EXPERIMENT

Aim

To determine the enthalpy of dissolution of given Solid Copper Sulphate ($CuSO_4.5H_2O$) in Water at Room Temperature.

Theory

A known volume of the water is taken in a polythene bottle. Its temperature is noted and then known weight of the solute is added to it. The solution is stirred gently and change in temperature is recorded. From the change in temperature, heat absorbed or evolved can be calculated. In this experiment one mole of solute is dissolved per 400 moles of water. For maintaining this ratio 7.0 g of $CuSO_4.5H_2O$ is dissolved in 200 mL of water.

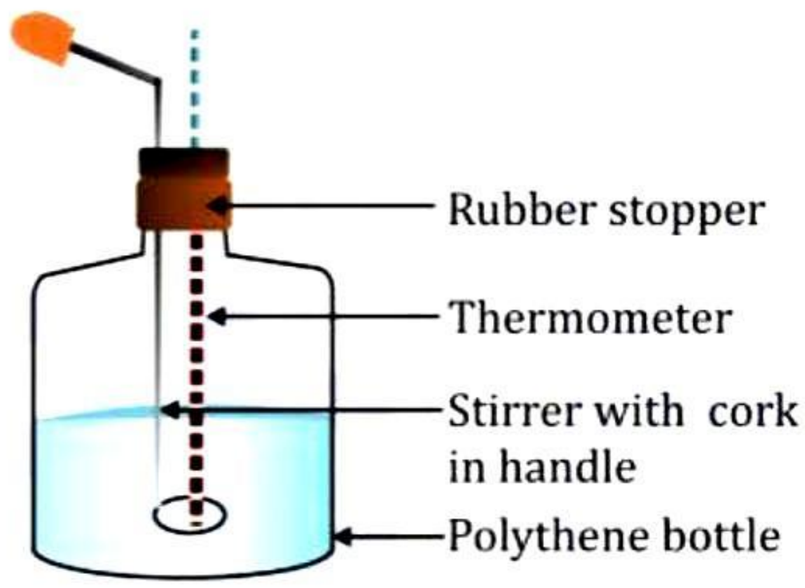
Material Required

250 ml or 500 ml polythene bottle fitted with a rubber cork with two holes, one for thermometer ($1/10^{th}$ degree) and other for stirrer, two beakers, stirrer, measuring cylinder. Hydrated copper sulphate, distilled water.

Procedure

A. Determination of Calorimeter Constant:

1. Put 100 ml of distilled water in polythene bottle with a thermometer and stir Fig.1.
2. Note the temperature (t_1°C).
3. Heat some water in a beaker to a temperature 20-30°C higher than that of room temperature.
4. Put 100 ml of this warm water in another beaker.
5. Note the temperature of this water. Let it be t_2°C.
6. Add warm water from the beaker into the polythene bottle without any loss of time.
7. Stir the contents.
8. Read the temperature attained after mixing. Let it be t_3°C.



Enthalpy of Dissolution of Copper Sulphate Or Pottassium Nitrate

Fig. 1

B. Determination of Enthalpy of Dissolution

1. Put 200 ml of distilled water into the polythene bottle.
2. Now fit a cork with two holes into the mouth of the polythene bottle. Insert a thermometer into one hole with its bulb of about 1 cm above the bottom of the bottle. Put the stirrer into the second hole.
3. Note down the temperature (t_1).

4. Take a known weight of finely powdered substance.
5. Transfer the known weight (let w gm) of finely powdered hydrated copper sulphate quickly by removing the rubber cork and putting it back into its position without any loss of time.
6. Stir it with the help of a stirrer till hydrated copper sulphate is dissolved. However, the rate of stirring should he kept as low as efficiency permits to minimize the energy introduced by stirring (vigorous stirring does cause some increase in temperature).
7. Note down the temperature (t_2) when the substance just dissolves.

Observations

Weight of the hydrated copper sulphate dissolved = w g

Volume of water taken into the bottle = 200 ml = 200 g (assuming density = 1 g/ml)

Temperature of water = t_1°C

Temperature of water after dissolving hydrated copper sulphate = t_2°C

Calorimeter constant of the polythene bottle = W J/°C

Calculations

Assuming density and specific heat of the solution to be same as that of water, heat evolved or absorbed for dissolution of w g of the solute

$$Q = W(t_2 - t_1) + (200 + w)(t_2 - t_1) \times 4.184\ J$$

Heat liberated on dissolution of 1 g of copper sulphate

$$= \frac{W(t_2 - t_1) + (200 + w)(t_2 - t_1) \times 4.184\ J}{w}$$

Heat liberated on dissolution of 1 mol (249.5 g) of copper sulphate

$$= \frac{W(t_2 - t_1) + (200 + w)(t_2 - t_1) \times 4.184}{w} \times 249.5\ J$$

$$\therefore \Delta_{Sol}H \text{ of copper sulphate} = \frac{W(t_2-t_1)+(200+w)(t_2-t_1)\times 4.184}{w} \times 249.5\ J$$

Result

Enthalpy of dissolution of copper sulphate is..... J/mol.

Note: If $t_2 > t_1$ heat is evolved during dissolution and Δsol H has negative sign.

Similarly, we can find out the enthalpy of dissolution of potassium nitrate. For that dissolve 5.5 g of KNO_3 in 200 mL of water. Here, the mole ratio of solute and solvent is 1: 200.

VIVA VOCE

Q 1. What is the primary objective of determining the enthalpy of dissolution of solid copper sulphate ($CuSO_4.5H_2O$) in water at room temperature?

Ans. The primary objective is to measure the heat absorbed or released when a known quantity of solid copper sulphate dissolves in water at room temperature, providing insight into the energetics of the dissolution process.

Q 2. What experimental techniques can be employed to determine the enthalpy of dissolution of

solid copper sulphate in water at room temperature?

Ans. Experimental techniques such as calorimetry, specifically solution calorimetry, can be utilized to measure the temperature change that occurs when solid copper sulphate dissolves in water. By monitoring the temperature change and knowing the mass of the reactants, the enthalpy of dissolution can be calculated.

Q 3. How does the enthalpy of dissolution of solid copper sulphate in water at room temperature relate to the spontaneity of the dissolution process?

Ans. The enthalpy of dissolution provides information about the energy changes associated with the dissolution process. A negative enthalpy change (exothermic) indicates that the process releases energy and is thermodynamically favourable, while a positive change (endothermic) suggests that energy is absorbed, and the process is less favourable.

Q 4. What factors might influence the accuracy of determining the enthalpy of dissolution of solid copper sulphate in water at room temperature?

Ans. Factors such as incomplete dissolution, heat loss to the surroundings, and impurities in the reactants can influence the accuracy of the measurements. Ensuring thorough mixing, insulating the calorimeter, and using high-purity reactants can help minimize these effects.

Q 5. What are the practical implications of knowing the enthalpy of dissolution of solid copper sulphate in water at room temperature?

Ans. Understanding the enthalpy of dissolution is crucial for various industrial processes, such as pharmaceutical manufacturing, metallurgy, and agriculture. It provides insight into the energy requirements and conditions needed for the dissolution of copper sulphate in water, aiding in process optimization and efficiency.

Q 6. What is the enthalpy of dissolution?

Ans. The enthalpy of dissolution is the heat change associated with the dissolution of a solute in a solvent at constant pressure and temperature.

Q 7. How is the enthalpy of dissolution different from the enthalpy of solution?

Ans. The enthalpy of dissolution specifically refers to the dissolution of a solid solute in a solvent, whereas the enthalpy of solution can include the dissolution of any solute (solid, liquid, or gas) in a solvent.

Q 8. What factors can affect the enthalpy of dissolution?

Ans. Factors such as temperature, pressure, and the nature of the solute and solvent can affect the enthalpy of dissolution.

Q 9. Why is it important to conduct the experiment at room temperature?

Ans. Conducting the experiment at room temperature ensures that the heat exchange with the surroundings is minimal and helps in accurately measuring the enthalpy change associated with dissolution.