Determining the Enthalpy Change of a Chemical Reaction

The purpose of this experiment is to determine the enthalpy change for the following reaction:

$$Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$$

By adding an excess of zinc powder to a measured amount of aqueous copper (II) sulphate, and measuring the temperature change over time, the change in enthalpy for the reaction can be determined using calorimetric calculations.

Materials and Apparatus

Burette containing copper (II) sulphate solution $[CuSO_4] = 0.64$ mol/L
Styrofoam cup and lid
Thermometer
Zinc powder
Balance
Stopwatch or clock with second hand

Procedure

1. Establish a data table that records temperature (ºC) and time (minutes). Include an appropriate title.
2. Place 25.0 mL of copper (II) sulphate solution from the burette into the Styrofoam cup.
3. Measure 3.00 g of zinc powder on a small piece of paper. There is an excess of zinc but the amount of zinc used must be known.
4. Insert the thermometer into the lid of the Styrofoam cup, stir and record the temperature every 0.5 min (30s) for 2.5 min.
5. At precisely 3 minutes, add the zinc powder to the cup.
6. Continue stirring and record the temperature every half minute for 6 minutes after addition.
7. Dispose of the chemicals in the "Copper waste" bottle.

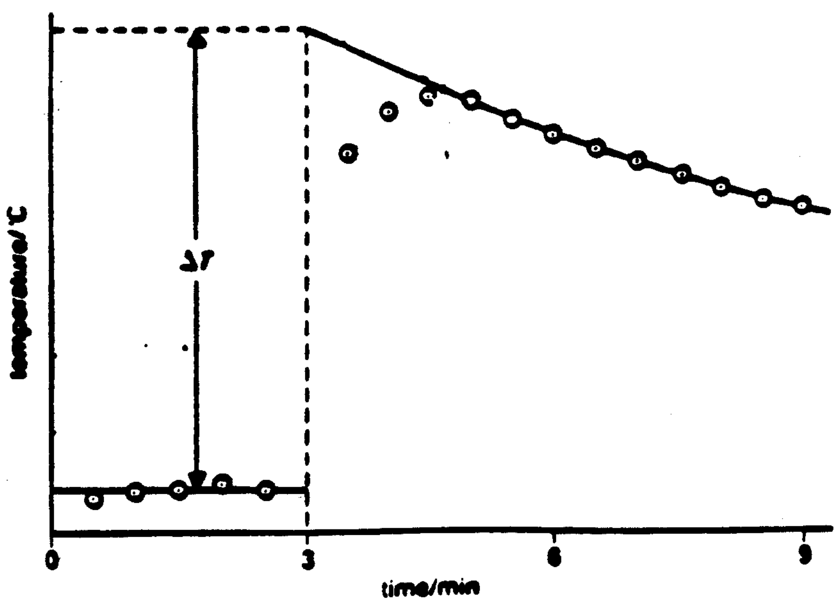
Observations
Data table : **Qualitative and Quantitative**

Data Analysis

A graph of temperature versus time is helpful in determining the enthalpy of the reaction. Time is the dependent variable

Plot such a graph using your data.

Extrapolate the curve on the right hand side of the graph back to the 3.0 min mark to establish the maximum temperature rise, as illustrated in the sample graph below:



Calculations

Using calorimetric equations, calculate the enthalpy change for the quantities used. Assume the specific heat capacity of the copper (II) sulphate solution is equal to that of water (4.18 J/(g°C) and the specific heat capacity of the Cu/Zn is 0.388 J/(g °C).

Assumptions

1. The mass of copper leaving the solution is equal to the mass of the zinc entering the solution.
2. The density of the solution is 1.0 g cm^{-3} and the specific heat capacity of the solution is 4.18 J g^{-1} $^{O}C^{-1}$

$$q_{rxn} = q_{solution} + q_{Zn}$$
$$q_{solution} = m_{solution} \cdot c_{water.}\ \Delta T$$
$$q_{Zn} = m_{Zn} \cdot c_{Zn.}\ \Delta T$$
$$\Delta H_{rxn} = -q_{rxn}$$

Calculate the enthalpy change for *one mole of copper (II) sulphate* used.

Compare your result with the **accepted value of –217 kJ/mol** by calculating the percentage error.
Using your knowledge of solution Stoichiometry, calculate the amount of zinc needed to completely react with 25.0 mL of 0.64 mol/L copper (II) sulphate solution**.**

Questions

1. Write the thermo-chemical equation for the reaction.
2. List several reasons for any difference between your value and the accepted value, and state how each may have affected your results.
3. Why does the temperature increase for a few readings after adding the zinc powder. (HINT: the temperature does not increase if more zinc is used or if the powder is even more finely divided.) Why must an extrapolation be used to establish the maximum temperature rise?

Conclusion: Include a concluding statement.