1.5 Specific Heat Capacity

Video: Specific Heat

The heat content of an object depends on three things:

1. it's temperature (T) measured in Kelvin
2. it's mass
3. the substance from which it is made.

Different substances also have differing abilities to hold heat. eg. water holds heat better than steel. Of course this will also depend on the amount of substance which we are testing, so scientists refer to a substances <u>specific heat capacity</u> (c) which is the amount of energy needed to raise the temperature of 1.00 Kg of a particular substance by 1.00 K. The unit of measurement is joule/kilogram/degree Kelvin, which is written as J Kg^{-1} K^{-1}.

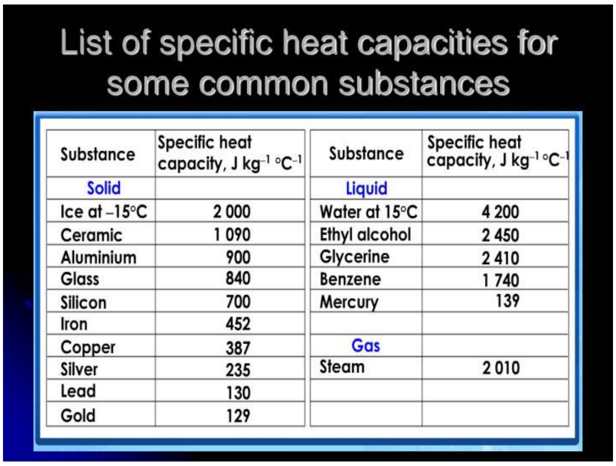
Example.
It takes 4.2×10^3 J of energy to raise the temperature of 1.00 Kg of water by 1.00 K.
So the specific heat capacity (c) of water is 4.2×10^3 J Kg^{-1} K^{-1}.

To calculate the amount of energy, Q, needed to change the temperature of an object by ΔT we use the following formula

$Q = m\,c\,\Delta T$

where:

Q = amount of heat energy
m = mass of the substance
c = specific heat capacity
ΔT = change in temperature


List of specific heat capacities for some common substances

Substance	Specific heat capacity, J kg^{-1} °C^{-1}	Substance	Specific heat capacity, J kg^{-1} °C^{-1}
Solid		Liquid	
Ice at –15°C	2 000	Water at 15°C	4 200
Ceramic	1 090	Ethyl alcohol	2 450
Aluminium	900	Glycerine	2 410
Glass	840	Benzene	1 740
Silicon	700	Mercury	139
Iron	452		
Copper	387	Gas	
Silver	235	Steam	2 010
Lead	130		
Gold	129		

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Note: Delta Δ is used to symbolise "change in"

Example.
Find the amount of heat energy needed to raise the temperature of 3.0 Kg of iron from 10 °C to 18°C, given that the specific heat capacity for iron is 450 J Kg^{-1} K^{-1}.

$Q = ?$ $m = 3.0$ $c = 450$ $\Delta T = 18 - 10 = 8.0$

$Q = 3.0 \times 450 \times 8.0$
$= 10800$
$= 1.1 \times 10^4$ J Note: 2 significant figures in answer

Example.
A chef pours 200ml of cold water with a temperature of 15 °C into a hot aluminum saucepan with a mass of 250 g and a temperature of 120 °C. What will be the common temperature of the water and the saucepan when the thermal equilibrium is reached?
The amount of energy gained by the water (Q_w) is the same as the energy lost by the aluminum saucepan (Q_s)

Note: 1 Litre of water has a mass of 1 kg

$$Q_w = Q_s$$

$Q_w = m_w c_w \Delta T_w$
$\Delta T_w = T_f - 15$
$c_w = 4200$
200 mL = 0.200 Kg

$Q_s = m_s c_s \Delta T_s$
$c_s = 900$
$\Delta T_s = 120 - T_f$

$0.200 \times 4200 \times (T_f - 15) = 0.25 \times 900 \times (120 - T_f)$
$840\, T_f - 12600 = 2700 - 225\, T_f$
$1065\, T_f = 39600$
$T_f = 37°$

Problem Set #2: Text Page 12 All Questions