PQ 13 Heat

Q and A

Q1

- How much heat energy is needed to change 2.0 kg of ice at 0°C to water at 0°C?

$$Q_L = m\ell$$

$$Q_L = (2.0\ \text{kg})(3.3 \times 10^5\ \text{J/kg})$$

$$Q_L = 6.6 \times 10^5\ \text{J}$$

Q2

- How much heat energy is needed to change 0.50 kg of water at 100°C to steam at 100°C?

$$Q_L = m\ell$$

$$Q_L = (0.50\ \text{kg})(2.3 \times 10^6\ \text{J/kg})$$

$$Q_L = 1.2 \times 10^6\ \text{J}$$

Q3

- How much heat does a refrigerator need to remove from 1.5 kg of water at 20.0 °C to make ice at 0°C?

Heat with temperature change:

$Q = mc\Delta T$

$Q = (1.5\ kg)(4.2 \times 10^3\ J/kg°C)(20.0°C)$

$Q = 1.25 \times 10^5 J$

Latent Heat

$Q_L = m\ell$

$Q_L = (1.5\ kg)(3.3 \times 10^5\ J/kg)$

$Q_L = 4.95 \times 10^5 J$

The total amount of heat needed is:

$Q + Q_L$

$1.25 \times 10^5 J + 4.95 \times 10^5\ J$

$6.2 \times 10^5\ J$

Q4

- You're in a restaurant with a glass of 100.0 grams of water at room temperature, 25 degrees Celsius, but you'd prefer ice water at 0 degrees Celsius. How much ice would you need?

- Heat absorbed by the melting ice must equal the heat lost by the water

$$\Delta Q_{water} = cm\Delta T = cm\left(T - T_0\right)$$

$$\Delta Q_{water} = cm\left(T - T_0\right)$$

$$= \left(4{,}186\ \text{J kg}^{-1}\ \text{K}^{-1}\right)\left(0.100\ \text{kg}\right)\left(0\,\text{K} - 25\,\text{K}\right) \approx -1.04 \times 10^4\ \text{J}$$

$$\Delta Q_{water} = -1.04 \times 10^4 \text{ joules of heat.}$$

Q4 continued

ΔQ_{water}, or -1.04×10^4 joules:

$$\Delta Q_{ice} = -\Delta Q_{water}$$

$$m_{ice}(3.35 \times 10^5 \text{ J/kg}) = -\left(-1.04 \times 10^4 \text{ J}\right)$$

In other words,

$$m_{ice} = \frac{1.04 \times 10^4 \text{ J}}{3.35 \times 10^5 \text{ J/kg}} = 3.10 \times 10^{-2} \text{ kg}$$

So you need 3.10×10^{-2} kilograms, or 31.0 grams of ice.

Q5

- An immersion heater has a power rating of 200 W. I
- t is used to heat 0.2 kg of a material from 20°C to 65°C. The time taken to do this is 3 minutes. Calculate the specific heat capacity of t he substance?

P = 200 W
c = ?
t = 3 minutes = 3 x 60 = 180 s
m= 0.2 kg
ΔT= 65 − 20 = 45°C

Energy supplied = Energy supplied by heater
= Power x time
= 200 x (3 x 60)
= 36 000 J

Energy absorbed = Energy needed to change temperature of substance
= cmΔT
= c x 0.2 x 45
= c x 9

Q5 continued

If no energy transferred to the surroundings:

Energy absorbed = Energy supplied

$$c \times 9 = 36\,000$$

$$c = \frac{36\,000}{9} = 4000 \text{ J kg}^{-1}\ {}^{\circ}C^{-1}$$

Specific heat capacity of substance is 4000 J $kg^{-1}\ {}^{\circ}C^{-1}$