DPP – 3 (Heat Transfer)

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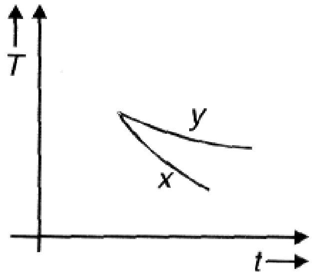
Q 1. The graph shown in diagram represents the variation of temperature T of bodies x and y having same surface area with time (t) due to emission of radiation. Find correct relation between emissivity and absorptive power of two bodies



(a) $e_x > e_y$ and $a_x < a_y$ (b) $e_x < e_y$ and $a_x > a_y$
(c) $e_x > e_y$ and $a_x > a_y$ (d) $e_x < e_y$ and $a_x < a_y$

Q 2. An ideal black body at room is thrown into furnace it is observed that
(a) Initially it is darkest body and at later times the brightest
(b) It is darkest body at all times
(c) It cannot be distinguished at all times
(d) Initially it is darkest body and at later times it cannot be distinguished

Q 3. A solid copper sphere (density p and specific heat capacity C) of radius r at an initial temperature 200 K is suspended inside a chamber whose walls are at almost 0 K. The time required (in μs) for temperature of sphere to drop to 100 K is
(a) $\frac{72\rho rc}{7\sigma}$ (b) $\frac{7\rho rc}{72\sigma}$
(c) $\frac{27\rho rc}{7\sigma}$ (d) $\frac{7\rho rc}{27\sigma}$

Q 4. A 100 Watt bulb has tungsten filament of total length 1.0 m and radius 4×10^{-5}m. The emissivity of the filament is 0.8 and $\sigma = 6.0 \times 10^{-8} W/m^2\text{-}K^4$. Calculate the temperature of the filament when the bulb is operating at correct wattage.
(a) 1605 K
(b) 1000 K
(c) 900 K
(d) 3000K

Q 5. A metal piece loses 200 J heat per second by radiation when its temperature is 1400 K, and the temperature of surrounding is 300 K. Calculate the rate of loss of heat when the temperature of the metal piece is 800 K.
(a) 21 J/sec (b) 115 J/sec

(c) 86 J/sec (d) 155 J/sec

Q 6. A polished metal with rough black spot on it is heated to about 1400 K and quickly taken to dark room. Which one of the following statements is true?
(a) Spot will appear brighter than plate
(b) Spot will appear darker than plate
(c) Spot and plate will be equally bright
(d) Spot and plate will not be visible in dark

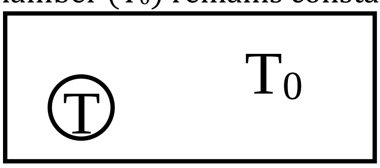
Q 7. Two sphere made of same substance have radii 1m and 4m, and temperatures 4000ºK and 2000ºK respectively. The ratio of power radiated by two spheres is –
(a) 1/2 (b) 1/4 (c) 4 (d) 1

Q 8. A thin spherical shell and a thin cylindrical shell (closed at both ends) have same volume. Both the shells are filled with water at the same temperature and are exposed to the same atmosphere. Initial temperature of water is slightly greater than that of surrounding. Then at initial moment –
(a) Rate of heat radiation from two shells will be same.
(b) Rate of fall of temperature in both the shells will be same.
(c)Rate of heat radiation and rate of fall of temperature, both in cylindrical shell are less than those in spherical shell.
(d) None of these.

Q 9. A black metal foil is warmed by radiation from a small sphere at temperature T and at a distance d. It is found that the power received by the foil is 'P'. If both the temperature and the distance are doubled, the power received by the foil will be–
(a) 16P (b) 4P
(c) 2P (d) P

Q 10. A black body does not–
(a) emit radiation (b) absorb radiation
(c) reflect radiation (d) refract radiation

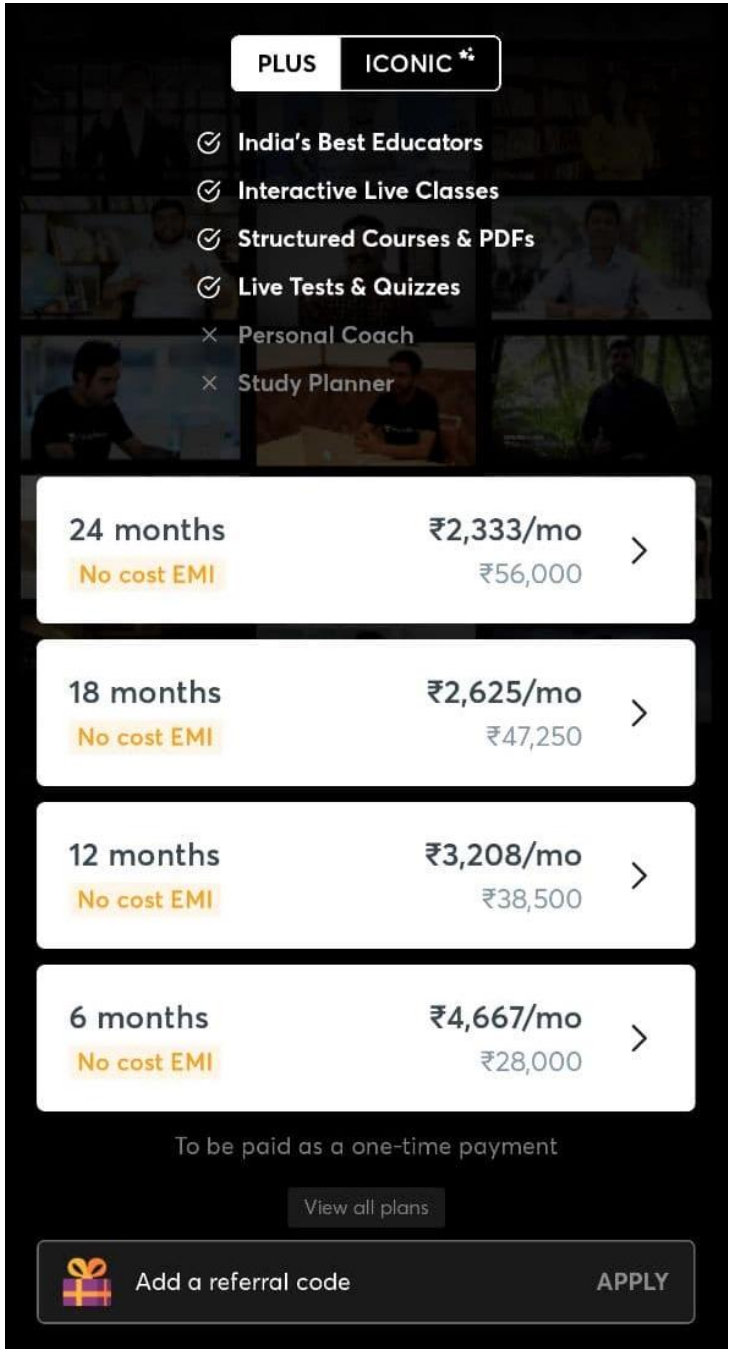
Q 11. A black body of temperature T is inside chamber of T_0 temperature initially. Sun rays are allowed to fall from a hole in the top of chamber. If the temperature of black body (T) and chamber (T_0) remains constant, then –



(a) Black body will absorb more radiation
(b) Black body will absorb less radiation
(c) Black body emit more energy
(d) Black body emit energy equal to energy absorbed by it

Answer Key

Q 1. c	**Q 2. a**	**Q 3. b**	**Q 4. a**	**Q 5. a**	**Q 6. a**
Q7. d	**Q 8. d**	**Q 9. b**	**Q10. c, d**	**Q11. a, c, d**	



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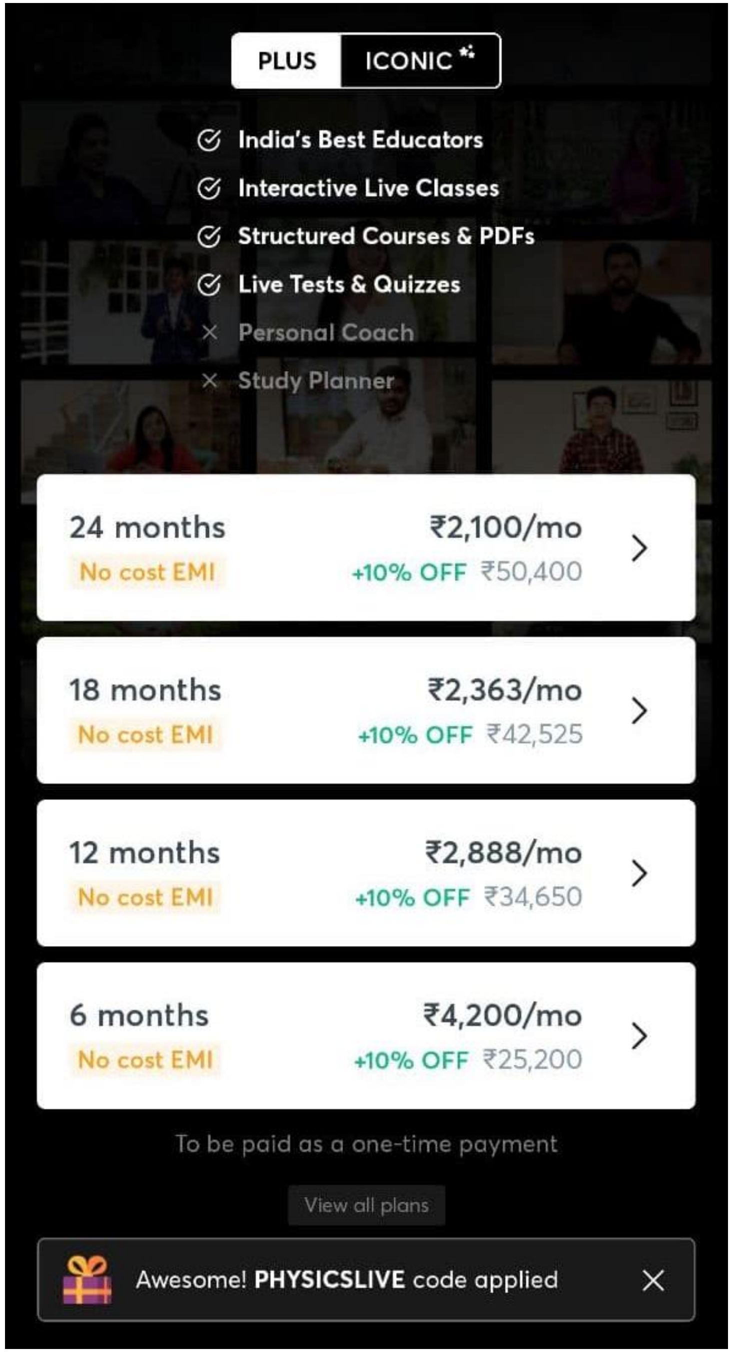

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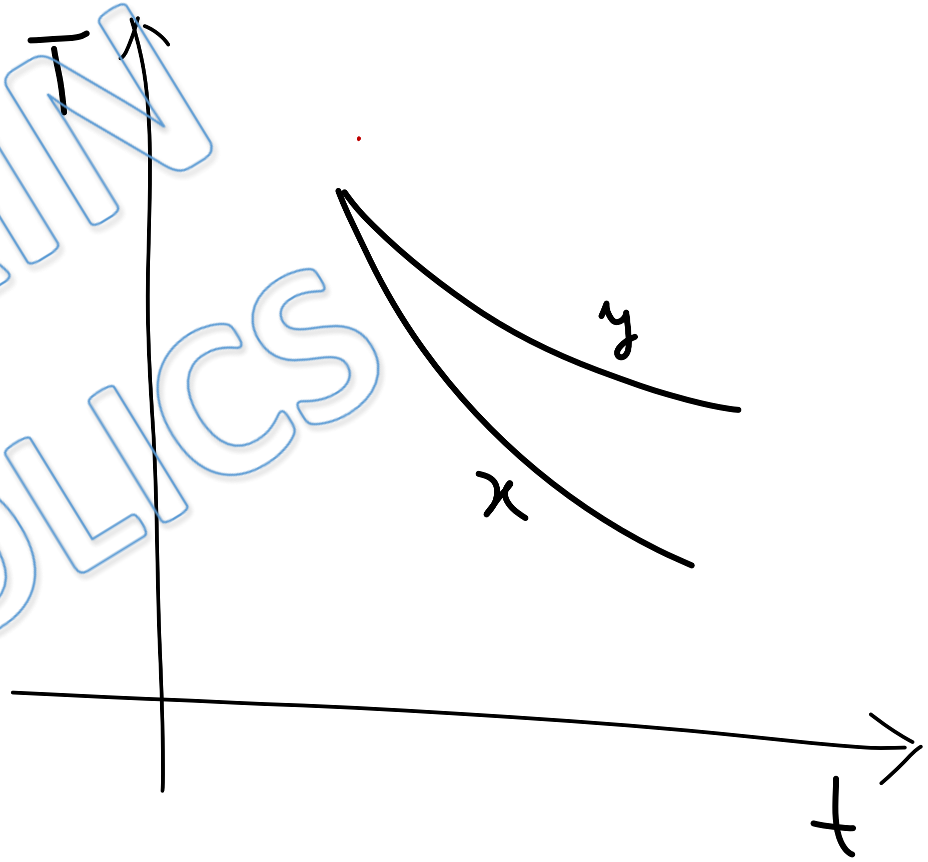
Written Solution

DPP- 3 Heat Transfer: Radiation, electromagnetic spectrum, Blackbody, Stefan's Law

By Physicsaholics Team

Solution.1

$$-\frac{dT}{dt} \propto -\frac{dQ}{dt} = e\sigma A\left(T^4 - T_0^4\right)$$



Since rate of fall of temperature is greater for x,

$$e_x > e_y$$

Since $e = a$

$$a_x > a_y$$

Ans (c)

Solution.2

Initially it is darkest as its temperature is lower.

finally it is brightest because at same temperature.

black body radiates more power per unit surface area

than others.

Ans(a)

Solution.3

at sphere temperature T

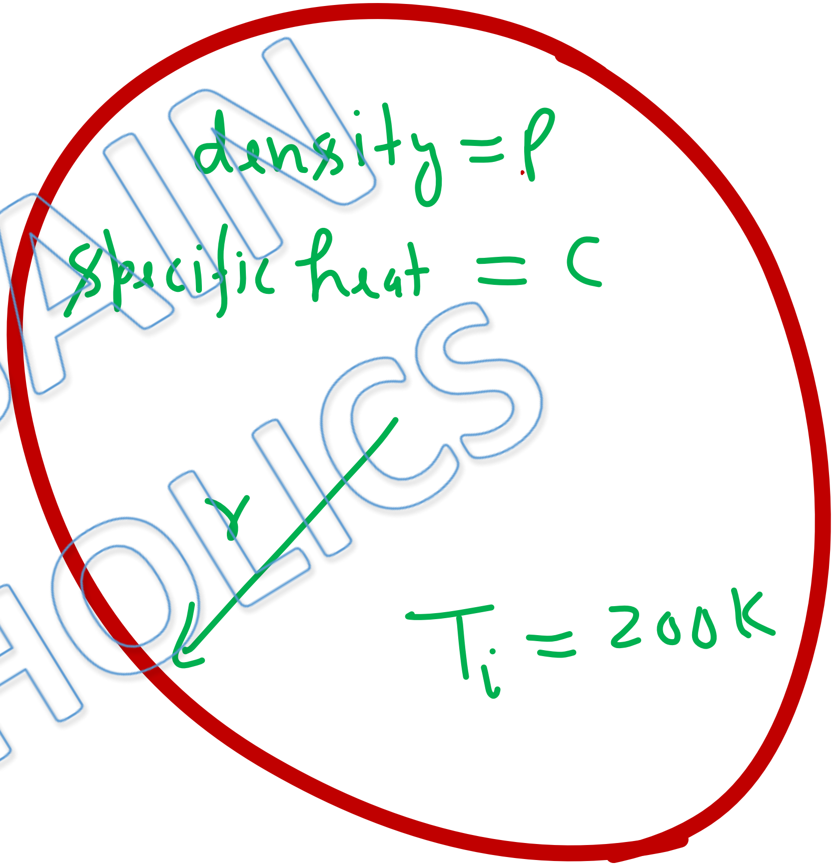
$$\frac{dQ}{dt} = -\sigma\, 4\pi r^2 (T^4 - 0^4)$$

$$mc\frac{dT}{dt} = -4\pi r^2 \sigma\, T^4$$

$$\Rightarrow \int_{200}^{100} \frac{dT}{T^4} = -\frac{4\pi r^2 \sigma}{c \cdot \frac{4}{3}\pi r^3 \rho} \int dt$$

$$\Rightarrow \left[\frac{1}{(100)^3} - \frac{1}{(200)^3}\right] \times \frac{1}{3} = \frac{3\sigma}{c\rho r}\, t$$

$$\Rightarrow t = \frac{7}{72}\frac{\rho r c}{\sigma} \times 10^{-6} = \frac{7\rho r c}{72\sigma}\ \mu\,\text{Sec.}$$



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Ans(b)

Solution.4

electrical power consumed = Power radiated

$\Rightarrow \quad 100 = e\sigma A T^4$

$\Rightarrow \quad 100 = .8 \times 6 \times 10^{-8} \times 2\pi(4 \times 10^{-5}) \times 1\, T^4$

$\Rightarrow \quad T^4 = \dfrac{100}{4.8 \times 2\pi \times 4 \times 10^{-13}}$

$\Rightarrow \quad T = 1605\, K$

Ans(a)

Solution.5

$$\text{Rate of heat loss} = e\sigma A(T^4 - T_0^4)$$

$$200 = e\sigma A\left((1400)^4 - (300)^4\right)$$

$$u = e\sigma A\left((800)^4 - (300)^4\right)$$

$$\Rightarrow \frac{u}{200} = \frac{8^4 - 3^4}{14^4 - 3^4} = \frac{4096 - 81}{38416 - 81}$$

$$\Rightarrow u = 21 \text{ J/Sec}$$

Ans(a)

Solution.6

Spot will appear brighter than plate because

$e_{blackbody} = 1$ but $e_{Metal} < 1$

Ans(a)

Solution:7

$$U = e\sigma A T^4 = e\sigma(4\pi R^2)T^4$$

$$\Rightarrow \frac{U_1}{U_2} = \left(\frac{R_1}{R_2}\right)^2\left(\frac{T_1}{T_2}\right)^4$$

$$= \left(\frac{1}{4}\right)^2\left(\frac{4000}{2000}\right)^4$$

$$= \frac{1}{16} \times 16 = 1$$

Ans(d)

Solution:8

for equal volume surface area is minimum for spherical shape.

$\Rightarrow$ Area of sphere < Area of cylinder

Since $u = e\sigma A(T^4 - T_0^4)$

$\Rightarrow$ Rate of heat loss is less for sphere.

$$-\frac{dT}{dt} = \frac{e\sigma A}{ms}(T^4 - T_0^4)$$

$\Rightarrow$ Rate of temperature fall is smaller for sphere. ANS(d)

Solution: 9

$$\text{Power received} = \frac{\text{Power emitted}}{4\pi d^2} A$$

$$\propto \frac{T^4}{d^2}$$

$$\frac{P}{P_f} = \frac{(T/T_f)^4}{(d/d_f)^2} = \frac{(1/2)^4}{(1/2)^2} = \frac{1}{4}$$

$$P_f = 4P$$

Ans(b)

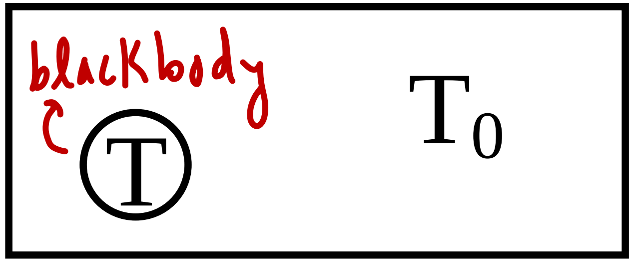
Solution:10

Black body absorbs all energy falling on it.

$\Rightarrow$ no reflection & no refraction

Ans (c, d)

Solution:11



When sun rays fall on black body it will absorb more energy.

Since T = constant ⇒ It will radiate more energy

& energy emitted = energy absorbed.

Ans (a, c, d)

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Chalo Niklo