PQ 6

Q and A

Q1

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:

$$Q = mC\Delta T$$

$$= (0.100\ \text{kg})(4180\ \text{J/kg}\cdot{}^\circ\text{C})(15.0^\circ\text{C})$$

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

Thus, heat lost by the aluminum block $= -6.27\ \text{kJ} = m_{\text{Aluminum}} C_{\text{Aluminum}} \Delta T$

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

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

$$= 8.36\times10^2\ \text{J/kg}\cdot{}^\circ\text{C}$$

Q2

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

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

$$= (0.100\ \text{kg})(2060\ \text{J/kg}\cdot°\text{C})(20.0°\text{C}) + (0.100\ \text{kg})(3.34\times10^5\ \text{J/kg})$$

$$= 3.75\times10^4\ \text{J}$$

Q3

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?

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

$$= (0.200\ \text{kg})(4180\ \text{J/kg·°C})(100.0\text{°C} - 60.0\text{°C}) + (0.200\ \text{kg})(2.26 \times 10^6\ \text{J/kg}) +$$

$$(0.200\ \text{kg})(2020\ \text{J/kg·°C})(140.0\text{°C} - 100.0\text{°C})$$

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

Q4

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

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

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

$$= 9.40\times10^2 \text{ kJ}$$

Q5

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

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

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

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

Q6

Heat of Vaporization The specific heat of mercury is 140 J/kg·°C. Its heat of vaporization is 3.06×10^5 J/kg. How much energy is needed to heat 1.0 kg of mercury metal from 10.0°C to its boiling point and vaporize it completely? The boiling point of mercury is 357°C.

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

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

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

$$(1.0\ \text{kg})(3.06 \times 10^5\ \text{J/kg})$$

$$= 3.5 \times 10^5\ \text{J}$$

Q7

A 5.00×10^2-g block of metal absorbs 5016 J of heat when its temperature changes from 20.0°C to 30.0°C. Calculate the specific heat of the metal.

$$Q = mC\Delta T$$

$$\text{so } C = \frac{Q}{m\Delta T}$$

$$= \frac{5016\ \text{J}}{(5.00 \times 10^{-1}\ \text{kg})(30.0°\text{C} - 20.0°\text{C})}$$

$$= 1.00 \times 10^3\ \text{J/kg·°C}$$

$$= 1.00 \times 10^3\ \text{J/kg·K}$$

Q8

Years ago, a block of ice with a mass of about 20.0 kg was used daily in a home icebox. The temperature of the ice was 0.0°C when it was delivered. As it melted, how much heat did the block of ice absorb?

$$Q = mH_f = (20.0\ \text{kg})(3.34\times10^5\ \text{J/kg}) = 6.68\times10^6\ \text{J}$$

Q9

A 40.0-g sample of chloroform is condensed from a vapor at 61.6°C to a liquid at 61.6°C. It liberates 9870 J of heat. What is the heat of vaporization of chloroform?

$$Q = mH_v$$

$$H_v = \frac{Q}{m} = \frac{9870\ \text{J}}{0.0400\ \text{kg}} = 2.47\times10^5\ \text{J/kg}$$

Q10

How much heat is added to 10.0 g of ice at $-20.0°C$ to convert it to steam at $120.0°C$?

Amount of heat needed to heat ice to 0.0°C:

$$Q = mC\Delta T$$
$$= (0.0100\ \text{kg})(2060\ \text{J/kg}\cdot°\text{C})(0.0°\text{C} - (-20.0°\text{C}))$$
$$= 412\ \text{J}$$

Q10 continued

Amount of heat to melt ice:

$$Q = mH_f$$

$$= (0.0100 \text{ kg})(3.34\times10^5 \text{ J/kg})$$

$$= 3.34\times10^3 \text{ J}$$

Amount of heat to heat water to 100.0°C:

$$Q = mC\Delta T$$

$$= (0.0100 \text{ kg})(4180 \text{ J/kg}\cdot°\text{C})$$

$$(100.0°\text{C} - 0.0°\text{C})$$

$$= 4.18\times10^3 \text{ J}$$

Q10 continued

Amount of heat to boil water:

$$Q = mH_v$$

$$= (0.0100 \text{ kg})(2.26\times10^6 \text{ J/kg})$$

$$= 2.26\times10^4 \text{ J}$$

Amount of heat to heat steam to 120.0°C: