

1 Variables

1.1 Independent Variable

The independent variable of this investigation was the absolute temperature of the water in which the ammonium nitrate was dissolved in (298.00K, 303.00K, 308.00K, 313.00K, 318.00K) with three repeats at each temperature value. These data values were chosen to ensure that the critical temperature of the reaction was not included in this temperature range. The temperature values were achieved through the use of a hotplate to heat up the water and a digital thermometer is used to verify the absolute temperature within the beaker.

1.2 Dependent Variable

The dependent variable of this investigation is the enthalpy of reaction as the Gibbs Free Energy cannot be directly measured experimentally. The enthalpy of reaction will be calculated based on the mass of the water, specific heat capacity of water and the temperature change measured through a calorimetric process. The calculated enthalpy of reaction can be used to determine the Gibbs Free Energy values at the respective absolute temperature values.

1.3 Controlled Variables

1.3.1 Coffee Cup Calorimeter

The same coffee cup calorimeter was used for all of the trials as different calorimeters have varying degrees of insulation and hence different rate of heat loss to environment. This controlled variable will alter the measured enthalpy of reaction as a calorimeter with greater insulation will result in a smaller magnitude of measured temperature change whereas a calorimeter with less insulation will produce a greater magnitude of temperature change.

1.3.2 Mass of Reactants

The mass of reactants must be kept constant between trials as the mass of the ammonium nitrate will determine the enthalpy of reaction. If the mass of ammonium nitrate dissolved was to be changed, then the temperature change will be different hence rendering the measured temperature change values useless.

1.3.3 Temperature of Surroundings

The temperature of the surroundings must be kept constant throughout the trials as different external temperature will result in a faster/slower rate of heat loss, causing a difference in the enthalpy of reaction. Therefore, the reaction must be conducted in the same location within a room as different parts of the room have different ambient room temperature. The room temperature can be verified between trials using the closest situated thermometer.

1.3.4 Even Distribution of Temperature within Water

The temperature of the water must be evenly distributed to ensure that the effect of temperature on the enthalpy of reaction is accurate. If only parts of the water is heated up to the specified temperature values, then only certain parts of the reactants come into contact with water at the desired temperature, which will make the measured enthalpy of reaction inconclusive.

1.3.5 Distilled Water

Distilled water is used in the calorimeter to ensure that the specific heat capacity of the water is exactly $4.18\text{J/g}^\circ\text{C}$ and does not contain any impurities which might alter the specific heat capacity value. This will also ensure that the

2 Experimental Procedure

2.1 Apparatus

- 75.0 g of solid ammonium nitrate (NH_4NO_3 (s))

- 1500 mL of distilled water (H_2O (l))
- Insulated Styrofoam container with Lid
- Pasco-thermometer
- Laptop with SparkVue software and Bluetooth connection
- Paper weighing boat
- Glass stirring rod
- Scapula
- Electronic balance (two decimal place)
- Electronic hot plate
- Mortar and pestle
- Two 100 mL beaker
- 40 mL beaker
- Paper towel

3 Experimental Procedure

1. Measure 5.00g of ammonium nitrate using a paper weighing boat on a two digit electronic balance and then pour the ammonium nitrate into a mortar.
2. Using a pestle, crush the ammonium nitrate into a fine powder and place the finer ammonium nitrate into a 40 mL beaker.
3. Measure 100.0mL of distilled water and pour the liquid into a 100 mL beaker.
4. Place the beaker of distilled water on to a electronic hot plate and insert the temperature probe inside. Turn on the hot plate and wait until the water is heated up to 298K.
5. Pour the heated distilled water into the coffee cup calorimeter and add the previously weighed ammonium nitrate. Immediately close the lid and insert the stirring rod and Pasco-thermometer through the opening in the lid.
6. As soon as the temperature probe has been inserted, start recording the temperature change over time in the Sparkvue software and begin to stir the ammonium nitrate using the glass stirring rod.
7. Record the reaction for 14 seconds and record the absolute temperature of the water in the calorimeter in 2s intervals.
8. After the data value has been recorded, stop recording the temperature change in the Sparkvue software and pour the ammonium nitrate solution down the drain.
9. Dry the inside of the calorimeter with a piece of paper towel and repeat steps (1-8) for three trials at each absolute temperature value and for all five independent variable values.