EXPERIMENT NO. 12

2 When an organic acid, RCOOH, is neutralised by an alkali an exothermic reaction takes place. You will determine the enthalpy change of neutralisation, ΔH, for the following reaction.

$$RCOOH(aq) + NaOH(aq) \rightarrow RCOONa(aq) + H_2O(l)$$

In this equation R is an alkyl group.

FA 3 is a solution containing 120.1 g dm^{-3} of RCOOH.
FA 4 is aqueous sodium hydroxide, NaOH.

(a) Method

Experiment 1

- Support the cup in the 250 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to transfer 25.0 cm^3 of **FA 3** into the cup.
- Measure and record the temperature of this **FA 3**. Rinse the thermometer.
- Place 25.0 cm^3 of **FA 4** into the 50 cm^3 measuring cylinder.
- Measure and record the temperature of the **FA 4** in the measuring cylinder. Rinse the thermometer.
- Tip the **FA 4** from the measuring cylinder into the cup. Stir, then measure and record the highest temperature reached.
- Calculate and record the average initial temperature of **FA 3** and **FA 4**.
- Calculate and record the difference between the average initial temperature and the highest temperature reached.
- Rinse and dry the cup for use in **Experiment 2**.

Experiment 2

- Repeat **Experiment 1** using 50.0 cm^3 of **FA 3** and **FA 4**. You will need to use the 25 cm^3 measuring cylinder twice to measure the **FA 3**.
- Calculate and record the average initial temperature of **FA 3** and **FA 4**.
- Calculate and record the difference between the average initial temperature and the highest temperature reached.

Experiment number	01	02
Temperature of FA3 / °C	22.0	22.5
Temperature of FA4 / °C	22.0	22.5
Average initial temperature / °C	22.0	22.5
Final temperature / °C	28.0	28.5
Change in temperature / °C	6.0	6.0

[4]

(b) Calculations

(i) Calculate the energy released in **Experiment 1**.
(Assume that 4.2 J of energy changes the temperature of $1.0\,cm^3$ of solution by 1.0 °C.)

$= mC\Delta T$ or $VC\Delta T$

$= 50 \times 4.2 \times 6.0$

energy released = ...1260.... J [1]

(ii) Calculate the number of moles of RCOOH used in **Experiment 1**. Assume that the relative molecular mass, M_r, of RCOOH is 122.
Show your working.

$n = \frac{m}{Mr}$

$= \frac{120.1}{122}$

$0.984\,mol\,dm^{-3}$

$n = CV$

$= 0.984 \times \frac{25.0}{1000}$

$0.0246\,mol$

moles of RCOOH = ...0.0246.... mol [2]

(iii) Calculate the enthalpy change of neutralisation, ΔH, of RCOOH. Assume that the sodium hydroxide is in excess.

0.0246 mol — 1260 J

1 mol — x

$\frac{51219.5\,J\,mol^{-1}}{1000}$

enthalpy change of neutralisation of RCOOH = ...−.... ....51.2.... $kJ\,mol^{-1}$

sign *value* [1]

(c) Each measuring cylinder can be read to an accuracy of $\pm 0.5\,cm^3$.

Calculate the total maximum percentage error in the volumes of solution measured in each of **Experiments 1** and **2**.

Experiment 1

% error in the vol. of FA3 $= \frac{\pm 0.5\,cm^3}{25.0\,cm^3} \times 100$ = 2%

% error in the vol. of FA4 $= \frac{\pm 0.5\,cm^3}{25.0\,cm^3} \times 100$ = 2%

= 2 + 2

total maximum percentage error = ...4.... %

Experiment 2

% error in the vol. of FA3 $= \frac{\pm 0.5\,cm^3}{25.0\,cm^3} \times 100$

2%

2% × 2 = 4%

% error in the vol. of FA4 $= \frac{\pm 0.5\,cm^3}{50.0\,cm^3} \times 100$ = 1%

= 4 + 1

total maximum percentage error = ...5.... %

[2]

(d) A student repeated both experiments in **(a)** using hydrochloric acid in place of RCOOH.

Suggest how the temperature rise when using HCl would compare to the temperature rise recorded in **(a)**. Assume all volumes and concentrations of solutions, in mol dm^{-3}, are the same.

Explain your answer by considering the chemical bonds involved.

With HCl temperature change would be more because in organic acid some energy needed to release H^+ ions. [2]

[Total: 12]