

How Much Heat In A Reusable Hand Warmer? Student Activity

Purpose:

You will determine how much heat energy in joules is released by the hot hands. You will also determine the heat of solidification (J/g) for sodium acetate based on the heat released by the hot hands and calculate the % error in your heat of solidification data.

Background:

The hand warmers are filled with sodium acetate. Click the metal disc and you will notice the liquid changes state and becomes a solid. In the process, heat is released. The sodium acetate is a supersaturated solution. We will discuss these more in our next unit, but for now you need to understand that they are unstable solutions. As a result, the clicking of the metal disc disturbs the solution enough that it causes it to crystallize or change states from a liquid to a solid. You will also need to know that the combined mass of the metal disc and the plastic that holds the sodium acetate was determined to be 8.4 g. The specific heat of sodium acetate is reported to be $3.0 \text{ J/g } ^\circ\text{C}$.

Prelab Questions:

1. When the hot hands are submerged in water and activated, describe the transfer of heat that occurs by completing the following statement. Heat is released by the _____ and absorbed by the _____ and _____.
2. Write an equation that relates the heat lost by the hot hands to the heat gained by the water in the calorimeter. Label the following variables. $-H_{\text{sol}}m$ of the _____ = $mC\Delta T$ of the _____ + $mC\Delta T$ of the _____.
3. Does the temperature of the hot hands remain constant, increase or decrease after they are activated?
4. The specific heat of sodium acetate is $3.0 \text{ J/g}^\circ\text{C}$. If the mass of sodium acetate is 21.4 g, how much heat was needed to increase the temperature of the sodium acetate from 21.0°C to 29.8°C . You may assume that all the heat is transferred to the sodium acetate.
5. Determine the heat required to convert 62.0 g of ice at -10.3°C to water at 0.0°C . The specific heat of ice is $2.09 \text{ J/g}^\circ\text{C}$.
6. Determine the mass of iron at 85.0°C that would need to be added to 54.0 g of ice to produce water at 12.5°C . The specific heat of iron is $0.45 \text{ J/g}^\circ\text{C}$.

Activities:

1. Brainstorm a way to determine the heat released by the hand warmer. Remember to review calorimetry
2. Write down your procedure and have it approved by your teacher
3. Obtain a hot hand from the teacher and perform your experiment. Be sure to record all experimental data.
4. Calculate the mass of sodium acetate used in your hand warmer package.
5. Calculate the heat released by the hot hands. HINT: Where did the heat go when it left the hot hands? Complete the following equation:
$$q(\text{released by the hot hands}) = q(\text{_____}) + q(\text{_____}).$$
6. Calculate the heat of solidification for sodium acetate. HINT: The heat released by the hot hands was due to what process? Write the equation for this process: $q = \text{_____}$.
7. Once you have calculated the heat of solidification, ask your teacher for the known value so you can calculate the % error.

Grading Rubric: Abbreviated Report from every student

Your final report must contain the following sections in this order.

- 1) Purpose (2 pts): One typed sentence that identifies the purpose of this activity.
- 2) Background (3 pts): 3 or 4 typed sentences that explain calorimetry as it is used in this experiment.
- 3) Procedure (4 pts): 3 or 4 sentences that describe the procedure used to perform the lab.
- 4) Calculations (11 pts): Neatly written work for the calculations of heat released by the hot hands, heat of solidification for sodium acetate and % error (sodium acetate $\Delta H_{\text{fus}} = 264\text{--}289$ kJ/kg). Each calculation should include the following.
 - Label to identify the calculation being performed.Label each calculation so it is clearly identified. For example, the label of "density" does not identify what substance is being investigated, but the label of "density of water" does. The second label is much clearer to the reader.
 - Formula used
 - Data plugged into the formula
 - Final answer circled
 - Proper units and significant figures
- 5) Results (2 pts): 1 or 2 typed sentence that summarizes the results of your experiment.
- 6) Conclusion (4 pts): 3 - 4 typed sentences that explain 1 thing you learned in the experiment as well as 2 possible sources of error and the effect on your results.
- 7) Format (4 pts): One point is earned for each of the following. Typed, stapled together in the order of this rubric, paragraph format and turned in on time.

Teacher Notes:

Grading Rubric: Abbreviated Report from every student

Your final report must contain the following sections in this order.

2 pts 1) Purpose: One typed sentence that identifies the purpose of this activity.

During this lab we will determine the heat of solidification for sodium acetate used in the hand warmer as well as our % error.

3 pts 2) Background: 3 or 4 typed sentences that explain calorimetry as it is used in this experiment.

Heat from the hand warmer will be absorbed by the water in the calorimeter and increase the temperature of the water. Using the formula $q = mC\Delta T$, we will calculate the heat absorbed by the water which is equal to the heat released by the hand warmer. The heat released by the hand warmer is due to the heat of solidification for sodium acetate ($q = \Delta H_{\text{fus}}m$)

4 pts 3) Procedure: 3 or 4 sentences that describe the procedure used to perform the lab.

Determine the mass of the hand warmer and subtract the mass of the plastic and metal disc to determine the mass of the sodium acetate in the hand warmer. Record the temperature and volume of water in the calorimeter. Place the hand warmer into the calorimeter and activate the hand warmer. Record the highest temperature of the water in the calorimeter.

11 pts total 4) Calculations: Neatly written work for the calculations of heat, heat of fusion for sodium acetate and % error (sodium acetate $\Delta H_{\text{fus}} = 264\text{--}289 \text{ kJ/kg}$). Each calculation should include the following.

2 pts Label to identify the calculation being performed

Label each calculation so it is clearly identified. For example, the label of "density" does not identify what substance is being investigated, but the label of "density of water" does. The second label is much clearer to the reader.

2 pts Formula used

3 pts Data plugged into the formula

2 pts Final answer circled

2 pts Calculations as always must include units and proper significant figures.

2 pts 5) Results: 1 or 2 typed sentences that summarize the results of your experiment.

We found that ____J of heat was released by the hand warmer, which meant that the heat of fusion was ____ J/g. Our % error for the heat of fusion of sodium acetate is ____ %

4 pts 6) Conclusion: 3 - 4 typed sentences that explain 1 thing you learned in the experiment as well as 2 possible sources of error and the affect of those errors on your results.

One sentence stating that the method was successful or that the heat released by the hot hands was significant. Two sources of error or improvements to the lab and a correct affect on the results.

4 pts 7) format: One point is earned for each of the following. Typed, stapled together in the order of this rubric, paragraph format and turned in on time.