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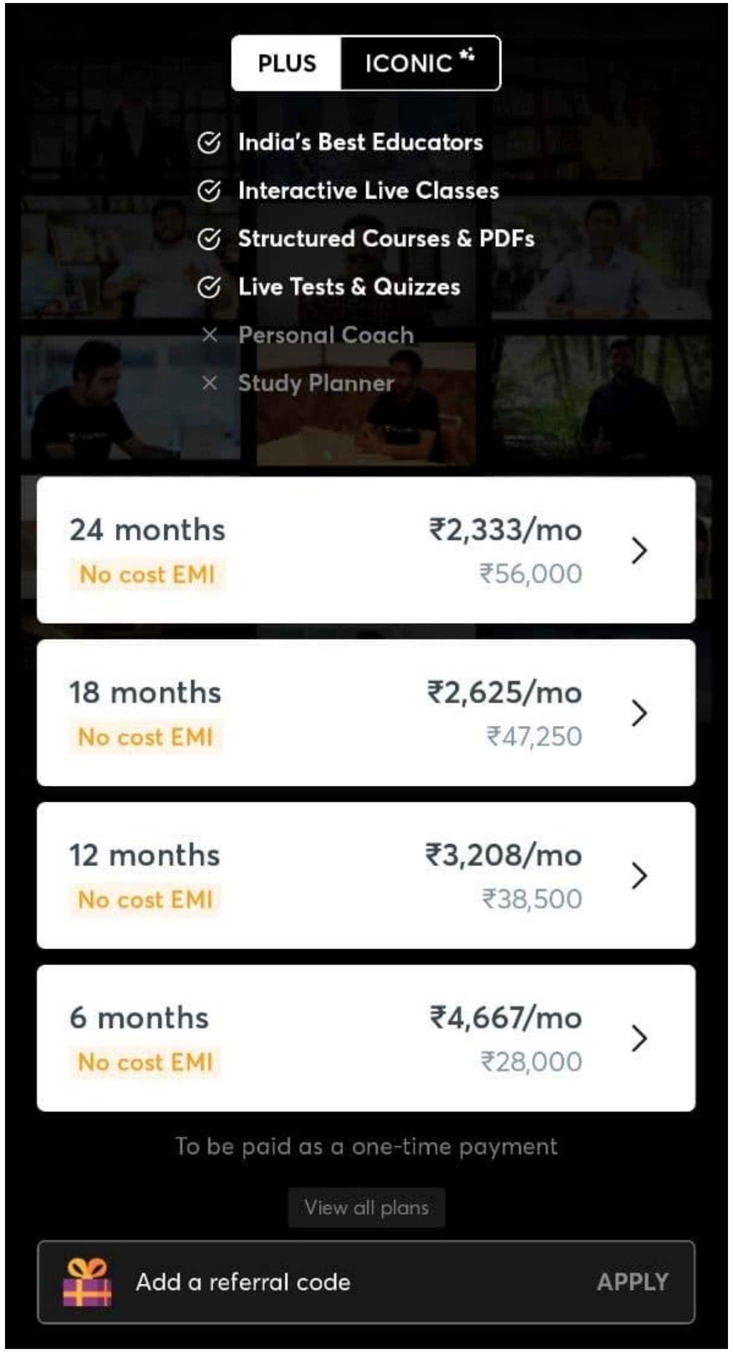

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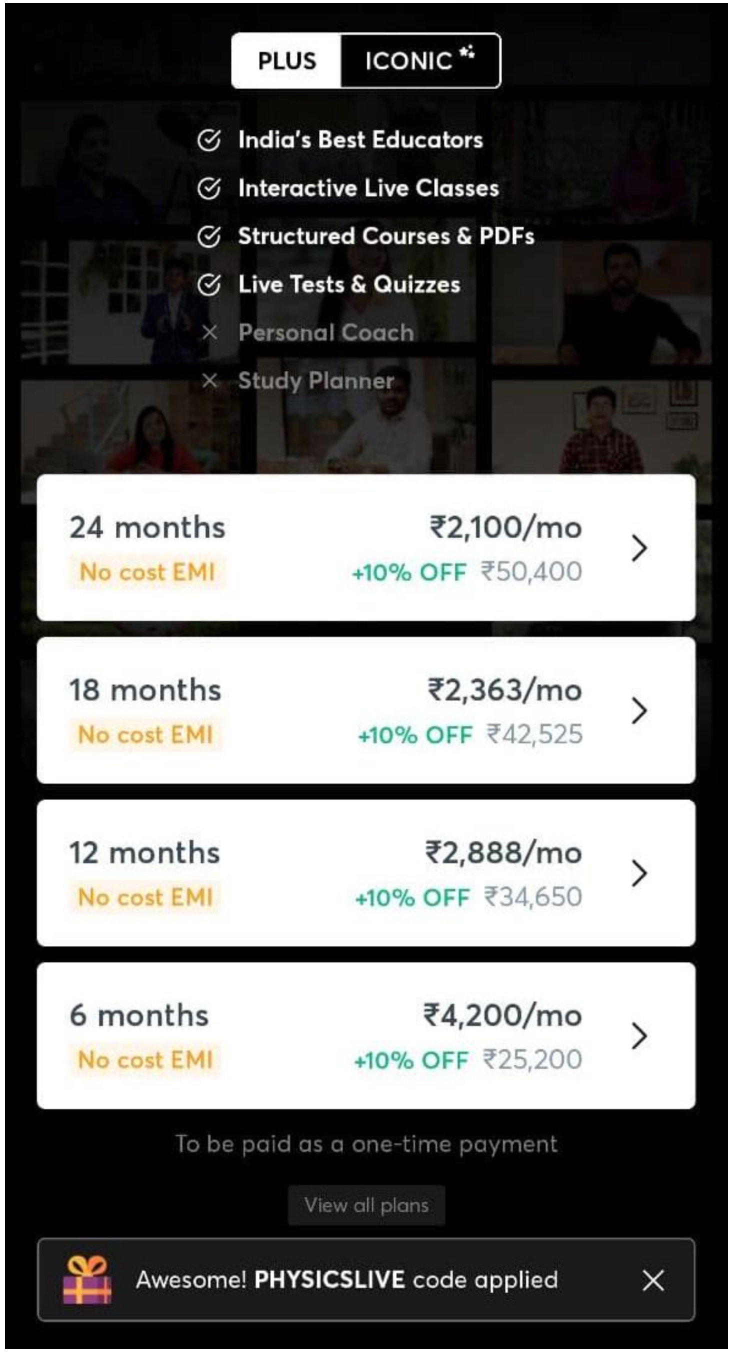

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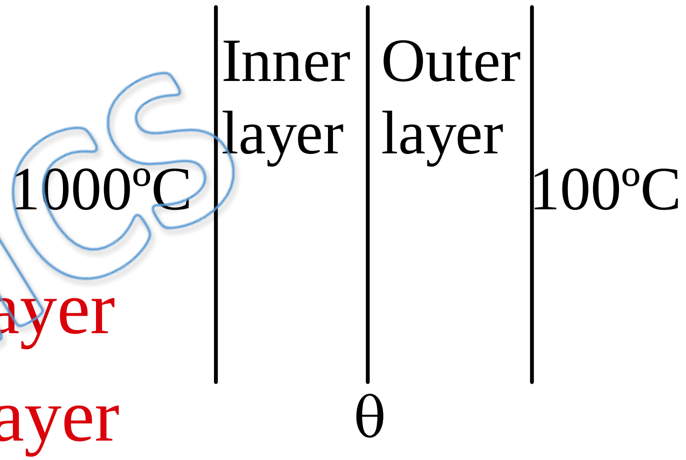
JEE Main & Advanced, NSEP, INPhO, IPhO Physics DPP

DPP- 1 Heat Transfer: conduction ,Heat current, Combination of rods

By Physicsaholics Team

Q) The temperature drop through a two layers furnace wall is 900ºC. Each layer is of equal area of cross-section. Which of the following actions will result in lowering the temperature θ of the interface?



(a) by increasing the thermal conductivity of outer layer

(b) by increasing the thermal conductivity of inner layer

(c) by increasing thickness of outer layer

(d) by increasing thickness of inner layer

Ans. a,d

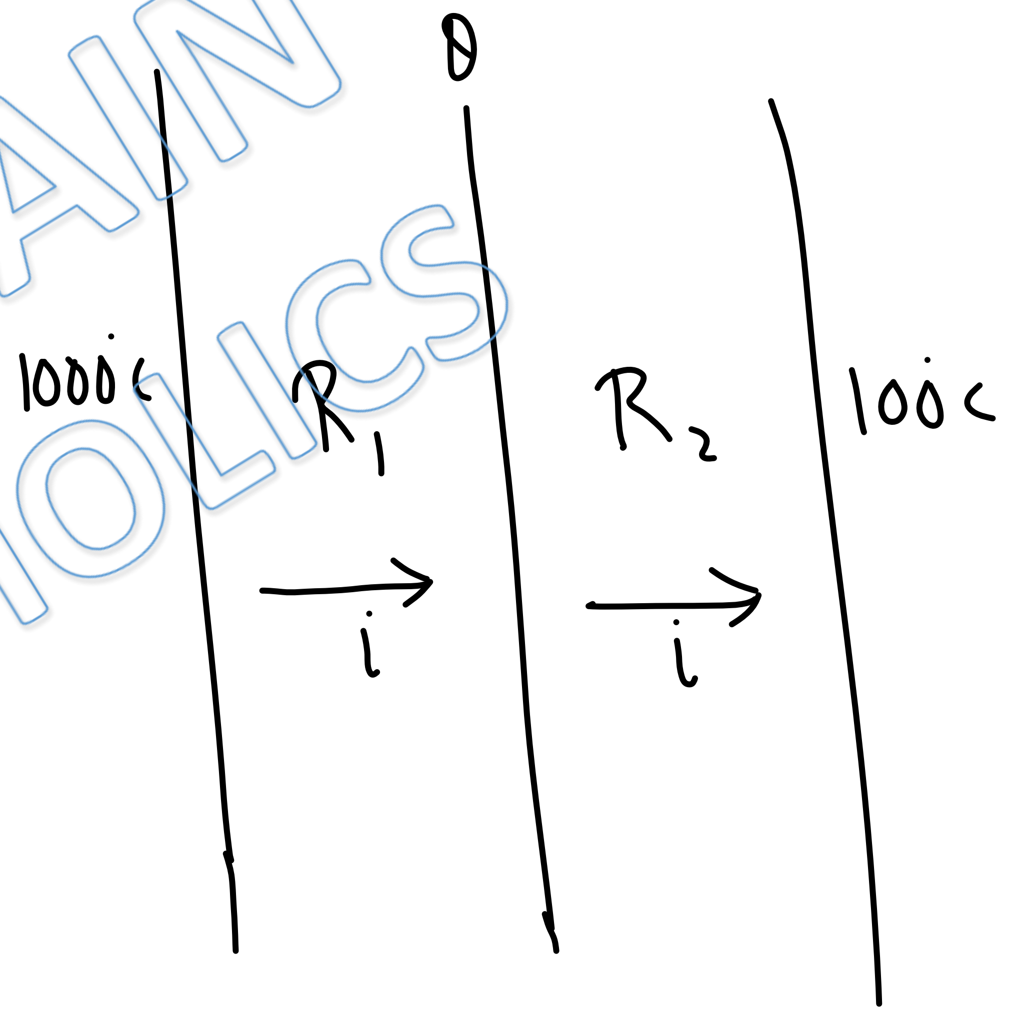
$$i = \frac{1000-\theta}{R_1} = \frac{\theta-100}{R_2}$$

$$\Rightarrow \quad 1000R_2 - R_2\theta = R_1\theta - 100R_1$$

$$\Rightarrow \quad \theta = \frac{1000R_2 + 100R_1}{R_1+R_2}$$

$$= 100 + \frac{900R_2}{R_1+R_2}$$

$$= 100 + \frac{900}{1+R_1/R_2}$$

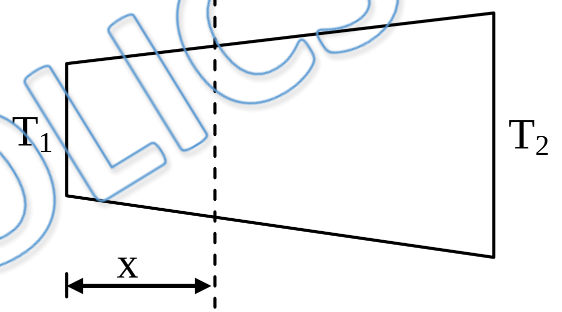


to decrease θ we need to increase R_1/R_2.

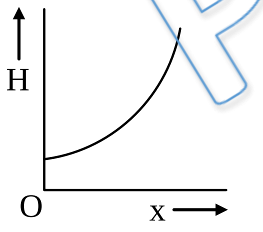
decrease $\theta \Rightarrow$ increase $\frac{R_1}{R_2} \Rightarrow$ increase $\frac{l_1 K_2}{K_1 l_2}$

Ans (a, d)

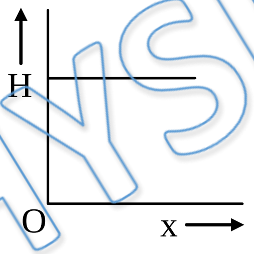
Q) Radius of a conductor increases uniformly from left end to right end as shown in figure. Material of the conductor is isotropic and its curved surface is thermally isolated from surrounding. Its ends are maintained at temperatures T_1 and T_2 $(T_1 > T_2)$. If, in steady state, heat flow rate is equal to H, then which of the following graphs is correct–



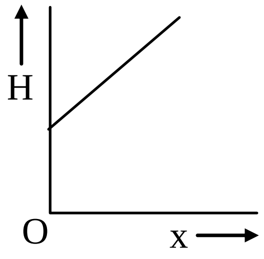
(a)



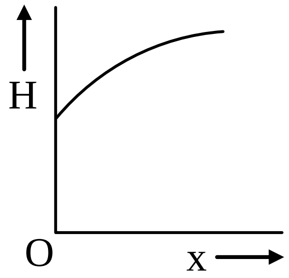
(b)



(c)



(d)



Ans. b

Thermal Current (Rate of heat flow) does not depend on cross sectional area.

It is same at all Cross sections.

Q) Two rods of length l and 2l, thermal conductivities 2K and K are connected end to end. If cross-sectional areas of to rods are equal, then equivalent thermal conductivity of the system is

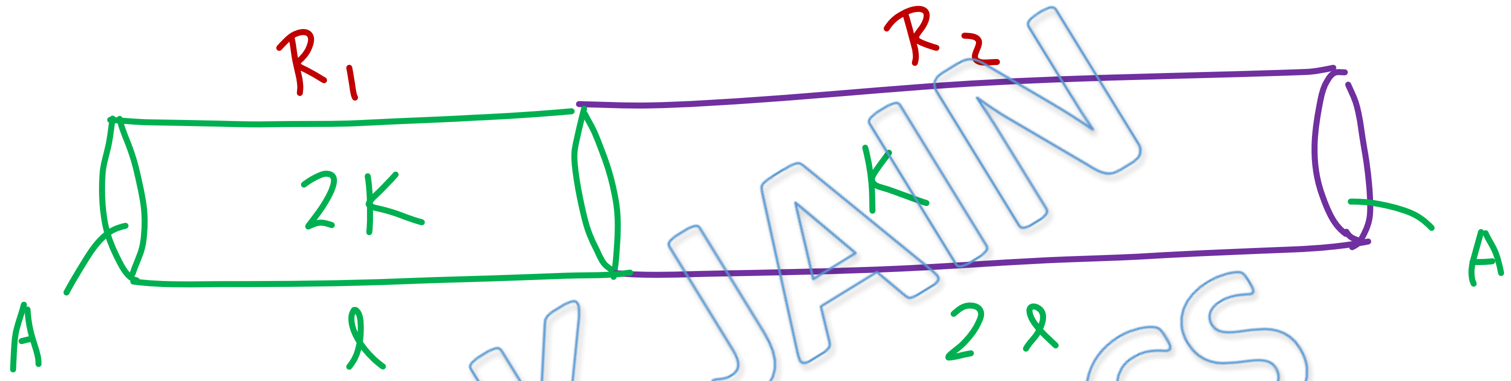
(a) (5/6/)K

(b) 1.5K

(c) 1.2 K

(d) (8/9)K

Ans. c



$\equiv$

$$R = R_1 + R_2 \Rightarrow \frac{3\ell}{K'A} = \frac{\ell}{2KA} + \frac{2\ell}{KA} = \frac{5\ell}{2KA}$$

$$\Rightarrow \frac{3}{K'} = \frac{5}{2K} \Rightarrow K' = \frac{6K}{5}$$

Ans (c)

Q) In conduction of steady state

(a)Temperature does not change with time
(b)All parts of body are at same temperature
(c)There is no flow of heat
(d)There is no net absorption of heat at particular cross section

Ans. a,d

In steady state temperature of any point of Conductor does not change with time.

Since $\Delta Q = ms\Delta T$

$\Rightarrow$ no net heat absorption by any part of Conductor.

Ans (a, d)

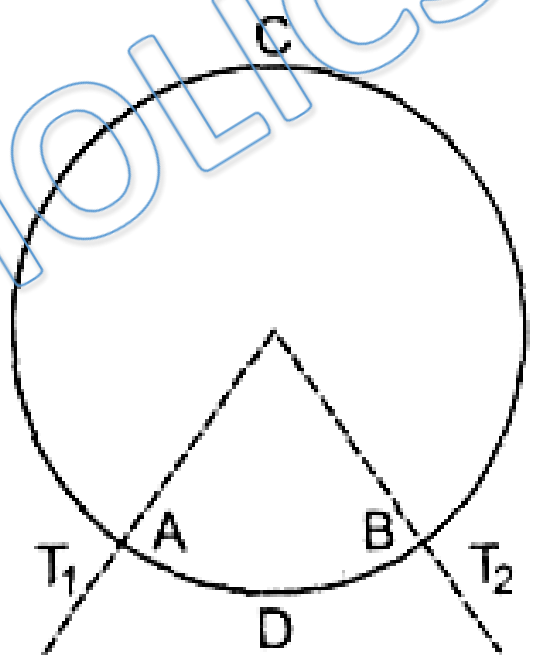
Q) A ring consisting of two parts ADB and ACB of same conductivity K carries an amount of heat H. The ADB part is now replaced with another metal keeping the temperatures T_1 and T_2 constant. The heat carried increases to 2H. What should be the conductivity of the new ADB part? Given $\frac{ACB}{ADB} = 3$

(a) $\frac{7}{3}$K

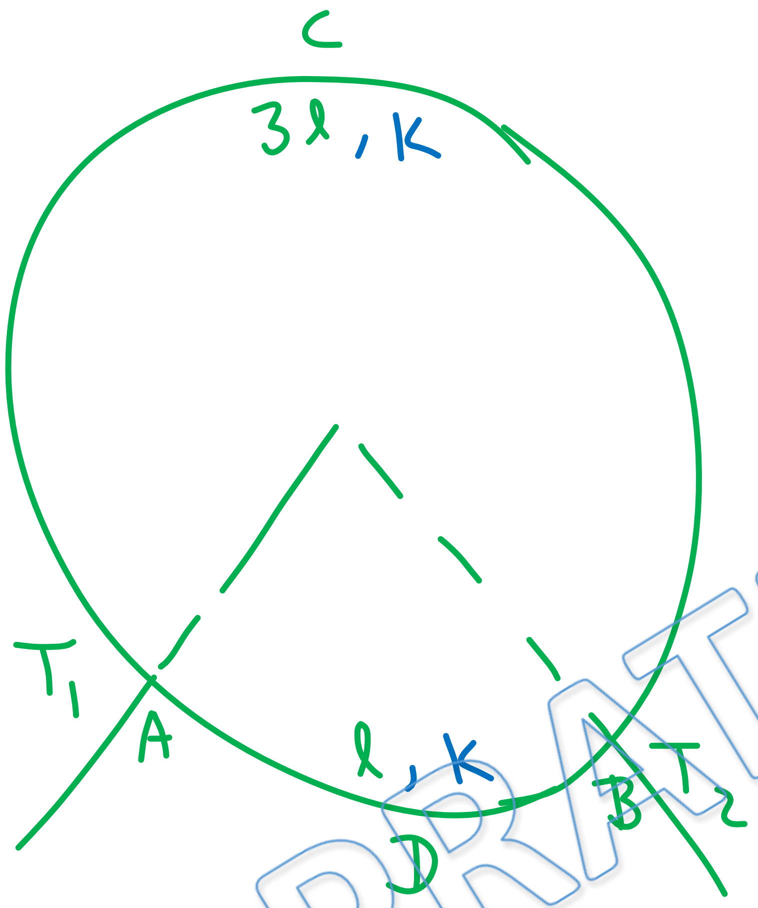
(b) 2K

(c) $\frac{5}{2}$K

(d) 3K



Ans. a



length of ACB = 3 × length of ADB

$\Rightarrow R_{ACB} = 3R_{ADB}$

Thermal resistance

$\Rightarrow H_{ACB} = \frac{1}{3} H_{ADB}$

Rate of Heat transfer

$\Rightarrow H_{ADB} = \frac{3H}{4}$, $H_{ACB} = \frac{H}{4}$

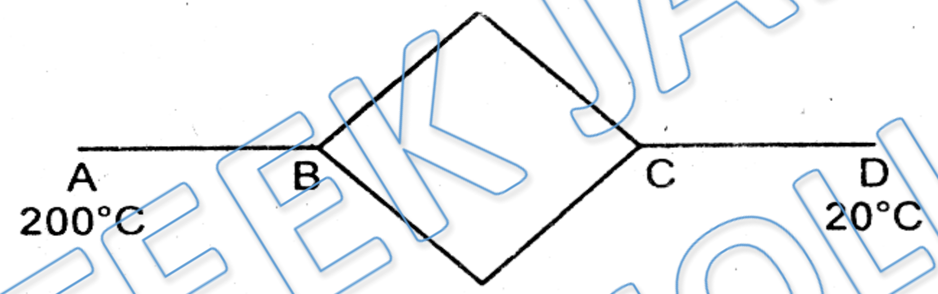
After replacing ADB →

net rate of Heat transfer = 2H , $H_{ACB} = H/4 \Rightarrow$ new $H_{ADB} = 2H - H/4 = \frac{7H}{4}$

$$\frac{\text{new } H_{ADB}}{\text{old } H_{ADB}} = \frac{K_{new}}{K} = \frac{7H/4}{3H/4} = 7/3$$

$$\Rightarrow K_{new} = \frac{7K}{3}$$

Q) Six identical conducting rods are joined as shown in figure. Points A and D are maintained at temperatures 200°C and 20°C respectively. The temperature of junction B will be

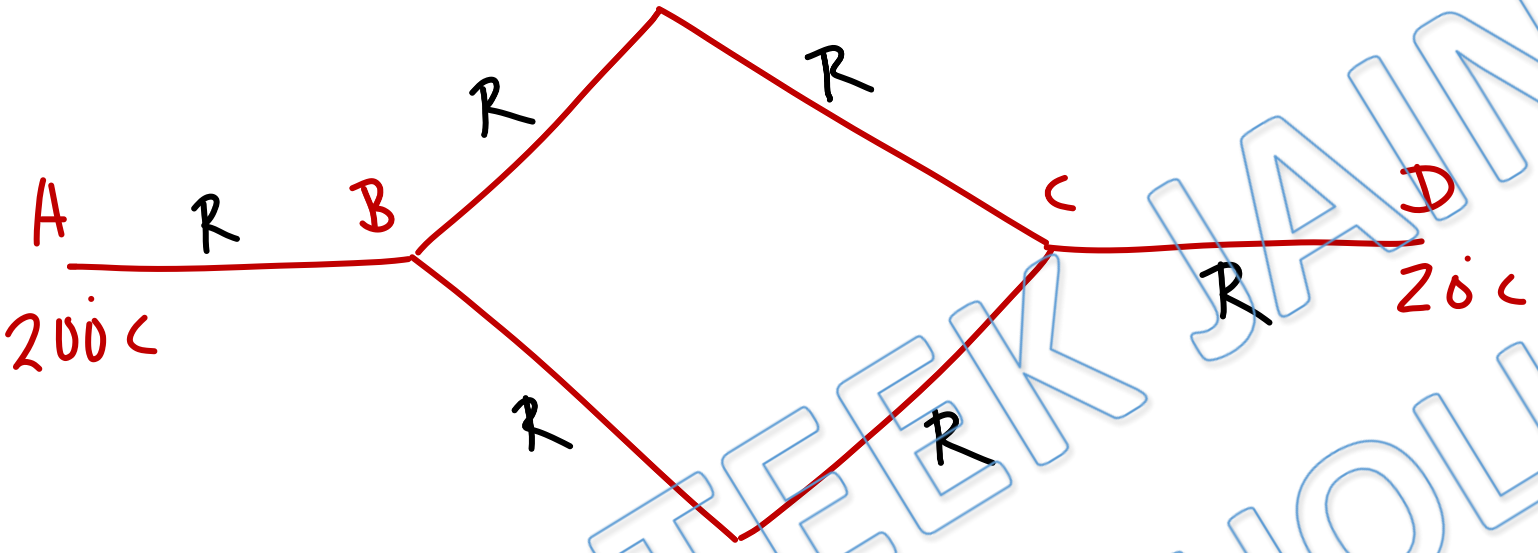


(a) 120°C (b) 100° (c) 140°C (d) 80°C.

Ans. c

$i \rightarrow$ Thermal Current

$R \rightarrow$ Thermal resistance of one rod



net thermal resistance b/w A & D = 3R

$\Rightarrow$ Thermal Current in AB $= i = \dfrac{200-20}{3R} = \dfrac{60}{R} = \dfrac{200-T_B}{R}$

$\Rightarrow T_B = 200 - 60 = 140^\circ C$

Ans(c)

Q) One end of a conducting rod is maintained at temperature 50°C and at the other end ice is melting at 0°C. The rate of melting of ice is doubled if :

(a) the temperature is made 200°C and the area of cross-section of the rod is doubled
(b) the temperature is made 100°C and the length of the rod is made four times
(c) area of cross section of rod is halved and length is doubled
(d) the temperature is made 100°C and area of cross-section of rod and length both are doubled.

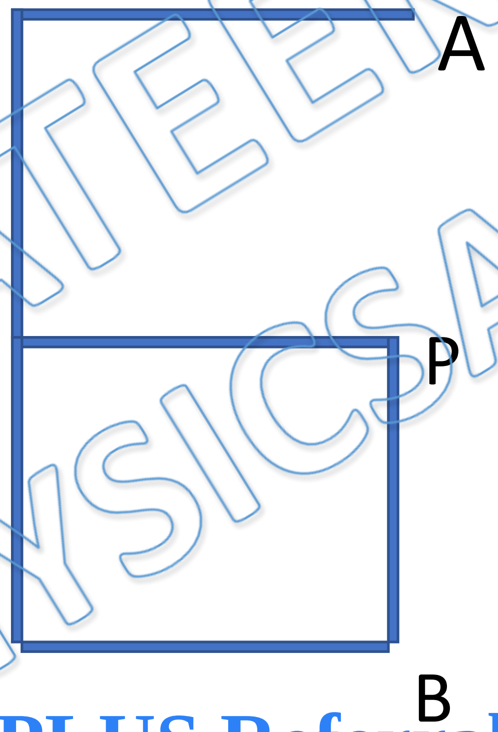
Ans. d

To double the rate of melting ice, It is required to double Rate of Heat flow.

Since $\dfrac{dQ}{dt} = \dfrac{KA(T - 0^\circ)}{l}$

(d) is correct option.

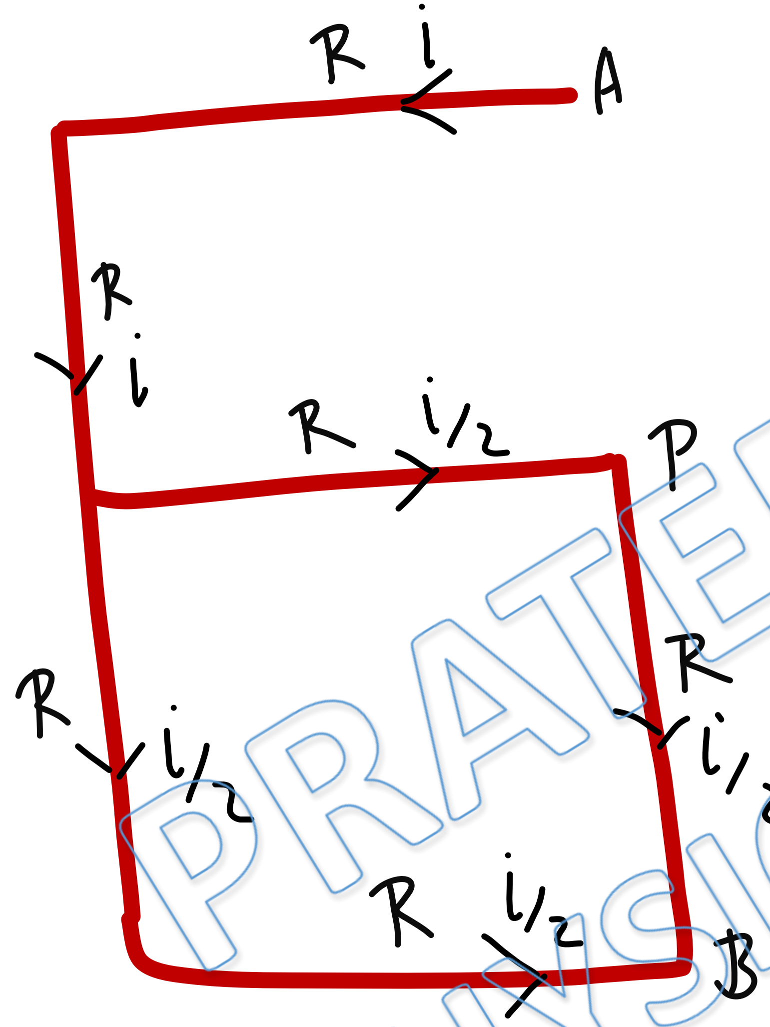
Q) Six identical rods are connected as shown in figure. Temperature of A is mentained at 400 K that of B is mentained at 100 K . Find temperature of point P ? Heat transfer with surrounding is possible from point A and B only. All other surfaces are insulated.



Ans. 150 K

$i \rightarrow$ Thermal Current

$R \rightarrow$ resistance of one rod.



$\equiv$

$R_{AB} = 3R$

$$i = \frac{\Delta T_{AB}}{3R} = \frac{300}{3R} = \frac{100}{R}, \quad \frac{i}{2} = \frac{\Delta T_{PB}}{R} \Rightarrow \frac{T_P - 100}{R} = \frac{100}{2R} \Rightarrow T_P = 150\,K$$

Q) One end of a copper rod of length 1.0 m and area of cross-sector 10^{-3} m² is immersed in boiling water and the other end in ice. If the coefficient of thermal conductivity of copper is 92 cal/ms °C and the latent heat of ice is 8×10^{4} cal/kg, then the amount of ice which will melt in one minute is -

(a) 9.2×10^{-3} kg

(b) 8×10^{-3} kg

(c) 6.9×10^{-3} kg

(d) 5.4×10^{-3} kg

Ans. c

$$\frac{\Delta Q}{\Delta t} = \frac{KA\,\Delta T}{l} \Rightarrow \frac{mL}{\Delta t} = \frac{KA\Delta T}{l}$$

$$\Rightarrow \frac{m \times 8 \times 10^4}{60} = \frac{92 \times 10^{-3}(100-0)}{1}$$

$$\Rightarrow m = \frac{\overset{23}{\cancel{92}} \times 6}{\underset{2}{\cancel{8}} \times 10^4}\,kg = 6.9 \times 10^{-3}\,kg$$

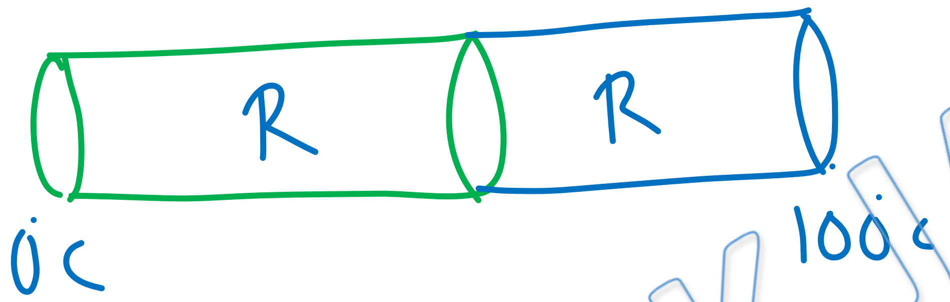
Ans(c)

Q) Two identical rods of metal are welded end to end as shown in figure (i), 20 calories of heat flows through it in 4 minutes. If the rods are welded as shown in figure (ii), the same amount of heat will flow through the rods in –

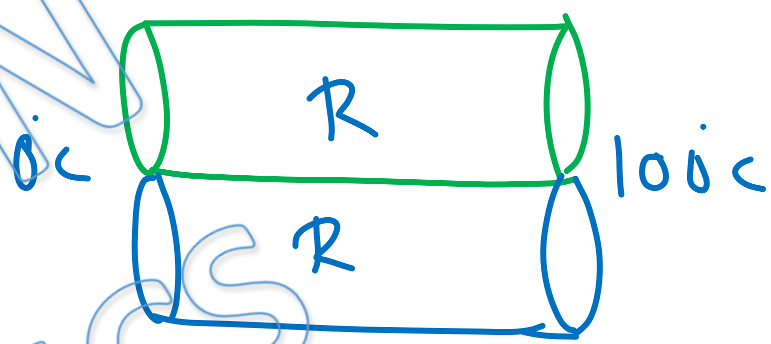
(A) 1 minute (B) 2 minutes

(C) 4 minutes (D) 16 minutes

Ans. a



Case 1



Case 2

In Case 1 $\rightarrow R_{eff} = 2R$

$$\frac{\Delta Q}{\Delta t} = \frac{\Delta Q}{4\,min} = \frac{100}{2R}$$

$$\Rightarrow \frac{\Delta Q \cdot R}{200} = 1\,min$$

In Case 2 $\rightarrow R_{eff} = R/2$

$$\frac{\Delta Q}{\Delta t} = \frac{100}{R/2} = \frac{200}{R}$$

$$\Rightarrow \Delta t = \frac{\Delta Q\,R}{200} = 1\,min$$

Ans (a)

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Chalo Niklo