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Research Question: Using calorimetric method of mixtures to determine the heat of fusion.

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ABSTRACT:
The heat of fusion is a fundamental thermodynamic parameter that describes the amount of energy necessary to convert a substance from its solid to liquid state at a fixed temperature. In this study, we will use the calorimetric method of mixtures to measure the heat of fusion for a substance. This approach includes measuring the heat transfer between two known-temperature substances, one of which is the substance undergoing fusion and the other serving as the calorimeter. We can properly determine the heat of fusion by using heat transport and calorimetry concepts. This study's experiment gives vital insights into the heat transfer processes involved with phase shifts and demonstrates the use of calorimetry to determine thermodynamic parameters.

I. INTRODUCTION:

The introduction part discusses the heat of fusion and its importance in thermodynamics. It describes how the heat of fusion indicates the energy required to transition a substance from its solid to liquid state while keeping the temperature constant. The section also examines the mixed calorimetric approach and its application to determining the heat of fusion. Researchers can reliably quantify this thermodynamic property by measuring the heat transport between substances using calorimetry. The section finishes by explaining the goal of the research work, which is to determine the heat of fusion of mixes using the calorimetric method.

Theory and Background:

This section dives into the experiment's theory and context. It begins by explaining the various heat transport techniques, such as conduction, convection, and radiation. The part then goes into calorimetric fundamentals including heat capacity and the rule of energy conservation. It also deduces the formula for determining heat of fusion using the calorimetric method of mixtures. This entails considering the heat transfer between the fusion substance and the calorimeter.

Experimental Setup:

The apparatus used in the experiment is described in the experimental setup section. It offers a comprehensive explanation of the calorimeter and temperature measurement instruments used. It also describes the chosen fusion substance and provides information about its qualities, such as melting point and specific heat capacity. The section closes with a description of the experimental process, which includes steps for measuring temperatures and combining the ingredients.

Hypothesis:

We should be able to easily compute the latent heat of water because the calorimeter and water lost heat that the ice gained, and we know the specific heat of water and aluminium. The heat required to convert 1.0 kg of a substance from solid to liquid is referred to as the heat of fusion. The quantity of heat emitted by a substance when it changes from a gas to a liquid or from a liquid to a solid is also referred to as the heat of fusion.
Calorimetry sometimes involves a change of state, and can measure latent heat:

$$m_w c_w \Delta T_w = m_i c_i \Delta T_i + m_i l_i + m_i c_w \Delta T_i + m_a c_a \Delta T_a$$

Given the following variables,
m_w = mass of water
c_w = specific heat of water
ΔT_w = change in temperature for water
m_i = mass of ice
c_i = specific heat of ice
ΔT_i= change in temperature for ice
m_a = mass of calorimeter
c_a = specific heat of Aluminum
ΔT_i= change in temperature for the calorimeter
l_f= latent heat of fusion

We don't have to be concerned about aluminum's latent heat because it will not alter physical state. We were also encouraged not to worry about the latent heat of ice in this experiment because we are working with ice at 0o and it would just heat up.

Using the following formula, I hypothesis that we will obtain an accurate value for the latent heat of fusion. $m_i l_f + m_i c_w \Delta T_i = m_w c_w \Delta T_w + m_a c_a \Delta T_a$

Variables:

The amount of ice supplied to the calorimeter is the independent variable. The amount to add on, or the angle to change to, was determined by how much the temperature had already increased.

The dependant variable that changed during the experiment and was contingent on the independent variable was the temperature of the system. The process transferred heat energy to the ice as more ice was added, causing the overall temperature to decline.

Many things remained constant during the trial, such as the ambient temperature. We utilised the same type of ice each time, and we made sure the calorimeter material of the cup and the stir was the same. Measurements were also kept consistent, which meant we measured everything in kilogrammes, degrees Celsius, and joules so we could convert to whatever was needed at the end.

Data Collection and Analysis:

In this section, the collected temperature data during the mixing process are presented. The data may be displayed in the form of tables, graphs, or charts. The section then explains how to calculate the heat transferred between the substances using calorimetric principles, such as the equation $Q = mc\Delta T$. The specific heat capacities of the substances and the temperature changes are considered to determine the heat transferred during the fusion process. Finally, the section outlines how to determine the heat of fusion through the derived formula and analyzes the obtained results.

Table 1: Needed Values

Masses	
Inside Cup + Stir Stick	0.059
Water added	0.13
Blocks of Ice	0.030
Temperature	
Initial temperature of water	41 ° C
Initial temperature of calorimeter cup	22 ° C
Final temperature of the system Change in temperature of calorimeter Change in temperature of the water	20 ° C 2 ° C 21 ° C
Given Values	
Specific heat of ice	2100 Joules / Kilogram ° C
Specific heat of water	4180 Joules / Kilogram ° C
Specific heat of Aluminum	910 Joules / Kilogram ° C

Data Analysis:

To find the value for the latent heat of fusion, we have all the neccasary data to use the equation:

$m_i l_f + m_i c_w \Delta T_i = m_w c_w \Delta T_w + m_a c_a \Delta T_a$

By rearranging the equation we can isolate latent heat of fusion

$l_f = (m_w c_w \Delta T_w + m_a c_a \Delta T_a - m_i c_w \Delta T_i) / m_i$

If we plug in all the neccasary data, we get,

l_f = (0.13 kg) (4180 / kg ° C) (21° C) + (0.059 kg) (910 J / kg) (2° C) – (0.030 kg) (4180J/kg ° C) (20 ° C) / (0.030 kg)

l_f = (11411.4 + 107.38 – 2508) / 0.030

l_f = 300359 Joules / Kilogram

Now, to change the unit from joules/kilogram to calories/gram, we first divide by 1000 to get joules/grams,

l_f = 300.3 Joules / gram

And now divide by 4.12, to get calories per gram

l_f = 74.90 calories / gram

The accepted value for $l_f$is 80 cal/g, so now to find the percent error between that and our found value

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$$\frac{80 \text{ cal/g} - 74.90 \text{ cal/g}}{80 \text{ cal/g}} \times 100\% = 6.37\%$$

The percent error in our experiment is 6.37 %

II. CONCLUSION:

As mentioned in my hypothesis, the number we discovered for the latent heat of fusion was quite near to the supplied and accepted value. A 6% difference is not terrible considering some of the experiment's minor shortcomings and the precision of the values we were dealing with. We can observe that aluminum's specific heat is not very high, making it a good candidate for calorimeter material because it did not "take" much of the heat given off by the heated water (just a 2 degree difference).

This mixes method demonstrates that when many compounds at various temperatures are mixed together, the hotter substances lose heat and the cooler substances gain heat until all of the components reach a similar equilibrium temperature. This is true even if one or more of the compounds changed phases. This experiment also shows that if the system is more or less insulated and minimal heat is lost to the surroundings, the heat lost by the hot chemicals will equal the heat received by the colder substances due to energy conservation.

The experiment was a success in many aspects, since we were able to achieve a value that appears to be extremely fair. The conclusion section summarises the results of the experiment and data analysis. It confirms whether the research goal of determining the heat of fusion using the calorimetric method of mixtures was met. The significance of the research in proving the application of calorimetry and heat transfer concepts in determining thermodynamic parameters is emphasised in this section. It may also include any noteworthy observations or unexpected results that were discovered throughout the experiment.

Evaluation:

Several sources of error could have arisen during this experiment, resulting in the minor percentage inaccuracy. The most likely source of these mistakes must be that the measurements were not as precise as feasible. It was difficult to read the thermometer at times, and part of the weight recorded was so light that it was difficult to get an exact reading. I also thought it interesting that we were informed the ice was at 0 degrees, thus we didn't need to consider the specific heat required to heat the ice.

After all, this ice came from our laboratory fridge, which typically retains contents at roughly -10 degrees, therefore I believe it was critical to monitor the temperature or ice, which we lacked. Furthermore, a little event such as when the ice was removed from the fridge until it was placed in the hot water was not taken into account. The accumulation of such minor mistakes could have resulted in a modest but major underestimation. Also, keep in mind that, while the calorimeter cup's duty is to reduce heat energy loss to the surroundings, it does not guarantee it.

The rubber stopper on the lid of the cup, or even the smallest gaps of air on the calorimeter, could be blamed for the unnecessary loss of energy. It was also difficult to round to anything other than the nearest degree while observing the thermometer and water temperature. Because the rise was only 2o, this created a tremendous deal of uncertainty.

Recommendations for improvement:

- If time allows, repeat the experiment two or three times to gain more results.
- Use less water to see a greater difference in temperature.
- Allow more time for the equilibrium to occur.