Hussain Ather

CHEM S117

Prof. de Souza and Iyengar

AI: Daniel Ashley

Determining the Heat Storage Capabilities of Sodium thiosulfate

**Introduction:**

As sodium thiosulfate nanocrystals (which can be used to store energy in power plants and other applications) freeze, the heat released into the surrounding can be recorded by measuring a temperature change in surrounding water. A coffee-cup calorimeter and a temperature probe can be used to plot the data to determine the heat given off by the reaction. From this heat, the molar heat of fusion can be calculated through thermodynamic equations.

**Beginning Questions:**

Why does the temperature change graph have two distinct “slopes”?

What makes the coffee cup setup a good calorimeter?

What does it mean that the thiosulfate is “supercooled”?

**Procedure:** (as described in the manual)

**Results:**

**Fig 1:** Mass measurements of the equipment and water for our group and for Carson’s group (4): The mass of the water will be used to determine the heat absorbed by the water during the freezing process. We had to borrow data from another group since we didn’t find the final mass of the nanocrystal and vial.

|  |  |  |
| --- | --- | --- |
| **Measurement** | **Mass (Carson’s group** | **Mass (our group)** |
| Mass of vial before freezing (g) | 14.1399 | 14.3434 |
| Calorimeter mass (g) | 15.3372 | 15.0211 |
| Calorimeter + water mass (g) | 214.57 | 212.08 |
| Water mass (g) | 199.23 | 197.06 |
| Final mass of vial after freezing (g) | 33.0576 | N/A |
| Mass of thiosulfate (g) | 18.9177 | N/A |

**Fig 2:** Graph of the temperature of water over time during the freezing process: The maximum for our data (shown in blue) 29.711689oC occurs at t=619.665 seconds, but also at other x-values due to the precision of the temperature probe. The maximum for Carson’s data (shown in green) 28.047979 oC occurs at t= 697.360 seconds.

**Fig 3:. Linear approximation to be extrapolated:** By extrapolating a linear best-fit line (using a range starting from just after the maximum and stopping just after the significant tempreature drop) to the the final temperature of the water after heating can be calculated using the first x-value. The graph isn’t shown due to size restraints. The line (y = -0.0005x + 27.963) was extrapolated all the way to the y-axis since the temperature probe was turned on as soon as the vial was inserted and the reaction had begun (x= 0.399999, y= 24.581914). From this temperature difference, the amount of heat absorbed by the water can be calculated using the specific heat capacity of water (4.1814 J/goC). This heat is equal in magnitude and opposite in direction to the heat given off by the nanocrystal during freezing. Then, the ΔHfus for sodium thiosulfate pentahydrate can be calculated (which was found to be -37.0 kJ/mol).

**Discussion:**

The actual value of the ΔHfus is -51.8 kJ/mol (5), giving a % error of 28.8%. This shows a relatively large amount of error that was most likely caused by the variability in deciding how to extrapolate a line of best fit and the variability of the temperature values given by the probe. Since the temperature values showed a certain maximum y-value but at several different x-values, it is not clear exactly where the maximum occurs and the linear approximation could have varied in which values it would include.   
Supercooling can be observed in antifreeze proteins that are able to lower the freezing point of water by “binding to ice crystals which reduces crystal size and growth” (2). The absence of these crystals prevents the solid from forming. These proteins allow liquid molecules to exist below their freezing points to allow biological systems such as thermoregulation of aquatic organisms in cold environments. It also holds future applications in cryopreservation, a technique that stops all biological process to theoretically prevent a cell from dying. Tissues of semen, stem cells, and heart cells can be preserved (3) through this technique.

Since we assumed the glass of the vial wouldn’t insulate the thiosulfate solution, there would be some heat lost to it during the freezing process. This would decrease the mass of the thiosulfate calculated since it doesn’t take into account this heat. Heat could also have been lost to the surrounding air (in the cup) and to the cup itself, even though it was a good insulator in the same way.

**Conclusion:**

This lab allowed us to learn how to calculate the enthalpy of fusion for a given molecule. The graph has two distinct slopes since the heat was transferred from the vial to the surrounding water immediately as it was placed in the calorimeter, but the rate at which the water’s temperature is raised is proportional to the difference between the water temperature and the vial temperature. This means the temperature of the water would heat up quickly at first, but slow down as it the temperature of the vial and water approached each other. The coffee-cup is a good insulator to prevent heat from escaping outside of it. This allows all the heat released in the freezing process to be transferred to the water to cause the temperature change. Supercooling a liquid allows it to exist as a liquid below its freezing point due to the absence of a seed crystal from which to create a solid.

Sources:

1. Lab Lecture. De Souza, Romualdo.
2. Zachariassen KE.1985.*Physiological Reviews: Physiology of Cold Tolerance in Insects.* The American Physiological Society 65:799-832
3. Crouser. "Future Applications of Freeze-Tolerant Mechanisms." *Biology Department.* Davidson College, n.d. Web.
4. Bickley, Carson, and Alex West. "Solar Heating Lab." *IU S117 Chemistry* (n.d.): n. pag. Print.
5. Chemical Dictionary. "Sodium Thiosulfate Pentahydrate." *Chemical Dictionary Online*. ChemicalDictionary.org, Inc., 2009. Web. 11 Dec. 2013.