# **SAC 1.1 Specific heat capacity and latent heat of fusion investigation**

##  Name\_\_\_\_\_\_\_\_\_\_\_\_\_

## Task Outline

In this assessment task you will experimentally determine the specific heat capacity of aluminium and the latent heat of fusion of water and compare these values with the theoretical values.

## Relevant Key Knowledge Descriptors

- convert between Celsius and kelvin scales

- investigate and analyse theoretically and practically the energy required to:

- raise the temperature of a substance: *Q* = *mc*Δ*T*

-change the state of a substance: *Q* = *mL*

## Timeline

Lesson 1 – Introduce theory and complete practical on specific heat capacity of aluminium.

Lesson 2 – Introduce theory and complete practical on latent heat of fusion of ice.

Lesson 3 &4 – Complete discussion plan for final assessment

Lesson 5 – Write discussion under test conditions (50 min)

# Experiment 8. Experimentally determine the specific heat capacity of aluminium

*Reference: Adapted from: VicPhysics,* [*Unit 1 How light and heat are explained*](https://www.vicphysics.org/teachers/unit1resources/lightheat/#HeatActivities)*,[ date accessed 22nd February 2023]*

## Foundational key knowledge

- convert between Celsius and kelvin scales

- investigate and analyse theoretically and practically the energy required to raise the temperature of a substance: *Q = mcΔT*

## Introduction

Some materials when heated will increase in temperature more quickly than others. The property that describes this is the specific heat capacity and is the amount of heat required to increase the temperature of 1 kg of substance by 1 K.

The formula that will be used in this experiment is: *Q = mcΔT*

So;

In this experiment, you will use a calorimeter to determine the specific heat capacity of aluminium. A calorimeter is an insulated container fitted with a device for measuring temperature.

where:

 *Q* is heat transferred (J)

*m* is mass in kg

 *c*, specific heat capacity (J.kg-1.K-1)

*ΔT is the change in temperature (T final – T initial).*

## Aim

To determine the experimental value for the specific heat capacity of aluminium and compare to the theoretical value.

## Materials

* water bath set at 60oC
* test tube
* aluminium block
* calorimeter
* electronic balance
* 100 mL measuring cylinder
* tap water
* temperature probe, Sparkvue app
* strainer

## Procedure

1. Record the temperature of the water bath in Table 1.
2. Find the mass of **the mass of the aluminium block** by placing onto the tray of the electronic balance. Record your value into Table 1. *Be careful with the units of mass.*
3. Add the aluminium block to the test tube, place into the water bath and cover with water. Leave in the water bath until required.
4. Place the calorimeter onto the electronic balance and find the mass. Use a measuring cylinder to add 50 mL of water into the calorimeter. Reweigh and **calculate the mass of the water** in Table 1. *Be careful with the units of mass.*
5. Place the temperature probe into the calorimeter and allow the temperature to stabilise for 45 seconds. **Record the starting temperature** in Table 1. *Think: What does K stand for?*
6. *This step needs to be completed quickly to avoid losing heat from the aluminium block.* Empty the water from the test tube by tipping the contents into the strainer over the sink and then transfer the aluminium block to the calorimeter.
7. Use the temperature probe to gently stir the contents of the cup. The temperature will start rising. When the temperature stops rising, end the data collection. **Record the final temperature** in Table 2.
8. Calculate the specific heat capacity of the aluminium block and record in Table 1.
9. Record the specific heat capacity of aluminium from other groups in Table 2

Table 1.

Temperature of water bath \_\_\_\_\_\_\_\_ (K)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | mass calorimeter mw(kg) | mass calorimeter + water (kg) | **mass water (kg)** | **mass Al block mAl(kg)** | T water(K) initial  | T water, Al (K) final  | c (J.kg-1.K-1) |  |  |
| Results |   |   |  |  |   |   |   |  |  |

### Assessment rubric for experiments

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **1** | **2** | **3** | **4** |
| Conducts experiment | reads procedure and allocates tasks to team members | follows steps in procedure | records data in table | explains how to complete calculations  |

Table 2

Calculated specific heat capacity of Aluminium from different groups

|  |  |  |
| --- | --- | --- |
| Trial |  |  |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| Average |  | Range |  |

## Calculations

In these calculations we assume that the heat lost by aluminium block is equal to the heat gained by water.

We can calculate heat using the formula *Q = mcΔT, where cwater =* 4200 J.kg-1.K-1

So, the heat gained by water is Qw = *mwcwΔTw*

|  |
| --- |
| Qw = *mwcw ΔTw*  |

As heat lost by the aluminium block is equal to the heat gained by water; so *Q*Al = - *Q*w

So *Q*Al = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

So; *Q*Al = *mAlcAl ΔTAl*

Rearranged, this gives us:

|  |
| --- |
|    |

# Experiment 9. Experimentally determine the latent heat of fusion of ice

*Reference: University of Arizona (n.d)* [*Measuring the latent heat of fusion of ice*](http://www.atmo.arizona.edu/students/courselinks/fall15/atmo170a1s2/online_class/week_4/LH_ice_expt/LH_ice_expt.html)*, [date accessed 22nd February 2023].*

## Foundational key knowledge

- convert between Celsius and kelvin scales

- investigate and analyse theoretically and practically the energy required to-change the state of a substance: *Q = mL*

## Introduction

Heat is absorbed by a solid when it is melting. In this experiment, you will determine how much heat is needed to melt 1 kg of ice. Heat has units of joules (J). The heat used to melt the ice will come from the cooling of warm water and will be measured with a calorimeter. A calorimeter is an insulated container fitted with a device for measuring temperature.

## Aim

To practically determine the latent heat of fusion of ice Lfusion and compare with the theoretical value.

## Materials

* calorimeter
* electronic balance
* 100 mL measuring cylinder
* temperature probe, Sparkvue app
* hammer, tea towel and board to crush ice
* crushed ice (left at room temperature for 15 – 20 min until just starting to melt)
* paper towel to dry slightly melting ice
* warm water (approx. 30oC)
* weighing tray

## Procedure

1. Place the calorimeter onto the mass balance and determine the mass. Use a 100 mL measuring cylinder to add 100 mL of water and reweigh. **Calculate the mass of water and record** in Table 1. *Be careful with the units of mass.*
2. Remove the calorimeter from the mass balance and place the temperature probe into the warm water and allow to stabilise. **Record the initial temperature i**n Table 1**.**
3. Place the ice into the tea towel and crush with a hammer onto a board. Dry the crushed ice with paper towel. Add the crushed ice into the calorimeter, place onto the balance and find the mass. **Calculate the mass of ice** in Table 1. *Be careful with the units of mass.*
4. Use the temperature probe to gently stir the contents of the cup as the ice melts. **Record the lowest temperature** in Table 1.
5. Calculate the latent heat of ice and record in Table 1.
6. Record the latent heat of ice from other groups in Table 2.

Table 1

Initial temperature of ice: 0oC or \_\_\_\_\_\_\_\_\_\_ K

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | mass calorimeter mw(kg) | mass calorimeter + water (kg) | **mass water (kg)** | mass calorimeter, water and ice mice(kg) | **mass ice mice(kg)** | T(K) initial  | T (K) final  | Lfusion |
| Results |   |   |  |  |  |   |   |  |

### Table 2

Latent heat of fusion from different groups

|  |  |  |
| --- | --- | --- |
| Trial |  |  |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| Average |  | Range |  |

## Theory

When heat is added to water, a temperature change usually occurs. The heat added, Q, to the system can be calculated from the temperature change by using the formula:

However, **no temperature change is observed** **when a change of state occurs,** as the energy is used to change the chemical arrangement of the atoms.

**Latent Heat** is the energy required to change the state of a substance.

|  |
| --- |
| Formula: *Q* = *mL* where *m* (kg), *L* is latent heat (J.kg**-1**) |

**Latent heat of Fusion** is the heat required (absorbed) to change 1 kg of solid to a liquid.

## Calculations

In these calculations we assume that the heat lost by the warm water is equal to the heat gained by the ice.

Calculate heat lost by water using *Q = mcΔT, where cwater =* 4200 J.kg-1.K-1

So, Qw = mw x 4200 x *(T1-T2)*

|  |
| --- |
| *Q = mcΔT, where cwater =* 4200 J.kg-1.K-1Qw = mw x 4200 x *(T2-T1)*Qw= |

Heat lost by the warm water is equal to the heat gained by the ice

*Qice = -Qw. So, Qice = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*

The heat gained by ice caused the ice to melt (latent heat) and increase in temperature until the melted ice was at the same temperature as the water.

So *Qice = miceL* + *mice cice ΔT where* cice = 2100 J.kg**-1** K-1

Qice = *miceL + mice x* 2100 *x (T­2 - 273)*

*Rearranged gives us:*

|  |
| --- |
|   |

|  |  |
| --- | --- |
| Practical A: Specific heat capacity | Practical B: Latent heat of fusion |
| Aim | Aim |
| Write an overall aim which links both experiments. |

# Discussion Planning Document

DOT POINTS ONLY

### Summarise the data (1-2 sentences)

Summarise the data by comparing the practical values with theoretical values.

### Evaluates the quality of the data (accuracy and precision) (1-2 sentences)

What is the precision of the data? How close are the data points from different groups?

Is the accurate? How close are the practical values to the theoretical values?

**Theoretical values - cAl = 903 J.kg-1.K-1 Lfusion ice = 3.34 x 105 J.Kg-1**

### Key finding - related to the overall aim (2 sentences)

Simply state what you found by looking at your data/observations

### Theory to explain key finding with in-text citation (3-4 sentences)

Use science theory to explain your key finding. Insert an intext citation to reference where you obtained the scientific information from. Include the reference in your bibliography.

## Errors in method

### Random error (2 sentences)

Identify an error in measurement which causes the values to fluctuate.

### Effect on quality of data (1 -2 sentences)

Explain how the error impacted your collected data. Did the error result in the values being more variable (data points are further apart)? Random errors affect the reliability of the experiment.

### Modification to address random error (1-2 sentences)

Identify a modification that could be made to the method/equipment to overcome the random error.

### Effect of modification on quality of data (1-2 sentences)

Explain how the modification would affect the reliability of your data.

### Systematic error (2 sentences)

Identify an error which created bias in the data. That is, the practical value differed from the theoretical value by the same amount each time. Systematic errors will result in an overestimation or an underestimation of the data.

### Effect of error on quality of data (1-2 sentences)

Explain how the error affected your data. Would the error make the data higher (overestimation) or lower (underestimation) than the theoretical value? Systematic errors affect the validity of the experiment.

### Modification to address systematic error (1-2 sentences)

Identify a modification that could be made to the method/equipment to overcome the systematic error and ensure the practical value is closer to the theoretical value.

### Effect on modification quality of data (1-2 sentences)

Explain how the modification would affect the accuracy of your collected data?

### Bibliography

Use the numbered referencing style where references are indicated in-text by superscript numbers, or numbers in brackets. Each number corresponds to a particular source and refers to the list below and provides full details of the sources used, arranged in the order they first appear in the text.

## Assessment Rubric

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **1** | **2** | **3** | **4** |
| Conducts experiment | reads procedure and allocates tasks to team members | follows steps in procedure | records data in table | explains how to complete calculations  |
| Reports data | includes relevant data | summarises data | evaluates the quality of the data |  |
| Analyses data | identifies a key finding related to one aim | devises key finding related to the overall aim |  |  |
| Explains key findings | explains key finding using a science theory | applies understanding of science theories to explain key finding | makes links between own data and other science studies |  |
| Evaluates method | lists equipment or steps which contribute to errors | categorises random and systematic errors | explains why errors occurred | evaluates how errors affect quality of data |
| Modifies method | identifies steps or equipment which can be modified | explains how modifications improve design | predicts the effect of modifications on the quality of data |  |
| Bibliography | includes references | follows required style |  |  |