Conduction

E is the mid-point of the rod.
Find heat current in EF.
All the rods are identical.
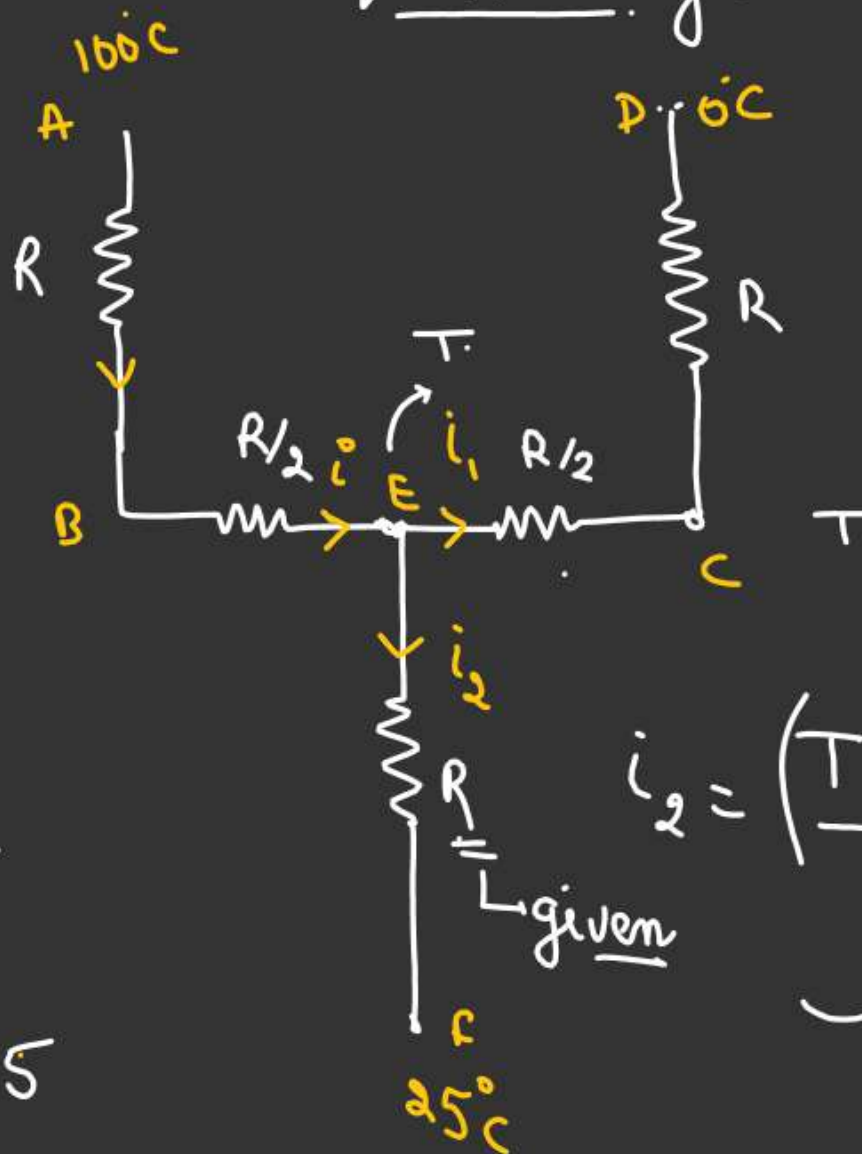
$i_2 = ??$

Junction rule

$$i = i_1 + i_2$$

$$\frac{100 - T}{\frac{3R}{2}} = \frac{T - 0}{\frac{3R}{2}} + \frac{T - 25}{R}$$

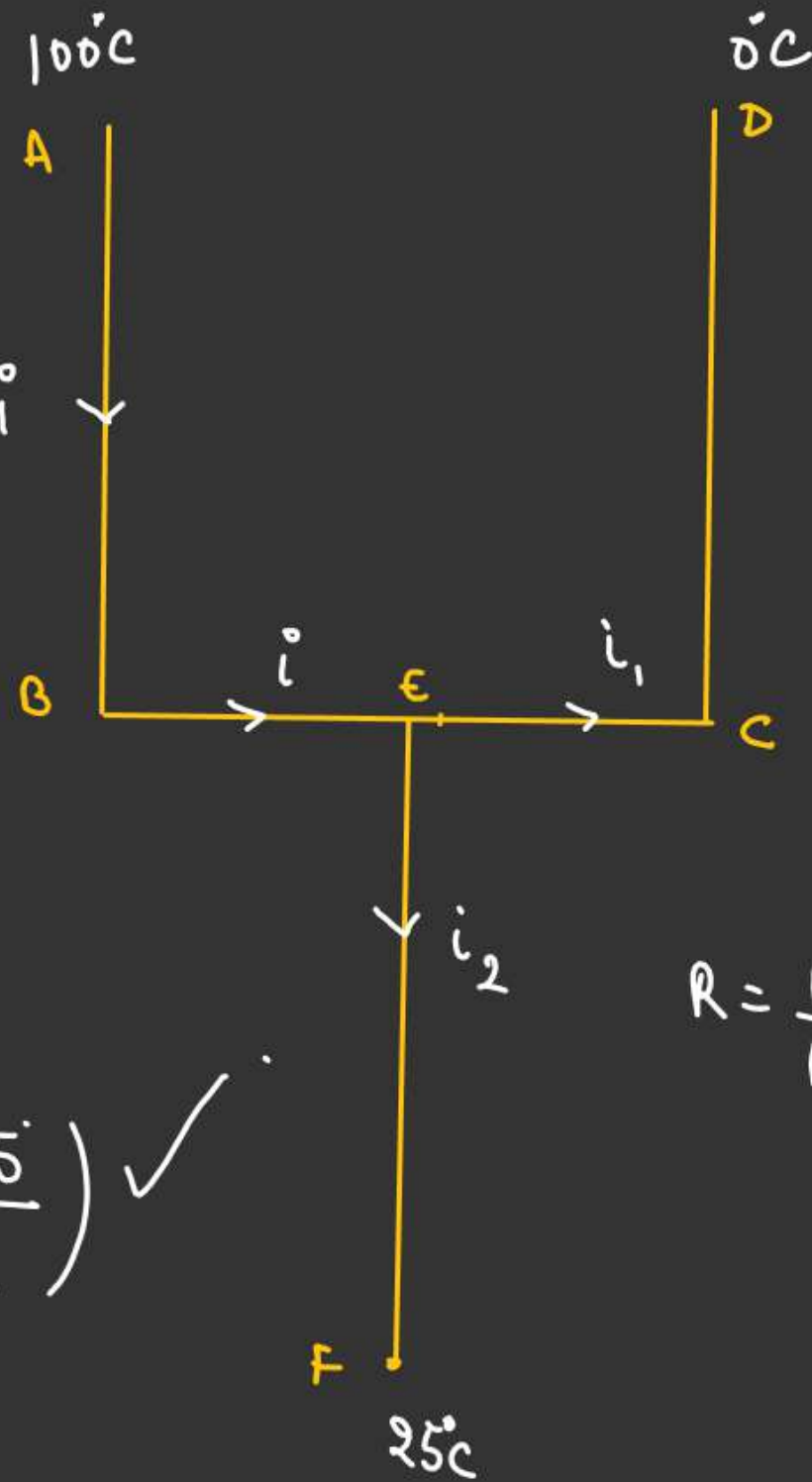$$\frac{2}{3}(100 - T) = \frac{2}{3}T + T - 25$$

$$\frac{200}{3} - \frac{2T}{3} = \frac{2T}{3} + T - 25$$

$$\hookrightarrow T = \left(\frac{275}{7}\right).$$

Eq. Ckt diagram

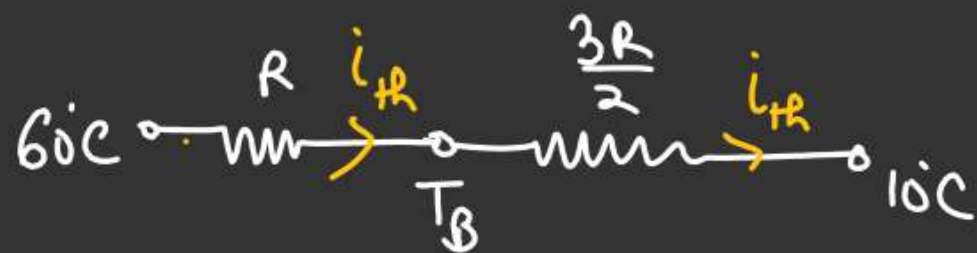$i_2 = \left(\dfrac{T - 25}{R}\right)$ ✓

$R = \dfrac{L}{KA}$

Conduction

Rod of Material x has Conductivity. $(2K)$
and rod of Material y has Conductivity K

   $L \to$ length of each rod

$T_B = ??$ $A \to$ Crosectional area of each rod.
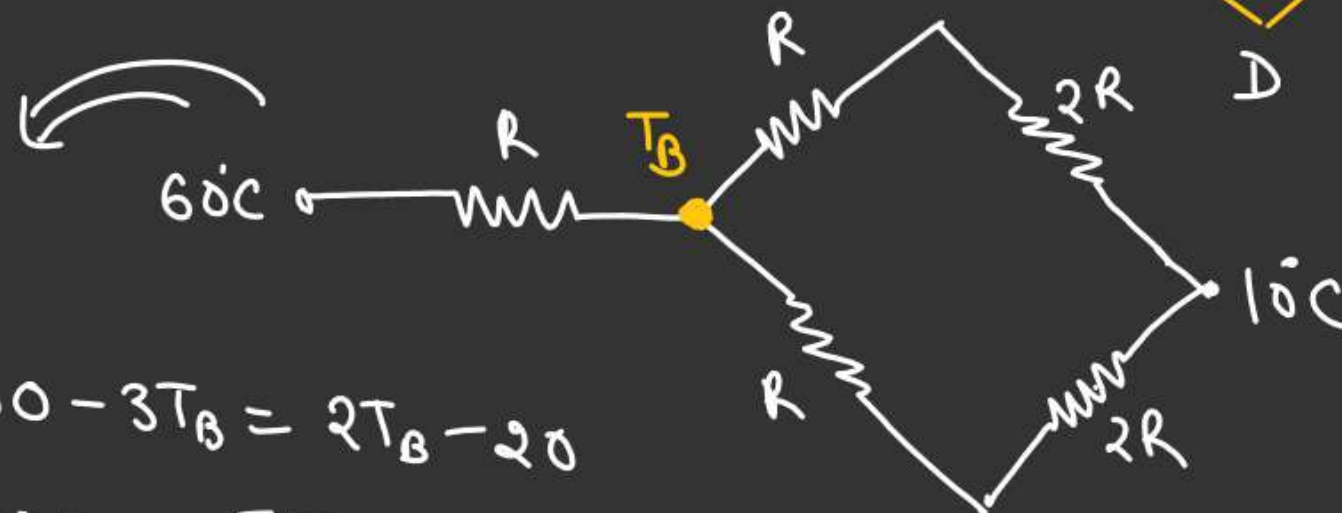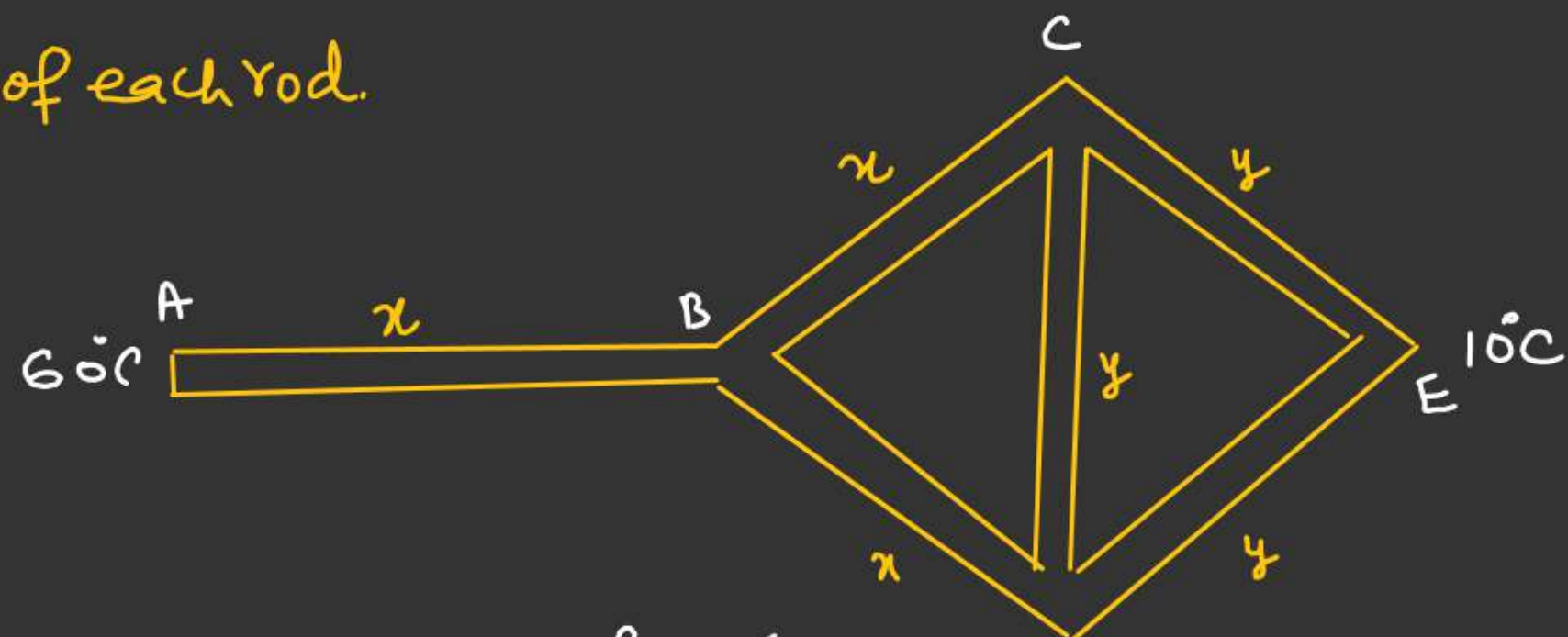
$$R_x = \frac{L}{2KA}, \quad R_y = \frac{L}{KA}$$

$$R_y = 2R_x.$$

If $R_x = R$, $R_y = 2R$

$$\frac{60 - T_B}{R} = \frac{T_B - 10}{\frac{3R}{2}}$$
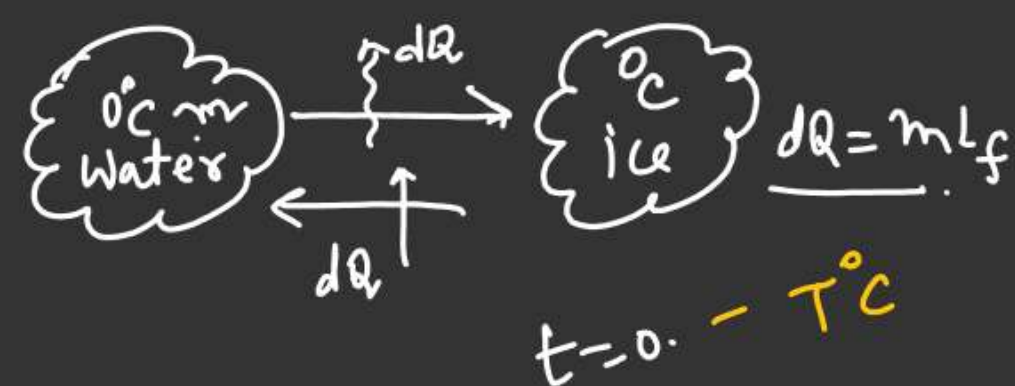
$$3\left(60 - T_B\right) = 2(T_B - 10)$$

$$180 - 3T_B = 2T_B - 20$$

$$200 = 5T_B$$

$$\underline{T_B = 40°C} \checkmark$$

$60°C \xrightarrow[T_B]{R \; i_{th}} \xrightarrow[\frac{3R}{2}]{i_{th}} 10°C$

$60°C \xrightarrow{R} T_B$

Conduction

Q4. Time taken for freezing of water.
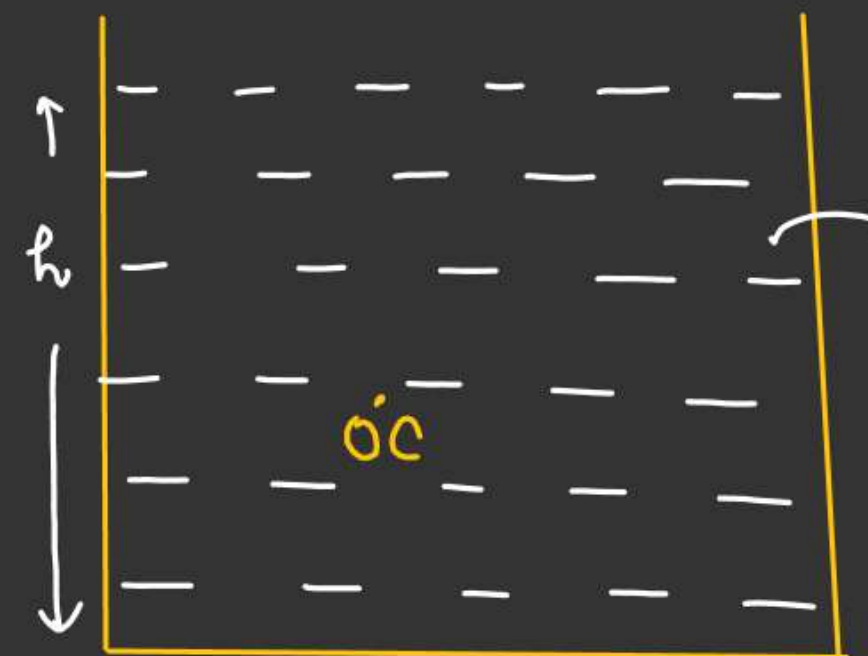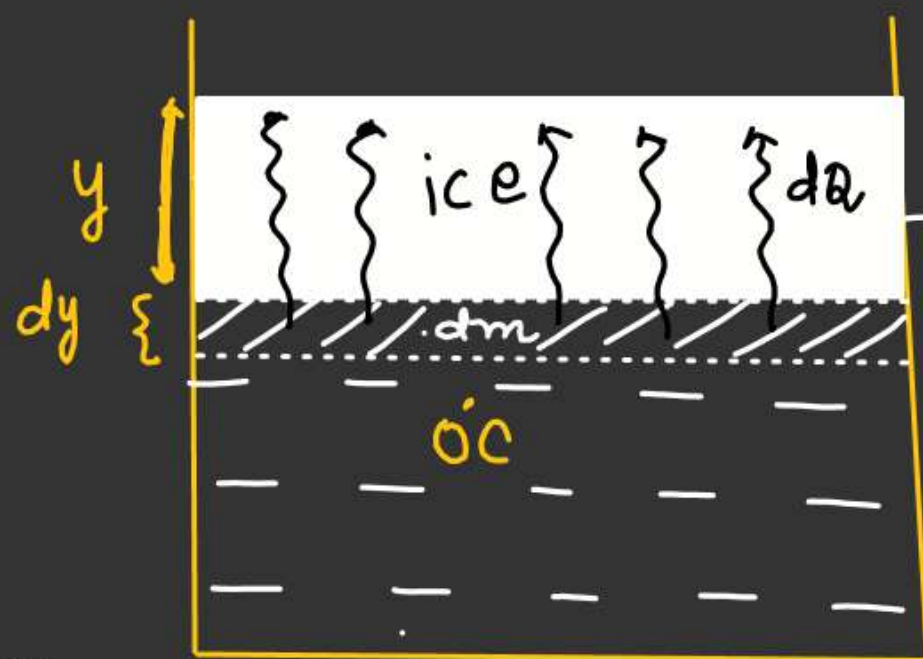
$dQ = dm \, L_f$

$dm = (\rho \cdot (A \, dy))$

dQ will conduct through y thickness of ice.

$\dfrac{dQ}{dt} = \dfrac{KA[0-(-T)]}{y}$

$\left(\dfrac{dQ}{dt} = \dfrac{KAT}{y} \right.$

$L_f \dfrac{dm}{dt} = \dfrac{KAT}{y}$

$L_f \rho A \left(\dfrac{dy}{dt} \right) = \dfrac{KAT}{y}$

$-T^\circ C$

$t = t$

ice

$dy \{$

y

dm

$0^\circ C$

$\rho L_f \int_0^y y \, dy = KT \int_0^t dt$

$k =$ conductivity of ice

Q4.

$\boxed{\dfrac{\rho L_f \, y^2}{2KT} = t}$

$T \rightarrow$ surrounding temp.

$0^\circ C$ m water → $\xrightarrow{dQ}$ $0^\circ C$ ice

$dQ = mL_f$

dQ

$t=0. \quad -T^\circ C$

h

$0^\circ C$

$L_f =$ Latent heat of fusion

$\rho =$ density of water.

$L_f =$ Latent heat of fusion.

$A =$ crossection area of vessel.

CONVECTION

$\Rightarrow$ Medium required & heat Conduct due to actual movement of medium.

$\Rightarrow$ Type of Convection

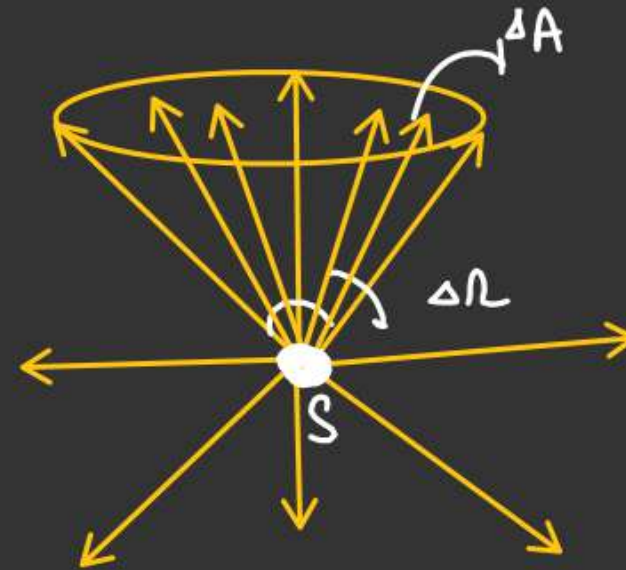(Natural Convection)   (Force Convection)

$\llcorner$
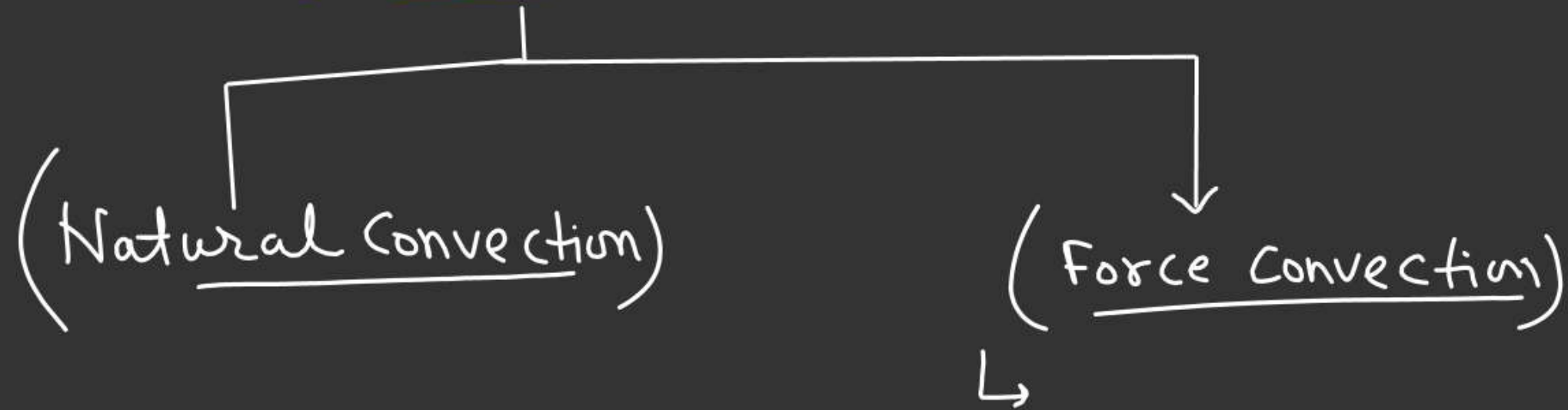
RADIATION

$\Rightarrow$ **Emissive power**

Energy radiated per unit Area, per unit time & per unit Solid Angle.

$$\Delta E = \left(\frac{\Delta U}{\Delta A \cdot \Delta t \cdot \Delta \Omega} \right)$$
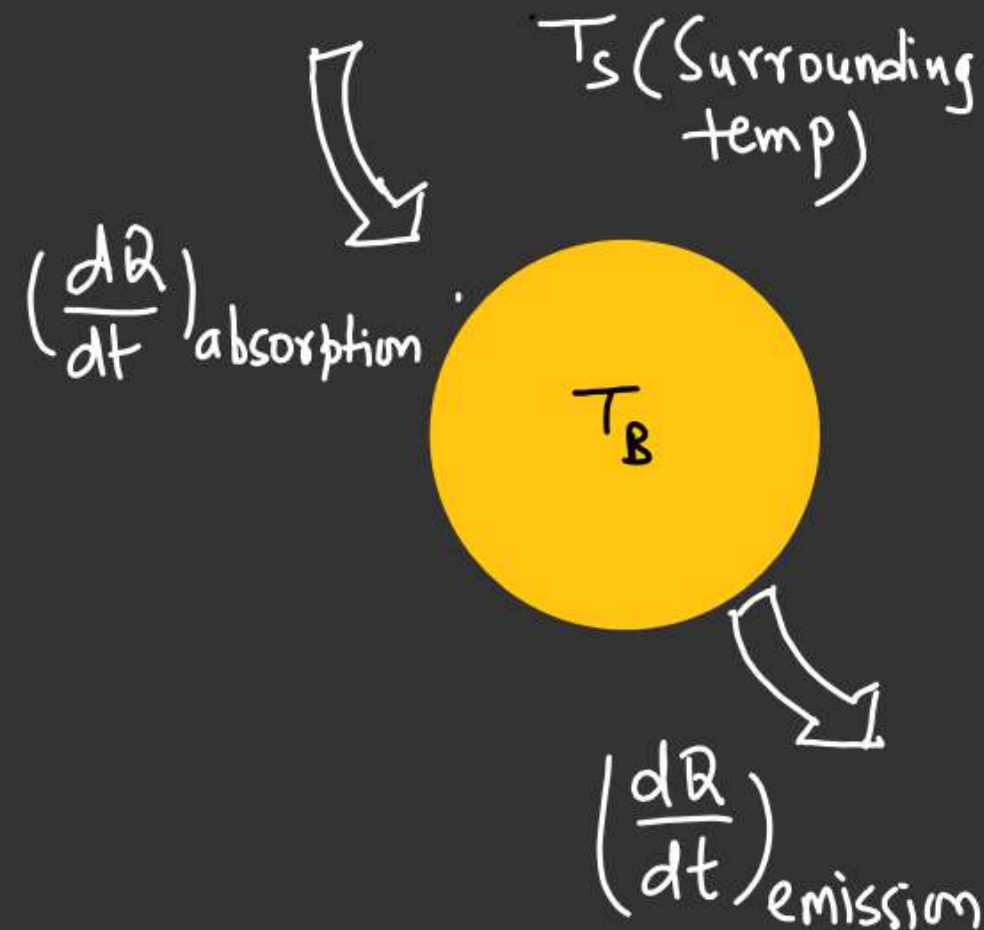

$\Rightarrow$ **Absorptive power**

$$a = \left(\frac{\text{Energy absorb}}{\text{Energy incident}} \right)$$

Q4

PREVOST THEORY OF HEAT EXCHANGE

- Every body absorb as well as emit radiation Simultaneously. at every time.

- If Rate of absorption is more than rate of emission then temp of body will increase

$$\left(\frac{dQ}{dt}\right)_{absorption} > \left(\frac{dQ}{dt}\right)_{emission}$$

$$T_B \rightarrow increase$$

- If Rate of emission is more than rate of absorption then temp of body will decrease.

$$\left(\frac{dQ}{dt}\right)_{emission} > \left(\frac{dQ}{dt}\right)_{absorption}$$

$$T_B \rightarrow decreases$$

T_S (Surrounding temp)

$$\left(\frac{dQ}{dt}\right)_{absorption}$$

T_B

$$\left(\frac{dQ}{dt}\right)_{emission}$$

- If $\left(\frac{dQ}{dt}\right)_{absorption} = \left(\frac{dQ}{dt}\right)_{emission}$

$$\Rightarrow T_B = Constant$$

44 : ## Black body

$\Rightarrow$ $a = 1$

$\Rightarrow$ Good emitter is a good absorber.

&& ## KRICHHOFF'S LAW

↳ The ratio of emissive power to absorptive power for any body is constant & is equal to emissive power of black body

$$\frac{(E)_{body}}{(a)_{body}} = \frac{E_{black\,body}}{(a_{black\,body})} = \frac{E_{black\,body}}{1}$$

Conduction

✦✦ : STEFAN LAW

$$\left(\frac{dQ}{dt}\right)_{black\,body} \propto A T^4$$

Energy per second

$$\Downarrow \left(\frac{dQ}{dt}\right)_{black\,body} = \sigma A T^4$$

$\Big[$ A = Surface Area of black body

T = Temp of black body.

σ = Stefan constant

$5.67 \times 10^{-8} \left(\frac{W}{m^2 K^4}\right)$

$$\boxed{\left(\frac{dQ}{dt}\right)_{body} = e \sigma A T^4}$$

$e \rightarrow$ emissivity which is a Constant for any body.

$(0 < e < 1)$

By Krichhoff's law.

$$\frac{\left(\frac{dQ}{dt}\right)_{body}}{a} = \left(\frac{dQ}{dt}\right)_{black\,body}$$

$$\frac{e \sigma A T^4}{a} = \frac{\sigma A T^4}{(1)} = 1 \qquad \boxed{e = a}$$

⤷ Emissivity is equal to absorptive power

Conduction

$$\left(\frac{dQ}{dt}\right)_{net} = e\sigma A T_b^4 - a\sigma A T_s^4 - ①$$
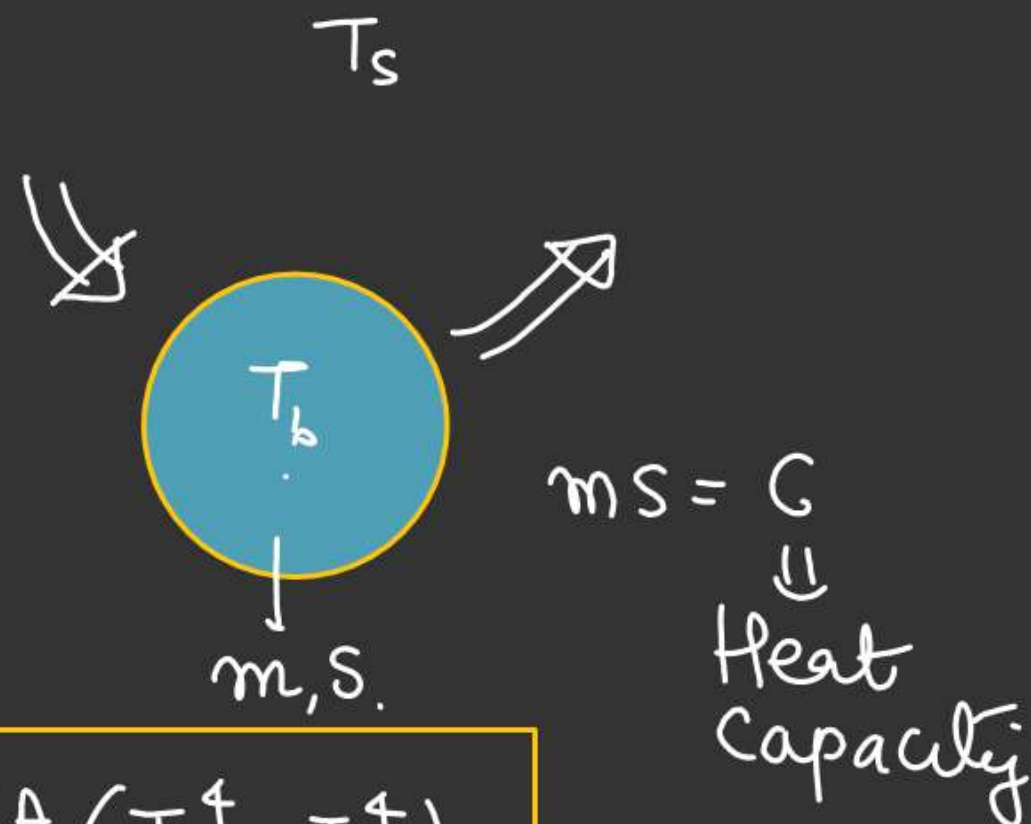
$$\Downarrow$$

$$\boxed{P = e\sigma A (T_b^4 - T_s^4)} \qquad (e = a)$$

P = net energy radiated per second.

$$Q = msT_b.$$

$$\frac{dQ}{dt} = ms\left(\frac{dT_b}{dt}\right) - ②$$

$$ms\left(\frac{dT_b}{dt}\right) = e\sigma A (T_b^4 - T_s^4)$$

T_s

T_b

$m, s.$

$ms = C$

$\underset{\text{Heat}}{\parallel}$ capacity

$$\boxed{\frac{dT_b}{dt} = \frac{e\sigma A}{ms}(T_b^4 - T_s^4)}$$

Conduction

$$\frac{dT_b}{dt} = \frac{e\sigma A}{ms}\left(T_b^4 - T_s^4\right)$$

↓

NEWTON'S LAW OF COOLING

If $T_b = (T_s + \Delta T)$

$\Delta T << T_s$

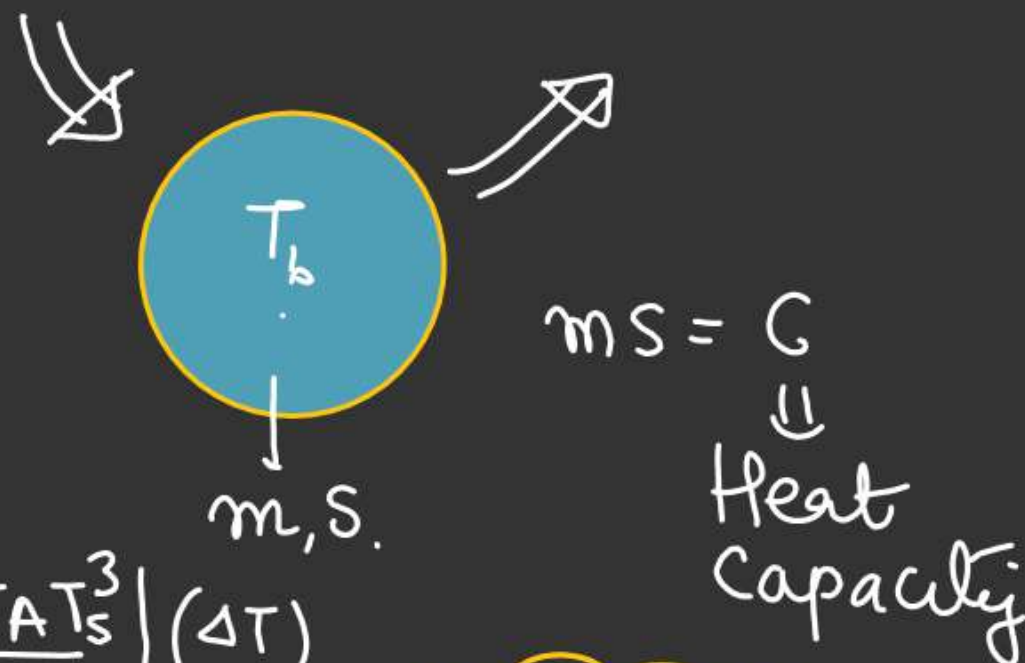$$\left(-\frac{dT_b}{dt}\right) = \frac{e\sigma A}{ms}\left[\left(T_s + \Delta T\right)^4 - T_s^4\right]$$

$$-\frac{dT_b}{dt} = \frac{e\sigma A}{ms}\left[T_s^4\left(1 + \frac{\Delta T}{T_s}\right)^4 - T_s^4\right]$$

$$-\frac{dT_b}{dt} = \left(\frac{e\sigma A T_s^4}{ms}\right)\left[1 + \frac{4\Delta T}{T_s} - 1\right]$$

$$-\frac{dT_b}{dt} = \left(\frac{4e\sigma A T_s^3}{ms}\right)(\Delta T)$$

$\underbrace{ms}_{\text{constant}}$

$$-\frac{dT_b}{dt} \propto (T_b - T_s)$$

$$\boxed{-\frac{dT_b}{dt} = K(T_b - T_s)}$$

T_s

T_b

$m, s.$

$ms = C$

⇕

Heat capacity

$$K = \frac{4e\sigma A T_s^3}{ms}$$