Enthalpy changes in solution

Answer all the questions below then check your answers.

1. In calorimetry, what do each of the terms in the equation below mean?

$q = c \times m \times \Delta T$

b. State the units for each of the terms in this equation.

term	units
q	
c	
m	
ΔH	

2. A student set up an experiment similar to the one opposite to measure the enthalpy change of neutralisation. She added 50ml of 1M hydrochloric acid (HCl) to the coffee cup calorimeter and recorded the temperature every minute for 4 minutes. She then added 50ml of 2M sodium hydroxide and stirred at a time of 4 minutes.

No temperature reading was taken at time 4 minutes, when the sodium hydroxide was added. She then recorded the temperature every minute for the next 10 minutes.

a. Why was this experiment carried in a coffee cup sitting inside another coffee cup with a cork lid on top?

b. Calculate the number of moles of hydrochloric acid present using the formula ($n = c \times v$).

c. Calculate the number of moles of sodium hydroxide added.

d. Write a balanced symbolic equation for the neutralisation of sodium hydroxide (NaOH) by hydrochloric acid (HCl) to form sodium chloride (NaCl) and water.

e. The sodium hydroxide solution is in excess. What does this mean and why is it in used in excess?

f. The maximum temperature rise recorded was 5.7°C. Calculate the enthalpy change for this neutralisation reaction. ($c = 4.18\ J\ g^{-1}\ K^{-1}$)

g. Calculate the molar enthalpy change for this reaction.

h. Explain why the calculate enthalpy change is likely to be lower than the actual enthalpy change for this neutralisation reaction.

i. Explain how the student could use an extrapolation method to calculate a more accurate value for the enthalpy of neutralisation.

3. An excess of magnesium ribbon was added to 50ml of 1M copper sulfate solution in a coffee cup calorimeter. The temperature change was 25°C. specific heat capacity is 4.18 J kg^{-1} K^{-1}.

a. How would the student know if the magnesium was in excess in this displacement reaction?

b. A balanced equation for this reaction is:

$$Mg + CuSO_4 \longrightarrow MgSO_4 + Cu$$

i. Calculate the enthalpy change for this reaction.

ii. Calculate the number of moles of copper sulfate that reacted.

iii. Use your answer to part ii to calculate the molar enthalpy change (heat released from 1 mole of copper sulfate solution).

Answers

Answer all the questions below then check your answers.

1. In calorimetry, what do each of the terms in the equation below mean?

$q = c \times m \times \Delta T$

q= amount of heat energy released to the surroundings (lost by the system) if the reaction is exothermic or vice versa for an endothermic reaction.

b. State the units for each of the terms in this equation.

term	units
q	KJ or $kJmol^{-1}$
c	$J\ g^{-1}\ K^{-1}$ or $kJ\ kg^{-1}\ K^{-}$
m	g or kg
ΔT	K

2. A student set up an experiment similar to the one opposite to measure the enthalpy change of neutralisation. She added 50ml of 1M hydrochloric acid (HCl) to the coffee cup calorimeter and recorded the temperature every minute for 4 minutes. She then added 50ml of 2M sodium hydroxide and stirred at a time of 4 minutes.

No temperature reading was taken at time 4 minutes, when the sodium hydroxide was added. She then recorded the temperature every minute for the next 10 minutes.

a. Why was this experiment carried in a coffee cup sitting inside another coffee cup with a cork lid on top?

To prevent heat loss to the surrounding, provides extra insulation.

b. Calculate the number of moles of hydrochloric acid present using the formula

$n = c \times v$

$= 1 \times 0.05$

$=0.05$ moles of acid.

c. Calculate the number of moles of sodium hydroxide present added.

$n = c \times v$

$= 2 \times 0.05$

$=0.1$ moles of sodium hydroxide.

d. Write a balanced symbolic equation for the neutralisation of sodium hydroxide (NaOH) by hydrochloric acid (HCl) to form sodium chloride (NaCl) and water.

$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

e. The sodium hydroxide solution is in excess. What does this mean and why is it in used in excess? More than enough required to neutralise the acid is used. This is done to ensure all the acid reacts and none is left.

f. The maximum temperature rise recorded was 5.7°C. Calculate the enthalpy change for this neutralisation reaction. (c= 4.18 J g^{-1} K^{-1})

g. Calculate the molar enthalpy change for this reaction.

$\Delta H = c \times m \times \Delta T$

$\Delta H = 4.18 \times 0.1 \times 5.7$

$= 2.38$ kJ

Moles of acid used is calculated as:

$n = c \times v$

$= 1 \times 0.05$

$= 0.05$ moles.

To calculate the enthalpy change for 1 mole simply divide 2.38kJ/0.05 mol

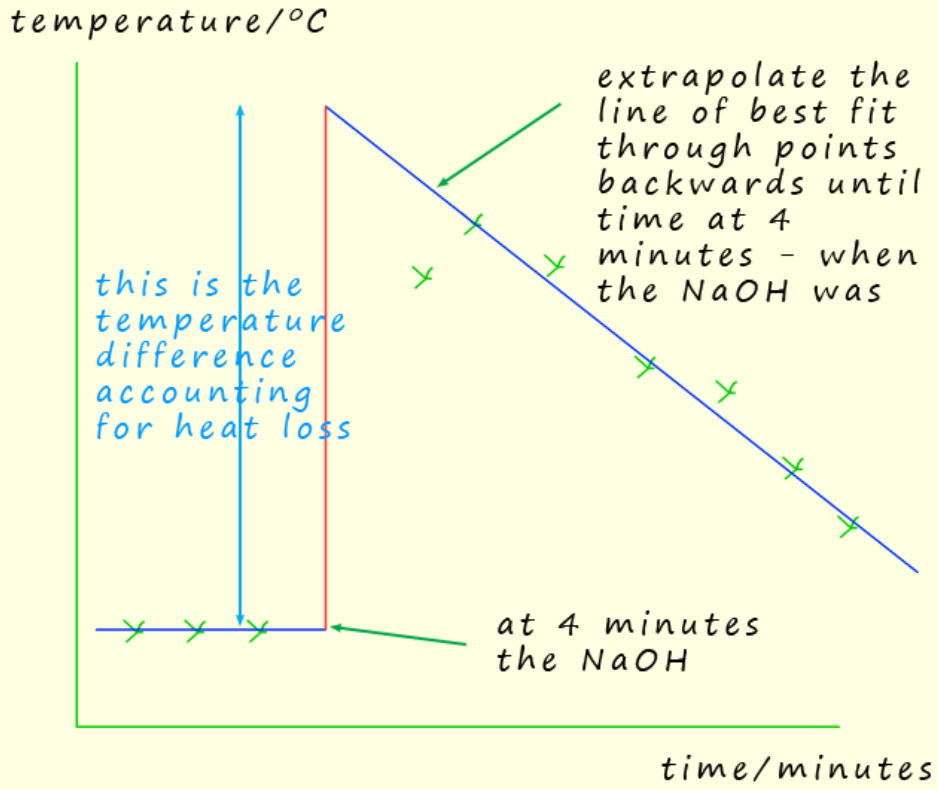
Molar enthalpy change is 47.6 kJ mol^{-1} of heat energy changed by the surroundings, so the heat lost by the system is -47.6 kJ mol^{-1}, the negative sign indicated the system is losing energy and that the reaction is exothermic.

h. Explain why the calculate enthalpy change is likely to be lower than the actual enthalpy change for this neutralisation reaction.

Main error will be heat loss to the surroundings, this heat loss will not be measured by the thermometer and so the calculated enthalpy change will be lower than expected.

i. Explain how the student could use an extrapolation method to calculate a more accurate value for the enthalpy of neutralisation.

Use the extrapolation method, extend a line of best fit through all the temperatures on a temperature/time graph as shown below.



3. An excess of magnesium ribbon was added to 50ml of 1M copper sulfate solution in a coffee cup calorimeter. The temperature change was 25°C, specific heat capacity is 4.18 J kg^{-1} K^{-1}.

a. How would the student know if the magnesium was in excess in this displacement reaction?

Will be unreacted magnesium left after it has reacted with the acid.

b. A balanced equation for this reaction is:

$Mg + CuSO_4 \longrightarrow MgSO_4 + Cu$

i. Calculate the enthalpy change for this reaction.

$\Delta H = c \times m \times \Delta T$

$\Delta H = 4.18 \times 0.05 \times 25$

$= 5.22$ kJ

ii. Calculate the number of moles of copper sulfate that reacted.

$n = c \times v$

$= 1 \times 0.05$

$= 0.05$ moles.

iii. Use your answer to part ii to calculate the molar enthalpy change (heat released from 1 mole of copper sulfate solution).

$5.22kJ/0.05mol = 104.5\ kJmol^{-1}$