Investigation: Latent Heat of Vaporisation

Introduction

When we want to increase the temperature of a substance, we need to supply heat. The amount of heat energy it takes to raise the temperature by one degree depends on the heat capacity.

Something different happens when we reach a phase change. If you take ice out of the freezer, it warms up until it starts to melt – and then stays at 0°C until it finishes melting! Does this mean that heat has stopped transferring to the ice?

In this experiment, we will analyse the heat transfer involved when water boils. We will be looking at what happens to the temperature of the water, and how much energy it takes to convert water into steam.

1. Questioning and predicting

Let us think about the aim of this investigation.

1. How does the temperature of water change when it is near or at its boiling point?
2. How much energy do we have to supply to boil a certain volume of water?

HYPOTHESIS

The temperature will \_\_\_\_\_\_\_\_ (increase/remain constant) once the water reaches its boiling point.

The amount of energy needed to boil a given volume of water is a constant.

2. Planning investigation

This investigation has been planned for you.

Each group will be given a Bunsen burner, a stopwatch, a beaker of water and a thermometer. There will be a weighing scale available for use. First, we must determine the rate at which the Bunsen burner supplies heat to the water.

1. Measure and record the temperature of the water before heating.
2. Measure the initial mass of the water. (Hint: find the mass of an empty beaker and subtract this from your measured value.)
3. Heat the water over the burner for one minute. Ensure it does not begin to boil at this stage.
4. Remove the beaker from the heat source. Stir gently to ensure the temperature is consistent and record the increased temperature.
5. Use the equation $ΔQ=mc∆T$ to determine how much heat was transferred to the water in one minute. Use the value *c = 4.18* kJ/kg/°C.

You can now assume the burner provides heat to the water at this constant rate. In the second phase of the experiment, we will examine how much heat is required to boil a certain mass of water.

1. Continue heating the water until it reaches boiling point at 100°C. Start timing on the stopwatch.
2. Record the temperature every 20 seconds and observe any trends.
3. After approximately three minutes, remove the beaker from the heat source. Determine the mass of water which remains in the beaker.
4. Use your value for the rate of heating (from step 5) to determine how much heat was required to boil off the difference in mass.
5. Using the equation $Q=mL$, calculate the latent heat of vaporisation L for water in kJ/kg.

3. Conducting investigation

Each group should fill in the following as you go:

Initial mass of water: \_\_\_\_\_\_\_\_

Initial temperature of water: \_\_\_\_\_\_\_\_\_

Temperature of water after heating: \_\_\_\_\_\_\_\_\_

Record the observations of temperature while boiling the water:

Final mass of water: \_\_\_\_\_\_\_\_

Final mass – initial mass: \_\_\_\_\_\_\_\_

**Did you make any changes to the method? What safety considerations were important? Did you have some ‘smart’ ways of doing the investigation?**

4. Processing and analysing

Before we can work out how much energy was supplied to boil the water, we have to know the approximate rate at which heat is transferred from the Bunsen burner to the water.

If a mass *m* of water is heated by an amount *ΔT*, then we can calculate how much heat was supplied in one minute, using the known value of the heat capacity of water *c = 4.18* kJ/kg/°C.

The equation to use is $ΔQ=mc∆T$.

Therefore *Q* kilojoules are supplied per minute. When you move on to boiling the water, you can determine the heat transferred to the water by multiplying this factor by the number of minutes during which it was boiling.

To determine the latent heat of vaporisation, divide this amount of heat by the mass of water lost to find the answer in kJ/kg. Note that sometimes this quantity is expressed in J/kg or J/g.

5. Problem solving

When a substance is undergoing a phase change, its temperature remains constant. However, in the case of melting or evaporation, heat energy must still be entering the system. The latent heat *L* of vaporisation is a quantity which describes how much energy is needed to evaporate a kilogram of water once it has reached its boiling point.

There is also a corresponding quality, the latent heat of fusion, which relates to the solid 🡪 liquid phase transition.

For water, the latent heat of **fusion** is 334 kJ/kg.

The latent heat of **vaporisation** is 2,230 kJ/kg. How does this compare to the answer you found?

6. Conclusions

During a phase change from liquid to gas, the temperature of a substance \_\_\_\_\_\_\_\_\_\_.

The experimentally measured latent heat of vaporisation of water is \_\_\_\_\_\_\_\_\_\_\_.