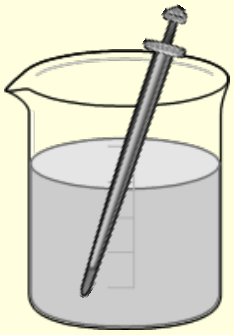
Law of Conservation of Energy

Energy can neither be created nor destroyed, it can only change location or form.

Principle of Heat Exchange



The heat lost by one object is gained by the second object

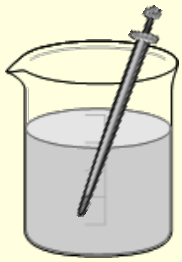
$$Q_1 = -Q_2$$

Or the total Heat of two objects in contact is Zero

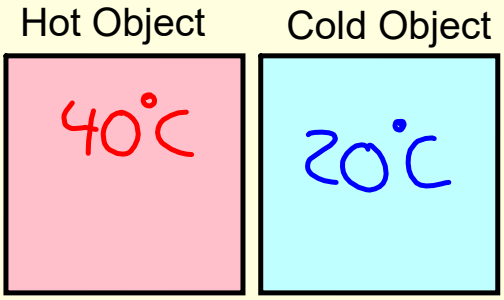
$$Q_1 + Q_2 = 0$$

Thermal Equilibrium

Two objects in a system will reach a balance with each other.

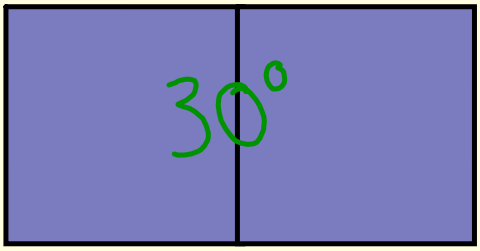


T_{1water} $T_{2(water + Sword)}$ T_{1sword}



$E_{KA} > E_{KB}$

After Thermal Equilibrium



$E_{KA} = E_{KB}$

A 0.200 kg piece of iron at 340 °C is cooled by placing it in water that is at 22 °C. How much water is needed if the mixture reaches a final temperature of 24 °C?

Iron

$m_I = 0.200\,kg$

$T_{1,I} = 340°C$

$T_2 = 24°C$

$C_I = 450\,J/kg°C$

$Q_I = m_I C_I (T_2 - T_{1I})$

$Q_I = 0.200\,kg \times 450\,J/kg°C\,(24°C - 340°C)$

$= 0.200 \times 450 \times -316$

$= -28440\,J$

water

$m_w = ?$

$T_{1w} = 22°C$

$T_2 = 24°C$

$C_w = 4180\,J/kg°C$

$-Q_I = Q_w$

$-(-28440\,J) = Q_w = 28440\,J$

$$\frac{Q_w}{C_w(T_2 - T_{1w})} = \frac{m_w C_w (T_2 - T_{1w})}{C_w(T_2 - T_{1w})}$$

$$\frac{28440\,J}{(4180\,J/kg°C\,(24°C - 22°C))} = m_w$$

$$\frac{28440\,J}{(4180\,J/kg°C \times 2°C)} = m_w = 3.4019138$$

$= 3\,kg$

Short version...

$-Q_I = Q_w$

$$\frac{-m_I C_I (T_2 - T_{1I})}{C_w(T_2 - T_{1w})} = \frac{m_w C_w (T_2 - T_{1w})}{C_w(T_2 - T_{1w})}$$

$$\frac{(-0.200\,kg \times 450\,J/kg°C\,(24 - 340°C))}{(4180\,J/kg°C\,(24 - 22°C))} = m_w$$

$$\frac{(-0.200\,kg \times 450 \times -316)}{(4180 \times 2)} = m_w = 3.40\ldots$$

$= 3\,kg$

0.50 Kg of water at 50.0°C is mixed with 0.20kg of water at 20.0°C. What is the final Temp?

water A
$m_A = 0.50kg$
$T_{1A} = 50.0°C$
$T_2 = ?$
$C = 4180 \frac{J}{kg°C}$

water B
$m_B = 0.20kg$
$T_{1B} = 20.0°C$
$T_2 = ?$

$$Q_A = -Q_B$$

$$m_A C (T_2 - T_{1A}) = -m_B C (T_2 - T_{1B})$$

$$m_A T_2 - m_A T_{1A} = -m_B T_2 + m_B T_{1B}$$

$$+m_A T_{1A} + m_B T_2 \quad +m_A T_{1A} + m_B T_2$$

$$m_A T_2 + m_B T_2 = m_B T_{1B} + m_A T_{1A}$$

$$\frac{T_2(m_A + m_B)}{(m_A + m_B)} = \frac{(m_B T_{1B} + m_A T_{1A})}{(m_A + m_B)}$$

$$T_2 = \frac{(0.20kg \times 20°C + 0.50kg \times 50.0°C)}{(0.50kg + 0.20kg)}$$

$$= 41.4286$$

$$= 41°C$$

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