

Physics 90939 Heat Capacity.

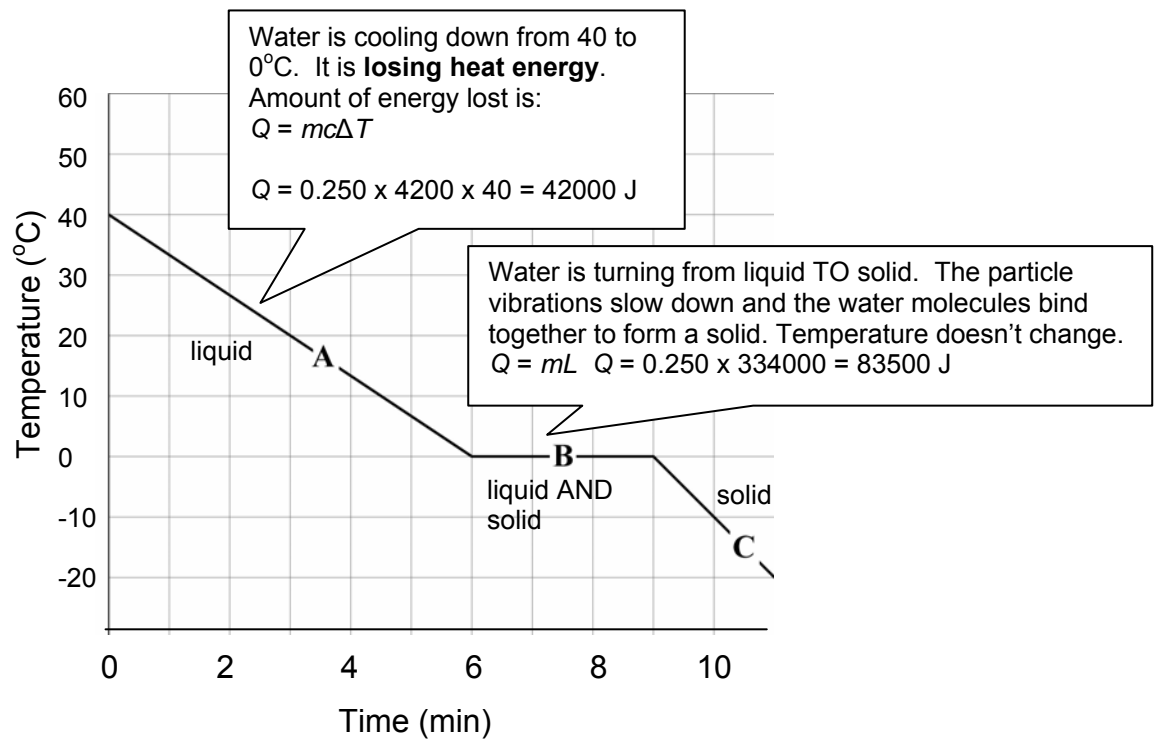
Examples involving specific heat capacity, latent heat, $Q = mc\Delta t$, $Q = mL$ & $P = E/t$

A student places an ice cream container full of water in the freezer. He records the temperature of the water every 2 minutes. His results are shown in the graph below.

The mass of the water is 0.250 kg.

The specific heat capacity of the water is $4200 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$.

The specific latent heat of fusion of ice at $0 \text{ }^\circ\text{C}$ is 334000 J kg^{-1}



Watch out for units... if c is given in $\text{J g}^{-1} \text{ }^\circ\text{C}$, then the mass must be in g.

Eg

Mass of water is 0.250 kg AND $c(\text{H}_2\text{O}) = 4.2 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$

$Q = mc\Delta t$ $Q = 250 \text{ (g)} \times 4.2 \times t$ Answer in J

OR

$Q = 0.250 \text{ (kg)} \times 4200 \times t$ Answer in J

To turn J to kJ divide by 1000 To turn kJ to J multiply x 1000

Sample calculation

Calculate the energy required to completely convert 50 g of ice at 0 °C to steam at 100 °C.

The specific heat capacity of water is 4200 J kg⁻¹ °C. The specific latent heat of fusion of ice is 334000 J kg⁻¹ and the specific latent heat of vaporisation of water is 2260000 J kg⁻¹.

There are 3 stages to this calculation

- Ice @ 0 °C to water @ 0 °C
- Water @ 0 °C to water @ 100 °C
- Water @ 100 °C to steam @ 100 °C

The energy change for the complete process is the sum of the energy changes in each stage

Ice @ 0 °C to water @ 0 °C

$$Q = mL$$

Q = mass of water x latent heat of fusion (there is no "T" in this equation as no change in T)

$$Q = 0.050 \times 334000$$

$$Q = 16700 \text{ J}$$

Water @ 0 °C to water @ 100 °C

mass of water x specific heat capacity x temperature change

$$Q = mc\Delta T$$

$$Q = 0.050 \times 4200 \times 100$$

$$Q = 21000 \text{ J}$$

Water @ 100 °C to steam @ 100 °C

$$Q = mL$$

Q = mass of water x latent heat of vaporisation

$$Q = 0.050 \times 2260000 \text{ J kg}^{-1}$$

$$Q = 113000 \text{ J}$$

The sum of these is 16700 + 21000 + 113000 = 150700 J or 150.7 kJ

If energy is supplied by a 2 kW heater, how long will it take to supply this 150.7 kJ of energy?

$$P = E / t \quad P = 2000 \text{ W or } 2000 \text{ J s}^{-1}. \quad E = 150700 \text{ J}$$

$$t = E / P = 150700 / 2000 = 75.35 \text{ s (or 1 minute and 15.35 s)*}$$

*Do a little "reality check" when you have an answer – if it is going to take 3 days, for example, to boil an electric jug, or warm enough water for a shower, you MAY have made an error!!