PHYSICS

BOOKS - CP SINGH PHYSICS (HINGLISH)

HEAT TRANSFER

Example

1. A metal frame of total length $50cm$ ad croos-sectional area $0.20cm^2$ froms five sides of a regular hexagon. The free ends are maintained at $20^\circ C$ and $40^\circ C$. Find the rate of heat flow through a cross-section of the frame $(K = 50W/m^\circ C)$

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2. (a) One end of a steel rod $(K = 46J/m - s - .^\circ C)$ length $1.0m$ is kept in ice at 0^C and the end is kept in boling water at $100^\circ C$. The area of cross-section of the rod is $0.4cm^2$. Assuming no heat loss to atmosphere, find the mass of of the ice melting per second. Latent heat of fusion of ice $= 3.36 \times 10^5 J/kg$

(b) An icebox almost completely filled with ice at $0^\circ C$ is dipped into a large volume of water at $20^\circ C$. The box has walls of surface area $2400cm^2$, thickness $2.0mm$ and thermal conductivity $0.6W/m -^\circ C$. Calculate the rate at which the ice melts in the box. Latent heat of fusion if ice $= 3.4 \times 10^5 J/kg$.

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3. Water is boiled in a container having a bottom of surface area $25cm^2$, thickness $1.0mm$ and thermal conductivity $50Wm^{-1}.^\circ C^{-1}$, $100g$ of water is converted into steam per minute in the steady state after the boiling starts.Assuming that no heat is lost to the atmosphere, calculate the temperature of the lower surface of the bottom. Latent heat of vaporization of water $= 2.26 \times 10^6 Jkg^{-1}$.

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4. A composite slab is prepared by pasting two plates of thickness L_1 and L_2 and thermal conductivites K_1 and K_2 . The slab have equal cross-sectional area. Find the equivalent conductivity of the composite slab.

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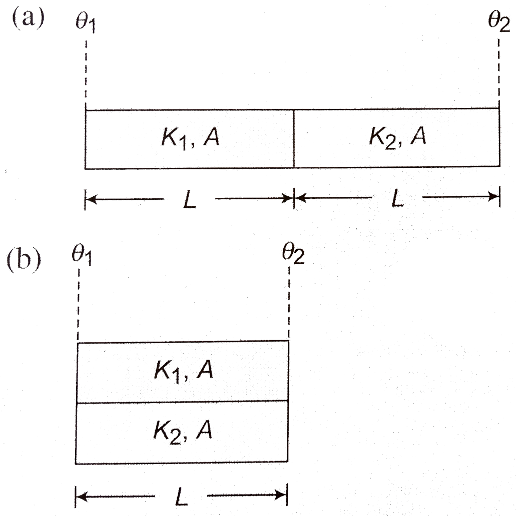
5. Find equivalent thermal conductivity in the following cases:



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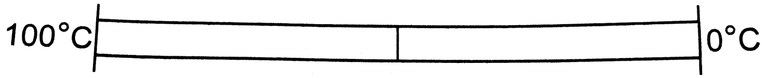
6. The two rods shown in figure have identical geometrical dimension. They are in contact with two heat baths at temperature $100^{\circ} C$ and $0^{\circ} C$. The temperature of the junction is $70^{\circ} C$. Find the temperature of the junction if the rods are

interchanged.



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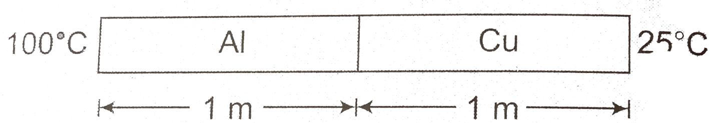
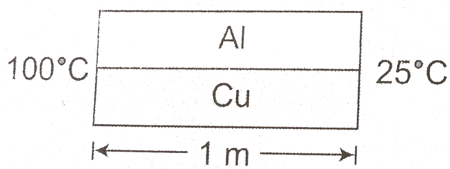
7. An aluminium rod and copper rod of equal length $1m$ and cross-sectional area $1cm^2$ are welded as shown. $K_{A1} = 200W/m^\circ C, K_{Cu} = 400W/m^\circ C$. Find heat current

(a)



(b)



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8. The ends of a metre stick are maintained at $100^\circ C$ and $0^\circ C$. One end of a rod is maintained at $25^\circ C$. Where should its other end be touched on the metre stick so that there is no heat current in the rod in steady state?

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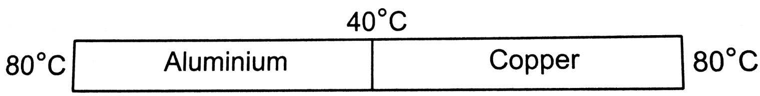
9. Figure shows an aluminium rod joined to a copper rod. Each of the rods has a length of $20cm$ and area of cross section $0.20cm^2$. The junction is maintained at a constant temperature $40^\circ C$ and the two ends are

maintained at $80^{\circ} C$. Calculate the amount of heat taken out from the cold junction in one minute after the steady state is reached. The conductivities are $K_{Al} = 200 W m^{-1} . ^{\circ} C^{-1}$. and $K_{Cu} = 400 W m^{-1} . ^{\circ} C^{-1}$.



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10. (a) Three rod of lengths $20 cm$ each and area of cross-section $1 cm^2$ are joined to form a triangle ABC. The conductivities of the rods are $K_{AB} = 50 J / m - s - . ^{\circ} C, K_{BC} = 200 J / m - s - . ^{\circ} C$ and $K_{AC} = 400 J / m - s - . ^{\circ} C$. The junctions A, B

and C are maintained at $40^\circ C$, $80^\circ C$ and $80^\circ C$ respectively. Find the rate of heat flowing through the rods AB, AC and BC.

(b) A semicircular rod is joineted as its end to a straight rod of the same material and the same cross-sectional area. The straight rod forms a diameter of the other rod. The junctions are maintained at different temperatures. Find the ratio of the heat transferred through a cross-section of the simicircular rod to the heat transferred through a cross-section of the straight rod in a given time.

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11. The three rods shown in figure have identical geometrical dimensions. Heat flows from the hot end at a rate of $40W$ in the arrangement (a). Find the rates of heat flow when the rods are joined as in arrangement (b) and in (c). Thermal conductivities of aluminium and copper are $200Wm^{-1}.^{\circ}C^{-1}$ and $00Wm^{-1}.^{\circ}C^{-1}$ respectively.

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12. A room has a window fitted with a single $0.1m \times 2.0m$ glass of thickness 2mm. (a) Calculate the rate of heat flow through the closed window when the temperature inside the room is $32^{\circ} C$ and that outside is $40^{\circ} C$. (b) The glass is now replaced by two glasspane, each having a thickness of $1mm$ and separated by a distance of $1mm$. Calculate the rate of heat flow under the same condition of temperature. Thermal conductivity of window glass $= 1.0 Js^{-1} m^{-1} .^{\circ} C^{-1}$ and that of air $= 0.025 Js^{-1} m^{-1} .^{\circ} C^{-1}$.

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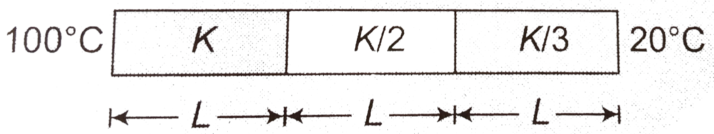
13. Three identical rods are joined in series as shown. Their thermal conductivities are K, $K/2$ and $K/3$ respectively. At steady, if the free ends of rods are at $100^{\circ} C$ and $20^{\circ} C$ respectively. Determine the temperature at two junction points. Also find the equivalent thermal conductivity.



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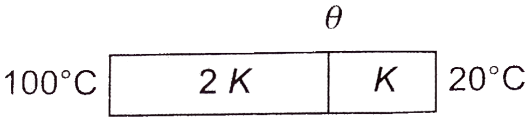
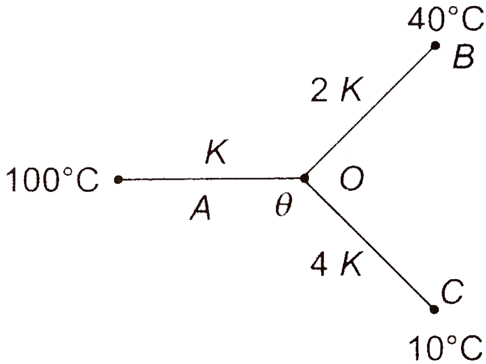
14. In the following situations, the length and area of cross-section of each rod is same. Find temperature θ at junction of rods.

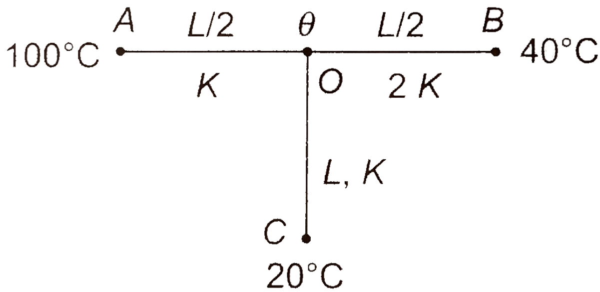
(a)


θ
100°C
2 K
K
20°C

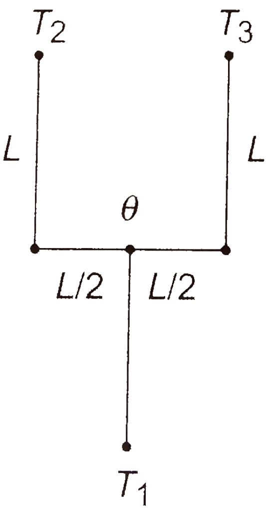
(b)


40°C
B
2 K
K
100°C
O
A
θ
4 K
C
10°C

(c)


A
L/2
θ
L/2
B
100°C
40°C
K
O
2 K
L, K
C
20°C

(d)


T2
T3
L
L
θ
L/2
L/2
T1

(a)

(b)

(c)

(d)

The thermal conductivity of each rod is K.

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15. A rod of negligible heat capacity has length L, area of cross-section A and thermal conductivity K. The temperature of one end is maintained at $0^\circ C$ and the other end is slowly linearly varied from $0^\circ C$ to $\theta_0^\circ C$ in time t_0 Assuming no loss of heat through the sides, find the total heat transimitted through the rod in time t_0

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16. On a winter day when the atmospheric temperature drops to $-10^\circ C$, ice form on the surface of a lake.

(a) Calculate the rate of increases of thickness of the ice when $10cm$ of ice is already formed.

(b) Calculate the total time taken in forming $10cm$ of ice. Assume that the temperature of the entire water reaches $0^\circ C$ before the ice starts froming. Density of water $=1000kg/m^3$, latent heat of fusion of ice $=3.36\times10^5 J/kg$ and thermal conductivity of ice $=1.7W/m-^\circ C$. Neglect the expansion of water on freezing

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17. Consider the situation of the previous problem. Assume that the temperature of the water at the botton of the lake remains constant at $4^\circ C$ as the ice forms on the surface (the heat required to maintain the temperature of the bottom layer may come from the bed of the lake). The depth of the lake is $1.0m$. Show that the thickness of the ice formed attains a steady state maximum value. Find this value. The thermal conductivity of water $= 0.50Wm^{-1}.^\circ C^{-1}$. Take other relevent data form the previous problelm.

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18. Calculate the amount of heat radiated per second by a body of surface are $10cm^2$ kept in thermal equilibrium in a roomat temperature $27^\circ C$. The emissivity of the surface $= 0.80$ and Stefan's constant

$\sigma \cong 6 \times 10^{-8} W / m^2 K^4$

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19. A spherical tungsten piece of radius $\frac{1}{\sqrt{\pi}} cm$ is suspended in an evacuated chamber maintained at $200K$. The piece is maintained at $400K$ by heating it electrically. Find the rate at which the electrial energy must be supplied. The emissivity of tungsten is 0.50, the Steafan constant σ is $6.0 \times 10^{-8} W / m^2 - K^4$

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20. A cubical block of mass $1.0kg$ and edge $5.0cm$ is heated to $227^{\circ}C$. It is kept in an evacuated chamber maintained at $27^{\circ}C$. Assming that the block emits radiation like a blackbody, find the rate at which the temperature of the block will decreases. Specific heat capacity of the material of the block is $400Jkg^{-1}K^{-1}$.

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21. A solid aluminium sphere and a solid copper sphere of twice the radius are heated to the same temperature and are allowed to cool under identical surrounding temperature. Assume that the emissivity of both the spheres is the same. Find the ratio of

(a) the rate of heat from the aluminium sphere to the rate of heat loss from the copper sphere and

(b) the rate of fall of temperature of the the aluminium sphere to the rate of fall temperature of teh copper sphere. The specific heat capacity of aluminium $= 900 J/kg-^{\circ} C$ and that of copper $= 390 J/kg-^{\circ} C$. The density of copper is `3.4 times the density of aluminium.

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22. One end of a rod length $20 cm$ is inserted in a furnace at $800 K$. The sides of the rod are covered with an insulating material and the other end emits radiation like a blackbody. The temperature of this end is $750K$ in the steady state. The temperature of the surrounding air is $300K$. Assuming radiation to be the only important mode of energy transfer between the surrounding and the open end of the rod, find the thermal conductivity of the rod. Stefan constant $\sigma = 6.0 \times 10^{-1} Wm^{-2}K^{-4}$.

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23. A solid copper sphere (density rho and specific heat c) of radius r at an initial temperature $200K$ is suspended inside a chamber whose walls are at almost $0K$. The time required for the temperature of the sphere to drop to 100K is ....

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24. A body cools down from $50^\circ C$ to $45^\circ C$ in 5 minutes and to $40^\circ C$ in another 8 minutes. Find the temperature of the surrounding.

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25. The temperature of a body falls from $40^\circ C$ to $30^\circ C$ in 10 min when placed in a surrounding of constant temperature $15^\circ C$. Find the time taken for the temperature of the body to becomes $20^\circ C$

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26. A calorimeter contains $10g$ of water at $20^{\circ} C$. The temperature falls to $15^{\circ} C$ in 10 min. When calorimeter contains $20g$ of water at $20^{\circ} C$, it takes 15 min for the temperature to become $15^{\circ} C$. Find the water equivalent of the calorimeter.

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27. A metal ball of mass $1kg$ is heated by means of a $20W$ heater in a room at $20^{\circ} C$. The temperature of the ball becomes steady at $50^{\circ} C$. (a) Find the rate of loss of heat to the surrounding when the ball is at $50^{\circ} C$. (b) Assuming Newton's law of cooling, calculate the rate of loss of heat to the surrounding when the ball is at $30^{\circ} C$.

(c) Assume that the temperature of the ball rises uniformly from $20^{\circ} C$ to $30^{\circ} C$ in 5 minutes. Find the total loss of heat to the surrounding during this period. (d) Calculate the specific heat capacity of the metal.

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28. A hot body placed in a surrounding of temperature θ_0 obeys Newtons's law of cooling $d\theta / dt = -k(\theta - \theta_0)$. Its temperature at $t = 0$ is θ_1. The specific heat capacity of the body is s and its mass is m.

Find

(a) the maximum heat that the body can lose and

(b) the time starting from $t = 0$ in which it will lose 90% of this maximum heat.

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29. Two bodies A and B have thermal emissivities of 0.01 and 0.081 respectively. The outer surface areas of the two bodies are same. The two bodies emit total radiant power at the same rate. The wavelength λ_B corresponding to maximum spectral radiancy in the radiation from B is shifted radiancy in the radiation from A by $1.00\mu m$. If the temperature of A is $5802K$, calculate

(a) the temperature of B and

(b) wavelength λ_B

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Exercises

1. When two ends of a rod wrapped with cotton are maintained at differences and after some time every point of the rod attains a constant temperature, then

A. Condition of heat at different points of the rod stops becasuse the temperature is not increasing

B. rod is bad conductor of heat

C. heat is being radiated from each point of the rod

D. each point of the rod is giving heat to its neighbour at the same rate at which it is receving heat

Answer: D

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2. The thermal conductivity of a rod depends on

A. length

B. mass

C. area of x-section

D. material of the rod

Answer: D

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3. One end of a metal rod is kept in a furnace. In steady state, the temperature of the rod

A. increases decrease

B. decrases

C. remains constant

D. is non-uniform

Answer: D

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4. In a room containing air, heat can go from one place to another

A. conduction converction

B. convection

C. radiation

D. all the three

Answer: D

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5. The two ends of uniform rod of thermal conductivity K are maintained at different but constant temperatre. The temperature gradient at any point on the rod is $d\theta/dx$. The heat flow per unit time per unit cross-section of the rod is I.

(i) $\frac{d\theta}{dx}$ is the same for all point on the rod

(ii) $I = K\frac{d\theta}{dx}$

A. (i) only

B. (ii) only

C. (i), (ii)

D. none

Answer: C

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6. Which of the following circular rods (given radius r and length l) each made of the same material and whose ends are maintained at the same temperature will conduct most heat?

A. $r = 2r_0, l = 2l_0$

B. $r = 2r_0, l = l_0$

C. $r = r_0, l = l_0$

D. $r = r_0, l = 2l_0$

Answer: B

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7. Two rods A and B are of equal lengths. Their ends of kept between the same temperature and their area of cross-section are A_1 and A_2 and thermal conductivities K_1 and K_2. The rate of heat transmission in the two rods will be equal, if

A. $K_1A_2 = K_2A_1$

B. $K_1A_1 = K_2A_2$

C. $K_1 = K_2$

D. $K_1A_1 = K_2A_2$

Answer: B

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8. The temperature gradient in a rod of $0.5m$ length is $80^{\circ}C/m$. It the temperature of hotter end of the rod is $30^{\circ}C$, then the temperature of the cooler end is

A. $40^{\circ}C$

B. $-10^{\circ}C$

C. $10^{\circ}C$

D. $0^{\circ}C$

Answer: B

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9. A cylindrical rod having temperature T_1 and T_2 at its ends. The rate of flow of heat is $Q_1 cal / \sec$. If all the linear dimensions are doubled keeping temperature constant, then rate of flow of heat Q_2 will be

A. $4Q_1$

B. $2Q_1$

C. $\frac{Q_1}{4}$

D. $\frac{Q_1}{2}$

Answer: B

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10. The heat is flowing through two cylinderical rods of same material. The diameters of the rods are in the ratio $1:2$ and their lengths are in the ratio $2:1$. If the temperature difference between their ends is the same, the ratio of rates of flow of heat through them will be

A. $1:4$

B. $4:1$

C. $1:8$

D. $8:1$

Answer: C

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11. Two identical vessels are filled with equal amounts of ice. The vessels are made from different materials. If the ice melts in the two vessels in times t_1 and t_2 respectively, then their thermal conductivities are in the ratio

A. $t_1 : t_2$

B. $t_2 : t_1$

C. $t_1^2 : t_2^2$

D. $t_2^2 : t_2^1$

Answer: B

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12. One end of a themally insulated copper rod of length $1m$ long and of $10cm^2$ in X-section is immersed in boiling water $(100^\circ C)$ and the other in ice $(0^\circ C)$. If $K_{Cu} = 0.92cal/cm./s/.^\circ C$ and $L_{ice} = 80cal/g$, the ice that will melt per minute is

A. $5.9g$

B. $6.9g$

C. $8.4g$

D. $9.2g$

Answer: B

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13. A glass window conducts out a certain quantity of heat per second when the inside temperature is $10^\circ C$ and the outside temperature is $-10^\circ C$. The same quantity of heat will be conductued in through the window per second when the inside temperature is $-43^\circ C$ and the outside temperature is

A. $43^\circ C$

B. $-23^\circ C$

C. $23^\circ C$

D. $0^\circ C$

Answer: B

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14. Two walls of thicknes l_1 and l_2 and ther-mal condctivities K_1 and K_2 are in contact In the steady state, if the temperature at the outer faces are T_1 and T_2 find the temperature at the common wall .

A. $\dfrac{K_1T_1D_2 + K_2T_2d_1}{K_1D_2 + K_2d_1}$

B. $\dfrac{K_1T_1 + K_2T_2}{d_1 + d_2}$

C. $\left(\dfrac{K_1d_1 + K_2d_2}{T_1 + T_2}\right)T_1T_2$

D. $\dfrac{K_1d_1T_1 + k_2d_2T_2}{K_1d_1 + K_2d_2}$

Answer: A

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15. A slab consists of two layers of different materials of the same thickness and having thermal conductivities K_1 and K_2. The equivalent thermal conductivity of the slab is

A. $K_1 + K_2$

B. $\dfrac{K_1 K_2}{K_1 + K_2}$

C. $\sqrt{K_1 K_2}$

D. $\dfrac{2K_1 K_2}{K_1 + K_2}$

Answer: D

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16. Two rods of the same length and diameter, having thermal conductivities K_1 and K_2, are joined in parallel. The equivalent thermal conductivity to the combinationk is

A. $\frac{K_1 K_2}{K_1 + K_2}$

B. $K_1 K_2$

C. $\frac{K_1 + K_2}{2}$

D. $\sqrt{K_1 K_2}$

Answer: C

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17. Consider a compound slab consisting of two different material having equal thickness and thermal conductivities K and $2K$ respectively. The equivalent thermal conductivity of the slab is

A. $2K$

B. $3K$

C. $\frac{4K}{3}$

D. $\frac{2K}{3}$

Answer: D

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18. A cylinder of radius R made of a material of thermal conductivity K_1 is surrounded by a cylindrical shell of inner radius R and outer radius 2R made of a material of thermal conductivity K_2. The two ends of the combined system are maintained at two different temperatures. There is no loss of heat across the cylindrical surface and the system is in steady state. The effective thermal conductivity of the system is

A. $K_1 + K_2$

B. $\frac{K_1 K_2}{K_1 + K_2}$

C. $\frac{K_1 + 3K_2}{4}$

D. $\frac{3K_1 + K_2}{4}$

Answer: C

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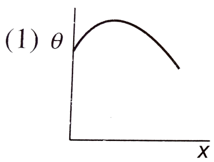
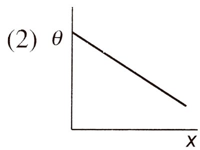
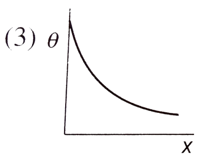
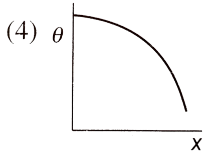
19. A long metallic bar is carrying heat from one of its ends to the other end under steady-state. The variation of temperature θ along the length x of the bar from its hot end is best described by which of the following figures?

A. 

B. 

C. 

D. 

Answer: B

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20. A and B are two points on uniform metal ring whose centre is O The angle $AOB = \theta$ A and B are maintaind at two different constant temperatures When $\theta = 180^\circ$ the rate of total heat flow from A to B is $1.2W$ When $\theta = 90^\circ$ this rate will be .

A. $0.6W$

B. $0.9W$

C. $1.6W$

D. $1.8W$

Answer: C

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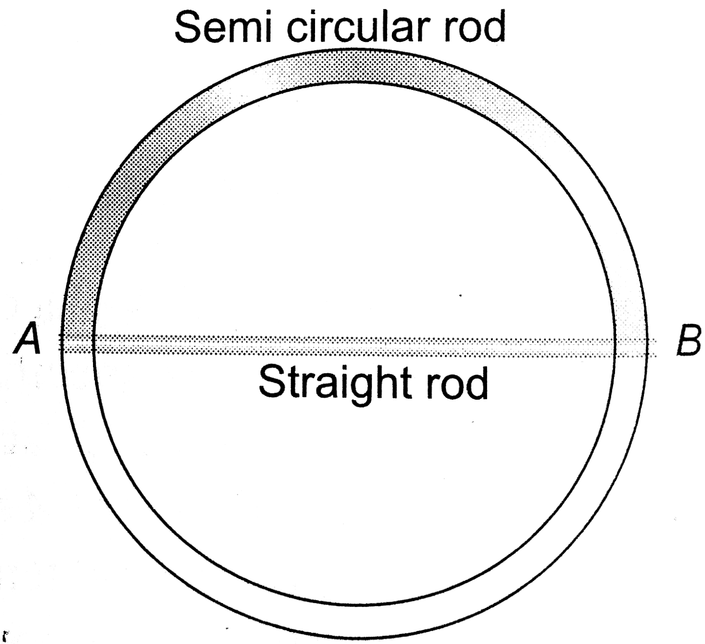
21. Two rods (one semi-circular and other straight) of same material and of same cross-sectional area are joined as shown in the figure. The point A and B are maintained at different temperature. Find the ratio of the heat transferred through a cross-section of a semi-circular rod to the heat transferred through a cross section of the straight rod in a given time.



A. $2 : \pi$

B. $1 : 2$

C. $\pi : 2$

D. $3 : 2$

Answer: A

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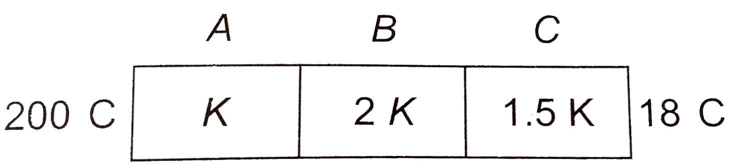
22. Three rods A, B and C of the same length and cross-sectional area are joined in series as shown. The temperature at the junction of A and B, in equilibriu, is



A. $74^{\circ} C$

B. $116^{\circ} C$

C. $156^{\circ} C$

D. $148^{\circ} C$

Answer: B

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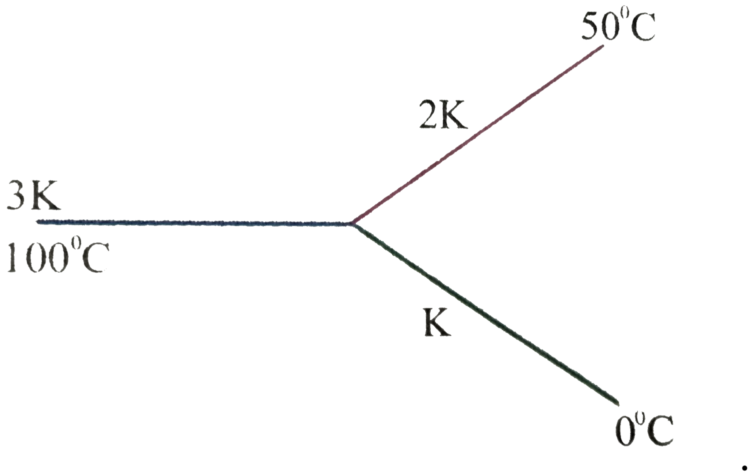
23. Three rods of same dimensions have thermal condutivity $3K$, $2K$ and K They are arranged as shown in Then the temperature of the junction in steady state is



A. $75^\circ C$

B. $\frac{200}{3} . ^\circ C$

C. $40^\circ C$

D. $\frac{100}{3} . ^\circ C$

Answer: B

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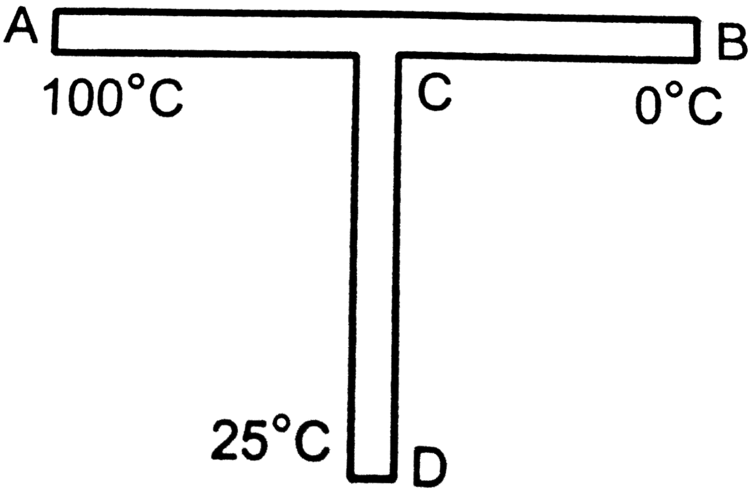
24. A rod CD of thermal resistance $5.0KW_{-1}$ is joined at the middle of an identical rod AB as shown in figure. The ends A,B and D are maintained at $100^\circ C$, $0^\circ C$ and

$25^\circ C$ respectively. Find the heat current in CD.



A. $35^\circ C, 4W$

B. $45^\circ C, 4W$

C. $35^\circ C, 3W$

D. $45^\circ C, 3W$

Answer: B

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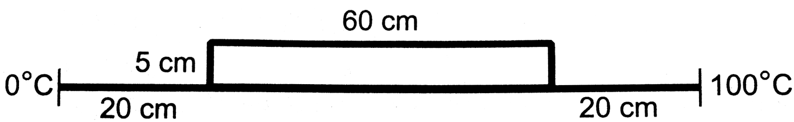
25. Consider the situation shown in figure. The frame is made of the same material and has a uniform cross-section area everywhere. Calculate the amount of heat flowing per second through a cross section of the bent part if the total heat taken out per second from the end at $100^{\circ} C$ is $130 J$.



A. $130 J$

B. $60 J$

C. $70 J$

D. $80 J$

Answer: B

Watch Video Solution

26. A wall has two layers A and B each made of different materials. Both the layers have the same thickness. The thermal conductivity of materials A is twice of B. Under thermal equilibrium temperature difference across the layer B is $36^\circ C$. The temperature difference across layer A is

A. $6^\circ C$

B. $12^\circ C$

C. $18^\circ C$

D. $24^{\circ} C$

Answer: B

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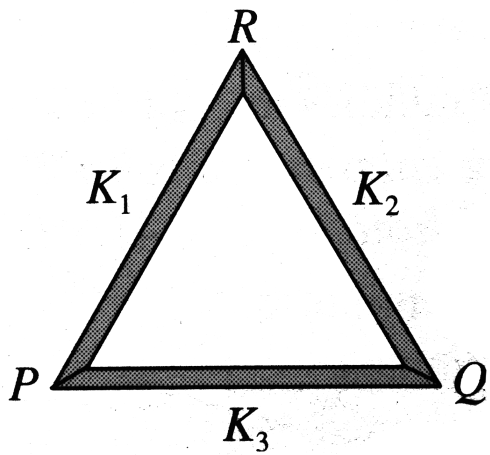
27.



Three rods of same dimensions are arranged as shown in Fig. They have thermal conductivities K_1,K_2 and K_3. The points P and Q are maintained at different temperature for the heat to flow at the same rate along PRQ and PQ.

Which of the following options correct?

A. $K_3 = \frac{1}{2}(K_1 + K_2)$

B. $K_3 = K_1 + K_2$

C. $K_3 = \frac{K_1 K_2}{K_1 + K_2}$

D. $K_3 = 2(K_1 + K_2)$

Answer: C

Watch Video Solution

28. Three rods of identical cross-sectional area and made from the same metal from the sides of an isosceles triangle ABC, right-angled at B. The point A and B are maintained at temperatures T and $\sqrt{2}$ T respectively. In the steady state, the temperature of the point C is T_c. Assuming that only heat conduction takes places, T_c / T is

A. $\frac{1}{\left(\sqrt{2}+1\right)}$

B. $\frac{2}{\left(\sqrt{2}+1\right)}$

C. $\frac{1}{2\left(\sqrt{2}-1\right)}$

D. $\frac{1}{\sqrt{3}\left(\sqrt{2}1\right)}$

Answer: B

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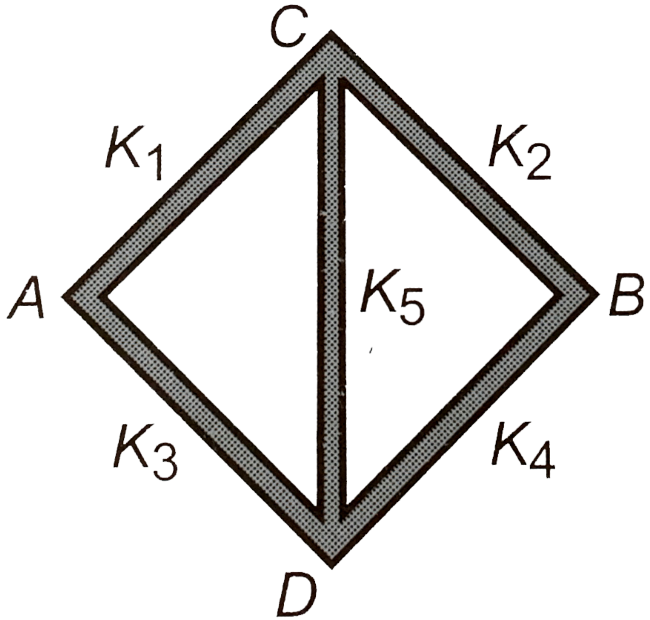
29. Five rods of same dimensions are arrranged as shown in the figure. They have thermal conductivities K_1, K_2, K_3, K_4 and K_5. When points A and B are maintained at different themperature, no heat flows through the central rod if



A. $K_1 = K_4$ and $K_2 = K_3$

B. $K_1 K_4 = K_2 K_3$

C. $K_1K_2 = K_3K_4$

D. $\frac{K_1}{K_4} = \frac{K_2}{K_3}$

Answer: B

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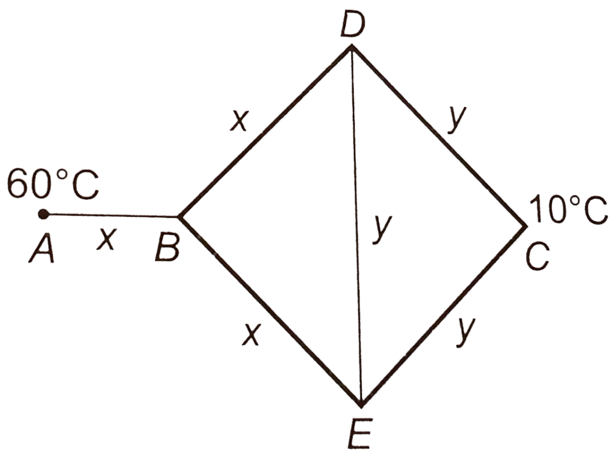
30. Consider the 6 idential rods as shown in figure, the conductivity of x is double that of y. The temperatre of the junciton B is



A. $30^\circ C$

B. $40^\circ C$

C. $50^\circ C$

D. $20^\circ C$

Answer: B

View Text Solution

31. A cylindrical rod with one end in a steam chamber and the other end in ice results in melting of 0.1 g of ice per second. If the rod is replaced by another with half the length and double the radius of the first and if the thermal conductivity of material of second rod is 1/4 that of first, the rate at which ice melts in g/s will be

A. 3.2

B. 1.6

C. 0.2

D. 0.1

Answer: C

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32. Two identical conducting rods are first connected independently to two vessels, one containing water at $100^\circ C$ and the other containing ice at $0^\circ C$. In the second case, the rods are joined end to end and connected to the same vessels. Let q_1 and q_2 gram per second be the rate of melting of ice in the two cases respectively. The ratio $\frac{q_1}{q_2}$ is

(a) $\frac{1}{2}$ (b) $\frac{2}{1}$ (c) $\frac{4}{1}$ (d) $\frac{1}{4}$

A. $1/2$

B. $2/1$

C. $4/1$

D. $1/4$

Answer: C

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33. A metal rod AB of length 10x has its one end A in ice at $0^\circ C$, and the other end B in water at $100^\circ C$. If a point P one the rod is maintained at $400^\circ C$, then it is found that equal amounts of water and ice evaporate and melt per unit time. The latent heat of evaporation of water is $540cal/g$ and latent heat of melting of ice is $80cal/g$. If the point P is at a distance of λx from the ice end A, find the value λ. [Neglect any heat loss to the surrounding.]

A. 9

B. 2

C. 6

D. 1

Answer: A

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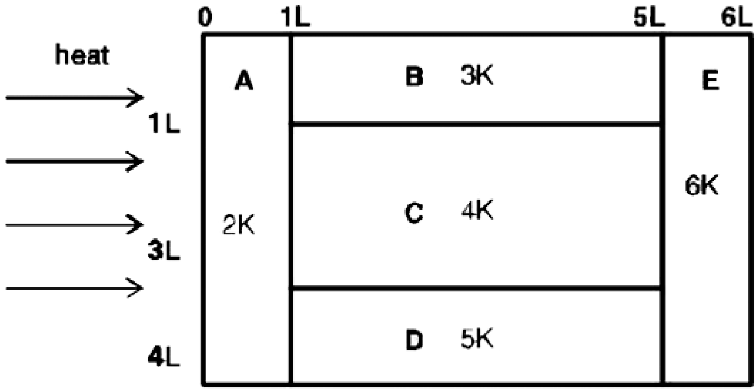
34. A composite block is made of slabs A,B,C,D and E of different thermal conductivities (given in terms of a constant K and sizes (given in terms of length, L) as shown in the figure. All slabs are of same width. Heat 'Q' flows only from left to right through the blocks. Then in steady state



A. (i),(ii)

B. (i), (ii), (iii)

C. (i), (iii),(iv)

D. (ii), (iv)

Answer: C

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35. According to the experiment of Ingen Hauze the relation between the thermal conductivity of a metal rod is K and the length of the rod whenever the wax melt is

A. K / l = constant

B. K^2 / l = constant

C. K / l^2 = constant

D. Kl = constant

Answer: C

View Text Solution

36. If the ratio of coefficient of thermal conductivity of silver and copper is $10:9$, then the ratio of the length upto which wax will melt in Ingen Hauze experiment will be

A. $6:10$

B. $\sqrt{10}:3$

C. $100:81$

D. $81:100$

Answer: B

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37. Temperature of water at the surface of lake is $-20^\circ C$. Then temperature of water just below the lower surface of ice layer is

A. $-4^\circ C$

B. $0^\circ C$

C. $4^\circ C$

D. $-20^\circ C$

Answer: B

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38. Ice starts forming in lake with water at $0^{\circ} C$ and when the atmospheric temperature is $-10^{\circ} C$. If the time taken for $1 cm$ of ice be 7 hours. Find the time taken for the thickness of ice to change from $1 cm$ to $2 cm$

A. 7 hours

B. 14 hours

C. lt 7 hours

D. gt 14 hours

Answer: D

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39. A $5cm$ thick ice block is there on the surface of water in a lake. The tmeperature of air $-10^{\circ}C$, how muct time it will take to double the thickness of the block?

$\left(L = 80cal/g, K_{ice} = 0.004cal/s - K, d_{ice} = 0.92gcm^{-3}\right)$

A. $1hour$

B. $191hour$

C. $19.1hour$

D. $1.91hour$

Answer: C

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40. In a 10 m deep lake, the bottom is at a constant temperature of $4^{\circ} C$. The air temperature is constant at $-4^{\circ} C$. $K_{ice} = 3K_{\omega}$. Neglecting the expansion of water on freezing, the maximum thickness of ice will be

A. $7.5m$

B. $6m$

C. $5m$

D. $2.5m$

Answer: A

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41. In heat transfer, which method is based on gravitation ?

A. Natural converction

B. Conduction

C. Radiation

D. Stirring of liquids

Answer: A

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42. When fluids are heated from the bottom, convection currents are prodcued because

A. molecular motion of fluid becomes aligned

B. molecular collisions take place within the fluid

C. heated fluid becomes more dense than the cold fluid above it

D. heated fluid becomes less dense than the cold fluid above it

Answer: D

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43. If a liquid is heated in weightlessness, the heat is tramsmitted thruogh

A. conduction

B. convectin

C. rediation

D. neither, because the liquid connot be heated in weightlessness

Answer: A

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44. In summer, a mild wind is often found on the shore of a clam river. This is caused due to

A. difference in thermal conductivity of water and soil

B. convection currents

C. conduction between air and the soil

D. radiation from the soil

Answer: B

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45. The process in which rate of transfer of heat maximum is .

A. Conduction

B. convection

C. radiation

D. In all these, heat is transferred with the same velocity

Answer: C

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46. Which of the following law states that "good absorbers of heat are good emitters"

A. Stefan's law

B. Kirchhoff's law

C. Planck's law

D. Wien's law

Answer: B

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47. For a perfectly black body, its abosrpitve power is

A. 1

B. 0.5

C. 0

D. infinity

Answer: A

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48. At a certain temperature for given wavelength, the ratio of emissive power of a body to emmisve power of black body in same circumstance in known as

A. relative emissivity

B. emmissivity

C. absorption coefficient

D. coefficient of reflection

Answer: B

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49. Three objects coloured black, gray and white can withstand hostile conditions upto $2800^\circ C$. These objects are thrown into a furance where each of them attains a temperature of $2000^\circ C$. Which object will glow brightest?

A. The white object

B. The black object

C. All glow with equal brightness

D. Gray object

Answer: B

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50. An ideal Black-body at room temperature is thrown into a furnace. It is observed that

A. initially it is the darkest body and at later times brightest

B. it is the darkest body at all times

C. it cannot be distinguised at all time

D. initially it is the darkest body and at later times cannot be distinguished

Answer: A

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51. A hot body will radiate maximum energy if its surface is

A. white and polished

B. blank poslished

C. white and rough

D. black and rough

Answer: D

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52. A black body does not

(i) emit radiation (ii) absorb radiation

(iii) reflect radiation (iv) refract radiation

A. (i), (iii)

B. (ii), (iii)

C. (iii), (iv)

D. (i), (ii)

Answer: C

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53. The thermal radiation emited by a body is proportional to T^n where T is its absolute temperature. The value of n is exactly 4 for

A. a blackbody

B. all bodies

C. bodies painted black only

D. polished bodies only

Answer: B

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54. A spherical black body with a radius of 12 cm radiates 450 watt power at 500 K. If the radius were halved and the temperature doubled, the power radiated in watt would be

A. 225

B. 450

C. 900

D. 1800

Answer: D

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55. A black body at $227^{\circ}C$ radiates heat at the rate of $7 cal cm^{-2} s^{-1}$. At a temperature of $727^{\circ}C$, the rate of heat radiated in the same unit will be

A. 60

B. 50

C. 112

D. 80

Answer: C

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56. Two spherical black bodies of radii R_1 and R_2 and with surface temperature T_1 and T_2 respectively radiate the same power. R_1 / R_2 must be equal to

A. $\left(\frac{T_1}{T_2}\right)^2$

B. $\left(\frac{T_2}{T_1}\right)^2$

C. $\left(\frac{T_1}{T_2}\right)^4$

D. $\left(\frac{T_2}{T_1}\right)^4$

Answer: B

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57. Two bodies A and B having equal surface areas are maintained at temperatures $10^\circ C$ and $20^\circ C$. The thermal radiation emitted in a given time by A and B are in the ratio

A. $1 : 1.15$

B. $1 : 1$

C. $1 : 2$

D. $1:4$

Answer: A

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58. 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 surronding. There are of cooling will be in the ratio

A. $2:1$

B. $1:1$

C. $1:2$

D. $1:4$

Answer: B

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59. A piece of charcoal and a piece of shining steel of the same surface area are kept for a long time in an open lawn in bright sun.

A. (i), (iii)

B. (ii), (iii)

C. (iii), (iv)

D. (i), (ii)

Answer: C

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60. In a dark room with ambient temperature T_0, a black body is kept at a temperature T. Keeping the temperatre of the black body constant (at T) sunrays are allowed to fall on the black body through a hole in the roof of the dark room. Assuimng that here is no charge in the ambient temperature of room, which of following statement is/are correct (i) The quantity of radiation absorbed by the black body in unit time will increase

(ii) Since emissivity = absorptivity, hence, the equantity increase

(iii) Black body radiation emitted by black body in unit time in the visible spectrum

(iv) The reflected energy in unit time by the black body remains same

A. (i).(ii)

B. (ii), (iii)

C. (ii), (iii), (iv)

D. all

Answer: D

View Text Solution

61. Three very large plates of same area are kept parrallel and close to each other. They are considered as ideal black surfaces and have high thermal conductivity. The first and third plates are maintained at temperatures 2T and 3T respectively. The temperature of the middle (i.e., second) plate under steady state condition is

A. $\left(\frac{65}{2}\right)^{\frac{1}{4}}T$

B. $\left(\frac{97}{4}\right)^{\frac{1}{4}}T$

C. $\left(\frac{97}{2}\right)^{\frac{1}{4}}T$

D. $(97)\&\left(\frac{1}{4}\right)T$

Answer: C

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62. A solid at temperature T_1 is kept in an evacuated chamber at temperature $T_2 > T_1$. The rate of increase of temperature of the body is proportional to

A. $T_2 - T_1$

B. $T_2^2 - T_1^2$

C. $T_2^3 - T_1^3$

D. $T_2^4 - T_1^4$

Answer: D

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63. A system S receives heat continuously from an electric heater of power $10W$. The temperature of S becomes constant at $50^\circ C$ when the surrounding temperature is $20^\circ C$. After the heater is switched off, S cools from $35.1^\circ C$ to $34.9^\circ C$ in $1 \min ute$. the heat capacity of S is

A. $100J/^\circ C$

B. $300J/^\circ C$

C. $750J/^\circ C$

D. $1500J/^\circ C$

Answer: D

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64. A spherical black body of radius r radiates power P, and its rate of cooling is R

(i)$P \propto r$

(ii)$P \propto r^2$

(iii)$R \propto r^2$

(iv)$R \propto \frac{1}{r}$

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65. The temperature of an isolated black body falls from T_1 to T_2 in time t. Let c be a constant

A. $t = c\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$

B. $t = c\left[\frac{1}{T_2^3} - \frac{1}{T_1^2}\right]$

C. $t = c\left[\frac{1}{T_2^3} - \frac{1}{T_1^3}\right]$

D. $t = c\left[\frac{1}{T_2^4} - \frac{1}{T_1^4}\right]$

Answer: C

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66. A solid cube and a solid sphere of the same material have equal surface area. Both are at the same temperature $120^\circ C$, then

A. both the cube and the sphere cool down at the same rate

B. the cube cools down faster than the sphere

C. the sphere cools down faster than the cube

D. whichever is having more mass will cool down cube

Answer: B

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67. A solide sphere and a hollow sphere of the same material and of equal radii are heated to the same temperature

(i) Both will emit equal amount of radiation per unit time in the beginning

(ii) Both will absorb equal amount of radiation from the surrounding in the beginning

(iii) The initial rate of cooling dT/dt will be same for the two spheres

(iv) The two spheres will have equal temperatures at any instant

A. (i),(ii)

B. (ii),(iii)

C. (iii).(iv)

D. (i),(ii)

Answer: A

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68. A sphere at temperature $600K$ is placed in an enviroment to temperature is $200K$. Its cooling rate is H. If its temperature reduced to $400K$ then cooling rate in same enviorment will become

A. $(3/16)H$

B. $(16/3)H$

C. $(9/27)H$

D. $(1/16)H$

Answer: A

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69. Two metallic spheres S_1 and S_2 are made of the same material and have got identical surface finish. The mass of S_1 is thrice that of S_2. Both the spheres are heated to the same high temperature and placed in the same room having lower temperature but are thermally insulated from each other. the ratio of the initial rate of cooling of S_1 to that of S_2 is

$(a)\frac{1}{3}(b)\frac{1}{\sqrt{3}}(c)\frac{\sqrt{3}}{1}(d)\left(\frac{1}{3}\right)^{\frac{1}{3}}$

A. $1/3$

B. $(1/3)^{1/3}$

C. $1/\sqrt{3}$

D. $\sqrt{3}/1$

Answer: B

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70. A sphere, a cube and a thin circular plate, all having the same mass and made of the same material are heated to the same temperature and them allowed to cool. Which of them cools fastest ?

A. Sphere

B. Cube

C. Circular plate

D. All at same rate

Answer: C

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71. If the temperature of the sun were to increase form T to 2T and its radius from R to 2R, then the ratio of the radiant energy received on earth to what it was previously will be

A. 4

B. 16

C. 32

D. 64

Answer: D

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72. If the radius of a star is R and it acts as a black body, what would b the temperature of the star, in which the rate of energy production is Q?

A. $Q/4\pi R^2\sigma$

B. $(Q/4\pi R^2\sigma)^{-1/2}$

C. $(4\pi R^2 Q/\sigma)^{1/4}$

D. $(Q/4\pi R^2\sigma)^{1/4}$

Answer: D

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73. The radiant energy from the Sun incident normally at the surface of earth is $20 kcal / m^2$ min What would have been the radiant energy incident normally on the earth if the sun had a temperature twice of the present one ? .

A. $160 kcal / m^2$ min

B. $40 kcal / m^2$ min

C. $320 kcal / m^2$ min

D. $80 kcal / m^2$ min

Answer: C

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74. Assuming the sun to have a spherical outer surface of radius r radiating like a black body at temperature $t^{\circ}C$. The power received by a unit surface (normal to the incident rays) at a distance R from the centre of the sun is where σ is the Stefan's constant.

A. $\frac{4\pi r^2 \sigma t^4}{R^2}$

B. $\frac{r^2 \sigma (t + 273)^4}{4\pi R^1}$

C. $\frac{16\pi^2 r^2 \sigma t^4}{R^2}$

D. $\frac{r^2 \sigma (t + 273)^4}{R^2}$

Answer: D

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75. Assuming the Sun to be a spherical body of radius R at a temperature of TK, evaluate the total radiant powered incident of Earth at a distance r from the sun

where r_0 is the radius of the Earth and σ is Stefan's constant.

A. $\frac{\pi r_0^2 R^2 \sigma T^4}{r^2}$

B. $\frac{r_0^2 R^2 \sigma T^4}{4\pi r^2}$

C. $\frac{R^2 \sigma T^4}{r^2}$

D. $\frac{4\pi r_0^2 R^2 \sigma T^4}{r^2}$

Answer: A

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76. The sun radiates energy in all directions. The average radiations received on the earth surface from the sun is $1.4\text{kilowatt}/m^2$. The average earth-sun distance is 1.5×10^{11} meters. The mass lost by the sun per day is.

A. $4.4 \times 10^9 kg$

B. $7.6 \times 10^{14} kg$

C. $3.8 \times 10^{12} kg$

D. $3.8 \times 10^{14} kg$

Answer: D

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77. Newton's law of cooling is a special case of .

A. Wien's law

B. Kirchhoff's law

C. Stefan's law

D. Planck's law

Answer: C

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78. A body cools from $50^\circ C$ to $40^\circ C$ in 5 min. The surroundings temperature is $20^\circ C$. In what further times (in minutes) will it cool to $30^\circ C$?

A. 5

B. $15/4$

C. $25/3$

D. 10

Answer: C

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79. In the previous question will be its temperature 5 min after reaching $40^{\circ}C$?

A. $35^{\circ}C$

B. $\frac{100}{(3)^{\circ}}C$

C. $32^\circ C$

D. $30^\circ C$

Answer: B

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80. A body with an initial temperature θ_1 is allowed to cool in a surrounding which is at a constant temperature of $\theta_0(\theta < \theta_1)$ Assume that Newton's law of cooling is obeyed Let $k =$ constant The temperature of the body after time t is best experssed by .

A. $(\theta_i - \theta_0)e^{-kt}$

B. $(\theta_i - \theta_0)$ 1n (kt)

C. $\theta_0 + (\theta_i - \theta_0)e^{-kt}$

D. $\theta_i e^{-k} - \theta_0$

Answer: C

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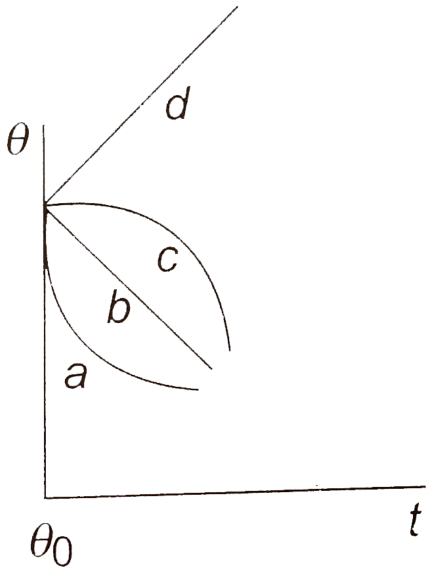
81. A hot liquid is kept in a big room. Its temperature is plotted as a function of time. Which of the following curves may present the plot ?



A. a

B. b

C. c

D. d

Answer: A

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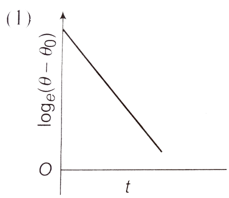
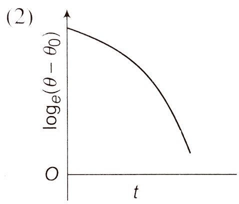
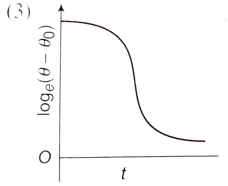
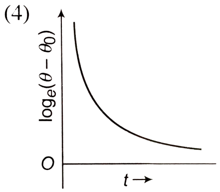
82. A liquid in a beaker has temperature $\theta(t)$ at time t and θ_0 is temperature of surroundings, then according to Newton's law of cooling the correct graph between $\log_e(\theta - \theta_0)$ and t is :

A. 

B. 

C. 

D. 

Answer: A

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83. A hot liquid is kept in a big room. The logarithm of the numerical value of the temperature difference between the liquid and the room is plotted against time.The plot will be very nearly

A. a straight line

B. a circular are

C. a parabola

D. an ellips

Answer: A

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84. Two solid spheres of radii R_1 and R_2 are made of the same material and have similar surfaces. These are raised to the same temperature and then allowed to cool under identical conditions. The ratio of their initial rates of loss of heat are

A. $\frac{R_1}{R_2}$

B. $\frac{R_2}{R_1}$

C. $\frac{R_1^2}{R_2^2}$

D. $\frac{R_2^2}{R_1^2}$

Answer: C

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85. In previous problem, the ratio of the initial rates of cooling (i.e., rates of fall of temperature) is

A. $\frac{R_1}{R_2}$

B. $\frac{R_2}{R_1}$

C. $\frac{R_1^2}{R_2^2}$

D. $\frac{R_2^2}{R_1^2}$

Answer: B

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86. Relation between the colour and the temperature of a star in given by

A. Wien's displacement law

B. Planck's law

C. Hubble's law

D. Fraunhoffer diffraction law

Answer: A

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87. A black body has maximum wavelength λ_m at temperature $2000K$. Its corresponding wavelength at temperature 3000 will be

A. $\frac{3}{2}\lambda_m$

B. $\frac{2}{3}\lambda_m$

C. $\frac{4}{9}\lambda_m$

D. $\frac{9}{4}\lambda_m$

Answer: B

88. The intensity of radiation emitted by the sun has its maximum value at a wavelength of 510 nm and that emitted by the North star has the maximum value at 350 nm. If these stars behave like black bodies, then the ratio of the surface temperatures of the sun and the north star is

A. 1.46

B. 0.69

C. 1.21

D. 0.83

Answer: B

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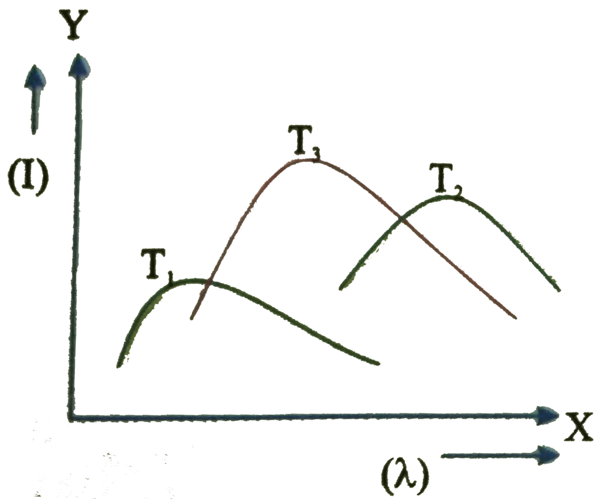
89. The plots of intensity versus wavelength for three black bodies at temperatures T_1, T_2 and T_3 respectively are shown in Their temperatures are shown in How their temperatures are related ?



A. $T_1 > T_2T_3$

B. $T_1 > T_3T_2$

C. $T_2 > T_3T_1$

D. $T_3 > T_2T_1$

Answer: B

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90. A black body is at a temperature of $2800K$ The energy of radiation emitted by this object with wavelength between $499nm$ and 500 nm is U_1 between 999nm and 1000nm is U_2 and between 1499 nm and 1500 nm is U_3 The Wien's constant $b = 2.80 \times 10^6$ nm K Then .

A. $U_1 = 0$

B. $U_3 = 0$

C. $U_1 > U_2$

D. $U_2 > U_1$

Answer: D

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91. The power radiated by a black body is P and it radiates maximum energy around the wavelength λ_0 If the temperature of the black body is now changed so that it radiates maximum energy around a wavelength $3\lambda_0 / 4$ the power radiated by it will increase by a factor of .

A. $\frac{4}{3}$

B. $\frac{16}{9}$

C. $\frac{64}{27}$

D. $\frac{256}{81}$

Answer: D

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92. A heater body emits radiation which has maximum intensity near the frequency v_0 The emissivity of the material is 0.5 . If the absolute temperature of the body is doubled,

A. (i), (iii)

B. (ii), (iii)

C. (iii), (iv)

D. (i), (ii)

Answer: B

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93. Three discs, A, B and C having radii 2m, 4m and6m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are $300nm$, $400nm$ and $500nm$, respectively. The power radiated by them are Q_A, Q_B and Q_C respectively

(a) Q_A is maximum (b) Q_B is maximum (c) Q_C is maximum

(d) $Q_A = Q_B = Q_C$

A. Q_a is maximum

B. Q_b is maximum

C. Q_C is maximum

D. $Q_a = Q_b = Q_c$

Answer: C

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94. Make the pairs

$A.$	Thermal conductivity	(i)	$MLT^{-3}K^{-1}$
$B.$	Thermal resistance	(ii)	$M^{-1}L^{-2}T^{3}K$
$C.$	Stefan's constant	(iii)	$MT^{-3}K^{-4}$
$D.$	Wien's constant	(iv)	LK

A. $\begin{matrix} \text{A} & B & C & D \\ (i) & (ii) & (iii) & (iv) \end{matrix}$

B. $\begin{matrix} \text{A} & B & C & D \\ (ii) & (i) & (iv) & (iii) \end{matrix}$

C. $\begin{matrix} \text{A} & B & C & D \\ (iv) & (iii) & (ii) & (i) \end{matrix}$

D. $\begin{matrix} \text{A} & B & C & D \\ (iv) & (ii) & (iii) & (i) \end{matrix}$

Answer: D

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