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 intermolecular 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

- $Q = Pt$

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

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

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

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

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

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

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

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