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PHYSICS

BOOKS - BHARATI BHAWAN PHYSICS (HINGLISH)

CONDUCTION OF HEAT AND RADIATION

Others

1. A vessel of surface area $1m^2$ made of a copper sheet of thicknes $5mm$ is filled with melting ice and is immersed in water at $100^\circ C$. Calculate the rate at which the ice melts. The conductivity of copper is $302.4Js^{-1}m^{-1}K^{-1}$ and the latent heat of fusion of ice is $336 \times 10^3 Jkg^{-2}$

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2. Two flat metal plates area placed with their surfaces in contact and their outer surfaces are maintained at temperatures of $100^\circ C$ and $0^\circ C$ respectively. If the thicknes of the plates are $2cm$ and $1cm$ and their thermal conductivities are $10calm^{-1}K^{-1}s^{-1}$ and $20calm^{-1}K^{-1}s^{-1}$ respectively, find the temperature of the surfaces in contact.

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3. Calculate the rate of increment of the thickness of the layer of ice on a lake when the thickness of is $20cm$ and the air temperature is $-40^\circ C$. Thermal conductivity of ice $= 1.68Ks^{-1}m^{-1}K^{-1}$, density of ice $920kgm^{-3}$ and latent heat capacity of ice $= 336 \times 10^3 Jkg^{-1}K^{-1}$.

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4. When the air temperature is $-10^{\circ}C$, the ice on a large shallow lake in creases by $1cm$ in $12 \min utes$. Find the thermal conductivity of ice. (Density of ice $= 900kgm^{-3}$ and $L = 330 \times 10^3 Jkg^{-1}$)

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5. There slabs of thickness d_1, d_2, d_3 and thermal conductivites λ_1, λ_2 and λ_3 are placed in contact. Show that in the steady the combination behaves as a single slab of material of conductivity λ given by

$$\frac{d_1 + d_2 + d_3}{\lambda} = \frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} + \frac{d_3}{\lambda_3}$$

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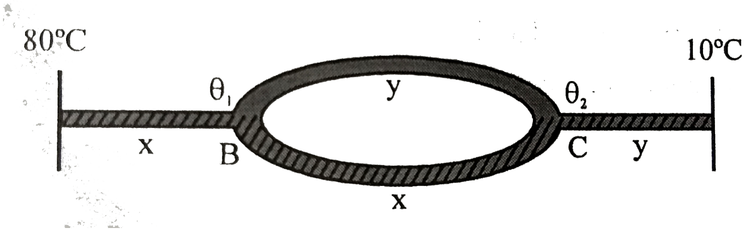
6. Two rods of material, x and two of y are connected as shown in the figure. All the rods are indentical in length and cross-sectional area. If the end A is maintained at $80^\circ C$ and the end D is maintained at $10^\circ C$, calculate the temperature of the junctions B and C in the steady state. Thermal conductivity of x is double that of y.



A.

B.

C.

D.

Answer: NA

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7. Two rods identical in length and cross-sectional area, but one of brass and the other of lead are coated with wax and then fitted into the holes in th sides of a bathl. Boiling water is poured into the bath. The wax coating of which rod wil melt first and to what extent? Thermal conductivity of brass $= 110$ SI units and theat of lead $= 32$ SI units. Sp. heat capacity of brass $= 370 Jkg^{-1}K^{-1}$ and that of lead $= 126 Jkg^{-1}K^{-1}$. Densitiy of brass

$= 8500 kgm^{-3}$ and that of lead $= 11340 kg, m^{-3}$

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8. A solid copper sphere (density $= 8900 kgm^{-3}$ and specific heat $C = 390 Jkg^{-1}K^{-1}$) of radius $r = 10 cm$ is at an initial temperature $T_1 = 200 K$. It is then suspended inside an chamber whose walls are at almost OK. Calculate the time required for the temperature of the sphere to drop to $T_2 = 100K, \sigma = 5.67 \times 10^{-8} Wm^{-2} K^{-4}$.

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9. The radiancy of a black body is $M_e = 3.0 W / cm^2$. Find the wavelength corresponding to the maximum emmissive capacity of the body.

$b = 2.9 \times 10^{-3} m. k, \sigma = 5.67 \times 10^{-2} K^{-4}$.

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10. A thin wire of length $l = 50cm$ and area of cross-section $S = 3 \times 10^{-4}m^2$ is heated to $727^\circ C$. How much electri power P is needed to maintain the wire at this temperature ? Assume that emmissivity of the wire's surface is $e = 0.25$.

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11. A furnace is at a temperature of $2000K$. At what wavelength does it emit most intensively?

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12. An iron boiler with walls $1.25cm$ thick contains water at atmospheric pressure. The heated surface is $2.5m^2$ in ara and the temperature of the underside is $120^\circ C$. Thermal conductivity of iron is $20cals^{-1}m^{-1}K^{-1}$ and the latent heat of evaporatioin of water $536 \times 10^3 calkg^{-1}$ ($J = 4.2Jcal^{-}$). Find the mass of water evaporated per hour.

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13. A slab consists of two parallel layers of different materials $4cm$ and $2cm$ thick and of thermal conductivities $54cals^{-1}m^{-1}K^{-1}$ and $36cals^{-1}m^{-1}K^{-1}$ respectively. If the faces of the slab are at $100^{\circ}C$ and $0^{\circ}C$ calculate the temperature of the surface dividing the two materials.

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14. Heat is conducted through a slab composed of paralel layers of two different materials of conductivities 134.4 SI units and 58.8 SI units and of thickness $3.6cm$ and $4.2cm$ respectively. The temperature of the outer faces of the compound slab are $96^\circ C$ and $8^\circ C$. Find (i) the temperature of the interface, (ii) temperature gradient in each section of the slab.

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15. One end of a copper rod of length $0.25m$ and area of cross-section $10^{-4}m^2$ is immersed in a liquid boiling at $125^\circ C$ whereas the other end is kept cold by dipping It in an ice-cold bath. Find (i) temperature gradient, (ii) the rate of heat transfer (iii) the temperature at a point $0.1m$ from the higher temperature end. (λ of copper $= 92 cal s^{-1} m^{-1} K^{-1}$)

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16. Calculate the thermal resistance of an aluminium rod of length $20cm$ and area of cross-section $4cm^2$. The thermal conductivity of aluminium is $210Js^{-1}m^{-1}K^{-1}$.

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17. Show that if three slabs of thermal resistance R_1, R_2 and R_3 are placed in contact, the thermal resistance of the compound slab is given by $R = R_1 + R_2 + R_3$.

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18. A hollow cube of metal has sides measuring $0.8cm$ (internal) and thickenes $0.5cm$. It is filled with ice $0^\circ C$ and immersed in boiling water at $100^\circ C$. How many kg of ice will melt in one minute? Thermal conductivity of metal $= 252Jm^{-1}s^{-1}K^{-1}$ and latent heat capacity of ic e $= 336 \times 10^3 Jkg^{-1}$.

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19. A steel boiler whose thickness is $3cm$ is placed on a plate of area $1m^2$. The temperature of the plate is $300^\circ C$ and that of the boiling water in the boiler is $100^\circ C$. How much water will evaporate per minute? (Conductivity of steel $= 63.0Js^{-1}m^{-1}K^{-1}$ and sp latent heat of vaporizatioin of water $= 2251.2 \times 10^3 Jkg^{-1}$).

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20. A hollow glass sphere whose thicknes is $2mm$ and external radius is $10cm$ is filled with ice and placed in a bath containing boiling water at $100^\circ C$. Calculate the rate of which the ice melts. Thermal conductivity of glass $= 1.1Js^{-1}m^{-1}K^{-1}$ and L of ice $= 336 \times 10^3 Jkg^{-1}$.

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21. In Ingen Hauz's experiment ther are two identical rods, (idetical in respect of length and cross-section area) coated uniformly with wax. The material of one rod is copper, whose thermal conductivity, sp. heat capacity and density are 285, 285 and 8930 SI units, respectively and the material of the other is silver whose thermal conductivity sp. heat capacity and density are 419, 235 and 10500 SI units, respectively. Compare the lengths to which wax will melt in the two rods. In which case will the wax melt first?

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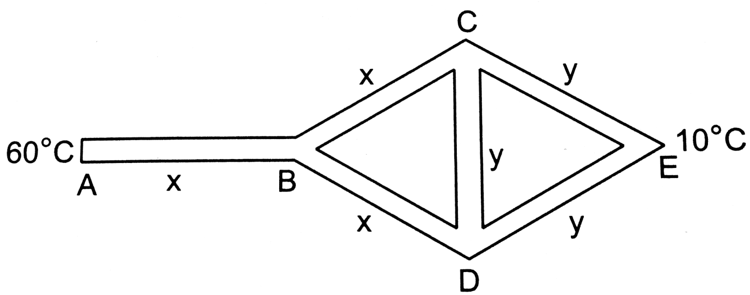
22. Three rods of material x and three of material y are connected as shown in figure. All the rods are identical in length and cross sectional area. If the end A is maintained at $60^{\circ} C$ and the junction E at $10^{\circ} C$, calculate the temperature of the junction B. The thermal conductivity of x is $800 W m^{-1} .^{\circ} C^{-1}$ and that of y is $400 W m^{-1} .^{\circ} C^{-1}$.



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23. A closed cubical box is made of perfectly insulating material and the only way for heat to enter or leave the box is through two solid cylindrical metal plugs, each of cross sectional area $12cm^2$ and length $8cm$ fixed in the opposite walls of the box. The outer surface of one plug is kept at a temperature of $100^{\circ}C$. while the outer surface of the plug is maintained at a temperature of $4(\circ)C$. The thermal conductivity of the material of the plug is $2.0Wm^{-1}.^{\circ}C^{-1}$. A source of energy generating $13W$ is enclosed inside the box. Find the equilibrium temperature of the inner surface of the box assuming that it is the same at all points on the inner surface.

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24. A room at $20^{\circ}C$ is heated by a heater of resistence 20 ohm connected to 200 VV mains. The temperature is uniform throughout the room and the heati s transmitted through a glass window of area $1m^2$ and thickness 0.2

cm. Calculate the temperature outside. Thermal conductivity of glass is $0.2cal / mC^{\circ}$ s and mechanical equivalent of heat is $4.2J / cal.$

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25. Two chunks of metal with heat capacities C_1 and C_2, are interconnected by a rod length l and cross-sectional area S and fairly low heat conductivity K. The whole system is thermally insulated from the environment. At a moment

$t = 0$ the temperature difference betwene the two chunks of metal equals $(\Delta T)_0$. Assuming the heat capacity of the rod to be negligible, find the temperature difference between the chucks as a function of time.

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26. Two rods whose lengths are l_1 and l_2 and heat conductivity coefficient x_1 and x_2 are placed end to end. Find the heat conductivity coefficient of a uniform rod of length $l_1 + l_2$

whose conductivity is the same as that of the system of these two rods. The lateral surfaces of the rods are assumed to be thermally insulated.

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27. A rod of length l with thermally insulated lateral surface is made of a material whose thermal conductivity varies as $K = sc/T$ where c is a constant. The ends are kept at temperatures T_1 and T_2. Find the temperature at a distance x from te first end where the temperature is T_1 and the heat flow density.

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28. Find the temperature distribution in a substance placed between two parallel plates kept at temperatures T_1 and T_2. The plate separation is l. The heat conductivity coefficient λ varies with temperature as $1/\sqrt{T}$.

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29. A constant current flows along a wire of radius R and heat conductivity coefficient λ. Heat is produced in unit volume of the wire at a constant rate W. Find the temperature distribution along the radius in the steady state, when the constant temperature of the surface of the wire is T_0.

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30. Thermal power of density W is generated uniformly inside a sphere of radius R and thermal conductivity λ. Find the temperature distribution along the radius of the sphere in the steady state of it when its outer surface is at temperature T_0.

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31. A blackened metal container of negligible heat capacity is filled with water. The container has sides of length $l = 10cm$. It is placed in an evacuated enclosure whose walls are kept at $27^\circ C$. How long will it take for the temperature of th water to change from $30^\circ C$ to $29^\circ C$. ($\sigma = 5.67 \times 10^{-8} Wm^{-2} K^{-4}$)

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32. A cube $a = 3.0cm$ on each side radiates energy at the rate of $P = 20J/s$ when its temperature is $727^\circ C$ and surrounding temperature $27^\circ C$. Determine its emissivity.

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33. The temperature of the tungsten filament of a 60-watt electric bulb is $T = 2000K$. Find the surface of the filament. The emmissivith of the surface is $e = 0.30$.

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34. The radiant emittance of a black bodyt is $R = 250kW/m^2$. At what wavelength will the emmisivity of this black body be maximum?

$(b = 2.9 \times 10^{-3} m. K$ and $\sigma = 5.67 \times 10^{-8} Wm^{-2} K^{-4})$

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