Volume of FA 3 added to mixture	/cm ³	6.00	11.00	15.00	20.00
Final burette reading	/cm ³	27.80	20.70	15.50	8.50
Initial burette reading	/cm ³	0.00	0.00	0.00	0.00
Volume of FA 2 added	/cm ³	27.80	20.70	15.50	8.50

YIJC 2020 Prelim H2 Chemistry Prelim P4 Suggested Answers

(c)

(b)

1



$$V_{max}$$
 (FA 3) = 26.25 cm³

V_{max}(FA 2) = 36.00 cm³

[6]

- (d) gradient = $\frac{36.0 0.0}{0.0 26.25} = -1.37$
- (e) The graph has a negative gradient because the more M_2CO_3 added, the lesser the amount of H_2SO_4 left in the mixture and hence, lesser NaOH is needed to neutralise the H_2SO_4 .
- (f) (i) Since $V_{max}(FA 2) = 36.00 \text{ cm}^3$,

$$n_{NaOH} = 0.550 \times 36.0 \times 10^{-3} = 0.0198 \text{mol}$$
$$n_{H_2SO_4} = \frac{1}{2} \times n_{NaOH} = \frac{1}{2} \times 0.0198 = 0.0099 \text{mol}$$
$$c_{H_2SO_4} = \frac{0.0099}{25.0 \times 10^{-3}} = 0.396 \text{ mol dm}^{-3}$$

(ii) $n_{M_2CO_3} = n_{H_2SO_4} = 0.0099 \text{ mol}$ Since $V_{max}(FA 3) = 26.25 \text{ cm}^3$, $c_{M_2CO_3} = \frac{0.0099}{26.25 \times 10^{-3}} = 0.377 \text{ mol dm}^{-3}$

(iii)
$$M_{\rm r}$$
 of M₂CO₃ = $\frac{39.75}{0.377}$ = 105.4
 $A_{\rm r}$ of M = $\frac{105.4 - 12.0 - (16.0 \times 3)}{2}$ = 22.7

- (g) Some NaOH will react with CO_2 in the air. Amount of NaOH left in FA 2 solution will decrease /[NaOH] decreases, resulting in a larger value of V_{max} (FA 2) required to neutralise the H₂SO₄ solution.
- (h) % error for mixture $1 = \frac{\pm 0.05 \times 2}{27.80} \times 100\% = \pm 0.360\%$

% error for mixture $\mathbf{2} = \frac{\pm 0.05 \times 2}{8.50} \times 100\% = \pm 1.18\%$

The percentage error is smaller as the titre volume for mixture 1 is larger than that of mixture 2.

(i) (i)						
	Experiment	Volume of	Volume of	Initial	Maximum	Maximum change in	
		FA 5 /cm ³	FA 6 /cm ³	temperature	temperature	temperature/°C	
				of FA 5 /ºC	∕°C		
	1	20.0	40.0	30.4	37.4	7.0	
	2	40.0	20.0	30.8	38.1	7.3	

(ii) Acid X is dibasic.

Amount of water formed in experiment 2 is same as that in experiment 1.

Heat released for experiment 2 is same as that of experiment 1. For the same volume of solution, change in temperature will be the same.

2 (a)	Experiment	Volume of FA 7 /cm ³	Volume of FA 8 /cm ³	Volume of FA 10/cm ³	volume of deionised water/cm ³	t/s	1/t/s ⁻¹
	1	5.0	5.0	10.0	10.0	69	0.0145
	2	10.0	5.0	10.0	5.0	35	0.0286
	3	5.0	10.0	10.0	5.0	34	0.0294
	4	5.0	5.0	20.0	0.0	18	0.0556

- (b) Total volume should be constant so that the **concentration of reactants is directly proportional to the volume used**.
- (c) [BrO₃[−]]

Comparing experiments 1 and 2, When [BrO₃⁻] doubles, (keeping [Br⁻] and [H⁺] constant), relative rate doubles.

Hence, order of reaction with respect to [BrO₃-] is one.

• [Br⁻]

Comparing experiments 1 and 3, When [Br⁻] doubles, (keeping [BrO₃⁻] and [H⁺] constant), relative rate doubles.

Hence, order of reaction with respect to [Br-] is one.

• [H⁺]

Comparing experiments 1 and 4,

When [H⁺] doubles, (keeping [BrO₃⁻] and [Br⁻] constant), relative rate quadruples.

Hence, order of reaction with respect to [H⁺] is two.

$$[\text{phenol}] = \frac{\frac{15}{1000} \times 0.030}{\frac{50}{1000}} = \frac{9.00 \times 10^{-3} \text{ mol dm}^{-3}}{1000}$$

(f) (decrease) change in
$$[BrO_3^-] = \frac{1}{3} \times [phenol]$$

= 3.00 × 10⁻³ mol dm⁻³

Rate = 3.00×10^{-3} / time in expt 1 = 3.00×10^{-3} / 69 = 4.35×10^{-5} mol dm⁻³ s⁻¹

(g) Rate = k
$$[BrO_3^-][Br^-][H^+]^2$$

$$4.35 \times 10^{-5} = k(\frac{5}{50} \times 0.350)(\frac{5}{50} \times 0.650)(\frac{10}{50} \times 0.250 \times 2)^{2}$$

k = 1.91 mol⁻³ dm⁹ s⁻¹

- (h) Any change in the rate of reaction is not due to change in concentration of FA 9.
 OR
 Volume of FA 9 should be kept constant as we are measuring the time taken for a fixed amount of Br₂ to be used up for the complete monobromination of FA 9 (and relating this time to the relative rate)
- (i) The bromo substituent is electron withdrawing / ring deactivating. This decreases the electron density in the ring and makes it less susceptible to electrophilic attacks.
- **3** (a) $K_{sp} = [Ca^{2+}] [OH^{-}]^2$
 - (b) 1. Using a 100.0 cm³ measuring cylinder, measure 100.0 cm³ of 0.100 moldm⁻³ NaOH (aq) into a 250 cm³ beaker.
 - 2. Using a spatula, add solid Ca(OH)₂ to the beaker containing NaOH(aq) until <u>no more solid is seen</u> to dissolve. (to prepare a saturated solution)
 - 3. Stir well with a glass rod (for three minutes).
 - 4. Allow the excess solid to settle and filter the mixture, using dry filter paper and dry filter funnel, into a dry 250 cm³ conical flask.
 - 5. Keep the filtrate.
 - 6. Fill the **burette** with 0.100 moldm⁻³ HCl.
 - 7. **Pipette** 25.0 cm³ of the filtrate into a clean 250cm³ conical flask.
 - 8. Add 2 3 drops of phenolphthalein / methyl orange / thymol blue indicator.

- 9. Titrate with HC*l* until the solution changes from **pink to colourless/ yellow to orange / blue to colourless**.
- 10. Repeat the titration until two consistent titres of within +/- 0.10 cm³ are obtained.
- (c) (i) Amount of $OH^- = (26.05/1000) \times 0.100 = 0.002605 \text{ mol}$

[OH⁻] = 0.002605 / 0.025 = <u>0.104 moldm⁻³</u>

- (ii) $[OH^{-}]$ from Ca(OH)₂ = $[OH^{-}]_{total} [OH^{-}]_{NaOH}$ = 0.1042 - 0.100 = <u>4.20 × 10⁻³ mol dm⁻³</u>
- (iii) $[Ca^{2+}] = 0.0042/2 = 2.10 \times 10^{-3} \text{ mol dm}^{-3}$
- (iv) $K_{sp} = [Ca^{2+}] [OH^{-}]^2$ = 2.10 x 10⁻³ x (0.1042)² = 2.28 x 10⁻⁵ mol³ dm⁻⁹
- (d) As NaOH is a strong base, it will fully dissociate to give Na⁺ and OH⁻. Hence, this **increases** the overall **concentration of OH⁻** in the solution which is a common ion.

As a result, according to LCP, the **position of equilibrium** $Ca(OH)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2OH^{-}(aq)$ will shift to the left, resulting in a decrease in solubility of calcium hydroxide.

