Chemistry experiment-calculating enthalpy change

Science, Chemistry

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Chemistry Internal Assessment

Determining the Enthalpy Change of a Displacement Reaction

Aim

To determine the enthalpy change for the reaction between copper(II) sulfate and zinc.

Background Theory

Bond breaking is endothermic while bond forming is exothermic. The reaction between copper(II) sulfate and zinc is exothermic as the energy required to form the bonds of the products is greater than the energy required to break the bonds of the reactants. In an exothermic reaction, heat is given off to the surroundings; thus, temperature of the surroundings will increase. By measuring the change in the temperature and using the formula Q= mc?

T, we can calculate the enthalpy change of the reaction. Equation 1: $CuSO_4$ + Zn ? $ZnSO_4$ Ionic Equation: Zn (s) + Cu^{2+} (aq) ? Cu (s) + Zn^{2+} (aq)

Materials/apparatus

- 1 insulated Styrofoam cup
- Copper(II) sulfate solution
- Zinc Powder
- 1 Thermometer
- 1 Stopwatch
- Weighing Boat
- Electronic Balance

Variables

Independent| Dependent| Mass of zinc powder and concentration of copper(II) sulfate solution used. | Temperature of the solution|

Procedure

1. Use a pipette to measure 25. 0cm3 of 1. 0 M copper(ll) sulfate to the insulated container.
2. Record the temperature every 30 seconds for 2. 5 minutes
3. Add the excess zing powder (6g) at exactly 3 minutes
4. Stir and record the temperature every 30 seconds for the following 10 minutes.

Data Collection And Processing

Time (s)| Temperature (°C)| Time| Temperature (°C)| 30| 25| 390| 62| 60| 25| 420| 61| 90| 25| 450| 60| 120| 25| 480| 59| 150| 25| 510| 58| 180| 25| 540| 56| 210| 45| 570| 55| 240| 52| 600| 54| 270| 56| 630| 52| 300| 60| 660| 51| 330| 61. 5| 690| 50| 360| 62| 720| 49|

Therefore, based on the graph shown above (representing the raw data), the change in temperature if the reaction had taken place instantaneously with no heat loss: ? T= 70. 5°C ? 25°C 45. 5°C The volume of the copper(II) sulfate solution used was 25cm3, thus the mass of the solution is 25g. Given that the specific heat capacity of the solution is 4. 18 J/K and the temperature change is 45. 5°C, as calculated above, thus, the heat, in joules, produced during the reaction can be calculated using the formula: Q = mc? T = mass of solution ? specific heat capacity of solution ? temperature change = 25 ? 4. 18 ? 45. 5 = 4754. 75 J In the experiment, 25cm3 of 1. 0 mol dm-3 copper(II) sulfate solution was used. Thus, number of moles of the copper(II) sulfate solution used: n(CuSO4) = (25? 000) ? 1. 0 = 0. 025 mol Therefore, the enthalpy change, in kJ/mol, for this reaction is: ? H = Q ? n(CuSO4) = 4754. 75 ? 0. 025 = -190. 19 kJ/mol Theoretical value/ Accepted Value= ? 217 kJ/mol Thus, percentage error = [(? 217+190. 19) ? (? 217)] ? 100 = 12. 35% CONCLUSION Thus, based on the experiment, the enthalpy change for the reaction is -190. 19 kJ/mol. However, as we can see from the above calculations, the percentage error is 12. 35%. This means that the result is inaccurate from the theoretical value of -217 kJ/mol by 12. 35%.

From the graph, we can also see that once zinc is added to the solution (at exactly 3 minutes), the temperature of the solution increases until it reaches the terminal or maximum temperature of 61°C. Then, the temperature of the solution gradually decreases until it reaches room temperature again (temperature of the surroundings).

Evaluation

(What can be done to improve the experiment?)

An assumption made for this experiment is that none of the heat produced by the exothermic reaction is lost to the surroundings and that the thermometer records the temperature change accurately. However, this is very unlikely to appen in reality, which would explain the percentage error. Thus, to improve the experiment, we can try to minimize the heat loss to the surroundings. This can be done by place a piece of cardboard (or any other insulated material) on top of the cup to cover the top of the cup. A hole can then be made in the cardboard for the thermometer. Another measure that we can take is to ensure that our eye is level with the thermometer when reading the temperature off the thermometer. We can also repeat the experiment a few times and get the average of the results recorded. This would allow us to obtain a more accurate value.