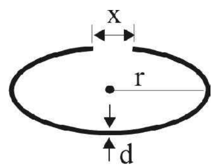
10 Thermal Properties of Matter

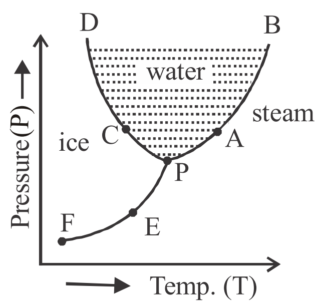
Diagram Based Questions :

1. A cylindrical metal rod is shaped into a ring with a small gap as shown. On heating the system :



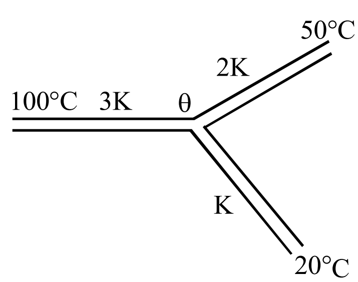
(a) x decreases, r and d increase
(b) x and r increase, d decreases
(c) x, r and d all increase
(d) x and r decreased, d remains constant

2. In the given pressure-temperature diagram, for water, which point indicates triple point ?



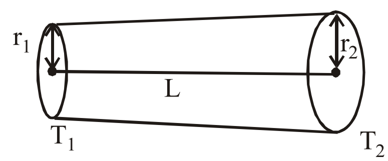
(a) A (b) C
(c) P (d) E

3. There rods of the same dimensions have thermal conductivities 3K, 2K and K. They are arranged as shown in fig. with their ends at 100°C, 50°C and 20°C. The temperature of their junction is



(a) 60° (b) 70°
(c) 50° (d) 35°

4. The rate of heat flow through the cross-section of the rod shown in figure is ($T_2 > T_1$ and thermal conductivity of the material of the rod is K)



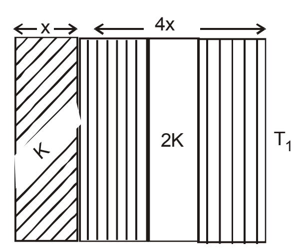
(a) $\dfrac{K\pi r_1 r_2 (T_2 - T_1)}{L}$

(b) $\dfrac{K\pi (r_1 + r_2)^2 (T_2 - T_1)}{4L}$

(c) $\dfrac{K\pi (r_1 + r_1)^2 (T_2 - T_1)}{L}$

(d) $\dfrac{K\pi (r_1 + r_1)^2 (T_2 - T_1)}{2L}$

5. The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and $2K$ and thickness x and $4x$, respectively, are T_2 and $T_1 (T_2 > T_1)$. The rate of heat transfer through the slab, in a steady state is $\left(\dfrac{A(T_2 - T_1)K}{x}\right) f$, with f equal to



(a) $\dfrac{2}{3}$

(b) $\dfrac{1}{2}$

(c) 1

(d) $\dfrac{1}{3}$

Solution

1. **(b)** Material expands outward and so x, r increases. Due to linear expansion diameter of rod will increase.

2. **(c)** The three curves AB, CD and EF meet at point P which is called the triple point of water. It is the point where all three states solid, liquid and gas of water co-exists.

3. **(b)** $\frac{dQ}{dt} = KA\frac{\Delta T}{L}$

   For the first rod, $\left(\frac{dQ}{dt}\right)_1 = \frac{3KA}{L}(100 - \ )$

   Similarly, $\left(\frac{dQ}{dt}\right)_2 = 2K\frac{A}{L}(\theta - 50)$

   $\left(\frac{dQ}{dt}\right)_3 = K\frac{A}{L}(\theta - 20)$

   Now, $\left(\frac{dQ}{dt}\right)_1 = \left(\frac{dQ}{dt}\right)_2 + \left(\frac{dQ}{dt}\right)_3$

   $\Rightarrow$ 3 (100 – θ) = 2 (θ – 50) + (θ – 20)

   $\Rightarrow$ θ = 70°

4. **(a)** $r_{eff} = \sqrt{r_1 r_2}$

   $\frac{dQ}{dt} = \frac{KA(T_2 - T_1)}{L} = \frac{K\pi r_1 r_2 (T_2 - T_1)}{}$

5. **(d)** The thermal resistance is given by

   $\frac{x}{KA} + \frac{4x}{2KA} = \frac{x}{KA} + \frac{2x}{KA} = \frac{3x}{KA}$

   $\therefore \frac{dQ}{dt} = \frac{\Delta T}{\frac{3x}{KA}} = \frac{(T_2 - T_1)KA}{3x}$

   $= \frac{1}{3}\left\{\frac{A(T_2 - T_1)K}{x}\right\} \quad \therefore f = \frac{1}{3}$