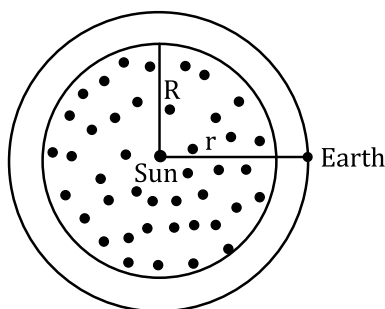


DPP 02

Solution

1. Energy radiated by sun, according to Stefan's law,



$$E = \sigma T^4 \times (\text{area } 4\pi R^2).$$

This energy is spread around sun in space, in a sphere of radius  $r$ .

Earth (E) in space receives part of this energy.

$$\frac{\text{Energy}}{\text{Area of envelope}} = \frac{\sigma T^4 \times 4\pi R^2 \times \text{time}}{4\pi r^2}$$

$$\text{Energy incident per unit area on earth} = \frac{\sigma T^4 R^2 \times \text{time}}{r^2}$$

$$\therefore \text{Power incident per unit area on earth} = \left( \frac{R^2 \sigma T^4}{r^2} \right)$$

$$\therefore \text{Power incident on earth} = \pi r_0^2 \times \frac{R^2 \sigma T^4}{r^2}$$

2. For conduction from inner sphere to outer one,

$$dQ = -KA \frac{dT}{dr} \times (\text{time } dt)$$

$$\frac{dQ}{dt} = -K \times (4\pi r^2) \frac{dT}{dr}$$

$$\therefore \text{Radial rate of flow } Q = -4\pi K r^2 \frac{dT}{dr}$$

$$\therefore Q \int_{r_1}^{r_2} \frac{dr}{r^2} = -4\pi K \int_{T_1}^{T_2} dT$$

$$Q \left[ \frac{r_1 - r_2}{r_1 r_2} \right] = 4\pi K [T_2 - T_1]$$

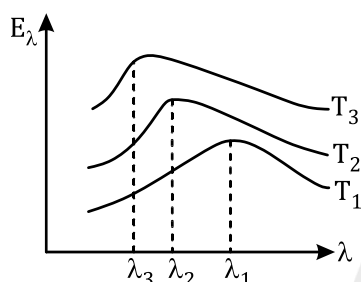
$$Q = \frac{4\pi K (T_1 - T_2) r_1 r_2}{(r_2 - r_1)}$$

$$\therefore Q \text{ is proportional to } \left( \frac{r_1 r_2}{r_2 - r_1} \right)$$

3. According to Stefan's law, energy radiated per second by a body of emissivity  $e$  at a temperature  $T$  is  $e\sigma AT^4$ ;  
 $\therefore E = 0.6\sigma AT^4$ .

4. Warming of glass of bulb due to filament is due to radiation mainly.  
 For convection process, a medium is required which can move between two points, to transfer heat. Bulb is almost evacuated to have no medium.

5. As per Wien's displacement law,  $\lambda T = \text{constant}$



From the graph given,

$$\lambda_3 < \lambda_2 < \lambda_1 \therefore T_3 > T_2 > T_1$$

Temperature of sun is higher than that of welding arc which is higher than that of tungsten filament lamp.

$$\therefore \text{Sun} = T_3, \text{Welding arc} = T_2$$

$$\text{Tungsten filament} = T_1$$

6. According to Stefan's law,  
 Radiant energy  $E = (\sigma T^4) \times \text{area} \times \text{time}$

$$\therefore \frac{E_2}{E_1} = \frac{\sigma(2T)^4 \times 4\pi(2R)^2 \times t}{\sigma T^4 \times (4\pi R)^2 \times t} = 16 \times 4$$

$$\therefore \frac{E_2}{E_1} = 64$$

7. According to Wien's displacement law,  
 $\lambda T = b = \text{Wien's constant}$ .

$$\therefore \lambda_A T_A = b \text{ or } T_A = \frac{b}{3 \times 10^{-7}}$$

$$T_A = \frac{b \times 10^7}{3} = \frac{z}{3} \text{ where } z = (b \times 10^7)$$

$$\text{Similarly } T_B = \frac{b \times 10^7}{4} = \frac{z}{4}$$

$$\text{and } T_C = \frac{b \times 10^7}{5} = \frac{z}{5}$$

Again, according to Stefan's law,

$$Q = \text{Power radiated by black body} = A\sigma T^4$$

where  $A = \text{area of disc} = \pi R^2$ .

$$Q_A = (\pi R_A^2) \times \sigma \times (T_A)^4$$

$$\text{or } Q_A = \pi(2 \times 10^{-2})^2 \times \sigma \times \left(\frac{z}{3}\right)^4$$

$$Q_A = \pi\sigma \times 10^{-4} \times z^4 \times \frac{2^2}{3^4}$$

$$\text{or } Q_A = (\pi\sigma \times 10^{-4} \times z^4) \times \frac{4}{81}$$

$$\text{Put } \pi\sigma \times 10^{-4} \times z^4 = k = \text{constant}$$

$$\text{or } Q_A = \frac{4k}{81} = 0.049k$$

$$\text{Similarly, } Q_B = \frac{k \times (4)^2}{(4)^4} = \frac{k}{16} = 0.062k$$

$$Q_C = \frac{k \times (6)^2}{(5)^4} = \frac{36k}{625} = 0.057k.$$

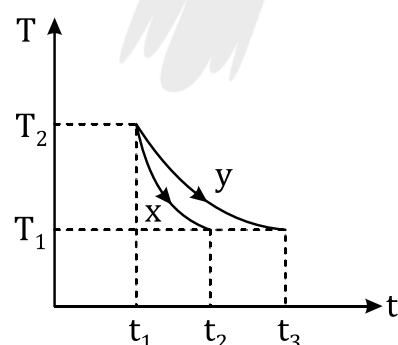
Hence  $Q_B$  is maximum.

8. According to Newton's law of cooling, rate of cooling is proportional to  $\Delta\theta$ .

$$\therefore (\Delta\theta)^n = (\Delta\theta) \text{ or } n = 1.$$

10. The two bodies x and y have same surface area. Emissivity ( $E$ )  $\propto$  rate of cooling or  $E \propto -\left(\frac{dT}{dt}\right)$

From graph, consider cooling of x and y from temperature



$T_2$  to  $T_1$ .

$$\text{Time taken by x} = (t_2 - t_1)$$

$$\text{Time taken by y} = (t_3 - t_1)$$

x takes less time and so  $E_x > E_y$  ... (i)

According to Kirchhoff's law, a good emitter is also a good absorber.

$$\therefore a_x > a_y \quad \dots (ii)$$

11. Energy radiated,

$$E = \sigma T^4 \times (\text{area } 4\pi R^2) \times \text{time} \times e$$

$$\frac{E_1}{E_2} = \frac{(4000)^4 \times (1)^2 \times 1 \times 4\pi\sigma e}{(2000)^4 \times (4)^2 \times 1 \times 4\pi\sigma e} = \frac{1}{1}$$

12. A good absorber is a good emitter but black holes do not emit all radiations.

