PQ 5 SHC LH Calculations

Q and A

Q1

- Western Power sell electricity by the kWh, where 1 kWh = 3.6106 J. Suppose that it costs $0.08 per kWh to run an electric water heater in your neighbourhood. How much does it cost to heat 75 kg of water from 15°C to 43°C to fill a bathtub?

$$Q = mC\Delta T$$

$$= (75\ \text{kg})(4180\ \text{J/kg·K})(43°\text{C} - 15°\text{C})$$

$$= 8.8 \times 10^6\ \text{J}$$

$$\frac{8.8 \times 10^6\ \text{J}}{3.6 \times 10^6\ \text{J/kWh}} = 2.4\ \text{kWh}$$

$$(2.4\ \text{kWh})(\$0.15\ \text{per kWh}) = \$0.36$$

Q2

A 2.00×10^2-g sample of water at 80.0°C is mixed with 2.00×10^2 g of water at 10.0°C. Assume that there is no heat loss to the surroundings. What is the final temperature of the mixture?

$$m_A C_A (T_f - T_{Ai}) + m_B C_B (T_f - T_{Bi}) = 0$$

Since $m_A = m_B$ and $C_A = C_B$,

there is cancellation in this particular case so that

$$T_f = \frac{T_{Ai} + T_{Bi}}{2} = \frac{80.0°C + 10.0°C}{2} = 45.0°C$$

Q3

Three lead fishing weights, each with a mass of 1.00×10^2 g and at a temperature of 100.0°C, are placed in 1.00×10^2 g of water at 35.0°C. The final temperature of the mixture is 45.0°C. What is the specific heat of the lead in the weights?

Heat gained by the water:

$$Q = mC\Delta T = (0.100 \text{ kg})(4180 \text{ J/kg}\cdot°\text{C})(10.0°\text{C}) = 4.18 \text{ kJ}$$

Thus, heat lost by the weights $= -4.18 \text{ kJ} = m_{\text{weights}}C_{\text{weights}}\Delta T$

$$\text{hence, } C_{\text{weights}} = \frac{(-4.184 \text{ kJ})(1000 \text{ J/kJ})}{(0.100 \text{ kg})(-55.0°\text{C})}$$

$$= 2.53\times10^2 \text{ J/kg}\cdot°\text{C}$$

Q4

A 1.00×10^2-g aluminum block at 100.0°C is placed in 1.00×10^2 g of water at 10.0°C. The final temperature of the mixture is 25.0°C. What is the specific heat of the aluminum?

Heat gained by the water:

$$Q = mC\Delta T$$

$$= (0.100\ \text{kg})(4180\ \text{J/kg·°C})(15.0°\text{C})$$

$$= 6.27\ \text{kJ}$$

Thus, heat lost by the aluminum block

$$= -6.27\ \text{kJ} = m_{\text{Aluminum}} C_{\text{Aluminum}} \Delta T$$

hence, $$C_{\text{Aluminum}} = \frac{Q}{m_{\text{Aluminum}} \Delta T}$$

$$= \frac{-6.27\ \text{kJ}}{(0.100\ \text{kg})(-75.0°\text{C})}$$

$$= 8.36 \times 10^2\ \text{J/kg·°C}$$

Q5

How much heat is absorbed by 1.00×10^2 g of ice at $-20.0°C$ to become water at $0.0°C$?

$$Q = mC\Delta T + mH_f$$

$$= (0.100\ \text{kg})(2060\ \text{J/kg}\cdot°\text{C})(20.0°\text{C}) + (0.100\ \text{kg})(3.34 \times 10^5\ \text{J/kg})$$

$$= 3.75 \times 10^4\ \text{J}$$

Q6

A 2.00×10^2-g sample of water at 60.0°C is heated to steam at 140.0°C. How much heat is absorbed?

$$Q = mC_{water}\Delta T + mH_v + mC_{steam}\Delta T$$

$$= (0.200\ \text{kg})(4180\ \text{J/kg}\cdot{}^\circ\text{C})(100.0^\circ\text{C} - 60.0^\circ\text{C}) + (0.200\ \text{kg})(2.26\times10^6\ \text{J/kg}) +$$

$$(0.200\ \text{kg})(2020\ \text{J/kg}\cdot{}^\circ\text{C})(140.0^\circ\text{C} - 100.0^\circ\text{C})$$

$$= 502\ \text{kJ}$$

Q7

How much heat is needed to change 3.00×10^2 g of ice at $-30.0°C$ to steam at $130.0°C$?

$$Q = mC_{ice}\Delta T + mH_f + mC_{water}\Delta T + mH_v + mC_{steam}\Delta T$$

$$= (0.300\ kg)(2060\ J/kg\cdot°C)(0.0°C - (-30.0°C)) + (0.300\ kg)(3.34\times10^5\ J/kg) + (0.300\ kg)(4180\ J/kg\cdot°C)(100.0°C - 0.0°C) + (0.300\ kg)(2.26\times10^6\ J/kg) + (0.300\ kg)(2020\ J/kg\cdot°C)(130.0°C - 100.0°C)$$

$$= 9.40\times10^2\ kJ$$

Q8

- How much heat is needed to change 50.0 g of water at 80.0°C to steam at 110.0°C?

$$Q = mC_{water}\Delta T + mH_v + mC_{steam}\Delta T$$

$$= (0.500\text{ kg})(4180\text{ J/kg}\cdot{}^\circ\text{C})(100.0^\circ\text{C} - 80.0^\circ\text{C}) + (0.500\text{ kg})(2.26\times10^6\text{ J/kg}) + (0.500\text{ kg})(2020\text{ J/kg}\cdot{}^\circ\text{C})(110.0^\circ\text{C} - 100.0^\circ\text{C})$$

$$= 1.18\times10^5\text{ J}$$

Q9

- The specific heat of mercury is 140 J/kg°C. Its heat of vaporisation is 3.06105 J/kg. How much energy is needed to heat 1.0 kg of mercury metal from 10.0°C to its boiling point and vaporise it completely? The boiling point of mercury is 357°C.

$$Q = mC_{Hg}\Delta T + mH_v$$

$$= (1.0\ \text{kg})(140\ \text{J/kg}\cdot{}^\circ\text{C})$$

$$(357^\circ\text{C} - 10.0^\circ\text{C}) +$$

$$(1.0\ \text{kg})(3.06\times10^5\ \text{J/kg})$$

$$= 3.5\times10^5\ \text{J}$$

Q10

- A 10.0-kg piece of zinc (c= 388 J/kg K) at 71.0°C is placed in a container of water, The water has a mass of 20.0 kg and a temperature of 10.0°C before the zinc is added. What is the final temperature of the water and the zinc?

$$T_f = \frac{m_A c_A \Delta T_{Ai} + m_B c_B \Delta T_{Bi}}{m_A c_A + m_B c_B}$$

$$= \frac{(10.0\ \text{kg})(388\ \text{J/kg}\cdot\text{K})(71.0°\text{C}) + (20.0\ \text{kg})(4180\ \text{J/kg}\cdot\text{K})(10.0°\text{C})}{(10.0\ \text{kg})(388\ \text{J/kg}\cdot\text{K}) + (20.0\ \text{kg})(4180\ \text{J/kg}\cdot\text{K})}$$

$$= 12.7°\text{C}$$