# PQ 8 Heat

Q and A

# Q1

A body of mass 0.150 kg has its temperature increased by 5 degrees K when 385J of thermal energy is provided to it. What is the body's specific heat capacity?

From the definition, $Q = mc\Delta\theta \Rightarrow c = \dfrac{Q}{m\Delta\theta} = \dfrac{385}{0.150 \times 5.00} = 513\ \text{J kg}^{-1}\ \text{K}^{-1}$.

# Q2

- A radiator made out of iron has a mass of 45 kg and is filled with 23 kg of water.
- A) What is the heat capacity of the water filled radiator?
- B) If thermal energy is provided to the radiator at the rate of 450W, how long will it take for the temperature to increase by 20 degree C?

# Q2 continued

∴ (a) $C = m_1c_1 + m_2c_2 = 45.0\times 470 + 23.0\times 4200 = 1.18\times 10^5\ \text{J K}^{-1}$. (b) $\Delta Q = C\Delta\theta \Rightarrow \frac{\Delta Q}{\Delta t} = C\frac{\Delta\theta}{\Delta t}$. Hence $450 = 1.18\times 10^5 \times \frac{\Delta\theta}{\Delta t} \Rightarrow \frac{\Delta\theta}{\Delta t} = 3.8\times 10^{-3}\ \text{K s}^{-1}$. For a change of temperature of 20.0 K we then require a time of

$$\frac{20}{3.8\times 10^{-3}} = 5.3\times 10^3\ \text{s} = 88\ \text{min}.$$

# Q3

- A car (1360 kg) descends from a hill of 86m at a constant speed of 20 kmph. Assuming that all the potential energy of the car goes into heating the brakes, find the rise in temperature of the brakes. Take the heat capacity of the brakes to be 16 kj degree K (ignore any other heat losses)

# Q3 continued

The loss of potential energy is $mgh = 1360 \times 10 \times 86 = 1.17 \times 10^6$ J. Then,

$$C\Delta\theta = 1.17 \times 10^6 \Rightarrow \Delta\theta = \frac{1.17 \times 10^6}{16 \times 10^3} = 73 \text{ K}.$$

# Q4

How much ice at −10 °C must be dropped into a cup containing 300 g of water at 20 °C in order for the temperature of the water to be reduced to 10 °C? The cup itself has a mass of 150 g and is made out of aluminium. Assume that no thermal energy is lost to the surroundings.

# Q4 continued

The thermal energy transferred from the water and the aluminum container is $Q = 0.300\times4200\times10 + 0.150\times910 = 12736\ \text{J}$. This is used to (a) raise the temperature of ice to he melting point of $0\ ^{\circ}\text{C}$, (b) melt the ice at $0\ ^{\circ}\text{C}$ and (c) raise the temperature of the melted ice (which is now water) to the final temperature of $0\ ^{\circ}\text{C}$. Thus $12736 = m\times2200\times10 + m\times334\times10^3 + m\times4200\times10$. Hence $m = 0.032\ \text{kg}$.

# Q5

The surface of a pond of area 20 $m^2$ is covered by ice of uniform thickness 6 cm. The temperature of the ice is −5 °C. How much thermal energy is required to melt this amount of ice into water at 0 °C? (Take the density of ice to be 900 kg $m^{-3}$.)

The mass of ice is $m = 20 \times 0.06 \times 900 = 1080$ kg . So we need $Q = 1080 \times 2200 \times 5 + 1080 \times 334 \times 10^3 = 3.7 \times 10^8$ J .

# Q6

(a) How much thermal energy is required to warm 1.0 kg ice initially at −10 °C to ice at 0 °C?

(b) How much thermal energy is required to melt the ice at 0 °C.

(c) How much thermal energy is required to further increase the temperature of the water from 0 °C to 10 °C.

# Q6 continued

(a) $Q_1 = 1.0 \times 2200 \times 10 = 2.2 \times 10^4$ J. (b) $Q_2 = 1.0 \times 334 \times 10^3 = 3.34 \times 10^5$ J. (c) $Q_3 = 1.0 \times 4200 \times 10 = 4.2 \times 10^4$ J.

# Q7

- Ice at 0 degrees C is added to 1 litre of water at 20 degree C cooling it down to 10 degrees C. How much ice was added?

The water will lose an amount of thermal energy $1.00 \times 4200 \times 10 = 42000$ J. This energy is used to (a) melt the ice and then raise the temperature of the melted ice to $10\,^{\circ}\mathrm{C}$. Thus $m \times 334 \times 10^3 + m \times 4200 \times 10 = 42000 \Rightarrow m = 0.112$ kg.