DPP – 2

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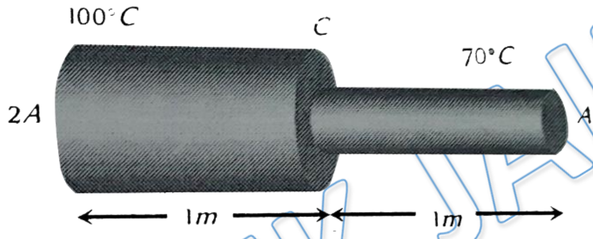
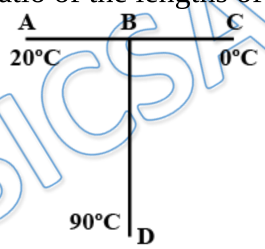
Q 1. A metal rod of length 2m has cross sectional areas 2A and A as shown in figure. The ends are maintained at temperatures 100°C and 70°C. The temperature at middle point C is



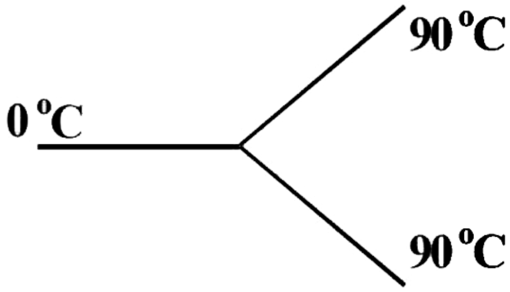
(a) 80 °C (b) 85 °C
(c) 90 °C (d) 95 °C

Q 2. Three conducting rods of same material and cross-section are connected as shown in figure. Temperatures of A, D and C are maintained at 20°C, 90°C and 0°C. If there is no flow of heat in AB, then ratio of the lengths of BC and BD is



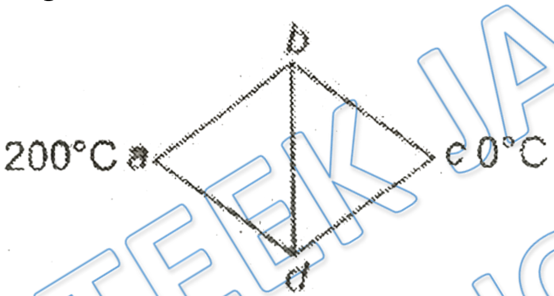
(a) 2/9 (b) 9/2
(c) 2/7 (d) 7/2

Q 3. Three rods made of the same material and having the same cross-section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0 °C, 90 °C and 90°C respectively. The temperature of junction of the three rods will be



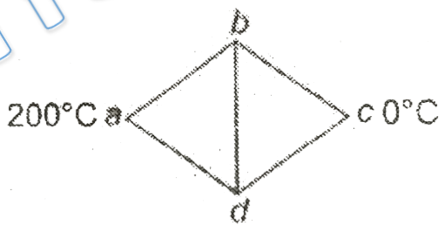
(a) 45 °C (b) 60 °C
(c) 30 °C (d) 20 °C

Q 4. Five rods of same material and same cross-section are joined as shown. Lengths of rods ab, ad and bc are l, $2l$ and $3l$ respectively. Ends a and c are maintained at temperatures 200°C and 0°C respectively. For what length x of rod dc there will be no heat flow through rod bd?



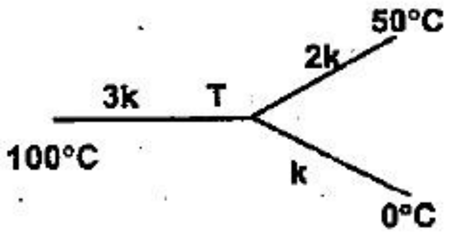
(a) $4l$ (b) $2l$
(c) $6l$ (d) $9l$

Q 5. Five rods of same material and same cross-section are joined as shown. Lengths of rods ab, ad, bc and dc are l, 2l, 3l and 6l respectively. Ends a and c are maintained at temperatures 200°C and 0°C respectively. Temperature of point b will be:



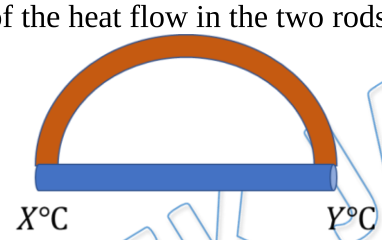
(a) 120 °C (b) 160 °C
(c) 150 °C (d) 90 °C

Q 6. Find the temperature T of the junction shown in the figure for three rods; identical in dimensions:



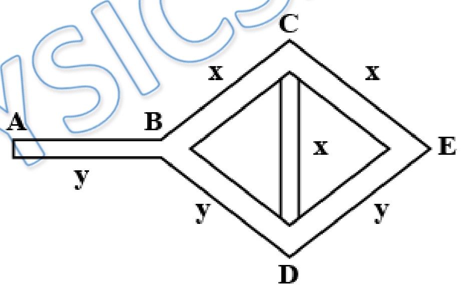
(a) $\frac{100}{3}$ °C
(b) $\frac{200}{3}$ °C
(c) 100 °C
(d) $\frac{50}{3}$ °C

Q 7. Two rods of same material and thickness are joined as shown below(one is semicircular and other is straight). The ends X and Y are maintained at X°C and Y°C respectively. The ratio of the heat flow in the two rods is –



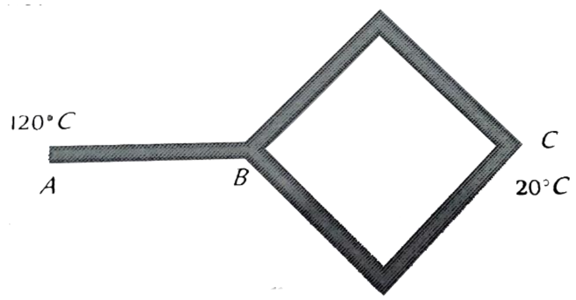
(a) 0.36
(b) 0.64
(c) 0.18
(d) 0.06

Q 8. Three rods of material x and three rods of material y are connected as shown in the figure. All rods are of identical length and cross-section. If the end A is maintained at 60°C and the junction E at 10°C, find the effective Thermal Resistance. Given the length of each rod = l, area of cross-section = A, conductivity of x = K and conductivity of y = 2K.



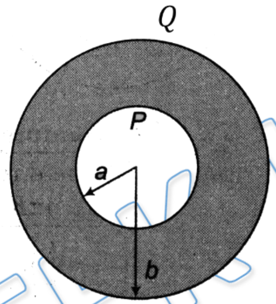
(a) $\frac{2l}{3KA}$
(b) $\frac{7l}{6KA}$
(c) $\frac{4KA}{3l}$
(d) $\frac{7KA}{3l}$

Q 9. Five identical rods are joined as shown in figure. Point A and C are maintained at temperature 120 °C and 20 °C respectively. The temperature of junction B will be



(a) 100°C (b) 80 °C
(c) 70 °C (d) 0 °C

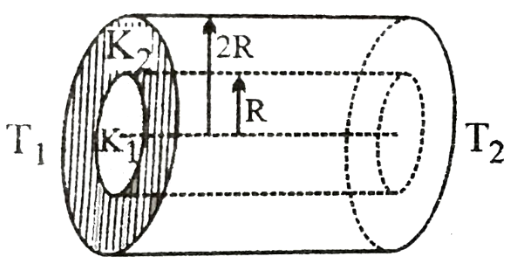
Q 10. A spherical body of radius 'b' has a concentric cavity of radius 'a' as shown. Thermal conductivity of the material is K. Find thermal resistance between inner surface P and outer surface Q.



(a) $\frac{1}{4\pi K}\left(\frac{1}{a}-\frac{1}{b}\right)$ (b) $\frac{1}{4\pi K}\left(\frac{1}{a}+\frac{1}{b}\right)$

(c) $\frac{1}{4\pi K}\left(\frac{ab}{\ln\frac{b}{a}}\right)$ (d) $\frac{1}{4\pi K}\left(\frac{\ln\frac{b}{a}}{ab}\right)$

Q 11. A composite cylinder is made of two materials having thermal conductivities K_1 and K_2 as shown. Temperature of the two flat faces of cylinder are maintained at T_1 and T_2. For what ratio $\frac{K_1}{K_2}$ the heat current throught the two materials will be same. Assume steady state and the rod is lagged (insulated from the curved surface).



(a) 1 (b) 2
(c) 3 (d) 4

Q 12. The thickness of ice in a lake is 5cm and the atmospheric temperature is -10°C. Calculate the time required for the thickness of ice to grow to 7cm. Thermal conductivity for ice = $4 \times 10^{-3}\ cal\ cm^{-1}\ s^{-1}\ °C^{-1}$, density of ice = 0.92 g/cc and latent heat of fusion of ice = 80 cal/gm.

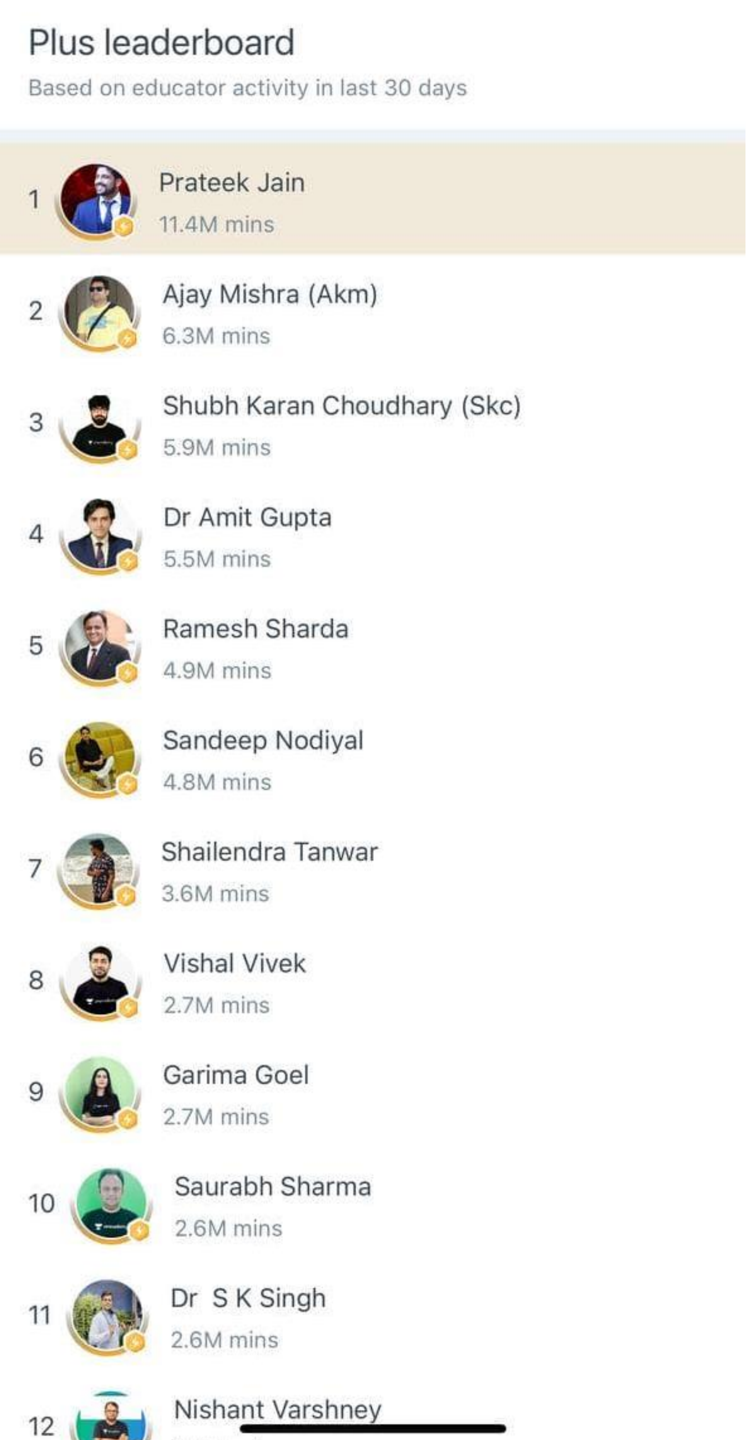
(a) 6.6 Hr (b) 3.5 Hr
(c) 1.02 Hr (d) 9.12 Hr

Q 13. Ice starts forming in lake with water at 0°C and when the atmospheric temperature is -10°C. If the time taken for 1cm of ice be 7 hours. Find the time taken for the thickness of ice to change from 1cm to 2cm

(a) 11 hours (b) 6 hours
(c) 16 hours (d) 21 hours

Answer Key

Q.1 c	**Q.2 c**	**Q.3 b**	**Q.4 c**	**Q.5 c**
Q.6 b	**Q.7 b**	**Q.8 b**	**Q.9 c**	**Q.10 a**
Q.11 c	**Q.12 a**	**Q.13 d**		



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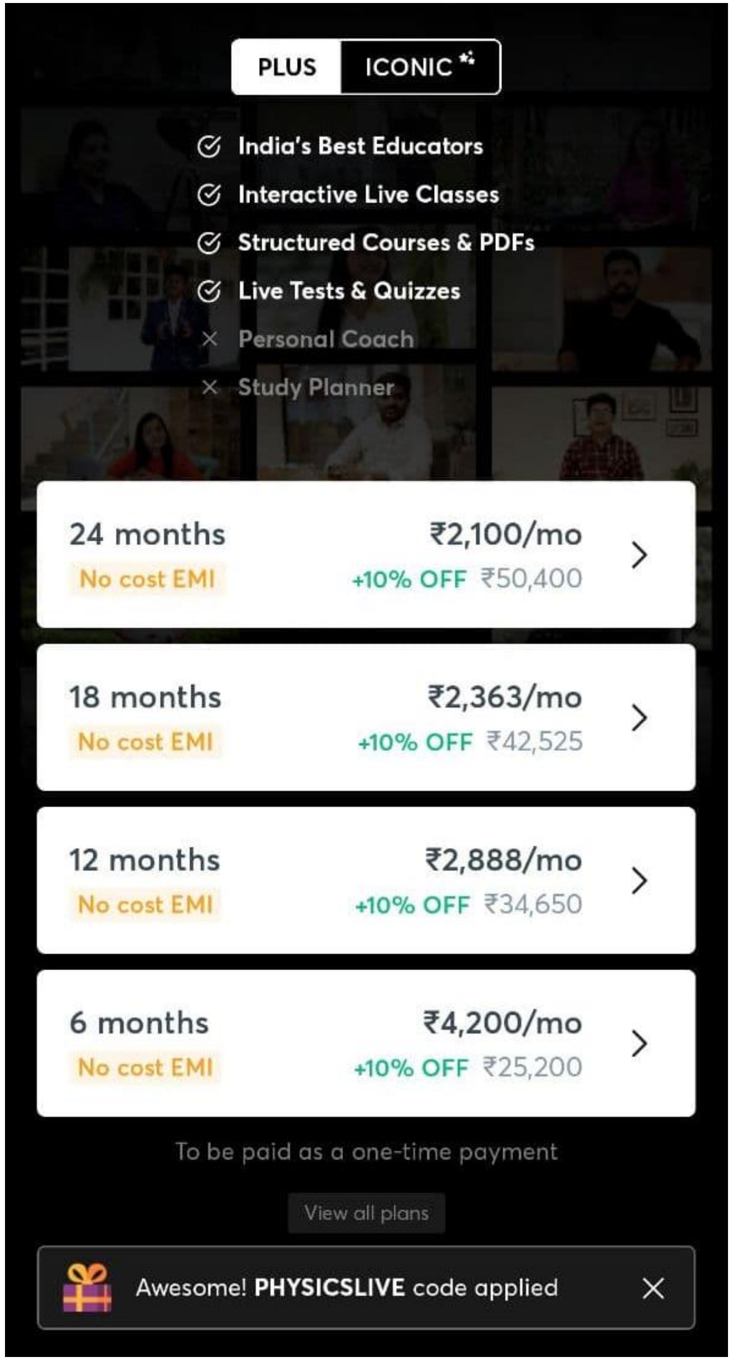
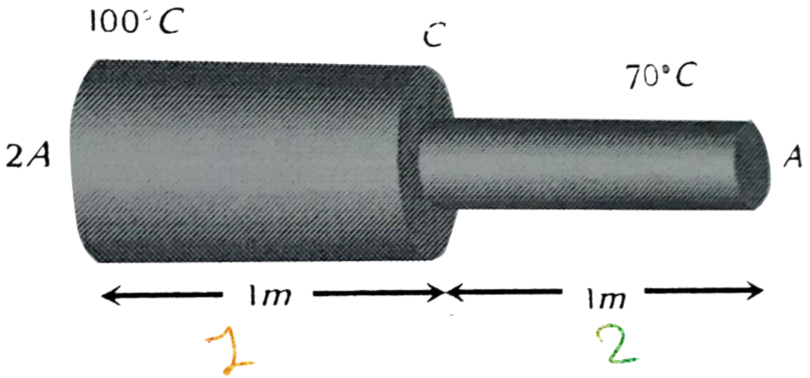


Written Solution

DPP-2 Heat Transfer: Kirchhoff's law, wheat stone bridge, Radial flow of heat, cylindrical flow, Formation of ice in lake

By Physicsaholics Team

Solution: 1



$$I_1 = I_2$$

$$\frac{K(2A)(100 - T_c)}{1} = \frac{K(A)(T_c - 70)}{1}$$

$$200 - 2T_c = T_c - 70$$

$$3T_c = 270$$

$$\boxed{T_c = 90°C}$$ Ans.

Ans. c

Solution: 2

L_{BC}

$20°C$

L_{DB}

if there is no flow of heat in AB; then $T_A = T_B = 20°C$

$\therefore \quad I_{DB} = I_{BC}$

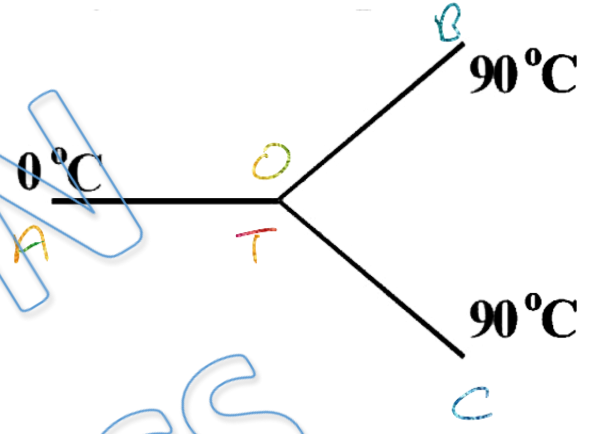
$$\frac{KA(90-20)}{L_{DB}} = \frac{KA(20-0)}{L_{BC}}$$

$$\frac{70}{L_{DB}} = \frac{2}{L_{BC}}$$

$$\boxed{\frac{L_{BC}}{L_{DB}} = \frac{2}{7}}$$ Ans.

Ans. c

Solution: 3



$I_{AO} + I_{OB} + I_{OC} = 0$

$\frac{KA(T-0)}{L} + \frac{KA(T-90)}{L} + \frac{KA(T-90)}{L} = 0$

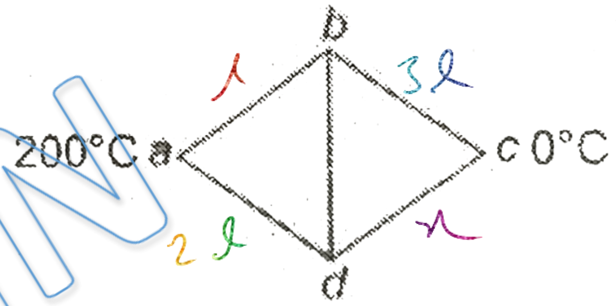
$T + T - 90 + T - 90 = 0$

$3T = 180$

$T = 60°C$ Ans.

Ans. b

Solution: 4



for no heat flow through 'bd'

$$\Rightarrow R_{ab} \cdot R_{dc} = R_{ad} \cdot R_{bc}$$

$$\left(\frac{l}{KA}\right) \cdot \left(\frac{x}{KA}\right) = \left(\frac{2l}{KA}\right) \cdot \left(\frac{3l}{KA}\right)$$

$$x \cdot l = 6l^2$$

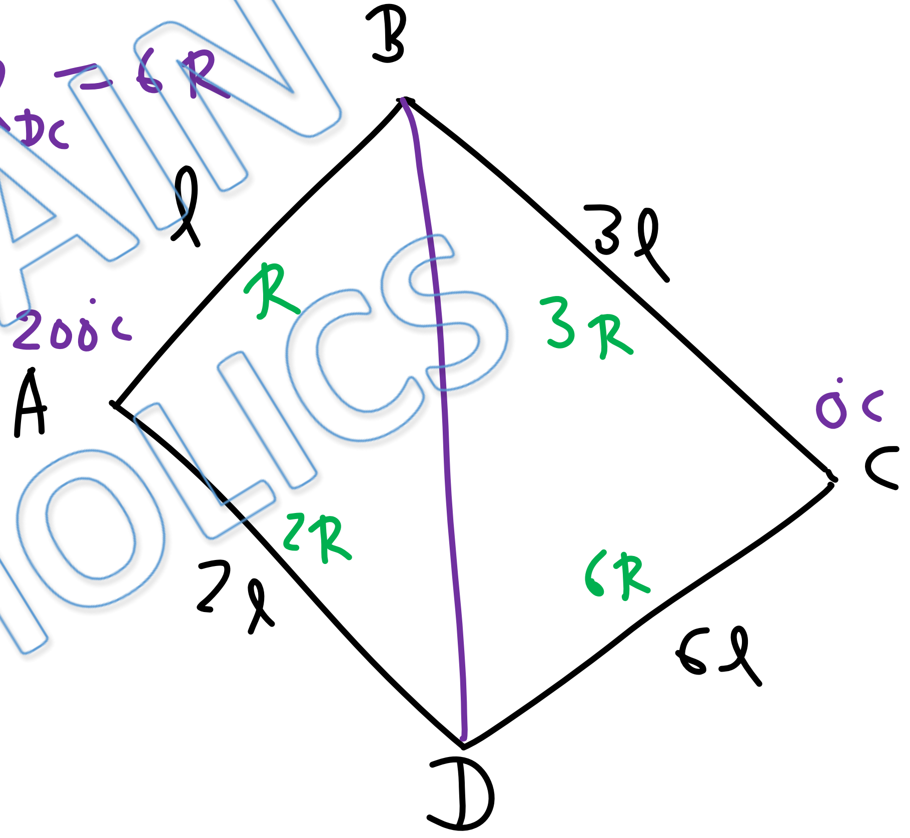
$$\boxed{x = 6l} \text{ Ans.}$$

Ans. c

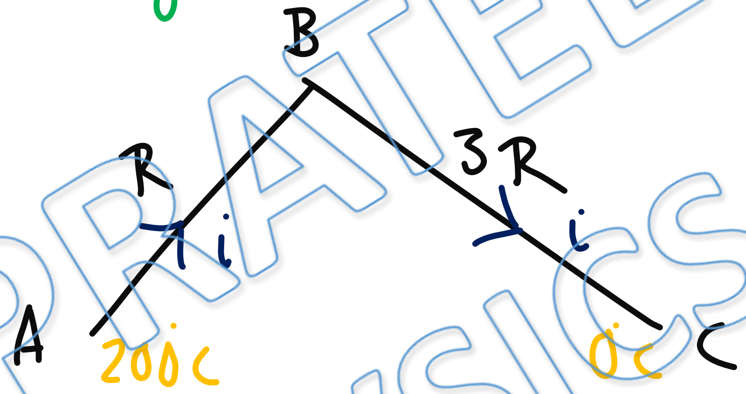
Solution: 5

Resistance of rod $\propto l$

If $R_{AB} = R \Rightarrow R_{BC} = 3R, R_{AD} = 2R, R_{DC} = 6R$



This Combination is ballanced Wheatstone bridge. ⇒ no thermal current in BD.



$$i = \frac{200 - T_B}{R} = \frac{200 - 0}{4R} \Rightarrow 200 - T_B = 50 \Rightarrow T_B = 150^\circ C$$

Ans (c)

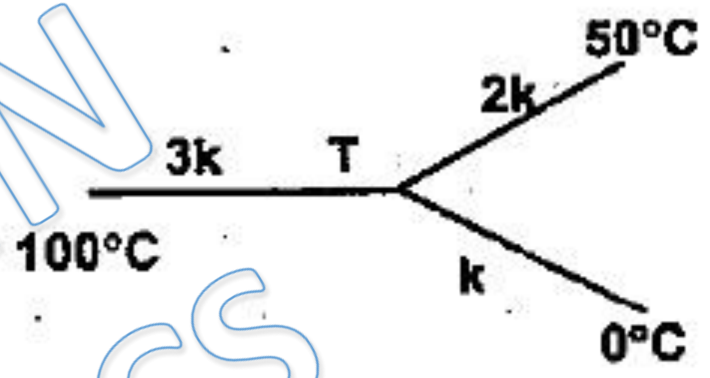
Solution: 6

$$3k(T-100) + 2k(T-50) + k(T-0)$$

$$3T - 300 + 2T - 100 + T = 0$$

$$6T = 400$$

$$T = \frac{200}{3}\ ^\circ C$$



Ans. b

Solution: 7

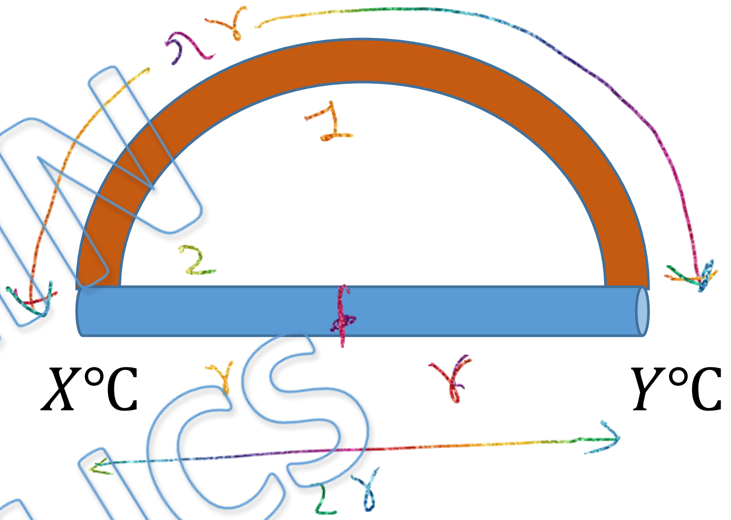
$$I_2 = \frac{KA\Delta\theta}{2r}$$

$$I_1 = \frac{KA(\Delta\theta)}{\pi r}$$

$$\frac{I_1}{I_2} = \frac{KA\Delta\theta/\pi r}{KA\Delta\theta/2r}$$

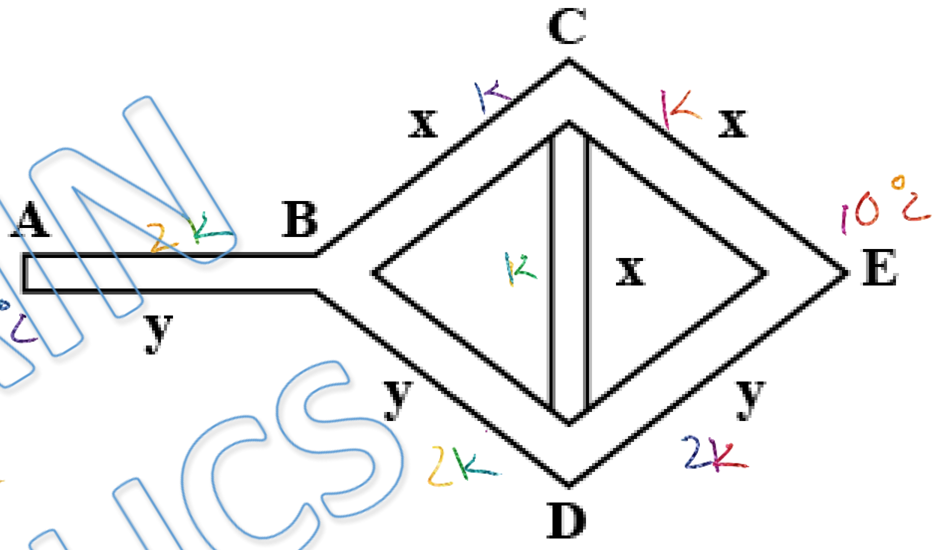
$$\frac{I_1}{I_2} = \frac{2}{\pi}$$

$$\boxed{\frac{I_1}{I_2} = 0.64}$$ Ans.



Ans. b

Solution: 8



$R = \frac{l}{KA}$

So; $R_{AB} = \frac{l}{2KA}$; $R_{BC} = \frac{l}{KA}$

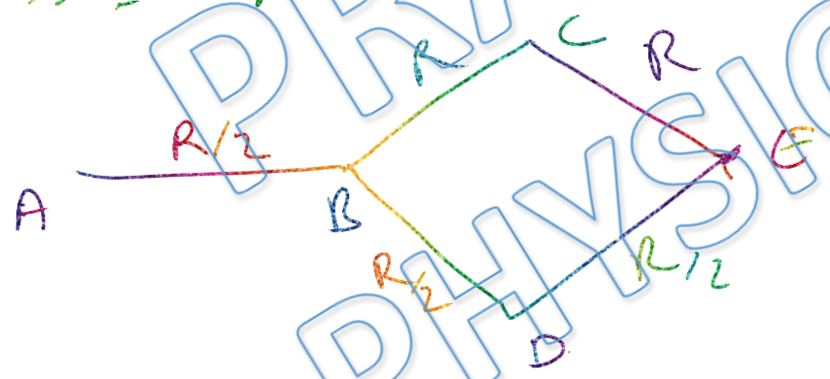
$R_{CE} = \frac{l}{KA}$; $R_{BD} = \frac{l}{2KA}$ & $R_{DE} = \frac{l}{2KA}$

Here; $\Rightarrow R_{BC} \cdot R_{DE} = R_{BD} \cdot R_{CE}$

So; BCEDB is a wheat stone bridge

$\Rightarrow \therefore$ No heat will flow through CD

$\Rightarrow$



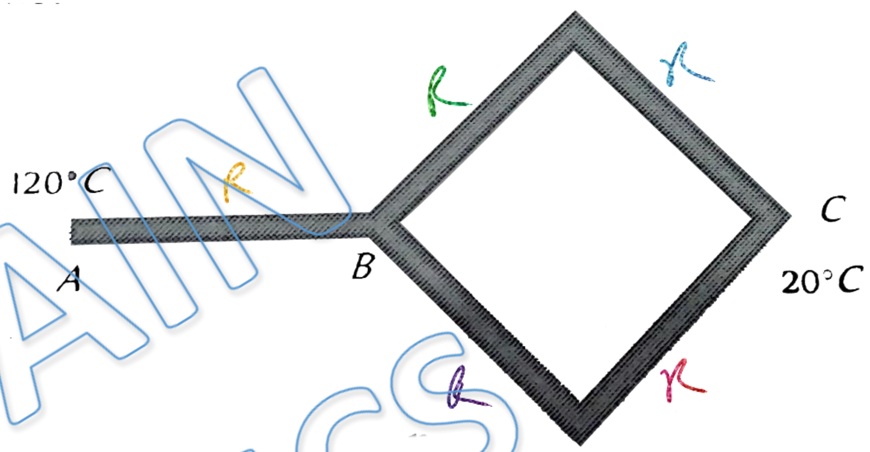
$\Rightarrow$

$$R_{eff} = \frac{7R}{6} = \frac{7l}{6KA} \text{ Ans.}$$

if $R_{BC} = R$, then; $R_{BC} = R_{CE} = R$ & $R_{AB} = R_{DB} = R_{DE} = R/2$

Ans. b

Solution: 9



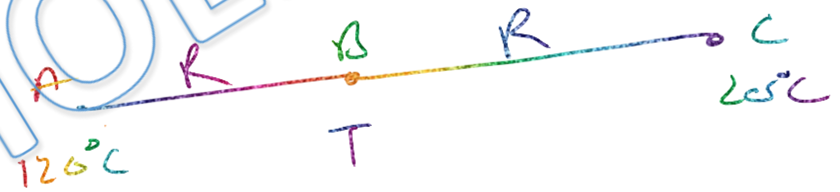
$\Rightarrow I_{AB} = I_{BC}$

$$\frac{120 - T}{R} = \frac{T - 20}{R}$$

$$120 - T = T - 20$$

$$2T = 140$$

$$T = 70°C$$ Ans.



Ans. c

Solution: 10

as; $R = \frac{l}{KA}$

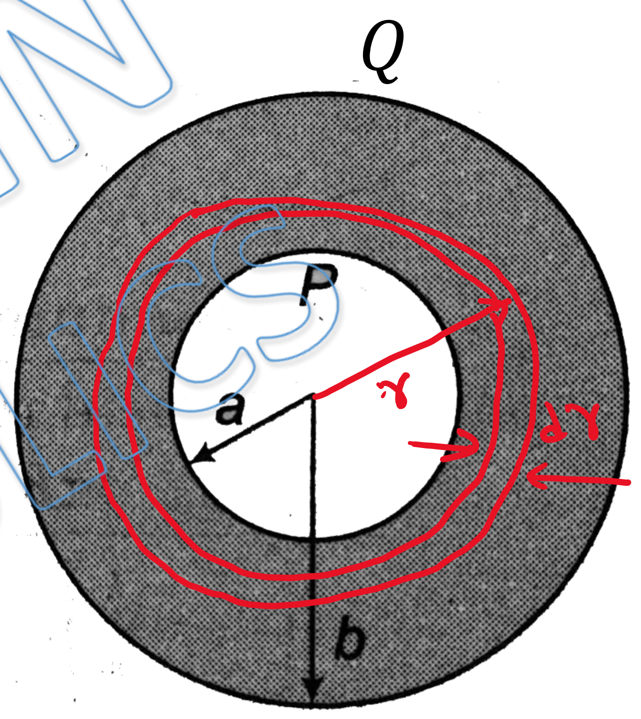
∴ Resistance of element of thickness dr will be: $dR = \frac{dr}{K(4\pi r^2)}$

$$\int dR = \int_a^b \frac{1}{4K\pi}\frac{dr}{r^2}$$

$$R = \frac{1}{4K\pi}\int_a^b \frac{dr}{r^2} = \frac{1}{4K\pi}\left[-\frac{1}{r}\right]_a^b$$

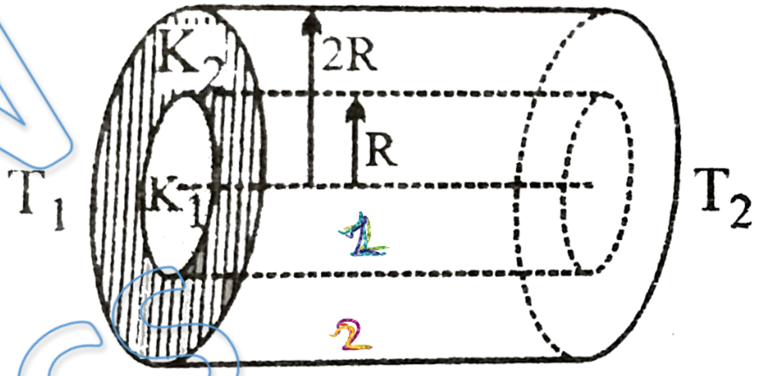
$$R = \frac{1}{4\pi K}\left[-\frac{1}{b}+\frac{1}{a}\right]$$

$$\boxed{R = \frac{1}{4\pi K}\left[\frac{1}{a}-\frac{1}{b}\right]}$$ Ans



Ans. a

Solution: 11



$R_1 = \frac{l}{K_1 A_1}$; $R_2 = \frac{l}{K_2 \pi (R_2^2 - R_1^2)}$

$R_1 = \frac{l}{K_1 \pi R^2}$; $R_2 = \frac{l}{K_2 \pi ((2R)^2 - R^2)} = \frac{l}{K_2 \pi (3R^2)}$

$I_1 = \frac{\Delta T}{R_1}$; $I_2 = \frac{\Delta T}{R_2}$

for $I_1 = I_2$

$\frac{\Delta T}{R_1} = \frac{\Delta T}{R_2} \Rightarrow R_1 = R_2$

$\frac{l}{K_1 \pi R^2} = \frac{l}{K_2 \pi (3R^2)} \Rightarrow \frac{1}{K_1} = \frac{1}{3K_2}$

$\boxed{\frac{K_1}{K_2} = \frac{3}{1}}$

Ans. c

Solution: 12

; y = thickness of ice

t = time taken by ice to freez

using; $y^2 = \frac{2 K_{ice} T}{\rho_w L} t$

$y^2 = \frac{2 \times 4 \times 10^{-3} \times 10}{1 \times 80} t_2$

$t_2 = 49,000$ sec $= 13.61$ hr

$\therefore t_2 - t_1 = 13.61 - 6.94$

$\Delta t = 6.67$ hr Ans.

Ans. a

Solution: 13

$\because y^2 \propto t$; y = thickness of ice

t = time taken by ice to freez

$$\frac{y_1^2}{y_2^2} = \frac{t_1}{t_2}$$

$y_1 = 1$ cm ; t_1 = time taken to freeze 1 cm = 7 hours (given)

$y_2 = 2$ cm ; t_2 = total time taken to freeze 2 cm

$$\therefore \frac{(1)^2}{(2)^2} = \frac{7}{t_2} \Rightarrow \frac{1}{4} = \frac{7}{t_2} \Rightarrow \boxed{t_2 = 28 \text{ hours}}$$

time taken to freeze 1 cm to 2 cm = $t_2 - t_1 = \Delta t$

$$\Delta t = 28 - 7 \Rightarrow \boxed{\Delta t = 21 \text{ hours}} \text{ Ans.}$$

Ans. d

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Chalo Niklo