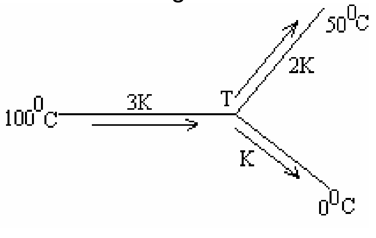
TRANSMISSION OF HEAT

PREVIOUS EAMCET QUESTIONS

ENGINEERING

1. Three rods of same dimensions have thermal conductivities 3K, 2K and K. They are arranged as shown in the figures below **(2009 E)**



Then the temperature of the junction in steady state is :

1) $\frac{200}{3}\,{}^0C$ 2) $\frac{100}{3}\,{}^0C$ 3) $75\,{}^0C$ 4) $\frac{50}{3}\,{}^0C$

Ans : 1

Sol: The amount of heat transmitted from one end to other end is $Q = \frac{KAT(t_1 - t_2)}{d}$

Where T is the time, $t_1 - t_2$ = temp. difference

At the junction

$$Q = Q_1 + Q_2$$

$$\Rightarrow \frac{3K(A)(100-t)T}{d}$$

$$\Rightarrow \frac{2K(A)(t-50)T}{d} + \frac{KA(t-0)T}{d}$$

Where t is the temperature of junction

$$\Rightarrow 6t = 400 \Rightarrow t = \frac{200}{3}\,{}^0C$$

2. Two slabs A and B of equal surface area are placed one over the other such that their surfaces are completely in contact. The thickness of slabs A is twice that of B. The coefficient of thermal conductivity of slab A is twice of B. The first surface of slab A is maintained at 100°C, while the second surface of slab B is maintained at 25^0C. The temperature at the contact of their surfaces is **(2008 E)**

1) 15^0C 2) 45^0C 3) 55^0C 4) none

Ans :2

Sol: As they are kept in contact

$$\frac{Q}{t} = \text{constant}$$

$$\therefore \frac{2KA(100-\theta)}{2l} = \frac{KA(\theta-25)}{l}$$

Where θ is the temperature of contact.

$$100 - \theta = \theta - 25$$

$$125 = 2\theta$$

$$\theta = \frac{125}{2} = 62.5^0C$$

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3. A black body radiates energy at the rate of E watt/ m^2 at a high temperature T.K. When the temperature is reduced to (T/2)k, the radiant energy is **[2007 E]**

1) E/2 2) 2E 3) E/4 4) E/16

Ans :4

Sol: From Stefans law E $E = \sigma T^4$

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

$$\Rightarrow \frac{E_2}{E_1} = \left(\frac{T}{2T}\right)^4$$

$$\Rightarrow E_2 = E/16$$

4. Two solid spheres A and B made of the same material have radii r_A and r_B respectively. Both the spheres are cooled from the same temperature under the conditions valid for Newton's law of cooling. The ratio of rate of change of temperature of A and B is **(2006 E)**

Ans : 2

Sol: From Newton's law of cooling, Rate of change of temperature

$$\frac{d\theta}{dt} \propto \frac{1}{r} \Rightarrow \frac{\left(\frac{d\theta}{dt}\right)_A}{\left(\frac{d\theta}{dt}\right)_B} = \frac{r_B}{r_A}$$

5. Two identical bodies have temperature 277^0C and 67^0C. If the surrounding temperature is 27^0C, the ratio loss of heat of the two bodies during the same interval of time is (approximately) **(2005 E)**

1) 4 : 1 2) 8 : 1 3) 12 : 1 4) 16 : 1

Ans : 4

Sol: According to stefans Boltzmann's law

$$\frac{E_1}{E_2} = \frac{T_1^4 - T_5^4}{T_2^4 - T_5^4} = \frac{(550)^4 - (300)^4}{(340)^4 - (300)^4} = 16$$

6. A black body of mass 34.38gm and surface area $19.2cm^2$ is at an initial temperature of 400k. It is allowed to cool inside an evacuated enclosure kept at constant temperature 300k. The rate of cooling is per second. The specific heat of the body in $Jkg^{-1}k^{-1}$ is (Stefan's constant $\sigma = 5.73 \times 10^{-8} Wm^{-2}k^{-4}$) **(2004 E)**

1) 2800 2) 2100 3) 1400 4) 1200

Ans : 3

Sol: From Stefan's law $Q = \sigma eAT\left(T_B^4 - T_S^4\right)$………………(1)

But $Q = msd\theta$ ………………………(2)

Comparing (1) & (2)

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$$\therefore \frac{dQ}{dt} = \frac{\sigma A\left(T_B^4 - T_S^4\right)}{ms}$$

$$\therefore S = \frac{\sigma A\left(T_B^4 - T_S^4\right)}{m\left(\frac{d\theta}{dt}\right)}$$

Substituting the values we get S = 1400Jkg^{-1}k^{-1}

7. The radiation emitted by a star A is 10,000 times that of the sun. If the surface temperature of the sun and the star A are 6000K and 2000k respectively, the ratio of the radii of the star A and the sun is **(2003 E)**

1) 300 : 1 2) 600: 1 3) 900 : 1 4) 1200:1

Ans :3

Sol: According to stefan's law $Q = \sigma eAT\left(T_B^4 - T_S^4\right)$..................(1)

But $\frac{Q_A}{Q_S} = 10,000$

$$\therefore \frac{\left(\sigma T_A^4\right)\left(4\pi r_A^2\right)}{\left(\sigma T_S^4\right)\left(4\pi r_S^2\right)} = 10,000$$

$$\therefore r_A : r_S = 900 : 1$$

8. When the temperature of a black body increases, it is observed that the wavelength corresponding to maximum energy changes from 0.26 mm to 0.13mm. The ratio of the emissive powers of the body at the respective temperatures is: **(2002 E)**

1.16/1 2.4/1 3.1/4 4.1/16

Ans : 4

Sol: From wiens displacement law $\lambda_m T$ = constant

$$\therefore \lambda_1 T_1 = \lambda_2 T_2$$

$$\Rightarrow \frac{T_1}{T_2} = \frac{\lambda_2}{\lambda_1} = \frac{1}{2}$$

But emissive power $\propto T^4$

$$\therefore \frac{E_1}{E_2} = \left(\frac{T_1}{T_2}\right)^4 = \frac{1}{16}$$

9. The wave length corresponding to maximum intensity of radiation emitted by a star is 289.8nm. The intensity of radiation for the star is (Stefan's constant = $5.6\times10^{-8} Wm^{-2}K^{-4}$) **(2001 E)**

1. $5.67\times10^{8}\,Wm^{-2}$ 2. $5.67\times10^{4} Wm^{-2}$ 3. $10.67\times10^{7}\,Wm^{-2}$ 4. $10.67\times10^{4}\,Wm^{-2}$

Ans : 1

Sol: From wiens law $\lambda_{\max} T$ = constant (b)

$$\Rightarrow T = \frac{b}{\lambda_{\max}} = \frac{2898\times10^{-6}}{289.8\times10^{-9}} = 10^4 K$$

According to stefan's law = $E = \sigma T^4$

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$$= 5.67\times10^{-8}\times\left(10^{4}\right)^{4}$$

$$= 5.67\times10^{-8}\ \text{Wm}^{-2}$$

10. Two metal rods A and B of equal lengths and equal cross sectional areas are joined end to end. K_A and K_B are in the ratio 2:3. When the free end of A is maintained at 100^0C and the free end of B is maintained at 0^0C, the temperature of junction is **(2000 E)**

1) 30^0C 2) 40^0C 3) 50^0C 4) 60^0C

Ans : 2

Sol: As the rods A and B are connected in series $\frac{Q}{t}$ = constant

Let the temperature of the junction be 't' under thermal equilibrium

$$\frac{K_A\times A\times\left(100-t\right)}{l}=\frac{K_B\times A\times\left(t-0\right)}{l}$$

$$\Rightarrow 2\left[100-t\right]=3t$$

$$\Rightarrow t=40^0C$$

MEDICAL

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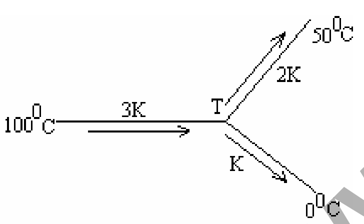

Then the temperature of the junction in steady state is :

1) $\frac{200}{3}\ ^0C$ 2) $\frac{100}{3}\ ^0C$ 3) $75\ ^0C$ 4) $\frac{50}{3}\ ^0C$

Ans : 1

Sol: The amount of heat transmitted from one end to other end is $Q=\frac{KAT\left(t_1-t_2\right)}{d}$

Where T is the time, t_1-t_2 = temp. difference

At the junction

$$Q=Q_1+Q_2$$

$$\Rightarrow \frac{3K\left(A\right)\left(100-t\right)T}{d}$$

$$\Rightarrow \frac{2K\left(A\right)\left(t-50\right)T}{d}+\frac{KA\left(t-0\right)T}{d}$$

Where t is the temperature of junction

$$\Rightarrow 6t=400\Rightarrow t=\frac{200}{3}\ ^0C$$

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12. A body cools from 70°C to 50°C in 5 minutes. Temperature of surrounding is 20°C. Its temperature after next 10 minutes is **[2008 M]**

1) 25°C 2) 30°C 3) 35°C 4) 45°C

Ans : 2

Sol: From Newton's law of cooling

$$\frac{d\theta}{dt} = K\left(\frac{\theta_1+\theta_2}{2} - \theta_S\right)$$

Where θ_S is the temperature of surroundings

$$\therefore \frac{70-50}{5} = K\left(\frac{70+50}{2} - 20\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$\frac{50-\theta}{10} = K\left(\frac{50+\theta}{2} - 20\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Dividing (1) & (2)

$$\theta = 30^0 C$$

13. The power of a black body at temperature 200 K is 544 watt. Its surface area is (σ = 5.67 x 10^{-8} wm^{-2} K^{-4}] **[2007 M]**

1) 6 x 10^{-2} m^2 2) $6m^2$ 3) 6 x 10^{-6} m^2 4) 6 x 10^2 m^2

Ans : 2

Sol: From stefans law $\frac{Q}{t} = P = \sigma A T^4$

$$\Rightarrow A = \frac{P}{\sigma T^4} = \frac{544}{5.67\times10^{-8}\times(200)^4} = 6m^2$$

14. Two bodies of same shape, same size and same radiating power have emissivities 0.2 and 0.8. The ratio of their temperature is **(2005/M)**

1) $\sqrt{3}:1$ 2) $\sqrt{2}:1$ 3) $1:\sqrt{5}$ 4) $1:\sqrt{3}$

Ans:2

Sol: Power radiated is $E = e\sigma T^4$, where e is emissivity

Given $E_1 = E_2 \Rightarrow e_1T_1^4 = e_2T_2^4$

$$\Rightarrow \frac{e_1}{e_2} = \left(\frac{T_2}{T_1}\right)^4 = \frac{0.2}{0.8} = \frac{1}{4}$$

$$\Rightarrow \frac{T_2}{T_1} = \frac{1}{(4)^{1/4}} = \frac{1}{\sqrt{2}}$$

$$\therefore \frac{T_1}{T_2} = \frac{\sqrt{2}}{1}$$

15. The absolute temperature of a body A is four times that of another body B. For two bodies, the difference in wave lengths at which energy radiated is maximum is 3.0 μm. Then the wavelength at which the body B radiates maximum energy in micrometer is **(2004 M)**

1) 2 2) 2.5 3) 4.0 4) 45

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Ans:3

Sol : From Wien's displacement law $\lambda_m T$ = constant

$$\therefore \frac{\lambda_A}{\lambda_B} = \frac{T_B}{T_A}$$

Given $T_A = 4T_B$

$$\therefore \frac{\lambda_A}{\lambda_B} = \frac{1}{4}$$

$$\Rightarrow \lambda_B = 4\lambda_A \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\lambda_B - \lambda_A = 3\mu m \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

From (1) & (2)

$\lambda_A = 1\mu m$ and $\lambda_B = 4\mu m$

16. A particular star (assuming it as a black body) has a surface temperature of about $5\times10^4 k$. The wave length in nano-meters at which its radiation becomes maximum is (b = 0.0029mk) **(2003M)**

1) 48 2) 58 3) 60 4) 70

Ans :2

Sol : From Wien's displacement law

$\lambda_m T$ = constant

$$\lambda = \frac{b}{T} = \frac{2.9\times10^{-3}}{5\times10^4} = 5.8\times10^{-8} m$$

= 58 nm

17. The rate of emission of a black body at temperature 27^0C is. If its temperature is increased to 327^0C, the rate of emission of radiation is E_2. The relation between E_1 and is **(2002 / M)**

1. $E_2 = 24E_1$ 2. $E_2 = 16E_1$ 3. $E_2 = 8E_1$ 4. $E_2 = 4E_1$

Ans :2

Sol: According to stefan's law $E = \sigma eAt\ T^4$

$$\therefore \frac{E_1}{E_2} = \left(\frac{T_1}{T_2}\right)^4 = \left(\frac{300}{600}\right)^4 = \frac{1}{16}$$

$$E_2 = 16E_1$$

18. The temperature of a black body is increased by 50% . Then the percentage of increase of radiation is approximately **(2001 M)**

1. 100% 2. 25% 3. 400% 4. 500%

Ans :3

Sol: From stefan's law $E = \sigma eAT + T^4$

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

$$\Rightarrow \frac{E_2}{E_1} = \left(\frac{T_1 + \frac{T_1}{2}}{T_1}\right)^4$$

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$$\Rightarrow \frac{E_2}{E_1} = \left(\frac{3}{2}\right)^4$$

$$\Rightarrow \frac{E_2}{E_1} = \frac{81}{16}$$

$$\Rightarrow \left(\frac{E_2}{E_1} - 1\right) \times 100 = \left(\frac{81}{16} - 1\right) \times 100\%$$

$$\Rightarrow \frac{65 \times 100}{16}$$

= 406.25%

19. One end of a metal rod of length 1.0 m and area of cross-section 100cm^2 is maintained at 100^{0}C. If the other end of the rod is maintained at 0^{0}C, the quantity of heat transmitted through the rod per minute is $\left[K = 100 wkg^{-1}k^{-1}\right]$ **(2000 M)**

1) 3×10^3 J 2) 6×10^3 J 3) 9×10^3 J 4) 12×10^3 J

Ans : 2

Sol: Rate of heat energy conducted = $\frac{\theta}{t} = \frac{KA(\theta_1 - \theta_2)}{d}$ = 100JS^{-1}

Quantity of heat transmitted per minute

$\theta = 100 \times 60 = 6 \times 10^3$ Joule

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