EXPERIMENT NO. 21

When an acid reacts with an alkali the neutralisation reaction is always exothermic.

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

You will determine the enthalpy change of neutralisation, ΔH, for a monoprotic acid **X**.

FA 3 is aqueous sodium hydroxide, NaOH.
FA 4 is a 2.00 mol dm^{-3} solution of monoprotic acid **X**.

(a) Method

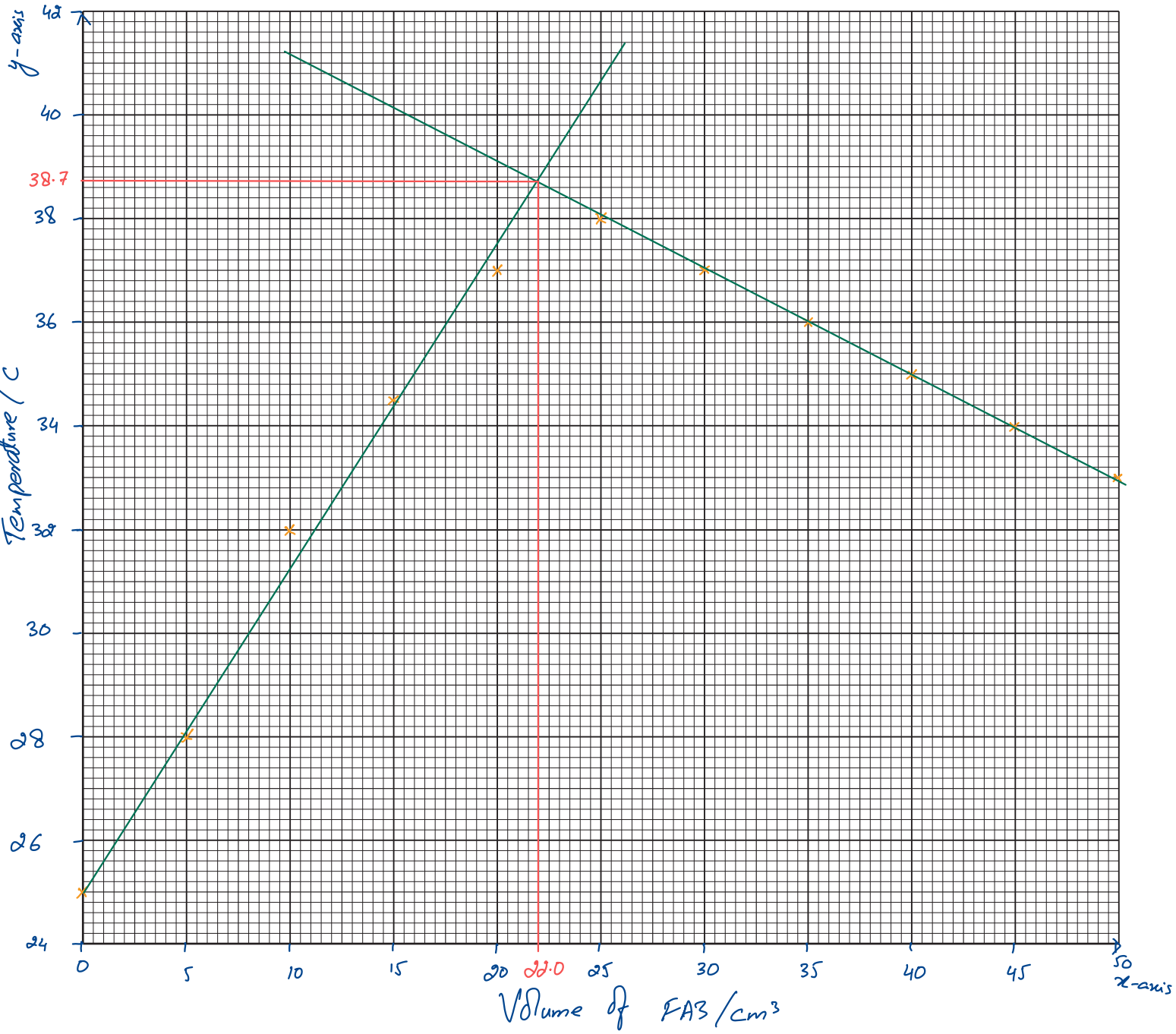
- Support the plastic cup in the 250 cm^3 beaker.
- Fill the burette with **FA 3**.
- Use the measuring cylinder to transfer 25.0 cm^3 of **FA 4** into the plastic cup.
- Measure and record the temperature of **FA 4** in the plastic cup.
- Add 5.00 cm^3 of **FA 3** from the burette into the plastic cup. Stir the contents of the cup. Read and record the maximum temperature of the solution.
- Add a further 5.00 cm^3 of **FA 3** from the burette into the cup. Stir the contents of the cup. Read and record the maximum temperature of the solution.
- Repeat the addition of **FA 3**, in 5.00 cm^3 portions, until 50.00 cm^3 have been added. Read and record the maximum temperature of the solution after each addition.

Vol. of FA3 /cm^3	Temperature /°C	Vol. of FA3 /cm^3	Temperature /°C
0.00	25.0	30.00	37.0
5.00	28.0	35.00	36.0
10.00	32.0	40.00	35.0
15.00	34.5	45.00	34.0
20.00	37.0	50.00	33.0
25.00	38.0		

I	
II	
III	
IV	

[4]

(b) On the grid plot a graph of temperature, (*y*-axis), against volume of **FA 3** added, (*x*-axis).
Your scale should allow a temperature of 2 °C above the maximum measured to be plotted.



On your graph draw two lines of best fit. One line should be for when the temperature was rising and the other for after the maximum temperature had been reached. You should indicate clearly any points you consider to be anomalous.

Extrapolate the lines so that they intersect. [4]

(c) From your graph, determine the maximum temperature reached in the experiment and the volume of **FA 3** added to produce this maximum temperature.

maximum temperature reached = ...38.7..... °C

volume of **FA 3** added to reach maximum temperature = ...22.0..... cm^3

[1]

(d) (i) Calculate the energy released during this experiment.

[Assume that 4.2 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.]

$= m c \Delta T$

$= 47 \times 4.2 \times 13.7$

energy released = ...2704..... J [1]

(ii) Calculate the number of moles of acid **X** in 25.0 cm^3 of **FA 4**.

$n = c V$

$= 2.00 \times \frac{25.0}{1000}$

moles of **X** = ...0.0500..... mol [1]

(iii) Calculate, in kJ mol^{-1}, the enthalpy change of neutralisation for acid **X**.

enthalpy change = $\frac{\text{heat energy}}{\text{moles}} = \frac{2.704\ kJ}{0.0500\ mol} = 54.01\ kJ\ mol^{-1}$

enthalpy change = (sign) − (value) 54.01 ..... kJ mol^{-1} [1]

(e) Without changing the apparatus or solutions used, suggest **one** way in which the experiment could be modified to make the values obtained in **(c)** more accurate.

Repeat the experiment with volumes of FA3 near the endpoint. [1]

(f) The enthalpy change of neutralisation of hydrochloric acid with aqueous sodium hydroxide is more exothermic than the enthalpy change of neutralisation of acid **X**.

Explain what this tells you about acid **X**.

Acid X is a weak acid

It consumes some energy to break H–X bond.

..... [2]

[Total: 15]