Specific Heat Capacity

The specific heat capacity (c) of a material is the energy required
to increase the temperature of 1.0 kg of it by 1.0 kelvin.
Different materials have different specific heat capacities.

Units of specific heat capacity (c) are J kg-1 K-1 (or J kg-1 °C-1, since 1 degree Celsius is the same as 1 kelvin)

To calculate specific heat: Q = mcΔT or mc(T2 – T1)

where: Q = heat gained or lost when temperature changes in joules (J)

 m = mass of substance in kilograms (kg)

 c = specific heat capacity (J kg-1 K-1) of the substance

 T = temperature in °C or K

*NOTE: T2 is always the higher temperature so there is never a negative answer.*

Specific Heat Calculations

Example:

A 400 kg block of iron is heated from 22 °C to 52 °C. How much heat is absorbed by the iron? (Specific heat of iron is 450 J kg-1 K-1)

 Q = mcΔT

 = 400 × 450 × (52 - 22)

 Q = 5.40 × 106 J

Example:

25.0 g of water at 90.0 °C has 3657.5 J of heat energy removed from it. What is its final temperature? (Specific heat of water is 4.18 × 103 J kg-1 K-1)

 Q = mcΔT

 3657.5 = 0.025 × 4180 × (90 – T1)

 3657.5 = 104.5 × (90 – T1)

 $\frac{3657.5}{104.5}$ = 90 – T­1

 T1 = 90 – 35

 T1 = 55.0°C

Example:

50.0 g of glass (specific heat of 670 J kg-1 K-1) at a temperature of 20 °C has 4.0 × 103 J of heat energy added. What is the final temperature of the glass?

 Q = mcΔT

 4000 = 0.050 × 670 × (T2 – 20)

 4000 = 33.5 (T2 – 20)

 119.4 = T2 – 20

 T2 = 119.4 + 20 = 139.4

 T2 = 139 °C

Questions

1. 43.0 g of aluminium (c = 8.80 × 102 J kg-1 K-1) at 90.0 °C is allowed to cool to room temperature (25.0 °C). How much heat did the aluminium give off in the cooling process?

 Q = mcΔT

 = 0.043 × 880 × (90 – 25)

 = 2.50 × 103 J

1. 2.145 × 103 J of heat is gained by a mass of copper (c = 3.90 × 102 J kg-1 K-1) when it is heated from 63.0 °C to 85.0 °C. What was the mass of the copper?

 Q = mcΔT

 2145 = m × 390 × (85 – 63)

 2145 = m × 390 × 22

 2145 = m × 8580

 m = 0.250 kg

1. 3.50 × 103 J of heat is added to 1.80 kg of lead (c = 1.30 × 102 J kg-1 K-1), which was initially at 10.0 °C. What is the final temperature of the lead?

 Q = mcΔT

 3500 = 1.80 × 130 × (T2 – 10)

 3500 = 234 (T2 – 10)

 14.96 = T2 – 10

 T2 = 25.0 °C

1. 855 g of aluminium (c = 8.80 × 102 J kg-1 K-1), initially at 68.0 °C, was cooled by removing 2.69 × 104 J of heat energy. What was the final temperature of the aluminium?

 Q = mcΔT

 26 900 = 0.85 × 800 × (68 – T1)

 26 900 = 748 × (68 – T1)

 35.96 = 68 – T1

 T1 = 32.0 °C

1. An aluminium saucepan of mass 855 g has 0.200 kg of milk (specific heat 3.90 × 103 J kg-1 K-1) in it which has been heated to a temperature of 90.0 °C. How much heat energy must be removed for them both to reach a temperature of 45.0 °C?

 Q = mcΔT

 QT = QA + QM

 = 0.855 × 880 × (90 – 45) + 0.200 × 3900 × (90 – 45)

 = 33858 + 35100

 = 68958

 QT = 6.90 × 104 J