11.THERMAL PROPERTIES OF MATTER

Single Correct Answer Type

1. A rod of length l and cross-sectional area A has a variable conductively given by $K = \alpha T$, where α is a positive constant and T is temperature in kelvin. Two ends of the rod are maintained at temperature T_1 and $T_2 (T_1 > T_2)$. Heat current flowing through the rod will be
a) $\frac{A\alpha(T_1^2 - T_2^2)}{l}$ b) $\frac{A\alpha(T_1^2 + T_2^2)}{l}$ c) $\frac{A\alpha(T_1^2 + T_2^2)}{3l}$ d) $\frac{A\alpha(T_1^2 - T_2^2)}{2l}$
2. A glass flask is filled up to a mark with 50 cc of mercury at 18°C. If the flask and contents are heated to 38°C, how much mercury will be above the mark (α for glass is 9×10^{-6}/°C and coefficient of real expansion of mercury is 180×10^{-6}/°C)?
a) 0.85 cc b) 0.46 cc c) 0.153 cc d) 0.05 cc
3. A piece of metal floats in mercury. The coefficients of volume expansion of the metal and mercury are γ_1 and γ_2, respectively. If the temperatures of both mercury and the metal are increased by ΔT, the fraction of the volume of the metal submerged in mercury changes by the factor of
a) $\frac{1 + \gamma_2 \Delta T}{1 + \gamma_1 \Delta T}$ b) $1 + \gamma_2 \Delta T$ c) $1 + \gamma_1 \Delta T$ d) $\frac{1 + \gamma_2 \Delta T}{1 - \gamma_1 \Delta T}$
4. Power radiated by a black body is P_0 and the wavelength corresponding to maximum energy is around λ_0. On changing the temperature of the black body, it was observed that the power radiated becomes $\frac{256}{81} P_0$. The shift in wavelength corresponding to the maximum energy will be
a) $+\frac{\lambda_0}{4}$ b) $+\frac{\lambda_0}{2}$ c) $-\frac{\lambda_0}{4}$ d) $-\frac{\lambda_0}{2}$
5. Three very large plates of same area are kept parallel and close to each other. They are considered as ideal black surfaces and have very 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) $(97)^{\frac{1}{4}} T$
6. A liquid of density 0.85 g/cm^3 flows through a calorimeter at the rate of 8.0 cm^3/s. Heat is added by means of a 250 W electric heating coil and a temperature difference of 15°C is established in steady-state conditions between the inflow and the outflow points of the liquid. The specific heat for the liquid will be
a) 0.6 kcal/kgK b) 0.3 kcal/kgK c) 0.5 kcal/kgK d) 0.4 kcal/kgK
7. The absolute coefficient of expansion of a liquid is 7 times that the volume coefficient of expansion of the vessel. Then the ratio of absolute and apparent expansion of the liquid is
a) $\frac{1}{7}$ b) $\frac{7}{6}$ c) $\frac{6}{7}$ d) None of these
8. A metallic sphere having radius 0.08 m and mass m =10 kg is heated to a temperature of 227°C and suspended inside a box whose walls are at a temperature of 27°C. The maximum rate at which its temperature will fall is (take $e = 1$, Stefan's constant $\sigma = 5.8 \times 10^{-8}$Wm^{2}K^{-4} and specific heat of the metal = 90cal/kg/ deg J = 4.2 J/cal)
a) 0.055°C/s b) 0.066°C/s c) 0.044°C/s d) 0.03°C/s
9. Liquid helium is stored at its boiling point (4.2 K) in a spherical can, separated by a vacuum space from a surrounding shield which is maintained at the temperature of liquid nitrogen (77 K). If the can is 0.1m in radius and is blacked on the outside so that it acts as a black body, how much helium boils away per hour? (Latent heat of vapourization is 21 kJ/kg)
a) 43 g/h b) 43 kg/h c) 4.3 g/h d) 43×10^{-3}g/h
10. The coefficient of apparent expansion of mercury in a glass vessel is 153×10^{-6}/°C and in a steel vessel is 114$\times 10^{-6}$/°C. If α for steel is 12×10^{-6}/°C, then that of glass is
a) 9×10^{-6}/C b) 6×10^{-6}/C c) 36×10^{-6}/C d) 27×10^{-6}/C

11. 2 kg of ice at $-20°C$ is mixed with 5 kg of water at $20°C$ in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. It is given that the specific heats of water and ice are 1 kcal/kg/°C and 0.5 kcal/kg/°C while the latent heat of fusion of ice is 80 kcal kg^{-1}

a) 7 kg b) 6 kg c) 4 kg d) 2 kg

12. A ball of thermal capacity 10 cal/°C is heated to the temperature of furnace. It is then transferred into a vessel containing water. The water equivalent of vessel and the contents is 200 g. The temperature of the vessel and its contents rises from 10°C to 40°C. What is the temperature of furnace?

a) 640°C b) 64°C c) 600°C d) 100°C

13. Two liquids A and B are at 32°C and 24°C. When mixed in equal masses the temperature of the mixture is found to be 28°C. Their specific heats are in the ratio of

a) 3:2 b) 2:3 c) 1:1 d) 4:3

14. A system receives heat continuously at the rate of 10 W. The temperature of the system becomes constant at 70°C when the temperature of the surroundings is 30°C. After the heater is switched off, the system cools from 50°C to 49.9°C in 1 min. The heat capacity of the system is

a) 1000 J/°C b) 1500 J/°C c) 3000 J/°C d) None of these

15. Water at 0°C, contained in a closed vessel, is abruptly opened in an evacuated chamber. If the specific latent heats of fusion and vapourization at 0°C are in the ratio λ: 1, the fraction of water evaporated will be

a) $\lambda/1$ b) $\lambda/(\lambda+1)$ c) $(1-\lambda)/\lambda$ d) $(\lambda-1)/(\lambda+1)$

16. The rectangular surface of area 8 cm × 4 cm of a black body at a temperature of 127°C emits energy at the rate of E per second. If the length and breadth of the surface are each reduced to half of the initial value and the temperature is raised to 327°C, the rate of emission of energy will become

a) $\frac{3}{8}E$ b) $\frac{81}{16}E$ c) $\frac{9}{16}E$ d) $\frac{81}{64}E$

17. A piece of ice (heat capacity=2100$JKg^{-1}\,°C^{-1}$ and latent heat=3.36×10^5 Jkg^{-1}) of mass m gram is at $-5°C$ at atmospheric pressure. It is given 420 J of heat so that the ice starts melting. Finally when the ice-water mixture is in equilibrium, it is found that 1 g of ice has melted. Assuming there is no other heat exchange in the process, the value of m is

a) 8 b) 6 c) 4 d) 8.5

18. An aluminium measuring rod, which is correct at 5°C measures the length of a line as 80 cm at 45° C. If thermal coefficient of linear expansion of aluminium is 2.50×10^{-5}/°C, the correct length of the line is:

a) 80.08 cm b) 79.92 cm c) 81.12 cm d) 79.62 cm

19. When the temperature of a black body increases, it is observed that the wavelength corresponding to maximum energy changes from 0.26 μm to 0.13 μm. The ratio of the emissive powers of the body at the respective temperatures is

a) $\frac{16}{1}$ b) $\frac{4}{1}$ c) $\frac{1}{4}$ d) $\frac{1}{16}$

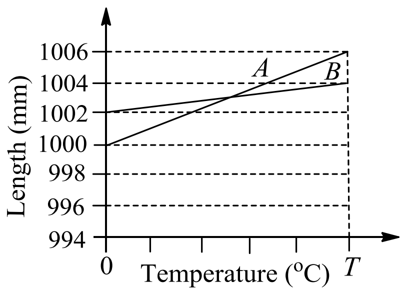
20. A piece of metal weighs 46 g in air. When immersed in a liquid of specific gravity 1.24 at 27°C it weights 30 g. When the temperature of liquid is raised to 42°C the metal piece weight 30.5 g. Specific gravity of liquid at 42° C is 1.20. Calculate the coefficient of linear expansion of metal:

a) 2.23×10^{-5}/°C b) 6.7×10^{-5}/°C c) 4.46×10^{-5}/°C d) None of these

21. A kettle with 2 L water at 27°C is heated by operating coil heater of power 1 kW. The heat is lost to the atmosphere at constant rate 160 J/s, when it is open. In how much time will water be heated to 77°C (sp. heat of water = 4.2 kJ/kg) with the lid open?

a) 8 min 20 s b) 6 min 2 s c) 14 min d) 7 min

22. The variation of lengths of two metal rods A and B with change in temperature is shown in Figure. The coefficients of linear expansion α_A for the metal A and the temperature T will be



(given $\alpha_B = 9 \times 10^{-6}/°C$)

a) $\alpha_A = 3 \times 10^{-6}/°C$, 500°C
b) $\alpha_A = 3 \times 10^{-6}/°C$, 222.22°C
c) $\alpha_A = 27 \times 10^{-6}/°C$,500°C
d) $\alpha_A = 27 \times 10^{-6}/°C$, 222.22°C

23. A black body is at a temperature of 2880 K. The energy of radiation emitted by this object with wavelength between 499 nm and 500 nm is U_1, between 999 nm and 1000 nm is U_2 and between 1499 nm and 1500 nm is U_3. Wien's constant $b = 2.88 \times 10^6$nm – K, Then

a) U_1=0
b) $U_2 = 0$
c) $U_1 = U_2$
d) $U_2 > U_1$

24. Three liquids with masses m_1, m_2, m_3 are thoroughly mixed. If their specific heats are c_1, c_2, c_3 and their temperatures T_1, T_2, T_3, respectively, then the temperature of the mixture is

a) $\frac{c_1T_1+c_2T_2+c_3T_3}{m_1c_1 + m_2c_2 + m_3c_3}$
b) $\frac{m_1c_1T_1 + m_2c_2T_2+m_3c_3T_3}{m_1c_1 + m_2c_2 + m_3c_3}$
c) $\frac{m_1c_1T_1+m_2c_2T_2+m_3c_3T_3}{m_1T_1 + m_2T_2 + m_3T_3}$
d) $\frac{m_1T_1+m_2T_2+m_3T_3}{c_1T_1 + c_2T_2 + c_3T_3}$

25. An iron rod and another of brass, both at 27°C differ in length by 10^{-3}m. The coefficient of linear expansion for iron is $1.1 \times 10^{-5}/°C$ and for brass is $1.9 \times 10^{-5}/°C$. The temperature at which both these rods will have the same length is

a) 0°C
b) 152°C
c) 175°C
d) Data is insufficient

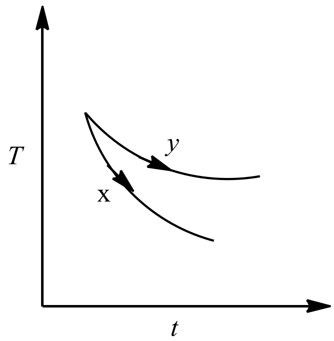
26. The densities of wood and benzene at 0°C are 880 kg/m^3 and 900 kg/m^3, respectively. The coefficient of volume of volume expansion of wood is $1.2 \times 10^{-3}/°C$ and of benzene $1.5 \times 10^{-3}/°C$. The temperature at which a piece of this wood would just sink in benzene at the same temperature is

a) 53°C
b) 63°C
c) 73°C
d) 83°C

27. Two metallic spheres S_1 and S_2 are made of the same material and have identical surface finish. The mass of S_1 is three times 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) 1/3
b) $(1/3)^{1/3}$
c) $1/\sqrt{3}$
d) $\sqrt{3}/1$

28. The graph, shown in the adjacent diagram, represents the variation of temperature (T) of two bodies, x and y having same surface area, with time (t) due to the emission of radiation. Find the correct relation between the emissivity and absorptivity power of the two bodies.



a) $E_x > E_y$ and $a_x < a_y$
b) $E_x < E_x$ and $a_x > a_y$

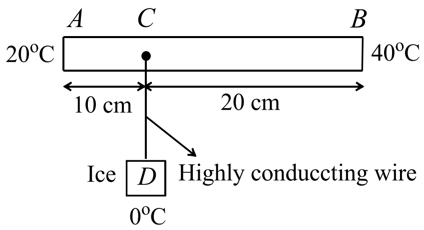
c) $E_x > E_x$ and $a_x > a_y$ d) $E_x < E_x$ and $a_x < a_y$

29. Steam at 100°C is passed into 1.1 kg of water contained in a calorimeter of water equivalent to 0.02 kg at 15°C till the temperature of the calorimeter and its contents rises to 80°C. The mass of the steam condensed in kg is
a) 0.130 b) 0.065 c) 0.260 d) 0.135

30. An incandescent lamp consuming $P = 54$ W is immersed into a transparent calorimeter containing $V = 10^3 \text{cm}^3$ of water. In 420 s the water is heated by 4°C. The percentage of the energy consumed by the lamp that passes out of the calorimeter in the form of radiant energy is
a) 81.5% b) 26% c) 40.5% d) 51.5%

31. Two identical conducting rods are first connected independently to two vessels, one containing water at 100°C and the other containing ice at 0°C. In the second case, the rods are joined end to end and connected to the same vessels. Let q_1 and q_2 gs^{-1} 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) $\frac{1}{4}$

32. As shown in Figure, AB is a rod of length 30 cm and area of cross section 1.0 cm^2 and thermal conductivity 336 SI units. The ends A and B are maintined at temperatures 20°C and 40°C, respectively. A point C of this rod is connected to a box D, containing ice at 0°C, through a highly conducting wire of negligible heat capacity. The rate at which ice melts in the box is (assume latent heat of fusion for ice $L_f = 80$ cal/g)

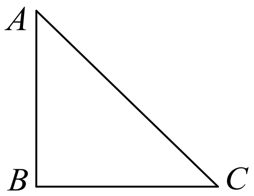


a) 84 mg/s b) 84 g/s c) 20 mg/s d) 40 mg/s

33. An ice box used for keeping eatables cool has a total wall area of m^2 and a wall thickness of 5.0 cm. The thermal conductivity of the ice box is $K = 0.01$ J/m°C. It is filled with large amount of ice at 0°C along with eatables on a day when temperature is 30°C. The latent heat of fusion of ice is 334×10^3 J/kg. The amount of ice melted in one day is (1 day = 86,400 s)
a) 776 g b) 7760g c) 11520 g d) 1552 g

34. 50 g of copper is heated to increase its temperature by 10°C. If the same quantity of heat is given to 10 g of water, the rise in its temperature is (specific heat of copper =420 J/Kg°C)
a) 5°C b) 6°C c) 7°C d) 8°C

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



a) $\frac{3T}{\sqrt{2}+1}$ b) $\frac{T}{\sqrt{2}+1}$ c) $\frac{T}{3(\sqrt{2}-1)}$ d) $\frac{T}{\sqrt{2}-1}$

36. A metal rod AB of length $10x$ has its one end A in ice at 0°C and the other end B in water at 100°C. If a point P on the rod is maintained at 400°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 540 cal/g latent heat of melting of ice is 80 cal/g. If the point P is at a distance of λx from the ice end A, find the value of λ. [Neglect any heat loss to the surrounding]

a) 9 b) 2 c) 6 d) 1

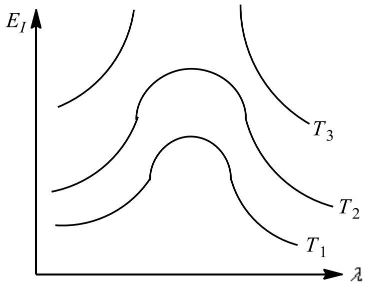
37. A thermometer has an ordinary glass bulb and thin glass tube filled with 1 mL of mercury. A temperature change of 1°C changes the level of mercury in the thin tube by 3 mm. The inside diameter of the thin glass is ($\gamma_{Hg} = 18 \times 10^{-5}/°C$, $\alpha_{glass} = 10^{-5}/°C$)

a) 0.13 mm b) 0.25 mm c) 0.40 mm d) 0.50 mm

38. A brass rod and a lead rod each 80 cm long at 0°C are clamped together at one end with their free ends coinciding. The separation of free ends of the rods if the system is placed in a steam bath is ($\alpha_{brass} = 18 \times 10^{-6}/°C$ and $\alpha_{lead} = 28 \times 10^{-6}/°C$)

a) 0.2 mm b) 0.8 mm c) 1.4 mm d) 1.6 mm

39. Variation of radiant energy emitted by sun, filament of tungsten lamp and welding are as a function of its wavelength is shown in figure. Which of the following option is the correct match?



a) Sun-T_1, tungsten filament$-T_2$, welding arc $- T_3$

b) Sun-T_2, tungsten filament$-T_1$, welding arc $- T_3$

c) Sun-T_3, tungsten filament$-T_2$, welding arc $- T_1$

d) Sun-T_1, tungsten filament$-T_3$, welding arc $- T_2$

40. The length of a steel rod exceeds that of a brass rod by 5 cm. If the difference in their lengths remains same at all temperatures, then the length of brass rod will be:
(α for iron and brass are $12 \times 10^{-6}/°C$ and $18 \times 10^{-6}/°C$, respectively)

a) 15 cm b) 5 cm c) 10 cm d) 2 cm

41. The molar heat capacity of a certain substance varies with temperature according to the given equation
$C = 27.2 + (4 \times 10^{-3})T$
The heat necessary to change the temperature of 2 mol of the substance from 300 K to 700 K is

a) 3.46×10^4 J b) 2.33×10^3 J c) 3.46×10^3 J d) 2.33×10^4 J

42. An iron rod of length 50 cm is joined at an end to an aluminium rod of length 100 cm. All measurements refer to 20°C. The coefficients of linear expansion of iron and aluminium are $12 \times 10^{-6}/°C$ and $24 \times 10^{-6}/°C$, respectively. The average coefficient of composite system is

a) $36 \times 10^{-6}/°C$ b) $12 \times 10^{-6}/°C$ c) $20 \times 10^{-6}/°C$ d) $48 \times 10^{-6}/°C$

43. Two rods of same length and material transfer a given amount of heat in 12 s, when they are joined end to end. But when they are joined lengthwise, they will transfer same heat in same conditions in

a) 24 s b) 3 s c) 1.5 s d) 48 s

44. A black body at 200 K is found to emit maximum energy at a wavelength of 14 μm. When its temperature is raised to 1000 K, the wavelength at which maximum energy is emitted is

a) 14 μm b) 70 μm c) 2.8 μm d) -2.8 μm

45. A cup of tea cools from 80°C in 1 min. The ambient temperature is 30°C. In cooling from 60°C to 50°C it will take

a) 30 s b) 60 s c) 90 s d) 48 s

46. Heat is required to change 1 kg of ice at -20°C into steam. Q_1 is the heat needed to warm then ice from -20°C to 0°C, Q_2 is the heat needed to melt the ice, Q_3 is the heat needed to warm the water from 0°C to 100°C and Q_4 is the heat needed to vapourize the water. Then

a) $Q_4 > Q_3 > Q_2 > Q_1$ b) $Q_4 > Q_3 > Q_1 > Q_2$ c) $Q_4 > Q_2 > Q_3 > Q_1$ d) $Q_4 > Q_2 > Q_1 > Q_3$

47. The coefficient of linear expansion expansion of crystal in one direction is α_1 and that in every direction perpendicular to it is α_2. The coefficient of cubical expansion is

a) $\alpha_1 + \alpha_2$ b) $2\alpha_1 + \alpha_2$ c) $\alpha_1 + 2\alpha_2$ d) None of these

48. Water of volume 2 L in a container is heated with a coil of 1 kW at 27°C . The lid of the container is open and energy dissipates at rate of 160 Js^{-1}. In how much time temperature will rise from 27°C to 77°C [Given specific heat of water is 4.2 kJ kg^{-1}]
a) 8 min 20 s b) 6 min 2 s c) 7 min d) 14 min

49. The coefficient of apparent expansion of a liquid in a copper vessel is C and in a silver vessel S. The coefficient of volume expansion of copper is γ_C. What is the coefficient of linear expansion of silver
a) $(C + \gamma_C + S)/3$ b) $(C - \gamma_C + S)/3$ c) $(C + \gamma_C - S)/3$ d) $(C - \gamma_C - S)/3$

50. Certain substance emits only the wavelengths $\lambda_1, \lambda_2, \lambda_3$ and λ_4 when it is at a high temperature. When this substance is at a colder temperature, it will absorb only the following wavelength
a) λ_1 b) λ_2 c) $\lambda_1$and λ_2 d) $\lambda_1, \lambda_2, \lambda_3$ and λ_4

51. Work done in converting 1 g of ice at −10°C into steam at 100°C is
a) 3045 J b) 6056 J c) 721 J d) 6 J

52. Hot water cools from 60°C to 50°C in the first 10 min and to 42°C in the next 10 min. The temperature of the surrounding is
a) 5°C b) 10°C c) 15°C d) 20°C

53. In similar calorimeters, equal volumes of water and alcohol, when poured, take 100 and 74 s, respectively, to cool from 50°C to 40°C. If the thermal capacity of each calorimeter is numerically equal to volume of either liquid, then calculate the specific heat capacity of alcohol (given: the relative density of alcohol as 0.8 and specific heat capacity of water as 1 cal/g/°C)
a) 0.8 cal/g°C b) 0.6 cal/g°C c) 0.9 cal/g°C d) 1 cal/g°C

54. Solar constant is 1370 W/m^2. 70% of the light incident on the earth is absorbed by the earth and the earth's average temperature is 288 K. The effective emissivity of the earth is
a) 0.2 b) 0.4 c) 0.6 d) 1

55. A flask of volume 10^3cc is completely filled with mercury at 0°C. The coefficient of cubical expansion of mercury is 180×10^{-6}/°C and heat of glass is 40×10^{-6}/°C. If the flask is now placed in boiling water at 100°C, how much mercury will overflow?
a) 7 cc b) 14 cc c) 21 cc d) 28 cc

56. A container or capacity 700 mL is filled with two immiscible liquids of volume 200 mL and 500 mL with respective volume expansivities as 1.4×10^{-5}/°C and 2.1×10^{-5}/°C. During the heating of the vessel, it is observed that neither any liquid overflows nor any empty space is created. The volume expansivity of the container is
a) 1.9×10^{-5}/°C b) 1.9×10^{-6}/°C c) 1.6×10^{-5}/°C d) 1.6×10^{-6}/°C

57. A steel ball of mass 0.1 kg falls freely from a height of 10 m and bounces to a height of 5.4 m from the ground. If the dissipated energy in this process is absorbed by the ball, the rise in its temperature is (specific heat of steel=460 K/kg/°C, g = 10 m/s^2)
a) 0.01°C b) 0.1°C c) 1°C d) 1.1°C

58. Two hollow spheres of different materials, one with double the radius and one-fourth wall thickness of the other, are filled with ice. If the times taken for complete melting of ice in the larger to the smaller one are in the ratio of 25:16, then their corresponding thermal conductivities are in the ratio
a) 4:5 b) 5:4 c) 8:25 d) 25:8

59. A sphere, a cube and a thin circular plate are made of same substance and all have same mass. These are heated to 200°C and then placed in a room. Then the
a) Temperature of sphere drops to room temperature at last
b) Temperature of cube drops to room temperature at last
c) Temperature of thin circular plate drop to room temperature at last
d) Temperature of all the three drop to room temperature at the same time

60. An earthen pitcher loses 1 g of water per minute due to evaporation. If the water equivalent of pitcher is 0.5 kg and the pitcher contains 9.5 kg of water, calculate the time required for the water in the pitcher to cool to 28°C from its original temperature of 30°C. Neglect radiation effects. Latent heat of vapourization

of water in this range of temperature is 580 cal/g and specific heat of water is 1 k cal/g C°

a) 38.6 min b) 30.5 min c) 34.5 min d) 41.2 min

61. Compared to a burn due to water at 100°C, a burn due to steam at 100°C is

a) More dangerous b) Less dangerous c) Equally dangerous d) None of these

62. A pendulum clock having copper rod keeps correct time at 20°C. It gains 15 s per day if cooled to 0°C. The coefficient of linear expansion of copper is

a) $1.7 \times 10^{-4}/°C$ b) $1.7 \times 10^{-5}/°C$ c) $3.4 \times 10^{-4}/°C$ d) $3.4 \times 10^{-5}/°C$

63. A beaker contains 200 g of water. The heat capacity of the beaker is equal to that of 20 g of water. The initial temperature of water in the beaker is 20°C. If 440 g of hot water at 92°C is poured in it, the final temperature (neglecting radiation loss) will be nearest to

a) 58°C b) 68°C c) 73°C d) 78°C

64. The earth receives on its surface radiation from the sun at the rate of 1400 W/m^2. The distance of the centre of the sun from the surface of the earth is 1.5×10^{11} m and the radius of the sun is 7.0×10^8 m. Treating sun as a black body, it follows from the above data that its surface temperature is

a) 5801 K b) 10^6 K c) 50.1 K d) 5801°C

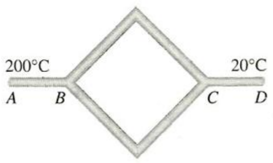
65. A solid copper sphere (density ρ and specific heat capacity c) of radius r at an initial temperature $200K$ is suspended inside a chamber whose walls are at almost $0K$. The time required (in $\mu\ s$) for the temperature of the sphere to drop to 100 K is

a) $\frac{72}{2}\frac{r\rho c}{\sigma}$ b) $\frac{7}{72}\frac{r\rho c}{\sigma}$ c) $\frac{27}{7}\frac{r\rho c}{\sigma}$ d) $\frac{7}{27}\frac{r\rho c}{\sigma}$

66. The design of a physical instrument requires that there be a constant difference in length of 10 cm between an iron rod and a copper cylinder laid side by side at all temperatures. If $\alpha_{\mathrm{Fe}} = 11 \times 10^{-6}/°C$ and $\alpha_{\mathrm{cu}} = 17 \times 10^{-6}/°C$, their length may be

a) 28.3 cm,18.3 cm b) 23.8 cm, 13.8 cm c) 23.9 cm, 10.9 cm d) 27.5 cm,14.5 cm

67. Six identical conducting rods are joined as shown in Figure. Points A and D are maintained at temperatures 200°C and 20°C, respectively. The temperatuire of junction B will be



a) 120°C b) 100°C c) 140°C d) 80°C

68. The coefficient of linear expansion for a certain metal varies with temperature as $\alpha(T)$. If L_0 is the initial length of the metal and the temperature of metal is changed from T_0 to ($T_0 > T$), then

a) $L = L_0 \int_{T_0}^{T} \alpha\,(T)dT$ b) $L = L_0\left[1 + \int_{T_0}^{T} \alpha\,(T)dT\right]$

c) $L = L_0\left[1 - \int_{T_0}^{T} \alpha\,(T)dT\right]$ d) $L > L_0$

69. 5 g of water at 30° C and 5 g of ice at −20°C are mixed together in a calorimeter. Find the final temperature of the mixture. Assume water equivalent of calorimeter to be negligible, sp. heats of ice and water are 0.5 and 1 cal/g C°, and latent heat of ice is 80 cal/g

a) 0°C b) 10°C c) −30°C d) >10°C

70. Which of the following, when mixed, would raise the temperature of 20 g of water at 30° C most?

a) 20 g of water at 40°C b) 40 g of water at 35°C c) 10 g of water at 50°C d) 4 g of water at 80°C

71. Two tanks A and B contains water at 30°C and 80°C, respectively; calculate the amount of water that must be taken from each tank respectively to prepare 40 kg of water at 50°C:

a) 24 kg, 16 kg b) 16 kg, 24 kg c) 20 kg, 20 kg d) 30 kg, 10 kg

72. Two metal strips that constitute a thermostat must necessarily differ in their

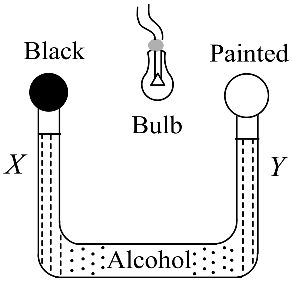
a) Mass b) Length

c) Resistivity d) Coefficient of linear expansion

73. A liquid takes 5 min to cool from 80°C to 50°C. How much time will it take to cool from 60°C to 30°C? The temperature of the surrounding is 20°C

a) 5 min b) 9 min c) 4 min d) 12 min

74. Figure shows two air-filled bulbs connected by a U-tube partly filled with alcohol. What happens to the levels of alcohol in the limbs X and Y when an electric bulb placed midway between the bulbs is lighted?



a) The level of alcohol in limb X falls while that in limb Y rises

b) The level of alcohol in limb X rises which that in limb Y falls

c) The level of alcohol falls in both limbs

d) There is no change in the levels of alcohol in either of the two limbs

75. Two rods of length L_2 and coefficient of linear expansion α_2 are connected freely to a third rod of length L_1 of coefficient of linear expansion $\alpha_1$to form an isosceles triangle. The arrangement is supported on the knife edge at the midpoint of L_1 which is horizontal. The apex of the isosceles tringle is to remain at a constant distance from the knife edge if

a) $\frac{L_1}{L_2} = \frac{\alpha_2}{\alpha_1}$ b) $\frac{L_1}{L_2} = \sqrt{\frac{\alpha_2}{\alpha_1}}$ c) $\frac{L_1}{L_2} = 2\frac{\alpha_2}{\alpha_1}$ d) $\frac{L_1}{L_2} = 2\sqrt{\frac{\alpha_2}{\alpha_1}}$

76. A planet radiates heat at a rate proportional to the fourth power of its surface temperature T. If such a steady temperature of the planet is due to an exactly equal amount of heat received from the sun then which of the following statements is true?

a) The planet's surface temperature varies inversely as the distance of the sun

b) The planet's surface temperature varies directly as the square of its distance from the sun

c) The planet's surface temperature varies inversely as the square root of its distance from the sun

d) The planet's surface temperature is proportional to the fourth power of distance from the sun

77. Four spheres A, B, C and D have their radii in arithmetic progression and the specific heat capacities of their substances are in geometric progression. If the ratios of heat capacities of D and B to that of C and A are as 8:27. The ratio of masses of B and A is (assume same density for all spheres)

a) 8:1 b) 4:1 c) 1:8 d) 1:4

78. 10 g of ice at −20°C is dropped into a calorimeter containing 10 g of water at 10°C; the specific heat of water is twice that of ice. When equilibrium of redached, the calorimeter will contains

a) 20 g of water b) 20 g of ice

c) 10 g ice and 10 g of water d) 5 g ice and 15 g of water

79. A thin circular metal disc of radius 500.0 mm is set rotating about a central axis normal to its plane. Upon raising its temperature gradually, the radius increase to 507.5 mm. The percentage change in the rotational kinetic energy will be

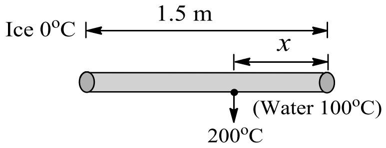
a) 1.5% b) −1.5% c) 3% d) −3%

80. There are three thermometers-one in contact with the skin of the man, other in between the vest and the shirt and third in between the shirt and coat. The reading of the thermometers are 30°C, 25°C and 22°C, respectively. If the vest and the shirt are of the same thickness, the ratio of their thermal conductivities is

a) 9:25 b) 25:9 c) 5:3 d) 3:5

81. One end of a copper rod of uniform cross section and of length 1.5 m is kept in contact with ice and the other end with water at 100°C. At what point along its length should a temperature of 200°C be maintained so that in steady state, the mass of ice melting be equal to that of the steam produced in same interval of time? Assume that the whole system is insulated from surroundings. Latent heat of fusion of ice

and vapourization of water are 80 cal/g and 540 cal/g, respectively



a) 8.59 cm from ice end
b) 10.34 cm from water end
c) 10.34 cm from ice end
d) 8.76 cm from water end

82. A bullet of mass 5 g moving at a speed of 200 m/s strikes a rigidly fixed wooden plank of thickness 0.2 m normally and passes through it losing half of its kinetic energy. If it again strikes an identical rigidly fixed wooden plank and passes through it, assuming the same resistance in the two planks, the ratio of the thermal energies produced in the two planks is
a) 1:1
b) 1:2
c) 2:1
d) 4:1

83. An iron ball (coefficient of linear expansion $= 1.2 \times 10^{-5}/°\text{C}$) has a diameter of 6 cm and is 0.010 mm too large to pass through a hole in a brass plate (coefficient of linear expansion $= 1.9 \times 10^{-5}/°\text{C}$) when the ball and the plate are both at a temperature of 30°C. At what common temperature of the ball and the plate will the ball just pass through the hole in the plate?
a) 23.8°C
b) 53.8°C
c) 42.5°C
d) 63.5°C

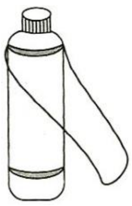
84. A black body emits radiation at the rate P when its temperature is T. At this temperature the wavelength at which the radiation has maximum intensity is λ_0. If at another temperature T' the power radiated is P' and wavelength at maximum intensity is $\lambda_0/2$ then
a) $P'T' = 32\, PT$
b) $P'T' = 16\, PT$
c) $P'T' = 8\, PT$
d) $P'T' = 4\, PT$

85. The wavelength of maximum energy released during an atomic explosion was 2.93×10^{-10}m. Given that Wien's constant is 2.93×10^{-3}m-K, the maximum temperature attained must be of the order of
a) 10^{-7} K
b) 10^{7} K
c) 10^{-13}K
d) 5.86×10^{7} K

86. A sphere, a cube and a thin circular plate, all made of the same material and having the same mass are initially heated to a temperature of 1000°C. Which one of these will cool first
a) Plate
b) Sphere
c) Cube
d) None of these

87. A thread of liquid is in a uniform capillary tube of length L, as measured by a ruler. The temperature of the tube and thread of liquid is raised by ΔT. If γ be the coefficient of volume expansion of the liquid and α be the coefficient of linear expansion of the material of the tube, then the increase ΔL in the length of the thread, again measured by the ruler will be
a) $\Delta L = L(\gamma - \alpha)\Delta T$
b) $\Delta L = L(\gamma - 2\alpha)\Delta T$
c) $\Delta L = L(\gamma - 3\alpha)\Delta T$
d) $\Delta L = L\gamma\, \Delta T$

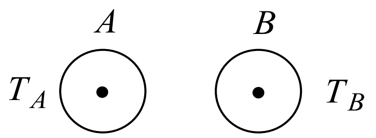
88. The only possibility of heat flow in a thermos flask is through its cork which is 75 cm^2 in area and 5 cm thick. Its thermal conductivity is 0.0075 cal/cm-s-°C. The outside temperature is 40°C and latent heat of ice is 80 cal/g. Time taken by 500 g of ice at 0°C in the flask to melt into water at 0°C is



a) 2.47 h
b) 4.27 h
c) 7.42 h
d) 4.72 h

89. A heat flux of 4000 J/s is to be passed through a copper rod of length 10 cm and area of cross section *100* cm^2. The thermal conductivity of copper is 400 W/m/°C. The two ends of this rod must be kept at a temperature difference of
a) 1°C
b) 10°C
c) 100°C
d) 1000°C

90. A and B are two isolated spheres kept in close proximity so that they can exchange energy by radiation. The two spheres have identical physical dimensions but the surface of A behaves like a perfectly black body while the surface of B reflects 20% of all the radiations it receives. They are isolated from all other sources of radiation



a) If they are in thermal equilibrium and exchange equal amounts of radiation per second, then they will be at same absolute temperature, $T_A = T_B$

b) If they are in thermal equilibrium and exchange equal amounts of radiation per second, then $T_A = (0.8)^{1/4} T_B$

c) If they are not in thermal equilibrium and are each at $t = 0$ at the same temperature $T_A = T_B = T$, then the sphere A will lose thermal energy and B will gain thermal energy

d) If they are not in thermal equilibrium and are each at $t = 0$ at the same temperature $T_A = T_B = T$, then the sphere A will gain thermal energy and B will lose thermal energy

91. A glass cylinder container $m_0 = 100$ g of mercury at a temperature of $t_0 = 0°$C. When temperature becomes $t_1 = 20°$C the cylinder contains $m_1 = 99.7$ g of mercury. The coefficient of volume expansion of mercury $y_{He} = 18 \times 10^{-5}/°$C. Assume that the temperature of the mercury is equal to that of the cylinder. The coefficient of linear expansion of glass α is

a) $10^{-5}/°$C　b) $2 \times 10^{-5}/°$C　c) $3 \times 10^{-5}/°$C　d) $6 \times 10^{-5}/°$C

92. A glass vessel is filled up to 3/5th of its volume by mercury. If the volume expansivities of glass and mercury be $9 \times 10^{-6}/°$C and $18 \times 10^{-5}/°$C, respectively, then the coefficient of apparent expansion of mercury is

a) $17.1 \times 10^{-5}/°$C　b) $9.9 \times 10^{-5}/°$C　c) $17.46 \times 10^{-5}/°$C　d) $16.5 \times 10^{-5}/°$C

93. A steel ball of mass m_1=1 kg moving with velocity 50 m/s collides with another ball of mass m_2=200 g lying on the ground. During the collision their internal energies change equally and $T_1$and T_2 are the rise in temperature of masses $m_1$and m_2, respectively. If specific heat of steel is 0.105 and J=4.18 J/cal, then

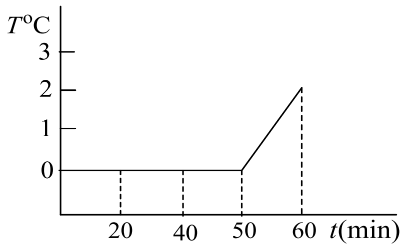
a) $T_1 = 7.1°$C and $T_2 = 1.47°$C　b) $T_1 = 1.47°$C and $T_2 = 7.1°$C

c) $T_1 = 3.4$ K and $T_2 = 17.0$ K　d) $T_1 = 7.1$ K and $T_2 = 1.4$ K

94. A wire is made by attaching two segments together end to end. One segment is made of aluminium and the other is steel. The effective coefficient of linear expansion of the two segment wire is $19 \times 10^{-6}/(°\text{C})$. The fraction length of aluminium is (linear coefficients of thermal expansion of aluminium and steel are $23 \times 10^{-6}(°\text{C})$ and $12 \times 10^{-6}/(°\text{C})$, respectively

a) $\frac{5}{11}$　b) $\frac{6}{11}$　c) $\frac{7}{11}$　d) $\frac{8}{11}$

95. A cooking vessel on a slow burner contains 5 kg of water and an unknown mass of ice in equilibrium at 0°C at time $t = 0$. The temperature of the mixture is measured at various times and the result is plotted as shown in Figure. During the first 50 min the mixture remains at 0°C. From 50 min to 60 min, the temperature increases to 2°C. Neglecting the heat capacity of the vessel, the initial mass of the ice is



a) $\frac{10}{7}$ kg　b) $\frac{5}{7}$ kg　c) $\frac{5}{4}$ kg　d) $\frac{5}{8}$ kg

96. Ice at 0°C is added to 200 g of water initially at 70°C in a vacuum flask. When 50 g of ice has been added and has all melted, the temperature of flask and contents is 40°C. When a further 80 g of ice is added and has all melted, the temperature of whole becomes 10°C. Neglecting heat lost to surrounding the latent heat of fusion of ice is

a) 80 cal/g　b) 90 cal/g　c) 70 cal/g　d) 540 cal/g

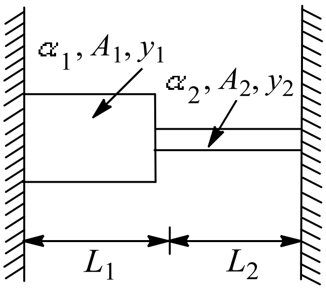
97. A body cools from 50°C to 49°C in 5 s. How long will it take to cool from 40°C to 39.5°C? assume the temperature of surroundings to be 30°C and Newton's law of cooling to be valid

a) 2.5 s b) 10 s c) 20 s d) 5 s

98. A uniform brass disc of radius a and mass m is set into spinning with angular speed ω_0 about an axis passing through centre of disc and perpendicular to the plane of disc. If its temperature increases from θ_1°C to θ_2°C without disturbing the disc, what will be its new angular speed? (The coefficient of linear expansion of brass is α

a) $\omega_0[1+2\alpha(\theta_2-\theta_1)]$ b) $\omega_0[1+\alpha(\theta_2-\theta_1)]$ c) $\dfrac{\omega_0}{[1+2\alpha(\theta_2-\theta_1)]}$ d) None of these

99. Two elastic rods are joined between fixed supports as shown in Figure. Condition for no change in the lengths of individual rods with the increase of temperature (α_1, α_2 =linear expansion coefficient, A_1, A_2= area of rods, y_1, y_2=Young's modulus) is



a) $\dfrac{A_1}{A_2}=\dfrac{\alpha_1 y_1}{\alpha_2 y_2}$ b) $\dfrac{A_1}{A_2}=\dfrac{L_1\alpha_1 y_1}{L_2\alpha_2 y_2}$ c) $\dfrac{A_1}{A_2}=\dfrac{L_2\alpha_2 y_2}{L_1\alpha_1 y_1}$ d) $\dfrac{A_1}{A_2}=\dfrac{\alpha_2 y_2}{\alpha_1 y_1}$

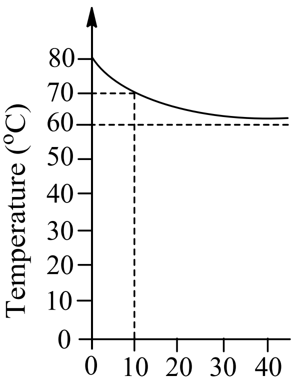
100. A bucket full of hot water cools from 75°C to 70°C in time T_1, from 70°C to 65°C in time T_2 and from 65°C to 60°C in time T_3, then

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

101. 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 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

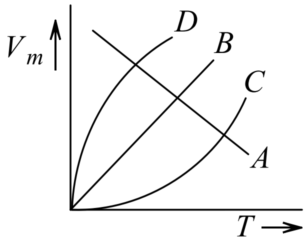
a) K_1+K_2 b) $\dfrac{K_1K_2}{K_1+K_2}$ c) $\dfrac{K_1+3K_2}{4}$ d) $\dfrac{3K_1+K_2}{4}$

102. A vessel contains M grams of water at a certain temperature and water at certain other temperature is passed into it at a constant rate of mg/s. The variation of temperature of the mixture with time is shown in Figure. The value of M and m are, respectively (the heat exchanged after a long time is 800 cal)



a) 40 & 2 b) 40 & 4 c) 20 & 4 d) 20 & 2

103. Which of the following is the v_m-T graph for a perfectly black body?



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

104. A sphere and a cube of same material and same volume are heated up to same temperature and allowed to cool in the same surroundings. The ratio of the amounts of radiations emitted in equal time intervals will be

a) 1:1 b) $\frac{4\pi}{3}:1$ c) $\left(\frac{\pi}{6}\right)^{1/3}:1$ d) $\frac{1}{2}\left(\frac{4\pi}{3}\right)^{2/3}:1$

105. A substance of mass m kg requires a power input of P watts to remain in the molten state at its melting point. When the power is turned off, the sample completely solidifies in time t sec. What is the latent heat of fusion of the substance

a) $\frac{Pm}{t}$ b) $\frac{Pt}{m}$ c) $\frac{m}{Pt}$ d) $\frac{t}{Pm}$

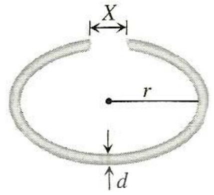
106. A 1 L glass flask contains some mercury. It is found that at different temperatures the volume of air inside the flask remains the same. What is the volumes of mercury in this flask if coefficient of linear expansion of glass is $9 \times 10^{-6}/°C$ while of valume expansion of mercury is $1.8 \times 10^{-4}/°C$?

a) 50 cc b) 100 cc c) 150 cc d) 200 cc

107. An iron rocket fragment initially at $-100°C$ enters the earth's atmosphere almost horizontally and quickly fuses completely friction. Specific heat of iron is 0.11 kcal/kg °C its melting point is 1535°C and the latent heat of fusion is 3 kcal/kg. The minimum velocity with which the fragment must have entered the atmosphere is

a) 0.45 km/s b) 1.32 km/s c) 2.32 km/s d) Zero

108. A cylindrical metal rod of length L_0 is shaped into a ring with a small gap as shown. On heating the system



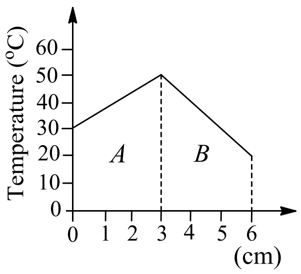
a) x decreases, r and d b) x and r increase, d decreases

c) x, r and d all increase d) Data insufficient to arrive at a conclusion

109. A liquid of mass m and specific heat c is heated to a temperature $2T$. Another liquid of mass $m/2$ and specific heat $2c$ is heated to a temperature T. If these two liquids are mixed, the resulting temperature of the mixture is

a) $(2/3)T$ b) $(8/5)T$ c) $(3/5)T$ d) $(3/2)T$

110. The temperatures across two different slabs A and B are shown in the steady state (as shown in Figure). The ratio of thermal conductivities of A and B is

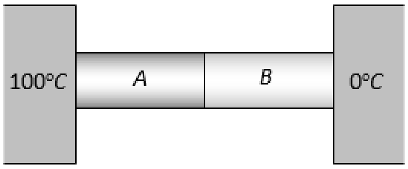


a) 2:3 b) 3:2 c) 1:1 d) 5:3

111. A lead bullet just melts when stopped by an obstacle. Assuming that 25% of heat is absorbed by the obstacle, find the minimum velocity of the bullet if its initial temperature is 27°C (melting point of lead = 327°C; specific heat of lead = 0.03 cal/g°C; latent heat of fusion of lead = 6 cal/g and $J = 4.2$ J/cal)

a) 450 m/s b) 398 m/s c) 420 m/s d) 410 m/s

112. Two metal cubes A and B of same size are arranged as shown in the figure. The extreme ends of the combination are maintained at the indicated temperatures. The arrangement is thermally insulated. The coefficients of thermal conductivity of A and B are $300W/m°C$ and $200W/m°C$, respectively. After steady state is reached, the temperature of the interface will be

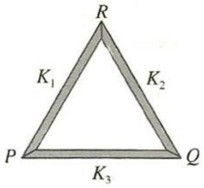


a) 45°C b) 90°C c) 30°C d) 60°C

113. A brass wire 2 m long at 27°C is held taut with negligible tension between two rigid supports. If the wire is cooled to a temperature of −33°C, then the tension developed in the wire, its diameter being 2 mm, will be (coefficient of linear expansion of brass $= 2.0 \times 10^{-5}$/°C and Young's modulus of brass $= 0.91 \times 10^{11}$ Pa)

a) 3400 N b) 34 kN c) 0.34 kN d) 6800 N

114. There rods of same dimensions are arranged as shown if Figure. They have thermal conductivities K_1, K_2 and K_3. The points P and Q are maintained at different temperatures for the heat to flow at the same rate along PQR and PQ. Which of the following options is correct?

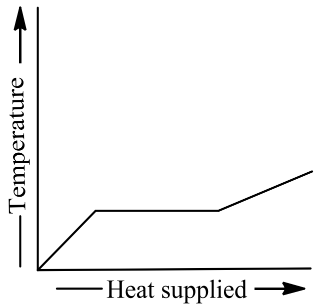


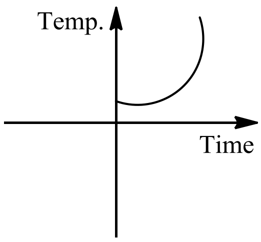
a) $K_3 = \frac{1}{2}(K_1 + K_2)$ b) $K_3 = K_1 + K_2$ c) $K_3 = \frac{K_1 K_2}{K_1 + K_2}$ d) $K_3 = 2(K_1 + K_2)$

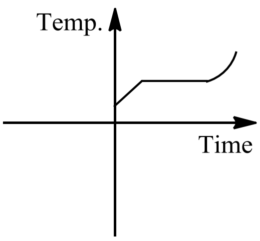
115. In an industrial process 10 kg of water per hour is to be heated from 20°C to 80°C. To do this steam at 150°C is passed from a boiler into a copper coil immersed in water. The steam condenses in the coil and is returned to the boiler as water at 90°C. How many kilograms of steam is required per hour (specific heat of steam=1 cal/g°C, Latent heat of vapourization = 540 cal/g)?

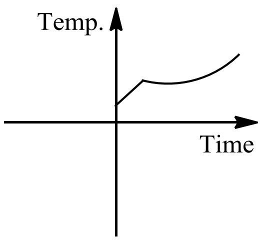
a) 1 g b) 1 kg c) 10 g d) 10 kg

116. Liquid oxygen at 50 K is heated to 300 K at constant pressure of 1 atm. The rate of heating is constant. Which of the following graphs represents the variations of temperature with time?

a) 

b) 

c) 

d) 

117. A mass m of lead shot is placed at the bottom of a vertical cardboard cylinder that is 1.5 m long and closed at both ends. The cylinder is suddenly inverted so that the shot falls 1.5 m. If this process is repeated quickly 100 times, assuming no heat is dissipated or lost, the temperature of the shot will increase by (specific heat of lead = 0.03 cal/g°C)

a) 0 b) 5°C c) 7.3°C d) 11.3°C

118. A refrigerator is thermally equivalent to a box of cork board 90 mm thick and 6 m^2 in inner surface area, the thermal conductivity of cork being 0.05 W/mK. The motor of the refrigerator runs 15% of the time while the door is closed. The inside wall of the door, when it is closed, is kept, on an average, 22°C below the temperature of the outside wall. The rate at which heat is taken from the interior wall while the motor

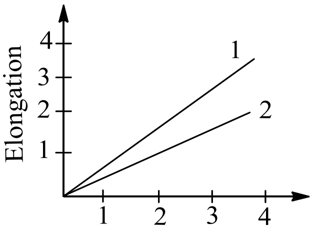
is running is

a) 400 W b) 500 W c) 300 W d) 250 W

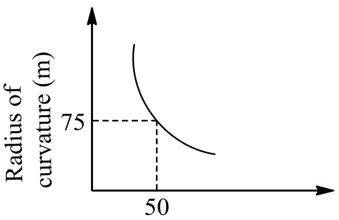
119. Consider two rods of same length and different specific heats (s_1 and s_2), conductivities $K_1$and K_2 and areas of cross section ($A_1$and A_2) and both having temperature T_1 and T_2 at their ends. If the rate of heat loss due to conduction is equal, then

a) $K_1A_1 = K_2A_2$ b) $K_2A_1 = K_1A_2$ c) $\frac{K_1A_1}{s_1} = \frac{K_2A_2}{s_2}$ d) $\frac{K_2A_1}{s_2} = \frac{K_1A_2}{s_1}$

120. Figure shows the graphs of elongation versus temperature for two different metals. If these are employed to form a straight bimetallic strip of thickness 6 cm and heated, it bends in the form of an arc, the radius of curvature changing with temperature approximately as shown in the figure. The linear expansivities of the two metals are



(a) Temperature (°C)



(b) Temperature (°C)

a) $24 \times 10^{-6}/°C$ and $12 \times 10^{-6}/°C$ b) $20 \times 10^{-6}/°C$ and $10 \times 10^{-6}/°C$

c) $18 \times 10^{-6}/°C$ and $9 \times 10^{-6}/°C$ d) $16 \times 10^{-6}/°C$ and $8 \times 10^{-6}/°C$

121. The apparent coefficient of expansion of a liquid when heated, filled in vessel A and B of identical volumes, is found to be γ_1 and γ_2, respectively. If α_1 be the linear expansivity of A then that of B will be

a) $\frac{\gamma_1 - \gamma_2}{3} - \alpha_1$ b) $\frac{(\gamma_2 - \gamma_1)}{3} + \alpha_1$ c) $\frac{(\gamma_2 - \gamma_1)}{3} - \alpha_1$ d) $\frac{(\gamma_1 - \gamma_2)}{3} + \alpha_1$

122. A planet is at an average distance d from the sun and its average surface temperature is T. Assume that the planet receives energy only from the sun and loses energy only through radiation from the surface. Neglect atmospheric effects. If $T \propto d^{-n}$, the value of n is

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

123. A point source of heat of power P is placed at the centre of a spherical shell of mean radius R. The material of the shall has thermal conductivity K. If the temperature difference between the outer and the inner surface of the shell is not to exceed T, then the thickness of the shell should not be less than

a) $\frac{2\pi R^2 KT}{P}$ b) $\frac{4\pi R^2 KT}{P}$ c) $\frac{\pi R^2 KT}{P}$ d) $\frac{\pi R^2 KT}{4P}$

124. A body cools in 7 min from 60°C to 40°C. What will be its temperature after the next 7 min? The temperature of surroundings is 10°C

a) 28°C b) 25°C c) 30°C d) 22°C

125. The specific heat of a substance varies with temperature t(°C) as

$c = 0.20 + 0.14t + 0.023t^2$(cal/g/°C)

The heat required to raise the temperature of 2 g of substance from 5°C to 15°C will be

a) 24 cal b) 56 cal c) 82 cal d) 100 c

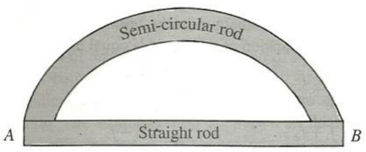
126. A slab consists of two parallel layers of copper and brass of the same thickness and having thermal conductivities in the ratio 1:4. If the free face of brass is at 100°C and that of copper at 0°C, the temperature of interface is

a) 80°C b) 20°C c) 60°C d) 40°C

127. A lead bullet at 27°C just melts when stopped by an obstacle. Assuming that 25% of heat is absorbed by the obstacle, then the velocity of the bullet at the time of striking (M.P. of lead = 327°C, specific heat of lead = $0.03 cal/g$°C, latent heat of fusion of lead = $6 cal/g$ and $J = 4.2 joule/cal$)
a) $410 m/s$ b) $1230 m/s$ c) $307.5 m/s$ d) None of the above

128. The radiation emitted by a star A is 1000 times that of the sun. If the surface temperatures of the sun and star A are 6000 K and 2000 K, respectively, the ratio of the radii of the star A and the sun is
a) 300:1 b) 600:1 c) 900:1 d) 1200:1

129. Two rods (one semi-circular and other straight) of same material and of same cross-sectional area are joined as shown in figure. The points A and B are maintained at different temperatures. 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 is



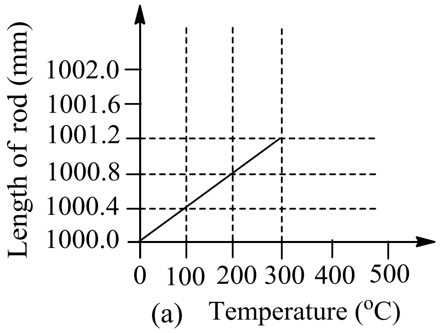
a) $2:\pi$ b) 1:2 c) $\pi:2$ d) 3:2

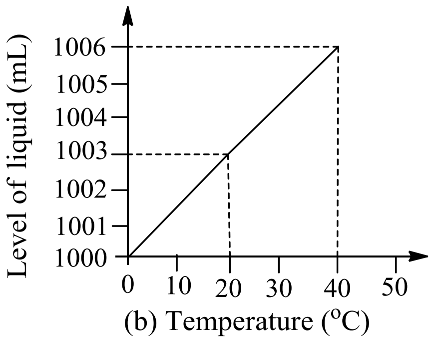
130. The coefficient of linear expansion of glass is α_s per °C and the cubical expansion of mercury is γ_m per °C. The volume of the bulb of a mercury thermometer at 0°C is V_0 and cross section of the capillary is A_0. What is the length of mercury column in capillary at T°C, if the mercury just fills the bulb at 0°C?
a) $\frac{V_0T(y_m + 3\alpha_g)}{A_0(1 + 2\alpha_g T)}$ b) $\frac{V_0T(y_m - 3\alpha_g)}{A_0(1 + 2\alpha_g T)}$ c) $\frac{V_0T(y_m + 2\alpha_g)}{A_0(1 + 3\alpha_g T)}$ d) $\frac{V_0T(y_m - 2\alpha_g)}{A_0(1 + 3\alpha_g T)}$

131. A room at 20°C is heated by a heater of resistance 20 ohm connected to 200 V mains. The temperature is uniform throughout the room and the heat is transmitted through a glass window of area 1 m^2 and thickness 0.2 cm. Calculate the temperature outside. Thermal conductivity of glass is 0.2 cal/m C° s and mechanical equivalent of heat is 4.2 J/cal
a) 13.69°C b) 15.24°C c) 17.85°C d) 19.96°C

132. Two spherical bodies A (radius 6 cm) and B (radius 18 cm) are at temperature T_1 and T_2 respectively. The maximum intensity in the emission spectrum of A is at 500 nm and in that of B is at 1500 nm. Considering them to be black bodies, what will be the ratio of the rate of total energy radiated by A to that of ?
a) 9 b) 9.5 c) 8 d) 8.5

133. The graph of elongation of rod of a substance A with temperature rise is shown in Figure. A liquid B contained in a cylindrical vessel made up of substance A, graduated in millitres at 0°C is heated gradually. The readings of the liquid level in the vessel corresponding to different temperatures are shown in the figure. The real volume expansivity of liquid is





a) $2.7 \times 10^{-5}/°C$ b) $15.4 \times 10^{-5}/°C$ c) $16.2 \times 10^{-5}/°C$ d) $151.2 \times 10^{-5}/°C$

134. It takes 10 min for an electric kettle to heat a certain quantity of water from 0°C to 100°C. It takes 54 min to convert this water at 100°C into steam. Then latent heat of steam is

a) 80 cal/g b) 540 cal/kg c) 540 cal/g d) 80 cal/kg

135. A clock with a metal pendulum beating seconds keeps correct time at 0°C. If it loses 12.5 s a day at 25°C, the coefficient of linear expansion of metal of pendulum is

a) $\frac{1}{86400}/°C$ b) $\frac{1}{43200}/°C$ c) $\frac{1}{14400}/°C$ d) $\frac{1}{28800}/°C$

136. The loss in weight of a solid when immersed in a liquid at 0°C is W_0 and at t°C is W. If cubical coefficients of expansion of the solid and the liquid are γ_s and γ_L, respectively, then W is equal to

a) $W_0[1 + (\gamma_s - \gamma_L)t]$ b) $W_0[1 - (\gamma_s - \gamma_L)t]$ c) $W_0[(\gamma_s - \gamma_L)t]$ d) $W_0 t[\gamma_s - \gamma_L]$

137. A uniform solid brass sphere is rotating with angular speed ω_0 about a diameter. If its temperature is now increased by 100°C, what will be its new angular speed. (Given $\alpha_B = 2.0 \times 10^{-5}$per °C)

a) $1.1\omega_0$ b) $1.01\omega_0$ c) $0.996\omega_0$ d) $0.824\omega_0$

138. A steel tape is placed around the earth at the equator. When the temperature is 0°C neglecting the expansion of the earth, the clearance between the tape and the ground if the temperature of the tape rises to 30°C, is nearly ($\alpha_{\text{steel}} = 11 \times 10^{-6}/\text{K}$)

a) 1.1 km b) 0.5 km c) 6400 km d) 2.1 km

139. Water falls from a height 500 m. The rise in temperature of water at bottom if whole of energy remains in water, will be (specific heat of water is c=4.2 kJ kg^{-1})

a) 0.23°C b) 1.16°C c) 0.96°C d) 1.02°C

140. A platinum sphere floats in mercury. Find the percentage change in the fraction of volume of sphere immersed in mercury when the temperature is raised by 80°C (volume expansivity of mercury is $182 \times 10^{-6}/°C$ and linear expansivity of platinum is $9 \times 10^{-6}/°C$)

a) 1.24% b) 1.38% c) 2.48% d) 2.76%

141. An electrically heated coil is immersed in a calorimeter containing 360 g of water at 10°C. The coil consumes energy at the rate of 90 W. The water equivalent of calorimeter and coil is 40 g. The temperature of water after 10 min is

a) 4.214°C b) 42.14°C c) 30°C d) None of these

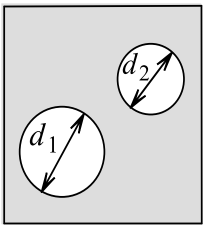
142. The energy spectrum of a black body exhibits a maximum around a wavelength λ_0. The temperature of the black body is now changed such that the energy is maximum around a wavelength $3\lambda_0/4$. The power radiated by the black body will now increase by a factor of

a) 256/81 b) 64/27 c) 16/9 d) 4/3

143. A body takes T minutes to cool from 62°C to 61°C when the surrounding temperature is 30°C. The time takes by the body to cool from 46°C to 45.5°C is

a) Greater than T minutes
b) Equal to T minutes
c) Less than T minutes
d) None of these

144. Two holes of unequal diameters d_1 and d_2 $(d_1 > d_2)$ are cut in a metal sheet. If the sheet is heated

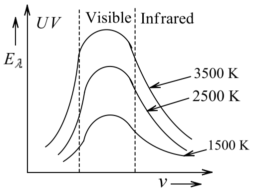


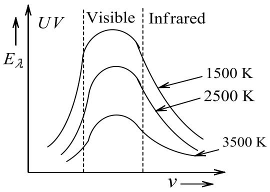
a) Both d_1 and d_2 will decrease
b) Both d_1 and d_2 will increase
c) d_1 will increase, d_2 will decrease
d) d_1 will decrease, d_2 will increase

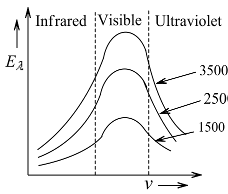
145. A block of wood is floating in water at 0°C. The temperature of water is slowly raised from 0°C to 10°C. With the rise in temperature the volume of block V above water level will

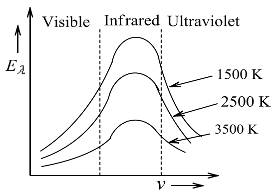
a) Increase
b) Decrease
c) First increase and then decrease
d) First decrease and then increase

146. Following graph shows the correct variation in intensity of heat radiations by black body and frequency at a fixed temperature

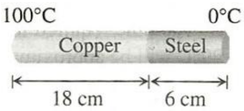
a) 

b) 

c) 

d) 

147. The coefficient of thermal conductivity of copper is nine times that of steel. In the composite cylindrical bar shown in Figure, what will be the temperature at the junction of copper and steel?



a) 75°C
b) 67°C
c) 33°C
d) 25°C

148. The temperature of a room heated by a heater is 20°C when outside temperature is −20°C and it is 10°C when the outside temperature is −40°C. The temperature of the heater is

a) 80°C
b) 100°C
c) 40°C
d) 60°C

149. The rates of cooling of two different liquids put in exactly similar calorimeters and kept in identical surroundings are the same if

a) The masses of the liquids are equal
b) Equal masses of the liquids at the same temperature are taken
c) Different volumes of the liquids at the same temperature are taken
d) Equal volumes of the liquids at the same temperature are taken

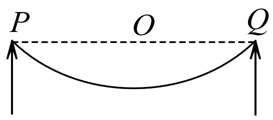
150. In a motor, the electrical power input is 500 W and the mechanical power output is 0.54 horse power. Heat developed in the motor in 1 h is (assuming that all the electric energy which is not converted to mechanical energy is converted to heat)is

a) 4.18×10^4 cal
b) 3.6×10^5 cal
c) 8.6×10^4 cal
d) 1.28×10^5 cal

151. A sphere and a cube of same material and same total surface area are placed in the same evacuated space turn by turn after they are heated to the same temperature. Find the ratio of their rates of cooling in the enclosure

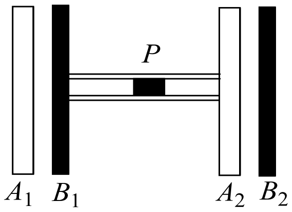
a) $\sqrt{\frac{\pi}{6}}:1$
b) $\sqrt{\frac{\pi}{3}}:1$
c) $\frac{\pi}{\sqrt{6}}:1$
d) $\frac{\pi}{\sqrt{3}}:1$

152. Span of a bridge is 2.4 km. At 30°C a cable along the span sags by 0.5 km. Taking $\alpha = 12 \times 10^{-6}$/°C, change in length of cable for a change in temperature from 10°C to 42°C is



a) 9.9 m b) 0.099 m c) 0.99 m d) 0.4 km

153. Two plates identical in size, one of black and rough surface (B_1) and the other smooth and polished (A_2) are interconnected by a thin horizontal pipe with a mercury pellet at the centre. Two more plates A_1(identical to A_2) and B_2(identical to B_1) are heated to the same temperature and placed closed to the plates B_1, and A_2 as shown in Figure. The mercury pellet



a) Moves to the right b) Moves to the left
c) Remains stationary d) Starts oscillating left and right

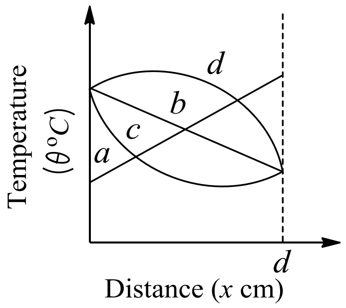
154. The coefficient of thermal conductivity of copper, mercury and glass are K_c, K_m and K_g, respectively, such that $K_c > K_m > K_g$. If the same quantity of heat is to flow per second per unit area of each and corresponding temperature gradients are, X_c, X_m and X_g, respectively then

a) $X_c = X_m = X_g$ b) $X_c > X_m > X_g$ c) $X_c < X_m < X_g$ d) $X_m < X_c < X_g$

155. A solid copper cube of edges 1 cm is suspended in an evacuated enclosure. Its temperature is found to fall from 100°C to 90°C in 100 s. Another solid copper cube of edges 2 cm, with similar surface nature, is suspended in a similar manner. The time required for this cube to cool from 100°C to 99°C will be approximately

a) 25 s b) 50 s c) 200 s d) 400 s

156. Figure shows then graph of the temperature θ of a section of a bar of length l, with distance x from the hot end, in the steady state for a metal rod polished with a poor thermal conductor on its lateral surface. Which is the correct graph?



a) a b) b c) c d) d

157. One end of a cooper rod of uniform cross section and length 1.5 m is kept in contact with ice and the other end with water at 100°C. At what point along its length should a temperature of 200°C be maintained so that in the steady state, the mass of ice melting be equal to that of the steam produced in same interval of time. Assume that the whole system is insulated from surroundings:
[$L_{\text{ice}} = 80$ cal/g, $L_{\text{steam}} = 540$ cal/g]

a) 10.34 cm from the end at 100°C b) 10.34 mm from the end at 100°C
c) 1.034 cm from the end at 100°C d) 1.034 m from the end at 100°C

158. A vessel is party filled with a liquid. Coefficients of cubical expansion of material of the vessel and liquid are γ_V and γ_L, respectively. If the system is heated, then volume unoccupied by the liquid will necessarily

a) Remain unchanged if $\gamma_V = \gamma_L$ b) Increase if $\gamma_V = \gamma_L$
c) decrease if $\gamma_V = \gamma_L$ d) None of the above

159. Latent heat of ice is 80cal/g. A man melts 60 g of ice by chewing in 1 min. His power is

a) 4800 W b) 336 W c) 1.33 W d) 0.75 W

160. An iron rod of length 50 cm is joined at an end to an aluminum rod of length 100 cm. All measurements

refer to 20°C. The coefficients of linear expansion of iron and aluminum are $12 \times 10^{-6}/°C$ and $24 \times 10^{-6}/°C$, respectively. The average coefficient of expansion of composite system is

a) $36 \times 10^{-6}/°C$ b) $12 \times 10^{-6}/°C$ c) $20 \times 10^{-6}/°C$ d) $48 \times 10^{-6}/°C$

161. A wire of length L_0 is supplied heat to raise its temperature by T. If γ is the coefficient of volume expension of the wire and Y is Young's modulus of the wire then the energy density stored in the wire is

a) $\frac{1}{2}\gamma^2T^2Y$ b) $\frac{1}{3}\gamma^2T^2Y^3$ c) $\frac{1}{18}\frac{\gamma^2T^2}{Y}$ d) $\frac{1}{18}\gamma^2T^2Y$

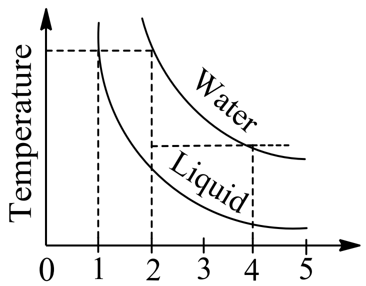
162. There are two thin spheres A and B of the same material and same thickness. They behave like black bodies. Radius of A is double that of B and both have same temperature T. When A and B are kept in a room of temperature $T_0(< T)$, the ratio of their rates of cooling is (assume negligible heat exchange between A and B)

a) 2:1 b) 1:1 c) 4:1 d) 8:1

163. A spherical black body with a radius of 12 cm radiates 440 W power at $500K$. If the radius were halved and the temperature doubled, the power radiated in watt would be

a) 225 b) 450 c) 900 d) 1800

164. Two identical calorimeters, each of water equivalent 100 g and volume 200 cm^3, are filled with water and a liquid. They are placed in identical constant-temperature enclosures to cool down. The temperatures are plotted at different times (the choice of units are completely arbitrary) as shown in Figure. If the density of the liquid is 800 kgm^{-3}, then its specific heat capacity is



a) 8400 J/kg°C b) 2100 J/kg°C c) 1312.5 J/kg°C d) 1680.5 J/kg°C

165. A thermally insulated piece of metal is heated under atmospheric pressure by an electric current so that it receives electric energy at a constant power P. This leads to an increase of absolute temperature T of the metal with time t as follows:

$T(t) = T_0[1 + a(t - t_0)]^{1/4}$. Here, a, t_0 and T_0 are constants the heat capacity $C_p(T)$ of the metal is

a) $\frac{4P}{aT_0}$ b) $\frac{4PT^3}{aT_0^4}$ c) $\frac{2PT^3}{aT_0^4}$ d) $\frac{2P}{aT_0}$

166. A calorimeter contains 0.2 kg of water at 30°C. 0.1 kg of water at 60°C is added to it, the mixture is well stirred and the resulting temperature is found to be 35°C. The thermal capacity of the calorimeter is

a) 6300 J/K b) 1260 J/K c) 4200 J/K d) None of these

167. A solid whose volume does not change with temperature floats in a liquid. For two different temperature t_1 and t_2 of the liquid, fractions f_1 and f_2 of the volume of the solid remain submerged in the liquid. The coefficient of volume expansion of the liquid is equal to

a) $\frac{f_1 - f_2}{f_2t_1 - f_1t_2}$ b) $\frac{f_1 - f_2}{f_1t_1 - f_2t_2}$ c) $\frac{f_1 + f_2}{f_2t_1 - f_1t_2}$ d) $\frac{f_1 + f_2}{f_1t_1 + f_2t_2}$

168. A drilling machine of 10 kW power is used to drill a bore in a small aluminium block of mass 8 kg. If 50% of power is used up in heating the machine itself or lost to the surroundings then how much is the rise in temperature of the block in 2.5 min (given: specific heat of aluminium= 0.91 J/g°C)?

a) 103°C b) 130°C c) 105°C d) 30°C

169. An ideal gas is expanding such that PT^2 = constant. The coefficient of volume expansion of the gas is

a) $\frac{1}{T}$ b) $\frac{2}{T}$ c) $\frac{3}{T}$ d) $\frac{4}{T}$

170. A uniform metal rod is used as a bar pendulum. If the room temperature rises by 10°C, and the coefficient of linear expansion of the metal of the rod is 2×10^{-6} per °C, the period of the pendulum will have

percentage increases of

a) -2×10^{-3} b) -1×10^{-3} c) 2×10^{-3} d) 1×10^{-3}

171. Calculate the compressional force required to prevent the metallic rod of length l cm and cross-sectional area A cm^2 when heated through t°C, from expanding lengthwise. Young's modulus of elasticity of the metal is E and mean coefficient of linear expension is α per degree celsius

a) $EA\alpha t$ b) $EA\alpha t/(1+\alpha t)$ c) $EA\alpha t/(1-\alpha t)$ d) $El\alpha t$

172. 250 g of water and equal volume of alcohol of mass 200 g are replaced successively in the same calorimeter and cool from 606°C to 55° C in 130 s and 67 s, respectively. If the water equivalent of the calorimeter is 10 g, then the specific heat of alcohol in cal/g-°C is

a) 1.30 b) 0.67 c) 0.62 d) 0.985

173. Calorie is defined as the amount of heat required to raise temperature of 1 g of water by 1 °C and it is defined under which of the following conditions?

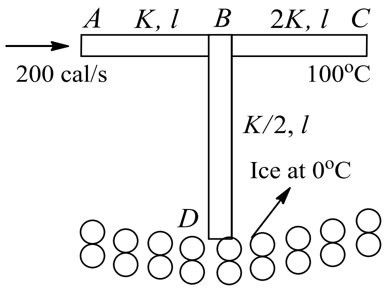
a) From 14.5°C to 15.5°C at 760 mm of Hg b) From 98.5°C to 99.5°C at 760 mm of Hg

c) From 13.5°C to 14.5°C at 76 mm of Hg d) From 3.5°C to 4.5°C at 76 mm of Hg

174. A flask of mercury is sealed off at 20°C and is completely filled with mercury. If the bulk modulus for mercury is 250 MPa and the coefficient of volume expansion of mercury is 1.82×10^{-4}/°C and the expension of glass is ignored, then pressure of mercury within the flask at 100°C will be

a) 100 MPa b) 72 MPa c) 36 MPa d) 24 MPa

175. Three rods AB, BC and BD of same length l and cross section A are arranged as shown. The end D is immersed in ice whose mass is 440 g and is at 0°C. The end C is maintained at 100°C. Heat is supplied at constant rate of 200 cal/s. Thermal conductivities of AB, BC and BD are K, $2K$ and $K/2$, respectively. Time after which whole ice will melt is ($K = 100$ cal/m-s-°C, $A = 10$ cm^2, l = 1 m)



a) 400 s b) 600 s c) 700 s d) 800 s

176. A wall is made up of two layers A and B. The thickness of the two layers is the same, but materials are different. The thermal conductivity of A is double than that of B. In thermal equilibrium the temperature difference between the two ends is 36°C. Then the difference of temperature at the two surfaces of A will be

a) 6°C b) 12°C c) 18°C d) 24°C

177. An iron tyre is to be fitted onto a wooden when 1.0 m in diameter. The diameter of the tyre is 6 mm smaller than that of wheel. The tyre should be heated so that its temperature increases by a minimum of (coefficient of volume expansion of iron is 3.6×10^{-5}/°C)

a) 167°C b) 334°C c) 500°C d) 1000°C

178. Two rods, one of aluminium and the other made of steel, having initial length l_1 and l_2 are connected together to form a single rod of length l_1+l_2. The coefficients of linear expansion for aluminium and steel are α_a and α_s respectively. If the length of each rod increases by the same amount when their temperature are raised by t°C, then find the ratio $\frac{l_1}{(l_1+l_2)}$.

a) $\frac{\alpha_s}{\alpha_a}$ b) $\frac{\alpha_a}{\alpha_s}$ c) $\frac{\alpha_s}{(\alpha_a+\alpha_s)}$ d) $\frac{\alpha_a}{(\alpha_{a+}\alpha_s)}$

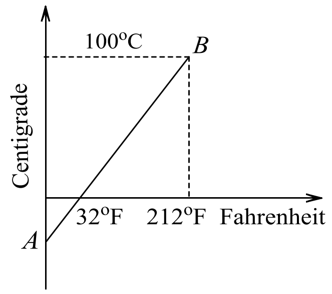
179. A 2 g bullet moving with a velocity of 200 m/s is brought to a sudden stoppage by an obstacle. The total heat produced goes to the bullet. If the specific heat of the bullet is 0.03 cal/g-°C, the rise in its temperature will be

a) 158.0°C b) 15.80°C c) 1.58°C d) 0.1580°C

180. Three discs, A, B and C having radii 2 m, 4 m and 6 m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensitios are 300 nm, 400 nm and 500 nm 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) $Q_A = Q_B = Q_C$

181. The graph AB shown in Fig. is a plot of temperature of a body in degree celsius and degree Fahrenheit. Then



a) Slope of line AB is $9/5$
b) Slope of line AB is $5/9$
c) Slope of line AB is $1/9$
d) Slope of line AB is $3/9$

182. The coefficient of linear expansion of an inhomogeneous rod changes linearly from α_1 to α_2 from one end to the other other end of the rod. The effective coefficient of linear expansion of rod is

a) $\alpha_1 + \alpha_2$ b) $\frac{\alpha_1 + \alpha_2}{2}$ c) $\sqrt{\alpha_1 \alpha_2}$ d) $\alpha_1 - \alpha_2$

Multiple Correct Answers Type

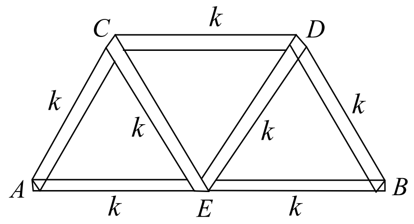
183. A metallic circular disc having a circular hole at its centre rotates about an axis passing through its centre and perpendicular to its plane. When the disc is heated

a) Its speed will decrease
b) Its diameter will decrease
c) Its moment of inertia will increase
d) Its speed will increase

184. The water equivalent of a copper calorimeter is 4.5 g. If the specific heat of copper is 0.09 cal/g°C

a) Mass of the calorimeter is 0.5 kg
b) Thermal capacity of the calorimeter is 4.5 cal/°C
c) Heat required to raise the temperature of the calorimeter by 8°C will be 36 cal
d) Heat required to melt 15 g of ice placed in the calorimeter will be 1200 cal

185. Seven identical rods of material of thermal conductivity k are connected as shown in Figure. All the rods are of identical length l and cross-sectional area A. If the one end B is kept at 100°C and the other end is kept at 0°C, what would be the temperature of the junctions C, D and $E (\theta_C, \theta_D$and θ_E in the steady state?



a) $\theta_C > \theta_E > \theta_D$
b) $\theta_E = 50°\text{C}$ and $\theta_D = 37.5°\text{C}$
c) $\theta_E = 50°\text{C}, \theta_C = 62.5°\text{C}$ and $\theta_D = 37.5°\text{C}$
d) $\theta_E = 50°\text{C}, \theta_C = 60°\text{C}$ and $\theta_D = 40°\text{C}$

186. Choose the correct statements from the following:

a) Good reflectors are good emitters of thermal radiation
b) Burns caused by water at 100°C are more severe than those caused by steam at 100°C
c) If the earth did not have atmosphere, it would become intolerably cold
d) It is impossible to construct a heat engine of 100% efficiency

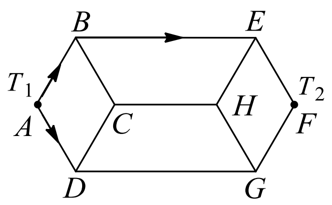
187. The ends of a metal rod are kept at temperature θ_1 and $\theta_2$with $\theta_2 > \theta_1$. The rate of flow of heat along the rod is directly proportional to

a) The length of the rod

b) The diameter of the rod
c) The cross-sectional area of the rod
d) The temperature difference $(\theta_2 - \theta_1)$ between the ends of the rod

188. A clock is calibrated at a temperature of 20°C. Assume that the pendulum is a thin brass rod of negligible mass with a heavy bob attached to the end $(\alpha_{\text{brass}} = 19 \times 10^{-6}/\text{K})$
a) On a hot day at 30°C the clock gains 8.2 s
b) On a hot day at 30°C the clock loses 8.2 s
c) On a cold day at 10°C the clock gains 8.2 s
d) On a cold day at 10°C the clock loses 8.2 s

189. Eleven identical rods are arranged as shown in Figure. Each rod has length l, cross sectional area A and thermal conductivity of material L. Ends A and F are maintained at temperature T_1 and $(T_2(< T_1)$, respectively. If lateral surface of each rod is thermally Insulated, the rate of heat transfer $\left(\frac{dQ}{dt}\right)$ in each rod is

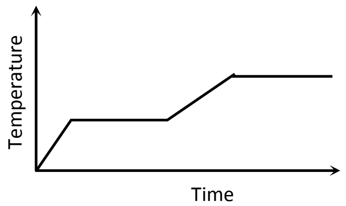


a) $\left(\frac{dQ}{dt}\right)_{AB} = \left(\frac{dQ}{dt}\right)_{CD}$
b) $\left(\frac{dQ}{dt}\right)_{BE} = \frac{2}{7}\frac{(T_1 - T_2)KA}{l}$
c) $\left(\frac{dQ}{dt}\right)_{CH} \neq \left(\frac{dQ}{dt}\right)_{DG}$
d) $\left(\frac{dQ}{dt}\right)_{BC} = \left(\frac{dQ}{dt}\right)_{DC}$

190. A rod of copper, uniform along its length l and of a rectangular cross section of sides of length a and width $b(< a)$ has one end maintained at 100°C and the other end at 0°C. The rod is insulated so that no heat is lost from the sides. Let Q_l be the amount of heat transmitted parallel to a and Q_b the heat transmitted parallel to b across any section after the steady state conditions are reached. Then
a) Q_1=constant, $Q_a > Q_b$and Q_a as well as Q_b are non-zero
b) $Q_1 = 0, Q_a = Q_b \neq 0$
c) $Q_1 = 0, Q_a = Q_b = 0$
d) Q_1 =constant, $Q_a = Q_b = 0$

191. Due to thermal expansion with rise in temperature:
a) Metallic scale reading becomes lesser than true value
b) Pendulum clock becomes fast
c) A floating body sinks a little more
d) The weight of a body in a liquid increases

192. Heat is supplied to a certain homogenous sample of matter, at a uniform rate. Its temperature is plotted against time, as shown. Which of the following conclusions can be drawn



a) Its specific heat capacity is greater in the solid state than in the liquid state
b) Its specific heat capacity is greater in the liquid state than in the solid state
c) Its latent heat of vaporization is greater than its latent heat of fusion
d) Its latent heat of vaporization is smaller than its latent of fusion

193. At 127°C , radiated energy is 2.7×10^{-3} Js^{-1}. At what temperature radiated energy is 4.32×10^{6} Js^{-1}?
a) 400 K
b) 4000 K
c) 80000 K
d) 40000 K

194. A polished metallic piece and a black painted wooden piece are kept in open in bright sun for a long time
a) The wooden piece will absorb less heat than the metallic piece
b) The wooden piece will have a lower temperature than the metallic piece

c) If touched, the metallic piece will be felt hotter than the wooden piece
d) When the two pieces are removed from the open to a cold room, the wooden piece will lose heat at a faster rate than the metallic piece

195. In a dark room with ambient temperature T_0 a black body is kept at a temperature T. Keeping the temperature 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. Assuming that there is no change in the ambient temperature of the room, which of the following statement is/are correct
a) The quantity of radiation absorbed by the black body in unit time will increase
b) Since emissivity = absorptivity, hence the quantity of radiation emitted by black body in unit time will increase
c) Black body radiates more energy in unit time in the visible spectrum
d) The reflected energy in unit time by the black body remains same

196. Two bodies A and B have thermal emissivities of 0.01 and 0.81 respectively. The outer surface areas of the two bodies are the 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 from the wavelength corresponding to maximum spectral radiancy in the radiation from A, by $1.00\mu m$. If the temperature of A is 5802 K
a) The temperature of B is 1934 K
b) $\lambda_B = 1.5\mu m$
c) The temperature of B is 11604 K
d) The temperature of B is 2901 K

197. A heated body emits radiation which has maximum intensity at frequency v_m. If the temperature of the body is doubled:
a) The maximum intensity radiation will be at frequency $2v_m$
b) The maximum intensity radiation will be at frequency $(1/2)v_m$
c) The total emitted energy will increase by a factor of 16
d) The total emitted energy will increase by a factor of 2

198. A bimetallic strip is formed out of two identical strips, one of copper and other of brass. The coefficients of linear expansion of the two metals are α_C and α_B. On heating, the temperature of the strip goes up by ΔT and the strip bends to form an arc of radius of curvature R. Then R is
a) Proportional to ΔT
b) Inversely proportional to ΔT
c) Proportional to $|\alpha_B - \alpha_C|$
d) Inversely proportional to $|\alpha_B - \alpha_C|$

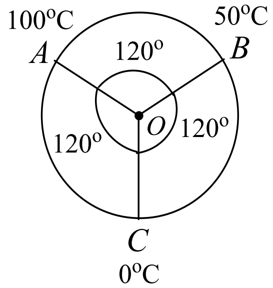
199. A vessel is partly filled with liquid. When the vessel is cooled to a lower temperature, the space in the vessel unoccupied by the liquid remains constant. Then the volume of the liquid remains constant. Then the volume of the liquid (V_L) volume of the vessel (V_V), the coefficient of cubical expansion of the material of the vessel (γ_v) and of the solid (γ_L) are related as
a) $\gamma_L > \gamma_v$
b) $\gamma_L < \gamma_v$
c) $\frac{\gamma_v}{\gamma_L} = \frac{V_v}{V_L}$
d) $\frac{\gamma_v}{\gamma_L} = \frac{V_L}{V_v}$

200. When m gram of water at 10°C is mixed with m grame of ice at 0°C, which of the following statements are false?
a) The temperature of the system will be given by the equation $m \times 80 + m \times 1 \times (T - 0) = m \times 1 \times (10 - T)$
b) Whole of ice will melt and temperature will be more than 0°C but lesser than 10°C
c) Whole of ice will melt and temperature will be 0°C
d) Whole of ice will not melt and temperature will be 0°C

201. During the melting of a slab of ice at 273 K at the atmospheric pressure
a) Positive work is done by the ice-water system on the atmosphere
b) Positive work is done on the ice-water system by the atmosphere
c) The internal energy of the ice-water system increases
d) The internal energy of the ice-water system decreases

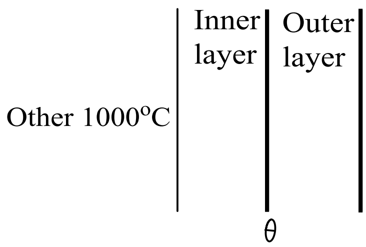
202. A circular ring (centre O) of radius a, and of uniform cross section is made up of three different metallic rods AB, BC and CA (joined together at the points A, B and C in pairs) of thermal conductivies α_1, α_2 and α_3, respectively (see diagram). The junctions A, B and C are maintained at the temperatures 100°C, 50°C and 0°C, respectively. All the rods are of equal lengths and cross sections. Under steady state conditions,

assume that no heat is lost from the sides of the rods. Let Q_1, Q_2 and Q_3 be the rates of transmission of heat along the three rods AB, BC and CA. Then



a) $Q_1 = Q_2 = Q_3$ and all are transmitted in the clockwise sense
b) Q_1 and Q_2 flow in clockwise sense and Q_3 in the anticlockwise sense
c) $Q_1 : Q_2 : Q_3 :: \alpha_1 : \alpha_2 : 2\alpha_3$
d) $\frac{Q_1}{\alpha_1} + \frac{Q_2}{\alpha_2} = \frac{Q_3}{\alpha_3}$

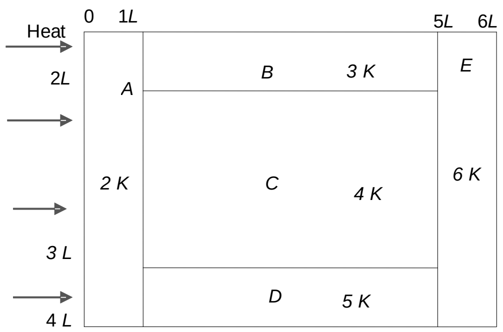
203. The temperature drop through a two-layer furnace wall is 900°C. Each layer is of equal area of cross section. Which of the following actions will result in lowering the temperature θ of the interface



a) By increasing the thermal conductivity of outer layer
b) By increasing the thermal conductivity of inner layer
c) By increasing thickness of outer layer
d) By increasing thickness of inner layer

204. During heat exchange, temperature of a solid mass does not change. In this process, heat
a) Is not being supplied to the mass
b) Is not being taken out from the mass
c) May have been supplied to the mass
d) May have been taken out from the mass

205. 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) Heat flow through A and E slabs are same
b) Heat flow through slab E is maximum
c) Temperature difference across slab E is smallest
d) Heat flow through C=heat flow through B +heat flow through D

206. When the temperature of a copper coin is raised by 80°C, its diameter increases by 0.2%
a) Percentage rise in the area of a face 0.4%
b) Percentage rise in the thickness is 0.4%
c) Percentage rise in the volume is 0.6%
d) Coefficient of linear expansion of copper is $0.25 \times 10^{-4}/°C$

207. Two identical objects A and B are at temperature T_A and T_B respectively. Both objects are placed in a room with perfectly absorbing walls maintained at a temperature $T(T_A > T > T_B)$. The objects A and B attain the temperature T eventually. Select the Correct statements from the following

a) A only emits radiation, while B only absorbs it until both attain the temperature T

b) A loses more heat by radiation than it absorbs, while B absorbs more radiation than it emits, until they attain the temperature T

c) Both A and B only absorb radiation, but do not emit it, until they attain the temperature T

d) Each object continuous to emit and absorb radiation even after attaining the temperature T

208. Choose the correct statements from the following:

a) A temperature change which increases the length of a steel rod by 0.1% will increase its volume by nearly 0.3%

b) The specific heat of a solid is different when the solid is heated at (i) constant pressure and (ii) the constant volume

c) The thermal conductivity of air being less than that for wool, we prefer wool to air for thermal insulation

d) When the distance between two fixed points is measured with a steel tape, the observed reading will be less on a hot day than on a cold day

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 209 to 208. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

209

Statement 1: The equivalent thermal conductivity of two plates of same thickness in contact (series) is less than the smaller value of thermal conductivity

Statement 2: For two plates of equal thickness in contact (series) the equivalent thermal conductivity is given by

$$\frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2}$$

210

Statement 1: A brass tumbler feels much colder than a wooden tray on a chilly day

Statement 2: The thermal conductivity of brass is less than that of wood

211

Statement 1: Blue star is at high temperature than red star

Statement 2: Wien's displacement law states that $T \propto (1/\lambda_m)$

212

Statement 1: A beaker is completely filled with water at 4°C. It will overflow, both when heated or cooled

Statement 2: There is expansion of water below and above 4°C.

213

Statement 1: Temperatures near the sea coast are moderate

Statement 2: Water has a high thermal conductivity

214

Statement 1: The melting point of ice decreases with increase of pressure

Statement 2: Ice contracts on melting

215

Statement 1: It is hotter over the top of a fire than at the same distance on the sides

Statement 2: Air surrounding the fire conducts more heat upwards

216

Statement 1: The thermal resistance of a multiple layer is equal to the sum of the thermal resistance of the individual laminas

Statement 2: Heat transferred is directly proportional to the temperature gradient in each layer

217

Statement 1: The absorbance of a perfect black body is unity

Statement 2: A perfect black body when heated emits radiations of all possible wavelengths at that temperatures

218

Statement 1: The temperature at which Centigrade and Fahrenheit thermometers read the same is -40^o

Statement 2: There is no relation between Fahrenheit and Centigrade temperature

219

Statement 1: The molecules at 0°C ice and 0°C water will have same potential energy

Statement 2: Potential energy depends only on temperature of the system

220

Statement 1: A man would feel iron or wooden balls equally hot at $98.4°F$

Statement 2: At $98.4°F$ both iron and wood have same thermal conductivity

221

Statement 1: A common model of a solid assumes the atoms to be point executing SHM about mean lattice positions. This model cannot explain thermal expansion of solids

Statement 2: The average distance over a time period of oscillation between the particles remains constant

222

Statement 1: If the temperature of a star is doubled then the rate of loss of heat from it becomes 16 times

Statement 2: Specific heat varies with temperature

223

Statement 1: Perspiration from human body helps in cooling the body

Statement 2: A thin layer of water on the skin enhances its emissivity

224

Statement 1: Two stars S_1 and S_2 radiate maximum energy at 360 nm and 480 nm, respectively. Ratio of their absolute temperatures is 4:3

Statement 2: According to Wien's law $\lambda T = b$ (constant)

225

Statement 1: While measuring the thermal conductivity of liquid experimentally, the upper layer is kept hot and the lower layer is kept cold

Statement 2: This avoids hearting of liquid by convection

226

Statement 1: Specific heat capacity is the cause of formation of land and sea breeze

Statement 2: The specific heat of water is more than land

227

Statement 1: In thermal conduction, energy is transferred due to chaotic motion of conduction electron and atomic vibrations from region of high temperature to low temperature

Statement 2: There is overall transference of particles of conducting body

228

Statement 1: Radiation is the speediest mode of heat transfer

Statement 2: Radiation can be transmitted in zig-zag motion

229

Statement 1: In natural convection, the fluid motion is caused due to density difference produced by temperature gradient

Statement 2: In forced convection, the fluid is forced to flow along the solid surface by means of fans or pumps

230

Statement 1: Fahrenheit is the smallest unit measuring temperature

Statement 2: Fahrenheit was the first temperature scale used for measuring temperature

231

Statement 1: The radiation from the sun's surface varies as the fourth power of its absolute temperature

Statement 2: The sun is not a black body

232

Statement 1: For higher temperature, the peak emission wavelength of a black body shifts to lower wavelength

Statement 2: Peak emission wavelength of a blackbody is proportional to the fourth power of temperature

233

Statement 1: Animals curl into a ball, when they feel very cold

Statement 2: Animals by curling their body reduce the surface area

234

Statement 1: Woolen clothes keep the body warm in winter

Statement 2: Air is a bad conductor of heat

235

Statement 1: Snow is better insulator than ice

Statement 2: Snow contains air packet and air is good insulator of heat

236

Statement 1: Two bodies at different temperatures, if brought in thermal contact do not necessary settle to the mean temperature

Statement 2: The two bodies may have different thermal capacities

237

Statement 1: Melting of solid causes no change in internal energy

Statement 2: Latent heat is the heat required to melt a unit mass of solid

238

Statement 1: The expanded length l of a rod of original length l_0 is not correctly given by (assuming α to be constant with T) $l = l_0(1 + \alpha\Delta T)$ if a ΔT is large

Statement 2: It is given by $l = l_0 e^{\alpha\Delta T}$, which cannot be treated as being approximately equal to $l = l_0(1 + \alpha\Delta T)$ for large value a ΔT

239

Statement 1: Like light radiations, thermal radiation are also electromagnetic radiation

Statement 2: The thermal radiations require no medium for propagation

240

Statement 1: Greater is the coefficient of thermal conductivity of a material, smaller is the thermal resistance of a that material

Statement 2: Thermal resistance is the ratio of temperature difference between the ends of the conductor and rate of flow of heat

241

Statement 1: As the temperature of the black body increases, the wavelength at which the spectral intensity (E_λ) is maximum decreases

Statement 2: The wavelength at which the spectral intensity will be maximum for a black body is proportional to the fourth power of its absolute temperature

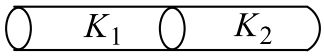
242

Statement 1: The bulb of one thermometer is spherical while that of the other is cylindrical. Both have equal amounts of mercury. The response of the cylindrical bulb thermometer will be quicker

Statement 2: Heat conduction in a body is directly proportional to cross-sectional area

243

Statement 1: Two solid cylindrical rods of identical size and different thermal conductivity $K_1$and K_2 are connected in series. Then the equivalent thermal conductivity of two rods system is less than that value of thermal conductivity of either rod



Statement 2: For two cylindrical rods of identical size and different thermal conductivity K_1 and K_2 connected in series, the equivalent thermal conductivity K is given by

$$\frac{2}{K}=\frac{1}{K_1}+\frac{1}{K_2}$$

244

Statement 1: A body that is a good radiator is also a good absorber of radiation at a given wavelength

Statement 2: According to Kirchoff's law the absorptivity of a body is equal to its emissivity at a given wavelength

245

Statement 1: All black coloured objects are considered black bodies

Statement 2: Black colour is a good absorber of heat

246

Statement 1: Water kept in an open vessel will quickly evaporate on the surface of the moon

Statement 2: The temperature at the surface of the moon is much higher than boiling point of the water

247

Statement 1: Specific heat of a body is always greater than its thermal capacity

Statement 2: Thermal capacity is the required for raising temperature of unit mass of the body through unit degree

248

Statement 1: Bodies radiate heat at all temperatures

Statement 2: Rate of radiation of heat is proportional to the fourth power of absolute temperature

249

Statement 1: The coefficient of volume expansion has dimension K^{-1}

Statement 2: The coefficient of volume expansion is defined as the change in volume per unit volume per unit change in temperature

250

Statement 1: A hollow metallic closed container maintained at a uniform temperature can act as a source of black body radiation

Statement 2: All metals act as a black body

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II**.

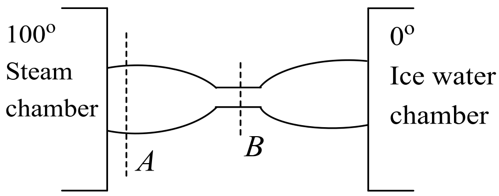
251. Match the conics in Column I with the statements/expressions in Column II

Column-I	Column- II
(A) Bimetallic strip	(p) Radiation from a hot body
(B) Steam engine	(q) Energy conversion
(C) Incandescent lamp	(r) Melting
(D) Electric fuses	(s) Thermal expansion of solids

CODES :

	A	**B**	**C**	**D**
a)	s	q	p,q	q,r
b)	p,q	q,r	s	q
c)	q	p,q	q,r	s
d)	q,r	s	q	p,q

252. A copper rod (initially at room temperature 20°C) of non-uniform cross section is placed between a steam chamber at 100°C and ice water chamber at 0°C. A and B are cross sections as shown in Figure. Then match the statements in Column I with results in Column II comparing only between cross section A and B. (The mathematical expressions in Column I have their usual meanings in heat transfer)

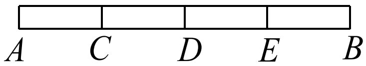


Column-I	Column- II
(A) Initially rate of heat flow $\left(\frac{dQ}{dt}\right)$ will be	(p) Maximum at section A
(B) At steady state rate of heat flow $\left(\frac{dQ}{dt}\right)$ will be	(q) Maximum at section B
(C) At steady state temperature gradient $\left\|\left(\frac{dT}{dx}\right)\right\|$ will be	(r) Minimum at section B
(D) At steady state rate of change of temperature $\left(\frac{dT}{dt}\right)$ will be	(s) Same for all section

CODES :

	A	B	C	D
a)	A,c	d	b	d
b)	a	b	c	d
c)	d	a	b	c
d)	dc	ad	b	a

253. A rod AB of uniform cross section consists of four sections AC, CD, DE and EB of different metals with thermal conductivities K, (0, 8) K, (1.2) K and (1.50) K, respectively. Their lengths are respectively L, (1.2) L, (1.5) L and (0.6)L. They are joined rigidly in succession at C, D and E to form the rod AB. The end A is maintained at 100°C and the end B is maintained at 0°C. The steady state temperature of the joints C, D and E are respectively T_C, $T_D$and T_E, Column I lists the temperature differences $(T_A - T_C)$, $(T_C - T_D)$, $(T_D -$ TE and $(TE{-}TB)$ in the four sections and Column II their values jumbled up. Match each item in Column I with its correct value in Column II



Column-I	**Column- II**
(A) $(T_A - T_C)$	(p) 9.6
(B) $(T_C - T_D)$	(q) 30.1
(C) $(T_D - T_E)$	(r) 24.1
(D) $(T_E - T_B)$	(s) 36.2

CODES :

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

254. The surface of a household radiator has an emissivity of 0.55 and an area of 1.5 m^2. Its equilibrium temperature is 50°C and the surroundings are at 22°C ($\sigma = 5.67\times 10^{-8}$ W/m^2K^4)

Column-I	**Column- II**
(A) At what rate is radiation emitted by the radiator?	(p) 155
(B) At what rate is radiation absorbed by the radiator?	(q) 509
(C) What is the net value of radiation from the radiation?	(r) 354

CODES :

	A	B	C	D

a)	B	a	c
b)	a	c	b
c)	b	c	a
d)	c	a	b

255. In Column I some statements or expressions related to first law of thermodynamics are given, and corresponding process are given in Column II. Match the entries of Column I with the entries of Column II

	Column-I		Column- II
(A)	Work done by the system on the surrounding can be non-zero in	(p)	Adiabatic process
(B)	$dU = nC_v dT$ is valid for	(q)	Isothermal process
(C)	dU is zero for	(r)	Isothermal expansion process
(D)	$dQ = nCdT$ is non zero for	(s)	Polytropic process

CODES :

	A	**B**	**C**	**D**
a)	D,c,	a,b,c	d	a,d
b)	a,b,c,d	a,b,c,d	b,c	b,c,d
c)	a,c	d	b	d
d)	a	b	c	d

256. In a container of negligible mass $'m'$ grams of steam at 100°C is added to 100 g of water that has temperature 20°C. If no heat is lost to the surrounding at equilibrium, match the items given in Column I with that in Column II

	Column-I		Column- II
(A)	Mass of steam in the mixture , if m=20 g (in g)	(p)	114.8
(B)	Mass of water in the mixture, if m =20 g (in g)	(q)	76.4
(C)	If m =20 g, final temperature of the mixture (in °C)	(r)	5.2
(D)	If m=10 g, final temperature of the mixture (in °C)	(s)	100

CODES :

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

257. On the average, the temperature of the earth's crust increases 1°C for every 30 m of depth. The average thermal conductivity of the earth's crust is 0.75 J/msK. Solar constant is 1.35 kW/m^2. Match the items in Column I with that in Column II:

	Column-I		Column- II
(A)	Heat lost by the core of the earth per second due to conduction (in W)	(p)	276
(B)	Heat received by the earth per second from the sun (in W)	(q)	7.5×10^{-5}
(C)	If e=1, average surface temperature of the earth in equilibrium (in K)	(r)	1.3×10^{13}
(D)	Ratio of heat lost by the earth to the heat received from the sun	(s)	1.7×10^{17}

CODES :

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

258. A piece of metal of density $\rho_1$floats on mercury of density ρ_2. The coefficients of expansion of the metal and mercury are $\gamma_1$and γ_2, respectively. The temperatures of both mercury and, metal are increased by ΔT. Then match the following

	Column-I		Column- II
(A)	If $\gamma_2 > \gamma_1$	(p)	No effect on fraction of solid submerged in mercury
(B)	$\gamma_2 = \gamma_1$	(q)	Fraction of the volume of metal submerged in mercury increases
(C)	If $\gamma_2 < \gamma_1$	(r)	The solid sinks
		(s)	The solid lifts up

CODES :

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

Linked Comprehension Type

This section contain(s) 19 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 259 to -259

A body cools in a surrounding of constant temperature 30°C. Its heat capacity is 2 J/°C. Initial temperature of the body is 40°C. Assume Newton's law of cooling is valid. The body cools to 38°C in 10 min

259. In further 10 min it will cool from 38°C to________________:
a) 36°C b) 36.4°C c) 37°C d) 37.5°C

Paragraph for Question Nos. 260 to - 260

The internal energy of a solid also increases when heat is transferred to it from its surroundings. A 5 kg solid bar is heated at atmospheric pressure. Its temperature increases from 20°C to 70°C. The linear expansion coefficient of solid bar is $1 \times 10^{-3}/\mathrm{C}°$. The density of solid bar is $50\ \mathrm{kg/m^3}$. The specific heat capacity of solid bar is 200 J/kg C°. The atmospheric pressure is $1 \times 10^5 \mathrm{N/m^2}$

260. The work done by the solid bar due to thermal expansion, under atmospheric pressure, is
a) 500 J b) 1000 J c) 1500 J d) 2000 J

Paragraph for Question Nos. 261 to - 261

A wire of length 1 m and radius 10^{-3} m is carrying a heavy current and is assumed to radiate as a black body. At equilibrium, its temperature is 900 K while that of surrounding is 300 K. The resistivity of the material of the wire at 300 K is $\pi^2 \times 10^{-8}$ ohm m and its temperature coefficient of resistance is $7.8 \times 10^{-3}/°\mathrm{C}$ (Stefan's constant $\sigma = 5.68 \times 10^{-8}\ \mathrm{W/m^2K^4}$)

261. The resistivity of wire at 900 K is nearly
a) 2.4×10^7ohm m b) 2.4×10^{-7}ohm m c) 1.2×10^{-7}ohm m d) 1.2×10^7ohm m

Paragraph for Question Nos. 262 to - 262

A solid aluminium sphere and a solid lead sphere of same radius are heated to the same temperature and allowed to cool under identical surrounding temperatures. The specific heat capacity of aluminium$=$ 900 J/ kg°C and that of lead $=$ 130 J/kg°C. The density of lead $=10^4\ \mathrm{kg/m^3}$ and that of aluminum $= 2.7 \times 10^3 \mathrm{kg/m^3}$. Assume that the emissivity of both the spheres is the same

262. The ratio of rate of fall of temperature of the aluminium sphere to the rate of heat loss from the lead sphere is
a) 1:1 b) 9:1.3 c) 11:2.7 d) 1:4

Paragraph for Question Nos. 263 to - 263

Assume that the thermal conductivity of copper is twice that of aluminium and four times that of brass. Three metal rods made of copper, aluminium and brass are each 15 cm long and 2 cm in diameter. These rods are placed end to end, with aluminium between the other two. The free ends of the copper and brass rods are maintained at 100°C and 0°C, respectively. The system is allowed to reach the steady state condition. Assume there is no loss of heat anywhere

263. When steady state condition is reached everywhere which of the following statement is true?
a) No heat is transmitted across the copper-aluminium or aluminium-brass junctions
b) More heat is transmitted across the copper-aluminium junction than across the aluminium-brass junction
c) More heat is transmitted across the aluminium-brass junction than the copper-aluminium junction
d) Equal amount of heat is transmitted at the copper-aluminium and aluminium–brass junctions

Paragraph for Question Nos. 264 to - 264

A thin copper rod of uniform cross section A square metres and of length L metres has a spherical metal sphere of radius r metre at its one end symmetrically attached to the copper rod. The thermal conductivity of copper is ε. The free end of the copper rod is maintained at the temperature T kelvin by supplying thermal energy form a P watt source. Steady state conditions are allowed to be established while the rod is properly insulated against heat loss from its lateral surface. Surroundings are at 0°C. Stefan's constant $= \sigma\ \mathrm{W/m^2K^4}$

264. After the steady state conditions are reached, the temperature of the spherical end rod, T_S is
a) $T_S = T - \frac{PL}{KA}$ b) $T_S = 0°C$ c) $T_S = \frac{PL}{KA}$ d) $T_S = T - \frac{P(L+r)}{KA}$

Paragraph for Question Nos. 265 to - 265

An immersion heater, in an insulated vessel of negligible heat capacity brings 10 g of water to the boiling point from 16°C in 7 min. Then

265. Power of heater is nearly
a) 8.4×10^3 b) 84 W c) 8.4×10^3 cal/s d) 20 W

Paragraph for Question Nos. 266 to - 266

A body of area $0.8 \times 10^{-2}\mathrm{m^2}$ and mass 5×10^{-4} kg directly faces the sum on a clear day. The body has an emissivity of 0.8 and specific heat of 0.8cal/kg K. The surrounding are at 27°C. (solar constant =1.4 $\mathrm{kW/m^2}$)

266. The rate of rise of the body's temperature is nearly
a) 0.36°C/s b) 3.6 K/s c) 36°C/s d) 72 K/s

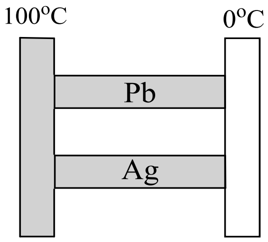
Paragraph for Question Nos. 267 to - 267

A copper collar is to fit tightly about a steel shaft that has a diameter of 6 cm at 20°C. The inside diameter of the copper collar at that temperature is 5.98 cm

267. To what temperature must the copper collar be raised so that it will just slip on the steel shaft, assuming the steel shaft remains at 20°C? ($\alpha_{\mathrm{copper}} = 17 \times 10^{-6}$/K)
a) 324°C b) 21.7°C c) 217°C d) 32.4°C

Paragraph for Question Nos. 268 to - 268

Two insulated metal bars each of length 5 cm and rectangular cross section with sides 2 cm and 3 cm are wedged between two walls, one held at 100° C and the other at 0° C. The bars are made of lead and silver. $K_{\text{pb}} = 350 \text{ W/mK}, K_{\text{Ag}} = 425 \text{ W/mK}$



268. Thermal current through lead bar is
   a) 210 W b) 420 W c) 510 W d) 930 W

Integer Answer Type

269. Two vessels connected at the bottom by a thin pipe with a sliding pulg constain liquid at 20°C and 80°C respectively. The coefficient of cubic expansion of liquid is $10^{-3} K^{-1}$ the ratio of heights of liquid columns in the vessel (H_{20}/H_{80}) is nearest to which integer?
270. A body is cooled in 2 min in a room at temperature of 30°C from 75°C. If the same body is cooled from 55°C to 45°C in the same room, find the time taken (in minute).
271. 2 kg of ice at −20°C is mixed with 5 kg of water at 20°C in an insulating vessel having a negligible heat capacity calculate the final mass of water (in Kg) remaining in the container.
272. 2 kg of ice at −15°C is mixed with with 2.5 kh of water at 25°C in an insulting container. If the specific heat capacities of ice and water are 0.5 cal/g°C and 1 cal/g°C, find the amount of water present in the container?(in kg nearest integer)
273. In two experiments with a continuous flow calorimeter to determine the specific heat capacity of a liquid, an input power of 16 W produced a rise of 10K in the liquid. When the power was doubled, the same temperature rise was achieved by making the rate of flow of liquid three times faster the power lost (in W) to the surrounding in each case
274. Two identical conducting rods are first, connected independently to two vessels, one containing water at 100°C and other containing ice at 0°C. in the second case, rods are joined end to end and are connected to the same vessel. If q_1 and q_2 (in g/s) are the rates of melting of ice in two cases, then find the ratio of q_1/q_2.
275. Four cylinder rods of same material with length and radius (ℓ, r), $(2\ell, r)$, $(2\ell, 2r)$ and $(\ell, 2r)$ are connected bet-ween two reservious at 0°C and 100°C, find the ratio of the maximum to minimum rate of conduction in them
276. A clock with a metallic pendulum at 15°C runs faster by 5 s each day and at 30°C, runs slow by 10 s. Find the coefficient of linear expansion of the metal. (nearly in 10^{-6}/°C)

: ANSWER KEY :

1)	d	2)	c	3)	a	4)	c	157)	a	158)	b	159)	b	160)	c
5)	c	6)	a	7)	b	8)	b	161)	d	162)	b	163)	d	164)	c
9)	a	10)	a	11)	b	12)	a	165)	b	166)	b	167)	a	168)	a
13)	c	14)	c	15)	b	16)	d	169)	c	170)	d	171)	b	172)	c
17)	a	18)	a	19)	d	20)	a	173)	a	174)	c	175)	d	176)	b
21)	a	22)	d	23)	d	24)	b	177)	c	178)	c	179)	a	180)	b
25)	a	26)	d	27)	b	28)	c	181)	b	182)	b	1)	a,c	2)	
29)	a	30)	b	31)	c	32)	d		b,c,d	3)	a,c	4)	c,d		
33)	d	34)	a	35)	a	36)	a	5)	c,d	6)	b,c	7)	b,c,d	8)	
37)	b	38)	b	39)	c	40)	c		c,d						
41)	d	42)	c	43)	b	44)	c	9)	a,c,d	10)	b,c	11)	c	12)	
45)	d	46)	a	47)	c	48)	a		c,d						
49)	c	50)	d	51)	a	52)	b	13)	a,b,c,d	14)	a,b	15)	a,c	16)	
53)	b	54)	c	55)	d	56)	a		b,d						
57)	b	58)	c	59)	a	60)	a	17)	a,d	18)	a,b,c	19)	b,c	20)	
61)	a	62)	b	63)	b	64)	a		b,c,d						
65)	b	66)	a	67)	c	68)	b	21)	a,d	22)	c,d	23)	a,c,d	24)	
69)	a	70)	d	71)	a	72)	d		a,c,d						
73)	b	74)	a	75)	d	76)	c	25)	b,d	26)	a,b,d	1)	d	2)	c
77)	a	78)	c	79)	d	80)	d		3)	a	4)	a			
81)	b	82)	a	83)	b	84)	a	5)	b	6)	a	7)	c	8)	d
85)	b	86)	a	87)	b	88)	a	9)	b	10)	c	11)	d	12)	c
89)	c	90)	a	91)	a	92)	d	13)	a	14)	b	15)	c	16)	a
93)	c	94)	c	95)	b	96)	b	17)	a	18)	a	19)	c	20)	c
97)	b	98)	c	99)	d	100)	c	21)	b	22)	c	23)	c	24)	c
101)	c	102)	b	103)	b	104)	c	25)	a	26)	a	27)	a	28)	a
105)	b	106)	c	107)	b	108)	c	29)	e	30)	a	31)	b	32)	b
109)	d	110)	b	111)	c	112)	d	33)	c	34)	a	35)	d	36)	a
113)	c	114)	c	115)	b	116)	c	37)	e	38)	c	39)	d	40)	e
117)	d	118)	b	119)	a	120)	d	41)	a	42)	c	1)	a	2)	a
121)	b	122)	c	123)	b	124)	a		3)	c	4)	c			
125)	c	126)	a	127)	a	128)	c	5)	b	6)	d	7)	b	8)	a
129)	a	130)	b	131)	b	132)	a	1)	b	2)	c	3)	b	4)	a
133)	c	134)	c	135)	a	136)	a	5)	d	6)	d	7)	b	8)	b
137)	c	138)	d	139)	b	140)	a	9)	c	10)	b	1)	1	2)	4
141)	b	142)	a	143)	b	144)	b		3)	6	4)	3			
145)	c	146)	c	147)	a	148)	d	5)	8	6)	4	7)	8	8)	5
149)	d	150)	c	151)	a	152)	c								
153)	c	154)	c	155)	c	156)	b								

: HINTS AND SOLUTIONS :

1 **(d)**

Heat current:

$$i = -kA\frac{dT}{dx}$$

$$idx = -kA\,dT$$

$$i\int_{o}^{l} dx = -A\alpha\int_{T_1}^{T_2} TdT$$

$$il = -A\alpha\frac{(T_2^2 - T_1^2)}{2}\quad i = \frac{A\alpha(T_1^2 - T_2^2)}{2l}$$

2 **(c)**

Volume of mercury at 18°C

$V_0 = 50$ cc

Volume of mercury at 38°C

$(V_{38})_r = V_0(1 + \gamma_m\Delta\theta)$

Volume of flask at 38°C

$(V_{38})_f = V_0(1 + \gamma_f\Delta\theta)$

Volume of mercury at 38°C above the tank

$= V_0(1 + \gamma_m\Delta\theta) - V_0(1 + \gamma_f\Delta\theta)$

$= V_0(\gamma_m - \gamma_t)\Delta\theta$

$= 50[180 \times 10^{-6} - 3 \times 9 \times 10^{-6}](38 - 18)$

$= 0.153$ cc

3 **(a)**

As, $\gamma_1 = \frac{\Delta V_1}{V_1\Delta T}$ and $\gamma_2 = \frac{\Delta V_2}{V_2\Delta T}$

$\Rightarrow \Delta V_1 = \gamma_1 V_1\Delta T$

and $\Delta V_2 = \gamma_2 V_2\Delta T$

Fraction of volume submerged before temperature is raised is given by $f = \rho_1/\rho_2$

$$\alpha' = \left(\frac{\rho_1}{1 + \gamma_1\Delta T}\right)\left(\frac{1 + \gamma_2\Delta T}{\rho_2}\right) = \left(\frac{\rho_1}{\rho_2}\right)\left(\frac{1 + \gamma_2\Delta T}{1 + \gamma_1\Delta T}\right)$$

$$\Rightarrow \alpha' = f\left(\frac{1 + \gamma_2\Delta T}{1 + \gamma_1\Delta T}\right)$$

$$\frac{\alpha'}{f} = \frac{1 + \gamma_2\Delta T}{1 + \gamma_1\Delta T}$$

4 **(c)**

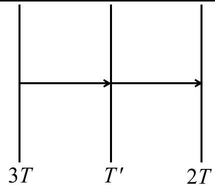
According to Wien's law $\lambda_0 T_0 = \lambda T$

According to Stefan's law $\frac{P_0}{P} = \left(\frac{T_0}{T}\right)^4$

As $P = \frac{256}{81}P_0 \Rightarrow \lambda = \frac{3}{4}\lambda_0$

$\therefore$ Wavelength shift $D\lambda = \lambda - \lambda_0 = -\frac{\lambda_0}{4}$

5 **(c)**



In steady state energy absorbed by middle plate is equal to energy released by middle plate

$\sigma A(3T)^4 - \sigma A(T'')^4 = \sigma A(T'')^4 - \sigma A(2T)^4$

$(3T)^4 - (T'')^4 = (T'')^4 - (2T)^4$

$2(T'')^4 - (16 + 81)T^4$

$$T'' = \left(\frac{97}{2}\right)^{1/4} T$$

6 **(a)**

This is a problem on 'flow calorimeter' used to measure specific heat of a liquid Amount of heat supplied to the water per second by the heating coil $= Q_S = 250$ J

$= \frac{250}{4186}$ kcal

The volume of liquid flowing out per second

$= 8.0\ \text{cm}^3 = 8 \times 10^{-6}\text{m}^3$

Mass of this liquid $= (0.85) \times 1000 \times 8 \times 10^{-6}$kg

Temperature rise of this mass of liquids = 15°C

Hence, $\frac{250}{4186} = mst = 0.85 \times 8 \times 10^{-3} \times s \times 15$

Hence, $s = \frac{250\times10^3}{4186\times0.85\times8\times15} = 0.6$ kcal/kg K

7 **(b)**

Apparent coefficient of volume expansion

$\gamma_{\text{app}} = \gamma_L - \gamma_s = 7\gamma_s - \gamma_s = 6\gamma_s$ (given $\gamma_L = 7\gamma_s$)

Ratio of absolute and apparent expansion of liquid

$$\frac{\gamma_L}{\gamma_{\text{app}}} = \frac{7\gamma_s}{6\gamma_s} = \frac{7}{6}$$

8 **(b)**

Rate of heat loss $= \sigma eA(T^4 - T_S^4)$

$$-ms\frac{dT}{dt} = \sigma eA(T^4 - T_S^4)$$

$$-\frac{dT}{dt} = \frac{5.8 \times 10^{-4} \times 1 \times \pi(0.08)^2[(500)^4 - (300)^4]}{10 \times 4.2 \times 90}$$

$$\frac{-dT}{dt} = 0.066\text{°C/s}$$

9 **(a)**

Heat absorbed per second by liquid helium= $\alpha A(T_0^4 - T^4)$

Heat required to boil liquid helium away

$= \left(\frac{dm}{dt}\right) L$

$\left(\frac{dm}{dt}\right) = \frac{\sigma A(T_0^4 - T^4)}{L}$

$= \frac{5.67 \times 10^{-8} \times 4 \times 3.14 \times (0.1)^2 (77^4 - 4.2^4)}{21 \times 10^3}$

$= 1.19 \times 10^{-5}$ kg/s

$= 4.3 \times 10^{-2}$ kg/h $= 43$ g/h

10 **(a)**

$\gamma_{\text{real}} = \gamma_{\text{app}} + \gamma_{\text{vessel}}$

$\Rightarrow 153 \times 10^{-6} + (\gamma_{\text{vessel}})_{\text{glass}}$

$= 144 \times 10^{-6} + (\gamma_{\text{vessel}})_{\text{steel}}$

Further $(\gamma_{\text{vessel}})_{\text{steel}} = 3\alpha = 3 \times (12 \times 10^{-6})$

$= 36 \times 10^{-6}/°C$

$\therefore 153 \times 10^{-6} + (\gamma_{\text{vessel}})_{\text{glass}}$

$= 144 \times 10^{-6} + 36 \times 10^{-6}$

$\therefore (\gamma_{\text{vessel}})_{glass} = 27 \times 10^{-6}/°\text{C}$

Or $\alpha = \frac{\gamma_{\text{glass}}}{3} = 9 \times 10^{-6}/°\text{C}$

11 **(b)**

Heat released by 5 kg of water when its temperature falls from 20°C to 0°C is,

$Q_1 = m_1 c_1 \Delta\theta_1 = (5)(10^3)(20 - 0) = 10^5$ cal

When 2 kg ice at −20°C comes to a temperature of 0°C, it takes an energy

$Q_2 = m_2 c_2 \Delta\theta_2 = (2)(500)(20) = 0.2 \times 10^5$ cal

The remaining heat

$Q = Q_1 - Q_2 = 0.8 \times 10^5$ cal will melt a mass m of the ice, thus

$m = \frac{Q}{L} = \frac{0.8 \times 10^5}{80 \times 10^3} = 1$ kg

So, the temperature of the mixture will be 0°C, mass of water in it is 5+1=6 kg and mass of ice is 2−1=1 kg

12 **(a)**

Thermal capacity of ball = $mc = 10$ cal/°C

Let T be the furnace temperature

Water eq. of vessel and contents = $mc = 200$ g

Resultant temperature=40°C

According to principle of calorimetry

Heat lost by hot body = heat gained by cold body

$m_1 c_1 (T - 40) = m_2 c_2 (40 - 10)$

$10(T - 40) = 200 \times 30$

$T = 640$°C

13 **(c)**

Heat lost by A= Heat gained by B

$\Rightarrow m_A \times c_A \times (T_A - T) = m_B \times c_B \times (T - T_B)$

Since $m_A = m_B$ and temperature of the mixture $(T) = 28$°C

$\therefore c_A \times (32 - 28) = c_B \times (28 - 24)$

$\Rightarrow \frac{c_A}{c_B} = 1:1$

14 **(c)**

At 70°C, the system attains steady state

i.e., Rate of heat generated = Rate of heat loss

or 10 W = $k(70 - 30)$°C

(From Newton's law of cooling)

or, $k = (1/4)$ W/°C

At 50°C, rate of loss should be $k(50 - 30)$°C = 5 W, But rate of heat loss = (heat capacity)× (rate of cooling)

i.e., $\frac{-dQ}{dT} = c\left(\frac{-dT}{dt}\right) - 5\text{ W} = c\left[\frac{49.9-50}{60}\right]$°C/s

or 3000 J/°C

15 **(b)**

Given $\frac{\text{Latent heat of fusion}}{\text{Latent heat of vapourization}} = \frac{\lambda}{1} = \frac{L_f}{L_v}$ (say)

i.e., $L_f = \lambda L_v$

Now, if k is required fraction

Then, $(1 - k)L_f = kL_v$

or $\frac{(1-k)}{k} = \frac{1}{\lambda}$ or, $\frac{1}{k} = \frac{1}{\lambda} + 1$

or $k = \frac{\lambda}{\lambda+1}$

16 **(d)**

Energy radiated by body per second $\frac{Q}{t} = A\sigma T^4$

Or $\frac{Q}{t} \propto l \times b \times T^4$ (Area= $l \times b$)

$\therefore \frac{E_2}{E_1} = \frac{l_2}{l_1} \times \frac{b_2}{b_1} \times \left(\frac{T_2}{T_1}\right)^4$

$= \frac{(l_1/2)}{l_1} \times \frac{(b_1/2)}{b_1} \times \left(\frac{600}{400}\right)^4$

$= \frac{1}{2} \times \frac{1}{2} \times \left(\frac{3}{2}\right)^4 \Rightarrow E_2 = \frac{81}{64} E$

17 **(a)**

Language of question is slightly wrong. As heat capacity and specific heat are two different physical quantities. Unit of heat capacity is Jkg^{-1}, not $\text{Jkg}^{-1}°\text{C}^{-1}$. The heat capacity given in the question is really the specific heat. Now applying the heat exchange equation:

$420 = (m \times 10^{-3})(2100)(5) + (1 \times 10^{-3})(3.36 \times 10^5)$

Solving this equation, we get

m=8g

$\therefore$ The correct answer is 8.

18 **(a)**

The 80 cm mark on the aluminium rod is really at a greater distance from the zero position than indicated because of the increase in temperature $\Delta\theta = 40°\text{C}$. The increased length is

$\Delta L = \alpha_{A1} L_{A1} \Delta\theta$

$= (2.50 \times 10^{-5}(80)(40)$

$= 0.08\text{cm}$

The correct length of the line is

$L = 80 + 0.08 + 80.08$ cm

19 **(d)**

Suppose the temperatures of junction B, C, D are θ_1, θ_2 and θ_3, respectively. Let Q_1, Q_2, Q_3, Q_4, Q_5 and Q_6 be the amounts of heat flowing from A to B, B to C, B to D, C to D to E and C to E per second, respectively. Temperature of junction A and E are 60°C and 10°C, respectively

$\lambda_1 T_1 = \lambda_2 T_2$

$\therefore \dfrac{\lambda_1}{\lambda_2} = \dfrac{T_2}{T_1} = \dfrac{0.26}{0.13} = 2$

$\therefore T_2 = 2T_1$

By Stefan's law, emissive power $E = \sigma T^4$

$E_1 = \sigma T_1^4; E_2 = \sigma T_2^4$

$\therefore \dfrac{E_1}{E_2} = \dfrac{\sigma T_1^4}{\sigma T_2^4} = \dfrac{T_1^4}{(2T_1)^4} = \dfrac{1}{16}$

20 **(a)**

Let volume of metal piece be V_1 at $t_1°\text{C}(= 27°\text{C})$ and V_2 at $t_2°\text{C} = (42°\text{C})$

Given weight of metal piece in liquid at $27°\text{C} = 30$ g

As weight of metal piece in air $= 46$ g, loss of weight of metal piece in liquid $= 46 - 30 =$ 16 g=weight of liquid displaced $= -$ volume of liquid displaced $\times$ density

$\therefore 16 = V_1 \times 1.24$ or $V_1 = \dfrac{16}{1.24}\text{cm}^3$

Similarly $V_2 = \frac{46-30.5}{1.20} = \frac{15.5}{1.210}\text{cm}^3$

Now $V_{42} = V_{27}(1 + \gamma\Delta\theta)$

Or $V_2 = V_1(1 + \gamma\Delta\theta) = V_1(1 + \gamma \times 15)$

$\therefore 1 + 15\gamma = \dfrac{V_2}{V_1} = \dfrac{15.5/1.20}{16/1.24} = 1.0010$

$\therefore \gamma = 6.7 \times 10^{-5}/°\text{C}$

$\therefore \alpha = \dfrac{\gamma}{3} = 2.23 \times 10^{-5}/°\text{C}$

21 **(a)**

By the law of conservation of energy, energy given by heater must be equal to the sum of energy gained by water and energy lost from the lid

$Pt = ms\Delta\theta$ +energy lost

i.e., $1000t = 2 \times (4.2 \times 10^2) \times 50 + 160t$

or $840t = 8.4 \times 10^3 \times 50$

or $t = 500$ s

$= 8$ min 20 s

22 **(d)**

Slope of line $A = \frac{(1006-1000)\text{mm}}{T°\text{C}} = \frac{\Delta L}{\Delta T} = L\alpha_A$

i.e., $\frac{6}{T} mm/°\text{C} = (1000 \text{ mm})\alpha_A$ (i)

Similarly, for line B,

$\frac{2}{T}\text{mm}/°\text{C} = (1002 \text{ mm})\alpha_B$ (ii)

Dividing Eq.(i) by Eq.(ii),

$3 = \frac{1000\alpha_A}{1002\alpha_B} = \alpha_A = 3\alpha_B$ (iii)

From Eq.(iii), $\alpha_A = 3 \times 9 \times 10^{-6} = 27 \times 10^{-6}/°\text{C}$

From Eq.(i), $T = \frac{6}{1000\alpha_A} = \frac{6\times10^6}{1000\times27}$

$= 222.22°\text{C}$

23 **(d)**

From Wien's law, $\lambda_m T =$ constant, where T is the temperature of black body and λ_m is the wavelength corresponding to maximum energy of emission. Energy distribution of black body radiation is given below:

1. $U_1$and U_2 are not zero because a black body emits radiations of nearly all wavelengths

2. Since U_1 corresponding to lower wavelength, U_3 corresponds to heigher wavelength and U_2 corresponds to medium wave length, hence $U_2 > U_1$

24 **(b)**

Let the final temperature be $T°\text{C}$

Total heat supplied by the three liquids in coming down to 0°C

$= m_1c_1T_1 + m_2c_2T_2 + m_3c_3T_3$ (i)

Total heat used by three liquids in raising temperature from 0°C to T°C

$= m_1c_1T + m_2c_2T + m_3c_3T$ (ii)

By equating Eqs. (i) and (ii) we get

$(m_1c_1 + m_2c_2 + m_3c_3)T$

$= m_1c_1T_1 + m_2c_2T_2 + m_3c_3T_3$

$\Rightarrow T = \dfrac{m_1c_1T_1 + m_2c_2T_2 + m_3c_3T_3}{m_1c_1 + m_2c_2 + m_3c_3}$

25 **(a)**

The given data is normally insufficient to determine the result. Either the length of one of the rods at 0°C must be known or one has to assume that both the rods had the same length at 0°C which is not possible if they have the same length again at another temperature. Suppose the two rods has the same length L at 0°C. Then by the given problem,

$L[1 + 1.9 \times 10^{-5} \times 27] - L[1 + 1.1 \times 10^{-5} \times 27] = 10^{-3}$

$L \times 0.8 \times 27 \times 10^{-5} = 10^{-3}$

or $L = \frac{10^{-3}}{0.8 \times 27 \times 10^{-5}}$ m $= 4.63$ m

Hence 0°C is a possible choice and the rods had equal length of 4.63 m at 0°C

26 **(d)**

It is clear that at desired temperature, T°C, the densities of the wood and benzene must be equal for the wood to just sink

i.e., $\rho_W(T) = \rho_B(T)$

If m is the mass of wood (which is assumed to be constant) then, if $(V_0)_W$ and $(V_0)_B$ are the respective volumes at 0°C of mass m of wood and Benzene,

$(\rho_0)_W (V_0)_W = (\rho_0)_B (V_0)_B = m$

$(\rho_0)_W = 880$ kg/m^3 and $(\rho_0)_B = 900$ kg/m^3

Hence $(V_0)_W = \frac{m}{880}(m^3)$

End $(V_0)_B = \frac{m}{900}(m^3)$

We then have, $(V_T)_W = (V_0)_W(1 + 1.2 \times 10^{-3}T)$

$(V_T)_B = (V_0)_B(1 + 1.5 \times 10^{-3}T)$

Thus $\frac{(V_T)W}{(V_T)_B} = \frac{(\rho_B)_T}{(\rho_W)_T} = 1 = \frac{(V_0)_W 1+1.2\times10^{-3}T}{(V_0)_B 1+1.5\times10^{-3}T}$

Thus $\frac{(V_o)W}{(V_o)_B} = \frac{900}{880} = \frac{90}{88} = \frac{1+1.5\times10^{-3}T}{1+1.2\times10^{-3}T}$

Solving for T, we have $T = 83.2$°C

27 **(b)**

Rate of cooling $(R) = \frac{\Delta\theta}{t} = \frac{A\epsilon\sigma(T^4 - T_0^4)}{mc}$

$$\Rightarrow R \propto \frac{A}{m} \propto \frac{\text{Area}}{\text{Volume}} \propto \frac{r^2}{r^3} \propto \frac{1}{r}$$

$$\Rightarrow \text{ Rate } (R) \propto \frac{1}{r}$$

$$\propto \frac{1}{m^{1/3}} \left[\because m = \rho \times \frac{4}{3}\pi r^3 \Rightarrow r \propto m^{1/3}\right]$$

$$\Rightarrow \frac{R_1}{R_2} = \left(\frac{m_2}{m_1}\right)^{1/3} = \left(\frac{1}{3}\right)^{1/3}$$

28 **(c)**

Rate of cooling $(-\frac{dT}{dt}) \propto$ emissivity(e)

From the graph,

$$\left(-\frac{dT}{dt}\right)_x > \left(-\frac{dT}{dt}\right)_y$$

$\therefore \qquad e_x > e_y$

Further emissivity $(e) \propto$ absorptive power (a) (good absorbers are good emitters also)

$\therefore \qquad a_x > a_y$

29 **(a)**

Heat is lost by steam in two stages (i) for change of state from steam at 100°C to water at 100°C is $m \times 540$ (ii) to change water at 100°C to water at 80°C is $m \times 1 \times (100 - 80)$, where m is the mass of steam condensed

Total heat lost by is $m \times 540 + m \times 20 = 560\ m(cals)$. Heat gained by calorimeter and its contents is $= (1.1 + 0.02) \times (80 - 15) = 1.12 \times 65\ cals$

Using Principle of calorimetery, Heat gained = heat lost

$\therefore 560\ m = 1.12 \times 65, m = 0.130\ g$

30 **(b)**

Power sent to heat the water in the calorimeter

$P' = \frac{ms\Delta\theta}{t}$

$$= \frac{V\rho s\Delta\theta}{t} = \frac{10^3 \times 10^{-6} \times 10^3 \times 4200 \times 4}{420} = 40 \text{ W}$$

Required ratio

$$= \frac{P - P'}{P} = \frac{54 - 40}{54} = \frac{14}{54} = 26\%$$

31 **(c)**

Heat current, $\frac{dQ}{dt} = L.\left(\frac{dm}{dt}\right)$

Or $\quad \frac{\text{Temperature difference}}{\text{Thermal resistance}} = L.\left(\frac{dm}{dt}\right)$

Or $\quad \left(\frac{dm}{dt}\right) \propto \frac{1}{\text{Thermal resistance}}$

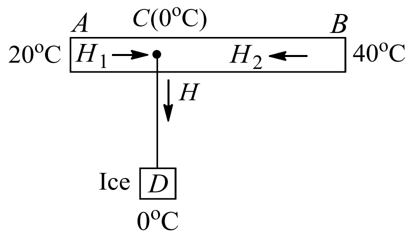
Or $\quad q \propto \frac{1}{R}$

In the first case rods are in parallel and thermal resistance is $\frac{R}{2}$ while in second case rods are in series and thermal resistance is $2R$.

$\therefore \quad \frac{q_1}{q_2} = \frac{2R}{R/2} = \frac{4}{1}$

32 **(d)**

Thermal resistance of $AC = \frac{L}{KA} = \frac{0.1}{336\times10^{-4}} = \frac{10^3}{336} = R$(let)



Thermal resistance of $BC = \frac{0.2}{336\times10^{-4}} = 2R$

Heat flow rates are

$$H_1 = \frac{20}{R}; H_2 = \frac{40}{2R} = \frac{20}{R}$$

$$H = H_1 + H_2 = \frac{40}{R} = \frac{40 \times 336}{10^3}$$

$= \dfrac{13440}{10^3} = 13.44$ W

Rate of melting of ice

$= \dfrac{H}{L_f} = \dfrac{13.44/4.2}{80}$ g/s $= 40$ mg/s

33 **(d)**

Quantity of heat transferred through wall will be utilized in melting of ice

$Q = \dfrac{KA\Delta\theta t}{\Delta x} = mL$

$\therefore$ Amount of ice melted $m = \frac{KA\Delta\theta t}{\Delta x L}$

$\therefore m = \dfrac{0.01 \times 1 \times (30 - 0) \times 86400}{5 \times 10^{-2} \times 334 \times 10^3}$

$= 1.552$ kg or 1552 kg

34 **(a)**

Same amount of heat is supplied to copper and water; so

$m_c c_c \Delta T_c = m_\omega c_\omega \Delta T_\omega$

$\Rightarrow (\Delta T)_\omega = \dfrac{m_c c_c \Delta T_c}{m_\omega c_\omega} = \dfrac{50 \times 10^{-3} \times 420 \times 10}{10 \times 10^{-3} \times 4200}$

$= 5°\text{C}$

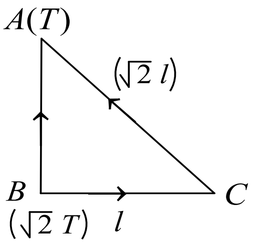
35 **(a)**

As $T_B > T_A$,heat flows from B to A through both paths BA and BCA

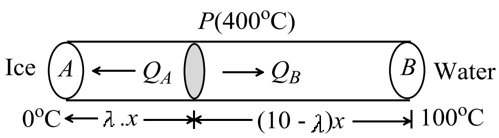
Rate of heat flow in BC = Rate of heat flow in CA

$\dfrac{KA(\sqrt{2}T - T_c)}{l} = \dfrac{KA(T_c - T)}{\sqrt{2}l}$

Solving this, we get $T_c = \frac{3T}{\sqrt{2}+1}$



36 **(a)**



Hear received by end A, for melting of ice

$Q_A = \frac{K\,A(400-0)t}{\lambda \cdot x} = m\,L_{ice}$ ...(i)

Heat received by end B, for vaporization of water

$Q_B = \frac{K\,A(400-100)t}{(10-\lambda)x} = m\,L_{vap}$ ...(i)

Dividing both equation, $\dfrac{\frac{400}{\lambda \cdot x}}{\frac{300}{(10-\lambda)x}} = \dfrac{L_{ice}}{L_{vap}}$

$\Rightarrow \dfrac{4}{3}\dfrac{(10-\lambda)}{\lambda} = \dfrac{80}{540} \Rightarrow \lambda = 9$

37 **(b)**

Let V_0 and V_t be volumes of mercury at 0°C and t°C, respectively; A_0 and A_t are areas of cross section of tube at 0°C and t°C, respectively

Apparent increase in volume

$\Delta V = \Delta V_a - \Delta V_g$

$= (\gamma_{Hg} - 3\alpha_g)V\Delta T$

$\Delta l = l\alpha_g \Delta T$

$A_t(\Delta l) = \Delta V = (\gamma_{Hg} - 3\alpha_g)V\Delta T$

$A_t = \dfrac{\gamma_{Hg} - 3\alpha_g)V}{\Delta l}$

$= \dfrac{(18 \times 10^{-5} - 3 \times 10^{-5})(10^{-6})}{3 \times 10^{-3}}$

$\pi r^2 = \dfrac{15}{3} \times 10^{-8}$

$r = \left(\dfrac{15}{3 \times 3.14} \times 10^{-8}\right)^{\frac{1}{2}} = 1.26 \times 10^{-4}$m

Diameter of tube $= 2r = 0.25$ mm

38 **(b)**

The brass rod and the lead rod will suffer expansion when placed in steam bath

$\therefore$ Length of brass rod at 100°C

$L_{brass} = L_{brass}(1 + \alpha_{brass}\Delta T) = 80[1+18 \times 10^{-6} \times 100]$

and the length of lead rod at 100°C

$L_{lead} = L_{lead}(1 + \alpha_{lead}\Delta T)$

$= 80[1 + 28 \times 10^{-6} \times 100]$

Separation of free ends of the rods after heating

$= L_{lead} - L_{brass} = 80[28 - 18] \times 10^{-4} = 8 \times 10^{-2}$cm =0.8 mm

39 **(c)**

$\lambda_m T =$ constant

From the graph $T_3 > T_2 > T_1$

Temperature of sun will be maximum

40 **(c)**

Let l_s and l_b be the initial lengths of the steel and brass rod, respectively, and l_s' and l_b' be the corresponding lengths at any other temperature, then,

$l_s - l_b = l_s - l_b = 5$ cm (i)

Or $l_s - l_b = l_s(1 + \alpha_s \Delta T) - l_b(1 + \alpha_b \Delta T)$

$\Rightarrow l_s\,\alpha_s = l_b \alpha_b$

or , $\frac{l_s}{l_b} = \frac{\alpha_b}{\alpha_s} = \frac{18\times10^{-6}/°\text{C}}{12\times10^{-6}/°\text{C}} = \frac{3}{2}$ (ii)

Solving Eqs. (i) and (ii), we get, $I_b = 10$ cm

41 **(d)**

Initial temperature, $T_i = 300$ K

Final temperature, $T_f = 700$ K

$Q = \displaystyle\int_{300}^{700} nC\,dT = \int_{300}^{700} 2 \times (27.2 + 4 \times 10^{-3} \times T)dT$

$= [54.4T + 4 \times 10^{-3} T^2]_{300}^{700}$
$= 2.33 \times 10^4$ J

42 **(c)**
Initially (at 20°C) length of composite system
$L = 50 + 100 = 150$ cm
Length of iron rod at 100°C $= 50\ [1 + 12 \times 10^{-6} \times (100 - 20)] = 50.048$ cm
Length of aluminum rod at 100°C $= 100[1 + 24 \times$ *10−6×100−20=100.192*cm Finally (at 100 ℃) length of composite system $L' = 50.048 + 100.192 = 150.24$ cm
Change in length of the composite system
$\Delta L = L' - L = 150.24 - 150 = 0.24$ cm
∴ Average coefficient of expansion at 100°C
$\alpha = \frac{\Delta L}{L \times \Delta T} = \frac{0.24}{150 \times (100-20)} = 20 \times 10^{-6}/°C$

43 **(b)**
$Q = KA \frac{\Delta\theta}{l} t \ \therefore t \propto \frac{l}{A}$ (As Q, K and $\Delta\theta$ are constant)

$$\frac{t_1}{t_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1} = \left(\frac{l_1}{l_1/2}\right) \times \left(\frac{2A_1}{A_1}\right)$$
$$\frac{t_1}{t_2} = 4 \Rightarrow t_2 = \frac{t_1}{4} = \frac{12}{4} = 3 \text{ s}$$

44 **(c)**
$\lambda_m T =$ constant
$$\Rightarrow \frac{(\lambda_m)_2}{(\lambda_m)_1} = \frac{T_1}{T_2} = \frac{200}{1000} = \frac{1}{5}$$
$$\Rightarrow (\lambda_m)_2 = \frac{(\lambda_m)_1}{5} = \frac{14 \times \mu\text{m}}{5} = 2.8\ \mu\text{m}$$

45 **(d)**
According to Newton's law of cooling
$$\frac{\theta_1 - \theta_2}{t} \propto \left[\frac{\theta_1 + \theta_2}{2} - \theta\right]$$
For the first condition
$$\frac{80 - 60}{60} \propto \left[\frac{80 + 60}{2} - 30\right]$$
And for the second condition
$$\frac{60 - 50}{t} \propto \left[\frac{60 + 50}{2} - 30\right]$$
By solving Eqs (i) and (ii), we get $t = 48$ s

46 **(a)**
$Q_4 = mL_w = 540$ cal
$Q_3 = ms_w(100 - 0) = 100$ cal
$Q_2 = mL_{ice} = 80\ cal$
$Q_1 = ms_{ice}(20 - 0) = 20$ cal
$Q_4 > Q_3 > Q_2 > Q_1$

47 **(c)**
$V = V_0(1 + \gamma\ \Delta\theta)$
Or $L^3 = L_0(1 + \alpha_1 \Delta\theta) L_0^2 (1 + \alpha_2 \Delta\theta)^2$
$\Rightarrow L^3 = L_0^3 (1 + \alpha_1 \Delta\theta)(1 + \alpha_2 \Delta\theta)^2$
Since $L_0^3 = V_0$, hence
$1 + \gamma\ \Delta\theta = (1 + \alpha_1 \Delta\theta)(1 + \alpha_2 \Delta\theta)^2$
$\cong (1 + \alpha_1 \Delta\theta)(1 + 2\alpha_2 \Delta\theta)$
$\cong 1 + \alpha_1 \Delta\theta + 2\alpha_2\ \Delta\theta$
$\therefore \gamma = \alpha_1 + 2\alpha_2$

48 **(a)**
Energy gained by water (in 1 s)
= Energy supplied−energy lost
= (1000 J-160 J)=840 J
Total heat required to raise the temperature of water from 27°C to 77°C is $ms\Delta\theta$. Hence, the required time,
$$t = \frac{ms\Delta\theta}{\text{rate by which energy is gained by water}}$$
$$= \frac{(2)(4.2 \times 10^3)(50)}{840} = 500 \text{ s}$$
= 8 min 20 s.

49 **(c)**
Apparent coefficient of volume expansion for liquid
$\gamma_{\text{app}} = \gamma_L - \gamma_S$
$\therefore \gamma_L = \gamma_{\text{app}} + \gamma_S$
Where γ_S is coefficient of volume expansion for solid vessel
When liquid is placed in copper vessel
$\gamma_L = C + \gamma_{\text{copper}}$ (i)
(As γ_{app} for liquid in copper vessel= C)
When liquid is placed in silver vessel
$\gamma_L = S + \gamma_{\text{silver}}$ (ii)
(As γ_{app} for liquid in silver vessel= S)
From Eqs. (i) and (ii), we get $C + \gamma_{\text{copper}} = S + \gamma_{\text{silver}}$
$\therefore \gamma_{\text{silver}} = C + \gamma_{\text{copper}} - S$
Coefficient of volume expansion = 3 × Coefficient of linear expansion
$$\Rightarrow \alpha_{\text{silver}} = \frac{\gamma_{\text{silver}}}{3} = \frac{C + \gamma_{\text{copper}} - S}{3}$$

50 **(d)**
If a body emits wavelength $\lambda_1, \lambda_2, \lambda_3$ and λ_4 at a high temperature then at a lower temperature it will absorb the radiation of same wavelength. This is in accordance with Kirchoff's law

51 **(a)**
Work done in converting 1 g of ice at −10°C to steam at 100°C
= Heat supplied to raise temperature of 1 g of ice from−10°C to 0°C$(m \times c_{ice} \times \Delta T)$
+ Heat supplied to convert 1 g ice into water at

$0°C\ (m \times L_{ice})$
+ Heat supplied to raise temperature of 1 g of water from 0°C to $100°C$ $(m \times c_{water} \times \Delta T)$
+ Heat supplied to convert 1 g water into steam at 100°C $[m \times L_{vapour}]$
$= [m \times c_{ice} \times \Delta T] + [m \times L_{ice}] + [m \times c_{water} \times \Delta T] + [m \times L_{vapour}]$
$= [1 \times 0.5 \times 10] + [1 \times 80] + [1 \times 1 \times 100] + [1 \times 540] = 725\ cal = 725 \times 4.2 = 3045$ J

52 **(b)**
$\frac{\theta_1 - \theta_2}{t} \propto \left[\frac{\theta_1+\theta_2}{2} - \theta\right]$
For the first condition
$\frac{60-50}{10} \propto \left[\frac{60+50}{2} - \theta\right] \Rightarrow 1 = K[55 - \theta]$ (i)
For the second condition
$\frac{50-42}{10} \propto \left[\frac{50+42}{2} - \theta\right] \Rightarrow 0.8 = K[46 - \theta]$ (ii)
From Eqs (i) and (ii), we get $\theta = 10°C$

53 **(b)**
Let V be volume of either liquid
Mass of water $= V \times 1$ g
Mass of alcohol$= V \times 0.8 = 0.8\ V$g
Rate of cooling of the calorimeter
$= \frac{1}{100}[V \times (50° - 40°) + V \times 1 \times (50° - 40°)]$
$= (1/5)V$ cal/s
Rate of cooling of alcohol calorimeter
$= \frac{1}{74}[V \times (50° - 40°) + 0.5V \times s(50° - 40°)]$
$= (1/74)(10\ V + 8Vs)$cal/s
As, rate of cooling of both is same
$5V = (1/74)(10V + 8Vs)$
$s = 0.6$ cal/g°C

54 **(c)**
Energy absorbed by the earth $= \left(\frac{70}{100} \times S\right)\pi R_e^2$
Energy radiated by the earth $= e\sigma 4\pi R_e^2 T^4$
$e = \frac{7S}{10 \times 4T^4\sigma}$
$= \frac{0.7 \times 1370}{4(288)^4 \times 5.67 \times 10^{-8}} \simeq 0.6$

55 **(d)**
Increase in volume of flask
$= 40 \times 10^{-6} \times 10^3 \times 10^2 = 4$ cc
Increase in volume of mercury
$= 180 \times 10^{-6} \times 10^3 \times 10^2 = 18$ cc
Volume of mercury overflow
$= 18 - 4 = 14$ cc

56 **(a)**
The increase in volumes of the two liquids due to an increase in temperature ΔT will be
$\Delta V_1 = V_1\gamma_1\Delta T$
and $\Delta V_2 = V_2\gamma_2\Delta T$
∴ Total volume expansion
$\Delta V_1 + \Delta V_2 = (V_1\gamma_1 + V_2\gamma_2)\Delta T$
The average increase in volume per unit volume per degree rise in temperature will be
$\frac{(\Delta V_1 + \Delta V_2)}{(V_1 + V_2)\Delta T}$
$\gamma = \frac{V_1\gamma_1 + V_2\gamma_2}{V_1 + V_2}$ (i)
But, since the cubical expansion of the two liquids compensates that of the container, γ for the container will be given by Eq (i)
$\therefore \gamma = \frac{200 \times 1.4 \times 10^{-5} + 500 \times 2.1 \times 10^{-5}}{200 + 50}$
$= 1.9 \times 10^{-5}/°C$

57 **(b)**
Loss in energy $= mg(h - h')$
$= 0.1 \times 10 \times (10 - 5.4)$
$= 4.6$ J
Now, $4.6\ J = ms\ \Delta\theta$
$= 0.1 \times 460 \times \Delta\theta$
$\therefore \Delta\theta = 0.1°C$

58 **(c)**
$\frac{\Delta Q}{\Delta t} = \frac{KA\Delta T}{\Delta x}\ \Delta Q = KA\left(\frac{\Delta T}{\Delta x}\right)\Delta t$
Assuming the thickness of the sphere to be small, we have For smaller sphere:
(rate of heat flow) = (volume of ice melted)(ρL)
i.e., $K_1(4\pi r^2)\frac{\Delta\theta}{d} \cdot 16 = \frac{4}{3}\pi r^3 \rho L$ (i)
for larger sphere:
$K_2[4\pi(2r)^2]\frac{\Delta\theta}{d/4} \cdot 25 = \frac{4\pi}{3}(2r)^3\rho L$ (ii)
Dividing Eq.(ii) by Eq (i)
$K_2/K_1 = 8/25$

59 **(a)**
$\frac{dT}{dt} = \frac{eA\sigma}{mc}(T^4 - T_0^4) = \frac{eA\sigma}{V\rho c}(T^4 - T_0^4)$
∴ Rate of cooling $R \propto A$
(As masses are equal, volume of each body must be equal because material is same)
i.e., rate of cooling depends on the area of cross section and we know that for a given volume the area of cross section will be minimum for sphere. It means the rate of cooling will be minimum in case of sphere.
So the temperature of sphere drops to room temperature at last

60 **(a)**
As water equivalent of pitcher is 0.5 kg, i.e., pitcher is equivalent to 0.5 kg of water, heat to be

extracted from the system of water and pitcher for decreasing its temperature from 30 to 28° C is
$Q_1 = (m + M)c\Delta T$
$= (9.5 + 0.5)$ kg (1 kcal/kgC°)(30 − 28)°C
$= 20$ kcal
And heat extracted from the pitcher through evaporation in t minutes
$Q_2 = mL = \left[\frac{dm}{dt} \times t\right] L = \left[\frac{1\text{g}}{\text{min}} \times t\right] 580 \frac{\text{cal}}{\text{g}}$
$= 580 \times t$ cal
According to given problem $Q_2 = Q_1$.,i,e., $580 \times t = 20 \times 10^3$
$t = 34.5$ min

61 **(a)**
Steam at 100°C contains extra 540 cal/g energy as compared to water at 100°C. So it's more dangerous to burn with steam than water

62 **(b)**
$\frac{T_{20} - T_0}{T_0} = \frac{1}{2} \times \alpha \times 20 = 10\alpha$
Here T_{20} is the correct time period. The time period at 0°C is smaller so that the clock runs fast. The time gained in 24 h
$= 24\text{h} \times \alpha \times 10$
$\Rightarrow 15 \text{ s} = 24\text{h} \times \alpha \times 10$
$\alpha = \frac{15\text{s}}{86400s \times 10°\text{C}} = 1.7 \times 10^{-5}/°\text{C}$

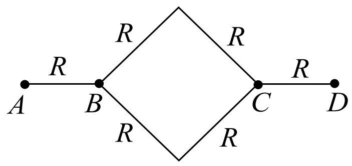
63 **(b)**
Heat lost by hot water = Heat gained by cold by cold water in beaker + Heat absorbed by beaker
$\Rightarrow 440(92 - T)$
$= 200 \times (T - 20) + 20 \times (T - 20)$
$\Rightarrow T = 68°\text{C}$

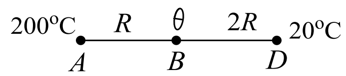
64 **(a)**
According to Stefan's law,
$E = \sigma T^4$
Total surface area of the sun $= 4\pi R_s^2$
Therefore, the total energy radiated per second by the sun per unit solid angle
$= -\frac{\sigma T^4 \times 4\pi R_s^2}{4\pi} = \sigma T^4 R_s^2$
Let R_{es} be the distance of earth from the sun.
Hence intensity of radiation of earth
$l = \sigma T^4 R_s^2 / R_{es}^2$
$\therefore 1400 = (5.6 \times 10^{-8}) T^4 \left[\frac{7.0 \times 10^8}{1.5 \times 10^{11}}\right]^2$
$T = 5801$ K

65 **(b)**
$\frac{dT}{dt} = \frac{\sigma A}{mcJ}(T^4 - T_0^4)$ [In the given problem fall in temperature of body $dT = (200 - 100) = 100K$, temp. of surrounding $T_0 = 0K$, Initial temperature of body $T = 200K$]
$\frac{100}{dt} = \frac{\sigma 4\pi r^2}{\frac{4}{3}\pi r^3 \rho c J}(200^4 - 0^4)$
$\Rightarrow dt = \frac{r\rho cJ}{48\sigma} \times 10^{-6} s = \frac{r\rho c}{\sigma} . \frac{4.2}{48} \times 10^{-6}$
$= \frac{7}{80} \frac{r\rho c}{\sigma} \mu s \approx \frac{7}{72} \frac{r\rho c}{\sigma} \mu s$ [As $J = 4.2$]

66 **(a)**
Since a constant difference in length of 10 cm between an iron rod and a copper cylinder is required
$L_{\text{Fe}} - L_{\text{Cu}} = 10$ cm (i)
or $\Delta L_{\text{Fe}} - \Delta L_{\text{Cu}} = O \ \therefore \Delta L_{\text{Fe}} = \Delta L_{\text{Cu}}$
i.e., linear expansion of iron rod = linear expansion of copper cylinder
$\Rightarrow L_{\text{Fe}} \times \alpha_{\text{Fe}} \times \Delta T = L_{\text{Cu}} \times \alpha_{\text{Cu}} \times \Delta T$
$\Rightarrow \frac{L_{\text{Fe}}}{L_{\text{Cu}}} = \frac{\alpha_{\text{Cu}}}{\alpha_{\text{Fe}}} = \frac{17}{11}$
$\therefore \frac{L_{\text{Fe}}}{L_{\text{Cu}}} = \frac{17}{11}$ (ii)
From Eqs. (i) and (ii) $L_{\text{Fe}} = 28.3$ cm, $L_{\text{Cu}} = 18.3$ cm

67 **(c)**
Let the thermal resistance of each rod be R. The two resistance connected along two paths from B to C are equivalent to $2R$ each and their parallel combination is R
Effective thermal resistance between B and $D = 2R$





Temperature of interface $\theta = \frac{R_1\theta_2 + R_2\theta_1}{R_1 + R_2}$
$\theta = \frac{R \times 20 + 2R \times 200}{R + 2R} = \frac{420}{3} = 140°\text{C}$

68 **(b)**
As, $\frac{dL}{L_0} = \alpha(T)dT$
$\int_{L_0}^{L} dL = L_0 \int_{T_0}^{T} \alpha(T)dT$
$L - L_0 = L_0 \int_{T_0}^{T} \alpha(T)dT$
$L = L_0 \left[1 + \int_{T_0}^{T} \alpha(T)dT\right]$

69 **(a)**
Here ice will absorb heat while hot water will release it. So if T is the final temperature of the mixture, heat given by water
$Q_1 = mc\Delta T = 5 \times 1 \times (30 - T)$
And heat absorbed by ice
$Q_2 = 5 \times (1/2)[0-(-20) + 5 \times 80 + 5 \times 1(T - 0)$
So, by principal of calorimetry $Q_1 = Q_2$, i.e.,
$150 - 5T = 450 + 5T$
$T = -30°\text{C}$
Which is impossible as a body cannot be cooled to a temperature below the temperature of cooling body. The physical reason for this discrepancy is the heat remaining after changing the temperature of ice from -20 to 0°C with some ice left unmelted and we are taking it for granted that heat is transferred from water at 0°C to ice at 0°C so that temperature of system drops below 0°C However, as heat cannot flow from one body (water) to the other (ice) at same temperature (0°C), the temperature of system will not fall below 0°C

70 **(d)**
Let m grams of water whose temperature is $\theta_0(> 30°\text{C})$ and specific heat is 1 cal/g-°C be added to 20 g water at 30°C and let θ be the final temperature of mixture
$m(1)(\theta_0 - \theta)(20)(1)(\theta - 30)$
$$\therefore \theta = \frac{600 + m\theta_0}{20 + m}$$
The right-hand is maximum for option (d). Therefore, the correct answer is (d)

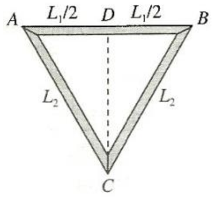
71 **(a)**
$m_1 \times 1 \times (50 - 30) = m_2 \times 1 \times (80 - 10)$
$m_1 \times 20 = m_2 \times 30$ or $\frac{m_1}{n_2} = \frac{3}{2}$
Mass of water from tank $A = \frac{3}{5} \times 40 = 24$ kg
Mass of water from tank $B = \frac{2}{5} \times 40 = 16$ kg

72 **(d)**
Thermostat is used in electric apparatus like refrigerator, iron *etc* for automatic cut off. Therefore for metallic strips to bend on heating their coefficient if linear expansion should be different

73 **(b)**
According to Newton's law of cooling
$$\left(\frac{\theta_1 - \theta_2}{t}\right) = K\left[\left(\frac{\theta_1 + \theta_2}{2} - \theta_0\right)\right]$$
So that $\left(\frac{80-50}{5}\right) = K\left[\left(\frac{80+50}{2} - 20\right)\right]$
And $\left(\frac{60-30}{t}\right) = K\left[\left(\frac{60+30}{2}\right) - 20\right]$
Solving these for t,we get $t = 9$ min

74 **(a)**
Black bulb absorbs more heat in comparison with painted bulb. So air in black bulb expands more. Hence the level of alcohol in limb X falls while that in limb Y rises

75 **(d)**
The apex of the isosceles triangle to remain at a constant distance from the knife edge. Thus, DC should remain constant before and after heating



Before expansion: In triangle ADC
$(DC)^2 = L_2^2 - \left(\frac{L_1}{2}\right)^2$ (i)
After expansion
$(DC)^2 = [L_2(1 + \alpha_2 t)]^2 - \left[\frac{L_1}{2}(1 + \alpha_1 t)\right]^2$ (ii)
Equation Eqs. (i) and (ii), we get
$$L_2^2 - \left(\frac{L_1}{2}\right)^1 = [L_2(1 + \alpha_2 t)]^2 - \left[\frac{L_1}{2}(1 + \alpha_1 t)\right]^2$$
$$L_2^2 - \frac{L_1^2}{4} = L_2^2 + L_2^2 \times 2\alpha_2 \times t - \frac{L_1^2}{4} - \frac{L_1^2}{4} \times 2\alpha_3 \times t$$
(Neglecting higher terms)
$$\Rightarrow \frac{L_1^2}{4}(2\alpha_1 t) = L_2^2(2\alpha_2 t) \Rightarrow \frac{L_1}{L_2} = 2\sqrt{\frac{\alpha_2}{\alpha_1}}$$

76 **(c)**
Rate of loss of energy by unit area of the planet $= \sigma T^4$, where σ is the Stefan's constant. Let Q be the total energy emitted by the sun every second. If d is the distance of the planet from sun, then Q falls uniformly over the inner surface of the sphere of radius d. Rate of gain of heat by unit area of planet
$$= \frac{Q}{4\pi d^2}$$
For steady temperature of plant
$$\sigma T^4 = \frac{Q}{4\pi d^2}$$
$$T^4 = \frac{Q}{4\pi\sigma d^2} \text{ or } T = \left(\frac{Q}{4\pi\sigma d^2}\right)^{1/4}$$
Or $T \propto \frac{1}{\sqrt{d}}$

77 **(a)**
Let the radii of the spheres be $R, R + a, R + 2a$ and $R + 3a$,where a is a constant and the specific heat capacities be s, sr, sr^2 and sr^3 where

r is another constant

Given $\left(\frac{\text{heat capacity of } D}{\text{heat capacity of } B}\right):\left(\frac{\text{heat capacity of } C}{\text{heat capacity of } A}\right) = 8:27$

Or , $\left[\frac{(R+3a)^3 sr^3}{(R+a)^3 sr}\right]:\left[\frac{(R+2a)^3 sr^2}{Rs}\right] = 8:27$

Or, $\left(1+\frac{2a}{R+a}\right):\left(1+\frac{2a}{R}\right) = 2:3$

Or $\frac{2a}{R+a}:\frac{2a}{R} = 1:2$

Or, $R = a$

$$\frac{m_2}{m_1} = \frac{(4/3)\pi(R+R)^3\rho}{(4/3)\pi(R)^3\rho} = \frac{8}{1}$$

78 **(c)**

$Q_1 = 10 \times 1 \times 10 = 100$ cal

$Q_2 = 10 \times 0.50[0-(-20)] + 10 \times 80$

$= (100+800)\text{cal} = 900$ cal

As $Q_1 < Q_2$, so ice will not completely melt and final temperature=0°C

As heat given by water in cooling up to 0°C is only just sufficient to increase the temperature of the ice from -20°C to 0°C, hence mixture in equilibrium will consist of 10 g of ice and 10 g of water, both at 0°C

79 **(d)**

Given $\frac{dR}{R} \times 100 = \frac{(507.5-500.0)}{500.0} \times 100 = 1.5\%$

Now, $K = \frac{1}{2} I\omega^2 = \frac{1}{2I}(I\omega)^2 = \frac{L^2}{2I}$

Or $K = \frac{L^2}{2(MR^2/2)} = \frac{L^2}{M}(R^{-2})$

Taking log and differentiating, $\frac{dK}{K} = -\frac{2dR}{R}$

Or, % change in $K = \frac{dK \times 100}{K} = -\frac{2dR}{R} \times 100 =$ -3%

80 **(d)**

Rate of flow of heat will be equal in both vest and shirt

$$\therefore \frac{K_{\text{vest}} A.\Delta\theta_{\text{vest}} t}{l} = \frac{K_{\text{shirt}} A \Delta\theta_{\text{shirt}} t}{l}$$

$$\Rightarrow \frac{K_{\text{vest}}}{K_{\text{shirt}}} = \frac{\Delta\theta_{\text{shirt}}}{\Delta\theta_{\text{vest}}} \Rightarrow \frac{K_{\text{vest}}}{K_{\text{shirt}}} = \frac{25-22}{30-25} = \frac{3}{5}$$

81 **(b)**

If the point is at a distance x from water at 100°C, heat conducted to ice in time t,

$$Q_{\text{ice}} = KA\frac{(200-2)}{(1.5-x)} \times t$$

So ice melted by this heat

$$m_{\text{ice}} = \frac{Q_{\text{ice}}}{L_F} = \frac{KA}{80}\frac{(200-0)}{(1.5-x)} \times t$$

Similarly heat conducted by the rod to the water at 100°C in time t,

$$Q_{\text{water}} = KA\frac{(200-100)}{x} t$$

Steam formed by this heat

$$m_{\text{steam}} = \frac{Q_{\text{water}}}{L_V} = KA\frac{(200-100)}{540 \times x)} t$$

According to given problem $m_{\text{ice}} = m_{\text{stream}}$,

i.e., $\frac{200}{80(1.5-x)} = \frac{100}{540 \times x} x = \frac{6}{58} m = 10.34$ cm

i.e., 200°C temperature must be maintained at a distance 10.34 cm from water at 100°C

82 **(a)**

Here we assume that all the work done on the bullet inside the wood is converted into thermal energy

Thermal energy produced in the first case is

$$H_1 = \frac{1}{2}(5 \times 10^{-3})(200)^2 \text{ J}$$

Since the resistance in the second plank is the same as the first and also the thickness is equal, the same amount of work will be done on the bullet as in the first case and hence the thermal energy $H_2 = H_1$. The ratio is 1:1

83 **(b)**

Using the suffixes I and B for the iron ball and the brass plate we have $L_I = 6$ cm, $L_1 - L_B =$ 0.001 cm at $t = 30$°C Heating both the ball and the plate increase the diameter of the ball as well as the hole in the plane, with the hole diameter increasing at a faster rate, since $\alpha_B > \alpha_L$

Now we required that $\Delta L_B - \Delta L_I = 0.001$ cm at the desired temperature t, with $\Delta L_B = L_B \alpha_B \Delta t$ and $\Delta L_I = L_I \alpha_I \Delta t$

Then $\Delta L_B - \Delta L_I = (L_B\alpha_B - L_I\alpha_I)\Delta T = 0.001$ cm $\approx L_I(\alpha_B - \alpha_l)\Delta t$, approximating by putting $L_B \simeq L_I$ or (6 cm)$[1.9 \times 10^{-5} - 1.2 \times 10^{-5}]\Delta t =$ 0.001 cm

Hence $\Delta t = \frac{0.001}{6[1.9\times10^{-5} - 1.2\times10^{-5}]}$°C

$\Delta t = 23.8$°C

Hence final temperature $= 30 + 23.8$°C $= 53.8$°C

84 **(a)**

For a black body, wavelength for maximum intensity:

$$\lambda \propto \frac{1}{T} \,\&\, P \propto T^4 \Rightarrow P \propto \frac{1}{\lambda^4}$$

$P' = 16P \therefore P'T' = 32\, PT$

85 **(b)**

From Wien's displacement law $\lambda_m T = b$

$$\therefore T = \frac{b}{\lambda_m} = \frac{2.93 \times 10^{-3}}{2.93 \times 10^{-10}} = 10^7 \text{K}$$

86 **(a)**

Rate of cooling $\frac{\Delta\theta}{t} = \frac{A\varepsilon\sigma(T^4 - T_0^4)}{mc} \Rightarrow \frac{\Delta\theta}{t} \propto A$. Since area of plate is largest so it will cool fastest

87 **(b)**

Since a ruler is used, the scale used not expand with the tube if the radius of the capillary be r, the increase due to thermal expansion is given by $dr = r\alpha\, dT$ for a temperature rise of dT. Since area of cross section is $A = \pi r^2$, we see that $dA/A = 2dr/r$ or $dA = A(2\alpha)dT$. Thus if the temperature is increased from T to $T + dT$, the cross-sectional area changes from A to $A(1 + 2\alpha\, dT)$. The volume expansion of the liquid gives $V' = V + dV = V(1 + \gamma dT)$, where γ is the coefficient of the volume expansion of the liquid. This causes change in length of thread and final length becomes $L' = L + dL$. The mass of liquid is constant; hence $L'A' = V' = V(1 + \gamma dT) = LA(1 + \gamma dT)$

But $A' = A(1 + 2\alpha\, dT)$

Hence, $L' = L\left(\frac{1+\gamma dT}{1+2\alpha dT}\right)$

$= L[1 + (\gamma - 2\alpha)dT - 2\alpha\gamma(dT)^2]$

The last term is negligible

Hence, $L' = L[1 + (\gamma - 2\alpha)dT]$

$\Delta L = L(\gamma - 2\alpha)dT$

88 **(a)**

$$mL = \frac{KA\Delta\theta t}{\Delta x}$$

$$\Rightarrow 500 \times 80 = \frac{0.0075 \times 75 \times (40 - 0)t}{5}$$

$\Rightarrow t = 8.9 \times 10^3 \text{s} = 2.47 \text{ h}$

89 **(c)**

From $\frac{dQ}{dt} = \frac{KA\Delta\theta}{l}$

$\Rightarrow \Delta\theta = \frac{l}{K \times A} \times \frac{dQ}{dt} = \frac{0.1}{400 \times (100 \times 10^{-4})} \times 4000 = 100°\text{C}$

90 **(a)**

Since they are in thermal equilibrium, the temperatures must necessarily be equal. Temperature equality is a necessary and sufficient condition for thermal equilibrium (zeroth law of thermodynamics)

91 **(a)**

When the cylinder is heated its volume increases as

$V_t = V_0(1 + \gamma_g t)$ (i)

If the densities of mercury at the temperatures t_0 and t_1 are denoted by ρ_0 and ρ_1

$m_0 = V_0\rho_0$ and $m_t = V_t\rho_t$ (ii)

$m_t = m_0$

$\rho_t = \frac{\rho_0}{(1+\gamma_{Hg}t)}$ (iii)

Form Eqs.(i), (ii) and (iii)

$$\gamma_{glass} = \frac{m_t(1 + \gamma_{Hg}t_t) - m_0}{m_0 t_t}$$

$$= \frac{99.7(1 + 18 \times 10^{-5} \times 20) - 100}{100 \times 20}$$

$= 2.946 \times 10^{-5}/°\text{C}$

The coefficient of linear expansion of glass

$$\alpha_{glass} = \frac{\gamma_{glass}}{3} \simeq 10^{-5}/°\text{C}$$

92 **(d)**

Let V be the volume of the glass vessel. Then volume of mercury will be $(3/5)V$

Expansion of mercury $= (3/5)V \times \gamma_m\Delta T$

and that of glass $= V\gamma_g\Delta T$

Net (effective of apparent) expansion of mercury

$$\Delta V = V\left(\frac{3\gamma_m}{5} - \gamma_g\right)\Delta T$$

$\therefore$ Coefficient of apparent expansion will be

$$\frac{\Delta V}{(3/5)V \times \Delta T} = \left(\frac{3}{5}\gamma_m - \gamma_g\right)\frac{5}{3}$$

93 **(c)**

Half of KE is attained as heat by each ball

$\frac{1}{2}\text{KE} = m_1 s_1 T_1 = m_2 s_2 T_2 = \frac{1}{2} \times 1 \times (50)^2$

$= 1 \times 0.105 \times 418 \times 10^3 \times T_1$

$$T_1 = \frac{50 \times 50}{2 \times 0.105 \times 4.18 \times 10^3}$$

$$= \frac{25}{2.1 \times 4.18} = \frac{25}{8.778} \cong 3.4\text{K}$$

As $m_2 = \frac{m_1}{5}$, so $T_2 = 5T_1 = 17\text{K}$

94 **(c)**

The change in length of wire $= l_{Al}\alpha_{Al}\Delta\theta + l_{st}\,\alpha_{st}\,\Delta\theta$ associated with temperature change of $\Delta\theta$, where α_{Al} and α_{St} are the coefficient of linear expansion of aluminium and steel, respectively

$\alpha_{Al} = 23 \times 10^{-6}/°\text{C}$

$\alpha_{st} = 12 \times 10^{-6}/°\text{C}$

The effective coefficient of linear expansion of the two segments of wire $= 19 \times 10^{-6}/°\text{C}$

$l_1\alpha_{Al}\Delta\theta + l_2\alpha_{st}\Delta\theta = (l_1 + l_2)\alpha\Delta\theta$

$$\frac{l_1}{(l_1 + l_2)} = \frac{\alpha - \frac{l_2}{(l_1+l_2)}\alpha_{st}}{\alpha_{Al}}$$

$$\left[\frac{l_1}{l_1 + l_2} = x \;\; l_1 + l_2 = l\left(\frac{l_2}{l_1 + l_2}\right) = 1 - x\right]$$

$$x = \frac{\alpha - (1 - x)\alpha_{st}}{\alpha_{Al}}$$

$$x = \frac{\alpha - \alpha_{st}}{\alpha_{Al} - \alpha_{st}} = \frac{19 \times 10^{-6} - 12 \times 10^{-6}}{23 \times 10^{-6} - 12 \times 10^{-6}} = \frac{7}{11}$$

95 **(b)**

Let m be the mass of ice.

Rate of heat given by the burner is constant. In the first 50 min

$\frac{dQ}{dt} = \frac{mL}{t_1} = \frac{m\text{ kg} \times (80 \times 4.2 \times 10^3)\text{J/kg}}{(50 \text{ min})}$ (i)

From 50 min to 60 min

$$\frac{dQ}{dt} = \frac{(m+5)S_{H_2O}\Delta\theta}{t_2}$$

$$= \frac{(m+5)\text{ kg }(4.2\times10^3)\text{ J/Kg}\times2°\text{C}}{10\text{ min}} \quad \text{(ii)}$$

From Eqs. (i) and (ii)

$$\frac{80m}{50} = \frac{2(m+5)}{10}$$

$$7m = 5 \Rightarrow m = \frac{5}{7}\text{kg} \simeq 0.7\text{ kg}$$

96 **(b)**

According to principle of calorimetry,

$ML_F + Ms\Delta T = (ms\Delta T)_{\text{water}} + (ms\Delta T)_{\text{flask}}$

$50L_F + 50 \times 1 \times (40 - 0)$

$= 200 \times 1 \times (70 - 40) + W(70 - 40)$

$50L_F + 2000(200 + W)30$

$5L_F = 400 + 3W$ (i)

Now the system contains (200+50) g of water at 40°C, so when further 80 g of ice is added

$80L_F + 80 \times 1 \times (10 - 0)$

$= 250 \times 1 \times (40 - 10) + W(40 - 10)$

$80L_F = 670 + 3W$ (ii)

Solving Eqs. (i) and (ii),

$L_F = 90$ cal/g and $W = \frac{50}{3}$ g

97 **(b)**

According to Newton's law of cooling, the ratio of cooling is directly proportional to the temperature difference. When the average temperature difference is halved, the rate of cooling is also halved. So, the time taken is 10 s

98 **(c)**

From the conservation principle of angular momentum

$L_i = L_f$

$I_0\omega_0 = I\omega$

Here, $I = I_0[1 + 2\alpha(\theta_2 - \theta_1)]$

$$\therefore \omega = \frac{I_0\omega_0}{I_0[1 + 2\alpha(\theta_2 - \theta_1)]} = \frac{\omega_0}{[1 + 2\alpha(\theta_2 - \theta_1)]}$$

99 **(d)**

Since tension the two rods will be same

$A_1Y_1\alpha_1\Delta\theta = A_2Y_2\alpha_2\Delta\theta$

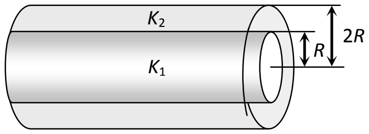
$A_1Y_1\alpha_1 = A_2Y_2\alpha_2$

100 **(c)**

According to Newton's law of cooling the rate of cooling depends upon the difference of temperature between the body and the surrounding. It means that when the difference of temperature between the body and the surrounding is small, time required for same fall in temperature is more in comparison with the same fall at higher temperature difference between the body and surrounding. So according to problem $T_1 < T_2 < T_3$

101 **(c)**

Both the cylinders are in parallel, for the heat flow from one end as shown



Hence $K_{eq} = \frac{K_1A_1 + K_2A_2}{A_1 + A_2}$

Where A_1 = Area of cross-section of inner cylinder $\propto \pi R^2$ and A_2 = Area of cross-section of cylindrical shell

$= \pi\{(2R)^2 - (R)^2\} = 3\pi R^2$

$$\Rightarrow K_{eq} = \frac{K_1(\pi R^2) + K_2(3\pi R^2)}{\pi R^2 + 3\pi R^2} = \frac{K_1 + 3K_2}{4}$$

102 **(b)**

Evidently the initial temperature of the water contained in the vessel (Mg) is 80°C, and the temperature of the water passed into it is 60°C, as the final temperature of the mixture tends to attain a value of 60°C

$M \times 1(80 - 70) = m \times 10 \times 1(70 - 60)$

Or $M/m = 10$

Since the heat exchanged after a long time is 800 cal

$(Mg)(1\text{ cal}/m°\text{C})(80 - 60°\text{C}) = 80$ cal

$M = 40$ g

$\Rightarrow m = 4$ g

103 **(b)**

Wien's law $\lambda_m \propto \frac{1}{T}$ or $v_m \propto T$

v_m increases with temperature. So the graph will be straight line

104 **(c)**

$Q = \sigma At(T^4 - T_0^4)$

If T, T_0, σ and t are same for both bodies then

$\frac{Q_{\text{sphere}}}{Q_{\text{cube}}} = \frac{A_{\text{sphere}}}{A_{\text{cube}}} = \frac{4\pi r^2}{6a^2}$ (i)

But according to problem, volume of sphere = Volume of cube

$$\Rightarrow \frac{4}{3}\pi r^3 = a^3$$

$$\Rightarrow a = \left(\frac{4}{3}\pi\right)^{1/3} r$$

Substituting the value of a in Eq. (i), we get

$$\frac{Q_{\text{sphere}}}{Q_{\text{cube}}} = \frac{4\pi r^2}{6a^2}$$

$$= \frac{4\pi r^2}{6\left\{\left(\frac{4}{3}\pi\right)^{1/3} r\right\}^2} = \frac{4\pi r^2}{6\left(\frac{4}{3}\pi\right)^{2/3} r^2}$$

$= \left(\frac{\pi}{6}\right)^{1/3} : 1$

105 **(b)**

Heat lost in t sec $= mL$ or heat lost per sec $= \frac{mL}{t}$.

This must be the heat supplied for keeping the substance in molten state per sec.

$\therefore \frac{mL}{t} = P$ or $L = \frac{Pt}{m}$

106 **(c)**

It is given that the volume of air in the flask remains the same. This means that the expansion in volume if the vessel is exactly equal to the volume expansion of mercury

i.e., $\Delta V_G = \Delta V_L$

or $V_G \gamma_G \Delta\theta = V_L \gamma_L \Delta\theta$

$\therefore V_L = \frac{V_G \gamma_G}{\gamma_L} = \frac{1000 \times (3 \times 9 \times 10^{-6})}{1.8 \times 10^{-4}} = 150$ cc

107 **(b)**

The entire kinetic energy of the fragment is changed to heat. Expressing mass m in kilograms everywhere, we have

$\frac{1}{2}mv^2 = [m(30) + m(0.11)(1535° + 100°)]4184$

$v^2 = (8368)[30 + 180 \simeq 1.76 \times 10^6$

Hence

$v = (\sqrt{1.76}) \times 10^3 = 1.32$ km/s

108 **(c)**

On heating the system; x, r and d all increase, since the expansion of isotropic solids is similar to true photographic enlargement

109 **(d)**

Temperature of mixture is given by

$$T = \frac{m_1 c_1 T_1 + m_2 c_2 T_2}{m_1 + m_2 c_2} = \frac{mc2T + \frac{m}{2}2cT}{mc + \frac{m}{2}2c} = \frac{3}{2}T$$

110 **(b)**

$\left(\frac{dQ}{dt}\right) \times \frac{1}{A} = K_A \frac{(50-30)}{3}$ (for slab A)

$= K_B \frac{(50-20)}{3}$ (for slab B)

$2KA = 3\ KB$

Or, $KA/KB = 3/2$

111 **(c)**

If mass of the bullet is m grams, heat absorbed by it to raise its temperature from 27°C to 327°C

$mc\ \Delta T = m \times 0.03 \times (327 - 27) = 9$m cal

And heat required by the bullet to melt

$mL = m \times 6 = 6$ m cal

So, the total heat required by the bullet

$Q_1 = (9m + 6m) = 15m$ cal $= (15m \times 4.2)$ J (as 1 cal = 4.2 J)

Now when the bullet is stopped by the obstacle, loss in its mechanical energy

$ME = \frac{1}{2}(m \times 10^{-3})v^2$ J (as m gram $= m \times 10^{-3}$kg)

As 25% of the energy is absorbed by the obstacle, the energy absorbed by the bullet

$Q_2 = \frac{75}{100} \times \frac{1}{2}mv^2 \times 10^{-3} = \frac{3}{8}mv^2 \times 10^{-3}$ J

Now the bullet will melt if

$Q_2 \geq Q_1$

$\frac{3}{8}mv^2 \times 10^{-3} \geq 15\ m \times 4.2$

$v \geq \sqrt{(4 \times 4.2)} \times 10^2$

$v_{\min} = 410$ m/s

112 **(d)**

Temperature of interface $T = \frac{K_1\theta_1 + K_2\theta_2}{K_1 + K_2}$

$= \frac{300 \times 100 + 200 \times 0}{300 + 200} = 60$°C

113 **(c)**

Thermal stress that is produced in an elastic wire is $Y\ \alpha\ \ \theta$ per unit area, where Y is Young's modulus, α coefficient of linear expansion and θ change of temperature

Thus, tension developed in the wire is

T =Thermal stress × area of cross section

$= Y\alpha \times (\Delta T)[\pi r^2]$ N

$= 0.91 \times 10^{11} \times 2 \times 10^{-5} \times [27 - (-33)[\pi \times 1 \times$ *10−6* N

$= 0.91 \times 2 \times 6 \times 3.14 \times 10$ N

$= 34.4 \times 10$ N $= 0.34$ kN

114 **(c)**

Rate of flow of heat along PQ

$\left(\frac{dQ}{dt}\right)_{PQ} = \frac{K_3 A\Delta\theta}{l}$ (i)

Rate of flow heat along PRQ

$\left(\frac{dQ}{dt}\right)_{PRQ} = \frac{K_3 A\Delta\theta}{l}$

Effective conductivity for series combination of two rods of same length

$K_1 = \frac{2K_1K_2}{K_1 + K_2}$

So $\left(\frac{dQ}{dt}\right)_{PRQ} = \frac{2K_1K_2}{K_1+K_2} \cdot \frac{A\Delta\theta}{2l} = \frac{K_1K_2}{K_1+K_2} \cdot \frac{A\Delta\theta}{l}$ (ii)

Equation Eqs .(i) and (ii) $K_3 = \frac{K_1K_2}{K_1+K_2}$

115 **(b)**

Heat required by 10 kg water to change its temperature from 20°C to 80°C in one hour is

$Q_1 = (mc\Delta T)_{\text{water}} = (10 \times 10^3) \times 1 \times (80 - 20) = 600 \times 10^3$ cal

In condensation

i. Steam releases heat when it loses its

temperature from 150°C to 100°CX. $[mc_{\text{steam}}\Delta T]$
ii. At 100°C it converts into water and gives the latent heat. $[mL]$
iii. Water releases heat when it loses its temperature from 100°C to 90°. $[ms_{\text{water}}\Delta T]$
If m grams of steam is condensed per hour, then heat released by steam in converting to water at 90°C
$Q_2 = (mc\Delta T)_{\text{steam}} + mL_{\text{steam}} + (ms\Delta T)_{\text{water}}$
$= m[1 \times (150-100) + 540 + 1 \times (100-90)] =$ 600 m cal
According to problem, $Q_1 = Q_2 \Rightarrow 600 \times 10^3 \text{cal} =$ 600 m cal
$\Rightarrow m = 10^3 \text{g} = 1 \text{ kg}$

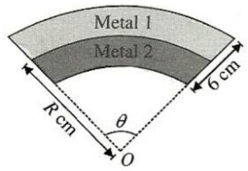
116 **(c)**
Temperature of liquid oxygen will first increase in the same phase. The phase change (liquid to gas) will take place. During which temperature will remain constant. After that temperature of oxygen in gaseous state will further increase.

117 **(d)**
Specific heat of lead = 0.03 kcal/kg°C. Gravitional potential energy is converted into thermal energy which is absorbed by the lead shot. If T_0 is the rise in temperature of the shot, then
$(100)[mgh] = (m \times s \times T)$ J
$$T = \frac{100 \times \text{g} \times h}{Js} = \frac{100 \times 9.8 \times 1.5}{0.03 \times 4.18 \times 10^3} \text{°C} = 11.3\text{°C}$$

118 **(b)**
Consider a time interval Δt while the door is closed. Then the rate of heat into the box is
$$\frac{Q}{\Delta t} = kA\left(\frac{\Delta T}{\Delta x}\right) = (0.05)(6)\left(\frac{22}{0.09}\right) = 73.3 \text{ W}$$
To remove heat at this rate, while the motor runs only for a time $(0.15)\Delta t$, it must cause heat to leave at the rate
$$H = \frac{73.3}{0.15} = 500 \text{ W}$$

119 **(a)**
According to problem, rate of heat loss in both rods in equal, i.e., $\left(\frac{dQ}{dt}\right)_1 = \left(\frac{dQ}{dt}\right)_2$
$$\Rightarrow \frac{K_1 A_1 \Delta\theta_1}{l_1} = \frac{K_2 A_2 \Delta\theta_2}{l_2}$$
$\therefore K_1 A_1 = K_2 A_2$ [As $\Delta\theta_1 = \Delta\theta_2 = (T_1 - T2$ and $l1 = l2$ given]

120 **(d)**
The slope of lines are
$\left(\frac{\Delta L}{\Delta T}\right)_1 = L\alpha_1 = \frac{4-0}{4-0} = 1$ (For the first metal)
and $\left(\frac{\Delta L}{\Delta T}\right)_2 = L\alpha_2 = \frac{2-0}{4-0} = \frac{1}{2}$ (For the second metal)



$L_0(1 + \alpha_1 T) = (R + 1.5)\theta$
and $L_0(1 + \alpha_2 T) = (R - 1.5)\theta$
$\therefore$ Dividing, we get, $\frac{1+\alpha_1 T}{1+\alpha_2 T} = \frac{R+1.5}{R-1.5}$
or, $(\alpha_1 - \alpha_2)T \simeq \frac{3}{R}$ and $\alpha_1 - \alpha_2 = \frac{3}{RT}$
From the graph [shown in Figure(a)]
$$\alpha_1 - \alpha_2 = \frac{3}{7500 \times 50} = 8 \times 10^{-6}/\text{°C}$$
But $\alpha_1/\alpha_2 = 2$
$\therefore \alpha_1 = 16 \times 10^{-6}/\text{°C}$ and $\alpha_2 = 8 \times 10^{-6}/\text{°C}$

121 **(b)**
Let V be the volume of the liquid and ΔT the rise in temperature. Since apparent expansion = true expansion –expansion of vessel
$\therefore V\gamma_1 \Delta T = V\gamma\Delta T + V(3\alpha_1)\Delta T$
Or $\gamma_1 = \gamma + 3\alpha_1$ (i) (for vessel A)
and $\gamma_2 = \gamma + 3\alpha_2$ (ii) (for vessel B)
Where γ is the coefficient of real expansion of the liquid. Subtracting Eq.(ii) from Eq (i),
$\gamma_1 - \gamma_2 = 3(\alpha_1 - \alpha_2)$
Or $\alpha_1 - \alpha_2 = (\gamma_1 - \gamma_2)/3$
Or $\alpha_2[(\gamma_1 - \gamma_2)/3] + \alpha_1$
Hence, correct option is (b)

122 **(c)**
Let P be the power radiated by the sun and R be the radius of planet. Energy radiated by planet
$= 4\pi R^2 \times (\sigma T^4)$
For thermal equilibrium
$$\frac{P}{4\pi d^2} \times \pi R^2 = 4\pi R^2(\sigma T^4)$$
$$\therefore T^4 \propto \frac{1}{d^2} \text{ or } T \propto d^{-1/2}$$
Hence $n = \frac{1}{2}$

123 **(b)**
Rate of flow of heat of power $P = \frac{KA\Delta\theta}{\Delta x} = \frac{K4\pi R^2 T}{\Delta x}$
$\therefore$ Thickness of shall $\Delta x = \frac{4\pi R^2 KT}{P}$

124 **(a)**

According to Newton's law of cooling

$$\left[\frac{\theta_1 - \theta_2}{t}\right] = K\left[\left(\frac{\theta_1 + \theta_2}{2}\right) - \theta_0\right]$$

So that $\left[\frac{60-40}{7}\right] = K\left[\left(\frac{60+40}{2}\right) - 10\right]$

$$\Rightarrow K = \frac{1}{14}$$

Now if after cooling from 40°C to 7 min the temperature of the body becomes θ, according to Newton's law of cooling

$$\left[\frac{40-\theta}{7}\right] = K\left[\left(\frac{40+\theta}{2}\right) - 10\right]$$

Which in the light of Eq. (i).,i.e., $K = (1/14)$, gives

$$\left[\frac{40-\theta}{7}\right] = \frac{1}{14}\left[\left(\frac{20+\theta}{2}\right)\right]$$

$160 - 4\theta = 20 + \theta : \theta = 28°\text{C}$

125 **(c)**

Heat required to raise the temperature of m grams of substance by dT is given as

$$dQ = mc\ dT \Rightarrow Q = \int mcdT$$

Therefore, to raise the temperature of 2 g of substance from 5°C to 15°C

$$Q = \int_5^{15} 2 \times (0.2 + 0.14t + 0.023t^2)dT$$

$$= 2 \times \left[0.2t + \frac{0.14t^2}{2} + \frac{0.023t^3}{3}\right]_5^{15} = 82 \text{ cal}$$

126 **(a)**

Temperature of interface $\theta = \frac{K_1\theta_1 + K_2\theta_2}{K_1 + K_2}$

$[\because \frac{K_1}{K_2} = \frac{1}{4} \Rightarrow \text{If } K_1 = K \text{ then } K_2 = 4K]$

$$\Rightarrow \theta = \frac{K \times 0 + 4K \times 100}{5K} = 80°\text{C}$$

127 **(a)**

If mass of the bullet is $m\ gm$,

Then total heat required for bullet to just melt down

$Q_1 = m\ c\ \Delta\theta + m\ L$

$= m \times 0.03(327 - 27) + m \times 6$

$= 15\ m\ cal = (15m \times 4.2)J$

Now when bullet is stopped by the obstacle, the loss in its mechanical energy $= \frac{1}{2}(m \times 10^{-3})v^2 J$

(As $m\ g = m \times 10^{-3} kg$)

As 25% of this energy is absorbed by the obstacle, The energy absorbed by the bullet

$$Q_2 = \frac{75}{100} \times \frac{1}{2}mv^2 \times 10^{-3} = \frac{3}{8} \times 10^{-3}J$$

Now the bullet will melt if $Q_2 \geq Q_1$

$i.e., \frac{3}{8}mv^2 \times 10^{-3} \geq 15m \times 4.2 \Rightarrow v_{\min}$

$= 410m/s$

128 **(c)**

According to Stefan-Boltzmann law, the energy radiated per second through the surface of area A is given by

$E = \sigma AT^4$

$$\therefore \frac{E_1}{E_2} = \frac{A_1}{A_2}\left(\frac{T_1}{T_2}\right)^4$$

Or $10000 = \frac{r_1^2}{r_2^2}\left(\frac{2000}{6000}\right)^4$

Or $\frac{r_1^2}{r_1^2} = (30)^4$

Or $r_1 : r_2 = 900 : 1$

129 **(a)**

$$\frac{dQ}{dt} = \frac{KA\Delta\theta}{l}$$

For both rods K, A and $\Delta\theta$ are same

$$\therefore \frac{dQ}{dt} \propto \frac{1}{l}$$

So $\frac{(dQ/dt)_{\text{semicircular}}}{(dQ/dt)_{\text{straigh}}} = \frac{l_{\text{straigh}}}{l_{\text{semicircular}}} = \frac{2r}{\pi r} = \frac{2}{\pi}$

130 **(b)**

Expansion in mercury= $V_0\gamma_m T$

Expansion in glass bulb=$V_0(3\alpha)T$

Apparent expansion in mercury= $V_0\gamma_m T - V_0(3\alpha)T$

$$\therefore \Delta l = \frac{V_0\gamma_m T - V_0 3\alpha T}{A_0(1 + 2\alpha_g T)}$$

Length of mercury column in capillary is

$$h = \Delta l = \frac{V_0 T(\gamma_m - 3\alpha_g)}{A_0(1 + 2\alpha_g T)}$$

131 **(b)**

If θ is the temperature of outside, heat passing per second through the glass window,

$$\frac{dQ}{dt} = KA\frac{(\theta_1 - \theta_2)}{L}$$

$$= \frac{0.2 \times 1 \times (20 - \theta)\text{cal}}{0.2 \times 10^{-2}} = 100(20 - \theta)$$

And heat produced per second by the heater in the room

$$P = \frac{V^2}{R}\frac{J}{s} = \frac{V^2}{RJ}\frac{\text{cal}}{\text{s}}$$

$$= \frac{200 \times 200}{20 \times 4.2} 476.2 \frac{\text{cal}}{\text{s}}$$

Now as the temperature of the room is constant, the heat produced per second by heater must be equal to the heat conducted through the glass window

$100(20 - \theta) = 476.2; \theta = 15.24°\text{C}$

132 **(a)**

$\lambda_m \propto \frac{1}{T}$

$\therefore \quad \frac{\lambda_A}{\lambda_B} = \frac{T_B}{T_A} = \frac{500}{1500} = \frac{1}{3}$

$E \propto T^4$ (where A = surface area = $4\pi R^2$)

$\therefore \quad E \propto T^4 R^2$

$\frac{E_A}{E_B} = \left(\frac{T_A}{T_B}\right)^4 \left(\frac{R_A}{R_B}\right)^2$

$= (3)^4 \left(\frac{16}{18}\right)^2 = 9$

133 **(c)**

From Figure (a), the slope of line is

$\frac{\Delta L}{\Delta T} = \frac{(1001.2 - 1000.0)\text{mm}}{(300-0)°\text{C}}$

$= 4 \times 10^{-6}\text{m/°C}$

But $\frac{\Delta L}{\Delta T} = L\alpha$

$\therefore \alpha = \frac{4 \times 10^{-6}}{1\, m}\text{m/°C}$

$= 4 \times 10^{-6}/°\text{C}$

As shown in figure (b) in the question, the slope of line is

$\frac{\Delta V_a}{\Delta T} = \frac{(1003 - 1000)\text{ mL}}{(20-0)°\text{C}} = \frac{3}{20}\text{mL/°C}$

But, $\frac{\Delta V_a}{\Delta T} = V\gamma_a$

$\therefore \gamma_a = \frac{3}{20 \times 10^3}/°\text{C} = 150 \times 10^{-6}/°\text{C}$

Since, $\gamma_a = \gamma_r - \gamma_c$

$\therefore \gamma_r = \gamma_a + \gamma_c = \gamma_a + 3\alpha$

$= (150 + 12) \times 10^{-6}/°\text{C}$

$= 16.2 \times 10^{-5}/°\text{C}$

134 **(c)**

Let m be the mass of water

Quantity of heat absorbed by water in 10 min

$= ms\,\Delta T = m \times 1 \times 100 = 100$ m (in calories)

Quantity of heat absorbed by water in 54 min

$= \frac{100\, m \times 54}{10}$

Quantity of heat required to convert water into steam $= mL$

Hence, $\frac{100m \times 54}{10} = mL$ or $L = 540$ cal/g

135 **(a)**

Loss of time due to heating a pendulum is given as

$\Delta T = \frac{1}{2}\alpha\Delta\theta T$

$\Rightarrow 12.5 = \frac{1}{2} \times \alpha \times (25-0)°\text{C} \times 86400\text{s}$

$\Rightarrow \alpha = \frac{1}{86400}/°\text{C}$

136 **(a)**

$U_0 = V_0\sigma°_L \text{g} = W_0$ and $U_t = V_t\sigma_L^1 \text{ g} = W$

$\frac{W}{W_0} = \frac{V_1}{V_0} \times \frac{\sigma_L^t}{\sigma_L^0} = \frac{(1+\gamma_B\Delta\theta)}{(1+\gamma_L\Delta\theta)}$

$= (1+\gamma_s\Delta\theta)(1+\gamma_L\Delta\theta)^{-1} = 1 + \gamma_s\Delta\theta - \gamma_L\Delta\theta$

$= W = W_0[1 + (\gamma_s - \gamma_L)\Delta\theta)]$

$= W_0[1 + (\gamma_s - \gamma_L)t]$

137 **(c)**

Due to increase in temperature, radius of the sphere changes

Let R_0 and R_{100} be radius of sphere at 0°C and 100°C, respectively. $R_{100} = R_0(1 + \alpha \times 100)$

Squaring both the sides and neglecting higher terms $R_{100}^2 = R_0^2(1 + 2\alpha \times 100)$

By the law of conservation of angular momentum

$I_1\omega_1 = I_2\omega_2$

$\Rightarrow \frac{2}{5}MR_0^2\omega_1 = \frac{2}{5}MR_{100}^2\omega_2$

$\Rightarrow R_0^2\omega_1 = R_0^2(1 + 2 \times 2 \times 10^{-5} \times 100)\omega_2$

$\Rightarrow \omega_2 = \frac{\omega_1}{(1 + 4 \times 10^{-3})} = \frac{\omega_0}{1.004} = 0.99\omega_0$

138 **(d)**

Increase in length of tape

$\Delta l = l\alpha\Delta T$

$= (6400 \times 10^3 \times 11 \times 10^{-6} \times 30) = 2113$ m

$\simeq 2.1$ km

139 **(b)**

When water falls from a height, it has potential energy (mgh),

this is used in heating up the water ($mc\Delta\theta$).

Hence, we have

$$mgh = mc\Delta\theta$$

$$\Rightarrow \quad \Delta\theta = \frac{gh}{c}$$

$$= \frac{9.8 \times 500}{4.2 \times 10^3} = 1.16°\text{C}$$

140 **(a)**

$\frac{V'}{V} = \frac{\rho}{\sigma}$ = fraction of volume of sphere submerged

$= \eta$ (say)

To find % change in η, i.e., $\frac{\eta' - \eta}{\eta} \times 100$

Or $\left(\frac{\eta'}{\eta} - 1\right) \times 100 = \left[\frac{(\rho/\sigma)'}{(\rho/\sigma)} - 1\right] \times 100$

$= \left[\frac{(1 + \gamma_m\Delta T)}{1 + \gamma_P\Delta T} - 1\right] \times 100 \simeq (\gamma_m - \gamma_p)\Delta T \times 100$

$= (182 - 27) \times 10^{-6} \times 100 = 1.24\%$

141 **(b)**

Energy supplied by the heater to the system in 10 min

$Q_1 = P \times t = 90 \text{ J/s} \times 10 \times 60 \text{ s}$

$= 54000 \text{ J} = \frac{54000}{4.2}$ cal $= 12857$ cal

Now if θ is the final temperature of the system, energy absorbed by it to change its temperature from 10°C to θ°C is

$Q_2 = (ms\Delta T)_{\text{water}} + (ms\Delta T)_{\text{coil+calometer}}$

$= 360 \times 1 \times (\theta - 10) + 40(\theta - 10)$

$= 400(\theta - 10)$

According to problem, $Q_1 = Q_2$

So $12857 = 400(\theta - 10)$ or $\theta = 42.14$°C

142 **(a)**

According to Wien's law, wavelength corresponding to maximum energy decreases. When the temperature of black body increases, i.e., $\lambda_m T$ =constant

$$\Rightarrow \frac{T_2}{T_1} = \frac{\lambda_1}{\lambda_2} = \frac{\lambda_0}{3\lambda_0/4} = \frac{4}{3}$$

Now according to Stefan's law

$$\frac{E_2}{E_1} = \left(\frac{T_2}{T_1}\right)^4 = \left(\frac{4}{3}\right)^4 = \frac{256}{81}$$

143 **(b)**

According to Newton's law of cooling

$$\frac{\theta_1 - \theta_2}{t} \propto \left[\frac{\theta_1 + \theta_2}{2} - \theta\right]$$

For the first condition

$\frac{62-61}{T} \propto \left[\frac{62+61}{2} - 30\right]$ (i)

And for the second condition

$\frac{46-45.5}{t} \propto \left[\frac{46+45.5}{2} - 30\right]$ (ii)

By solving Eqs (i) and (ii), we get $t = T$ minutes

144 **(b)**

If the sheet is heated then both d_1 and d_2 will increase since the thermal expansion of isotropic solid is similar to true photographic enlargement

145 **(c)**

Fraction of wooden block immersed at 0°C,

$$\frac{V_1}{V_0} = \frac{(\rho_{\text{wood}})_{0°\text{C}}}{(\rho_{\text{H}_2\text{O}})_{0°\text{C}}}$$

$$f_1 = \frac{V_0 - V_1}{V_0} = \frac{(\rho_{\text{H}_2\text{O}})_{0°\text{C}} - (\rho_{\text{wood}})_{0°\text{C}}}{(\rho_{\text{H}_2\text{O}})_{0°\text{C}}}$$

V_1 –Volume of wood immersed in water at 0°C

V_0 –Volume of wood

$(\rho_{\text{wood}})_{0°\text{C}}$ –Density of wood at 0°C

When the temperature is raised to 10°C, the volume of wood immersed in water changes to V_2

$$\frac{V_2}{V_0} = \frac{(\rho_{\text{wood}})_{10°\text{C}}}{(\rho_{\text{H}_2\text{O}})_{10°\text{C}}}$$

$$f_2 = \frac{V_0 - V_2}{V_0} = \frac{(\rho_{\text{H}_2\text{O}})_{10°\text{C}} - (\rho_{\text{wood}})_{10°\text{C}}}{(\rho_{\text{H}_2\text{O}})_{10°\text{C}}}$$

From 0°C to 4°C, the density of water increases, and from 4°C to 10°C the density of water decreases.

But for wood density decreases as temperature increases. The volume of block above water level will first increase and then decrease

146 **(c)**

As the temperature of body increases, frequency corresponding to maximum energy in radiation (v_m) increases. This is shown in graph (c)

147 **(a)**

$K_1 = 9K_2, l_1 = 18$ cm, $l_2 = 6$ cm, $\theta_1 = 100$°C, $\theta_2 = 0$°C

Temperature of the junction $\theta = \frac{\frac{K_1}{l_1}\theta_1 + \frac{K_2}{l_2}\theta_2}{\frac{K_1}{l_1} + \frac{K_2}{l_2}}$

$$\Rightarrow \theta = \frac{\frac{9K_2}{18}100 + \frac{K_2}{6} \times 0}{\frac{9K_2}{18} + \frac{K_2}{6}} = \frac{50 + 0}{8/12} = 75°\text{C}$$

148 **(d)**

Under steady state condition, heat released to the room = heat dissipated out of the room. Let θ be the temperature of heater. Then

$\theta - 20 = \alpha[20 - (-20)]$ (i)

and $\theta - 10 = \alpha[10 - (-40)]$ (ii)

Solving Eqs. (i) and (ii), we get

$\theta = 60$°C

149 **(d)**

$\frac{dT}{dt} = \frac{\sigma A}{mc}(T^4 - T_0^4)$. If the liquids are put in exactly similar calorimeters and identical surrounding then we can consider T_0 and A constant. Then

$\frac{dT}{dt} \propto \frac{(T^4 - T_0^4}{mc}$ (i)

If we consider that equal masses of liquids (m) are taken at the same temperature then

$$\frac{dT}{dt} \propto \frac{1}{c}$$

So for same rate of cooling c should be equal, which is not possisble because liquids are of different nature

Again from Eq.(i)

$$\frac{dT}{dt} \propto \frac{(T^4 - T_0^4)}{mc}$$

$$\Rightarrow \frac{dT}{dt} \propto \frac{(T^4 - T_0^4)}{V\rho c}$$

Now if we consider that equal volumes of liquids (V) are taken at the same temperature then

$$\frac{dT}{dt} \propto \frac{1}{\rho c}$$

So for same rate of cooling multiplication of $\rho \times c$ for two liquids of different nature can be possible. So option (d) may be correct

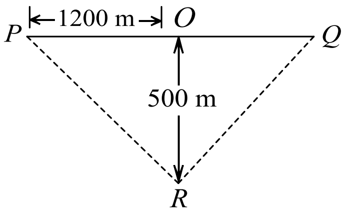
150 **(c)**

Efficiency $= \frac{0.54 \times 746}{500} = 0.80$ or 80%

(0.5 kW = 500 W and 0.54 hp = 0.54 × 746 W)
∴ 80% of the electrical energy is converted to mechanical energy and the rest 20% is converted to heat energy
∴ $\frac{20}{100} \times 500 = 100$ W of power is converted to heat
∴ Heat produced in 1 h (or 3600 s)
$= 100 \times 3600 = 36 \times 10^4$ J
$= \dfrac{36 \times 10^4}{4.18}$ cal $= 8.6 \times 10^4$cal

151 **(a)**
Rate of emission of energy $= \sigma T^4 s$
Let m_1 be the mass of sphere, C is specific heat and $(d\theta/dt)$, the rate of colling
For sphere
$\sigma T^4 S = m_1 C \left(\frac{d\theta}{dt}\right)_s$ (i)
Let m_2 be the mass of cube, C its specific heat and $(d\theta/dt)$. The rate of cooling
For cube
$\sigma T^4 S = m_2 C \left(\frac{d\theta}{dt}\right)_s$ (ii)
From Eqs. (i) and (ii)
$\dfrac{(d\theta/dt)_s}{(d\theta/dt)_c} = \dfrac{m_2}{m_1} = \dfrac{R_s}{R_c}$
Or $\frac{a^3\rho}{(4/3)\pi r^2 \rho} = \frac{R_s}{R_c}$
Where a is the side of cube and r is the radius of sphere, ρ is the density
∴ $\dfrac{R_s}{R_c} = \dfrac{3a^3}{4\pi r^3}$
But since S is the same,
$6a^2 = 4\pi r^2$
Or $a^2 = \left(\frac{2}{3}\right)\pi r^2$
∴ $\dfrac{R_s}{R_c} = \dfrac{3(2\pi r^2/3)^{3/2}}{4\pi r^3} = \dfrac{2\pi\sqrt{2\pi}}{\sqrt{3}(4\pi)}$
$= \sqrt{\dfrac{2\pi}{12}} = \sqrt{\dfrac{\pi}{6}}$

152 **(c)**
Span of bridge = 2400 m and bridge sags by 500 m at 30°(given)



From Figure 1.108, $L_{\mathrm{PRQ}} = 2\sqrt{1200^2 + 500^2} =$ 2600 m
But $L = L_0(1 + \alpha\Delta t)$
(Due to linear expansion)
⇒ $2600 = L_0(1 + 12 \times 10^{-6} \times 30)$
∴ Length of the cable $L_0 = 2599$ m
Now change in length of cable due to change in temperature from 10°C to 42°C
$\Delta L = 2599 \times 12 \times 10^{-6} \times (42 - 10) = 0.99$ m

153 **(c)**
Smooth and polished plates are poor radiators of heat. Hence, heat coming out from A small, even though B being a black and rough plate is a good absorber. Effictively the heat coming to the left of pellet P is small
Black and rough plates are good radiators of heat. Hence, plate B_2 radiates heat to a satisfactory level; however, plate A_2, being smooth and polisher, is a bad absorber. Effictively, the heat coming to the right of P is also small

154 **(c)**
$\frac{dQ/dt}{A} = K\left(\frac{\Delta\theta}{\Delta x}\right)$ ⇒Rate of flow of heat per unit area
=Thermal conductivity × Temperature gradient
Temperature gradient $(X) \propto \frac{1}{\text{Thermal conductivety (K)}}$
(As $\frac{dQ/dt}{A}$ = constant)
As $K_{\mathrm{c}} > K_{\mathrm{m}} > K_{\mathrm{g}}$, therefore $X_{\mathrm{c}} < X_{\mathrm{m}} < X_{\mathrm{g}}$

155 **(c)**
$\dfrac{dT}{dt} = \dfrac{eA\sigma}{mc}(T^4 - T_0^4) = \dfrac{e(6a^2)\sigma}{(a^3 \times \rho)c}(T^4 - T_0^4)$
⇒ For the same fall in temperature, time $dt \propto a$
$\dfrac{dt_2}{dt_1} = \dfrac{a_2}{a_1} = \dfrac{2\text{cm}}{1\text{cm}} \Rightarrow dt_2 = 2 \times dt_1 = 2 \times 100$ s
$= 200$ s
(As $A = 6a_2$ and $m = V \times \rho = a_3 \times \rho$)

156 **(b)**
In the steady state for a polished rod, the thermal current is constant
$i = \dfrac{dQ}{dt} = -KA\left(\dfrac{d\theta}{dx}\right)$
Or, $d\theta \cong c\, dx$
Where, c is a +ve constant $= i/KA$
i.e., $\theta \cong -cx + c_0$
a straight line having a negative slope

157 **(a)**
If the point is at a distance x from water at 100°C, heat transferred to ice in time t to melt it is
$m_1 L_1 = \dfrac{KA(200 - 0)t}{(1.5 - x)}$
Or $m_1 = \frac{KA \times 200t}{80(1.5 - x)}$
Similarly, heat conducted by the rod to water at 100°C in time t is

$$Q = \frac{KA(200-100)t}{x} = m_s L_s$$
$$\therefore m_s = \frac{KA(200-100)t}{xL_s} = \frac{KA \times 100t}{x \times 540}$$
According to problem, $m_l = m_s$
i.e., $\frac{KA\times 200t}{80(1.5-x)} = \frac{KA\times 100t}{x\times 540}$
or $\frac{2}{8(1.5-x)} = \frac{1}{54x}$
Solving it, we get, $x = 0.1034$ m or 10.34 cm

158 **(b)**
Since the vessel is partly filled, volume of the vessel is greater than that of the liquid. When a body having volume V is heated through $\Delta\theta$, then increase in its volume is given by
$\Delta V = V \cdot \gamma \cdot \Delta\theta$
Since, $\gamma_V = \gamma_L$, therefore $\Delta V \propto V$. Hence, on heating expansion of vessel will be greater than that of liquid. It means unoccupied volume will necessarily increase. So, option (b) is correct

159 **(b)**
Work done by man = Heat absorbed by ice
$= mL = 60 \times 80 = 4800$ cal $= 20160$ J
$\therefore$ Power $= \frac{W}{t} = \frac{20160}{60} = 336$ W

160 **(c)**
Length of iron rod at 100°C,
$L_1 = 50[1+12\times 10^{-6} \times (100-20)] = 50.048$ cm
Length of aluminum rod at 100°C,
$L_2 = 100[1 + 24 \times 10^{-6} \times (100 - 20)]$=100.192cm
The length of composite system at 20°C
$= 50 + 100 = 150$cm
and length of composite system at 100°C
$= 50.048 + 100.192 = 150.24$ cm
$\therefore$ Avarage $\alpha = \frac{0.24\text{cm}}{150\text{cm}\times(100-20)}$
$= 20 \times 10^{-6}/°$C
The above shortcut is applicable only if α varies linearly

161 **(d)**
Due to heated the length of the wire increases
$\therefore$ Longitudinal strain is produced $\Rightarrow \frac{\Delta L}{L} = \alpha \times \Delta T$
Elastic potential energy per unit volume
$E = \frac{1}{2}\times$Stress $\times$Strain $= \frac{1}{2} \times Y \times (\text{Strain})^2$
$$\Rightarrow E = \frac{1}{2} \times Y \times \left(\frac{\Delta L}{L}\right)^2 = \frac{1}{2} \times Y \times \alpha^2 \times \Delta T^2$$
or $E = \frac{1}{2} \times Y \times \left(\frac{\gamma}{3}\right)^2 \times T^2 = \frac{1}{18}\gamma^2 Y T^2$
[As $\gamma = 3\alpha$ and $\Delta T = T$(given)]

162 **(b)**
The rate of heat loss by a thin hollow sphere of thickness Δx, mean radius r and made of density ρ is given by
$$mS\frac{dT}{dt} = -\varepsilon\sigma A(T^4 - T_0^4)$$
$$(\rho 4\pi r^2 \Delta x)S\frac{dT}{dt} = -\varepsilon\sigma 4\pi r^2(T^4 - T_0^4)$$
$\frac{dT}{dt} - \frac{\varepsilon\sigma(T^4 - T_0^4)}{S\Delta x}$ is independent of radius
Hence the rate of cooling is same for both spheres

163 **(d)**
Radiated power by blackbody $P = \frac{Q}{t} = A\sigma T^4$
$$\Rightarrow P \propto AT^4 \propto r^2T^4 \Rightarrow \frac{P_1}{P_2} = \left(\frac{r_1}{r_2}\right)^2\left(\frac{T_1}{T_2}\right)^4$$
$$\Rightarrow \frac{440}{P_2} = \left(\frac{12}{6}\right)^2\left(\frac{500}{1000}\right)^4 \Rightarrow P_2 = 1760\ W$$
$$\approx 1800\ W$$

164 **(c)**
From the graph for the same temperature drop, (ΔTsay), the respective time taken by the liquid and water are 1 and 2 units, respectively. Average rate of heat losses for the two containers should be the same
$\therefore$ (100 g $\times$ 4200 J/kg°C + 160 g $\times$ s)($\Delta T/1$)
= (100 g + 200 g)4200 J/kg°C ($\Delta T/2$)
$\Rightarrow s = 1312.5$ J/kg°C

165 **(b)**
Heat given to the metal
$dQ = P\ dt = C_P(t)dT$ (i)
At constant pressure in the time interval at
Given $T = T_0[1 + a(t - t_0)]^{1/4}$
$\frac{dT}{dt} = \frac{T_0}{4}[1 + a(t - t_0)]^{-3/4} \times a$ (ii)
From Eqs (i) and (ii)
$$C_P(T) = \frac{P}{\left(\frac{dT}{dt}\right)} = \frac{4P[1 + a(t - t_0)]^{3/4}}{T_0 a} = \frac{4PT^3}{aT_0^4}$$

166 **(b)**
Let X be the thermal capacity of calorimeter and specific heat of water = 4200 J/kg-K
Heat lost by 0.1 kg of water = Heat gained by water in calorimeter + Heat gained by calorimeter
$\Rightarrow 0.1 \times 4200 \times (60 - 35)$
$= 0.2 \times 4200 \times (35 - 30) + X(35 - 30)$
$10500 = 4200 + 5X \Rightarrow X = 1260$ J/K

167 **(a)**
As with the rise in temperature, the liquid undergoes volume expansion therefore the fraction of solid submerged in liquid increases
Fraction of solid submerged at $t_1°C = f_1 =$ Volume of displaced liquid
$V_0(1 + \gamma t_1)$ (i)

and fraction of solid submerged at $t_2°C = f_2 =$ Volume of displaced liquid

$V_0(1+\gamma t_2)$ (ii)

From Eqs. (i) and (ii), $\frac{f_1}{f_2} = \frac{1+\gamma t_1}{1+\gamma t_2}$

$\Rightarrow \gamma = \dfrac{f_1 - f_2}{f_2 t_1 - f_1 t_2}$

168 **(a)**

$P = W/t$

Total work done by drill machine in 2.5× 60 s

$= (10 \times 10^3)(2.5 \times 60) = 15 \times 10^5$ J

$\therefore$ Energy lost = 50% of 15×10^5 J $= 7.5\times 10^5$ J

Energy taken by its surrounding, i.e., aluminium block

$\Delta Q = mc\Delta t = 8 \times 10^3 \times 0.91 \times \Delta T$J

Energy given = Energy taken

$7.5 \times 10^5 = 8 \times 10^3 \times 0.91 \times \Delta T$

$\Rightarrow \Delta T = 103°\text{C}$

169 **(c)**

From ideal gas equation $PV = \mu RT \Rightarrow P = \frac{\mu RT}{V}$

Given $PT^2 = K \Rightarrow \frac{\mu RT}{V}.T^2 = K \Rightarrow \mu RT^3 = KV$ ... (i)

Differentiating both sides, we get $3\mu RT^2 dT = K\,dV$ ... (ii)

Dividing equation (ii) by (i), we get $\frac{3}{T}dT = \frac{dV}{V}$

Coefficient of volume expansion $= \frac{dV}{V\,dT} = \frac{3}{T}$

170 **(d)**

We know that

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$\therefore \Delta T = \frac{2\pi}{2}\left(\frac{1}{Lg}\right)^{1/2} \Delta L$$

Or $\frac{\Delta T}{T} = \frac{\Delta L}{2L} = \frac{1}{2}\alpha\Delta\theta = \frac{2\times 10^{-6}\times 10}{2} = 10^{-5}$

$\therefore \dfrac{\Delta T}{T} \times 100 = 1 \times 10^{-5} \times 100 = 10^{-3}\%$

171 **(b)**

The change in natural length $= \Delta l_t = l\alpha t$

The natural length of rod at temperature $t°\text{C} = l + l\alpha t$

The decrease in natural length due to developed stress $= \Delta l$

But the length of rod remains constant

$\therefore \Delta l_t - \Delta l = 0$

$\therefore \Delta l = \Delta l_t - l\alpha\, t$

$$\therefore E = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{\frac{-\Delta l}{l+\Delta l_t}}$$

$$\therefore E = -\frac{EA\Delta l}{l+\Delta l_t} = -\frac{EA\Delta l_t}{l+\Delta l_t}$$

$$= -\frac{EAl\alpha t}{l + l\alpha t} = -\frac{EA\alpha t}{(1+\alpha t)}$$

172 **(c)**

Mass of water = 250g

Mass of alcohol = 200g

Water equivalent of calorimeter, $W = 10$ g

Fall of temperature = 60 − 55 = 5°C

Time taken by water to cool = 130 s

Time taken by alcohol to cool = 67 s

Heat lost by water and calorimeter

$= (250 + 10)5 = 260 \times 5 = 1300$ cal

Rate of loss of heat $= \frac{1300}{130} = 10$ cal/s

Heat lost by alcohol and calorimeter $= (200s + 10)5$

Rate of loss of heat $= \frac{(200s+10)5}{67}$ cal/s

Rates of loss of heat in the two cases are equal

$\therefore \frac{(200s+10)s}{67} = 10$ or $s = 0.62$ cal/g°C

173 **(a)**

1 calorie is the heat required to raise the temperature of 1 g of water from 14.5°C to 15.5°C at 760 mm of Hg.

174 **(c)**

We have $\frac{\Delta V}{V} = \gamma\Delta T = (1.82 \times 10^{-4})(100 - 20)$

$= 1.46 \times 10^{-2}$

Now the bulk modules, $P = B\left(\frac{\Delta V}{V}\right)$, where P is the pressure

$P = (2500) \times 1.46 \times 10^{-2}$MPa = 36 Mpa

175 **(d)**

Let θ be the temperature of B

$$\frac{2KA(\theta - 100)}{l} + \frac{\left(\frac{K}{2}\right)A(\theta - 0)}{l} = 200$$

Substituting values $\theta = 880°\text{C}$

Also from $B \to D$, $\frac{\frac{K}{2}A(\theta - 0)}{l} = \frac{440}{5} \times 80$

$t = 800$ s

176 **(b)**

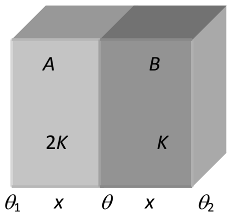
Suppose thickness of each wall is x then

$$\left(\frac{Q}{t}\right)_{combination} = \left(\frac{Q}{t}\right)_A \Rightarrow \frac{K_S A(\theta_1 - \theta_2)}{2x} = \frac{2KA(\theta_1 - \theta)}{x}$$

$\because K_S = \frac{2\times 2K\times K}{(2K+K)} = \frac{4}{3}K$ and $(\theta_1 - \theta_2) = 36°$

$$\Rightarrow \frac{\frac{4}{3}KA \times 36}{2x} = \frac{2KA(\theta_1 - \theta)}{x}$$

Hence temperature difference across will A is $(\theta_1 - \theta) = 12°\text{C}$



177 **(c)**
Initial diameter of tyre $= (1000 - 6)$mm;$= 994$ mm, so initial radius of tyre
$R = \frac{994}{2} = 497$ mm
and change in diameter $\Delta D = 6$ mm; so
$$\Delta R = \frac{6}{2} = 3 \text{ mm}$$
Given that after increasing temperature by ΔT tyre will fit onto wheel. Increment in the length (circumference) of the iron tyre
$$\Delta L = L \times \alpha \times \Delta T = L \times \frac{\gamma}{3} \times \Delta T$$
$$\left(\text{As } \alpha = \frac{\gamma}{3}\right)$$
$$\Rightarrow 2\pi \Delta R = 2\pi R \left(\frac{\gamma}{3}\right) \Delta T$$
$$\Rightarrow \Delta T = \frac{3}{\gamma}\frac{\Delta R}{R} = \frac{3 \times 3}{3.6 \times 10^{-5} \times 497}$$
[As $\Delta R = 3$ mm and $R = 497$ mm]
$\Rightarrow \Delta T = 500°$C

178 **(c)**
Given, $\Delta l_1 = \Delta l_2$
Or $l_1 \alpha_a t = l_2 \alpha_s t$
$\therefore \frac{l_1}{l_2} = \frac{\alpha_s}{\alpha_a}$
Or $\frac{l_1}{l_1 + l_2} = \frac{\alpha_s}{\alpha_a + \alpha_s}$

179 **(a)**
The kinetic energy of the bullet will be utilized to melt the bullet
$$\frac{1}{2} mv^2 = (ms\Delta\theta) \text{ J}$$
$$\frac{1}{2} \times 2 \times 10^{-3} \times (200)^2 = 2 \times 0.03 \times \Delta\theta \times 4.2$$
$\Delta\theta = 158°$C

180 **(b)**
Power radiated, $Q \propto AT^4$ and $\lambda_m T =$ constant. Hence, $Q \propto \frac{A}{(\lambda_m)^4}$
$$Q \propto \frac{A}{(\lambda_m)^4}$$
or $$Q \propto \frac{r^2}{(\lambda_m)^4}$$
$$Q_A : Q_B : Q_C = \frac{(2)^2}{(3)^4} : \frac{(4)^2}{(4)^4} : \frac{(6)^2}{(5)^4}$$
$$= \frac{4}{81} : \frac{1}{16} : \frac{36}{625}$$
$$= 0.05 : 0.0625 : 0.0576$$
$ie.$, Q_B is maximum.

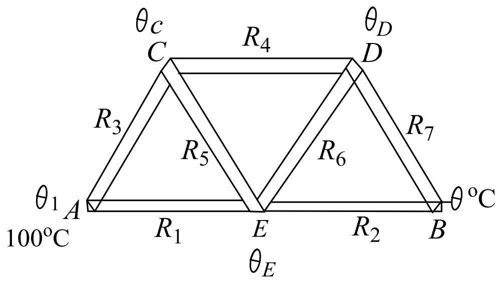
181 **(b)**
Relation between Celsius and Fahrenheit scale of temperature is $\frac{C}{5} = \frac{F-32}{9}$
By rearranging we get, $C = \frac{5}{9}F - \frac{160}{9}$
By equating above equation with standard equation of line $y = mx + c$ we get $m = \frac{5}{9}$

182 **(b)**
The effective value of α at a distance x from the left end is
$$\alpha_x = \alpha_1 + \left(\frac{\alpha_2 - \alpha_1}{L}\right) x$$
$$\Delta L = \int_0^L \alpha_x dx \Delta t$$
$$L = \left(\frac{\alpha_1 + \alpha_2}{2}\right) L\Delta T$$
$$\alpha_{\text{eff}} = \frac{\alpha_1 + \alpha_2}{2}$$

183 **(a,c)**
When the disc with a central hole is heated, diameter of hole as well as outer diameter of disc both increases. As a result of this, will be distributed more away from its axis which means that moment of inertia will increase on heating. Now according to the law of conservation of angular momentum, as $I\omega$ =constant so ω will decrease

184 **(b,c,d)**
$$W = ms \text{ or, } m = \frac{W}{s} = \frac{4.5}{0.09} = 50 \text{ g}$$
The thermal capacity and the water equivalent of a body have the same numerical value
Also, $Q = 4.5 \times 8 = 36$ cal
Since, the temperature remains constant, during the process of melting, no heat is exchanged with the calorimeter and hence,
$Q = 15 \times 80 = 1200$ cal
Hence, the correct choices are (b), (c) and (d)

185 **(a,c)**
This problem can be solved like electric current problem
Let $R_1, R_2, R_3, R_4, R_5, R_6$ and R_7 be the rates of heat flow through AE, EB, AC, CD, CE, ED and DB, respectively



Since $R_1 = R_2$ $\theta_{\mathrm{E}} = 50°\mathrm{C}$ (i)

$R_5 = R_6$ $R_3 = R_4 + R_5 = R_7$ (ii)

$R_4 + R_6 = R_7$

$$\frac{kA(\theta_c - 50)}{l} = \frac{kA}{l}(50 - \theta_D)$$

$$\frac{kA}{l}(100 - \theta_c) = \frac{kA}{l}(\theta_c - 50) + \frac{kA}{l}(\theta_c - \theta_D)$$

$$= \frac{kA}{l}\theta_D$$

$\theta_C + \theta_D = 100$

$2\theta_C - 2\theta_D = 50 \Rightarrow \theta_C = 62.5°\mathrm{C}$

$\theta_D = 37.5°\mathrm{C}$

$\therefore \theta_C > \theta_E > \theta_D$

186 **(c,d)**

Statement (a) is incorrect. According to Kirchhoff's law, the ratio of the emissive power e. and absorptive power a. Is constant for all substances at any given temperature and for radiation of the same wavelength,

i.e., $\frac{e}{a}$ = constant

Thus, if e is large, a must also be large i.e., if a body is a good emitter of a radiation of a particular wavelength, it is also a good absorber of that radiation. Conversely, if a body is a poor emitter of radiation, it is also a poor absorber (and hence, a good reflector) of the radiation

Statement (b) is also incorrect. The latent heat of steam is very high (2.25×10^6 J/Kg). This means that 1 kg of steam at 100°C gives out 2.25×10^6 J of heat energy to convert into 1 kg of boiling water at 100°C. Hence, the burns caused by steam are more severe than those caused by boiling water. For the same reason, heating systems based on circulation of steam are more efficient in warming a house than those based on circulation of hot water

Statement (c) is correct. The thermal radiation from the sun warms the earth during the day. Since, air is a poor conductor of heat, the atmosphere acts as a blanket for the earth and keeps the earth warm during the night. Moon is very cold because it has no atmosphere

Statement (d) is also correct. The efficiency of an ideal heat engine is give by

$$\eta = 1 - \frac{T_2}{T_1}$$

Where T_2 is the temperature of the sink. To have an efficiency $\eta = 1$(or 100%), $T_2 = 0$ K. Since, absolute zero cannot be achieved, even an ideal heat engine cannot have a 100% efficiency

187 **(c,d)**

The rate of flow of heat is given by

$$\frac{Q}{t} = \frac{KA(\theta_2 - \theta_1)}{l}$$

Where K is the thermal conductivity. A is the cross-sectional area and l the length of the rod.

Hence, the correct choices are (c) and (d)

188 **(b,c)**

$$T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{l_0 + \alpha l_0 \Delta\theta_0}{g}}$$

$$= T_0\left(1 + \frac{1}{2}\alpha\Delta\theta\right)$$

At 30°C, fraction loss of time=$\frac{T_{30°} - T_{20°}}{T_{20°}}$

$= 5\alpha = 5 \times 19 \times 10^{-6}$

Time lost in 24 h

$86400 \times 95 \times 10^{-6} = 8.2$ s

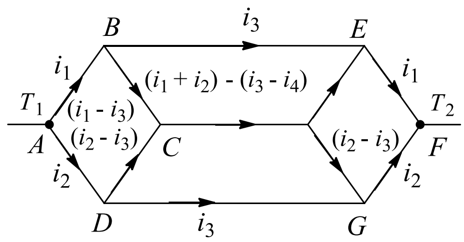
On a cold day at 10°C, fraction gain of time

$$= \frac{T_{10°} - T_{20°}}{T_{20°}} = -5\alpha$$

Time graph in 24 h = 8.2 s

189 **(b,c,d)**

Resistance of each rod $R = \frac{l}{kA}$



In steady state $T_B = T_D$

$T_E = T_G$

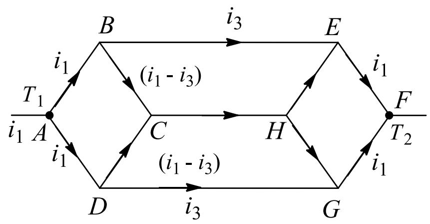
Thermal current $\left(\frac{dQ}{dt}\right) = i$

$i_1 R + i_3 R + i_1 R = (T_1 - T_2)$

$2i_1 + i_3 = \frac{T_1 - T_2}{R}$ (i)

$2i_1 + i_3 = \frac{T_1 - T_2}{R}$ (ii)

$I_1 = i_2$ (iii)



For the path ABCHGF

$$i_1R + (i_1 - i_3)R + 2(i_1 - i_3)R + (i_1 - i_3)R + i_1R = (T_1 - T_2)$$

$6i_i - 4i_3 = \frac{(T_1-T_2)}{R} = 2i_1 + i_3$ (iv)

$4i_i = 5i_3 \Rightarrow i_3 = \frac{4}{5}i_i$ (v)

From Eqs. (ii) and (v)

$$2i_i + \frac{4}{5}i_1 = \frac{(T_1 - T_2)}{R}$$

$$\frac{14i_i}{5} = \frac{(T_1 - T_2)}{R}$$

Equivalent thermal resistance $\frac{(T_1-T_2)}{2i_1} = \frac{7}{5}R$

$$\left(\frac{dQ}{dt}\right)_{AB} = i_1 = \frac{5(T_1 - T_2)KA}{14l}$$

$$\left(\frac{dQ}{dt}\right)_{BE} = \frac{2}{7}\frac{(T_1 - T_2)KA}{l}$$

$$\left(\frac{dQ}{dt}\right)_{BC} = \frac{(T_1 - T_2)KA}{14l}$$

$$\left(\frac{dQ}{dt}\right)_{CH} = \frac{(T_1 - T_2)KA}{7l}$$

190 **(c,d)**

The temperature gradient (which causes the heat to flow) is only along the length. The temperature at any point of a given cross section is the same and so $Q_a = Q_b = 0$

In the steady state Q_1 is constant $\neq 0$

191 **(a,c,d)**

True value = scale reading $[1 + \alpha(\theta' - \theta)]$

1. If $\theta' > \theta$, then

Scale reading < true value

2. $\Delta t = \frac{1}{2}\alpha\Delta\theta t$

If $\theta' > \theta$ or $\Delta\theta$ is positive , i. e.,clock will lose time, i.e., will become slow, hence, not correct

3. With rise in temperature, upthrust decreases. As weight remains same, hence, a floating body sinks a little more

4. As upthroust on the body decreases with rise in temperature, hence, weight of a body in a liquid ($= W_0 -$ th) increases

192 **(b,c)**

The horizontal parts of the curve, where the system absorbs heat at constant temperature must depict changes of state. Here the latent heats are proportional to lengths of the horizontal parts. In the sloping parts, specific heat capacity is inversely proportional to the slopes

193 **(c)**

According to Stefan's law,

$$E \propto T^4$$

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

Given, $T_1 = 127 + 273 = 400$ K

$E_1 = 2.7 \times 10^{-3}$ Js^{-1}

$E_2 = 4.32 \times 10^6$ Js^{-1}

Substituting the values in Eq. (i), we get

$$\frac{4.32\times10^6}{2.7\times10^{-3}} = \left(\frac{T_2}{400}\right)^4$$

or $T_2 = 400\left(\frac{4.32\times10^6}{2.7\times10^{-3}}\right)^{1/4}$

or $T_2 = 400(16 \times 10^8)^{1/4}$

or $T_2 = 400 \times 2 \times 10^2 = 80000$ K

194 **(c,d)**

From metallic piece, more heat is conducted into the body than from a wooden piece. So, alternative (c) is correct. Wooden piece will act as a black body. It will absorb more heat as compared to a polished metallic piece when placed in open in bright sun. Now, according to Kirchhoff's law, as a good absorber is also a good emitter, hence, wooden piece will lose heat at a faster rate than the metallic piece

195 **(a,b,c,d)**

Energy incident is to be absorbed, so choices (a) and (b) are correct. As temperature increases, energy emitted in the form of visible light, so choice (c) is correct. Reflection depends on the nature of surface which is independent of temperature, so choice (d) is correct

196 **(a,b)**

According to Stefan's law

$E = eA\sigma T^4 \Rightarrow E_A = e_A A\sigma T_A^4$ and $E_B = e_B A\sigma T_B^4$

$\because E_A = E_B \therefore e_A T_A^4 = e_B T_B^4$

$$\Rightarrow T_B = \left(\frac{e_A}{e_B}T_A^4\right) = \left(\frac{1}{81} \times (5802)^4\right)^{\frac{1}{4}} \Rightarrow T_B = 1934\ K$$

And, from Wien's law $\lambda_A \times T_A = \lambda_B \times T_B$

$$\Rightarrow \frac{\lambda_A}{\lambda_B} = \frac{T_B}{T_A} \Rightarrow \frac{\lambda_B - \lambda_A}{\lambda_B} = \frac{T_A - T_B}{T_A}$$

$$\Rightarrow \frac{1}{\lambda_B} = \frac{5802 - 1934}{5802} = \frac{3868}{5802} \Rightarrow \lambda_B = 1.5\ \mu m$$

197 **(a,c)**

According to Wien's law,

$\lambda_m T =$ constant

Or $\frac{T}{v_m} =$ constant

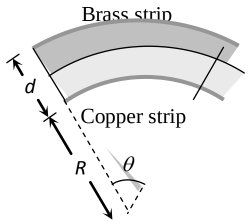
So, if T is doubled, v_m is also doubled Further, according to Stefan's law

$E \propto T^4$

When T is doubled, E increases by a factor of 16

198 **(b,d)**

Let L_0 be the initial length of each strip before heating.



Length after heating will be

$L_B = L_0(1 + \alpha_B \Delta T) = (R + d)\theta$

$L_C = L_0(1 + \alpha_C \Delta T) = R\theta$

$$\Rightarrow \frac{R+d}{R} = \frac{1+\alpha_B \Delta T}{1+\alpha_C \Delta T}$$

$$\Rightarrow 1 + \frac{d}{R} = 1 + (\alpha_B - \alpha_C)\Delta T$$

$$\Rightarrow R = \frac{d}{(\alpha_B - \alpha_C)\Delta T} \Rightarrow R \propto \frac{1}{\Delta T} \text{ and } R \propto \frac{1}{(\alpha_B - \alpha_C)}$$

199 **(a,d)**

$\Delta V_L = \Delta V_V$

$Y_L V_L = Y_V V_V$ or $\frac{Y_L}{Y_V} = \frac{V_V}{V_L}$

$V_V > V_L \Rightarrow Y_L > Y_V$

200 **(a,b,c)**

Q_1= heat given out by water if it was to cool up to 0°C

$= mg \times 1$ cal/g-$°C \times (10 - 0) = 10$ m cal

Q_2= heat required by ice to melt completely into water at 0°C

$= m \times L_F = mg \times 80$ cal/g $= 80$ m cal

As $Q_1 < Q_2$, equilibrium temperature will be 0°C and whole of ice will not melt

201 **(b,c)**

Melting involves an increase in potential energy and hence an increase internal energy

202 **(b,c,d)**

The flow of heat will always be in the direction of the temperature gradient from higher to lower temperature. Hence Q_1 in rod AB, Q_2 in rod BC will both be in clockwise sence while Q_3 in CA will be in anti-clockwise sence. Also , we have if L is the length of each rod and A its area of cross-section,

$$Q_1 = \frac{\alpha_1 A(100-50)}{L} = (50\alpha_1)\frac{A}{L}$$

$$Q_2 = \frac{\alpha_2 A(50-0)}{L} = (50\alpha_2)\frac{A}{L}$$

$$Q_3 = \frac{\alpha_3 A(100-0)}{L} = (100\alpha_3)\frac{A}{L}$$

Hence $Q_1 : Q_2 : Q_3 :: \alpha_1 : \alpha_2 : 2\alpha_3$

Also,

$$\frac{Q_1}{\alpha_1} + \frac{Q_2}{\alpha_2} = \left(50\frac{A}{L}\right) + \left(50\frac{A}{L}\right) = \frac{100A}{L} = \frac{Q_3}{\alpha_3}$$

203 **(a,d)**

H = rate of heat flow

$$= \frac{900}{\frac{l_i}{K_i A} + \frac{l_0}{K_0 A}}$$

Now, $1000 - \theta = \frac{H l_i}{K_i A}$

Or , $\theta = 1000 - \left[\frac{900}{\frac{l_i}{K_i A} + \frac{l_0}{K_0 A}}\right]\frac{l_i}{K_i A}$

$$= 100 - \frac{900}{1 + \frac{l_0}{K_0}\frac{K_i}{l_i}}$$

Now, we can see that θ can be decreased by increasing thermal conductivity of outer layer (K_0) and thickness of inner layer (l_i)

204 **(c,d)**

This situation arises during melting (alternative (c)) or freezing (alternative(d)) of the mass

205 **(a,c,d)**

Thermal resistane R=$\frac{l}{KA}$

$\therefore \quad R_A = \frac{L}{(2K)(4Lw)}$

$= \frac{1}{8Kw}$ (Here w=width)

$$R_B = \frac{4L}{(3K)(Lw)} = \frac{4}{3Kw}$$

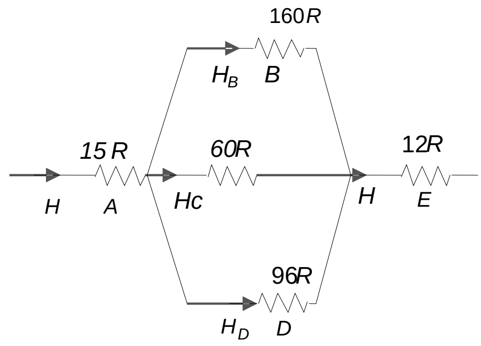
$$R_C = \frac{4L}{(4K)(2Lw)} = \frac{1}{2Kw}$$

$$R_D = \frac{4L}{(5K)(Lw)} = \frac{4}{5Kw}$$

$$R_E = \frac{L}{(6K)(Lw)} = \frac{1}{6Kw}$$

$R_A : R_B : R_C : R_D : R_E = 15 : 160 : 60 : 96 : 12$

So, let us write $R_A = 15\,R$, $R_B = 160\,R$ etc and draw a simple electrical circuit as shown in figure



H=Heat current=Rate of heat flow

$H_A = H_E = H$(let)

∴ Option (A) is correct.

In parallel current distributes in inverse ratio of resistance

$\therefore \quad H_B : H_C : H_D : \frac{1}{R_B} : \frac{1}{R_C} : \frac{1}{R_D}$

$= \frac{1}{160} : \frac{1}{60} : \frac{1}{96}$

$= 9 : 24 : 15$

$\therefore \quad H_B = \left(\frac{9}{9+24+15}\right) H = \frac{3}{16} H$

$H_C = \left(\frac{24}{9+24+15}\right) H = \frac{1}{2} H$

$H_D = \left(\frac{15}{9+24+15}\right) H = \frac{5}{16} H$

$H_A = H_B + H_D$

∴ Option (d) is correct.

Temperature difference (let us call it T)

= (Heat current) × (Thermal resistance)

$T_A = H_A R_A = (H)(15R) = 15HR$

$T_B = H_B R_B = \left(\frac{3}{16} H\right)(160R) = 30HR$

$T_C = H_C R_C = \left(\frac{1}{2} H\right)(60R) = 30HR$

$T_D = H_D R_D = \left(\frac{5}{16} H\right)(96R) = 30HR$

$T_E = H_E R_E = (H)(12R) = 12HR$

Here, T_E is minimum. Therefore option (c) is also correct.

∴ Correct options are (a), (c) and (d).

206 **(a,c,d)**

$\frac{\Delta A}{A} \times 100 = 2\left(\frac{\Delta l}{A}\right) \times 100$

% increase in area $= 2 \times 0.2 = 0.4$

$\frac{\Delta V}{V} \times 100 = 3 \times 0.2 = 0.6\%$

Since $\Delta l = I\alpha \Delta T$

$\frac{\Delta l}{l} \times 100 = \alpha \Delta T \times 100 = 0.2$

$\alpha = 0.25 \times 10^{-4}/°C$

207 **(b,d)**

Every object emits and absorbs the radiation simultaneously. If energy emitted is more than energy absorbed, temperature falls and vice versa

208 **(a,b,d)**

Statement (a) is correct because the coefficient of volume expansion is very nearly three times the coefficient of linear expansion

Statement (b) is also correct. When a solid is heated at constant pressure, it does expand a little and some heat is required for doing the mechanical work associated with this expansion. The difference between the two specific heats (at constant pressure and at constant volume) is small enough to be generally neglected for solids and liquids. This difference is large for gases

Statement (c) is incorrect. The thermal conductivity of air is less than that of wool. Yet we prefer wool which traps pockets of air between its fibres. There air pockets cannot carry heat by convection either

Statement (d) is correct because of the expansion of steel tape on a hot day, the markings on the tape would be farther apart than on a cold day

209 **(d)**

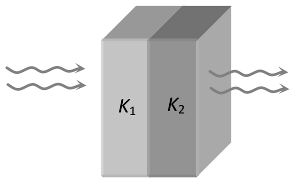
Equivalent thermal conductivity of two equally thick plates in series combination is given by

$\frac{2}{K} = \frac{1}{K_1} + \frac{1}{K_2}$

If $K_1 > K_2$

Then $K_1 < K < K_2$

Hence assertion and reason both are false



210 **(c)**

The thermal conductivity of brass is high $i.e.$, brass is a good conductor of heat. So, when a brass tumbler is touched, heat quickly flows from human body to tumbler. Consequently, the number appears colder, on the other hand wood is a bad conductor. So, heat does not flow from the human body to the wooden tray in this case. Thus it appears comparatively hotter

211 **(a)**

From Wien's displacement law, temperature $(T) \propto 1/\lambda_m$ (where λ_m is the maximum wavelength). Thus temperature of a body is inversely proportional to the wavelength. Since blue star has smaller wavelength and red star has maximum wavelength, therefore blue star is at higher temperature then red star

212 **(a)**

Water has maximum density at 4°C. On heating above 4°C, density of water decreases and its volume increases. Therefore, water overflows in both the cases

213 **(b)**

During the day when water is cooler than the land, the wind blows off the water onto the land (as warm air rises and cooler air fills the place). Also at night, the effect is reversed (since the water is usually warmer than the surrounding air on land). Due to this wind flow the temperature near the sea coast remains moderate

214 **(a)**

With rise in pressure melting point of ice decreases. Also ice contracts on melting

215 **(c)**

Heat is carried away from a fire sideways mainly by radiations. Above the fire, heat is carried by both radiation and by convection of air. The latter process carries much more heat

216 **(d)**

The correct reason is because under steady-state condition, when temperature becomes constant, the rate of conduction of heat across every lamina is the same

217 **(b)**

Both assertion and reason are true but reason is not correctly explaining the assertion

218 **(c)**

The relation between F and C scale is, $\frac{C}{5}=\frac{F-32}{9}$. If $F=C \Rightarrow C=-40°\text{C}$, *i.e.*, at -40^{o} the Centigrade and Fahrenheit thermometers reads the same

219 **(d)**

The potential energy of water molecules is more. The heat given to melt the ice at 0°C is used up in increasing the potential energy of water molecules formed at 0°C

220 **(c)**

The 98.4°F is the standard body temperature of a man. If a man touches an iron or wooden ball at 98.4°F, no heat transfer takes place between ball and man, so both the balls would feel equally hot for the man

221 **(a)**

The correct model is one in which the atoms fling away from the equilibrium position through a greater distance than the one by which they come closer

222 **(b)**

This is in accordance with the Stefan's law $E \propto T^4$

223 **(c)**

When water leaves the body through perspiration energy content of molecules remained in body decreases, therefore temperature also decreases

224 **(a)**

On comparison

$$\frac{T_1}{T_2}=\frac{\lambda_2}{\lambda_1}=\frac{480}{360}=\frac{4}{3}$$

225 **(a)**

We know that to measure thermal conductivity of liquids experimentally, they must be heated from the top *i.e.*, upper layer is kept hot and lower layer is kept cold, so as to prevent convection in liquids

226 **(a)**

The temperature of land rises rapidly as compared to sea because of specific heat of land is five times less than that of sea water. Thus, the air above the land becomes hot and light so rises up so pressure drops over land. To compensate the drop of pressure, the cooler air from sea starts blowing towards lands, setting up sea breeze. During night land as well sea radiate heat energy. The temperature of land falls more rapidly as compared to sea water, as sea water consists of higher specific heat capacity. The air above sea water being warm and light rises up and to take its place the cold air from land starts blowing towards sea and set up breeze

227 **(c)**

There is only energy transfer and not matter transfer

228 **(c)**

Actually, the process of radiation does not require any material for transmission of heat
Thermal radiation travels with the velocity of light and hence the fastest mode of the transfer.
Thermal radiation is always transmitted in a straight line

229 **(b)**

Statement I and II are true but Statement II is not correct explanation for Statement I

230 **(c)**

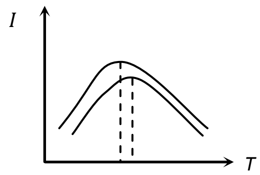
Celsius scale was the first temperature scale and Fahrenheit is the smallest unit measuring temperature

231 **(c)**

At a high temperature (6000 K), the sun acts like a perfect blackbody emitting complete radiation. That's why the radiation coming from the sun's surface follows Stefan's law $E=\sigma T^4$

232 **(c)**

According to Wien's law $\lambda_m T=$ constant *i.e.*, peak emission wavelength $\lambda_m \propto \frac{1}{T}$. Also as T increases λ_m decreases. Hence assertion is true but reason is false



233 **(a)**

When the animals feel cold, they curl their bodies into a ball so as to decrease the surface area of their bodies. As total energy radiated by body varies directly as the surface area of the body, the loss of heat due to radiation would be reduced

234 **(a)**

Woolen fibres enclose a large amount of air in them. Both wool and air are the bad conductors of heat and the coefficient of thermal conductivity is small. So, they prevent any loss of heat from our body

235 **(a)**

When the temperature of the atmosphere reaches below 0°C, then the water vapours present in air, instead of condensing, freeze directly in the form of minute particles of ice. Many particles coalesce and take cotton-like shape which is called snow. Thus snow contains air packets in which convection currents cannot be formed. Hence snow is a good heat insulator. In ice there is no air, so it is a bad insulator

236 **(a)**

When two bodies at temperature T_1 and T_2 are brought in thermal contract, they do settle to the mean temperature $(T_1 + T_2)/2$. They will do so, in case the two bodies were of same mass and material, $i.e.$, same thermal capacities. In other words, the two bodies may be having different thermal capacities, that's why they do not settle to the mean temperature, when brought together

237 **(e)**

Melting is associated with increasing of internal energy without change in temperature. In view of the reason being correct the amount of heat absorbed or given out during change of state is expressed $Q = mL$, where m is the mass of the substance and L is the latent heat of the substance

238 **(a)**

$$\alpha = \frac{1}{l}\frac{dl}{dT}$$

$$\Rightarrow \alpha \int_{T_0}^{T} dT = \int_{l_0}^{l} \frac{dl}{l}$$

$$\Rightarrow l = l_0 e^{\alpha \Delta T}$$

239 **(b)**

Light radiations and thermal radiations both belong to electromagnetic spectrum. Light radiations belong to visible region while thermal radiation belong to infrared region to EM spectrum. Also EM radiations requires no medium for propagation

240 **(b)**

$$R = \frac{(\theta_1 - \theta_2)}{\omega/t} = \frac{l}{KA} \Rightarrow R \propto \frac{1}{K}$$

241 **(c)**

From Wein's law $\lambda_m T =$ constant i.e., peak emission wavelength $\lambda_m \propto \frac{1}{T}$. Hence as T increases λ_m decreases

242 **(a)**

Both are true and Statement II explains Statement I because for same volume, surface area of the cylindrical bulb will be more

243 **(d)**

Equivalent thermal conductively of two identical rods in series is given by

$$\frac{2}{K} = \frac{1}{K_1} + \frac{1}{K_2}$$

If $K_1 < K_2$. Then $K_1 < K < K_2$

Hence statement I is false

244 **(a)**

According to Kirchoff's law $\frac{e_\lambda}{a_\lambda} = E_\lambda$

For a particular wavelength $E_\lambda = 1 \Rightarrow e_\lambda = a_\lambda$

$\therefore$ Emissivity = Absorptivity

245 **(e)**

It is not necessary that all black coloured objects are black bodies. For example, if we take a black surface which is highly polished, it will not behave as a perfect black body

A perfectly black body absorbs all the radiations incident on it

246 **(c)**

Water evaporates quickly because of lack of atmospheric pressure, also temperature of moon is much higher during day time but it is very low at night

247 **(d)**

Specific heat of a body is the amount of heat required to raise the temperature of unit mass of the body through unit degree. When mass of a body is less than unity, then its thermal capacity is less than its specific heat and vice-versa

248 **(e)**

Assertion is false because at absolute zero ($0\ K$), heat is neither radiated nor absorbed. Reason is the statement of Stefan's law, as $E \propto T^4$

249 **(a)**

As $r = \frac{\Delta V}{V\Delta t}$, i.e., unit of coefficient of volume expansion is K^{-1}

250 **(c)**

Hollow metallic closed container maintained at a uniform temperature can act as source of black body. It is also well-known that all metals cannot act as black body because if we take a highly metallic polished surface. It will not behave as a perfect black body

252 **(a)**

Initially temperature greatest at A will be more and also area is more at A. So the rate of flow of heat is maximum at A

At steady state, rate of flow of heat is constant at all sections as all section ate connected in series

As $\left(\frac{dQ}{dt}\right) = KA\left(-\frac{dT}{dx}\right)$

$\left|\frac{dT}{dx}\right| \propto \frac{1}{A}$

At steady state, the temperature at each at every section is constant. Hence $\frac{dT}{dt} = 0$ at each section

253 **(c)**

We have for the sections, AB, BC, CD and DE with (dQ/dt) as the steady state thermal, energy transmitted per second (A being the area of cross section)

$$\frac{dQ}{dt} = \frac{KA(100 - T_C)}{L} = \frac{A(0.8)K(T_C - T_D)}{(1.2)L}$$
$$= \frac{(1.2)KA(T_D - T_E)}{(1.5)L} = \frac{(1.5)KA\,T_E}{(0.6)L}$$

These give

$$(100 - T_c) = \left(\frac{0.8}{1.2}\right)(T_C - T_D)$$
$$= \left(\frac{1.2}{1.5}\right)(T_D - T_E) = \left(\frac{1.5}{0.6}\right)T_E$$
$$6(100 - T_C) = 4(T_C - T_D) = (4.8)(T_D - T_E)$$
$$= 15\,T_E$$

Solving for the differences $(100 - T_C), (T_C - TD, TD - TE$ and TE remaining that the sum of these differences is 100, we obtain

$(T_A - T_C) = 24.1, (T_C - T_D) = 36.2$

254 **(c)**

i. Rate at which heat is radiated from the body

$= Q_r$ J/s

$= e\sigma A T_1^4 = 0.55 \times 5.67 \times 10^{-8} \times 1.5 \times (323)^4$ J/s

$= 509$ W

ii. Rate at which heat radiation is absorbed by the body=

$= Q_a$ J/s

$= e\sigma A T_2^4 = 0.55 \times 5.67 \times 10^{-8} \times 1.5 \times (295)^4$ J/s

$= 354$ W

iii. Rate at which net radiation is emitted by the body

$= Q_n$ J/s $= Q_r - Q_a = (509 - 354)$W $= 155$ W

255 **(b)**

Work done by the system can be non-zero in any of the process

The relation $dU = nC_v = n\left(\frac{R}{r-1}\right)dT$ is valid for all the process

In isothermal process $dT = 0$

In adiabatic process $dQ = 0$ and non-zero for any other process

256 **(d)**

Let Q be the heat required to convert 100 g of water at 20°C to 100°C

Then $mc\Delta\theta = (100)(1)(100 - 20)$

$Q = 8000$ cal

Now suppose m_0 mass of steam converts into water to librate this much amount of heat. Then

$$m_0 = \frac{Q}{L} = \frac{8000\text{cal}}{540\text{cal/g}} = 14.8\text{ g}$$

Since it is less than $m = 20$ g, the temperature of the mixture is 100°C

Mass of steam in the mixture= $(20 - 14.8) =$ 5.2 g

Mass of water in the mixture $= (100 + 14.8) =$ 114.8 g

If $m = 10$ g, the amount of heat liberated by steam $= mL = 10 \times 540 = 5400$

Let θ be the final temperature of the mixture

$m_{H_2O}s_{H_2O}(\theta - 20) = m_{\text{steam}}L + ms_{H_2O}(100 - \theta)$

$100 \times 1(\theta - 20) = 10 \times 540 + 10 \times 1(100 - \theta)$

$110\theta = 5400 + 1000 + 2000$

$\theta = 76.4$°C

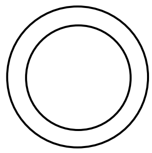
257 **(b)**

Solar constant $= 1.35\ \text{kW/m}^2$

Thermal conductivity of earth's crust $= 0.75$ J/s mK

Heat transferred per second is

$$\frac{dQ}{dt} = -K(4\pi r^2)\frac{dT}{dr}$$



$r = R_e = 6400$ km

$-\frac{dT}{dr} = -\frac{1°C}{30\text{ m}}$

Heat lost by the earth per second due to conduction from the core

$\frac{dQ}{dt} = \left(\frac{0.75\text{ J} \times 4\pi}{msK}\right) \times (6400 \times 10^3\text{m})^2 \frac{1°C}{30\text{m}}$

$P_1 = \left[\frac{0.75 \times 4\pi \times (6400 \times 10^3)^2}{30}\right]\text{J/s}$

$= 1.286 \times 10^{13}\text{J/s} \approx 1.3 \times 10^{13}\text{J/s}$

Heat absorbed from sun $= S\pi R_e^2$

$P_2 = \left(1.35 \times 10^3 \frac{\text{W}}{\text{m}^2}\right)\pi(6400 \times 10^3\text{m})^2$

$= 1.7 \times 10^{17}\text{W}$

Heat lost by the earth by radiation if $e = 1$

$P_2 = e\sigma A'T^4$

$(A' = 4\pi R_e^2)$

$1.7 \times 10^{17} = 1 \times 5.67 \times 20^{-8} \times 4\pi \times (6400 \times 10^3)^2 T^4$

$T^4 = \frac{1.7 \times 10^{17}}{5.67 \times 10^{-8} \times 4\pi \times (6400 \times 10^3)^2}$

$= 5.8 \times 10^9 = 58 \times 10^8$

Surface temperature T of earth

$= (58)^{1/4} \times 10^2 = (7.6)^{1/2} \times 10^2$

$= 2.76 \times 100 = 276$ K

$\frac{P_1}{P_2} = \frac{1.3 \times 10^{13}}{1.7 \times 10^{17}} = 7.5 \times 10^{-5}$

258 **(a)**

Fraction of volume submerged $f = \frac{V_i}{V} = \frac{\rho_1}{\rho_2}$

After increasing the temperature

$f' = \frac{V_i'}{V'} = \frac{\rho_1(1-\gamma_1\Delta T)}{\rho_2(1-\gamma_2\Delta T)} > f$(because $\gamma_2 > \gamma_1$)

If γ_1, then $f' = f$

If $\gamma_2 < \gamma_1$,then $f' < f$; it means fraction of volume submerged decreases and solid lifts up

259 **(b)**

We have $\theta - \theta_s = (\theta_0 - \theta_s)e^{-kt}$,

Where θ_0 –initial temperature of body = 40°C

θ= temperature of body after time t

Since body cools from 40 to 38 in 10 min, we have

$38 - 30 = (40 - 30)e^{-10k}$ (i)

Let after 10 min, the body temperature be θ

$\theta - 30° = (38 - 30)e^{-10k}$ (ii)

$\frac{\text{Eq. (i)}}{\text{Eq. (ii)}}$ gives $\frac{8}{\theta - 30} = \frac{10}{8}, \theta - 30 = 6.4$

$\theta = 36.4°C$

260 **(c)**

$\Delta V = \gamma V \Delta T$

$= 3\alpha\, V\Delta T = 3 \times 1 \times 10^{-3} \times \left(\frac{5\text{ kg}}{50\text{ kg/m}^3}\right) \times 50$

$= 15 \times 10^{-3}\text{m}^3$

$W = P\Delta V$

$= \left(1 \times 10^5 \frac{\text{N}}{\text{m}^2}\right) \times (15 \times 10^{-3}\text{m}^3) = 15 \times 10^2$

$= 1500$ J

261 **(b)**

$\rho_{300} = \pi^2 \times 10^{-8}$ ohm m

$\rho_{900} = \frac{\rho_{300}(1 + 900\alpha)}{(1 + 300\alpha)}$

$= \frac{\pi^2(10^{-8})(1 + 900 \times 7.8 \times 10^{-3})}{(1 + 300 \times 7.8 \times 10^{-3})}$

$= \pi^2 \times 10^{-8} \times \frac{8.02}{3.34}$

$= 2.4\pi^2 \times 10^{-8}$

$\simeq 2.4 \times 10^{-7}$ohm m $(\pi^2 \simeq 10)$

262 **(a)**

Heat emitted by the surface of sphere per unit time $P_{r'} = \sigma T^4(\pi R^2)$

Since the radius of both spheres is equal, the rate of heat loss by aluminium sphere = rate of heat loss by lead sphere

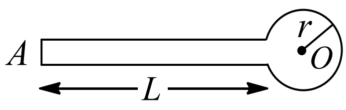
263 **(d)**

Under steady state conditions, the temperatures at all section in the system remain constant and maintain a constant temperature gradient for a given material. The temperature gradient in copper, aluminium and brass will not be same however, the rate of heat conducted across all sections whether in copper or aluminium or brass will be the same

264 **(d)**

The distance from the end A of the copper rod (where power is supplied) and centre O of the metal sphere is $(L + r)$. Hence, in the steady state conditions,

$P = \frac{KA(T - T_s)}{L + r}$



Which gives $T_S = T - \frac{P(L+r)}{KA}$

(The heat is transmitted up to centre of the spherical end, and the sphere loses energy by radiation out of its spherical surface)

265 **(b)**

In 7 min, temperature of 100 g of water is raised by (1000 − 16°C) = 84°C. The amount of the heat provided by heater

$Q_W = C_W m_W \Delta T = (1\text{ cal/g°C})(100\text{g})(84°C)$

$= 8.4 \times 10^3\text{cal} = (8.4 \times 10^3 \times 4.186)$ J

$\simeq 3.5 \times 10^4$ J

Power of heater= $\frac{Q_w}{t_1}$

$= \frac{8.4 \times 10^3 \text{cal}}{(7 \times 60)\text{ s}} = 20 \text{ cal/s}$

$= (20 \times 4.18) \text{ J/s} = 83.6 \text{ W} \approx 84 \text{ W}$

266 **(b)**

We consider the leaf to be a black body. The rate of energy radiated at any instant

$\left(\frac{dQ}{dt}\right)_e = \sigma e A T_0^4$ (i)

If m is the mass of the body and C is its specific heat then the heat gained

$\frac{dQ}{dt} = mc\frac{dT}{dt}$ (ii)

Since intensity of sun beam is uniform, power incident on the body is SA heat absorbed

$\left(\frac{\text{dQ}}{\text{dt}}\right)_{\text{ab}} = SA\ e$

Rate of increases of temperature

$= \frac{\text{(net power absorbed)}}{\text{thermal capacity of body}}$

$= \frac{(SA\alpha - \sigma A e T^4)}{mc}$

Given $\sigma = 5.67 \times 10^{-8} \text{J/s m}^2\text{K}^4$

$A = 0.8 \times 10^{-2}\text{m}^2; \alpha = \text{e} = 0.8$

$S = 1.4 \times 10^3 \text{W/m}^2$

$T = 300 \text{ K}$

$m = 5 \times 10^{-4}\text{kg}$

$C = 0.8 \text{ kcal/kg K} = 0.8 \times 4.2 \text{ kJ/kg K}$

$$\frac{dT}{dt} = \frac{[1.4 \times 10^3 \times 0.8 \times 10^{-2} \times 0.8 - 5.67 \times 10^{-8} \times 0.8 \times 10^{-2} \times 0.8 \times (300)^4]}{5 \times 10^{-4} \times (0.8 \times 4.2 \times 10^3)}$$

$= \frac{(8.96 - 2.9)}{1.68} = 3.6°\text{C/s} = 3.6 \text{ K/s}$

267 **(c)**

$l_1 = l_0(1 + \alpha t)$

$\frac{2\pi \times 6}{2} = l_0(1 + \alpha t)$

$\frac{2\pi \times 5.98}{2} = l_0(1 + 20\alpha)$

$\frac{6}{5.98} = \frac{1 + \alpha t}{1 + 20\alpha} = \frac{(1 + 17 \times 10^{-6} t)}{1 + 20 \times 17 \times 10^{-6}}$

$\therefore t = 216.8°\text{C} \approx 217°\text{C}$

268 **(b)**

Resistance of lead bar

$R_{\text{Pb}} = \frac{l_{\text{Pb}}}{K_{\text{Pb}} A_{\text{Pb}}} = \frac{5 \times 10^{-2}}{350 \times 6 \times 10^{-4}}$

$= \frac{10}{21} = \frac{5}{21} \text{K/W}$

Thermal current through lead bar

$I_{\text{Pb}} = \frac{\Delta T}{R_{\text{Pb}}} = \frac{100 \times 21}{5} = 420 \text{ W}$

269 **(1)**

Because the sliding plug stays in the connecting pipe the pressure in both the vellels at the level of the pipe must be the same

$h_{20} d_{20} = h_{80} d_{80} \Rightarrow \frac{h_{20}}{h_{80}} = \frac{d_{80}}{d_{20}}$

$\Rightarrow \frac{d_0(1 - 80\gamma)}{d_0(1 - 20\gamma)} = 0.94$

270 **(4)**

From $\frac{(\theta_1 - \theta_2)}{t} = \alpha\left(\frac{\theta_1 + \theta_2}{2} - \theta_0\right)$,in the first case we have

$\frac{75 - 65}{2} = \alpha\left[\frac{75 + 65}{2} - 30\right]$ (i)

For the second case

$\frac{55 - 45}{t} = \alpha\left[\frac{55 + 45}{2} - 30\right]$ (ii)

Divide Eq.(i) by Eq.(ii), $\frac{t}{2} = 2$

$\Rightarrow t = 4\text{min}$

271 **(6)**

Energy with 5 kg of H_2O at 20°C to become ice at 0°C

$E_1 = 5000 \times 1 \times 20 = 100000 \text{ cal}$

Energy to raise the temperature of 2kg ice from-20°C to 0°C

$E_1 5000 \times 0.5 \times 20 = 20000\text{cal}$

$(E_1 - E_2)$=80000 cal is available to melt ice at 0°C

So only 1000 g or 1 kg of ice would have melt

So, the amount of water available 1+5=6 kg

272 **(3)**

Energy released by water from 25°C to 0°C

$= 2500 \times 1 \times 25 = 62500\text{cal}$

Energy to bring ice to 0°C

$= 2000 \times \frac{1}{2} \times 15 = 15000 \text{ cal}$

Energy used to melt ice of $m 80\ cal$

$\therefore$Ice melt $m = \left(\frac{62500 - 1500}{80}\right) = 593.75\text{g}$

So, mass of water $= (2500 + 593.75)\text{g}$

$= 3093.75\text{g} \simeq 3\text{kg}$

273 **(8)**

Let power lost to surrounding is Q

$16 - Q = \left(\frac{dm}{dt}\right) S(10)$

And $32 - Q = 3\left[\left(\frac{dm}{dt}\right) S(10)\right]$

$\Rightarrow \frac{32 - Q}{16 - Q} = 3 \Rightarrow Q = 8\text{W}$

274 **(4)**

$\frac{\text{temperature difference}}{\text{Thermal resistance}} = L\left(\frac{dm}{dt}\right)$

$\frac{dm}{dt} \propto \frac{1}{\text{Thermal resistance}}$

$q \propto \frac{1}{R}$

The rods are in parallel in the first case and they are in series in the second case

$\frac{q_1}{q_2} = \frac{2R}{(R/2)} = 4$

275 **(8)**

Rate of conduction $R \propto \frac{r^2}{\ell}$

The ratio of conduction in them is

$\frac{r^2}{\ell} : \frac{r^2}{2\ell} : \frac{2r^2}{\ell} : \frac{4r^2}{\ell}, i.e 2: 1: 4: 8$

So, the ratio of maximum to minimum conduction rate is 8:1

276 **(5)**

Loss of gain per day $= dT = \frac{1}{2}\alpha dt \times 86400$

Since $T = 86400$s for each day

At 15°C, $5 = \frac{1}{2}\alpha(t - 15) \times 86400$

At 30°C $10 = \frac{1}{2}\alpha(30 - t) \times 86400$

$\therefore \frac{30-t}{t-15} = 2 \Rightarrow 3t = 60°C \Rightarrow t = 20$°C

$\therefore \alpha = \frac{10}{(t - 15) \times 86400} = \frac{10}{5 \times 86400} = 0.000023$

$= 2.3 \times \frac{10^{-5}}{\circ} = 2$