Investigating latent heat

Background

The latent heat of a substance is the energy needed to change its state (solid to liquid, liquid to gas etc). The specific latent heat of a substance is the amount of energy needed to change state for a unit mass of the substance (1 kg). To measure this accurately, the amount of energy supplied to a known mass of the substance has to be measured as the substance changes state. Measurement of the quantity of energy is difficult, so this investigation focuses upon observation of what happens to the temperature of water as it is heated.

Materials

- 250 mL beaker
- thermometer
- stop watch
- hot plate

Procedure

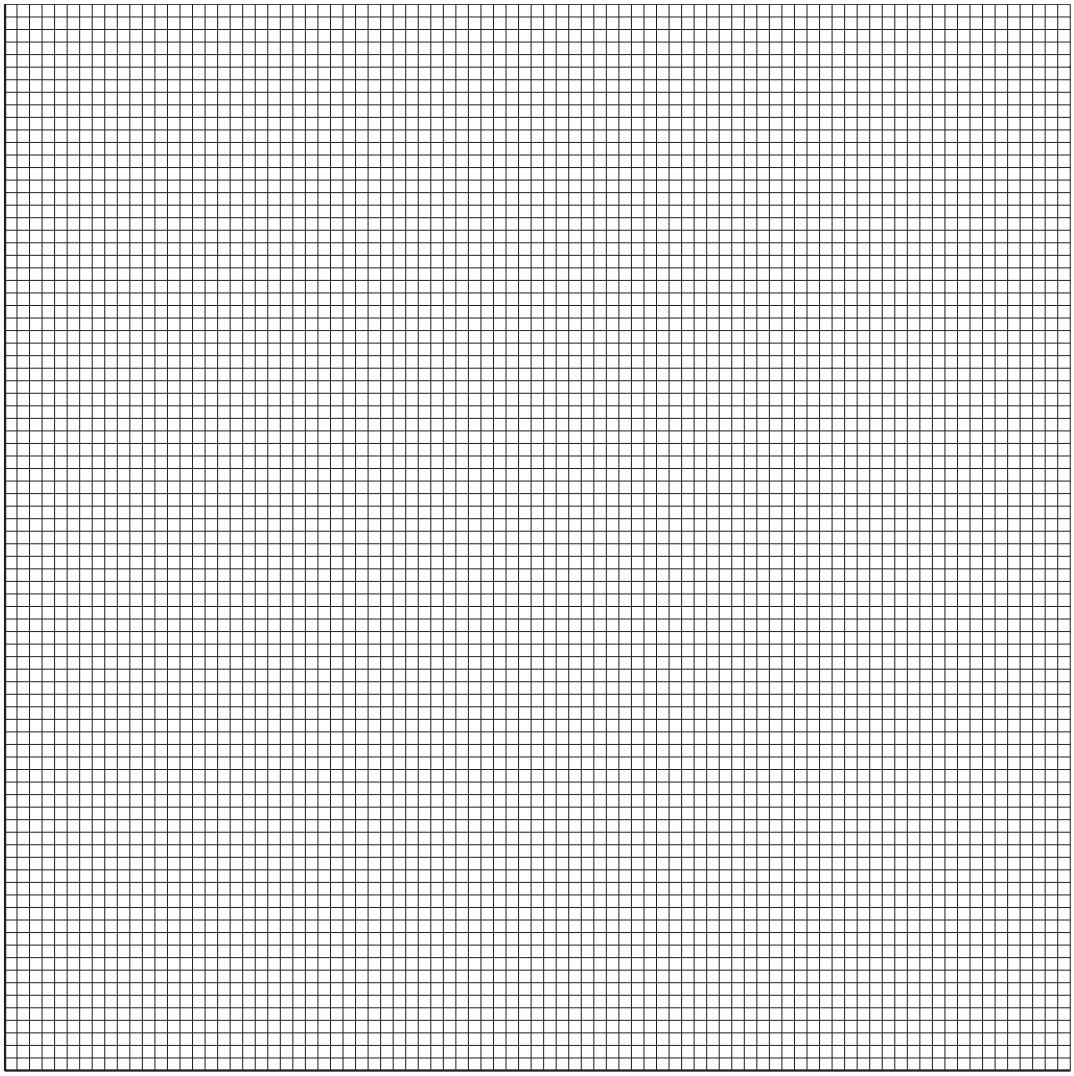
1. Turn on hot plate, set temperature to about 150 °C and allow it to equilibrate for several minutes.
2. Place about 200 mL of water and a thermometer in a beaker.
3. Record temperature of water. This is the temperature at time zero. Leave the thermometer in the beaker for the entire experiment.
4. Place beaker on the equilibrated hot plate and immediately start the stop watch. This starting point is time zero.
5. Keep the watch running for the duration of the experiment, and record temperature every 30 seconds until water has been boiling for 3 minutes.

TIME (s)	TEMPERATURE (°C)
0 (start)	
30	

TIME (s)	TEMPERATURE (°C)

Processing results

Graph temperature (y-axis) against time (x-axis).



Questions

1. What happens to the kinetic energy of water molecules as water is heated to boiling point?

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2. Using kinetic theory, explain why the temperature remained constant at about 100 °C despite constant supply of heat to the water by the hot plate.

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3. The units of latent heat are joules per kilogram (J kg^{-1}). Describe, in your own words, what the symbols (J kg^{-1}) mean in this case.

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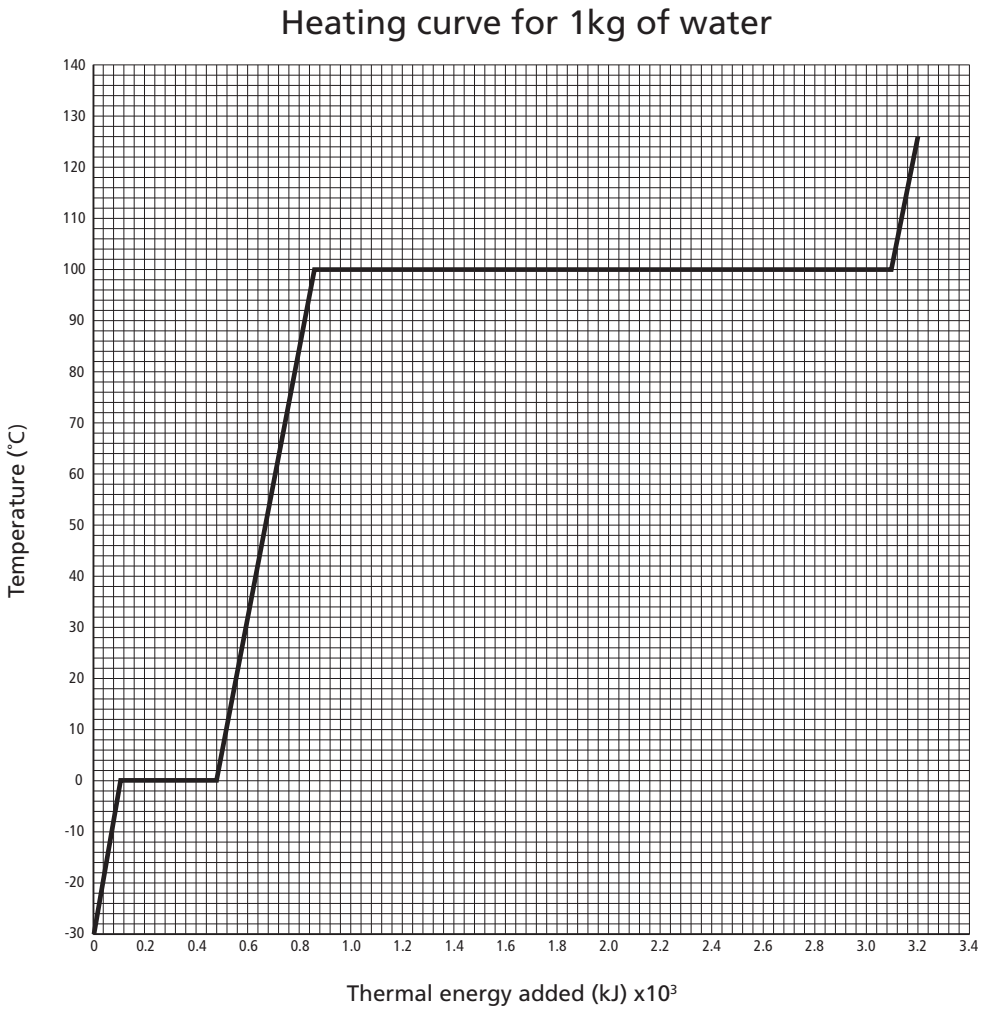
- The following graph of temperature versus energy input was produced from data collected when a constant heat source was used to heat 1 kg of ice for a given time.



4. Use the graph to determine the specific latent heat of vaporisation of water.

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5. Use the graph to determine the specific latent heat of fusion of ice.

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6. Is the quantity of heat required to melt 0.5 kg of ice the same as or different to the quantity of heat required to melt 1 kg of ice (at the same temperature)? Explain your answer.

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7. "It takes between six and seven times as much energy to vaporise water as to melt the same mass of ice." Use data from the graph to prove or disprove this statement.

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8. The formula to calculate the quantity of heat (Q) required to convert a mass of a substance from liquid to gas is given by $Q = m \times L$, where m is mass and L is the latent heat of vaporisation. What value for L would you use in this formula to calculate the energy required to convert 0.5 kg of water to gas?

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Further investigations

- Record temperature changes as ice is heated until it melts.
- Investigate the latent heat of other non-volatile substances.