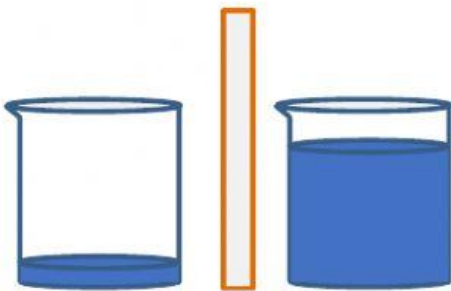


Thermal Energy

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 °C to 60 °C. 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 °C.

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 °C.

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 by 1°C or $^{\circ}\text{K}$

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 :

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

solution

- a. Given:

thermal energy supplied $Q = 84000 \text{ J}$

Temperature rise $\Delta T = 30^{\circ}\text{C} - 20^{\circ}\text{C} = 10^{\circ}\text{C}$

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

= $\quad \quad \quad \text{J}/^{\circ}\text{C}$

- b. Since 1 kg of water has $\frac{1}{2}$ of the mass of 2 kg of water, the heat capacity of 1 kg = $\frac{1}{2}$ 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)

= $\frac{1}{2}$ x $\quad \quad \quad$ = $\quad \quad \quad \text{J}/^{\circ}\text{C}$

- c. thermal energy needed Q to raise the temperature of 1 kg of water from 50°C to 70°C (for $70^{\circ}\text{C} - 50^{\circ}\text{C} = 20^{\circ}\text{C}$)

From b question you have $\quad \quad \quad \text{J}/^{\circ}\text{C}$ 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 $\quad \quad \quad \text{J}$

Specific Heat Capacity (Kalor jenis)

: Energy needed to raise the temperature of a unit mass (1 kg) by 1 °C or °K

Example

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

Solution :

$$Q = 30000 \text{ J}$$

$$m = 3 \text{ kg}$$

$$\text{Temperature rise } \Delta T = 15 \text{ }^{\circ}\text{C} - 10 \text{ }^{\circ}\text{C} = 5 \text{ }^{\circ}\text{C}$$

The thermal energy needed by **3 kg** of the liquid to rise the temperature by **5 °C** is **30000 J**

The thermal energy needed by **3 kg** of the liquid to rise the temperature by **1 °C** is J

The thermal energy needed by **1 kg** of the liquid to rise the temperature by **1 °C** is J

So, the specific heat capacity of the liquid is J/kg°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).

$$m = 4 \text{ kg}$$

$$\Delta T = \quad \text{°C}$$

$$c = 4200 \text{ J/kg °C}$$

- 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

$$\text{So, } Q = \quad \text{Joule}$$

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.

$$m = 2 \text{ kg}$$

$$\Delta T = \quad \text{°C}$$

$$Q = 60\,000 \text{ J}$$

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 $^{\circ}\text{C}$, find the final temperature of the alcohol.

the specific heat capacity of alcohol is 2 400 J/kg $^{\circ}\text{C}$

- 1 kg of water requires 2 400 J of thermal energy to rise its temperature by 1 $^{\circ}\text{C}$
- 1000 kg of water requires 2 400 J of thermal energy to rise its temperature by 1 $^{\circ}\text{C}$
- 100 kg of water requires J of thermal energy to rise its temperature by 1 $^{\circ}\text{C}$
- 200 kg of water requires J of thermal energy to rise its temperature by 1 $^{\circ}\text{C}$
- 200 kg of water requires 9 600 J of thermal energy to rise its temperature by $^{\circ}\text{C}$

So the change of temperature (ΔT) is $^{\circ}\text{C}$

The final temperature is $^{\circ}\text{C}$