1.6 Latent Heat

Video: Energy of Phase Changes

When we heat water it's temperature increases until it boils, at about 100 °C. If we continue to put in more heat the water will change into a gas, steam. To change the state from a liquid to a gas requires more energy, more than it does to raise the temperature of the water. This extra heat required to change the state is called Latent Heat. Of course this will also depend on the amount of substance which we are testing, the substance and the two states, so scientists refer to a substances specific latent heat (l) which is the amount of energy needed to change the state of 1.00 Kg of a particular substance. The unit of measurement is joule/kilogram, which is written as J Kg^{-1}.

Example.

It takes 3.4 x 10^5 J of energy to change 1.00 Kg of water from a solid to a liquid and It takes 2.3 x 10^6 J of energy to change 1.00 Kg of water from a liquid to a gas.

To calculate the amount of energy, Q, needed to change the state of a substance we use the following formula

$$Q = m\,l$$

where:

- Q = amount of heat energy required or given off
- m = mass of the substance
- l = specific latent heat

This extra energy is required because changing the state of a substance requires a greater rearrangement of the structure of the substance.

The latent heat when a substance changes from solid to liquid (or vice versa) is referred to as the latent heat of fusion.

The latent heat when a substance changes from liquid to gas (or vice versa) is referred to as the latent heat of vaporisation.

Note: The latent heat of fusion and the latent heat of vaporisation are very often different.

Substance	Melting point / °C	Specific latent heat of fusion, / J kg^{-1}	Boiling point / °C	Specific latent heat of vaporisation, / J kg^{-1}
Water	0	3.36×10^5	100	2.26×10^6
Mercury	−39	1.14×10^4	357	2.96×10^5
Ethanol	−114	1.08×10^5	78	8.55×10^5
Gold	1063	6.28×10^4	2808	1.72×10^6
Copper	1083	2.07×10^5	2566	4.73×10^6
Lead	327	2.32×10^4	1750	8.59×10^5
Nitrogen	−210	2.57×10^4	−196	2.00×10^5
Oxygen	−219	1.39×10^4	−183	2.13×10^5

https://www.aplustopper.com/specific-latent-heat/

Examples

1. Calculate the amount of heat energy necessary to change 1.5 Kg of ice at 0 °C to water at 0 °C. Given the latent heat of fusion for water is 3.34×10^5 J Kg^{-1}.

   Q = ? m = 1.5 l = 3.34×10^5
   Q = $1.5 \times 3.34 \times 10^5$
   = 501000
   = 5.01×10^5 J

2. Calculate the amount of heat energy needed to convert 2.5 Kg of ice at -20 °C to water at 20 °C.

This involves three processes first raising the temperature of the ice to 0 ° C, then changing the state via fusion and finally raising the temperature of the water to 20 ° C.

First heating (using Q = m c ΔT)

m = 2.5 c = 2.1×10^3 ΔT = 20
Q = $2.5 \times 2.1 \times 10^3 \times 20$
= 105000 J

Changing the state (using Q = m l)

m = 2.5 l = 3.34×10^5
Q = $2.5 \times 3.34 \times 10^5$
= 835000 J

Second heating (using Q = m c ΔT)

m = 2.5 c = 4.2×10^3 ΔT = 20
Q = $2.5 \times 4.2 \times 10^3 \times 20$
= 210000 J

Total energy required

Energy = 105000 + 835000 + 210000
= 1150000
= 1.2×10^6 J

1.6.1 Evaporation

Each of the molecules in a liquid will be moving at different speeds. This is the reason that we see steam rising from the surface of water before it reaches boiling point, some of the molecules are moving fast enough to escape from the liquid. When a single molecule escapes from the liquid this causes a drop in both the speed of the other molecules in the liquid and the temperature of the liquid. This explains why evaporation is a cooling process.

The rate of evaporation of a liquid depends on:

- The volatility of the liquid.
- The surface area.
- The temperature.
- The humidity.
- Air movement.

1.6.2 Cooling

Cooling is the process where heat is lost from a system. The rate of cooling follows Newton's law of cooling which states that the rate of heat loss is proportional to the surface area of the object and the temperature difference.

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