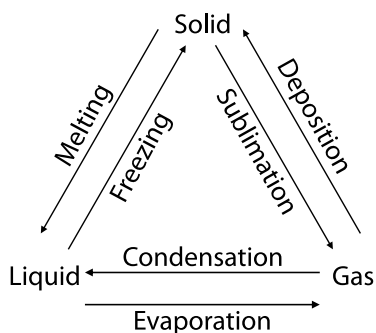


## 31 Latent Heat

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The three most commonly encountered states of matter are **solids, liquids and gases**.

When a substance changes state, it does not change **temperature** but thermal energy is still transferred.

The energy needed to change the state of a substance is called **latent heat**.

Specific latent heat of fusion,  $L$ , is the energy transferred from 1 kg of a substance changing from **liquid to solid** at a **constant** pressure. [unit: J/kg]

Specific latent heat of vaporisation is the energy transferred to 1 kg of a substance changing from **liquid to gas** at a **constant** pressure.

Equation:

thermal energy transferred for a change of state = mass  $\times$  specific latent heat

$$Q = mL$$

	Latent heat of fusion	Latent heat of vaporisation
<b>Melting</b>	Energy gained by substance	—
<b>Freezing</b>	Energy lost to surroundings	—
<b>Evaporating</b>	—	Energy gained by substance
<b>Condensing</b>	—	Energy lost to surroundings

**Example** – The specific latent heat of fusion of ice is  $3.36 \times 10^5$  J/kg. How much thermal energy is transferred to melt 2.00 kg of ice?

$$Q = mL = 2.00 \times 336\,000 = 672\,000 \text{ J} = 672 \text{ kJ}$$

**31.1** Work out the missing measurements from the following table.

$Q$	$m$	$L$
8.38 MJ	(a)	838 000 J/kg
251 kJ	0.75 kg	(b)
(c)	100 g	449 000 J/kg
740 mJ	10.0 mg	(d)
1.09 MJ	(e)	199 000 J/kg

**31.2** A student measures 250 g of water and pours it into a beaker. They boil the water over a Bunsen burner for five minutes, then measure the mass of the water again; this time it is 200 g. The specific latent heat of vaporisation of water is 2 260 kJ/kg. How much energy has been transferred in evaporating the water?

**31.3** Pure water boils at  $100^\circ\text{C}$ , has a specific latent heat of vaporisation of 2 260 kJ/kg and a specific heat capacity of 4 200 J/(kg K).

(a) How much energy is required to boil away 2.0 kg of water if it is already at  $100^\circ\text{C}$ ?

(b) How much energy is required if the water started at  $40^\circ\text{C}$ ? [*Hint: you need to use the heat capacity of water to work out the energy needed to raise the temperature of the water – see section 30 on page 91.*]

**31.4** 1 000 kg of steam is condensed back to water in the condenser of a power station each hour. The specific latent heat of vaporisation of water is 2 260 kJ/kg. Calculate the energy output to the environment this causes each second.

**31.5** A typical fluid used in a fridge has a latent heat of vaporisation of 200 kJ/kg. The fluid needs to remove 30 J from the fridge each second, and it does this by boiling alone. Calculate the minimum mass of fluid which must flow through the fridge each second.

- 31.6 How much energy would be required to enable  $5.0 \times 10^{-3}$  kg of ethanol to evaporate? The specific latent heat of vaporisation of ethanol is 840 kJ/kg.
- 31.7 A sample of solid ethanoic acid is at its melting point of  $17.0^\circ\text{C}$ . It has a specific latent heat of fusion of 192 000 J/kg. How much ethanoic acid can be melted with 864 kJ of thermal energy?
- 31.8 Liquid nitrogen boils at  $-196^\circ\text{C}$ . 40.0 kg of liquid nitrogen in a dewar flask completely evaporates when 7.96 MJ of thermal energy is transferred. What is its latent heat of vaporisation?
- 31.9 A 1000 W heater is placed in an insulated beaker containing 750 g of water at  $100^\circ\text{C}$ . The water vapour is allowed to escape. Assume that there is no loss to the surroundings via conduction, convection or radiation. The specific latent heat of vaporisation of water is 2 260 kJ/kg.
- (a) How much water is left after 5.0 minutes?
- (b) How long will it take for half of the water to have evaporated?