# PHYSICS

# BOOKS - MODERN PUBLICATION

# Transfer of heat

## Example

**1.** A plate 4 mm thick as a temperature difference of $32^{\circ}$ to between its faces. It transmit $200 kcal h^{-1}$ through and area of

$5cm^2$ calculate the thermal conductivity of the material of the plate

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**2.** A metal rod of length 20 cm and diamter 2 cm is convered with a non conducting substance. One of its ends is maintained at 100^(@)C , while the other end is put at 0^(@)C. It is found that 25 g ice melts in 5 min. calculate the coefficient of thermal conductivity of the metal. Latent that of ice = 80 cal g^(-1).

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**3.** A body takes 10 minutes to cool from $60^\circ C$ to $50^\circ C$. If the temperature of surrounding s is $25^\circ C$, then temperature of body after next 10 minutes will be

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**4.** The surface temperature of a hot body is $1227^\circ C$. Find the wavelength at which it radiates maximum energy. Given Wien's constant = 2898 cm K.

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**5.** Calculate the temperature (in K) at which a perfect black body radiates energy at the rate of $5.67 W cm^{-2}$. Given $\sigma = 5.67$ xx 10^(-8)Wm^(-2)K^(-4)`

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**6.** Temperature of a perfect black body is 2000K and area of its radiating surface is $2 \times 10^{-4} m^2$. Find the energy radiated by it in 15 minutes. Given that Stefan's constant = $5.7 \times 10^{-8} W m^{-2} K^{-4}$

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**7.** 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.......?

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8. Consider the sun to be a perfect sphere of radius $6.8 \times 10^8$m. Calculate the energy radiated by sun in one minute. Surface temperature of the sun = 6200 K. Stefan's constant = $5.67 \times 10^{-8} Jm^{-2}s^{-1}K^{-4}$

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**9.** A full radiator at $0^{\circ} C$ radiates energy at the rate of $3.2 \times 10^{4} erg cm^{-2} s^{-1}$. Find (i) Stefan's constant and (ii) the amount of heat radiated per second by a sphere of radius 4 cm and at a temperature of $1000^{\circ} C$.

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**10.** A full radiator at $0^{\circ} C$ radiates energy at the rate of $3.2 \times 10^{4} erg cm^{-2} s^{-1}$. Find (i) Stefan's constant and (ii) the amount of heat radiated per second by a sphere of radius 4 cm and at a temperature of $1000^{\circ} C$.

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**11.** An indirectly heated filament is radiating maximum energy of wavelength $2.16 \times 10^{-5} cm$. Find the net amount of heat energy lost per second per unit area, the temperature of the surrounding air is $13^{\circ} C$. Given b=0.288cmK and $\sigma = 5.77 \times 10^{-5} ergs^{-1} cm^{-2} K^{-4}$

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**12.** A body at a temperature of $727^{\circ}C$ and having surface area $5cm^2$, radiations 300 J of energy each minute. What is the emissivity. (Given Boltzmann constant = $5.67 \times 10^{-8} Wm^{-2} K^{-4}$

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**13.** Which is the only way of heat transfer through a solid?

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**14.** define coefficient of thermal conductivity

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**15.** why are steam pipes wrapped with insulating material?

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**16.** teapots are generally covered with tea-cosy made of fur or wool. Why?

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**17.** Why do we wear woolen clothes in winter?

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**18.** Is fur coat a source of heat to our bodies?

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**19.** water can be boiled in a paper cup explain

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**20.** why do two layers of cloth of equal thickness provide warmer covering than a single layer of cloth of double the thickness?

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**21.** Why is new quilt warmer than old one ?

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**22.** why filt is used for thermal insulation in preference to air?

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**23.** if there is a bad conductor of heat why do we not feel warm without clothes?

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**24.** is it possible that when one end of a rod is heated then after sometime the temperature of the end rod becomes the same. under what conditions would this happen?

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**25.** why do electrons in insulators not contributing to its conductivity?

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**26.** State Newton's law of cooling.

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**27.** According to Neton's law of cooling, the rate of colling of a body is proportional to $(\Delta\theta)^n$, where $\Delta\theta$ is difference of temprature of the body and the surroundings, and n is equal to

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**28.** What is the temperature range upto which Newton's law of couling bolds good?

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**29.** In which method of heat transfer, gravity does not play any role?

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**30.** In which method of heat transfer, gravity does not play any role?

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**31.** It is hotter at some distance over the fire than in front of it, because:

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**32.** Ventilators are provided in mans just below the roof. Why?

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**33.** A body is at $0^\circ C$ . Is it radiating heat?

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**34.** At what temperature does a body stop radiating?

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**35.** If kelvin temperature of an ideal black body is doubled, what will be the effect on the energy radiated by it?

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**36.** Which instrument is used to measure temperature through radiation from the object?

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**37.** a glass rod can even be melted by holding it close in the flame while the copper rod held even at a distance becomes too hot to hold explain why?

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**38.** a blanket which keeps us warm in the winter is also able to protect ice from melting explain.

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**39.** a flannel keeps the ice cold but keeps people warm.

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**40.** Birds swell their feathers in winter .why ?

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**41.** marble floor appears colder than cemented floor in winter though both are at same temperature explain why.

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**42.** The iron chairs apperas to be colder than wooden chairs in winter . Explain why ?

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**43.** pieces of copper and glass are heated to the same temperature. why does a piece of copper feel hotter on touching?

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**44.** Stainless steel cooking pans are preferred with extra copper bottom. Why?

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**45.** a piece of paper wrapped tightly on a wooden rod is found to be charred, when held over a flame compared to similar piece of paper when wrapped around a brass rod why?

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**46.** place a safety pin on a sheet of white paper. hold the sheet over a burning candle, until the paper becomes yellow and charrs. on removing the pin its white trace is observed on the paper. explain why.

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**47.** at what common temperature would a block of wood and a block of metal feel equally cold or equally hot when touched?

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**48.** if a drop of water falls on a very hot iron it does not evaporate for a long time explain why

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**49.** A wire gauge is generally used when a glass vessel is heated over a flame why?

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**50.** a liquid is generally heated from below why?

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**51.** on a hot day the surface water of a pond is warmer than the water below. but on a day when it is nearly freezing the surface water is colder why?

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**52.** why do lamp black and platinum black Serve as perfect black body only for absorption of heat radiation?

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**53.** is it necessary that all black colour objects should be considered black bodies?

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**54.** if all objects radiate electromagnetic radiation why do not the objects around us in everyday life grow colder and colder?

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**55.** tea in a thermos flask remains hot for a long time. Why?

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**56.** vacuum is created between two walls of a thermos flask explain why?

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**57.** Animals curl into a ball when there is very cold .Why ?

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**58.** heat is generated continuously in an electric heater but its temperature remains constant after some time why?

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**59.** the earth constantly receives heat radiation from the sun and gets warmed up why does a earth not get heated as the sun?

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**60.** Explain, why a cloudy night is more warmer than a clear night is more warmer than a clear night.

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**61.** On a winter night, you feel warmer when clouds cover the sky than when the sky is clear. Explain.

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**62.** on a hot day the surface water of a pond is warmer than the water below. but on a day when it is nearly freezing the surface water is colder why?

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**63.** in a solar eclipse bright lines are observed in the place of a dark Fraunhofer`s lines. explain why?

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**64.** A blackbody is at a temperature of 2880K. The energy of radiation emitted by this object with wavelength between 499nm and 500nm is $U_1$ , between 999nm and 1000nm is $U_2$ and between 1499 nm and 1500 nm is $U_3$ . The Wien constant b=$2.88 \times 10^6 nmK$, predict which of the three ( $U_1, U_2$ and $U_3$) is greater.

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**65.** A sphere a cube and thin circular plate, all made of the same material and having the same mass are initially heated to a temperature of $200^\circ C$. Which one of these will cool first and which one slowest when left in air at room temperature?

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**66.** Explain why:

An optical pyrometer (for measuring high temperature) calibrated for an ideal black body radiation gives too low value for the temperature of a red hot iron piece in the open, but gives a correct value for the temperature when the same piece is in the furnace.

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**67.** draw a labelled graph of experimentally observed spectrum of a black body for at least three different temperatures. draw two important conclusions from it

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**68.** What is a black body?

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**69.** Newton 's Law of Cooling : According to Newton 's law of cooling the rate of cooling is directly proportional to the temperature difference of body and its surrounding .If body cools from $\theta_1 \text{to} \theta_2$ in t seconds then $\left(ms\frac{\theta_1 - \theta_2}{t} = \alpha\left[\frac{\theta_1 + \theta_2}{t} - \theta_0\right]\right.$ . Where $\theta_0$ is the temperature of the surrounding . Is the statement true?

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**70.** Thickness of ice on a lake is 5 cm. and the temperature of air is $-20^{\circ} C$. If the rate of cooling of water inside the lake be $20000 cal min^{-1}$ through each square metre surface, find K for ice.

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**71.** The inside of the glass window 2 mm thick and one square metre in area is at a temperature of $15^{\circ}C$ and the temperature outside is $-5^{\circ}$C. Calculate the rate at which heat escaping from the room by conduction through the glass. K of glass is $0.002 cal cm^{-1}(s^{-1})^{\circ}C^{-1}$

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**72.** Estimate the rate at which ice would melt in a wooden box 2.5 mm thick and of inside measurement 100 cm x 60 cm x 40 cm, assumming that external temperature is $32^{\circ} C$ and coefficient of thermal conductivity of wood is $0.168 W m^{-1} K^{-1}$.

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**73.** A slab of stone of area of $0.36 m^2$ and thickness 0.1 m is exposed on the lower surface to steam at $100^\circ C$. A block of ice at $0^\circ C$ rests on the upper surface of the slab. In one hour 4.8 kg of ice is melted. Calculate the thermal conductivity of slab.

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**74.** One end of a 0.25 m long metal bar is in steam and the other is in contact with ice . If 12 g of ice melts per minute, what is the thermal conductivity of the metal? Given cross-section of the bar $=5 \times 10^{-4} m^2$ and latent heat of ice is $80 cal g^{-1}$

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**75.** The only possibility of heat flow in a thermos flask is through its cork which is $75 cm^2$ in area and 5 cm thick. Its thermal conductivity is $0.0075 cal / cm \sec^{\circ} C$. How lolng will 500 g of ice at $0^{\circ} C$ in thermos flask will is $40^{\circ} C$ and latent heat of ise is $80 cala / g$

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**76.** The outer face of a rectangular slab of equal thickness of iron and brass are maintained at $100^{\circ} C$ and $0^{\circ} C$, respectively. Find the temperature of the interface. The conductivities of iron and brass are 14 and 126 $W / mK$ respectively.

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**77.** The outer face of a rectangular slab of equal thickness of iron and brass are maintained at $100^\circ C$ and $0^\circ C$, respectively. Find the temperature of the interface. The conductivities of iron and brass are 14 and 126 $W/mK$ respectively.

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**78.** A copper tube (length, 3.0 m, inner diameter, 1.5 cm, outer diameter, 1.7 cm) passes through a vat of rapidly circulating water maintained at $20^\circ C$. Live steam at $100^\circ C$ passes through the tube. What is the heat flow rate from the steam into the vat? For copper, kT = 1.0 cal/s·cm·°C.

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**79.** A body cools from $60^\circ C \rightarrow 40^\circ C$ in 7 minutes. What will be its temperature after next 7 minutes. The temperature of surrounding is $10^\circ C$.

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**80.** A body cools from $60^{\circ}C \rightarrow 40^{\circ}C$ in 7 minutes. What will be its temperature after next 7 minutes. The temperature of surrounding is $10^{\circ}C$.

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**81.** The temperature of ordinary electric bulb is around 3,000 K. At what wavelength will it radiate maximum energy? Will this wavelength be within visible region? Given, Wien's constant, b=0.288 cm K.

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**82.** The spectral energy distribution of the sun has a maximum at 4754Å. If the temperature of the sun is 6050 K, what is the temperature of a star for which this maximum is at 9506Å?

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**83.** Two stars radiate maximum energy at wavelength, $3.6 \times 10^{-7}$ m and $4.8 \times 10^{-7}$ m respectively. What is the ratio of their temperatures ?

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**84.** Calculate the temperature (in K) at which a perfect black body radiates energy at the rate of $5.67 W cm^{-2}$. Given $\sigma =$ 5.67 xx 10^(-8)Wm^(-2)K^(-4)`

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**85.** To what temperature must a black body be raised in order to double total radiation, if original temperature is $727^{\circ} C$?

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**86.** At what temperature will the filament of 100 W lamp operate if it is supposed to be perfectly black of area $1 cm^2$. Given sigma = $5.67 \times 10^{-5} erg cm^{-2} s^{-1} K^{-4}$

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**87.** Due to change in mains voltage, the temperature of an electric bulb rises from 3,000 K to 4,000 K. What is the percentage rise in electric power consumed?

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**88.** A black body initially at $27^\circ C$ is heated to $327^\circ C$. How many times is total heat emitted at the higher temperature than emitted at lower temperature ? What is the wavelength of the maximum energy radiation at the higher temperature ? Wien's constant = $2.898 \times 10^{-3} mK$.

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**89.** The temperature of a body in increased from $27^{\circ} C$ to $127^{\circ} C$. By what factor would the radiation emitted by it increase?

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**90.** Surface temperature of sun is 6000 K. Considering sun as a perfectly black body, calculate the energy given out by sun per second in radiation. Radius of sun= $6.9 \times 10^8$ m and $\sigma$ = $5.67 \times 10^{-8} Js^{-1} m^{-2} K^{-4}$

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**91.** A sphere of radius 10 cm is hung inside an oven whose walls are at a temperature of 1000 K. Calculate total heat energy incident per second (in $joe\underline{e}s / \sec$) on the sphere, $\sigma = 5.67 \times 10^{-8} W / (m^{\circ} C^{-4})$ units.

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**92.** A body at a temperature of $727^{\circ} C$ and having surface area $5 cm^2$, radiations 300 J of energy each minute. What is the emissivity. (Given Boltzmann constant = $5.67 \times 10^{-8} Wm^{-2} K^{-4}$

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**93.** How much energy in radiated per minute from the filament of an incandescent lamp at 3000 K, if the surface area is $10^{-4}m^2$ and its emissivity is 0.4? Stefan's constant $\sigma$ = $5.67 \times 10^{-8}Wm^{-2}K^{-4}$

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**94.** An electric bulb with tungsten filament having an area of $0.25cm^2$ is raised to a temperature of 3000 K, when a current passes through it. Calculate the electrical energy being consumed in watt, if the emissivity of the filament is 0.35. Stefan's constant, $\sigma = 5.67 \times 10^{-5} erg^{-1} cm^{-2} K^{-4}$. If due to fall in main voltage the fialment temperature falls to 2500 K, what will be wattage of the bulb?

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**95.** A blackened solid copper sphere of radius 2 cm is placed in an evacuated enclosure whose walls are kept at $100^\circ C$. At what rate must energy be supplied to the sphere to keep its temperature constant at $127^{\circ}C$ ? Stefan constant = $5.67 \times 10^{-8} Jm^{-2}K^{-4}$

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**96.** A black body at 27^(@)C surrounds another black body at -73^(@)C. Calculate the net heat transfer per second per square meter of the body at higher temperature.. Stefan constant = $5.67 \times 10^{-8} Jm^{-2}K^{-4}$

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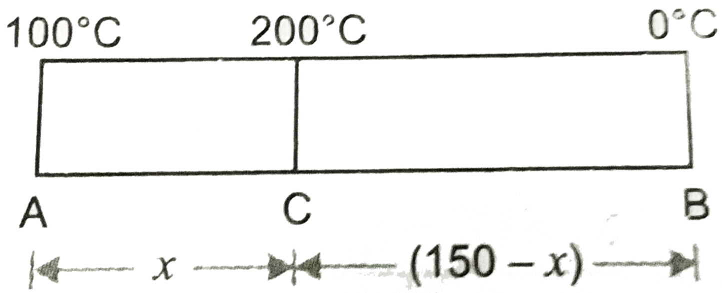
**97.** One end of a copper rod of uniform cross sectional area and length 150 cm is in contact with ice and the other end with water at $100^\circ$. at what point along its length should a temperature of of 200 degree Celsius be maintained so that in steady state the mass of the ice melting is equal to that of steam produced in the same interval of time. assume that whole system is insulated from the surrounding.

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**98.** Suppose that ice 10 cm thick has already been formed on a pond and that air is at $-5^\circ C$. How long will it take for next 1 mm of ice to form? Given that K for ice = 0-008

$calcm^{-1}s^{-1})^{\circ}C^{-1}. Densityofice =$ 0.9 g cm^3 and $latentheatofice =$ 80 cal//g`

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**99.** A room is at 20 degree Celsius by a heater of resistance $20ohm$ connected to 200 V mains. the temperature his uniform throughout the room and that heat is transmitted through a glass window of area $1m^2$ and thickness 0.2 cm. calculate the temperature outside. given that the thermal conductivity of glass K= $0.2 cal / (ms^{\circ} C)$ and mechanical equivalent of heat J=$4.2 J / cal$

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**100.** A body cools from $80^{\circ} C$ to $50^{\circ} C$ in 5 minuts. Calculate the time it takes to cool from $60^{\circ} C$ to $30^{\circ} C$. The temperature of surrounding is $20^{\circ} C$.

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## Exercise

**1.** What are the three modes of transfer of heat ?

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**2.** derive an expression for coefficient of thermal conductivity and hence define it

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**3.** derive an expression for coefficient of thermal conductivity and hence define it

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**4.** define coefficient of thermal conductivity. explain its formula. give some applications of the conduction in everyday life.

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**5.** A slab consists fo two parallel layer of different materials of same thickness and thermal conductivities $K_1$ and $K_2$.The equivalent thermal conductivity off the slab is :

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**6.** two metallic plates of thickness $d_1$ and $d_2$ thermal conductivities $K_1$ and $K_2$ are placed in contact. prove that their equivalent thermal conductivity is given by

$$K = (d_1 + d_2) / \left( \left( \frac{d_1}{K_1} \right) + \left( \frac{d_2}{K_2} \right) \right)$$

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**7.** distinguish between conduction and convection. give one application in each case of conduction and convection.

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**8.** State Newton's law of cooling.

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**9.** two copper vessels are identical in every respect except that outer surface of one is highly polished while that of the other is black. the two vessels have got equal quantities of water at $50^{\circ}$. when left in a room which will cool faster and why? state the physical law applicable to the situation.

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**10.** what are the different win cycles formed in the atmosphere? which phenomenon is responsible for their formation?

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**11.** explain the formation of land and sea breeze.

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**12.** what is radiation? list out the main properties of heat radiation

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**13.** Define a black body and explain how it can be realised in practice.

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**14.** Explain the significance of Kirchhoff's law.

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**15.** Explain the significance of Kirchhoff's law.

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**16.** what is meant by the emissive power of a surface at a given wavelength?

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**17.** discuss the general characteristics of a black body spectrum

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**18.** discuss the general characteristics of a black body spectrum

Watch Video Solution

**19.** Write Stefan's law.

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**20.** What is Stefan's law? what are the SI and CGS units

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**21.** discuss the general characteristics of a black body spectrum

Watch Video Solution

**22.** draw a labelled graph of experimentally observed spectrum of a black body for at least three different temperatures. draw two important conclusions from it

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**23.** State Newton's law of cooling.

Watch Video Solution

**24.** What are the three modes of transfer of heat ?

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**25.** Define conductivity of a conductor. Give its S.I. unit?

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**26.** State Newton's law of cooling.

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**27.** state Newton's law of cooling. deduce the relation $\log_e(\theta - \theta_0)$ = -Kt +C, where the letters have their usual meanings.

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