Interesting Heat Exchange

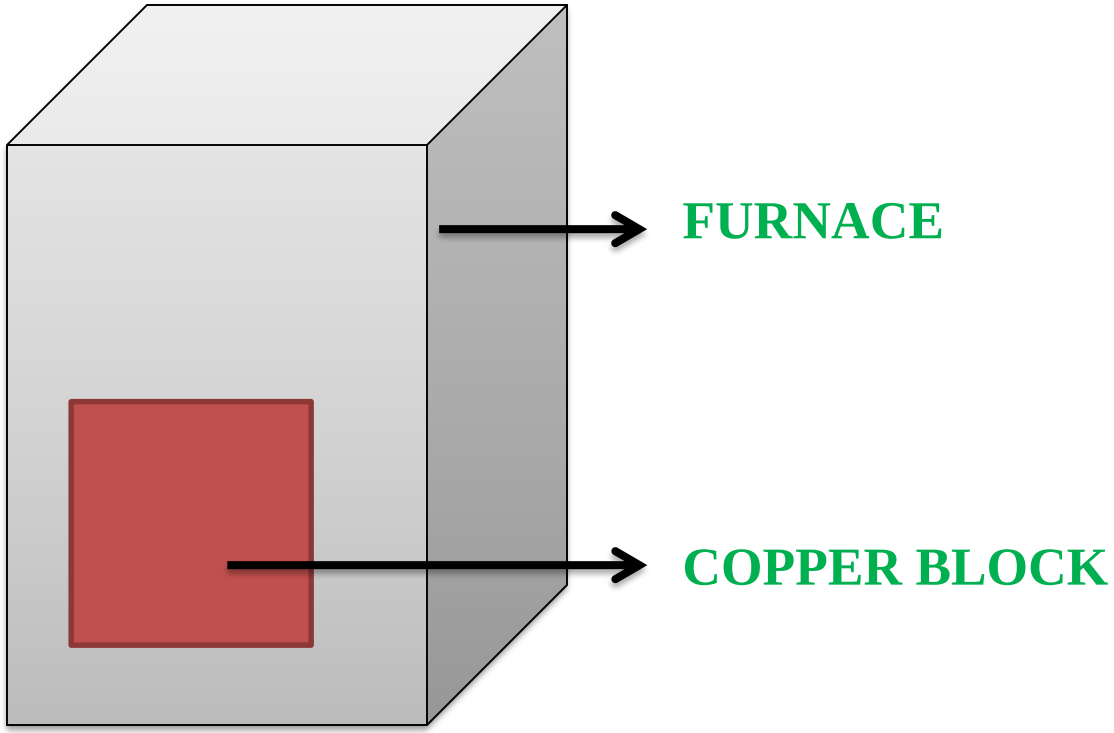
A copper block of mass 2.5 kg is heated in a furnace to a temperature of 500 °C and then placed on a large ice block.

What is the maximum amount of ice that can melt?

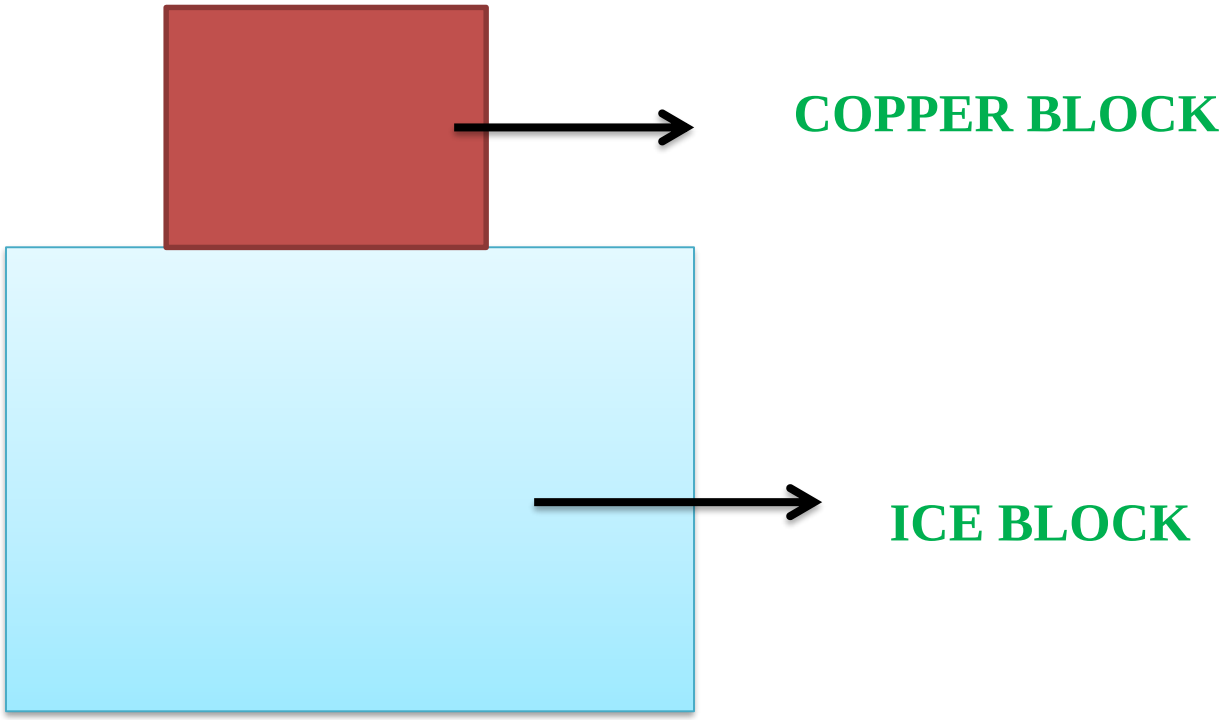
(Specific heat of copper = 0.39 J$g^{-1}K^{-1}$; heat of fusion of water = 335 J g^{-1}).

Let us imagine

Let us consider a furnace in which copper block of mass 2.5 kg is heated to a temperature of 500 °C.



Now put this copper block on a large ice block as shown in picture.



Let us see what we know :

mass of the copper block, $M_1 = 2.5\ kg$

Specific heat of copper (c)= $0.39\ \mathrm{J}g^{-1}K^{-1}$

$= 0.39 \times 10^3\ \mathrm{J}kg^{-1}K^{-1}$

Temperature of the furnace, $\theta = 500\ ℃$

Ice will remain at 0 ℃ till it melts completely

So the copper block will stop melting ice the moment its temperature becomes 0 ℃

Therefore, heat absorbed by the copper block

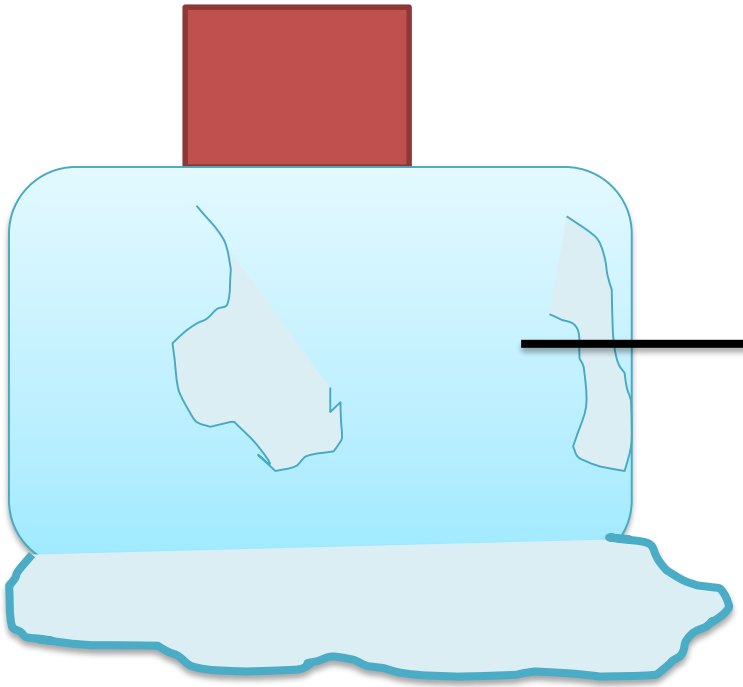
,

$$\mathbf{Q} = \boldsymbol{M_1 c\, \Delta T}$$
$$= \mathbf{2.5 \times 0.39 \times 10^3 \times (500 - 0)}$$

Latent heat of ice,

$$\mathrm{L} = 335\ \mathrm{J}\ g^{-1} = 335 \times 10^{3} J kg^{-1}$$

Suppose that mass $M_2(\,kg)$ of the ice melts, when the copper block is placed on it.



Ice starts melting when copper block placed on it

Then

$$Q = M_2 L = M_2 \times 335 \times 10^3$$

From principle of heat exchange
Heat lost is equal to heat gained

Provided there is no other system involved
No heat lost to surrounding container etc.

Heat gained by block of ice = Heat lost by copper block

Heat gained = Heat lost

$$M_2 \times 335 \times 10^3 = 2.5 \times 0.39 \times 10^3 \times 500$$

$$M_2 = \frac{2.5 \times 0.39 \times 10^3 \times 500}{335 \times 10^3}$$

= 1.455 kg

1.455 kg ice will melt

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