Energy – Heat Energy and Specific Heat Capacity

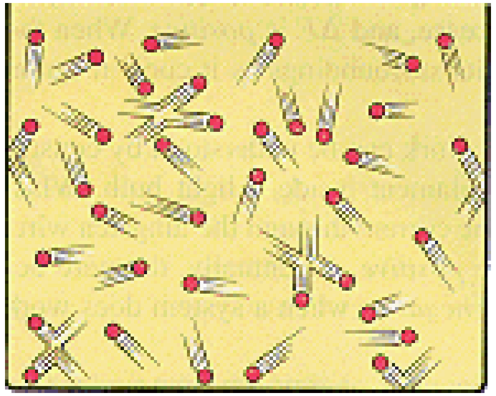
1. Temperature Vs. Heat energy Vs. Heat

a. The particles of matter are always moving which gives them mechanical energy

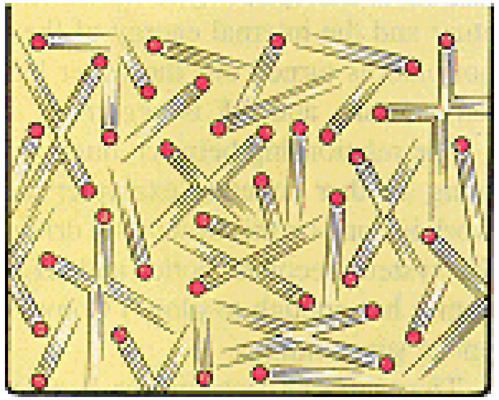
b. Temperature refers to the average amount of mechanical energy in the particles of a substance

c. Heat energy refers to the total amount of mechanical energy in the particles of a substances

- i. The more the particles move, the more thermal energy it has
- ii. The more particles that there are, the more thermal energy there is



Low Temperature

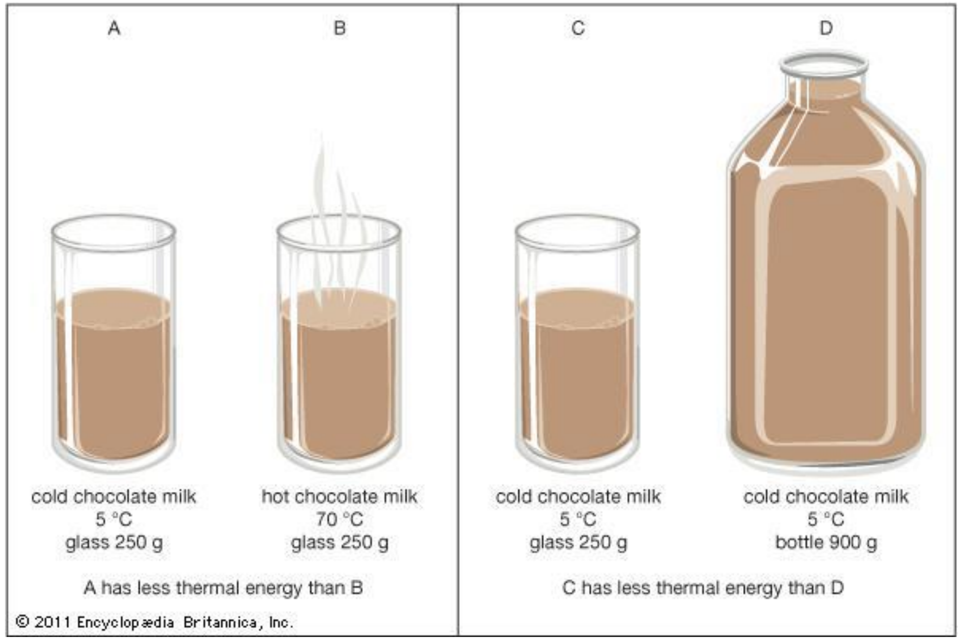


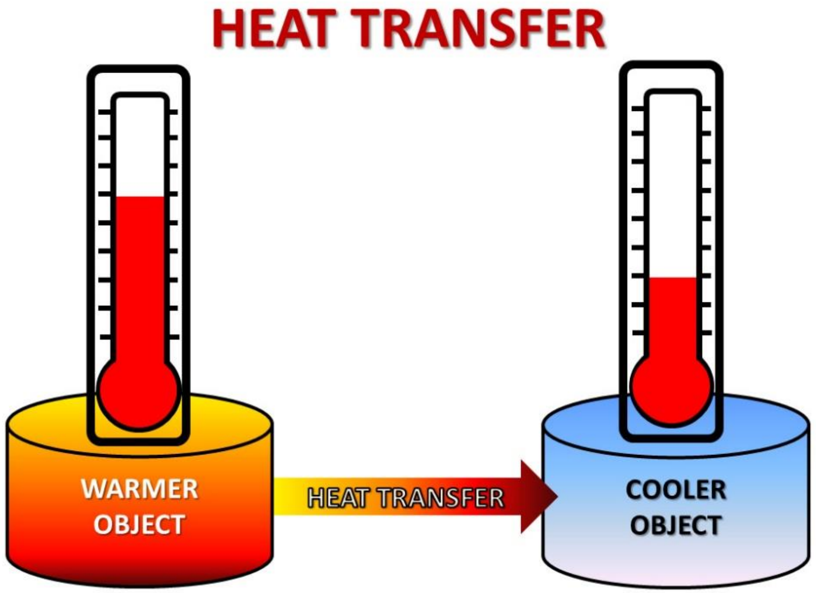
High Temperature

d. E.g. A cup of water and a swimming pool can have the same temperature, but the swimming pool has more heat energy since it contains more water molecules

e. Heat energy will always move from a hotter object to a colder object

  i. The term “heat” refers to the amount of heat energy that is transferred from a hotter object to a cooler object





2. Energy can be measured in units called Joules

a. One joule is roughly equivalent to the energy used to lift a small apple 1 m into the air

3. Specific heat refers to the amount of heat energy needed to raise the temperature of 1 g of a material by 1^{o}C

Material	Specific Heat (Joules/g^{o}C)
Copper	0.38
Iron	0.44
Aluminum	0.91
Dry Air	1.01
Liquid water	4.2

a. Different materials have different specific heats e.g. aluminum vs water

i. 1 gram of aluminum takes less heat energy to heat up by 1^{o}C than 1 gram of water

ii. If you give 4.2 J of energy to 1 g of water you will increase the mechanical energy of the particles to raise the temperature 1^{o}C.

iii. If you give 4.2 J of energy to 1 g of aluminum you will increase the mechanical energy of the particles to raise the temperature 4.8^{o}C.

b. One reason for the difference is that 1 g of water contains 1.5 times as many particles as there are in 1 g of aluminum

  i. This means that the 4.2 J of energy has to be shared by more water particles compared to the number of aluminum atoms

c. Since it has a high heat capacity, water can absorb or release a lot of heat without changing temperature very much

  i. Water does not heat up or cool down very quickly

  ii. This make water an excellent temperature regulator for our bodies, engines, and the Earth itself

  iii. Large bodies of water like the oceans have essentially a uniform temperature

3. Calculating heat energy

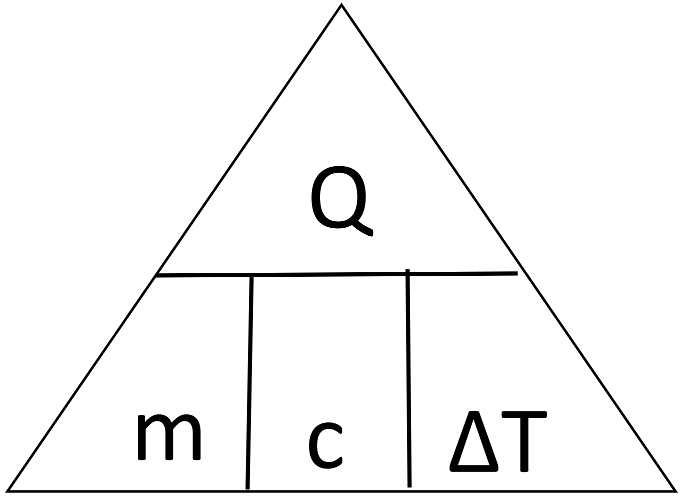
a. $Q = mc\Delta T$

i. Q – the amount of heat energy measured in Joules (J)

ii. m – the mass of the material measured in grams (g)

iii. c – the specific heat of the material measured in J/g^{o}C

iv. ΔT – the change in temperature measured in degrees Celsius (^{o}C)



b. E.g. How much heat is required to heat 5.0 g of water by 3^oC?

i. $Q = mc\Delta T$

$= (5.0g)(4.2\ J/g^oC)(3^oC)$

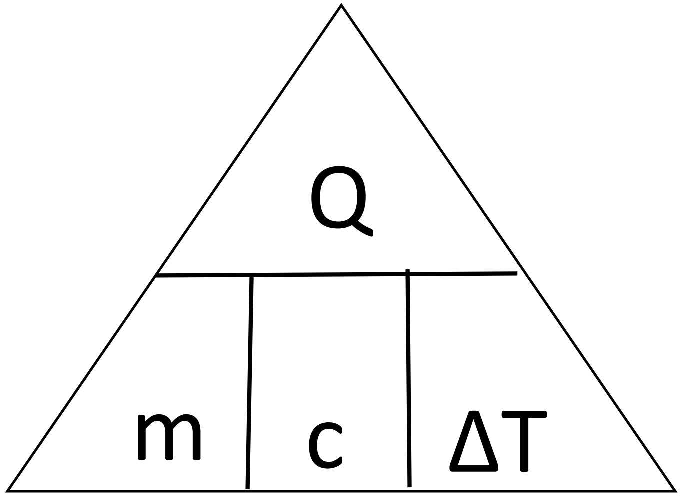
$= 63\ J$

c. E.g. What mass of water will change its temperature by 10^oC when given 5800 J of energy?

i. $m = \dfrac{Q}{c\Delta T}$

$= \dfrac{5800J}{(4.2\ J/g^oC)(10^oC)}$

$= 138\ g$



d. E.g. Compare the increase in temperature of 1.0 g of H_2O and 1.0 g of ethanol when they each absorb 10 J of thermal energy. ($C_{ethanol}$ = 2.43 J/g°C)

i. Water

- $\Delta T = \frac{Q}{mc}$

  $= \frac{10\ J}{(1.0g)\ (4.2\ J/g^oC)}$

  $= 2.4^oC$

ii. Alcohol

- $\Delta T = \frac{Q}{mc}$

  $= \frac{10\ J}{(1.0g)\ (2.43\ J/g^oC)}$

  $= 4.1^oC$