1(a)(i)

tests	observations
Test **FA 1** with Universal Indicator paper.	Universal Indicator paper turns <u>orange</u>. <u>pH is 3</u>
Add 1 cm depth of **FA 1** into a test-tube. Add aqueous sodium hydroxide, slowly with shaking, until no further change is seen. Filter the mixture into a clean test-tube. To the filtrate, add dilute nitric acid drop-wise until in excess.	 <u>Off-white/white ppt</u> formed, insoluble in excess NaOH. Off-white ppt <u>turned brown</u> on contact with air. <u>Off-white/brown residue</u>. <u>Colourless filtrate</u>. <u>White ppt formed, soluble in excess</u> dilute nitric acid to give a colourless solution.
Add 1 cm depth of **FA 2** into a test-tube. Add 1 cm depth of dilute nitric acid.	 <u>Effervescence</u>. <u>CO_2 gas evolved gave a white ppt with limewater</u>.

1(a)(ii)

	identity	evidence
cation in **FA 1**	Mn^{2+}	In <u>test 2</u>, **FA 1** reacted with <u>NaOH(aq)</u> to give an <u>off-white ppt of $Mn(OH)_2$</u> which was insoluble in excess NaOH(aq). On contact with air, $Mn(OH)_2$ was oxidised to brown $Mn(OH)_3$.
cation in **FA 1**	Al^{3+}	In <u>test 2</u>, **FA 1** reacted with excess NaOH(aq) to form a colourless filtrate after filtration. On adding <u>dilute nitric acid</u>, a <u>white ppt of $Al(OH)_3$</u> is formed. Also, in <u>test 1</u>, **FA 1** is <u>acidic</u>.
anion in **FA 2**	CO_3^{2-}	In <u>test 3</u>, **FA 2** reacted with <u>dilute nitric acid</u> to give effervescence of <u>CO_2</u> gas which gave a white ppt with limewater.

1(b)

test	observations with **FA 3**	observations with **FA 4**
Add 1 cm depth of **FA 3** to a test-tube. Add all of the magnesium turnings provided in the vial to this test-tube.	Effervescence. Colourless H_2 gas is evolved and 'pops' with a lighted splint.	no observable change
Add about 1 cm depth of **FA** solution to a test-tube. To this test-tube, add 8 drops of sodium hydroxide solution followed by iodine solution, dropwise, until a permanent orange/red colour is present.	Solution **FA 3** turns orange OR no yellow ppt	Solution **FA 4** turns orange. Yellow ppt forms.
Add 1 cm depth of aqueous silver nitrate to a test-tube. Then slowly add 1 cm depth of aqueous sodium hydroxide. Add aqueous ammonia slowly, with shaking, until the precipitate just dissolves. You may use a clean glass rod to stir the mixture and help dissolve the precipitate. Add 1 cm depth of **FA 4** to this mixture, shake the tube and place it in the test-tube rack to stand.	no observable change	Silver mirror formed

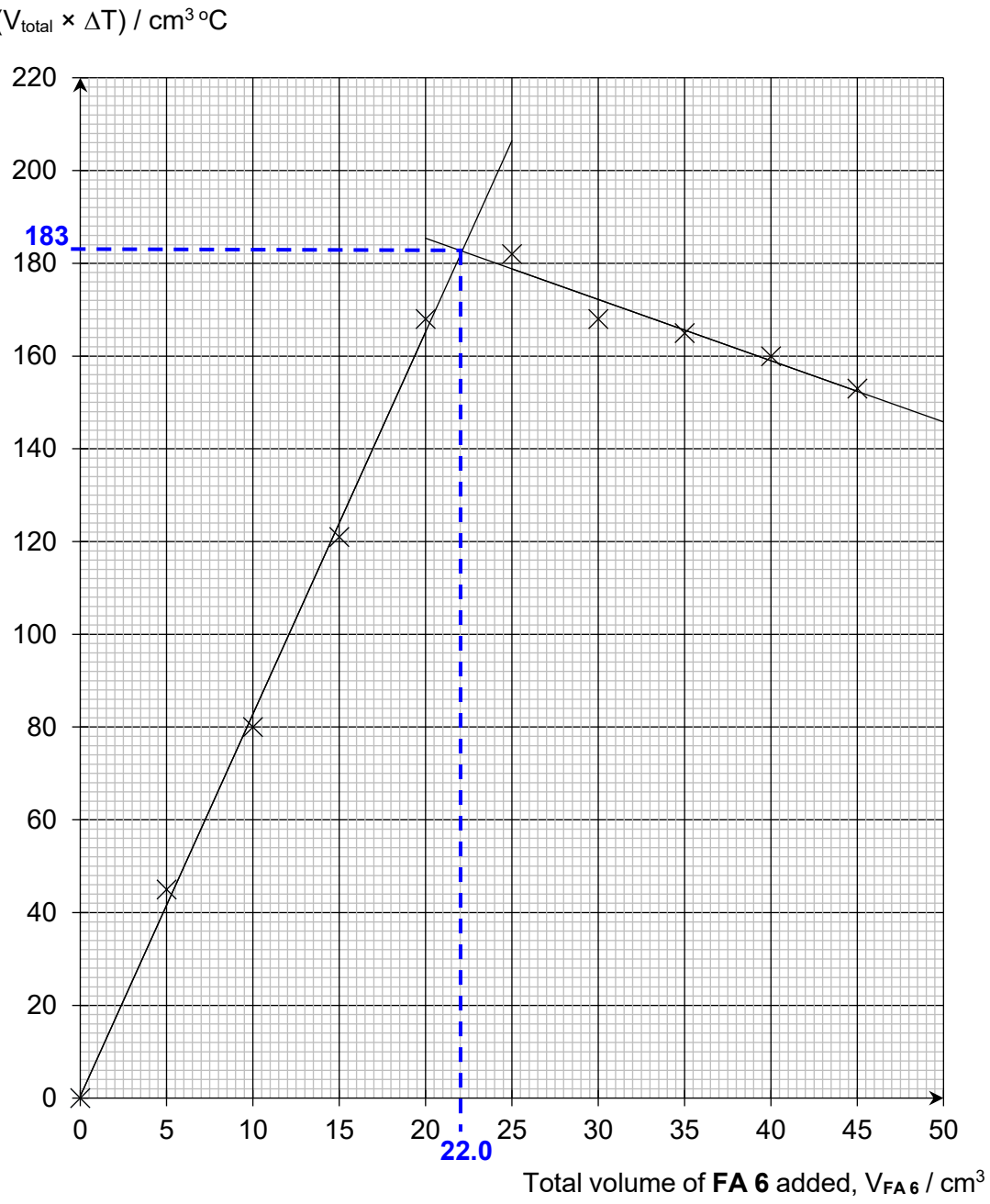
1(b)(iv)

	identity
Y in **FA 3**	CH_3COOH or ethanoic acid
Z in **FA 4**	CH_3CHO or ethanal

2(a)

Total volume of **FA 6** added, $V_{FA\ 6}$ / cm^3	Total volume of solution in the cup, V_{total} / cm^3	Maximum temperature, T / °C	$\Delta T = T - T_0$ / °C	$(V_{total} \times \Delta T)$ / cm^3 °C
0.00	40.0	29.4	0.0	0.00
5.00	45.0	30.4	+1.0	45.0
10.00	50.0	31.0	+1.6	80.0
15.00	55.0	31.6	+2.2	121
20.00	60.0	32.2	+2.8	168
25.00	65.0	32.2	+2.8	182
30.00	70.0	31.8	+2.4	168
35.00	75.0	31.6	+2.2	165
40.00	80.0	31.4	+2.0	160
45.00	85.0	31.2	+1.8	153

2(b)(i)



V_{eq} = 22.0 cm^3

Maximum value of (V_{total} × ΔT) = 183

2(b)(ii)

$n(NaHCO_3)$ used = $\frac{40.0}{1000}$ x 0.6 = 0.0240 mol = n(NaOH) reacted

concentration of NaOH in **FA 6** = 0.024 ÷ $\frac{22}{1000}$ = 1.09 mol dm^{-3}

2(b)(iii) From the graph, max (V_{total} × ΔT) = 183

heat change, q = m x c x ΔT = (m x ΔT) x c = (V_{total} × ΔT) x c = 183 x 4.18

= +764.94 J

$\Delta H_1 = -(764.94 \times 10^{-3}) \div 0.0240 = -31.9$ kJ mol^{-1}

2(b)(iv) (V_{total} × ΔT) will vary more linearly with (or is directly proportional to) the total volume of **FA 6** added while curves are obtained when plotting T against total volume of **FA 6** added. It is more accurate to extrapolate straight lines than curves.

2(c)(i) $T_{average} = \dfrac{(40.0 \times 28.6) + (50.0 \times 28.9)}{40.0 + 50.0} = 28.77\ ^\circ C = 28.8\ ^\circ C$ (3 s.f.)

2(c)(ii) heat change, q = (40.0 + 50.0)(4.18)(26.2 – 28.8) = −978.12 J

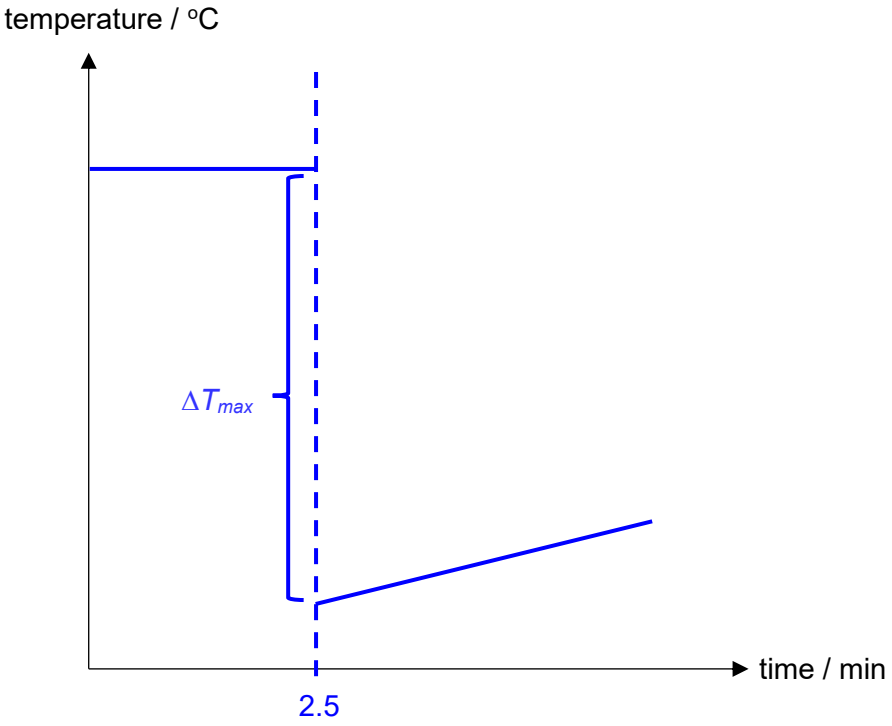
$n(NaHCO_3)$ used = $0.60 \times \dfrac{40.0}{1000} = 0.0240$ mol
Since $NaHCO_3$ is the limiting reagent,
$\Delta H_2 = + (-978.12 \times 10^{-3}) \div 0.0240 = +40.8$ kJ mol^{-1}

2(d)(i) Let mass of $NaHCO_3$ used be 5.0 g,
$n(NaHCO_3)$ used = 5.0 / 84.1 = 0.059453 mol

n(HC*l*) needed = 0.059453 mol
volume of HC*l* needed = 0.059453 / 2.00 = 0.02973 dm^3 = 29.7 cm^3

Since HC*l* used must be in excess, use 50.0 cm^3 of 2 mol dm^{-3} HC*l*.

2(d)(ii)



2(d)(iii) ΔT_{max} obtained by the graphical method is more accurate as heat gained from surroundings has been accounted for by extrapolation to find the lowest temperature reached from the graph.

2(d)(iv) Addition of HC*l* solution in small portions can minimise the acid spray caused by effervescence of CO_2(g).

3(a)(i) **Dilution of FA 6**

Final burette reading / cm^3	33.50
Initial burette reading / cm^3	21.00
Volume of **FA 6** used / cm^3	12.50

Titration results

Final burette reading / cm^3	29.10	39.10
Initial burette reading / cm^3	10.00	20.00
Volume of **FA 7** used / cm^3	19.10	19.10
Values used (✓)	✓	✓

3(a)(ii) Average volume of **FA 7** used = $\frac{19.10 + 19.10}{2}$ = 19.10 cm^3

3(b)(i) Concentration of $KHC_8H_4O_4$ in **FA 8** = $\frac{8.15}{204.2}$ = 0.03991 mol dm^{-3}

Amount of $KHC_8H_4O_4$ in 25.0 cm^3 of **FA 8** = $0.03991 \times 0.0250 = 9.978 \times 10^{-4}$ mol

Amount of NaOH used = 9.978×10^{-4} mol

Concentration of NaOH in **FA 7** = $\frac{9.978 \times 10^{-4}}{0.01910}$ = 0.05224 mol dm^{-3}
= 0.0522 mol dm^{-3} (3 s.f.)

3(b)(ii) Concentration of NaOH in **FA 6** = $\frac{250.0}{12.50}$ × 0.05224 = 1.04 mol dm^{-3}

3(c)(i) percentage error = $\frac{1.09 - 1.04}{1.04}$ × 100% = 4.81%

3(c)(ii) The volumetric titration method is more accurate as a <u>burette is used to measure equivalence volume accurately</u>. However, the thermometric titration method used a <u>less accurate method of extrapolating the graph to determine V_{eq}</u>.

OR

There in greater inaccuracy in data obtained using the thermometric titration method due to <u>heat loss to surroundings</u> whereas volumetric titration eliminates the need to account for heat exchange with surroundings.

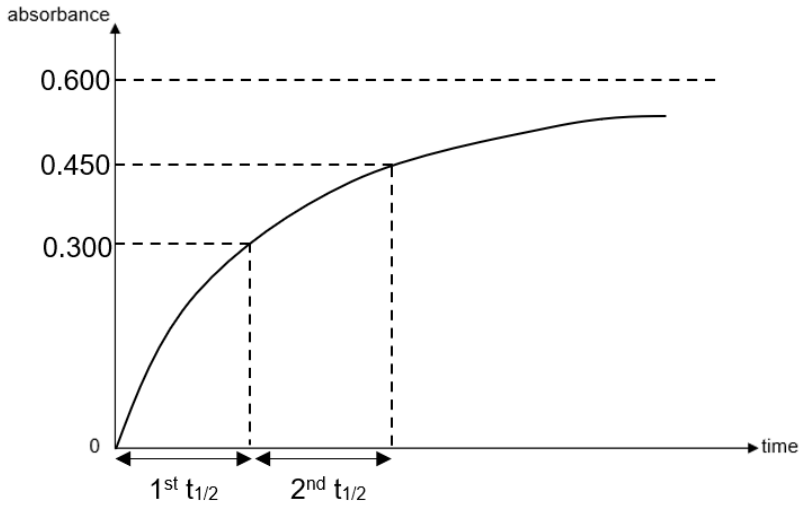
4(a) [NaC*l*O_3] in reaction mixture = $(0.00144 \times \frac{30}{1000}) \div \frac{90}{1000}$
= 0.000480 mol dm^{-3}
Limiting reagent is C*l*O_3^-
Maximum [C*l*O_2] = 0.000480 mol dm^{-3}

Applying Beer-Lambert's Law, $A = \varepsilon c\ell$
Maximum absorbance value = (1250)(0.000480)(1) = <u>0.600</u>

4(b) Procedure

1. Using a 50 cm^3 measuring cylinder, transfer 30.0 cm^3 of NaC*l*(aq) into a 250 cm^3 conical flask (or beaker).
2. To the same conical flask, add 30.0 cm^3 of H_2SO_4(aq) using another 50 cm^3 measuring cylinder.
3. Measure 30.0 cm^3 of NaC*l*O_3(aq) using a 50 cm^3 measuring cylinder.
4. Add the NaC*l*O_3(aq) into the same 250 cm^3 conical flask in step 1. Start the stopwatch immediately. Swirl the conical flask to ensure even mixing.
5. Using a 10 cm^3 pipette, transfer 10.0 cm^3 of the reaction mixture (aliquot) into a 50 cm^3 beaker.
6. At time 2 min, place the beaker containing the aliquot in an ice bath and allow it to cool for 3 minutes.
7. Measure the absorbance of the aliquot using the UV-vis spectrometer.
8. Repeat steps 5 - 7 at 6, 10, 14, 18, 22, 26 minutes.

4(c)



1^{st} $t_{1/2}$ = 2^{nd} $t_{1/2}$, $t_{1/2}$ is constant and reaction is first order with respect to C*l*O_3^-.