a)	1	Obs 1.	red-brown ppt formed	M1
			Obs 2.	insoluble in excess	M2
			Obs 3.	red-brown residue	M3
			Obs 4.	colourless filtrate	M4
		2	Obs 5.	no gas evolved (<i>on warming</i>)	M5
			Obs 6.	white ppt formed insoluble in excess (<i>on adding H₂SO₄</i>)	M6
		3 4	Obs 7.	(red-brown residue dissolves to give) yellow solution	M7
			Obs 8.	solution turns darker yellow/orange/brown (<i>on adding KI</i>)	M8
		5	Obs 9.	solution decolourises (<i>on addition of thiosulfate</i>)	
			Obs 10.	solution turns purple/violet/brown/grey	
			Obs 11.	solution turns colourless (<i>on standing</i>)	
			Obs 12.	green ppt (turns brown on standing) (<i>on adding NaOH</i>)	
		6	Obs 13.	insoluble in excess	
			Obs 14.	green ppt turns reddish brown (on adding H ₂ O ₂)	
			Obs 15.	effervescence of gas that relights a glowing splint	
			Obs 16.	gas is O ₂	

15 – 16 = [8]

13 – 14 = [7]

11 – 12 = [6]

9 – 10 = [5]

7 – 8 = [4]

5 – 6 = [3]

3 – 4 = [2]

1 – 2 = [1]

0 = [0]

1	(b)	(i)	Ba ²⁺ , Fe ³⁺	M9
			[1] for each	M10

- 1 (b) (ii) Role of KI: **M11**
 It is a reducing agent. Solution turned brown, showing that I^- has been oxidised to I_2 , this means that Fe^{3+} has been reduced. **[1]**
- Role of H_2O_2 :
 Oxidising agent. When added to green ppt of $Fe(OH)_2$, it oxidised $Fe(OH)_2$ to $Fe(OH)_3$ which is the red-brown ppt. **[1]** **M12**
- 1 (c) Obs 1. white ppt formed **M13**
 Obs 2. ppt dissolves in ammonia (to give a colourless solution) **M14**
- [1]** for each observation
- 1 (d) Cl^- **[1]** **M15**

- 2 (a) All the burette readings are recorded to the nearest 0.05 cm³. **M16**
 (b) (i) ➤ volume of FA 3 calculated correctly & final and initial burette readings are not inverted
 ➤ Volume of FA 2 used is between 49.00 - 49.50 cm³

At least two consistent titre readings of end-point within 0.10 cm³ **M17**

Sample results:

(a)

Final burette reading / cm ³	49.50
Initial burette reading / cm ³	0.00
Volume of FA 2 used / cm ³	49.50

(b)(i)

	1	2
Final burette reading / cm ³	20.90	20.90
Initial burette reading / cm ³	0.00	0.00
Volume of FA 5 used / cm ³	20.90	20.90

✓

✓

Calculate the Teacher's and the student's scaled mean titre values using the following expression:

$$\text{Scaled mean titre} = \frac{49.25 \times \text{mean titre}}{\text{volume of FA 2 diluted}}$$

Calculate the difference between the student's scaled mean titre value and the Teacher's scaled mean titre value.

Teacher's scaled mean titre = **20.79 cm³**

- Give 2 marks if this difference is ≤ 0.3 **M18**
 Give 1 mark if this difference is > 0.3 but ≤ 0.5 **M19**
 Give 0 marks if this difference is > 0.5

- 2 (b) (ii) working shown using two consistent titres & average calculated to 2 d.p. with units stated **M20**
 ➤ *Mark is lost if the titres used are not identified either in the table (by, for example, a tick) or in a calculation or identified wrongly or no titre within 0.10 cm³.*
 ➤ *Mark is lost if there are arithmetic errors in the titration results table.*
 ➤ *Mark is lost if the candidate made an arithmetic error in the calculation of the mean titre.*

2 (d) (i) n_{O_2} produced by 1 cm^3 of $H_2O_2 = 0.75 \div 24000 = 3.125 \times 10^{-5} \text{ mol}$ **M21**
 $n_{H_2O_2}$ in $1 \text{ cm}^3 = 3.125 \times 10^{-5} \times 2 = 6.25 \times 10^{-5} \text{ mol}$

$[H_2O_2] = 6.25 \times 10^{-5} \div 1/1000 = 0.0625 \text{ mol dm}^{-3}$ **M22**

2 (d) (ii) $n_{H_2O_2}$ in $25.0 \text{ cm}^3 = 0.0625 \times 25/1000 = 1.56 \times 10^{-3} \text{ mol} = n_{I_2}$ **M23**

$n_{S_2O_3^{2-}} = 1.56 \times 10^{-3} \times 2 = 3.125 \times 10^{-3} \text{ mol}$ **M24**
 $[S_2O_3^{2-}] = 3.125 \times 10^{-3} \div 31.50/1000 = 0.0992 \text{ mol dm}^{-3}$

2 (d) (iii) 1. $n_{S_2O_3^{2-}} = 0.0992(\text{or ecf}) \times (\text{titre in (b)(ii)} \div 1000)$ **M25**
M26

2. $n_{KIO_3} = n_{S_2O_3^{2-}} \div 6$

3. $[KIO_3]$ in **FA 6** $= n_{KIO_3} \div 25/1000$

Award 1 mark for the correct use of the mole ratio in step 2 and 1 mark for steps 1 and 3 if both correct (allow ecf for step 3 if step 2 is wrong).

2 (d) (iv) $[KIO_3]$ in **FA 2** $= \text{ANS(d(iii))} \times (250 \div \text{volume of FA2 used})$ **M27**

Correct s.f. (3 s.f) for final answer from (d)(i) to (iv) **M28**

3 (a) Correct headers and units

M29

Correct precision

M30

- Time to nearest second
- 1/t to 3 s.f
- Volume reading to 1 d.p. (FA3, FA7, FA8, Deionised water)

Correctly calculates 1/t

M31

Volumes of **FA7** chosen are well spaced over 5 - 25 cm³

M32

- Total volume kept constant by adding deionised water
- Constant volume of **FA 3** and **FA 8**

M33

Sample results:

Experiment No.	Volume / cm ³				Time / s	$\frac{1}{\text{time}} / \text{s}^{-1}$
	FA 8	FA 7	FA 3	Deionised water		
1	50.0	25.0	25.0	0.0	10	0.100
3	50.0	20.0	25.0	5.0	13	0.0769
4	50.0	15.0	25.0	10.0	17	0.0588
5	50.0	10.0	25.0	15.0	26	0.0385
2	50.0	5.0	25.0	20.0	54	0.0185

3 (b) If total volume is kept constant, **vol (H₂O₂) used would be directly proportional to [H₂O₂]** in the reaction mixture.

M34

3 (c) • Labels both axes with headings and units and uses appropriate scale

M35

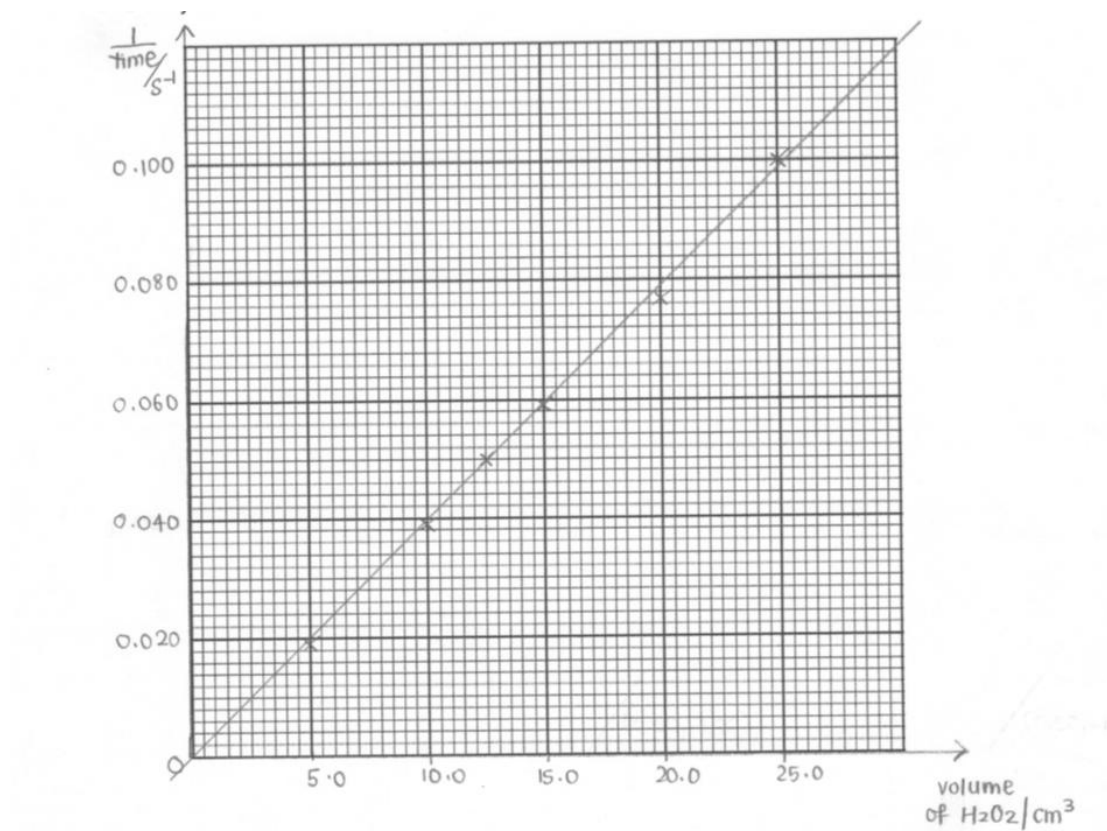
- All points plotted to within half small square

M36

- Obtains best-fit straight line passing through the origin / almost passing through origin

M37

Sample graph:



3 (d) Graph of $1/\text{time}$ vs vol (H_2O_2) is a **straight line passing through the origin/ almost passing through zero** M38

$\Rightarrow \text{rate} \propto [\text{H}_2\text{O}_2]$

M39

$\Rightarrow$ **first order** wrt $[\text{H}_2\text{O}_2]$

3 (e) $\text{rate} = k [\text{H}_2\text{O}_2][\text{I}^-][\text{H}^+]$

M40

$$\text{units of } k = \frac{\text{mol dm}^{-3} \text{ s}^{-1}}{(\text{mol dm}^{-3})^3} = \text{mol}^{-2} \text{ dm}^6 \text{ s}^{-1} \text{ ecf from (d)}$$

4 (a)

$$\frac{[\text{Ba}(\text{OH})_2] \times \text{Volume Ba}(\text{OH})_2}{[\text{CH}_3\text{CO}_2\text{H}] \times \text{Volume CH}_3\text{CO}_2\text{H}} = \frac{1}{2}$$

Given $[\text{CH}_3\text{CO}_2\text{H}] \approx [\text{Ba}(\text{OH})_2]$

$\Rightarrow \text{Volume Ba}(\text{OH})_2 : \text{Volume CH}_3\text{CO}_2\text{H} = 1:2$

Volume of $\text{Ba}(\text{OH})_2 = 50 \times 1/3 = 17 \text{ cm}^3$

Volume of $\text{CH}_3\text{CO}_2\text{H} = 50 \times 2/3 = 33 \text{ cm}^3$

or use algebra:

Let volume $\text{Ba}(\text{OH})_2 = V \text{ cm}^3$, then volume $\text{CH}_3\text{CO}_2\text{H} = (50 - V) \text{ cm}^3$

$$\frac{[\text{Ba}(\text{OH})_2] \times V}{[\text{CH}_3\text{CO}_2\text{H}] \times (50 - V)} = \frac{1}{2}$$

Volume of $\text{Ba}(\text{OH})_2 = V = 17 \text{ cm}^3$

Volume of $\text{CH}_3\text{CO}_2\text{H} = 50 - V = 33 \text{ cm}^3$

[0.5] × 2 for each volume, including working

M41

4 (b)

M42: A table showing all the chosen different volumes of the two solutions to be used. Total volume must be 50 cm^3 . There should be at least three $\text{Ba}(\text{OH})_2$ volumes $< 17 \text{ cm}^3$ and at least three $\text{Ba}(\text{OH})_2$ volumes $> 17 \text{ cm}^3$ so that there are at least three plotted points on each line.

M42

M43: Same table showing measurement of initial temperature of $\text{Ba}(\text{OH})_2$ (or $\text{CH}_3\text{CO}_2\text{H}$), the highest temperature reached after mixing and ΔT .

M43

M44: Use of thermometer, two measuring cylinders. Burette can be used for the first reagent added, but second reagent added must be measuring cylinder. However, student is not penalised here for apparatus if they used burettes for both reagents. **M46** will be lost instead.

M44

M45: Took action to minimise heat loss e.g. using two styrofoam cups stacking one into the other / use a lid for the styrofoam cup / switch off the fans to ensure draft-free environment. **M45** is lost if student uses a beaker as the reaction container (instead of styrofoam cup / polystyrene cup). Using just one styrofoam cup is not good enough to score **M45**.

M45

M46: Overall sequence of actions:

M46

measure volume of one solution, **add quickly into a styrofoam cup**



measure temperature of this solution in the cup



measure volume of second solution, **add it into the same cup**



stir and measure the highest temperature reached

M46 is lost if the student designed a *temperature vs. time* graph experiment i.e. took temperature readings at 1 min, 2 min, 3 min, 4 min, 5 min etc, or any other wrong approach. **M46** is also lost if burettes were used for both reagents as you will be unable to add fast.

Sample Answers:

<i>Volume of CH₃CO₂H /cm³</i>	<i>Volume of Ba(OH)₂ /cm³</i>	<i>Initial temperature CH₃CO₂H / °C</i>	<i>Highest temperature after mixing / °C</i>	<i>ΔT / °C</i>
10	40			
20	30			
30	20			
35	15			
40	10			
45	5			

1. Use a 50 cm³ measuring cylinder to measure 40 cm³ of Ba(OH)₂ (or 10 cm³ CH₃CO₂H) and add it into a styrofoam cup. Place this styrofoam cup into a second styrofoam cup, which is then placed in a beaker for support. The two layers of styrofoam cups help to minimise heat loss to the surroundings (during the reaction).
2. Use a thermometer to measure and record the initial temperature of the solution in the cup.
3. Use a second 50 cm³ measuring cylinder to measure 10 cm³ of CH₃CO₂H (or 40 cm³ Ba(OH)₂). Add this second solution to the first solution in the cup. Cover the cup with a lid that has a hole for the thermometer. The lid also helps to minimise heat loss to the surroundings. Use the thermometer to stir the mixture and measure the highest temperature reached. Wash and dry the styrofoam cup and the thermometer.
4. Repeat the above steps using the volumes shown in the table.

$$4 \text{ (c) (i)} \quad \frac{[\text{Ba}(\text{OH})_2] \times (50 - V_{\text{neut}})/1000}{[\text{CH}_3\text{CO}_2\text{H}] \times (V_{\text{neut}})/1000} = \frac{1}{2}$$

$$\frac{0.50 \times (50 - V_{\text{neut}})/1000}{[\text{CH}_3\text{CO}_2\text{H}] \times (V_{\text{neut}})/1000} = \frac{1}{2}$$

$$(50 - V_{\text{neut}})/1000 = [\text{CH}_3\text{CO}_2\text{H}] \times (V_{\text{neut}})/1000$$

M47

$$\begin{aligned} \therefore [\text{CH}_3\text{CO}_2\text{H}] &= \frac{(50 - V_{\text{neut}})/1000}{V_{\text{neut}}/1000} \\ &= \frac{(50 - V_{\text{neut}})}{V_{\text{neut}}} \end{aligned}$$

[1] for calculation steps to determine $[\text{CH}_3\text{CO}_2\text{H}]$ in mol dm^{-3}

M48

$$\text{Heat change } q = 50 \times 4.18 \times \Delta T_{\text{max}}$$

$$n(\text{H}_2\text{O}) \text{ produced} = 2 \times n(\text{Ba}(\text{OH})_2) \text{ reacted} = 2 \times 0.50 \times (50 - V_{\text{neut}})/1000$$

$$\Delta H_{\text{neut}} = -q \div n(\text{H}_2\text{O})$$

[1] for calculation steps to determine ΔH_{neut}

4 (c) (ii) V_{neut} will not change because both HCl and $\text{CH}_3\text{CO}_2\text{H}$ are monobasic acids/react in same mole ratio with $\text{Ba}(\text{OH})_2$ and the concentration remains the same. **[1]** **M49**

HCl is a strong acid which ionises completely unlike $\text{CH}_3\text{CO}_2\text{H}$ which is a weak acid that ionises partially and some energy released from the neutralisation reaction is used to completely ionise $\text{CH}_3\text{CO}_2\text{H}$ / ΔH_{neut} for HCl is more negative, hence ΔT_{max} will increase. **[1]** **M50**