SPH3U 6.3 Heat Capacity

1. Specific heat capacity

Specific heat capacity: c — amount of energy (J) to increase the temperature of 1 kg of a substance by 1°C $\left(\frac{J}{kg°C}\right)$

Substance	Specific Heat Capacity, c	Substance	Specific Heat Capacity, c	Substance	Specific Heat Capacity, c
water	4.18×10^3	aluminum	9.2×10^2	copper	3.8×10^2
ethyl alcohol	2.46×10^3	glass	8.4×10^2	silver	2.4×10^2
ice	2.1×10^3	iron	4.5×10^2	lead	1.3×10^2

Quantity of heat: Q, amount of energy transferred between 2 objects.

equation $Q = mc\Delta T = mc(T_f - T_i)$. Units: J.

When 200.0 mL of water is heated from 15.0 °C to 40.0 °C, how much thermal energy is absorbed by the water?

$c = 4.18 \times 10^3 \frac{J}{kg°C}$. $m = 0.2000\ kg$. (1 mL of water = 1 g).

$Q = mc\Delta T = (0.2)(4.18 \times 10^3)(40 - 15)$

$= 20900\ J = 20.9\ kJ$.

An empty copper pot is sitting on the stove, with a mass of 1.2 kg and a temperature of 130.0 °C. If the pot cools down to 21.0 °C, how much thermal energy does it release?

$c = 3.8 \times 10^2$, $m = 1.2\ kg$.

$Q = mc\Delta T = (1.2)(3.8 \times 10^2)(21 - 130)$

$= -50\ kJ$.

A block of iron starts off at a temperature of 22.0 °C. It is heated t o100.0 °C by placing it in boiling water. The energy required is 4.91×10^5 J. Calculate the mass of the iron block.

$c = 4.5 \times 10^2$, $Q = 4.91 \times 10^5\ J$, $\Delta T = (100 - 22)$.

$Q = mc\Delta T$ $\quad m = \frac{Q}{c\Delta T} = \frac{4.91 \times 10^5}{(4.5 \times 10^2)(100 - 22)}$

$= 14.0\ kg$.

2. The principle of thermal energy exchange

Principle of thermal energy exchange:	When a warmer object touches a cooler object, the heat it loses = the heat the cooler object gains.
equation	$Q_{released} = -Q_{absorbed}$ $Q_R = -Q_A$.

A 60.0 g sample of metal is heated to 100.0 °C before being placed in 200.0 mL of water with an initial temperature of 10.0 °C. Together, they reach a final temperature of 15.6 °C. What is the metal?

$m_1 = 0.06\ kg$, $T_{i1} = 100°C$, $m_2 = 0.2\ kg$, $T_{i2} = 10°C$, $T_f = 15.6°C$.

$c_2 = 4.18 \times 10^3$

$Q_R = -Q_A$, $Q = mc\Delta T$ $\rightarrow$ $m_1 c_1 (T_f - T_{i1}) = -m_2 c_2 (T_f - T_{i2})$.

$$c_1 = \frac{-m_2 c_2 (T_f - T_{i2})}{m_1 (T_f - T_{i1})} = \frac{-(0.2)(4.18\times10^3)(15.6-10)}{(0.06)(15.6-100)} = 9.24\times10^2 \ \frac{J}{kg°C}$$

∴ the metal is aluminum.

A sample of iron is heated to 80.0 °C and placed in 100.0 mL of water at 20.0 °C. The final temperature of the mixture is 22.0 °C. What is the mass of the iron?

$m_1 c_1 (T_f - T_{i1}) = -m_2 c_2 (T_f - T_{i2})$

$$m_1 = \frac{-m_2 c_2 (T_f - T_{i2})}{c_1 (T_f - T_{i1})} = \frac{-(0.1\ kg)(4.18\times10^3)(22-20)}{(4.5\times10^2)(22-80)}$$

$$= 3.2\times10^{-2}\ kg.$$

200.0 g of silver is heated to 90.0 °C. The hot silver is then placed into 300.0 g of ethyl alcohol with an initial temperature of 5.0 °C. What is the final temperature of the mixture?

$m_1 c_1 (T_f - T_{i1}) = -m_2 c_2 (T_f - T_{i2})$ $T_f (m_1 c_1 + m_2 c_2) = m_1 c_1 T_{i1} + m_2 c_2 T_{i2}$

$$T_f = \frac{m_1 c_1 T_{i1} + m_2 c_2 T_{i2}}{m_1 c_1 + m_2 c_2} = \frac{(0.2)(2.4\times10^2)(90) + (0.3)(2.46\times10^3)(5)}{(0.2)(2.4\times10^2) + (0.3)(2.4\times10^3)}$$

$$= 10°C.$$

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