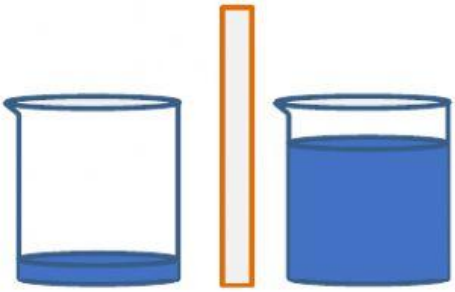
Thermal Energy

Thermal energy is used to :

1. to raise the temperature of an object
2. to change the state of the matter.

Two beakers, one beaker containing 100 g of water and the other containing 1000 g of water, are heated from 30 ºC to 60 ºC. using the same heater.



Which beaker will take the longer time?

If beaker 1 takes 5 seconds, how long does beaker 2 take?

It takes about ten times as long to heat 1000 g of water to 60 ºC.

If beaker 1 needs 3 joule of energy, how much energy does beaker 2 need?

It needs ten times as much thermal energy as 100 g of water to be heated to 60 ºC.

It means that 1000 g of water has ten times the heat capacity of 100 g of water.

Heat Capacity (kapasitas kalor)

: Energy needed to raise the temperature of a substance by1 °C or °K

Example

84000 Joule of thermal energy was required to raise the temperature of 2 kg of water from 20 °C to 30 °C. Find the :

a. Heat capacity of 2 kg of water.
b. Heat capacity of 1 kg of water.
c. Thermal energy needed to raise the temperature of 1 kg of water from 50 °C to 70 °C.

solution

a. Given:

thermal energy supplied Q = 84000 J

Temperature rise ΔT = 30 °C - 20 °C = 10 °C

The heat capacity of 2 kg of water (the amount energy of 2 kg of water needed to rise the temperature by 1 °C)

= J/ °C

b. Since 1 kg of water has ½ of the mass of 2 kg of water, the heat capacity of 1 kg = ½ x heat capacity of 2 kg of water

The heat capacity of 1 kg of water (the amount energy of 1 kg of water needed to rise the temperature by 1 °C)

= ½ x = J/ °C

c. thermal energy needed Q to raise the temperature of 1 kg of water from 50 °C to 70 °C (for 70 °C – 50 °C = 20 °C)

From b question you have J/ °C as **the heat capacity of 1 kg of water**

It is the energy needed to rise the temperature by 1 °C

So, the thermal energy needed to rise the temperature by 20 °C is J

Specific Heat Capacity (Kalor jenis)

: Energy needed to raise the temperature of a unit mass (1 kg) by1 ^{o}C or ^{o}K

Example

30000 Joule of thermal energy was required to raise the temperature of 3 kg of liquid from 10 ^{o}C to 15 ^{o}C. Find the specific heat capacity of the liquid.

Solution :

Q = 30000 J

m = 3 kg

Temperature rise ΔT = 15 ^{o}C - 10 ^{o}C = 5 ^{o}C

The thermal energy needed by **3 kg** of the liquid to rise the temperature by **5 ^{o}C** is **30000** J

The thermal energy needed by **3 kg** of the liquid to rise the temperature by **1 ^{o}C** is J

The thermal energy needed by **1 kg** of the liquid to rise the temperature by **1 ^{o}C** is J

So, the specific heat capacity of the liquid is J/kg^{o}C

Latent Heat of Fusion (L_f)

Thermal energy required to change solid into liquid.

Specific latent heat of fusion (l_f)

The amount of thermal energy required to change unit of mass (e.g 1 kg) of the substance from solid to liquid state, without a change in temperature

Example:

If the specific latent heat of fusion of ice cream is 340 000 J/kg, find the thermal energy released when 100 g of liquid ice cream solidifies at its freezing point.

Solution

given :

the specific latent heat of fusion of ice cream (l_f)= 340 000 J/kg

It means it releases 340 000 J of thermal energy every 1 kg

It means it releases 340 000 J of thermal energy every 1000 g

It means it releases J of thermal energy every 1 g

It means it releases J of thermal energy every 10 g

So it releases J of thermal energy every 100 g

Exercise

1. 4 kg of water is heated from 30 °C to 50 °C. If the specific heat capacity of water is 4200 J/kg °C, find the thermal energy needed (Q).

   m = 4 kg

   ΔT = °C

   c = 4200 J/kg °C

   - 1 kg of water requires 4200 J of thermal energy to rise its temperature by 1 °C
   - 4 kg of water requires J of thermal energy to rise its temperature by 1 °C
   - 4 kg of water requires J of thermal energy to rise its temperature by °C

   So, Q = Joule

2. To raise the temperature of 2 kg of matter from 5°C until 15°C, it is needed 60 000 J of thermal energy. Find the specific heat capacity of the matter.

   m = 2 kg

   ΔT = °C

   Q = 60 000 J

   It requires 60 000 J for 2 kg of matter to rise its temperature by °C

   It requires J for 1 kg of matter to rise its temperature by °C

   It requires J for 1 kg of matter to rise its temperature by 1 °C

   So, the specific heat capacity of the matter is J/kg °C

3. 200 gram of alcohol at 24°C is heated with thermal energy of 9 600 J. If the specific heat capacity of alcohol is 2 400 J/kg °C, find the final temperature of the alcohol.

the specific heat capacity of alcohol is 2 400 J/kg °C

- 1 kg of water requires 2 400 J of thermal energy to rise its temperature by 1 °C
- 1000 kg of water requires 2 400 J of thermal energy to rise its temperature by 1 °C
- 100 kg of water requires J of thermal energy to rise its temperature by 1 °C
- 200 kg of water requires J of thermal energy to rise its temperature by 1 °C
- 200 kg of water requires 9 600 J of thermal energy to rise its temperature by °C

  So the change of temperature (ΔT) is °C

The final temperature is °C