EXPERIMENT NO. 12
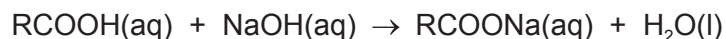
2   When an organic acid, RCOOH, is neutralised by an alkali an exothermic reaction takes place. You will determine the enthalpy change of neutralisation, ΔH, for the following reaction.

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

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.

[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.)

energy released = ... 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.

moles of RCOOH = ... mol [2]

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

enthalpy change of neutralisation of RCOOH = ... kJ mol^{-1}
sign   *value*   [1]

(c) Each measuring cylinder can be read to an accuracy of ± 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

total maximum percentage error = ... %

Experiment 2

total maximum percentage error = ... %
[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.

....

....

.... [2]

[Total: 12]