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DPP – 3

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Q 1. The amount of radiation emitted by a perfectly black body is proportional to
(a) Temperature
(b) Fourth root of temperature
(c) Fourth power of temperature
(d) Source of temperature

Q 2. If the emission rate of blackbody at 0 °C is R, then the rate of emission at 273°C is
(a) 2R (b) 4R
(c) 8R (d) 16R

Q 3. Two bodies of same shape and having emissivity 0.1 and 0.9 respectively radiate same energy per second. The ratio of their temperature is :
(a) $\sqrt{3} : 1$ (b) $1 : \sqrt{3}$
(c) 3 : 1 (d) 1 : 3

Q 4. The radiation emitted by a star A is 10000 times that of the sun. If the surface temperature of the sun and star A are 6000K and 2000K, respectively, the ratio of the radii of the star A and the sun is
(a) 300 : 1 (b) 600 : 1
(c) 900 : 1 (d) 1200 : 1

Q 5. Two black metallic spheres of radius 4m, at 2000 K and 1m at 4000 K will have ratio of energy radiation as
(a) 1 : 1 (b) 4 : 1
(c) 1 : 4 (d) 2 : 1

Q 6. The rate of cooling at 600K, if surrounding temperature is 300K is H. The rate of cooling at 900K is:
(a) $\frac{16}{3}$ H (b) 2 H
(c) 3 H (d) $\frac{2}{3}$ H

Q 7. The area of a hole of heat furnace is $10^{-4}\ m^2$. It radiates 1.58×10^5 calories of heat per hour. If the emissivity of the furnace is 0.80, then its temperature is nearly:
(Stefan's constant = $5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$)
(a) 1500K (b) 2000K
(c) 2500K (d) 3000K

Q 8. A sphere at temperature 600K is placed in an environment of temperature 200K. Its cooling rate is H. If its temperature reduced to 400K then cooling rate in same environment will become:

(a) $\frac{3}{16}$ H (b) $\frac{16}{3}$ H

(c) $\frac{9}{27}$ H (d) $\frac{1}{16}$ H

Q 9. The radiant energy from the sun incident normally at the surface of earth is 20 $K\,cal\,m^{-2}\,\text{min}^{-1}$. What would have been the radiant energy incident normally on the earth, if the sun had a temperature twice of the present one

(a) 160 $K\,cal\,m^{-2}\,\text{min}^{-1}$ (b) 40 $K\,cal\,m^{-2}\,\text{min}^{-1}$

(c) 320 $K\,cal\,m^{-2}\,\text{min}^{-1}$ (d) 80 $K\,cal\,m^{-2}\,\text{min}^{-1}$

Q 10. If the initial temperatures of metallic sphere and disc, of the same mass, radius and nature are equal, then the ratio of their rate of cooling in same environment will be

(a) 1 : 4 (b) 4 : 1

(c) 1 : 2 (d) 2 : 1

Q 11. Two spheres of radii in the ratio 1:2 and densities in the ratio 2:1 and of same specific heat, are heated to same temperature and left in the same surrounding. The rate of cooling will be in the ratio

(a) 2 : 1 (b) 1 : 1

(c) 1 : 2 (d) 1 : 4

Answer Key

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

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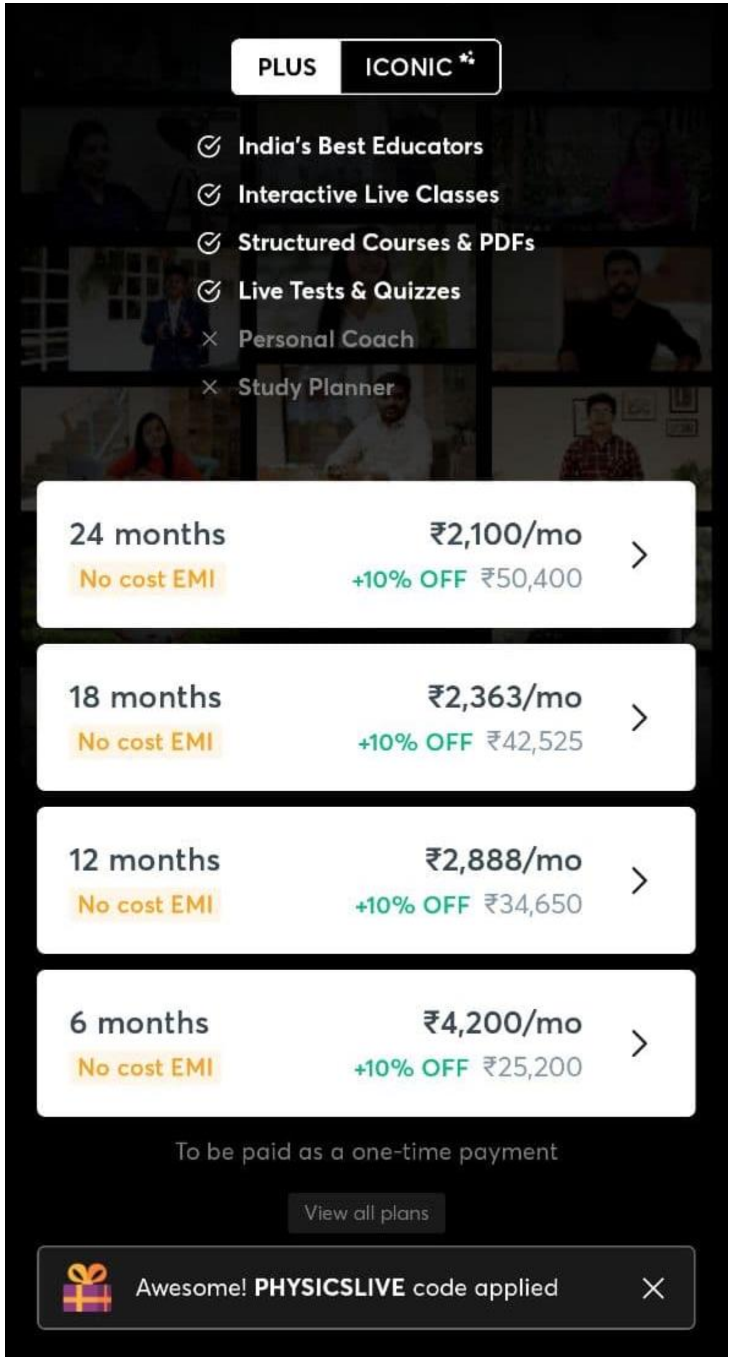

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Written Solution

DPP-3 Heat Transfer: Radiation: Electromagnetic spectrum, Black body, Stefan’s law, Stefan's-Boltzmann law

By Physicsaholics Team

Solution: 1

From Stefan's Law

$$E \propto T^4$$

Ans. c

Solution: 2

$$E \propto T^4$$

$$\frac{E_1}{E_2} = \left(\frac{T_1}{T_2}\right)^4$$

$$\frac{R}{E_2} = \left(\frac{0+273}{273+273}\right)^4$$

$$\frac{R}{E_2} = \left(\frac{273}{2\times 273}\right)^4 = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$$

$$\boxed{E_2 = 16R} \text{ Ans.}$$

Ans. d

Solution: 3

$$P = e(\sigma A T^4)$$

$$P_1 = e_1(\sigma A T_1^4)$$

$$P_2 = e_2(\sigma A T_2^4)$$

for $P_1 = P_2$

$$e_1(\sigma A T_1^4) = e_2(\sigma A T_2^4)$$

$$e_1 T_1^4 = e_2 T_2^4$$

$$\frac{T_1}{T_2} = \left(\frac{e_2}{e_1}\right)^{1/4}$$

$$\Rightarrow \frac{T_1}{T_2} = \left(\frac{0.9}{0.1}\right)^{1/4} = \left(\frac{9}{1}\right)^{1/4}$$

$$\frac{T_1}{T_2} = \left(\frac{3}{1}\right)^{1/2}$$

$$\boxed{\frac{T_1}{T_2} = \frac{\sqrt{3}}{1}}$$ Ans.

Ans. a

Solution: 4

$$P = \sigma A T^4$$

$$P \propto A T^4$$

given; $P_A = 10{,}000\, P_S$

$$\frac{P_A}{P_S} = \frac{A_A}{A_S}\frac{(T_A)^4}{(T_S)^4}$$

$$\frac{10000\, P_S}{P_S} = \frac{\pi r_A^2}{\pi r_S^2}\left(\frac{2000}{6000}\right)^4$$

$$10^4 = \left(\frac{r_A}{r_S}\right)^2\left(\frac{1}{3}\right)^4$$

$$\left(\frac{r_A}{r_S}\right)^2 = 3^4 \times 10^4$$

$$\frac{r_A}{r_S} = 3^2 \times 10^2$$

$$\boxed{\frac{r_A}{r_S} = \frac{900}{1}}$$ Ans.

Ans. c

Solution: 5

$$P = \sigma e A T^4$$

$$P \propto A T^4$$

$$\frac{P_1}{P_2} = \frac{A_1 T_1^4}{A_2 T_2^4} = \frac{4\pi r_1^2}{4\pi r_2^2}\left(\frac{T_1}{T_2}\right)^4$$

$$\frac{P_1}{P_2} = \left(\frac{r_1}{r_2}\right)^2\left(\frac{T_1}{T_2}\right)^4 = \left(\frac{4}{1}\right)^2\left(\frac{2000}{4000}\right)^4$$

$$\frac{P_1}{P_2} = \frac{16}{1} \times \frac{1}{16}$$

$$\boxed{\frac{P_1}{P_2} = \frac{1}{1}}$$ Ans.

Ans. a

Solution: 6

Rate of cooling :-

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

given; $T_s = 300\,K$

when $T = 600\,K$

$$-\frac{dT}{dt} = H$$

so; when $T = 900\,K$

then $H_2 = ?$

$$\frac{\left(-\frac{dT}{dt}\right)_1}{\left(-\frac{dT}{dt}\right)_2} = \frac{e\sigma A(T_1^4 - T_s^4)}{e\sigma A(T_2^4 - T_s^4)}$$

$$\frac{H}{H_2} = \frac{(600)^4 - (300)^4}{(900)^4 - (300)^4}$$

$$\Rightarrow \frac{H}{H_2} = \frac{1296 \times 10^8 - 81 \times 10^8}{6561 \times 10^8 - 81 \times 10^8}$$

$$\frac{H}{H_2} = \frac{1215 \times 10^8}{6480 \times 10^8}$$

$$\frac{H}{H_2} = \frac{3}{16}$$

$$\boxed{H_2 = \frac{16}{3} H}$$ Ans.

Ans. a

Solution: 7

$A = 10^{-4}\ m^2$

$P = 1.58 \times 10^5\ cal/hr = \dfrac{1.58 \times 10^5 \times 4.2\ J}{60 \times 60\ sec} = 184.3\ J/s$

$e = 0.8$

$T = ?$

$P = e\sigma A T^4$

$184.3 = 0.8 \times 5.67 \times 10^{-8} \times 10^{-4} \times T^4$

$T^4 = \dfrac{184.3}{0.8 \times 5.67} \times 10^{12} = 40.64 \times 10^{12}$

$T = 2.5 \times 10^3$

$\boxed{T = 2500\ K}$ Ans.

Ans. c

Solution: 8

$P \propto (T^4 - T_s^4)$

T = Temperature of body

T_s = Temperature of surrounding

$T_s = 200K$

$T_1 = 600K$; $T_2 = 400K$

$$\frac{H}{H_2} = \frac{(600)^4 - (200)^4}{(400)^4 - (200)^4} = \frac{6^4 - 2^4}{4^4 - 2^4}$$

$$\frac{H}{H_2} = \frac{1296 - 16}{256 - 16} = \frac{1280}{240} = \frac{16}{3}$$

$$\boxed{H_2 = \frac{3}{16}H}$$ Ans.

Ans. a

Solution: 9

$$E \propto T^4$$

$$\frac{E_1}{E_2} = \frac{T_1^4}{T_2^4}$$

$$\frac{20}{E_2} = \left(\frac{T}{2T}\right)^4$$

$$\frac{20}{E_2} = \frac{1}{2^4}$$

$$E_2 = 20 \times 2^4$$

$$\boxed{E_2 = 320 \text{ Kcal/m}^2\text{-min}}$$ Ans

Ans. c

Solution: 10

1 - Sphere   2 - Disc.

$A_1 = 4\pi r^2$ $A_2 = 2\pi r^2$ [Area of both side exposed surfaces]

$$\frac{E_1}{E_2} = \frac{A_1 (T^4 - T_s^4)}{A_2 (T^4 - T_s^4)}$$ (as $T_1 = T_2 = T$)

$$\frac{E_1}{E_2} = \frac{4\pi r^2}{2\pi r^2}$$

$$\boxed{\frac{E_1}{E_2} = \frac{2}{1}}$$

Ans. d

Solution: 11

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

$$\frac{\left(-dT/dt\right)_1}{\left(-dT/dt\right)_2} = \frac{A_1}{m_1} \times \frac{m_2}{A_2} = \frac{4\pi r_1^2}{\rho_1 \times \frac{4}{3}\pi r_1^3} \times \frac{\rho_2 \times \frac{4}{3}\pi r_2^3}{4\pi r_2^2}$$

$$\frac{\left(dT/dt\right)_1}{\left(dT/dt\right)_2} = \frac{\rho_2 r_2}{\rho_1 r_1} = \frac{\rho_2}{\rho_1} \times \frac{r_2}{r_1} = \frac{2}{1} \times \frac{1}{2}$$

$$\boxed{\frac{\left(dT/dt\right)_1}{\left(dT/dt\right)_2} = \frac{1}{1}}$$ Ans.

Ans. b

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