DPP – 4

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Written Solution on Website:- https://physicsaholics.com/note/notesDetalis/48

Q 1. Hot water cools from 60°C to 50°C in the first 10 minutes and to 42°C in the next 10 minutes. The temperature of the surrounding is

(a) 5 °C (b) 10 °C
(c) 15 °C (d) 20°C

Q 2. A body cools down from 45°C to 40°C in 5 minutes and to 35°C in next 8 minutes. Find the temperature of the surrounding (nearly)

(a) 30 °C (b) -30 °C
(c) 58 °C (d) 50 °C

Q 3. A body cools from 80 °C to 50 °C in 5 minutes. Calculate the time it takes to cool from 60 °C to 30 °C. The temperature of the surroundings is 20°C ?

(a) 5 min (b) 10 min
(c) 15 min (d) 20 min

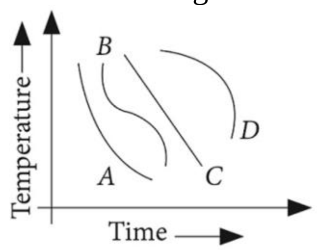
Q 4. A bucket full of hot water is kept in a room and it cools from 75°C to 70°C in T_1 minutes, from 70°C to 65°C in T_2 minutes and from 65°C to 60°C in T_3 minutes. Then

(a) $T_1 = T_2 = T_3$ (b) $T_1 < T_2 < T_3$
(c) $T_1 > T_2 > T_3$ (d) $T_1 < T_2 > T_3$

Q 5. A body with an initial temperature θ_1 is allowed to cool in a surrounding which is at a constant temperature of θ_o $(\theta_o < \theta_1)$. Assume that Newton's law of cooling is obeyed. The temperature of the body after time t is best expressed by, Let k=constant.

(a) $(\theta_o - \theta_1)\, e^{-kt}$ (b) $(\theta_1 - \theta_0)\ln(kt)$
(c) $\theta_0 + (\theta_1 - \theta_0)\, e^{-kt}$ (d) $\theta_1\, e^{-kt} - \theta_0$

Q 6. A block of steel is heated at 100°C is left in room to cool. Which of the curves shown in figure best represents the correct cooling behavior?



(a) A (b) B
(c) C (d) D

Q 7. A body takes 10 minutes to cool from 60°C to 50°C. The temperature of surroundings is constant at 25°C. Then, the temperature of the body after next 10 minutes will be approximately

(a) 43°C (b) 47°C

(c) 40°C (d) 45°C

Q 8. The solar constant for the earth is about 1.8 J/m^2-s. What is the solar constant for a black body situated on a planet which is situated at a distance of 0.3 times the distance of the earth from the sun?

(a) 9 J/m^2-s (b) 12 J/m^2-s

(c) 15 J/m^2-s (d) 20 J/m^2-s

Q 9. If wavelengths of maximum intensity of radiations emitted by the sun and the moon are $0.5 \times 10^{-6} m$ and $10^{-4} m$ respectively, the ratio of their temperatures is

(a) $\frac{1}{100}$ (b) $\frac{1}{200}$

(c) 100 (d) 200

Q 10. The wavelength of maximum energy released during an atomic explosion was $2.93 \times 10^{-10} m$. Given that Wein's constant is 2.93×10^{-3} m-K, the maximum temperature attained must be of the order of

(a) 10^{-7}K (b) 10^{7}K

(c) 10^{-13}K (d) 5.86×10^{8}K

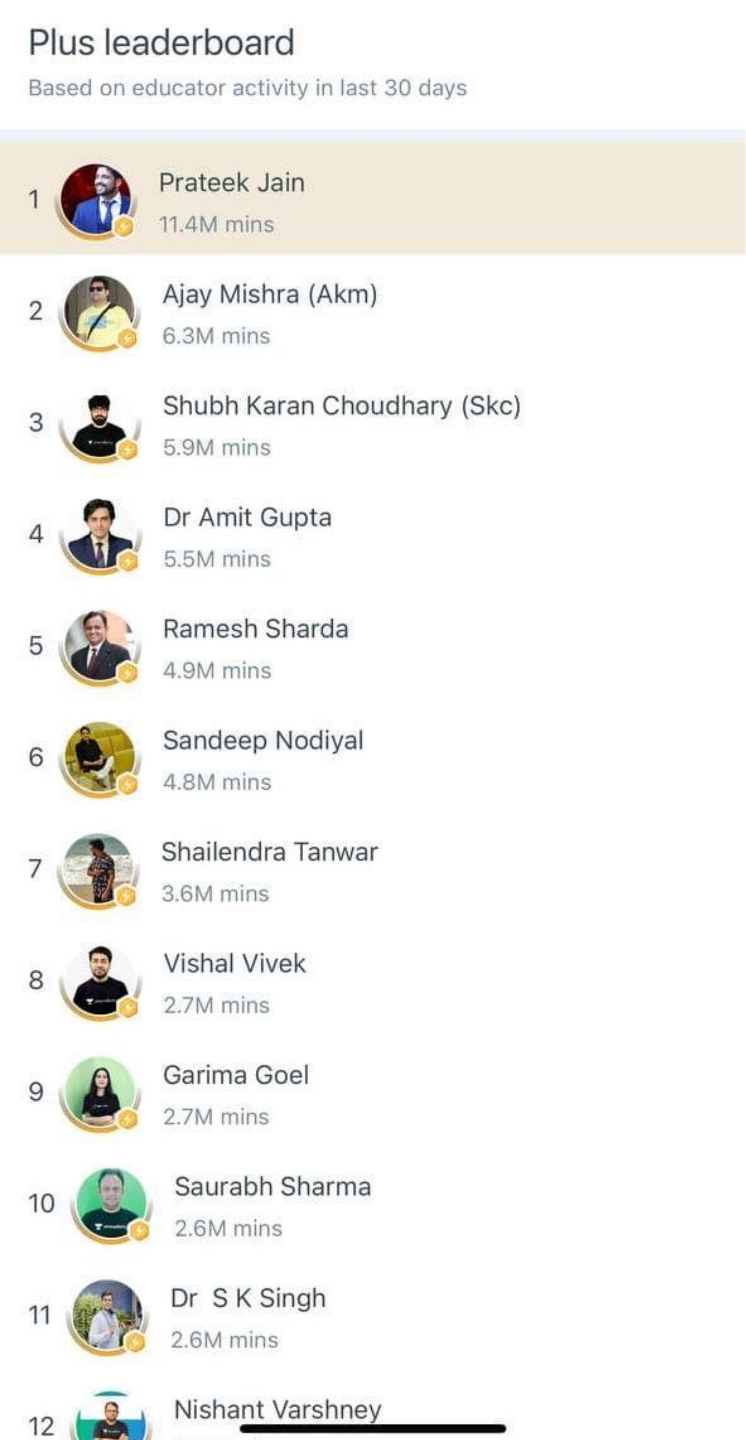
Q 11. A black body at a temperature of 1640 K has the wavelength corresponding to maximum emission equal to 1.75 μm. Assuming the moon to be a perfectly black body, the temperature of the moon, if the wavelength corresponding to maximum emission is 14.35 μm is

(a) 100K (b) 150K

(c) 200K (d) 250K

Answer Key

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



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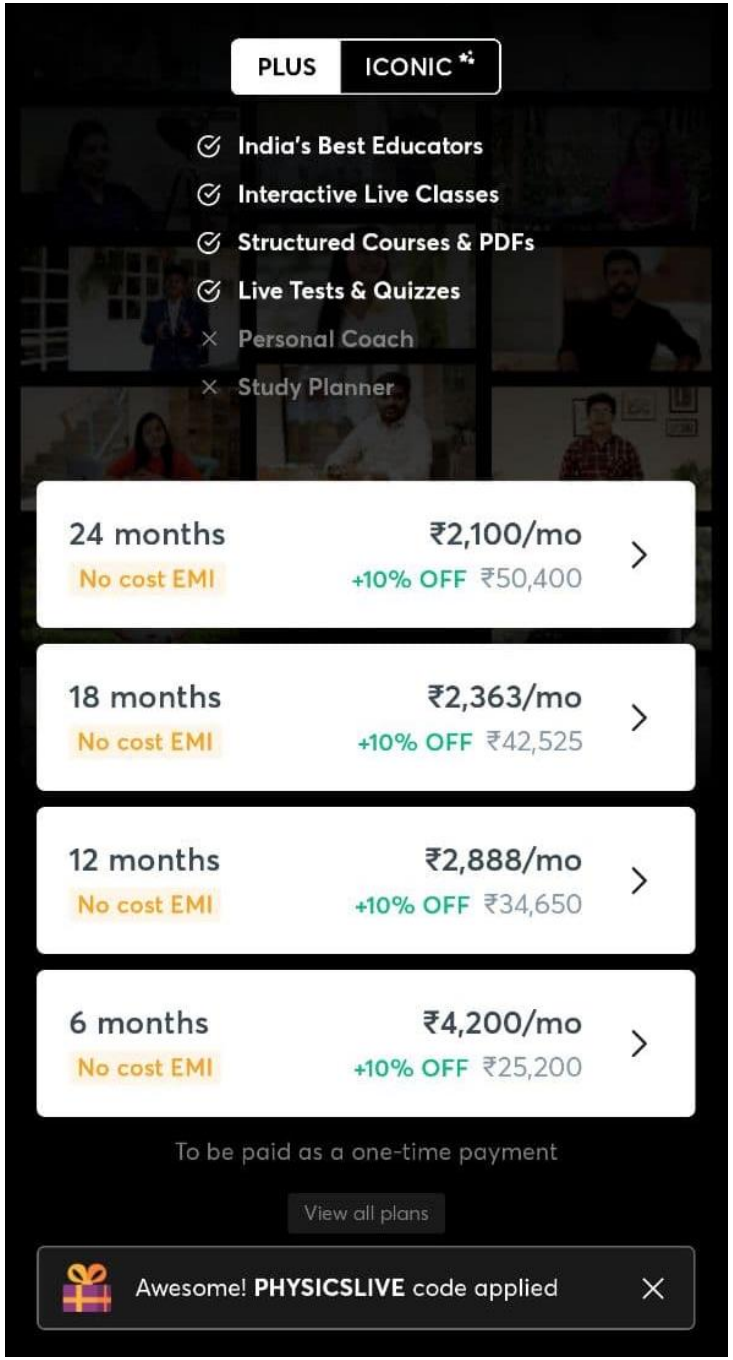

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Written Solution

DPP-4 Heat Transfer: Newton’s law of cooling, Cooling curve, Solar constant, Intensity of sunlight, Emissive power, Spectral emissive power, Black body spectrum

By Physicsaholics Team

Solution: 1

$$\frac{T_1 - T_2}{t} = K\left[\frac{T_1+T_2}{2} - T_s\right]$$

$60^\circ \xrightarrow{10\,min} 50^\circ$

$$\frac{60-50}{10} = K\left[\frac{60+50}{2} - T_s\right]$$

$$\Rightarrow \quad 1 = K[55 - T_s] \quad — (1)$$

$50^\circ \xrightarrow{10} 42^\circ$

$$\frac{50-42}{10} = K\left[\frac{50+42}{2} - T_s\right]$$

$$\Rightarrow \quad 0.8 = K[46 - T_s] \quad — (2)$$

$$\frac{(1)}{(2)} \Rightarrow \frac{1}{0.8} = \frac{K[55 - T_s]}{K[46 - T_s]}$$

$$\Rightarrow 46 - T_s = 0.8[55 - T_s]$$

$$46 - (0.8 \times 55) = T_s - 0.8T_s$$

$$0.2T_s = 46 - 44$$

$$0.2T_s = 2$$

$$T_s = \frac{2}{0.2}$$

$$\boxed{T_s = 10^\circ C} \text{ Ans}$$

Ans. b

Solution: 2

$$\frac{T_1 - T_2}{t} = k\left[\frac{T_1 + T_2}{2} - T_s\right]$$

$$45^\circ \xrightarrow[5\text{ min}]{} 40^\circ$$

$$\frac{45 - 40}{5} = k\left[\frac{45 + 40}{2} - T_s\right]$$

$$\Rightarrow 1 = k\left[\frac{85}{2} - T_s\right] \quad \text{—— (1)}$$

$$40^\circ \xrightarrow[8\text{ min}]{} 35^\circ C$$

$$\frac{40 - 35}{8} = k\left[\frac{40 + 35}{2} - T_s\right]$$

$$\Rightarrow \frac{5}{8} = k\left[\frac{75}{2} - T_s\right] \quad \text{—— (2)}$$

$$\frac{(1)}{(2)} \Rightarrow \frac{1}{5/8} = \frac{k\left[\frac{85}{2} - T_s\right]}{k\left[\frac{75}{2} - T_s\right]}$$

$$\frac{8}{5} = \frac{85 - 2T_s}{75 - 2T_s}$$

$$75 \times 8 - 16T_s = 5 \times 85 - 10T_s$$

$$75 \times 8 - 85 \times 5 = 6T_s$$

$$6T_s = 600 - 425$$

$$6T_s = 175$$

$$\boxed{T_s = 29.2^\circ C} \quad \text{Ans.}$$

Ans. a

Solution: 3

$$T_f - T_s = (T_i - T_s)e^{-kt}$$

& $T_s = 20^\circ C$

$80^\circ \xrightarrow{t = 5\text{ min.}} 50^\circ$

$$50 - 20 = (80 - 20)e^{-k5}$$

$$30 = (60)e^{-5k}$$

$$e^{-5k} = \frac{1}{2}$$

$$-5k = \ln\frac{1}{2} = -\ln 2$$

$$k = \frac{\ln 2}{5} \quad \text{—(1)}$$

$60^\circ \xrightarrow{t = ?} 30^\circ$

$$30 - 20 = (60 - 20)e^{-kt}$$

$$10 = 40e^{-kt}$$

$$e^{-kt} = \frac{1}{4}$$

$$-kt = \ln\frac{1}{4} = -2\ln 2$$

$$k = \frac{2\ln 2}{t} \quad \text{—(2)}$$

(1) = (2)

$$\frac{\ln 2}{5} = \frac{2\ln 2}{t}$$

$$\boxed{t = 10\text{ min}} \quad \text{Ans}$$

Ans. b

Solution: 4

according to Newton's Law of cooling:

$$\frac{d\theta}{dt} = (\theta - \theta_s)$$

$\because \theta_s =$ Constant

$\therefore$ when $\Delta\theta \uparrow \Rightarrow \frac{d\theta}{dt} \uparrow$ And if $\Delta\theta \downarrow \Rightarrow \frac{d\theta}{dt} \downarrow$

The time of cooling increases as the difference between the temperature of body & surrounding is reduce

as $\theta_1 = 75^\circ C$, $\theta_2 = 70^\circ C$, $\theta_3 = 65^\circ C$ $\Rightarrow \theta_1 > \theta_2 > \theta_3$

$\Rightarrow \Delta\theta_1 > \Delta\theta_2 > \Delta\theta_3$

$\Rightarrow \boxed{T_1 < T_2 < T_3}$ Ans.

Ans. b

Solution: 5

From Newton's Law of cooling

$$\theta_f = \theta_s + (\theta_i - \theta_s) e^{-kt}$$

here; $\theta_s = \theta_0$

& $\theta_i = \theta_1$

$$\therefore \boxed{\theta_f = \theta_0 + (\theta_1 - \theta_0) e^{-kt}} \text{ Ans.}$$

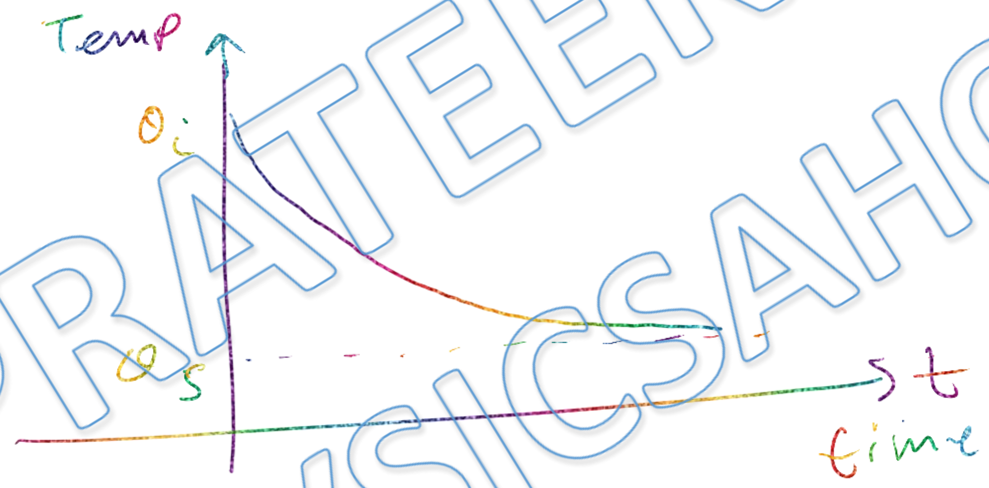
Ans. c

Solution: 6

From Newton's Law of cooling

$$\theta_f = \theta_s + (\theta_i - \theta_s) e^{-kt}$$

$$\theta_i = 100°C = 373 K$$



Ans. a

Solution: 7

$$\frac{T_1 - T_2}{t} = k\left[\frac{T_1 + T_2}{2} - T_0\right]$$

$60^\circ \xrightarrow{t = 10\,min} 50^\circ$

$$\frac{60 - 50}{10} = k\left[\frac{60 + 50}{2} - 25\right]$$

$$1 = k[55 - 25]$$

$$k = \frac{1}{30}$$

$50^\circ \xrightarrow{t = 10\,min} T = ?$

$$\frac{50 - T}{10} = k\left[\frac{50 + T}{2} - 25\right]$$

$$\frac{50 - T}{10} = \left(\frac{1}{30}\right)\left[\frac{50 + T - 50}{2}\right]$$

$$\frac{50 - T}{1} = \frac{1}{3}\left[\frac{T}{2}\right]$$

$$50 - T = \frac{T}{6}$$

$$50 = T + \frac{T}{6} = \frac{7T}{6}$$

$$T = \frac{50 \times 6}{7}$$

$$T = \frac{300}{7}$$

$$T \simeq 43^\circ C$$

Ans. a

Solution: 8

Solar Constant; $S = \sigma T_s^4 \left(\frac{R_s}{r}\right)^2$

$\Rightarrow S \propto \frac{1}{r^2}$

$\frac{S_1}{S_2} = \left(\frac{r_2}{r_1}\right)^2$ $\left[\begin{array}{l} S_1 = 1.8\ J/m^2 s \\ r_2 = r_0 \end{array}\right.$

$\frac{1.8}{S_2} = \left(\frac{0.3r}{r}\right)^2$

$\Rightarrow \frac{1.8}{S_2} = \left(\frac{0.3}{1}\right)^2 = \left(\frac{3}{10}\right)^2 = \frac{9}{100}$

$\frac{1.8}{S_2} = \frac{9}{100}$ $\Rightarrow S_2 = \frac{180}{9}$

$\Rightarrow \boxed{S_2 = 20\ J/m^2 sec}$ Ans.

Ans. d

Solution: 9

$\lambda T = \text{constant}$

$\lambda_1 T_1 = \lambda_2 T_2$

$0.5 \times 10^{-6} \times T_1 = 10^{-4}\, T_2$

$\frac{T_1}{T_2} = \frac{10^{-4}}{5 \times 10^{-7}} = \frac{1000}{5}$

$\boxed{\frac{T_1}{T_2} = \frac{200}{1}}$ Ans.

Ans. d

Solution: 10

$$\lambda_m = \frac{b}{T}$$

$$T = \frac{b}{\lambda_m}$$

$$T = \frac{2.93 \times 10^{-3}}{2.93 \times 10^{-10}}$$

$$T = 10^{7}\ K$$ Ans.

Ans. b

Solution: 11

$$dt = \text{constant}$$

$$d_1 T_1 = d_2 T_2$$

$$(1.75\ \mu m) \times 1640 = (14.35\ \mu m) T_2$$

$$T_2 = \frac{1640 \times 1.75}{14.35}$$

$$T_2 = \frac{1640}{8.2}$$

$$\boxed{T_2 = 200\ K} \text{ Ans.}$$

Ans. c

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