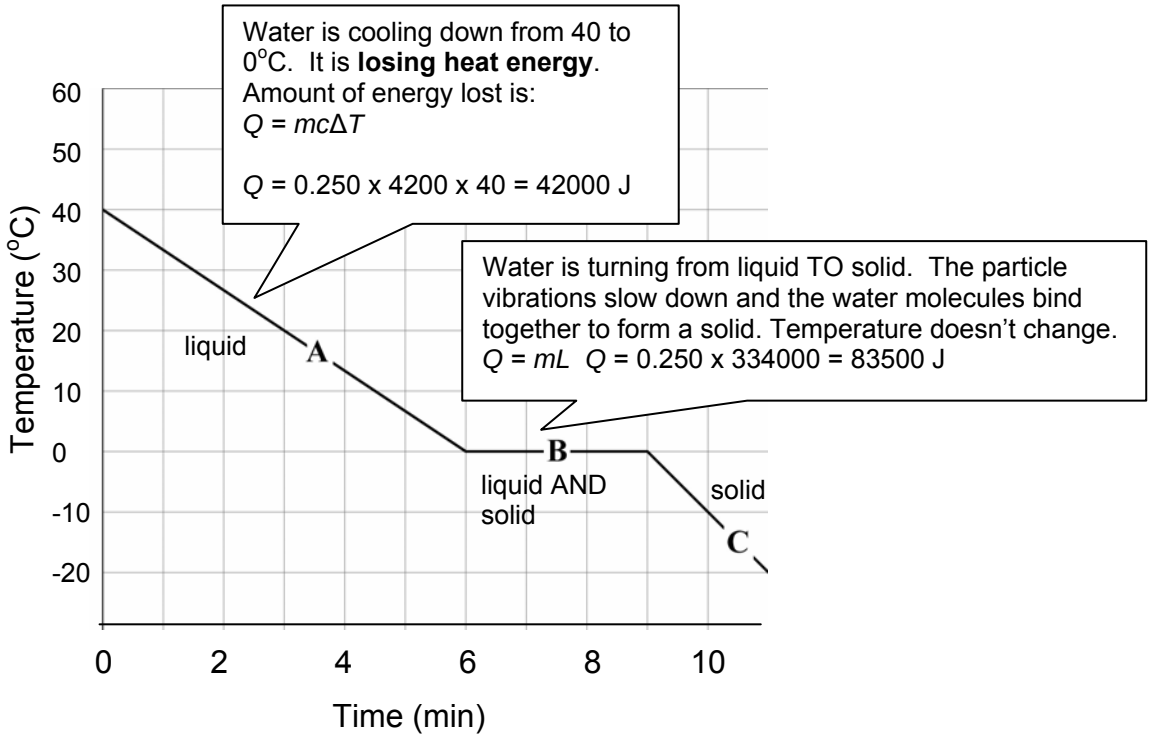
Physics 90939 Heat Capacity.

Examples involving specific heat capacity, latent heat, Q = mcΔt, 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 J kg^{-1} $°C^{-1}$.
The specific latent heat of fusion of ice at 0 ºC is 334000 J kg^{-1}



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

Eg
Mass of water is 0.250 kg AND c(H_2O) = 4.2 J g^{-1} $°C^{-1}$

Q = mcΔt Q = 250 (g) x 4.2 x t Answer in J
OR
Q = 0.250 (kg) x 4200 x 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 ºC to steam at 100 ºC.

The specific heat capacity of water is 4200 J kg^{-1} ^{o}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 ºC to water @ 0 ºC
- Water @ 0 ºC to water @ 100 ºC
- Water @ 100 ºC to steam @ 100 ºC

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

Ice @ 0 ºC to water @ 0 ºC

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 x 334000
Q = 16700 J

Water @ 0 ºC to water @ 100 ºC

mass of water x specific heat capacity x temperature change

Q = mcΔT
Q = 0.050 x 4200 x 100
Q = 21000 J

Water @ 100 ºC to steam @ 100 ºC

Q= mL

Q = mass of water x latent heat of vaporisation
Q = 0.050 x 2260000 J kg^{-1}
Q = 113000 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 P = 2000 W or 2000 J s^{-1}. E = 150700 J

t = E / P = 150700 / 2000 = 75.35 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!!