A copper bar is 80 cm long at 15 degree celsius. What is the increase in length when it is heated to 35 degree celsius? The linear expansion coefficient for copper is ~~1.7*10^-5~~ $1.7 \times 10^{-5}\,°C^{-1}$

Here,

$t_1\,°C = 15\,°C$

$L_1 = 80\,cm = 0.80\,m$

$t_2\,°C = 35\,°C$

$\Delta l = ?$ $\quad \Delta l = L_2 - L_1$

$$\Delta L = L_2 - L_1$$

$$L_2 = L_1 [1 + \alpha (t_2 - t_1)]$$

$$= 0.80 [1 + 1.7 \times 10^{-5} (35 - 15)]$$

$$= 0.800272$$

Determine the change in volume of a block of cast iron 5.0cm*10cm*6.0cm, when the temperature of the block is made to change from 15 degree celsius to 47 degree celsius. The coefficient of linear expansion of cast iron is 0.000010 $^\circ C^{-1}$

V_1

$$\Delta V = V_2 - V_1$$

$$V_2 = V_1[1 + \gamma(t_2 - t_1)]$$

$$\gamma = 3\alpha$$

$$\gamma = 3 \times 10^{-5}\ ^\circ C^{-1}$$

$$= 300.288\ cm^3$$

$$V_1 = 300\ cm^3$$

$$V_2 = 300.288\ cm^3$$

$$\Delta V = V_2 - V_1 = 0.288\ cm^3$$

$$= 0.29\ cm^3$$

Expansion of liquid

When a liquid is heated, its volume changes. Liquid have no shape of their own but conform to the shape of the containing vessel. When a liquid is heated, the containing vessel also expands and hence the measured increase in volume of the liquid is the apparent increase in volume. The real increase in volume of the liquid is equal to the sum of the apparent increase in volume of the liquid and the increase in volume of the containing vessel. Thus a liquid has two coefficients of expansion.

i) Coefficient of apparent expansion
ii) Coefficient of real expansion

Apparent expansion of liquid γ_a

The coefficient of apparent expansion of liquid is defined as the apparent increase in volume per unit volume with degree rise in temperature when the liquid is heated in a vessel that expands on heating.

Real expansion of liquid γ_r

The coefficient of real expansion of a liquid is defined as the actual increase in volume per unit volume per unit is a rise in temperature.

Relation Between γ_a and γ_r:

Consider a liquid contained in a graduated vessel which reads the volume correctly at 0^0C. Let V_0 and V_1 be the volumes of the liquids at 0^0C and t^0C. Then the coefficient of apparent expansion

Newton's law of cooling

Newton's law of cooling states that the rate of loss of heat of a body is directly proportional to the difference of temperature of the body and the surrounding. The law holds good only for small difference of temperature. Also, the loss of heat by radiation depends upon the nature of the surface of the body and area of the exposed surface.

$$\frac{dH}{dt} \propto (\theta - \theta_0)$$

$$or, -\frac{dH}{dt} = k(\theta - \theta_0)$$

Specific heat

It is defined as the quantity of heat required to raise the temperature of unit mass of a substance through one degree.

$$S = \frac{H}{m\Delta\theta}$$

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Thermal capacity

It is the quantity of heat required to rise the temperature of the whole of the substance through 1^0C.

Gas has two specific heat

i) specific heat at constant volume (C_V)

ii) specific heat at constant pressure (C_P)

C_V:

It is defined as the quantity of heat required to write the temperature of 1 gram of a gas through 1^0C at constant volume.

C_P:

It is define as the quantity of heat required to raise the temperature of 1 gram of a gas through 1^0C at constant pressure.

C_P is greater than C_V

$C_p > C_V$

Relation between Cp and Cv:

Consider one gram of a gas at a pressure P, volume V and temperature T. Heat is supplied to the gas to raise its temperature through dT. As the pressure has to remain constant,
Work done,

$$W = PW = P \times A \times x = P \times dV;$$

From the gas equation

$$PV = rT$$

Differentiating

$$PdV + VdP = rdT$$
$$\text{But } dP = 0$$
$$PdV = rdT$$

Work done in heat units= $\frac{r.dT}{J}$ calories

Heat Supplied= $1 \times C_P \times dT = 1 \times C_v dT + \frac{rdT}{J}$

$or, C_P - C_v = \frac{r}{J}$

Where, r is the gas constant for 1 gram of a gas. If C_P and C_V represent gram molecular specific heat then,

$C_p - C_v = \frac{R}{J}$

Where, R is the universal gas constant.

- **British thermal unit (B. T. U.)**

  It is the amount of heat required to raise the temperature of one pound water by 1 F. (1 B.T.U. = 252 calorie).

MECHANICAL EQUIVALENT OF HEAT

According to Joule, work may be converted into heat and vice–versa. The ratio of work done to heat produced is always constant. $\frac{W}{H}$ = constant (J) $\Rightarrow W = J\,H$

W must be in joule, irrespective of nature of energy or work and H must be in calorie.

J is called mechanical equivalent of heat. It is not a physical quantity but simply a conversion factor.

It converts unit of work into that of heat and vice–versa.

J = 4.18 joule/cal or 4.18 10 joule per kilo–cal. For rough calculations we take $\boxed{J = 4.2 \text{ joule/cal}}$

SPECIFIC HEAT (s or c)

It is the amount of energy required to raise the temperature of unit mass of that substance by 1 C (or 1K) is called specific heat. It is represented by s or c.

If the temperature of a substance of mass m changes from T to T + dT when it exchanges an amount of heat dQ with its surroundings then its specific heat is $c = \frac{1}{m}\frac{dQ}{dT}$

The specific heat depends on the pressure, volume and temperature of the substance.

- These specific heats can be molar or gram.

MOLAR HEAT CAPACITY

The amount of energy needed to raise the temperature of one mole of a substance by 1 C (or 1K) is called molar heat capacity. The molar heat capacity is the product of molecular weight and specific heat i.e.,

Molar heat capacity C = Molecular weight (M) Specific heat(c) $\Rightarrow C = \frac{1}{\mu}\left(\frac{dQ}{dT}\right)$

If the molecular mass of the substance is M and the mass of the substance is m then number of moles of the substance $\mu = \frac{m}{M} \Rightarrow C = \frac{M}{m}\left(\frac{dQ}{dT}\right)$ **SI UNIT :** J/mol-K

THERMAL CAPACITY

The quantity of heat required to raise the temperature of the whole of that substance through 1 C is called thermal capacity. The thermal capacity of mass m of the whole of substance of specific heat s is = ms

Thermal capacity = mass specific heat

Thermal capacity depends on property of material of the body and mass of the body.

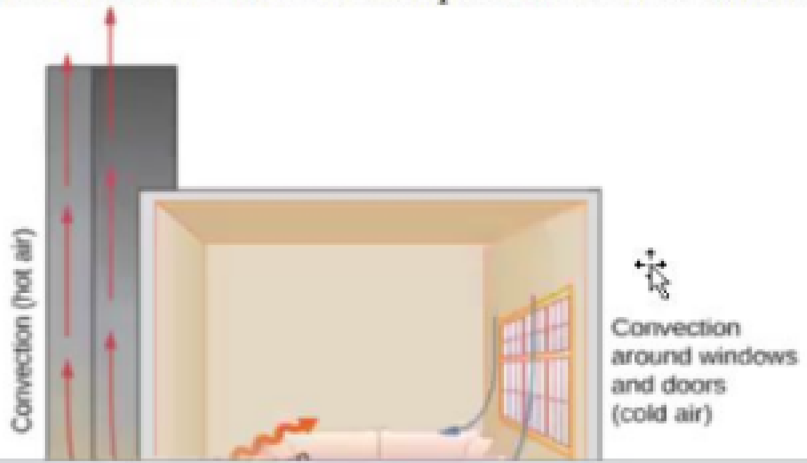
SI UNIT : cal/ C or cal/K, **Dimensions :** $ML^2 T^{-2}K^{-1}$

heat transfer that it is hard to imagine a situation where no heat transfer occurs. Yet every heat transfer takes place by only three methods:

1. **Conduction** is heat transfer through stationary matter by physical contact. (The matter is stationary on a macroscopic scale—we know that thermal motion of the atoms and molecules occurs at any temperature above absolute zero.) Heat transferred from the burner of a stove through the bottom of a pan to food in the pan is transferred by conduction.

2. **Convection** is the heat transfer by the macroscopic movement of a fluid. This type of transfer takes place in a forced-air furnace and in weather systems, for example.

3. Heat transfer by **radiation** occurs when microwaves, infrared radiation, visible light, or another form of electromagnetic radiation is emitted or absorbed. An obvious example is the warming of Earth by the Sun. A less obvious example is thermal radiation from the human body.



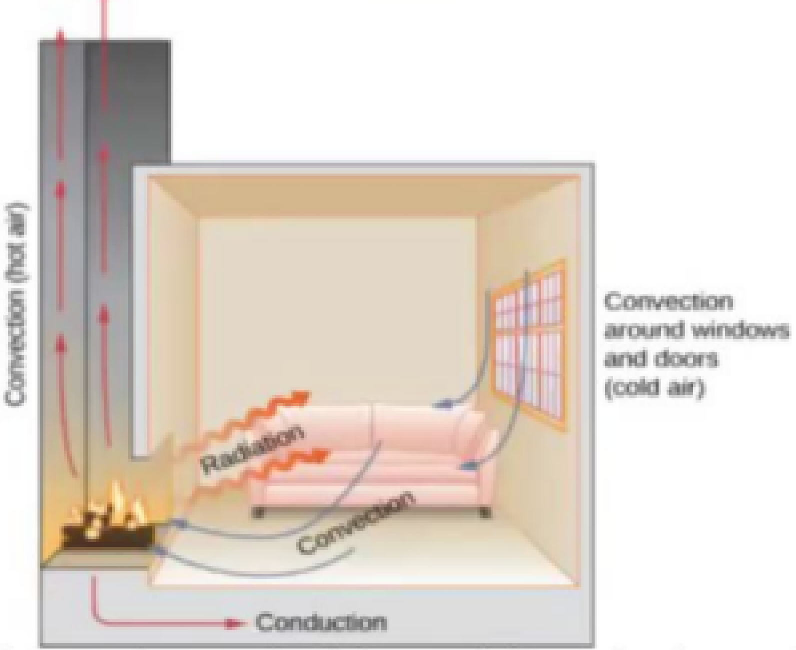


Figure: In a fireplace, heat transfer occurs by all three methods: conduction, convection, and radiation. Radiation is responsible for most of the heat transferred into the room. Heat transfer also occurs through conduction into the room, but much slower. Heat transfer by convection also occurs through cold air