

Solutions

Each answer shows the steps, then the **result**.

2.1

- the energy needed to raise the temperature of **unit mass** (1 kg) by **one kelvin**

2.2

- $Q = mc\Delta T$

$$Q = (0.50 \text{ kg})(4200 \text{ J kg}^{-1} \text{ K}^{-1})(80 \text{ K}) = \mathbf{1.68 \times 10^5 \text{ J}}$$

2.3

- the energy needed to change the state of **unit mass** at **constant temperature**

2.4

- melting only **loosens** the lattice: the molecules stay about the same distance apart, so only some of the bonds have to be broken
- boiling must separate the molecules **completely**, breaking essentially all of the inter-molecular bonds
- the vapour occupies a far greater volume, so work is done **pushing back the atmosphere** — energy that melting barely needs

3.1 B

- latent heat is the energy for a **change of state**
- A** is specific heat capacity; **C** is a temperature rise; **D** is power

3.2

- $Q = Pt$

$$Q = (60 \text{ W})(120 \text{ s}) = 7200 \text{ J}$$

- $c = Q/(m\Delta T)$

$$c = \frac{7200 \text{ J}}{(0.25 \text{ kg})(9.6 \text{ K})} = \mathbf{3000 \text{ J kg}^{-1} \text{ K}^{-1}}$$

3.3

- energy lost by the water = $m_{\text{w}}c\Delta T$

$$Q = (0.25 \text{ kg})(4200 \text{ J kg}^{-1} \text{ K}^{-1})(15 - 5) \text{ K} = 10\,500 \text{ J}$$

- this melts the ice **and** warms the melted ice from 0 to 5 °C

$$10\,500 \text{ J} = (0.030 \text{ kg})L + (0.030 \text{ kg})(4200 \text{ J kg}^{-1} \text{ K}^{-1})(5 \text{ K})$$

$$(0.030 \text{ kg})L = 10\,500 \text{ J} - 630 \text{ J} = 9870 \text{ J}$$

$$L = \frac{9870 \text{ J}}{0.030 \text{ kg}} = \mathbf{3.3 \times 10^5 \text{ J kg}^{-1}}$$

3.4

- the energy is used to **break the bonds** between particles (increase their potential energy / separate them)
- not to increase their kinetic energy, so the temperature stays constant

3.5

(a) the energy required to raise the temperature of **unit mass** of the substance by **one kelvin** (or one degree Celsius)

- without any change of state

(b) $E = mc\Delta\theta$

$$E = (0.80 \text{ kg})(4200 \text{ J kg}^{-1} \text{ K}^{-1})(100 - 18) \text{ K} = 2.75 \times 10^5 \text{ J}$$

$$t = \frac{E}{P} = \frac{2.75 \times 10^5 \text{ J}}{2000 \text{ W}} = \mathbf{138 \text{ s}}$$

(about 2.3 minutes)

(c) energy supplied = Pt

$$E = (2000 \text{ W})(240 \text{ s}) = 4.8 \times 10^5 \text{ J}$$

$$m = \frac{E}{L} = \frac{4.8 \times 10^5 \text{ J}}{2.26 \times 10^6 \text{ J kg}^{-1}} = \mathbf{0.21 \text{ kg}}$$

(d) any two of: thermal energy is lost to the surroundings and to the beaker; the beaker itself must be warmed; some water evaporates before boiling; the heater is not 100% efficient

- part (c) is affected more — the water is then at its highest temperature, so the temperature difference with the room is greatest and the rate of energy loss is largest, and it lasts longer