2021 Y6 H2 Chemistry Prelim Exam Paper 4 – Suggested Solutions

1(b)(i)

Titration number	**1**	**2**
Final burette reading / cm^3	22.75	22.75
Initial burette reading / cm^3	0.00	0.00
Volume of **FA 2** used / cm^3	22.75	22.75
Values used	✓	✓

(b)(ii) Average titre volume = $\frac{22.75+22.75}{2}$ = $\underline{22.75\ cm^3}$ (2 d.p.)

(c)(i) Amount of $S_2O_3^{2-}$ ions = $0.100 \times \frac{22.75}{1000} = 2.275 \times 10^{-3} = \underline{2.28 \times 10^{-3}\ mol}$ (3 s.f.)

(c)(ii) Amount of I_2 reacted = $\left(\frac{1}{2}\right)(2.275 \times 10^{-3}) = 1.138 \times 10^{-3}$ mol

Amount of IO_3^- ions in 25.0 cm^3 of **FA 1** = $\left(\frac{1}{3}\right)(1.138 \times 10^{-3})$

$= 3.793 \times 10^{-4} = \underline{3.79 \times 10^{-4}\ mol}$ (3 s.f.)

(c)(iii) Amount of IO_3^- ions in saturated solution prepared in **(a)**

$=\left(\frac{100.0}{25.0}\right)(3.793 \times 10^{-4}) = 1.517 \times 10^{-3} = \underline{1.52 \times 10^{-3}\ mol}$ (3 s.f.)

(c)(iv) Amount of IO_3^- from KIO_3 = $0.0100 \times \frac{50.0}{1000} = 5.00 \times 10^{-4}$ mol

Amount of IO_3^- ions from the $Ca(IO_3)_2$ that has dissolved

$= 1.517 \times 10^{-3} - 5.00 \times 10^{-4}$

$= 1.017 \times 10^{-3} = \underline{1.02 \times 10^{-3}\ mol}$ (3 s.f.)

(c)(v) Amount of Ca^{2+} ions in saturated solution prepared in **(a)**

$= \left(\frac{1}{2}\right)(1.017 \times 10^{-3}) = 5.085 \times 10^{-4} = \underline{5.09 \times 10^{-4}\ mol}$ (3 s.f.)

(c)(vi) K_{sp} of $Ca(IO_3)_2 = [Ca^{2+}][IO_3^-]^2$

units: $mol^3\ dm^{-9}$

(c)(vii)

$$K_{sp} \text{ of } Ca(IO_3)_2 = \left(\frac{5.085 \times 10^{-4}}{0.100}\right)\left(\frac{1.517 \times 10^{-3}}{0.100}\right)^2$$

$$= \underline{1.17 \times 10^{-6}}\ mol^3\ dm^{-9} \text{ (3 s.f.)}$$

(d) The concentration of IO_3^- in **FA 1** is lowered. This forms lesser I_2 for reaction with $S_2O_3^{2-}$. Therefore, the titre volume would be lower.

(e)(i) Total [ions] in solvent prepared for Experiment 1 = 2 x 0.0100

$= \underline{0.0200\ mol\ dm^{-3}}$

Total amount ions in solvent prepared for Experiment 2

$= 2\left(0.0100 \times \frac{25.0}{1000}\right) + 2\left(0.0100 \times \frac{75.0}{1000}\right)$

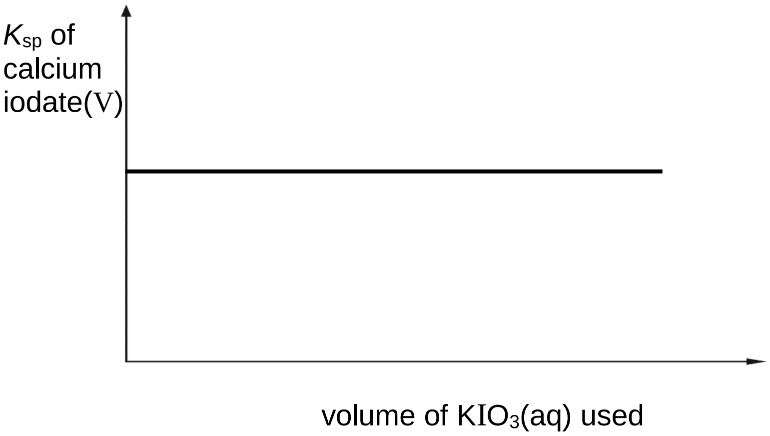
= 0.002 mol

Total [ions] in solvent prepared for Experiment 2 = $\frac{0.002}{0.100} = \underline{0.0200\ mol\ dm^{-3}}$

The total concentration of ions in both solvents are the same.

(e)(ii) As the volume of $KIO_3(aq)$ used increases, the concentration of IO_3^- increases and further suppresses the dissociation of calcium iodate. The solubility of $Ca(IO_3)_2$ decreases, hence the amount of IO_3^- ions obtained from $Ca(IO_3)_2$ that has dissolved will decrease.

(e)(iii) Do not agree.



2(a) The dissolving of KIO_3 is endothermic, as an increase in temperature shifts the equilibrium position to the right, favouring the endothermic dissolving process to remove some of the extra heat supplied.

(b) Solubility = $\frac{100}{V}$ × mass of KIO_3 = $\frac{100}{4.0}$ × 1.00 = 25.0 g per 100 g of water

(c) Solubility = $\frac{100}{V}$ × mass of KIO_3

$6.25 = \frac{100}{V} \times 1.00 \Rightarrow V = 16.0\ cm^3$

Hence the volume of water that will just dissolve 1.00 g KIO_3 at 10 °C is $16.0\ cm^3$.

(d) Procedure:

1. Weigh an empty boiling tube using a weighing balance and record its mass.
2. Transfer the contents of the weighing bottle with KIO_3 to the boiling tube. Reweigh the boiling tube and its contents using a weighing balance and record the mass.
3. Use a 10 cm^3 measuring cylinder (or burette) to transfer 4.0 cm^3 of deionised water to the weighed boiling tube with KIO_3.
4. Prepare a hot water bath by filling a 250 cm^3 beaker half full of water and heat it over the Bunsen burner.
5. Warm the boiling tube carefully in the water bath, while stirring the contents with a thermometer, until all the solid has dissolved.
6. Clamp the tube on a retort stand. Let the boiling tube cool and continue to stir gently with the thermometer.
7. Note and record the temperature at which crystals are first formed in the solution.
8. Add a further 2.0 cm^3 of deionised water to the boiling tube using the 10 cm^3 measuring cylinder/burette.
9. Warm the boiling tube in the water bath to re-dissolve the solid, and repeat steps 6 and 7.
10. Repeat steps 8, 5, 6 and 7 until five (if 3 cm^3 portions are added) OR seven readings (if 2 cm^3 portions are added) in total are obtained (with the lowest temperature at about 10 °C).

11. If crystals do not appear at temperatures close to room temperature, add ice cubes to the water bath to further lower the temperature.
12. Calculate the corresponding solubilities at the different temperatures.

(e) Weighing by difference for boiling tube:

Mass of boiling tube + KIO_3 / g	m_1
Mass of empty boiling tube / g	m_2
Mass of KIO_3 used / g	$m_1 - m_2$

OR

Weighing by difference for weighing bottle:

Mass of weighing bottle + KIO_3 / g	m_1
Mass of emptied weighing bottle / g	m_2
Mass of KIO_3 used / g	$m_1 - m_2$

OR

Use of TARE for boiling tube:

Mass of KIO_3 used = m g (TARE)

Table for volume of water and temperature:

Total volume of water, V / cm^3	Temperature at first appearance of crystals/ ^oC
4	T
6	
8	
10	
12	
14	
16	

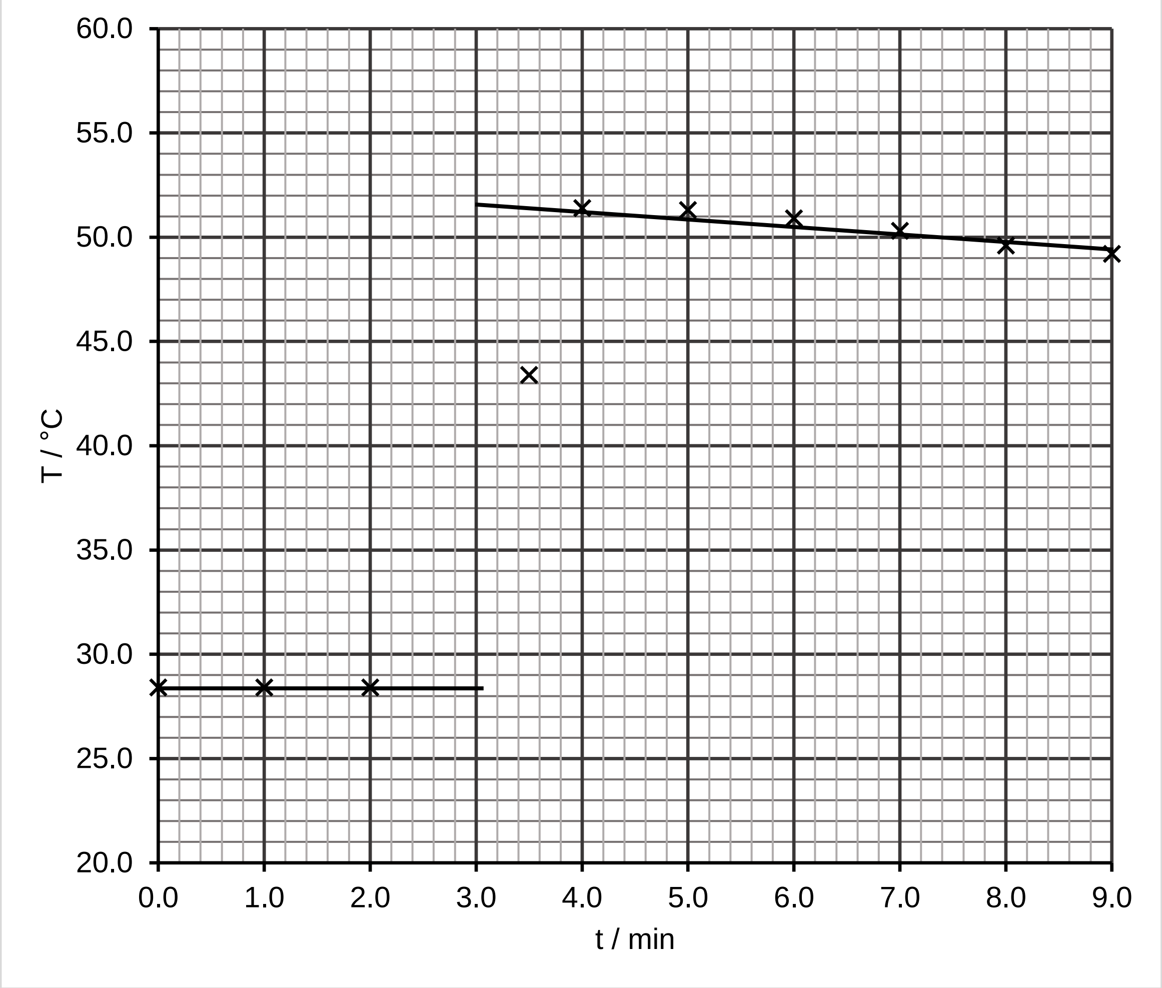
Solubility s at temperature $T = \frac{100}{V} \times (m_1 - m_2)$ or $\frac{100}{V} \times m$

3(a)(i)

Mass of bottle and **FA 5** / g	6.095
Mass of emptied bottle / g	5.222
Mass of **FA 5** / g	0.873

t / min	T / °C
0.0	28.4
1.0	28.4
2.0	28.4
3.5	43.4
4.0	51.4
5.0	51.3
6.0	50.9
7.0	50.3
8.0	49.6
9.0	49.2

(a)(ii) Plot a graph of *T* / °C against *t* / min



(a)(iii) T_{min} = 28.4 °C
T_{max} = 52.5 °C
ΔT = +24.1 °C

(a)(iv) q = (50.0) (4.18) (24.1)
= 5036.9 J = 5040 J or 5.04 kJ

(a)(v) Using 100 cm^3 of **FA 4** would lead to the value of ΔT being halved.
However, since m is doubled, this would lead to the same value of q.

(b)(i) **M** cannot be calcium because calcium sulfate is insoluble and no ppt was observed in the final mixture.

(b)(ii) **M** is Mg.

(c) Mass of MgO in **FA 5** = (0.87)(0.873) = 0.7595 g
Mass of Mg in **FA 5** = (0.13)(0.873) = 0.1135 g

$q = q_{Mg} + q_{MgO}$

$$5.0369 = (-466.8) - \frac{0.1135}{24.3} + \Delta H_1\left(-\frac{0.7595}{40.3}\right)$$
$$5.0369 = 2.180 - (0.01871)\,\Delta H_1$$
$$\Delta H_1 = -153 \text{ kJ mol}^{-1}$$

4(a) **Table 4.1**

	Test	observations
1	Test the solution of **FA 6** with Universal Indicator Paper.	pH = 2 or 3 dark orange / orange
2	Add 1 cm depth of **FA 6** to a boiling tube. Add aqueous sodium hydroxide until no further change occurs, then warm the boiling tube gently.	No ppt / No NH_3 evolved / no observable change
	Allow the mixture to cool slightly. Add 1 piece of aluminium foil, then warm the boiling tube gently.	No NH_3 evolved / no observable change.
3	Add 1 cm depth of **FA 6** to a test-tube. Add 1 cm depth of aqueous barium nitrate. Add dilute nitric acid dropwise until no further change occurs.	White ppt formed. White ppt insoluble in dilute nitric acid.

(b)(i) **Table 4.2**

	identity	**evidence**
anion **P**	SO_4^{2-}	In test 3, a white ppt of $BaSO_4$ was formed which was insoluble in nitric acid.
cation **Q**	H^+	In test 1, the pH of the solution is acidic. In test 2, when FA 6 was heated with NaOH, there was no ppt/no observable change.

(b)(ii) $S_2O_8^{2-}$

(c)(i) A red-brown ppt is formed.
There is effervescence of CO_2 which gave a white ppt in limewater.

(c)(ii) Fe^{3+}
Red-brown ppt of $Fe(OH)_3$ formed.
There is effervescence of CO_2 which gave a white ppt in limewater.

(d)(i) Solution in test tube A turned brown faster than the solution in test tube B.

(d)(ii) **FA 6** is an oxidising agent as it oxidises iodide in potassium iodide to the brown iodine observed.

(d)(iii) **Table 4.3**

test-tube A	test-tube B
Brown solution decolourises Red-brown ppt formed.	Brown solution decolourises

(d)(iv) **FA 7** is a homogeneous catalyst.
From (i), iodide was oxidised to brown iodine more quickly in test-tube A than B, hence **FA 7** sped up the reaction rate in test-tube A.
From (iii), the formation of red-brown ppt $Fe(OH)_3$ showed that **FA 7** is consumed and regenerated in test tube A.