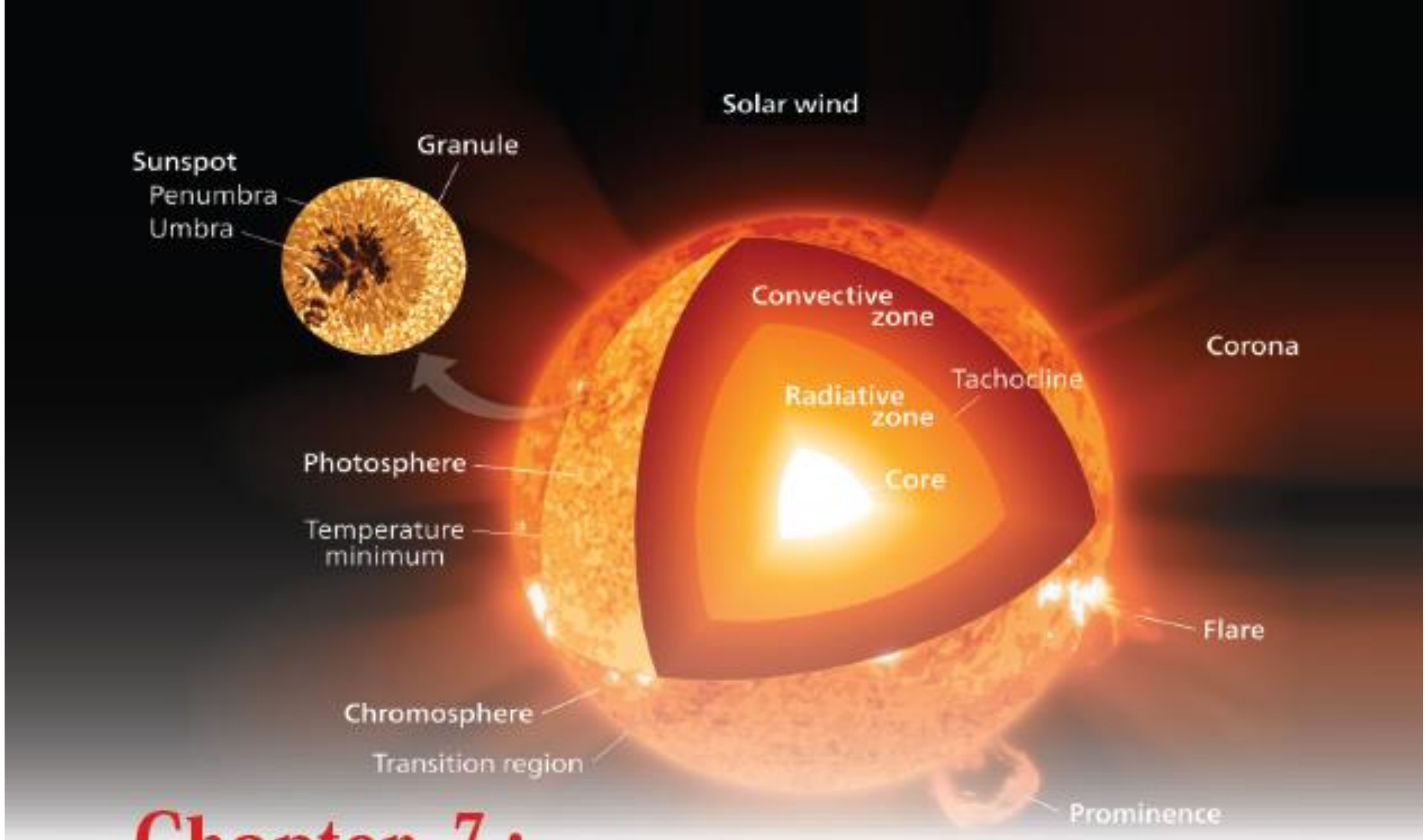
Heat



Chapter 7 :

Heat

1. Temperature scales
2. Thermal expansion
3. Specific heat
4. Heat transfer

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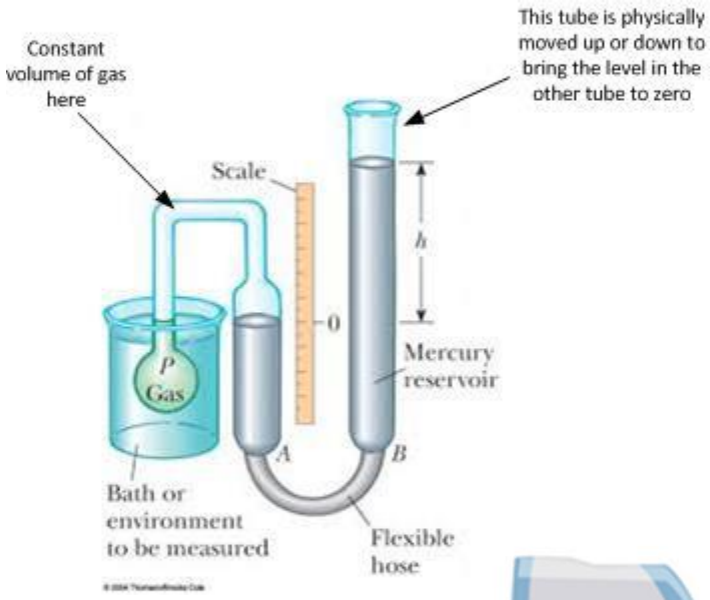
1. Temperature Scales

Temperature is a measure of a heat of the body. Thermometers are depend on the principle of changing a physical property with temperature.

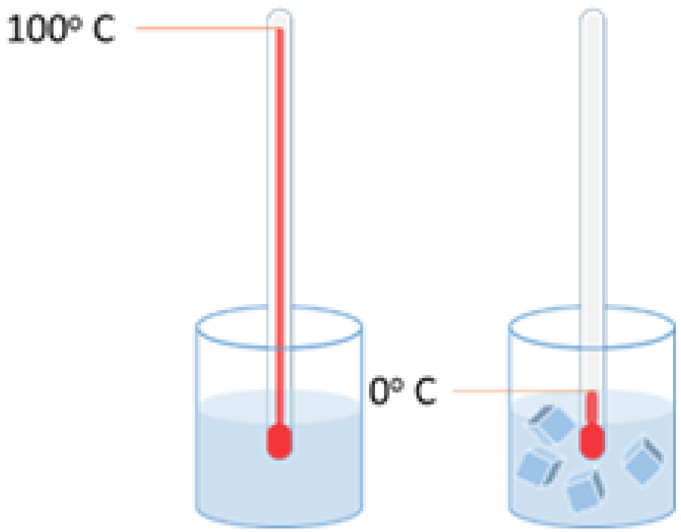
1. Liquid volume at constant pressure.
2. Gas volume at constant pressure.
3. Gas pressure at a fixed volume.
4. The dimensions of the solid body.
5. Electrical resistance of the conductive material.
6. The radioactive wavelength has changed with the temperature of the hot body.



1. Temperature Scales

Celsius Scale

In the Celsius scale: the lower point is called the melting point of ice, and the upper point is the boiling point of water at standard atmospheric pressure.



Fahrenheit Scale

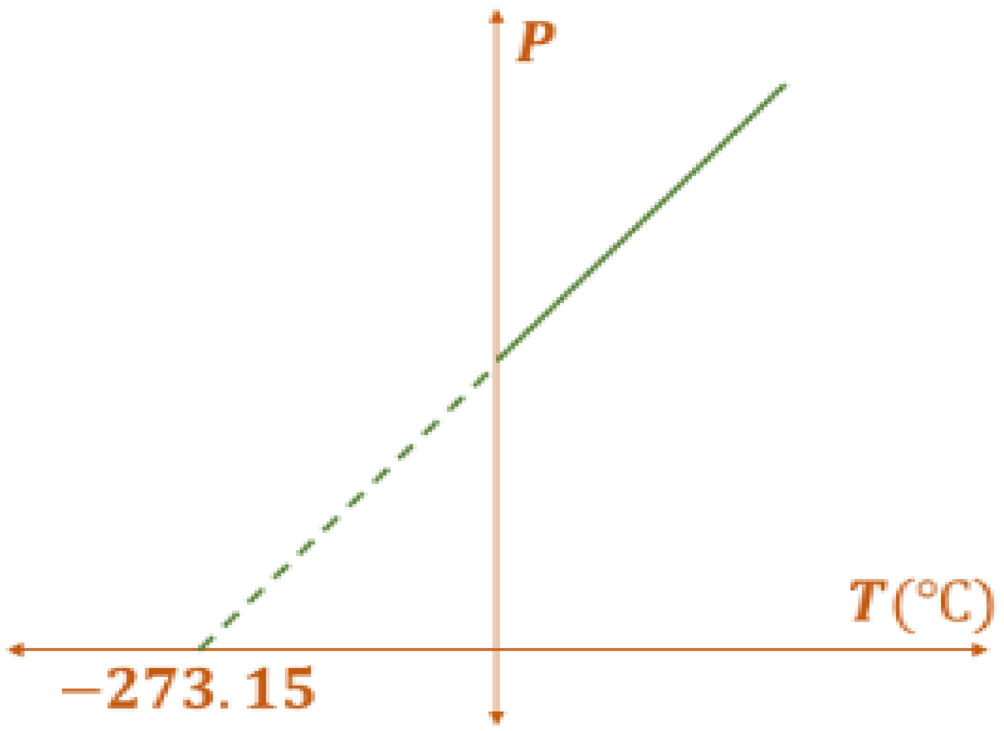
In the Fahrenheit scale: the degree of freezing water at the standard atmospheric pressure is 32° Fahrenheit and the boiling point of water is 212° Fahrenheit.

1. Temperature Scales

Kelvin Scale

In the Kelvin Scale: the smallest point is the melting point of ice and given $273.15°K$.

The greatest point is the boiling point of water and given $373.15°K$.



1. Temperature Scales

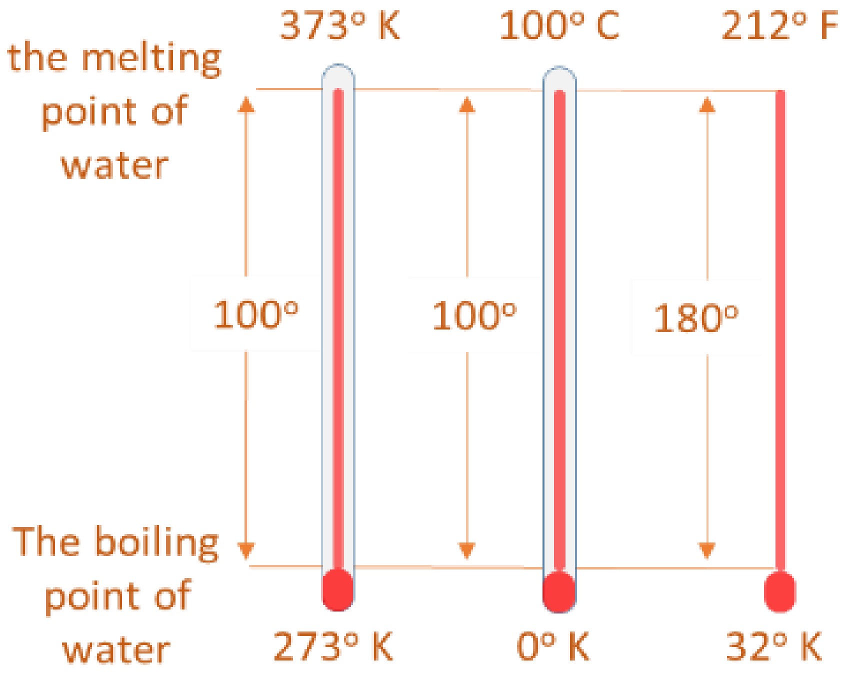
The relationship between thermometric scales

The following equation is used to convert from one of these scale to the other:

$$\frac{T_C}{100} = \frac{T_K - 273}{100} = \frac{T_F - 32}{180}$$

$$T_C = \frac{5}{9}(T_F - 32)$$

$$T_K = T_C + 273$$



1. Temperature Scales

Example: 7.1

If the room temperature on a summer day is 100 °F , then how much is it on the Celsius and on the Kelvin scale?

Solution

First on the Celsius scale:

$$T_C = \frac{5}{9}(T_F - 32)$$

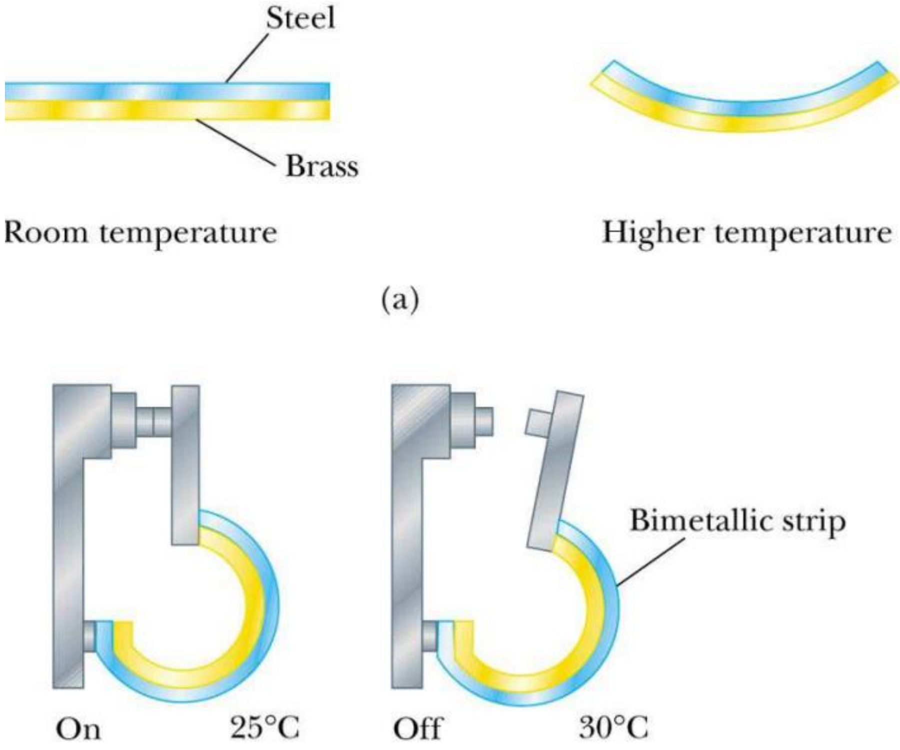
$$= \frac{5}{9}(100 - 32) = 37.8°C$$

Second, on the Kelvin scale:

$$T_K = T_C + 273$$

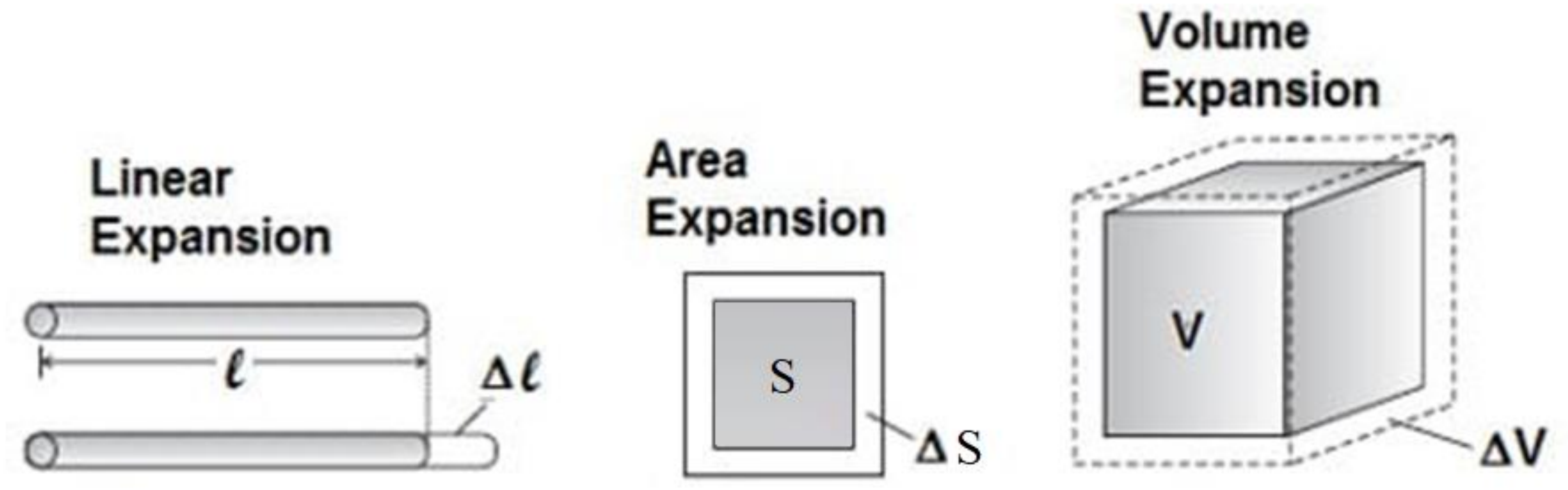
$$= 37.8 + 273 = 310.8\ K$$

2. Thermal expansion



2. Thermal expansion

The length of a metal bar is extended due to the increase in temperature.



$$\Delta\ell = \alpha\ell\Delta T$$

$$\Delta S = \gamma S\Delta T$$

$$\gamma = 2\alpha$$

$$\Delta V = \beta V\Delta T$$

$$B = 3\alpha$$

2. Thermal expansion

Example

A length of copper bar is 10 m at zero Celsius, raising its temperature to 500°C. calculate the expansion of length of the copper bar.

$$\text{Note that } \alpha = 1.8 \times 10^{-5}\ \ \text{C}^{\circ\,-1}$$

Solution

$$\Delta\ell = \alpha\, \ell_1\, \Delta T$$

$$= 1.8 \times 10^{-5}\ \times 10 \times 500 = 0.09\ \text{m}$$

2. Thermal expansion

Longitudinal expansion coefficient

Longitudinal expansion coefficient: **α** defined as the amount of change in length for each temperature change of one-degree Kelvin.

Surface expansion coefficient

Surface expansion coefficient **γ**: defined as the relative change in the area of a slide when its temperature changes by one-degree Kelvin.

Volume expansion coefficient

Volume expansion coefficient **β**: defined as the relative change in slide size when the temperature changes by one-degree Kelvin.

2. Thermal expansion

Example

A size of metal box is $0.55\ m^3$ at a temperature $20°C$. if the temperature increases to $100°C$, what is the expansion of the box size?

$$\text{Note that } \alpha = 1.7 \times 10^{-5}\ C°^{-1}$$

Solution

$$\Delta V = 3\alpha V \Delta T$$

$$= 3 \times 1.7 \times 10^{-5} \times 0.55 \times (100 - 20) = 0.002\ m^3$$

3. Specific Heat

Heat is a type of energy. An amount of heat **Q** acquired or lost by a system is proportional to its mass **m** and change in temperature of the ΔT:

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

The unit of heat Q calorie, where 1 Calorie = 4.18 Joule

Example: 7.6

Calculate the amount of heat needed to change the $720\ gm$ of ice at $-10°\ C$ to $0°\ C$. Note that the specific heat of the ice $c = 2220\ J/kg\ K$.

Solution

$$Q = m\ \text{c}\ \Delta T$$

$$= 0.72 \times 2220 \times [0 - (-10)] = 15984\ J$$

3. Specific Heat

Specific heat of material **c** is defined as the amount of heat needed to raise the temperature of one gram of the material 1°C.

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

Heat capacity is the amount of heat needed to raise the temperature of the material 1°C, and it is symbolized by the symbol **C**.

$$Q = C\ \Delta T$$

L is the latent heat that is known as the amount of heat needed to convert one gram of material from a phase to another phase, when the temperature is constant.

$$Q = m\ L$$

3. Specific Heat

Example: 7.7

A system of liquid water and ice with mass equal 720 gm is heated until the ice is completely melted, how much should it be gained during the presence of the liquid and ice phase in the system?

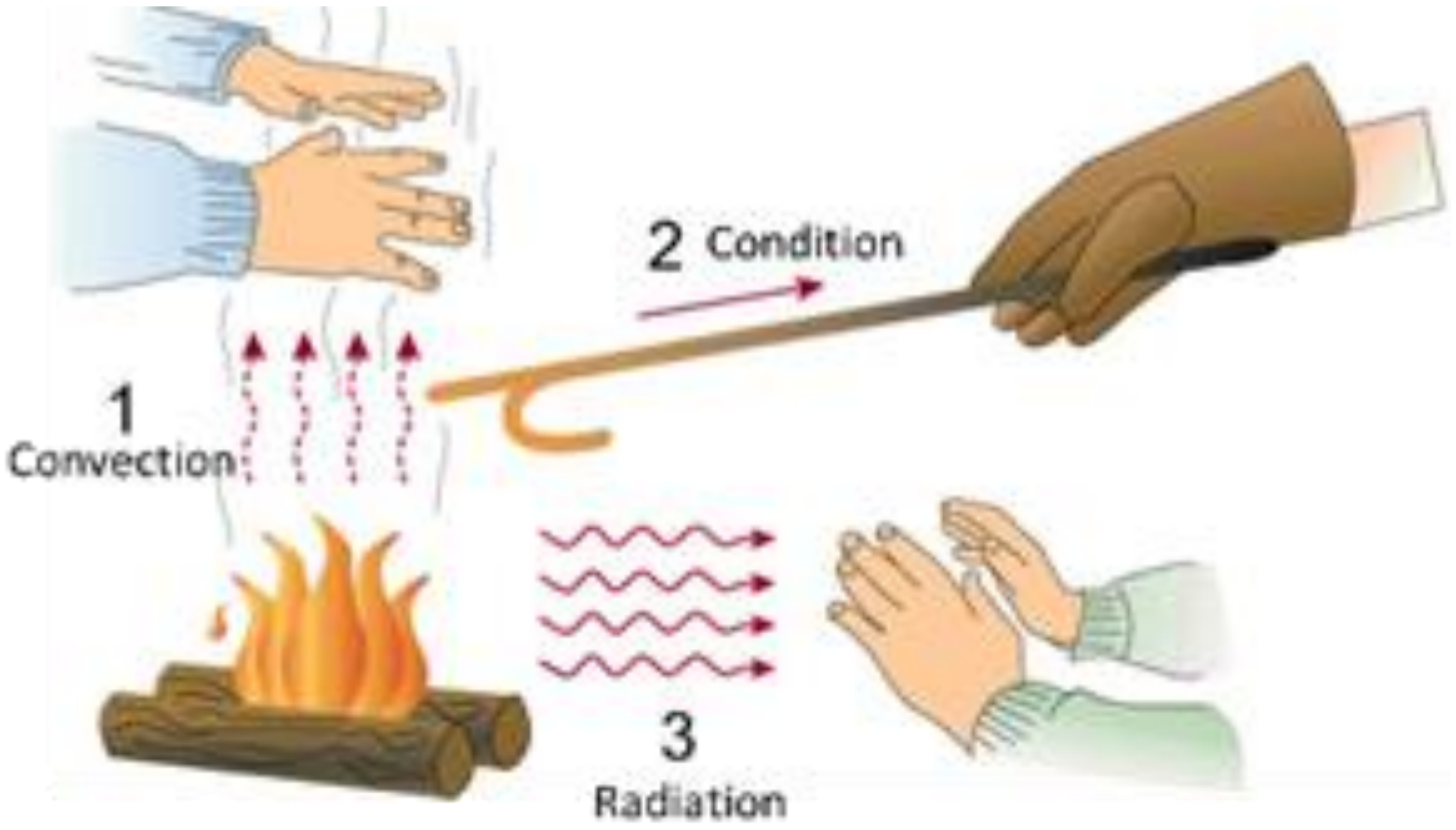
Note that the latent heat of the ice melt is 333 kJ/kg

Solution

$$Q = m\,L$$

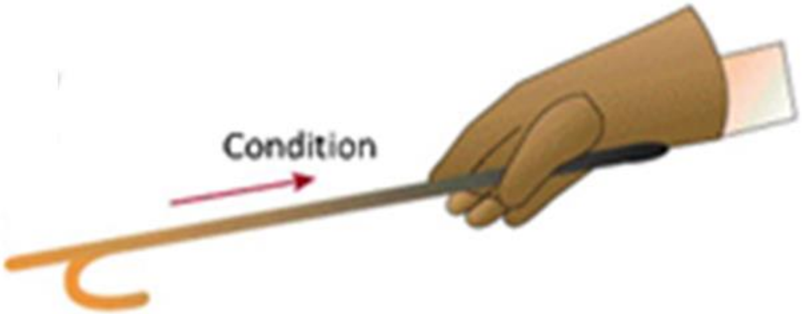
$$= 0.72 \times 333 \times 10^3 = \; 239760 \; J$$

4. Heat transfer



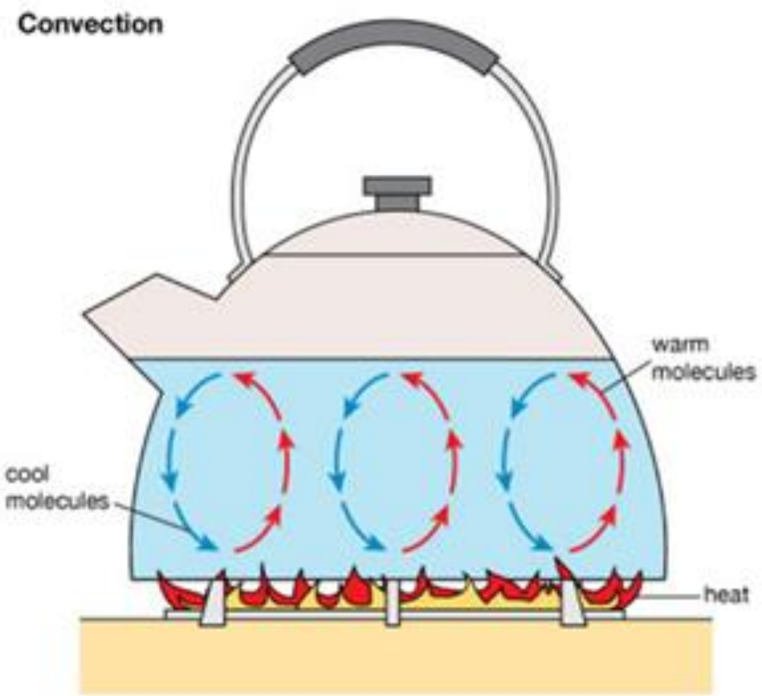
4. Heat transfer

Thermal Conduction

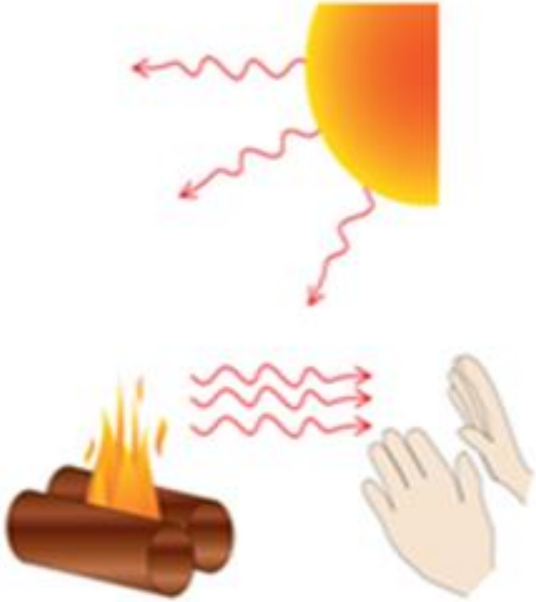


$$H = k_c A \frac{T_1 - T_2}{x}$$

Convection



Radiation



$$Q = \sigma A T^4$$