2018 Y6 H2 Chemistry Preliminary Exams Paper 4 (Suggested Solutions)

1(a) Volume of **FA 2** needed = $\frac{5}{30}$ x 250 = <u>41.67 cm^3</u>

1(b) Dilution of **FA 2**:

Final burette reading / cm^3	41.00
Initial burette reading / cm^3	0.00
Volume of **FA 2** used / cm^3	41.00

Titration Results:

Titration number	**1**	**2**
Final burette reading / cm^3	24.80	24.80
Initial burette reading / cm^3	0.00	0.00
Volume of **FA 1** used / cm^3	24.80	24.80
Values used	✓	✓

1(c) Average volume of **FA 1** used = $\frac{24.80 + 24.80}{2}$
= <u>24.80 cm^3</u>

<u>25.0</u> cm^3 of **FA 4** produced an amount of iodine which required <u>24.80</u> cm^3 of **FA 1**.

1(d) Amount of thiosulfate ions = $0.0500 \times \frac{24.80}{1000}$ = <u>1.24×10^{-3} mol</u>

Mole ratio of Cu^{2+} : I_2 : $S_2O_3^{2-}$ = 2 : 1 : 2
Amount of Cu^{2+} in 25.0 cm^3 of **FA 4** = amount of $S_2O_3^{2-}$
= 1.24×10^{-3} mol

[Cu^{2+}] in **FA 4** = $\frac{1.24 \times 10^{-3}}{25.0 \times 10^{-3}}$ = <u>0.0496 mol dm^{-3}</u>

1(e) [Cu^{2+}] in **FA 2** = 0.0496 x $\frac{250}{41}$ = <u>0.302 mol dm^{-3}</u>

1(f) Amount of NaI in 10 cm^3 of 50 g dm^{-3} sodium iodide
= $\frac{50}{23.0 + 126.9}$ x 0.010 = <u>0.00334 mol</u>

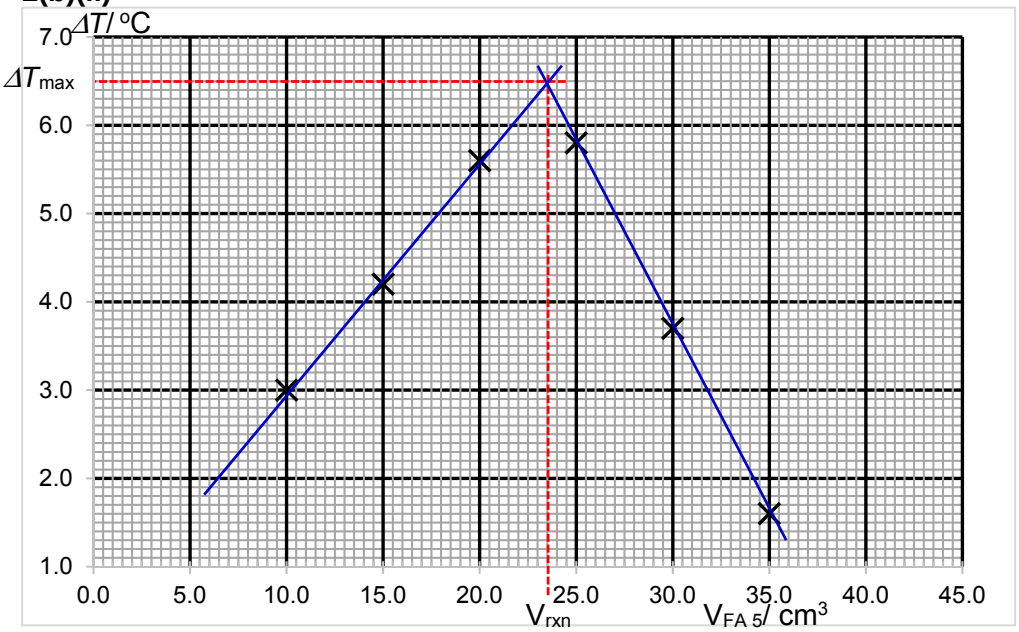
Amount of NaI required to react with Cu^{2+} in 25.0 cm^3 of **FA 4**
= 2 x 25.0 x 10^{-3} x 0.0496 = 0.00248 mol

When using 50 g dm^{-3} sodium iodide, amount of <u>iodide is still in excess</u>. Hence there is <u>no effect</u> on the titre volume as the same amount of I_2 will be produced.

2(b)(i) Results:

No	V_{FA5}/ cm^3	V_{FA6}/ cm^3	T_1/ ^{o}C	T_2/ ^{o}C	ΔT/ ^{o}C
1	10.0	30.0	29.0	32.0	3.0
2	20.0	20.0	29.6	35.2	5.6
3	30.0	10.0	29.6	33.3	3.7
4	35.0	5.0	30.0	31.6	1.6
5	25.0	15.0	29.6	35.4	5.8
6	15.0	25.0	29.0	33.2	4.2

2(b)(ii)



2(b)(iii) maximum temperature change of reaction mixture, ΔT_{max} = 6.5 ^{0}C
volume of **FA 5** required for complete reaction, V_{rxn} = 23.5 cm^3

2(c)(i) To obtain ΔT_{max}, V_{FA6} = 40.0 – 23.5 = 16.5 cm^3

Amount of $S_2O_3^{2-}$ = $\frac{16.5}{1000}$ x 0.100 = 0.00165 mol

Amount of NaC*l*O in 23.5 cm^3 of **FA 5**

= 4 x amount of $S_2O_3^{2-}$ = 0.00660 mol

Concentration of NaC*l*O in **FA 5** = $\frac{0.00660}{0.0235}$ = 0.281 mol dm^{-3}

2(c)(ii) Heat given out = 40.0 x 4.18 x 6.5 = 1086.8 J

$\Delta H_1 = -\frac{1086.8}{0.00165}$ J mol^{-1} = −659 kJ mol^{-1}

2(d) $q = mc\Delta T_{max} = n \times \Delta H_1 \Rightarrow \Delta T_{max} = \frac{n \times \Delta H_1}{m \times c}$

When **V_{FA5}** and **V_{FA6}** are doubled, both n and m are doubled (ΔH_1 and c remain constant).
Hence ΔT_{max} is unaffected.

2(e)(i) Amount of $S_2O_3^{2-}$ = 0.030 x 0.100 = 3.00 x 10^{-3} mol
Amount of C*l*O$^-$ = 4 x amount of $S_2O_3^{2-}$ = 0.0120 mol
Mass of NaC*l*O = 0.0120 x (23.0 + 35.5 + 16.0) = 0.894 g

2(e)(ii) Assuming a percentage purity of 80 % NaC*l*O,

Mass of **FA 7** required $= \frac{0.894}{0.80} =$ <u>1.12 g</u>

2(e)(iii) **<u>Using an analytical balance</u>**, weigh accurately about 0.400 g of **FA 7. <u>Record the mass of the weighing bottle and the mass of FA 7,</u>** m_1.

<u>Using a burette, add 30.00 cm^3 of FA 6 in a clean and dry Styrofoam cup</u>. Place the cup inside a second Styrofoam cup which is placed in a 250 cm^3 glass beaker to prevent it from tipping over.

<u>Place a thermometer into the cup containing FA 6. Stir gently, measure and record the initial temperature of FA 6</u>, T_1.

Pour **FA 7** from the weighing bottle into the cup containing **FA 6.** Using the thermometer, **<u>stir to dissolve FA 7, measure and record the highest temperature of the mixture</u>**, T_2.

<u>Weigh and record the mass of the emptied weighing bottle</u>, m_2.

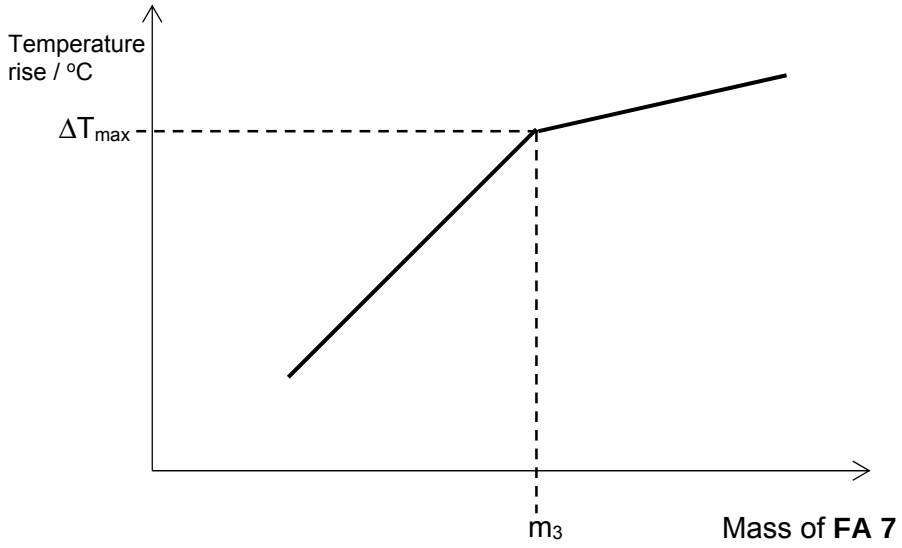
Mass of **FA 7** used = $m_1 - m_2$.

Maximum temperature change = $T_2 - T_1$.

<u>Repeat the experiment using 0.600 g, 0.800 g, 1.200 g, 1.400 g and 1.600 g</u> of **FA 7.**

<u>Plot graph of maximum temperature change against mass of FA 7</u> used.

A graph similar to the following graph would be obtained:



m_3 and ΔT_{max} may be obtained.

Percentage purity of NaC*l*O in **FA 7** $= \frac{0.894}{m_3} \times 100\ \%$

Heat change, q = 30.00 x 4.18 x ΔT_{max}

Enthalpy change of reaction 2, $\Delta H_2 = -\frac{30.00 \times 4.18 \times \Delta T_{max}}{\text{amount of } S_2O_3^{2-}} = -\frac{30.00 \times 4.18 \times \Delta T_{max}}{0.003}$

$= \underline{-41800\ \Delta T_{max}\ \text{J mol}^{-1}}$

2(e)(iii)

$$4NaClO(s) + Na_2S_2O_3(aq) + 2NaOH(aq) \xrightarrow{\Delta H_2} 4NaCl(aq) + 2Na_2SO_4(aq) + H_2O(l)$$

$4\Delta H_{sol}$ ↘ ↗ ΔH_1

$$4NaClO(aq) + Na_2S_2O_3(aq) + 2NaOH(aq)$$

$\Delta H_{sol} = ¼ (\Delta H_2 - \Delta H_1)$

3(a)

	Test	Observations
(i)	Using a measuring cylinder, add 10 cm^3 of **FA 2** into a boiling tube. Add 4 spatulas of **FA 8**. Warm the mixture cautiously till boiling. Leave to cool for 5 minutes. Filter the mixture and keep the filtrate for tests **(ii)** and **(iii)**.	Blue **FA 2** turns colourless. Red-brown/brown/black residue colourless filtrate
(ii)	To 1 cm depth of the filtrate, add aqueous ammonia.	White ppt formed, soluble in excess NH_3 to give a colourless solution.
(iii)	To another 1 cm depth of the filtrate, add 2 spatulas of solid ammonium chloride, followed by aqueous ammonia.	No ppt formed.
(v)	Using a spatula, add a **very small quantity** of **FA 8** to the boiling tube containing **FA 10** solution from test **(iv)**. Swirl the mixture gently and record your observations. Continue to add more **FA 8** in small quantities with swirling, until no further colour change is observed. Record all colour changes observed.	Yellow solution turns green Green solution turns blue Blue solution turns green Green solution turns violet/purple Effervescence of H_2 gas extinguished lighted splint with a 'pop sound.
(vi)	To 1 cm depth of the filtrate from test **(v)**, add an equal volume of aqueous hydrogen peroxide.	Violet solution turns red brown/brown/orange/orange-brown. Effervescence of O_2 gas relighted glowing splint.

3(b)(i)

Identity of FA 8	Evidence
Zn	In test (i), Zn was oxidised to Zn^{2+} by Cu^{2+} in **FA 2**. In test (ii) The Zn^{2+} formed a white ppt of $Zn(OH)_2$, soluble in excess NH_3 to give a colourless solution.

3(b)(ii)

$NH_4Cl \rightarrow NH_4^+ + Cl^-$

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ ----(1)

In the presence of NH_4^+ from the full dissociation of ammonium chloride, the dissociation of NH_3 is suppressed (or position of equilibrium of (1) lies to the left).

The concentration of OH^- is too low for the ionic product to exceed K_{sp} or for ppt to form.

3(b)(iii) The grey ppt was $V(OH)_2$.

3(c) Add **FA 2** to the four unknown solutions. The solution that produces a bluish green ppt of $CuCO_3$ is Na_2CO_3.

To the three remaining solutions that did not give a blue–green ppt, add an equal volume of Solution **X** and warm.
The solution that produces a reddish brown ppt of Cu_2O is CH_3CH_2CHO.

The two remaining solutions that did not produce any ppt are $Al_2(SO_4)_3$ and CH_3COOH.

To the two remaining solutions, add the unknown that was identified as Na_2CO_3.

The solution that produces effervescence of CO_2 is CH_3COOH.

The solution that produces effervescence of CO_2 and a white ppt of $Al(OH)_3$ is $Al_2(SO_4)_3$.