Outcome 3 – Topic 2
Specific Heat Capacity

Specific heat Capacity

- Specific heat capacity is the amount of energy required to raise the temperature of 1 gram of substance by 1°C.

    - Iron has a specific heat capacity of 0.45 J/g °C

    This means that it takes 0.45 Joules of incoming heat energy to raise 1 gram of iron by 1°C

    This also means that if we were to allow 1 g of iron to cool down by 1°C, it would release 0.45 Joules of heat.

    - Water has a specific heat capacity of 4.19 J/g °C

    This means that it takes 4.19 Joules of incoming heat energy to raise the temperature of water by 1°C.

    This also means that if we were to cool 1g of water down by 1°C, 4.19 Joules of energy would be released.

http://www.youtube.com/watch?v=hyPLusD-tyM

Quantity of Thermal Energy, Q

- If we know the specific heat capacity of a substance, we can use the equation $Q = mc\Delta t$ to find out exactly how much heat energy is being absorbed by a particular mass of a substance.

Q = quantity of heat energy (Joules (J))

m = mass of substance (g)

c = specific heat capacity of the substance (J/g °C)

Δ = change in

Δt = change in temperature (°C)

Δt = final temperature – initial/starting temperature

$\Delta t = t_f - t_i$

So say we have 50g of water that is in a beaker on a hotplate. The temperature of this mass of water started at 20°C and rose to a final temperature of 50°C.

We know that it takes 4.19 J of energy to change 1 g of water by 1 °C, how much energy does it take to raise 50 g of water by 30 °C?

Q = ??
m = 50 g
c = 4.19 J/g °C
$\Delta t = t_f - t_i$
= 50 °C – 20 °C
= 30 °C

$50\,g \times \frac{4.19\,J}{g \cdot °C} \times 30\,°C$

Q = mcΔt
= 50g x 4.19 J/ g °C x 30 °C
= 6285 J
= 6.3×10^3 J   6.3 kJ

Rearranging Equations

If we are given the values for any 3 of the four variables in the Q = mcΔt equation above, we can solve for the missing one.

To do this we must be able to rearrange the equation properly to solve for the unknown variable

Q = mcΔt

Solve for **m**, m = Q /(c Δt)

Solve for **c**, c = Q /(m Δt)

Solve for **Δt**, Δt = Q /(m c)

Examples

1. Calculate the amount of thermal energy required to raise the temperature of 3.0 kg of aluminum from 20.0 to 80.0°C. The specific heat capacity of aluminum is 0.897 J/g °C.

Q = ?
m = 3.0 kg
c = 0.897 J/g·°C
Δt = 80.0 − 20.0 = 60.0 °C

$Q = mc\Delta t$
$= (3000\ g)(0.897\ J/g\cdot°C)(60.0\ °C)$
$= 161460\ J$
$1.6 \times 10^5\ J$

2. When 60.0 J of energy is added to a mass of copper, the temperature of the copper increases by 10.4 °C. The specific heat capacity of copper is 0.385 J/g °C. What mass of copper was heated?

Q = 60.0 J
m = ?
c = 0.385 J/g·°C
Δt = 10.4 °C

$Q = mc\Delta t$
$60.0\ J = m(0.385\ J/g\cdot°C)(10.4\ °C)$
$\frac{60.0\ J}{4.004\ J/g} = \frac{m(4.004\ J/g)}{4.004}$
$m = 14.985...\ g$
$= 15.0\ g$

3. A 2.50 g mass of iron is at 24.0°C. Determine the final temperature of the iron after it absorbs 13.5 J of thermal energy. The specific heat capacity of iron is 0.449 J/g °C.

Q = 13.5 J
m = 2.50 g
c = 0.449 J/g·°C
Δt = ?

$Q = mc\Delta t$
$13.5\ J = (2.50\ g)(0.449\ J/g\cdot°C)(\Delta t)$
$13.5\ J = (1.1225\ J/°C)\Delta t$
$\Delta t = 12.0267...\ °C$
$t_f = 24.0 + 12.0... = 36.0\ °C$

4. The heat capacity of water is 4.19 J/g °C, the heat capacity of aluminum is 0.897 J/g °C. 1.00 g of water and 1.00 g of aluminum are both heated from 20°C to 50°C.

a. Which substance will have absorbed more energy? Explain

b. Which will reach 50°C first? Explain

c. Which will cool down slower after the heat source is taken away? Explain