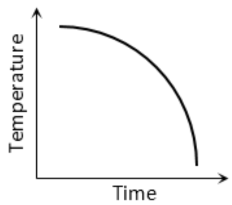
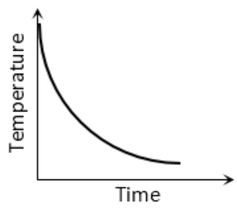
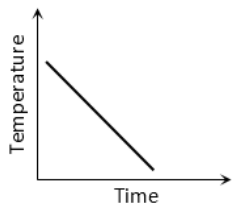
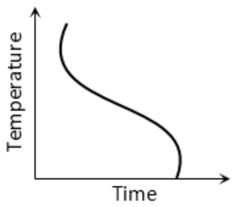
THERMAL PROPERTIES OF MATTER

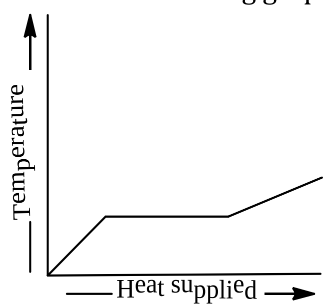
Single Correct Answer Type

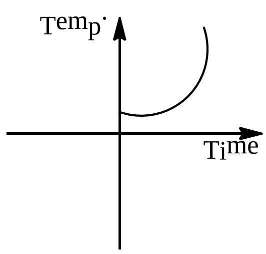
1. What should be the lengths of a steel and copper rod at 0°C so that the length of the steel rod is 5 cm longer than the copper rod at any temperature?
   α (Steel) $= 1.1 \times 10^{-5}$°C^{-1}
   α (Copper)$= 1.7 \times 10^{-5}$°C^{-1}
   a) 14.17 cm; 9.17 cm b) 9.17 cm, 14.17 cm
   c) 28.34 cm; 18.34 cm d) 14.17 cm, 18.34 cm
2. A block of metal is heated to a temperature much higher than the room temperature and allowed to cool in a room free from air currents. Which of the following curves correctly represents the rate of cooling
   a) 

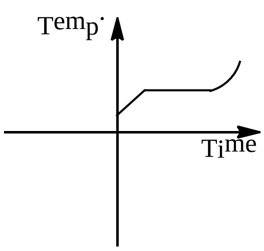
   b) 

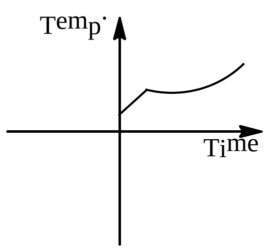
   c) 

   d) 

3. 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) 

4. "Good emitters are good absorbers" is a statement concluded from
   a) Newton's law of cooling b) Stefan's law of radiation
   c) Provost's theory d) Kirchhoff's law
5. When vapour condenses into liquid
   a) It absorbs heat b) It liberates heat
   c) Its temperature increases d) Its temperature decreases
6. Four rods of different radii r and length l are used to connect two reservoirs of heat at different temperatures. Which one will conduct heat fastest?
   a) r= 2 cm, l 0.5 m b) r = 1 cm, l= 0.5 m c) r = 2 cm, l = 2 m d) r = 1 cm, l= 1 m
7. Flash light equipped with a new set of batteries, produces bright white light. As the batteries were out

a) The light intensity gets reduced with no change in its colour
b) Light colour changes first to yellow and then red with no change in intensity
c) It stops working suddenly while giving white light
d) Colour changes to red and also intensity gets reduced

8. The rate of radiation of a black body at 0°C is EJ/s. The rate of radiation of this black body at 273°C will be
a) 16 E b) 8 E c) 4 E d) E

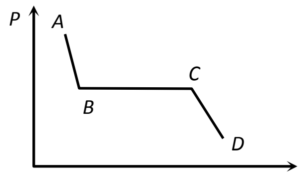
9. For a perfectly black body, its absorptive power is
a) 1 b) 0.5 c) 0 d) Infinity

10. A solid sphere and a hollow sphere of the same material and size are heated to the same temperature and allowed to cool in the same surroundings. If the temperature difference between each sphere and its surroundings is T, then
a) The hollow sphere will cool at a faster rate for all values of T
b) The solid sphere will cool at a faster rate for all values of T
c) Both spheres will cool at the same rate for all values of T
d) Both spheres will cool at the same rate only for small values of T

11. Which of the following statements is true/correct
a) During clear nights, the temperature rises steadily upward near the ground level
b) Newton's law of cooling, an appropriate form of Stefan's law, is valid only for natural convection
c) The total energy emitted by a black body per unit time per unit area is proportional to the square of its temperature in the Kelvin scale
d) Two spheres of the same material have radii 1m and 4m and temperatures 4000K and 2000K respectively. The energy radiated per second by the first sphere is greater than that radiated per second by the second sphere

12. The earth radiates in the infra-red region of the spectrum. The spectrum is correctly given by
a) Wien's law b) Rayleigh Jeans law
c) Planck's law of radiation d) Stefan's law of radiation

13. The portion AB of the indicator diagram representing the state of matter denotes



a) The liquid state of matter b) Gaseous state of matter
c) Change from liquid to gaseous state d) Change from gaseous state to liquid state

14. Melting point of ice
a) Increases with increasing pressure b) Decreases with increasing pressure
c) Is independent of pressure d) Is proportional to pressure

15. A black body has maximum wavelength λ_m at temperature 2000 K. Its corresponding wavelength at temperature 3000 K will be
a) $\frac{3}{2}\lambda_m$ b) $\frac{2}{3}\lambda_m$ c) $\frac{4}{9}\lambda_m$ d) $\frac{9}{4}\lambda_m$

16. A black body at a temperature of 227°C radiates heat at the rate of 20 cal $m^{-2}s^{-1}$. When its temperature rises to 727°C, the rate of heat radiated will be
a) 40 cal $m^{-2}s^{-1}$ b) 160 cal $m^{-2}s^{-1}$ c) 320 cal $m^{-2}s^{-1}$ d) 640 cal $m^{-2}s^{-1}$

17. When a copper ball is heated, the largest percentage increase will occur in its
a) Diameter b) Area c) Volume d) Density

18. Two rods of the same length and diameter having thermal conductivities K_1 and K_2 are joined in parallel. The equivalent thermal conductivity of the combination is

a) $\frac{K_1K_2}{K_1+K_2}$ b) K_1+K_2 c) $\frac{K_1K_2}{2}$ d) $\sqrt{K_1}K_2$

19. Temperature of water at the surface of lake is -20°C. Then temperature of water just below the lower surface of ice layer is

a) -4°C b) 0°C c) 4°C d) -20°C

20. An ideal black body at room temperature is thrown into a furnance. It is observed that

a) It is the darkest body at all times

b) It cannot be distinguished at all times

c) Initially it is the darkest body and later it becomes brightest

d) Initially it is the darkest body and later it cannot be distinguished

21. Two beakers A and B are filled to the brim with water at 4°C. When A is heated and B is cooled, the water

a) Level in B decreases b) Will overflow in A only

c) Will overflow in B only d) Will overflow in both A and B

22. A metal rod having linear expansion coefficient 2×10^{-5}°C^{-1} has a length of 1 m at 20°C. The temperature at which it is shortened by 1 mm is

a) -20°C b) -15°C c) -30°C d) -25°C

23. 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) $\sqrt{3}/1$

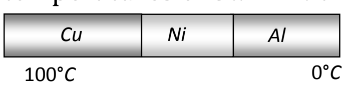
24. Hot water cools from 60°C to 50°C in the first 10 min and to 42°C in the first 10 min and to 42°C in the next 10 min. Then the temperature of the surroundings is

a) 20°C b) 30°C c) 15°C d) 10°C

25. A clock which keeps correct time at 20°C, is subjected to 40°C. If coefficient of linear expansion of the pendulum is 12×10^{-6}°C^{-1}. How much will it gain or lose time?

a) 10.3 s day^{-1} b) 20.6 s day^{-1} c) 5 s day^{-1} d) 20 min day^{-1}

26. A composite metal bar of uniform section is made up of length 25 cm of copper, 10 cm of nickel and 15 cm of aluminium. Each part being in perfect thermal contact with the adjoining part. The copper end of the composite rod is maintained at 100°C and the aluminium end at 0°C. The whole rod is covered with belt so that no heat loss occurs at the sides. If $K_{Cu}=2K_{Al}$ and $K_{Al}=3K_{Ni}$, then what will be the temperatures of $Cu-Ni$ and $Ni-Al$ junctions respectively



a) 23.33°C and 78.8°C b) 83.33°C and 20°C c) 50°C and 30°C d) 30°C and 50°C

27. A partition wall has two layers A and B in contanct, each made of a different material. They have the same thickness but the thermal conductivity of layer A is twice that of layer B. If the steady state temperature difference across the wall is 60K, then the corresponding difference across the layer A is

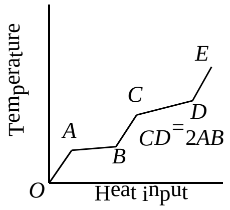
a) 10 K b) 20 K c) 30 K d) 40 K

28. Two rods of different materials having coefficient of thermal expansions α_1 and α_2 and Young's moduli Y_1 and Y_2 respectively are fixed between two rigid walls. The rods are heated, such that they undergo the same increase in temperature. There is no bending of rods. If $\alpha_1/\alpha_2=2/3$ and stresses developed in the two rods are equal, then $\frac{Y1}{Y2}$ is

a) 3/2 b) 1 c) 2/3 d) 1/2

29. When red glass is heated in dark room it will seen
a) Green b) Purple c) Black d) Yellow
30. Colour of shinning bright star is an indication of its
a) Distance from the earth b) Size
c) Temperature d) Mass
31. 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 surroundings is
a) 10°C b) 5°C c) 15°C d) 20°C
32. The surface temperature of the sun is
a) 2900 K b) 4000 K c) 5800 K d) 9000 K
33. Recently, the phenomenon of superconductivity has been observed at 95 K. This temperature is nearly equal to
a) -288^oF b) -146^oF c) -368^oF d) $+178^oF$
34. At NTP water boils at 100°C. Deep down the mine, water will boil at a temperature
a) 100°C b) $>$ 100°C c) $<$ 100°C d) Will not boil at all
35. 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) $(97)^{\frac{1}{4}}T$
36. No other thermometer is as suitable as a platinum resistance thermometer to measure temperature in the entire range of
a) 0°C to 100°C b) 100°C to 1500°C c) -50°C to $+$ 350°C d) -200°C to 600°C
37. One gram of ice is mixed with one gram of steam. At thermal equilibrium the temperature of mixture is
a) 0°C b) 100°C c) 55°C d) 80°C
38. Water is used to cool radiators of engines, because
a) Of its lower density b) It is easily available
c) It is cheap d) It has high specific heat
39. A body has same temperature as that of the surrounding. Then
a) It radiates same heat as it absorbs b) It absorbs more, radiates less heat
c) It radiates more, absorbs less heat d) It never radiates heat
40. The weight of a person is 60 kg. If he gets 10^5 calories heat through food and the efficiency of his body is 28%, then upto how much height he can climb (approximately)
a) 100 m b) 200 m c) 400 m d) 1000 m
41. A black body radiates at the rate of W watts at a temperature T. If the temperature of the body is reduced to $T/3$, it will radiate at the rate of (in $Watts$)
a) $\frac{W}{81}$ b) $\frac{W}{27}$ c) $\frac{W}{9}$ d) $\frac{W}{3}$
42. If the ratio of densities of two substances is 5 : 6 and that of the specific heats is 3 : 5. Then the ratio between heat capacities per unit volume is
a) 1 : 1 b) 2 : 1 c) 1 : 2 d) 1 : 3
43. The thermal conductivity of a material in CGS system is 0.4. In steady state, the rate of flow of heat is 10 $cal/s\text{-}cm^2$, then the thermal gradient will be
a) 10°C/cm b) 12°C/cm c) 25°C/cm d) 20°C/cm

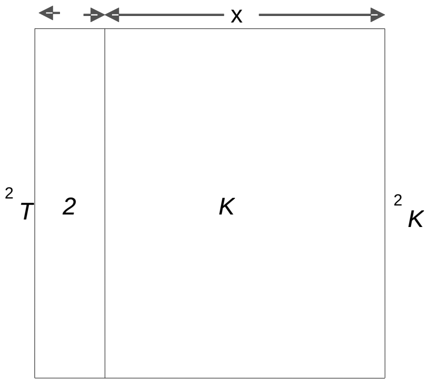
44. One quality of a thermometer is that its heat capacity should be small. If P is a mercury thermometer, Q is a resistance thermometer and R thermocouple type then
a) P is best, R worst b) R is best, P worst c) R is best, Q worst d) P is best, Q worst
45. Newton's law of cooling holds good only, if the temperature difference between the body and the surroundings is
a) Less than 10°C b) More than 10°C c) Less than 100°C d) More than 100°C
46. The gas thermometers are more sensitive than liquid thermometers because
a) Gases expand more than liquids b) Gases are easily obtained
c) Gases are much lighter d) Gases do not easily change their states
47. The heat is flowing through two cylindrical rods of same material. The diameters of the rods are in the ratio 1:2 and their lengths are in the ratio 2:1. If the temperature difference between their ends is the same, the ratio of rate of flow of heat through them will be
a) 1 : 1 b) 2 : 1 c) 1 : 4 d) 1 : 8
48. The coefficient of thermal conductivity of a rod depends on
a) Area b) Length
c) Material of rod d) Temperature difference
49. It is known that wax contracts on solidification. If molten wax is taken in a large vessel and it is allowed to cool slowly, then
a) It will start solidifying from the top to downward
b) It will start solidifying from the bottom to upward
c) It will start solidifying from the middle, upward and downward at equal rates
d) The whole mass will solidify simultaneously
50. When two ends of a rod wrapped with cotton are maintained at different temperatures and after same time every point of the rod attains a constant temperature, then
a) Conduction of heat at different points of the rod stops because the temperature is not increasing
b) Rod is bad conductor of heat
c) Heat is being radiated from each point of the rod
d) Each point of the rod is giving heat to its neighbour at the same rate at which it is receiving heat
51. Can we boil water inside the earth satellite by convection
a) Yes b) No
c) Nothing can be said d) In complete information is given
52. A body of area $1cm^2$ is heated to a temperature $1000K$. The amount of energy radiated by the body in $1\ s$ is (Stefan's constant $\sigma = 5.67 \times 10^{-8} Wm^{-2}K^{-4}$)
a) 5.67 joule b) 0.567 joule c) 56.7 joule d) 567 joule
53. The temperature of hot and cold end of a $20cm$ long rod in thermal steady state are at 100°C and 20°C respectively. Temperature at the centre of the rod is
a) 50°C b) 60°C c) 40°C d) 30°C
54. A black body at a temperature of 227°C radiates heat at the rate of 5 cal $cm^{-2}s^{-1}$. At a temperature of 727°C the rate of heat radiated per unit area in cal $cm^{-2}s^{-1}$ is
a) 400 b) 80 c) 40 d) 15
55. In which of the following process convection does not take place primarily
a) Sea and land breeze b) Boiling of water
c) Warming of glass of bulb due to filament d) Heating air around a furnace
56. A solid material is supplied with heat at constant rate and the temperature of the material changes as shown. From the graph, the false conclusion drawn is



a) AB and CD of the graph represent phase changes
b) AB represents the change of state from solid to liquid
c) Latent heat of fusion is twice the latent heat of vaporization
d) CD represents change of state from liquid to vapour

57. The thermal radiation from a hot body travels with a velocity of
a) $330\ ms^{-1}$ b) $2 \times 10^8\ ms^{-1}$ c) $1200\ ms^{-1}$ d) $3 \times 10^8\ ms^{-1}$

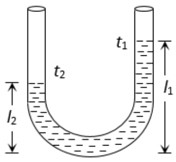
58. The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and $2K$ and thickness x and $4x$, respectively are T_2 and T_1 ($T_2 > T_1$). The rate of heat transfer through the slab, in a steady state is $\left(\frac{A(T_2-T_1)K}{x}\right) f$, with f equals to



a) 1 b) 1/3 c) 2/3 d) 1/3

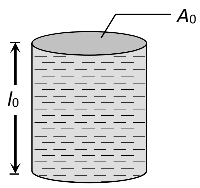
59. A faulty thermometer has its lower fixed point marked as -10°C and upper fixed point marked as 110^o. If the temperature of the body shown in this scale is 62^o, the temperature shown on the Celsius scale is
a) 72°C b) 82°C c) 60°C d) 42°C

60. In a vertical U-tube containing a liquid, the two arms are maintained at different temperatures t_1 and t_2. The liquid columns in the two arms have heights l_1 and l_2 respectively. The coefficient of volume expansion of the liquid is equal to



a) $\frac{l_1 - l_2}{l_2 t_1 - l_1 t_2}$ b) $\frac{l_1 - l_2}{l_1 t_1 - l_2 t_2}$ c) $\frac{l_1 + l_2}{l_2 t_1 + l_1 t_2}$ d) $\frac{l_1 + l_2}{l_1 t_1 + l_2 t_2}$

61. The figure shows a glass tube (linear co-efficient of expansion is α) completely filled with a liquid of volume expansion co-efficient γ. On heating length of the liquid column does not change. Choose the correct relation between γ and α



a) $\gamma = \alpha$ b) $\gamma = 2\alpha$ c) $\gamma = 3\alpha$ d) $\gamma = \frac{\alpha}{3}$

62. If the temperature of the sun (black body) is doubled, the rate of energy received on earth will be increased by a factor of

a) 2 b) 4 c) 8 d) 16

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

a) $r = 2r_0; l = 2l_0$ b) $r = 2r_0; l = l_0$ c) $r = r_0; l = l_0$ d) $r = r_0; l = 2l_0$

64. 10 g of ice at 0°C is mixed with 100 g of water at 50°C. What is the resultant temperature of mixture

a) 31.2°C b) 32.8°C c) 36.7°C d) 38.2°C

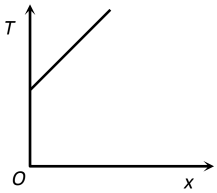
65. Which of the following has maximum specific heat

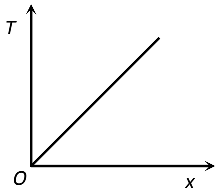
a) Water b) Alcohol c) Glycerine d) Oil

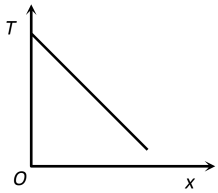
66. Calculate the amount of heat (in calories) required to convert 5 g of ice at 0°C to steam at 100°C

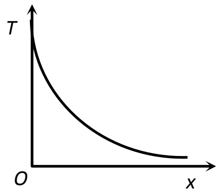
a) 3100 cal b) 3200 cal c) 3600 cal d) 4200 cal

67. Heat is flowing through a conductor of length l from $x = 0$ to $x = l$. If its thermal resistance per unit length is uniform, which of the following graphs is correct

a) 

b) 

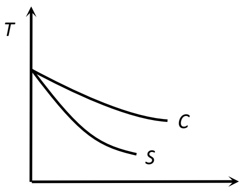
c) 

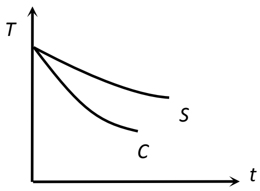
d) 

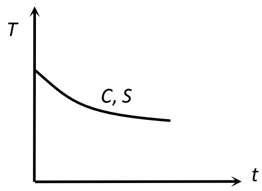
68. A metal rod AB of length $10x$ has its one end A in ice at 0°C and the other end B in water at 100°C. If a point P on the rod is maintained at 400°C, then it is found that equal amounts of water and ice evaporate and melt per unit time. The latent heat of evaporation of water is 540 cal/g latent 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]

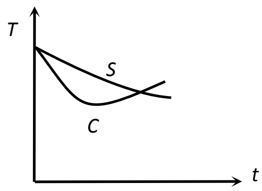
a) 9 b) 2 c) 6 d) 1

69. A hollow copper sphere S and a hollow copper cube C, both of negligible thin walls of same area, are filled with water at 90°C and allowed to cool in the same environment. The graph that correctly represents their cooling is

a) 

b) 

c) 

d) 

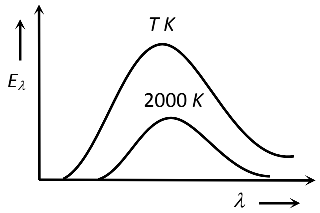
70. The volume of a metal sphere increases by 0.24% when its temperature is raised by 40°C . The coefficient of linear expansion of the metal is .../°C.

a) 2×10^{-5} b) 6×10^{-5} c) 18×10^{-5} d) 1.2×10^{-5}

71. Two spheres of radii 8 cm and 2 cm are cooling. Their temperatures are 127°C and 527°C respectively. Find the ratio of energy radiated by them in the same time

a) 0.06 b) 0.5 c) 1 d) 2

72. The adjoining diagram shows the spectral energy density distribution E_λ of a black body at two different temperatures. If the areas under the curves are in the ratio 16 : 1, the value of temperature T is



a) 32,000 K b) 16,000 K c) 8,000 K d) 4,000 K

73. A calorimeter of mass 0.2 kg and specific heat 900 J/kg-K. Containing 0.5 kg of a liquid of specific heat 2400 J/kg-K. Its temperature falls from 60°C to 55°C in one minute. The rate of cooling is
a) 5 J/s b) 15 J/s c) 100 J/s d) 115 J/s

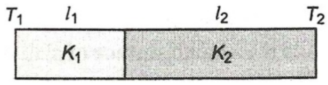
74. A cane is taken out from a refrigerator at 0°C. The atmospheric temperature is 25°C. If t_1 is the time taken to heat from 0°C to 5°C and t_2 is the time taken from 10°C to 15°C, then
a) $t_1 > t_2$ b) $t_1 < t_2$ c) $t_1 = t_2$ d) There is no relation

75. The apparent coefficient of expansion of a liquid when heated in a copper vessel is C and when heated in a silver vessel is S. If A is the linear coefficient of expansion of copper, then the linear coefficient of expansion of silver is
a) $\frac{C+S-3A}{3}$ b) $\frac{C+3A-S}{3}$ c) $\frac{S+3A-C}{3}$ d) $\frac{C+S+3A}{3}$

76. For an opaque body coefficient of transmission is
a) Zero b) 1 c) 0.5 d) ∞

77. A particular star (assuming it as a black body) has a surface temperature of about $5 \times 10^4 K$. The wavelength in nanometers at which its radiation becomes maximum is ($b = 0.0029\ mK$)
a) 48 b) 58 c) 60 d) 70

78. One end of a thermally insulated rod is kept at a temperature T_1 and other at T_2. The rod is composed of two sections of lengths l_1 and l_2 and thermal conductivities K_1 and K_2 respectively. The temperature at the interface of the two sections is



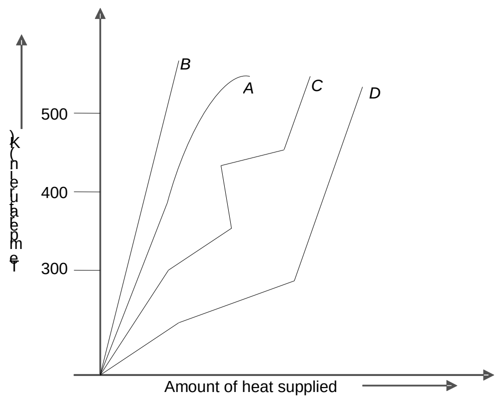
a) $(K_2l_2T_1 + K_1l_1T_2) / (K_1l_1 + K_2l_2)$ b) $(K_2l_1T_1 + K_1l_2T_2) / (K_2l_1 + K_1l_2)$
c) $(K_1l_2T_1 + K_2l_1T_2) / (K_1l_2 + K_2l_1)$ d) $(K_1l_1T_1 + K_2l_2T_2) / (K_1l_1 + K_2l_2)$

79. We have seen that a gamma-ray does of 3 Gy is lethal to half the people exposed to it. If the equivalent energy were absorbed as heat, what rise in body temperature would result
a) $300\mu K$ b) $700\mu K$ c) $455\mu K$ d) $390\mu K$

80. Wires A and B have identical lengths and have circular cross-section. The radius of A is twice the radius of B $i.e.$ $r_A = 2r_B$. For a given temperature difference between the two ends, both wires conduct heat at the same rate. The relation between the thermal conductivities is given by
a) $K_A = 4K_B$ b) $K_A = 2K_B$ c) $K_A = K_B/2$ d) $K_A = K_B/4$

81. A piece of blue glass heated to a high temperature and a piece of red glass at room temperature, are taken inside a dimly lit room then
a) The blue piece will look blue and red will look as usual
b) Red look brighter red and blue look ordinary blue
c) Blue shines like brighter red compared to the red piece
d) Both the pieces will look equally red

82. Which curve shows the rise of temperature with the amount of heat supplied, for a piece of ice?



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

83. For cooking the food, which of the following type of utensil is most suitable

a) High specific heat and low conductivity
b) High specific heat and high conductivity
c) Low specific heat and low conductivity
d) Low specific heat and high conductivity

84. Ice formed over lakes has

a) Very high thermal conductivity and helps in further ice formation
b) Very low conductivity and retards further formation of ice
c) It permits quick convection and retards further formation of ice
d) It is very good radiator

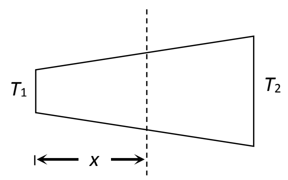
85. Two slabs are of the thickness d_1 and d_2. Their thermal conductivities are K_1 and K_2 respectively. They are in series. The free ends of the combination of these two slabs are kept at temperature θ_1 and θ_2. Assume $\theta_1 > \theta_2$. The temperature θ of their common junction is

a) $\frac{K_1\theta_1 + K_2\theta_2}{\theta_1 + \theta_2}$ b) $\frac{K_1\theta_1 d_1 + K_2\theta_2 d_2}{K_1 d_2 + K_2 d_1}$ c) $\frac{K_1\theta_1 d_2 + K_2\theta_2 d_1}{K_1 d_2 + K_2 d_1}$ d) $\frac{K_1\theta_1 + K_2\theta_2}{K_1 + K_2}$

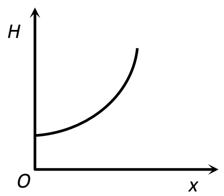
86. Energy is being emitted from the surface of a black body at 127°C temperature at the rate of $1.0 \times 10^6 J/s - m^2$. Temperature of the black body at which the rate of energy emission is $16.0 \times 10^6 J/s - m^2$ will be

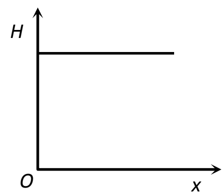
a) 254°C b) 508°C c) 527°C d) 727°C

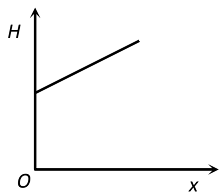
87. Radius of a conductor increases uniformly from left end to right end as shown in fig

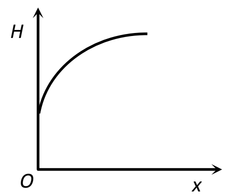


Material of the conductor is isotropic and its curved surface is thermally insulated from surrounding. Its ends are maintained at temperatures T_1 and $T_2 (T_1 > T_2)$: If, in steady state, heat flow rate is equal to H, then which of the following graphs is correct

a)


b)


c)


d)


88. Hot water kept in a beaker placed in a room cools from 70°C to 60°C in 4 *minutes*. The time taken by it to cool from 69°C to 59°C will be

a) The same 4 minutes
b) More than 4 minutes
c) Less than 4 minutes
d) We cannot say definitely

89. Which one of the following would raise the temperature of 20 g of water at 30°C most when mixed with it?
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 water at 80°C
90. The energy emitted per second by a black body at 27°C is 10 J. If the temperature of the black body is increased to 327°C, the energy emitted per second will be
a) 20 J
b) 40 J
c) 80 J
d) 160 J
91. If a black body is heated at a high temperature, it seems to be
a) Blue
b) White
c) Red
d) Black
92. Two rods of equal length and area of cross-section are kept parallel and lagged between temperature 20°C and 80°C. The ratio of the effective thermal conductivity to that of the first rod is $\left[\text{the ratio } \left(\frac{K_1}{K_2}\right) = \frac{3}{4}\right]$
a) 7 : 4
b) 7 : 6
c) 4 : 7
d) 7 : 8
93. The two opposite faces of a cubical piece of iron (thermal conductivity = 0.2 CGS unit) are at 100°C and 0°C in ice. If the area of a surface is $4cm^2$, then the mass of ice melted in a 10 minutes will be
a) 30 g
b) 300 g
c) 5 g
d) 50 g
94. Two cylinders P and Q have the same length and diameter and are made of different materials having thermal conductivities in the ratio 2:3. These two cylinders are combined to make a cylinder. One end of P is kept of 100°C and another end of Q at 0°C. The temperature at the interface of P and Q is
a) 30°C
b) 40°C
c) 50°C
d) 60°C
95. The absolute zero temperature in Fahrenheit scale is
a) -273^oF
b) -32^oF
c) -460^oF
d) -132^oF
96. An iron bar of length l and having a cross-section A is heated from 0 to 100°C. If this bar is so held that it is not permitted to expand or bend, the force that is developed, is
a) Inversely proportional to the cross-sectional area of the bar
b) Independent of the length of the bar
c) Inversely proportional to the length of the bar
d) Directly proportional to the length of the bar
97. The wavelength of radiation emitted by a body depends upon
a) The nature of its surface
b) The area of its surface
c) The temperature of its surface
d) All the above factors
98. Absolute scale of temperature is reproduced in the laboratory by making use of a
a) Radiation pyrometer
b) Platinum resistance thermometer
c) Constant volume helium gas thermometer
d) Constant pressure ideal gas thermometer
99. 4200 J of work is required for
a) Increasing the temperature of 10 gm of water through 10°C
b) Increasing the temperature of 100 gm of water through 10°C
c) Increasing the temperature of 1 kg of water through 10°C
d) Increasing the temperature of 10 kg of water through 10°C
100. If earth suddenly stops rotating about its own axis, the increase in it's temperature will be
a) $\frac{R^2\omega^2}{5Js}$
b) $\frac{R^2\omega^2}{Js}$
c) $\frac{Rm\omega^2}{5Js}$
d) None of these
101. Water is used to cool the radiators of engines in cars because
a) Of its low boiling point
b) Of its high specific heat

c) Of its low density
d) Of its easy availability

102. A stationary object at 4°C and weighing 3.5 kg falls from a height of 2000 m on a snow mountain at 0°C. If the temperature of the object just before hitting the snow is 0°C and the object comes to rest immediately ($g = 10m/s^2$) and (latent heat of ice $= 3.5 \times 10^5$ $joule/s$), then the mass of ice that will melt is

a) 2 kg
b) 200 g
c) 20 g
d) 2 g

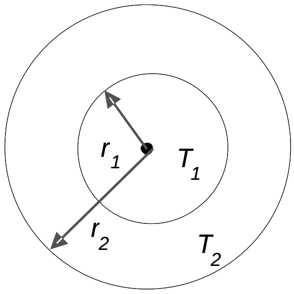
103. A bar of iron is 10 cm at 20°C. At 19°C it will be (α of iron $= 11 \times 10^{-6}$/°C)

a) $11 \times 10^{-6} cm$ longer
b) $11 \times 10^{-6} cm$ shorter
c) $11 \times 10^{-5} cm$ shorter
d) $11 \times 10^{-5} cm$ longer

104. The ratio of radiant energies radiated per unit surface area by two bodies is 16 : 1, the temperature of hotter body is 1000K, then the temperature of colder body will be

a) 250 K
b) 500 K
c) 1000 K
d) 62.5 K

105. The figure shows a system of two concentric spheres of radii r_1 and r_2 and kept at temperatures T_1 and T_2 respectively. The radial rate of flow of heat in a substance between the two concentric spheres, is proportional to



a) $\frac{(r_2 - r_1)}{(r_1 r_2)}$
b) $\text{In}\left(\frac{r_2}{r_1}\right)$
c) $\frac{(r_1 r_2)}{(r_2 - r_1)}$
d) $(r_2 - r_1)$

106. When the pressure on water is increased the boiling temperature of water as compared to 100°C will be

a) Lower
b) The same
c) Higher
d) On the critical temperature

107. Newton's law of cooling is used in laboratory for the determination of the

a) Specific heat of the gases
b) The latent heat of gases
c) Specific heat of liquids
d) Latent heat of liquids

108. On a new scale of temperature (which is linear) and called the W scale, the freezing and boiling points of water are 39° W and 239°W respectively. What will be the temperature on the new scale, corresponding to a temperature of 39°C on the Celsius scale

a) 200°W
b) 139°W
c) 78°W
d) 117°W

109. A beaker is completely filled with water at 4°C. It will overflow

a) When heated, but not when cooled
b) When cooled, but not when heated
c) Both when heated or cooled
d) Neither when heated nor when cooled

110. How many grams of a liquid of specific heat 0.2 at a temperature 40°C must be mixed with 100 gm of a liquid of specific heat of 0.5 at a temperature 20°C, so that the final temperature of the mixture becomes 32°C

a) 175 gm
b) 300 g
c) 295 gm
d) 375 g

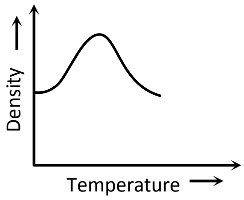
111. The area of the glass of a window of a room is 10 m^2 and thickness 2mm. The outer and inner temperature are 40°C and 20°C respectively. Thermal conductivity of glass in MKS system is 0.2. The heat flowing in the room per second will be

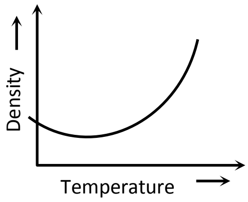
a) 3×10^4 $joules$
b) 2×10^4 $joules$
c) 30 $joules$
d) 45 $joules$

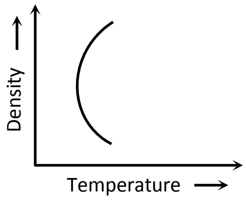
112. If black wire of platinum is heated, then its colour first appear red, then yellow and finally white. It can be understood on the basis of

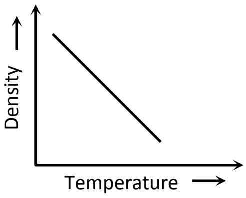
a) Wien's displacement law b) Prevost theory of heat exchange
c) Newton's law of cooling d) None of the above

113. The variation of density of water with temperature is represented by the

a) 

b) 

c) 

d) 

114. The ratio of energy of emitted radiation of a black body at 27°C and 927°C is
a) 1 : 4 b) 1 : 16 c) 1 : 64 d) 1 : 256

115. Two rods of same length and material transfer a given amount of heat in 12 s, when they are joined end to end (*ie*, in series). But when they are joined in parallel, they will transfer same heat under same conditions in
a) 24 s b) 3 s c) 48 s d) 1.5 s

116. Heat capacity of a substance is infinite. It means
a) Heat is given out
b) Heat is taken in
c) No change in temperature whether heat is taken in or given out
d) All of the above

117. Which of the following is the example of ideal black body
a) Kajal b) Black board c) A pin hole in a box d) None of these

118. When a bimetallic strip is heated, it
a) Does not bend at all
b) Gets twisted in the from of an helix
c) Bend in the form of an arc with the more expandable metal outside
d) Bends in the form of an arc with the more expandable metal inside

119. 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

120. If a cylinder a diameter 1.0 cm at 30°C is to be fitted into a hole of diameter 0.9997 cm in a steel plate at the same temperature, then minimum required rise in the temperature of the plate is : (Coefficient of linear expansion of steel = 12×10^{-6}/°C)
a) 25°C b) 35°C c) 45°C d) 55°C

121. The temperature of the sun is measured with
a) Platinum thermometer b) Gas thermometer
c) Pyrometer d) Vapour pressure thermometer

122. A solid ball of metal has a concentric spherical cavity within it. If the ball is heated, the volume of the cavity will
a) Increase b) Decrease c) Remain unaffected d) None of these

123. The temperature of a body on Kelvin scale is found to be x K. When it is measured by Fahrenheit thermometer, it is found to be $x^{o}F$, then the value of x is
a) 40 b) 313 c) 574.25 d) 301.25

124. A liquid cools down from 70°C to 60°C in 5 $minutes$. The time taken to cool it from 60°C to 50°C will be
a) 5 $minutes$
b) Lesser than 5 $minutes$

c) Greater than 5 $minutes$

d) Lesser or greater than 5 $minutes$ depending upon the density of the liquid

125. A quantity of heat required to change the unit mass of a solid substance, from solid state to liquid state, while the temperature remains constant, is known as

a) Latent heat b) Sublimation c) Hoar frost d) Latent heat of fusion

126. A black body radiates 20 W at temperature 227°C. If temperature of the black body is changed to 727°C then its radiating power will be

a) 120 W b) 240 W c) 320 W d) 360 W

127. Four rods of silver, copper, brass and wood are of same shape. They are heated together after wrapping a paper on it, the paper will burn first on

a) Silver b) Copper c) Brass d) Wood

128. At a common temperature, a block of wood and a block of metal feel equally cold or hot. The temperature of block of wood and block of metal are

a) Equal to temperature of the body b) Less than the temperature of the body

c) Greater than temperature of the body d) Either (b) or (c)

129. The relative humidity on a day when partial pressure of water vapour is 0.012×10^5 Pa at 12°C is (Take vapour pressure of water at this temperature as 0.016×10^5 Pa)

a) 70% b) 40% c) 75% d) 25%

130. The radiation emitted by a star A is 10,000 times that of the sun. If the surface temperature of the sun and the star A are 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

131. The spectral energy distribution of a star is maximum at twice temperature as that of sun. the total energy radiated by star is

a) Twice as that of the sun b) Same as that of the sun

c) Sixteen times as that of the sun d) One-sixteenth of the sun

132. If temperature of a black body increases from 7°C to 287°C, then the rate of energy radiation increases by

a) $\left(\frac{287}{7}\right)^4$ b) 16 c) 4 d) 2

133. Solids expand on heating because

a) Kinetic energy of the atoms increases

b) Potential energy of the atoms increases

c) Total energy of the atoms increases

d) The potential energy curve is asymmetric about the equilibrium distance between neighbouring atoms

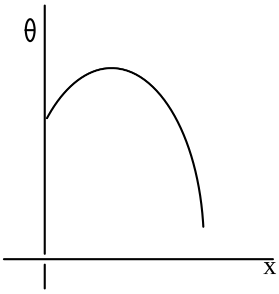
134. The temperature on Celsius scale is 25°C. What is the corresponding temperature on the Fahrenheit scale

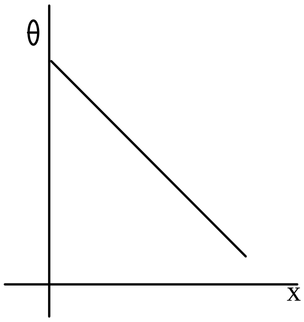
a) $40^\circ F$ b) $77^\circ F$ c) $50^\circ F$ d) $45^\circ F$

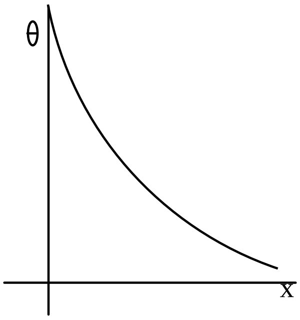
135. A bubble of 8 mole of helium is submerged at a certain depth in water. The temperature of water increases by 30°C. How much that is added approximately to helium during expansion

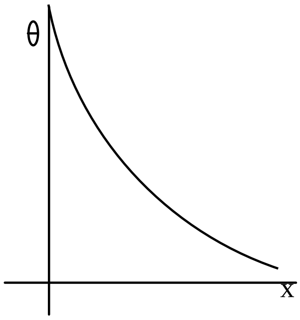
a) 4000 J b) 3000 J c) 3500 J d) 5000 J

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

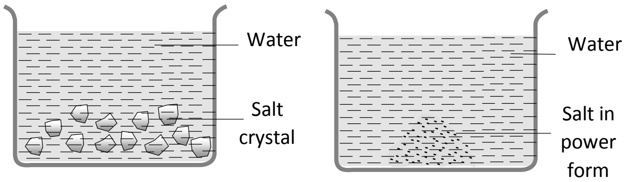
a) 

b) 

c) 

d) 

137. Out of the following, in which vessel will the temperature of the solution be higher after the salt is completely dissolved



a) A
b) B
c) Equal in both
d) Information is not sufficient

138. In a closed room, which method is based on gravitation

a) Conduction
b) Convection
c) Radiation
d) All of these

139. Surface of the lake is at 2°C. Find the temperature of the bottom of the lake

a) 2°C
b) 3°C
c) 4°C
d) 1°C

: ANSWER KEY :

1)	a	2)	b	3)	c	4)	d	5)	b	6)	a	7)	d	8)	a
9)	a	10)	a	11)	b	12)	c	13)	a	14)	b	15)	b	16)	c
17)	c	18)	c	19)	b	20)	c	21)	d	22)	c	23)	b	24)	d
25)	a	26)	b	27)	b	28)	a	29)	a	30)	c	31)	a	32)	c
33)	a	34)	b	35)	c	36)	d	37)	b	38)	d	39)	a	40)	b
41)	a	42)	c	43)	c	44)	c	45)	a	46)	a	47)	d	48)	c
49)	b	50)	d	51)	b	52)	a	53)	b	54)	b	55)	c	56)	c
57)	d	58)	d	59)	c	60)	a	61)	b	62)	d	63)	b	64)	d
65)	a	66)	c	67)	c	68)	a	69)	c	70)	a	71)	c	72)	d
73)	d	74)	b	75)	b	76)	a	77)	b	78)	c	79)	b	80)	d
81)	c	82)	d	83)	d	84)	b	85)	c	86)	c	87)	b	88)	b
89)	c	90)	d	91)	b	92)	b	93)	b	94)	b	95)	c	96)	b
97)	c	98)	c	99)	b	100)	a	101)	b	102)	b	103)	c	104)	b
105)	c	106)	c	107)	c	108)	d	109)	c	110)	d	111)	b	112)	a
113)	a	114)	d	115)	b	116)	c	117)	c	118)	c	119)	a	120)	a
121)	c	122)	b	123)	c	124)	c	125)	d	126)	c	127)	d	128)	a
129)	c	130)	c	131)	c	132)	b	133)	d	134)	b	135)	d	136)	b
137)	b	138)	b	139)	c										

: HINTS AND SOLUTIONS :

1 **(a)**

Here, $\alpha(\text{steel}) = 1.1 \times 10^{-5}{}^{\circ}\text{C}^{-1}$

$\alpha(\text{copper}) = 1.7 \times 10^{-5}{}^{\circ}\text{C}^{-1}$

$$\frac{l_0(s)}{l_0(c)} = \frac{\alpha(c)}{\alpha(s)} = \frac{1.7 \times 10^{-5}}{1.1 \times 10^{-5}} = 1.545$$

$\therefore\ l_0(s) = 1.545 l_0(c)$

Also, $l_0(s) - l_0(c) = 5$

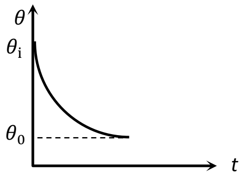
$0.545 l_0(c) = 5$

$$l_0(c) = \frac{5}{0.545} = 9.17 \text{ cm}$$

And $l_0(s) = 1.545 \times 9.17$ cm 14.17 cm

2 **(b)**

According to Newton's law of cooling



Rate of cooling ∝ Temperature difference

$$\Rightarrow -\frac{d\theta}{dt} \propto (\theta - \theta_0) \Rightarrow -\frac{d\theta}{dt} = \alpha(\theta - \theta_0)\ \ [\alpha = \text{constant}]$$

$$\Rightarrow \int_{\theta_1}^{\theta} \frac{d\theta}{(\theta - \theta_0)} = -\alpha \int_0^1 dt \ \Rightarrow \theta = \theta_0 + (\theta_1 - \theta_0)e^{-\alpha t}$$

This relation tells us that, temperature of the body varies exponentially with time from θ_1 to θ_0

Hence graph (b) is correct

3 **(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.

4 **(d)**

According to Kirchhoff's law the ratio of emissive power to absorptive power is same for all surfaces at the same temperature and is equal to the emissive power of a perfectly black body at that temperature

Hence, $\frac{e_1}{a_1} = \frac{e_2}{a_2} = \cdots \left[\frac{E}{A}\right]$ perfectly black body

Now, since $(E\lambda)_{\text{black}}$ is constant at a given temperature, this implies that good absorber is a good emitter (or radiator).

5 **(b)**

In vapor to liquid phase transition, heat liberates

6 **(a)**

$$\frac{\Delta T}{\Delta t} = KA\left(\frac{\Delta T}{\Delta x}\right) = K(\pi r^2)\frac{\Delta T}{(l)}$$

$\therefore \left(\frac{\Delta Q}{\Delta t}\right) \propto \frac{r^2}{l}$, which is maximum in case (a).

7 **(d)**

As batteries wear out, temperature of filament of flash light attains a lesser value, therefore intensity of radiation reduces. Also dominating wavelength (λ_m) in spectrum, which is the red colour, increases.

8 (a)

$$\frac{E_1}{E_2} = \left(\frac{T_1}{T_2}\right)^4 \Rightarrow \frac{E}{E_2} = \left(\frac{273+0}{273+273}\right)^4 \Rightarrow E_2 = 16\,E$$

9 (a)

A perfectly black body is a good absorber of radiations falls on it. So it's absorptive power is 1

10 (a)

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

As surface area, material and temperature difference are same, so rate of loss of heat is same in both, the spheres. Now in this case rate of cooling depends on mass

$\Rightarrow$ Rate of cooling $\frac{\Delta\theta}{t} \propto \frac{1}{m}$

$\because m_{solid} > m_{hollow}$. Hence hollow sphere will cool fast

11 (b)

During clear nights object on surface of earth radiate out heat and temperature falls. Hence option (a) is wrong

The total energy radiated by a body per unit time per unit area $E \propto T^4$. Hence option (c) is wrong

Energy radiated per second is given by $\frac{Q}{t} = PA\varepsilon\sigma T^4$

$$\Rightarrow \frac{P_1}{P_2} = \frac{A_1}{A_2}.\left(\frac{T_1}{T_2}\right)^4 = \left(\frac{r_1}{r_2}\right)^2.\left(\frac{T_1}{T_2}\right)^4 = \left(\frac{1}{4}\right)^2\left(\frac{4000}{200}\right) = \frac{1}{1}$$

$\because P_1 = P_2$, hence option (d) is wrong

Newton's law is an approximate form of Stefan's law of radiation and works well for natural convection. Hence option (b) is correct

13 (a)

The volume of matter in portion AB of the curve is almost constant and pressure is decreasing. These are the characteristics of liquid state

14 (b)

Melting point of ice decreases with increase in pressure (as ice expands on solidification)

15 (b)

$$\lambda_{m_2} = \frac{T_1}{T_2} \times \lambda_{m_1} = \frac{2000}{3000} \times \lambda_{m_1} = \frac{2}{3}\lambda_{m_1} = \frac{2}{3}\lambda_m$$

16 (c)

The Stefan's law,

$$E = \sigma T^4$$

Given, $T_1 = 227°\text{C} = 227 + 273 = 500\text{ K}$

$T_2 = 727°\text{C} = 273 + 727 = 1000\text{ K}$

$$\therefore \quad \frac{E_1}{E_2} = \frac{T_1^4}{T_2^4}$$

$$\Rightarrow \quad E_2 = \frac{T_2^4}{T_2^4} E_1$$

$$E_2 = \frac{(1000)^4}{(500)^4} \times 20$$

$$E_2 = 16 \times 20$$

$$E_2 = 320\text{ cal m}^{-2}\text{s}^{-1}$$

17 (c)

When a copper ball is heated, it's size increases. As Volume ∝ (radius)^3 and Area ∝ (radius)^2, so percentage increase will be largest in it's volume. Density will decrease with rise in temperature

18 **(c)**

Let n slabs each of length l, areas

$A_1, A_2, A_3, \dots \dots, A_n$ and thermal conductivities

$K_1, K_2, K_3, \dots \dots, K_n$ are connected in parallel, then,

$$K_{eq} = \frac{K_1+K_2+K_3+\dots+K_n}{n}$$

For two slabs of equal area $K_{eq} = \frac{K_1+K_2}{2}$

19 **(b)**

Temperature of water just below the lower surface of ice layer is 0°C

20 **(c)**

When the temperature of black body becomes equal to the temperature of the furnace, the black body will radiate maximum energy and it will be brightest of all. Initially it will absorb all the radiant energy incident on it. So, it is the darkest one.

21 **(d)**

Density of water is maximum at 4°C. In both heating and cooling of water from this temperature, level of water rises due to decrease in density, $i.e.$, water will over flow in both A and B

22 **(c)**

From, $l_2 = l_1[1 + \alpha(t_2 - t_1)]$

$$t_2 = t_1 + \frac{l_2 - l_1}{l_1 \alpha}$$

$$= 20 + \frac{-10^{-3}}{1.0 \times 2 \times 10^{-5}} = -30°C$$

23 **(b)**

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

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

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

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

24 **(d)**

According to Newton's law of cooling

$$\frac{\theta_2 - \theta_1}{t} = K\left[\frac{\theta_1 + \theta_2}{2} - \theta_s\right]$$

Where, θ_s is the temperature of the surroundings.

$$\frac{60-50}{10} = K\left[\frac{60+50}{2} - \theta_s\right]$$

$$1 = K[55 - \theta_s] \quad \dots(i)$$

Similarly, $\frac{50-42}{10} = K(46 - \theta_s)$

$$\frac{8}{10} = K(46 - \theta_s) \quad \dots(ii)$$

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

$$\frac{10}{8} = \frac{K(55-\theta_s)}{K(46-\theta_s)}$$

$$\Rightarrow \quad \theta_s = 10°C$$

25 **(a)**

Time period, $T=2\pi\sqrt{\frac{1}{g}}$

$$\frac{\Delta T}{T}=\frac{1}{2}\frac{\Delta l}{l}=\frac{1}{2}\alpha\Delta\theta$$

$$=\frac{1}{2}\times 12\times 10^{-6}(40-20)=12\times 10^{-5}$$

$$\Delta T=T\times 12\times 10^{-5}$$

$$=24\times 60\times 60\times 12\times 10^{-5}$$

$$=10.3\text{ s day}^{-1}$$

26 **(b)**

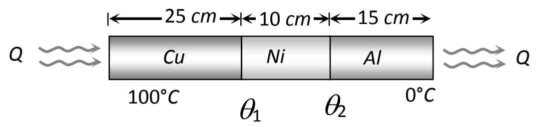
If suppose $K_{Ni}=K\Rightarrow K_{Al}=3K$ and $K_{Cu}=6K$

Since all metal bars are connected in series

So $\left(\frac{Q}{t}\right)_{Combination}=\left(\frac{Q}{t}\right)_{Cu}=\left(\frac{Q}{t}\right)_{Al}=\left(\frac{Q}{t}\right)_{Ni}$

and $\frac{3}{K_{eq}}=\frac{1}{K_{Cu}}+\frac{1}{K_{Al}}+\frac{1}{K_{Ni}}=\frac{1}{6K}+\frac{1}{3K}+\frac{1}{K}=\frac{9}{6K}$

$\Rightarrow K_{eq}=2K$



Hence, it $\left(\frac{Q}{t}\right)_{Combination}=\left(\frac{Q}{t}\right)_{Cu}$

$$\Rightarrow\frac{K_{eq}A(100-0)}{l_{Combination}}=\frac{K_{Cu}A(100-\theta_1)}{l_{Cu}}$$

$$\Rightarrow\frac{2K\,A(100-0)}{(25+10+15)}=\frac{6K\,A(100-\theta_1)}{25}\Rightarrow\theta_1=83.33°\text{C}$$

Similar if $\left(\frac{Q}{t}\right)_{Combination}=\left(\frac{Q}{t}\right)_{Al}$

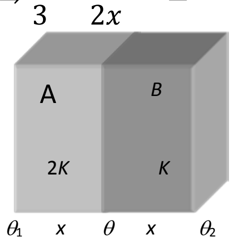
$$\Rightarrow\frac{2K\,A(100-0)}{50}=\frac{3K\,A(\theta_2-0)}{15}\Rightarrow\theta_2=20°\text{C}$$

27 **(b)**

Suppose conductivity of layer B is K, then it is $2K$ for layer A. Also conductivity of combination layers A and B is $K_S=\frac{2\times 2K\times K}{(2K+K)}=\frac{4}{3}K$

Hence $\left(\frac{Q}{t}\right)_{Combination}=\left(\frac{Q}{t}\right)_{A}$

$$\Rightarrow\frac{4}{3}\frac{KA\times 60}{2x}=\frac{2K.A\times(\Delta\theta)_A}{x}\Rightarrow(\Delta\theta)_A=20K$$



28 **(a)**

Thermal stress is a measure of the internal distribution of force per unit area within body that is applied to the body, in the form of heat

Thermal stress=$Y\alpha\Delta T$

Where $Y$is Young's modulus, α the coefficient of linear expansion and ΔT the change in temperature

Both the rods are heated,

∴ $Y_1\alpha_1\Delta T_1 = Y_2\alpha_2\Delta T_2$

Since, $\Delta T_1 = \Delta T_2$

$\Rightarrow \frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1} = \frac{3}{2}$

29 **(a)**

Red and green colours are complementary to each other. When red glass is heated it emits green light strongly, hence according to Kirchhoff's law, the emissive power of red glass should be maximum for green light. That's why when this heated red glass is taken in dark room it strongly emits green light and looks greenish

30 **(c)**

According to Wien's displacement law

31 **(a)**

According to Newton's law of cooling

$$\frac{\theta_1-\theta_2}{t} = K\left[\frac{\theta_1+\theta_2}{2} - \theta_0\right]$$

In the first case,

$\Rightarrow \frac{60-50}{10} = K\left[\frac{60+50}{2} - \theta_0\right]$

$\Rightarrow 1 = K(55-\theta)$ ...(i)

In the second case,

$\Rightarrow \frac{60-50}{10} = K\left[\frac{50+42}{2} - \theta_0\right]$

$\Rightarrow 0.8 = K[46-\theta]$ ...(ii)

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

$$\frac{1}{0.8} = \frac{55-\theta}{46-\theta}$$

or $40 - \theta = 44 - 0.8\theta$

$\Rightarrow \theta = 10$

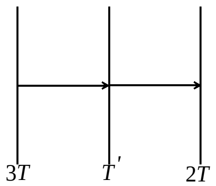
33 **(a)**

$$\frac{F-32}{9} = \frac{K-273}{5} \Rightarrow \frac{F-32}{9} = \frac{95-273}{5} \Rightarrow F = -288^{o}F$$

34 **(b)**

Pressure inside the mines is greater than that of normal pressure. Also we know that boiling point increases with increase in pressure

35 **(c)**



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

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

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

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

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

36 **(d)**

-200°C to 600°C can be measured by platinum resistance thermometer

37 **(b)**

Heat required to melt 1 g of ice at 0°C to water at 0°C
= 1× 80 cal.
Heat required to raise temperature of 1 g of water from 0°C to 100°C = 1 × 1 × 100 cal
Total heat required for maximum temperature of 100°C = 80 + 100 = 180 cal
As one gram of steam gives 540 cal of heat when it is converted to water at 100°C, therefore, temperature of the mixture would be 100°C

38 **(d)**
Due to large specific heat of water, it releases large heat with very small temperature change

39 **(a)**
The temperature of the body is same that of its surroundings, so the amount of heat absorbed by it should be equal to amount of heat radiated by it.

40 **(b)**
Suppose person climbs upto height h, then by using
$W = JQ \Rightarrow mgh = JQ$
$$\Rightarrow 60 \times 9.8 \times h = 4.2 \times \left(10^5 \times \frac{28}{100}\right) \Rightarrow h = 200\ m$$

41 **(a)**
$$P = \left(\frac{Q}{t}\right) \propto T^4 \Rightarrow \frac{W}{P_2} = \left(\frac{T}{T/3}\right)^4 \Rightarrow P_2 = \frac{W}{81}$$

42 **(c)**
Heat capacity/volume $= c\ \times \frac{m}{V} = c \times \rho$
Desired ratio $= \frac{c_1\rho_1}{c_2\rho_1} = \frac{3}{5} \times \frac{5}{6} = 1 : 2$

43 **(c)**
$\frac{\Delta Q}{\Delta t} = \frac{KA\Delta\theta}{\Delta x} \Rightarrow$ Thermal gradient $\frac{\Delta\theta}{\Delta x}$
$$= \frac{(\Delta Q/\Delta t)}{KA} = \frac{10}{0.4} = 25°\text{C}/cm$$

44 **(c)**
Thermoelectric thermometer is used for finding rapidly varying temperature

45 **(a)**
Newton's law of cooling states that the rate of cooling of a body is directly proportional to temperature difference between the body and the surroundings, provided the temperature difference is small, (less than 10°C), and Newton's law of cooling is given by
$$\frac{dT}{dt} \propto (\theta - \theta_0)$$

46 **(a)**
For gases γ is more

47 **(d)**
$\frac{Q}{t} = \frac{KA\Delta\theta}{l} \Rightarrow \frac{Q}{t} \propto \frac{A}{l} \propto \frac{d^2}{l}$ [d = diameter of rod]
$$\Rightarrow \frac{(Q/t)_1}{(Q/t)_2} = \left(\frac{d_1}{d_2}\right)^2 \times \frac{l_2}{l_1} = \left(\frac{1}{2}\right)^2 \times \left(\frac{1}{2}\right) = \frac{1}{8}$$

49 **(b)**
Substances are classified into two categories
(i) water like substances which expand on solidification.
(ii) CO_2 like (Wax, Ghee *etc.*) substances which contract on solidification.
Their behaviour regarding solidification is opposite.

Melting point of ice decreases with rise of pressure but that of wax etc increases with increase in pressure. Similarly ice starts forming from top to downwards whereas wax starts its formation from bottom to upwards

50 **(d)**

Because steady state has been reached

51 **(b)**

No, in convection the hot liquid at the bottom becomes lighter and hence it rises up. In this way the base of the convection is the difference in weight and upthrust. In the state of weightlessness this difference does not occur, so convection is not possible

52 **(a)**

Here, $A = 1cm^2 = 10^{-4}m^2, T = 1000K, t = 1s$ and $\sigma = 5.67 \times 10^{-8} Wm^{-2}K^{-4}$

According to Stefan-Boltzmann law, energy radiated by a body is

$E = \sigma AT^4 t = 5.67 \times 10^{-8} \times 10^{-4} \times (1000)^4 \times 1 = 5.67J$

53 **(b)**

Temperature gradient $= \frac{100-20}{20} = 4°\text{C}/cm$

Temperature of centre $= 100 - 4 \times 10 = 60°\text{C}$

54 **(b)**

According to Stefan's law radiant energy emitted by a perfectly black body per unit area per sec (ie, emissive power of black body) is directly proportional to the fourth power of its absolute temperature ie $E \propto T^4$

$$\Rightarrow \quad \frac{E_1}{E_2} = \frac{T_1^4}{T_2^4}$$

$$\frac{5}{E_2} = \frac{(273+227)^4}{(273+727)^4}$$

$$E_2 = 5 \times \left[\frac{1000}{500}\right]^4$$

$$= 5 \times 16 = 80 \text{ cal cm}^{-2}s^{-1}$$

57 **(d)**

The thermal radiation from a hot body travels with a velocity of light in vacuum $i.e. 3 \times 10^8 m\ s^{-1}$

58 **(d)**

Let the temperature of common interface be T°C. Rate of heat flow

$$H = \frac{Q}{t} = \frac{KA\Delta T}{l}$$

$$\therefore \quad H_1 = \left(\frac{Q}{t}\right)_1 = \frac{2KA(T-T_1)}{4x}$$

$$\text{And} \quad H_2 = \left(\frac{Q}{t}\right)_2 = \frac{KA(T_2-T)}{x}$$

In steady state, the rate of heat flow should be same in whole system ie,

$$H_1 = H_2$$

$$\Rightarrow \quad \frac{2KA(T-T_1)}{4x} = \frac{KA(T_2-T)}{x}$$

$$\Rightarrow \quad \frac{T-T_1}{2} = T_2 - T$$

$$\Rightarrow \quad T - T_1 = 2T_2 - 2T$$

$$\Rightarrow \quad T = \frac{2T_2+T_1}{3} \quad \text{...(i)}$$

Hence, heat flow from composite slab is

$$H = \frac{KA(T_2-T)}{x}$$

$$= \frac{KA}{x}\left(T_2 - \frac{2T_2+T_1}{3}\right) = \frac{KA}{3x}(T_2 - T_1) \quad \text{...(ii)}$$

[from Eq. (i)]

Accordingly, $H = \left[\frac{A(T_2-T_1)K}{x}\right] f$ ... (iii)

By comparing Eqs. (ii) and (iii), we get

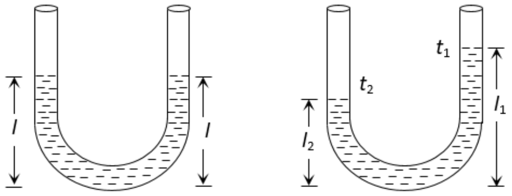
$\Rightarrow \quad f = \frac{1}{3}$

59 **(c)**

$$\frac{X-L}{U-L} = \frac{C}{100} \Rightarrow \frac{62-(-10)}{110-(-10)} = \frac{C}{100} \quad (C = 60°\text{C})$$

60 **(a)**

Suppose, height of liquid in each arm before rising the temperature is l.



With temperature rise height of liquid in each arm increases $i.e. l_1 > l$ and $l_2 > l$

Also $l = \frac{l_1}{1+\gamma t_1} = \frac{l_2}{1+\gamma t_2}$

$$\Rightarrow l_1 + \gamma l_1 t_2 = l_2 + \gamma l_2 t_1 \Rightarrow \gamma = \frac{l_1 - l_2}{l_2 t_1 - l_1 t_2}$$

61 **(b)**

When length of the liquid column remains constant, then the level of liquid moves down with respect to the container, thus γ must be less than 3α

Now we can write $V = V_0(1+\gamma\Delta T)$

Since $V = Al_0 = [A_0(1+2\alpha\Delta T)]l_0 = V_0(1+2\alpha\Delta T)$

Hence $V_0(1+\gamma\Delta T) = V_0(1+2\alpha\Delta T) \Rightarrow \gamma = 2\alpha$

62 **(d)**

Amount of energy radiated $\propto$ (Temperature)^4

63 **(b)**

Heat current $\frac{Q}{t} \propto \frac{r^2}{l}$, from the given options, option (b) has higher value of $\frac{r^2}{l}$.

64 **(d)**

$$\theta_{\text{mix}} = \frac{m_W\theta_W - \frac{m_i L_i}{c_W}}{m_i + m_W} = \frac{100 \times 50 - 10 \times \frac{80}{1}}{10 + 100} = 38.2°\text{C}$$

65 **(a)**

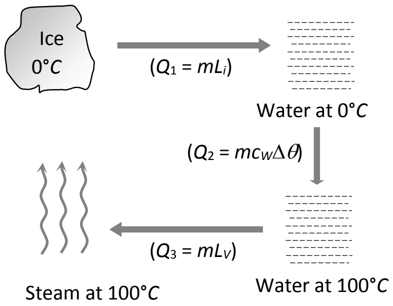
Water has maximum specific heat

66 **(c)**

Ice (0°C) converts into steam (100°C) in following three steps.

Total heat required $Q = Q_1 + Q_2 + Q_3$

$= 5 \times 80 + 5 \times 1 \times (100-0) + 5 \times 540 = 3600\ cal$



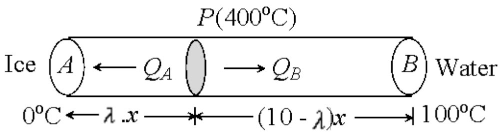
67 **(c)**

$$\frac{dQ}{dt} = -KA\frac{d\theta}{dx}$$

$\because \frac{dQ}{dt}$, K and A are constants for all points

$\Rightarrow d\theta \propto -dx$; *i.e.*, temperature will decrease linearly with x

68 **(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, $\frac{\frac{400}{\lambda\cdot x}}{\frac{300}{(10-\lambda)x}} = \frac{L_{ice}}{L_{vap}}$

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

69 **(c)**

$$\frac{d\theta}{dt} = \frac{\varepsilon A\sigma}{mc}4\theta_0^3\Delta\theta$$

For given sphere and cube $\frac{\varepsilon A\sigma}{mc}4\theta_0^3\Delta\theta$ is constant so for both rate of fall of temperature $\frac{d\theta}{dt} =$ constant

70 **(a)**

Change in volume, $\Delta V = V\gamma\,\Delta t$

$\Rightarrow \quad 0.24 = 100 \times \gamma \times 40$

$\gamma = \frac{0.24}{100\times 40}$

$= 0.00006 = 6 \times 10^{-5}$

$\alpha = \frac{\gamma}{3}$

$\Rightarrow \quad \alpha = 2 \times 10^{-5}{}^\circ\text{C}^{-1}$

71 **(c)**

Total energy radiated from a body

$Q = A\varepsilon\sigma T^4 t$

Or $\quad \frac{Q}{t} \propto AT^4$

$\frac{Q}{t} \propto r^2T^4 \qquad (\because \; A = 4\pi r^2)$

$$\frac{Q_1}{Q_2} = \left(\frac{r_1}{r_2}\right)^2 \left(\frac{T_1}{T_2}\right)^4 j = \left(\frac{8}{2}\right)^2 \left[\frac{273+127}{273+527}\right]^4 = 1$$

72 **(d)**

$\frac{A_T}{A_{2000}} = \frac{16}{1}$ [Given]

Area under $e_\lambda - \lambda$ curve represents the emissive power of body and emissive power $\propto T^4$

[Hence area under $e_\lambda - \lambda$ curve) $\propto T^4$

$$\Rightarrow \frac{A_T}{A_{2000}} = \left(\frac{T}{2000}\right)^4 \Rightarrow \frac{16}{1} = \left(\frac{T}{2000}\right)^4 \Rightarrow T = 4000K$$

73 **(d)**

Rate of cooling (here it is rate of loss of heat)

$$\frac{dQ}{dt} = (mc + W)\frac{d\theta}{dt} = (m_l c_l + m_c c_c)\frac{d\theta}{dt}$$

$$\Rightarrow \frac{dQ}{dt} = (0.5 \times 2400 + 0.2 \times 900)\left(\frac{60-55}{60}\right) = 115 \frac{J}{s}$$

74 **(b)**

According to Newton's law of cooling t_1 will be less than t_2.

75 **(b)**

$\gamma_r = \gamma_a + \gamma_v$; where γ_r = coefficient of real expansion,

γ_a = coefficient of apparent expansion and

γ_v = coefficient of expansion of vessel.

For copper $\gamma_r = C + 3\alpha_{Cu} = C + 3A$

For silver $\gamma_r = S + 3\alpha_{Ag}$

$$= C + 3A = S + 3\alpha_{Ag} \Rightarrow \alpha_{Ag} = \frac{C - S + 3A}{3}$$

76 **(a)**

An opaque body does not transmit any radiation, hence transmission coefficient of an opaque body is zero.

77 **(b)**

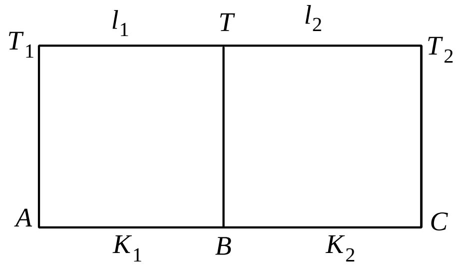
According to Wien's displacement law

$$\lambda_m T = b \text{ or } \lambda_m = \frac{b}{T} = \frac{0.0029}{5 \times 10^4} = 58 \times 10^{-9} m = 58nm$$

78 **(c)**

Let temperature at the interface is T.

For part AB,



$$\frac{Q_1}{t} \propto \frac{(T_1 - T)K_1}{l_1}$$

For part BC,

$$\frac{Q_2}{t} \propto \frac{(T - T_2)K_2}{l_2}$$

At equilibrium, $\frac{Q_1}{t} = \frac{Q_2}{t}$

$\therefore \qquad \frac{(T_1-T)K_1}{l_1} = \frac{(T-T_2)K_2}{l_2}$

$\Rightarrow \qquad T = \frac{T_1K_1l_2+T_2K_2l_1}{K_1l_2+K_2l_1}$

79 **(b)**

We can relate an absorbed energy Q and the resulting temperature increase ΔT with relation $Q = cm\Delta T$. In that equation, m is the mass of the material absorbing the energy and c is the specific heat of the material. An absorbed dose of 3 Gy corresponds to an absorbed energy per unit mass of 3 J/kg. Let us assume that c the specific heat of human body, is the same as that of water, 4180 J/kg K. Then we find that

$$\Delta T = \frac{Q/m}{c} = \frac{3}{4180} = 7.2 \times 10^{-4} K = 700\mu K$$

Obviously the damage done by ionizing radiation has nothing to do with thermal heating. The harmful effects arise because the radiation damages DNA and thus interferes with the normal functioning of tissues in which it is absorbed

80 **(d)**

$$\frac{Q}{t} = \frac{KA\Delta\theta}{l} \Rightarrow \frac{K_A}{K_B} = \frac{A_B}{A_A} = \left(\frac{r_B}{r_A}\right)^2 = \frac{1}{4} \Rightarrow K_A = \frac{K_B}{4}$$

81 **(c)**

When blue glass is heated at high temperature, it absorbs all the radiations of higher wavelength except blue. If it is taken inside a dark room, it emits all the radiation of higher wavelength, hence it looks brighter red as compared to the red piece

82 **(d)**

Initially on heating temperature rises from −73℃ (200K) to 0°(273K). Then ice melts and temperature does not rise. After the whole ice has melted, temperature begins to rise until it reaches 100℃ (373K). Then it becomes constant and after that it changes to vapours.

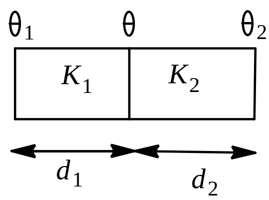
83 **(d)**

For cooking utensils, low specific heat is preferred for it's material as it should need less heat to raise it's temperature and it should have high conductivity, because, it should transfer heat quickly

85 **(c)**

For first slab,

Heat current, $H_1 = \frac{K_1(\theta_1-\theta)A}{d_1}$



For second slab,

Heat current, $H_2 = \frac{K_2(\theta-\theta_2)A}{d_2}$

As slabs are in series

$$H_1 = H_2$$

$\therefore \quad \frac{K_1(\theta_1-\theta)A}{d_1} = \frac{K_2(\theta-\theta_2)A}{d_2}$

$\Rightarrow \quad \theta = \frac{K_1\theta_1d_2+K_2\theta_2d_1}{K_2d_1+K_1d_2}$

86 **(c)**

$$\frac{E_2}{E_1}=\left(\frac{T_2}{T_1}\right)^4 \Rightarrow T_2=\left(\frac{E_2}{E_1}\right)^{1/4}\times T_1=(16)^{1/4}\times(273+127)$$

$\Rightarrow T_2 = 800\ K = 527°\text{C}$

87 **(b)**

Since the curved surface of the conductor is thermally insulated, therefore, in steady state, the rate of flow of heat at every section will be the same. Hence the curve between H and x will be straight line parallel to x-axis

88 **(b)**

Rate of cooling $=\frac{-d\theta}{dt}\propto\left(\frac{\theta_1+\theta_2}{2}-\theta_0\right)$

In second case average temperature will be less hence rate of cooling will be less. Therefore time taken will be more than 4 minutes

89 **(c)**

Let m gram of water, whose temperature is $\theta(>30°\text{C})$, be added to 20 g of water at 30°C. If $m\times 1(\theta-\theta_0)=20\times 1(\theta_0-30)$

$(m+20)\theta_0=60+m\theta$

$\theta_0=\frac{600+m\theta}{20+m}$

For θ_0 to be maximum m should be small and θ should be large

90 **(d)**

$(Q)_{Black\ body}=A\sigma T^4 t\Rightarrow Q\propto T^4$

$$\Rightarrow Q_2=Q_1\left(\frac{T_2}{T_1}\right)^4=10\left(\frac{273+327}{273+27}\right)^4=10\left(\frac{600}{300}\right)^4=160J$$

91 **(b)**

At low temperature short wavelength radiation is emitted. As the temperature rises colour of emitted radiations are in the following order

Red → Yellow → Blue → White (at highest temperature)

92 **(b)**

For parallel combination of two rods of equal length and equal area of cross-section.

$$K=\frac{K_1+K_2}{2}=\frac{K_1+\frac{4K_1}{3}}{2}$$

$=\frac{7K_1}{6}$

Hence , $\frac{K}{K_1}=\frac{7}{6}$

93 **(b)**

$$Q=mL=KA\frac{(\theta_1-\theta_2)}{l}t\Rightarrow m=\frac{1}{L}\times KA\frac{(\theta_1-\theta_2)}{l}\times t$$

$$=\frac{1}{80}\times 0.2\times 4\times\frac{(100-0)}{\sqrt{4}}\times 10\times 60\ [\because l^2=4\Rightarrow l=\sqrt{4}]$$

$$=\frac{0.2\times 4\times 100\times 600}{80\times 2}=300\ gm$$

94 **(b)**

Temperature of interface $\theta=\frac{K_1\theta_1+K_2\theta_2}{K_1+K_2}$

Where $K_1=2K$ and $K_2=3K$ $\left[\because\frac{K_1}{K_2}=\frac{2}{3}\right]$

$$\Rightarrow\theta=\frac{2K\times 100+3K\times 0}{2K+3K}=\frac{200K}{5K}=40°\text{C}$$

95 **(c)**

$$\frac{F-32}{9}=\frac{K-273}{5}\Rightarrow\frac{F-32}{9}=\frac{0-273}{5}$$
$\Rightarrow F=-459.4^{o}F=-460°F$

96 **(b)**

$Y=\frac{FL}{Al}$ where Y is Young's modulus, A is area

$\Rightarrow F=\frac{YAl}{L}$ ... (i)

From the formula for linear expansion

$\alpha=\frac{l}{L\times100}$ ... (ii)

According to the condition the bar should not bend or expand

Now from equations (i) and (ii)

$F=YA\times100\alpha$

Hence, force is independent of length L

97 **(c)**

$\lambda_m T=\text{constant}$

99 **(b)**

Work done to raise the temperature of 100 gm water through 10°C is

$W=JQ=4.2\times(100\times10^{-3}\times1000\times10)=4200\,J$

100 **(a)**

$$W=JQ\Rightarrow\frac{1}{2}I\omega^2=J(MS\Delta\theta)$$
$$\Rightarrow\frac{1}{2}\left(\frac{2}{5}MR^2\right)\omega^2=J(MS\Delta\theta)\Rightarrow\Delta\theta=\frac{1}{5}\frac{R^2\omega^2}{JS}$$

101 **(b)**

We know that heat lost $=mc\theta$

For a given quantity of heat, we must need a minimum mass of water for cooling the radiators due to a high value of specific heat

102 **(b)**

Suppose $m\,kg$ if ice melts then by using $\underset{(\text{Joules})}{W}=\underset{(\text{Joules})}{H}$

$\Rightarrow Mgh=mL\Rightarrow3.5\times10\times2000=m\times3.5\times10^5$

$\Rightarrow m=0.2\,kg=200\,gm$

103 **(c)**

$$L=L_0(1+\alpha\Delta\theta)\Rightarrow\frac{L_1}{L_2}=\frac{1+\alpha(\Delta\theta)_1}{1+\alpha(\Delta\theta)_2}$$
$$\Rightarrow\frac{10}{L_2}=\frac{1+11\times10^{-6}\times20}{1+11\times10^{-6}\times19}\Rightarrow L_2=9.99989$$

$\Rightarrow$ Length is shorten by

$10-9.99989=0.00011=11\times10^{-5}cm$

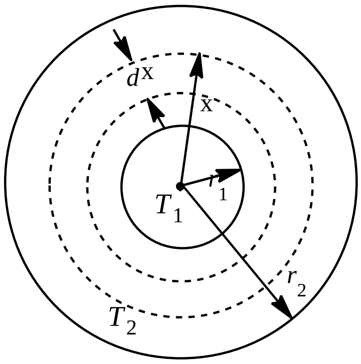
104 **(b)**

$$Q\propto T^4\Rightarrow\frac{Q_1}{Q_2}=\frac{T_1^4}{T_2^4}\Rightarrow T_2^4=\left(\frac{E_2}{E_1}\right)T_1^4$$
$$\Rightarrow T_2^4=\frac{1}{16}\times(1000)^4=\left(\frac{1000}{2}\right)^4$$

$\Rightarrow T_2=500K$

105 **(c)**

To measure the radial rate of heat flow, we have to go for integration technique as here the area of the surface through which heat will flow is not constant.



Let us consider an element (spherical shell) of thickness dx and radius x as shown in figure. Let us first find the equivalent thermal resistance between inner and outer sphere.

Resistance of shell$=dR = \frac{dx}{K\times 4\pi x^2}$

$\left(\begin{matrix}\text{From } R=\frac{l}{KA} \text{ where,} \\ K=\text{thermal conductivity}\end{matrix}\right)$

$\Rightarrow \quad \int dR = R = \int_{r_1}^{r_2} \frac{dx}{4\pi K x^2}$

$= \frac{1}{4\pi K}\left[\frac{1}{r_1} - \frac{1}{r_2}\right] = \frac{r_2 - r_1}{4\pi K(r_1 r_2)}$

Rate of heat flow $= H$

$= \frac{T_1 - T_2}{R}$

$= \frac{T_1 - T_2}{r_2 - r_1} \times 4\pi K(r_1 r_2)$

$\propto \frac{r_1 r_2}{r_2 - r_1}$

106 **(c)**

When pressure increases boiling point also increases

107 **(c)**

Newton's law of cooling is used for the determination of specific heat of liquids

108 **(d)**

$\frac{X - LFP}{UFP - LFP} = \text{constant}$

Where $X =$ Any given temperature on that scale

L. F. P. = Lower fixed point (Freezing point)

U. F. P. = Upper fixed point (Boiling point)

$\frac{W - 39}{239 - 39} = \frac{39 - 0}{100 - 0}$

$\Rightarrow \frac{W - 39}{200} = \frac{39}{100} \Rightarrow W = 78 + 39 \Rightarrow W = 117^{o}W$

109 **(c)**

Water will overflow, both when heated or cooled because water has maximum density at 4°C or minimum volume at 4°C

110 **(d)**

Temperature of mixture $\theta = \frac{m_1 c_1 \theta_1 + m_2 c_2 \theta_2}{m_1 c_1 + m_2 c_2}$

$\Rightarrow 32 = \frac{m_1 \times 0.2 \times 40 + 100 \times 0.5 \times 20}{m_1 \times 0.2 + 100 \times 0.5} \Rightarrow m_1 = 375 gm$

111 **(b)**

$\frac{Q}{t} = \frac{KA(\theta_1 - \theta_2)}{l} = \frac{0.2 \times 10 \times 20}{2 \times 10^{-3}} = 2 \times 10^4 J/s$

112 **(a)**

According to Wien's law $\lambda_m T$ = constant, on heating up to ordinary temperatures, only long wavelength (red) radiation is emitted. As the temperature rises, shorter wavelengths are also emitted in more and more quantity. Hence the colour of radiation emitted by the hot wire shifts from red to yellow, then to blue and finally to white

113 **(a)**

Density of water is maximum at 4°C and is less on either side of this temperature

114 **(d)**

$\frac{Q_1}{Q_2} = \left(\frac{T_1}{T_2}\right)^4 = \left(\frac{273+27}{273+927}\right)^4 = \left(\frac{1}{4}\right)^4 = \frac{1}{256}$

115 **(b)**

$\Delta t = \frac{\Delta Q(\Delta x)}{KA(\Delta T)}$

When two rods of same length are joined in parallel,

$A \rightarrow 2$ and $(\Delta x) \rightarrow \frac{1}{2}$ times

$\therefore$ Δt becomes $\frac{1}{4}$ times *ie*, $\frac{1}{4} \times 12s = 3s$

116 **(c)**

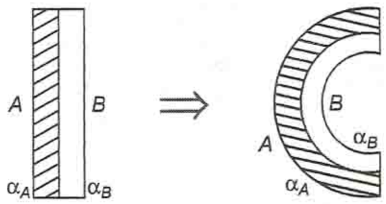
Infinite thermal capacity implies that there would be practically no change in temperature whether heat is taken in or given out.

117 **(c)**

When light incident on pin hole, enters into the box and suffers successive reflection at the inner wall. At each reflection some energy is absorbed. Hence the ray once it enters the box can never come out and pin hole acts like a perfect black body

118 **(c)**

A bimetallic strip on being heated bends in from of an arc with more expandable metal (A) outside (as shown)



119 **(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 $Q_2 \geq Q_1$

$i.e., \frac{3}{8}mv^2 \times 10^{-3} \geq 15m \times 4.2 \Rightarrow v_{\min} = 410m/s$

120 (a)

$$\theta = \frac{\Delta L}{L_0 \Delta\alpha} = \frac{(1-0.9997)}{0.9997 \times 12 \times 10^{-6}} = 25°\text{C}$$

121 (c)

Pyrometer can measure temperature from 800°C to 6000°C. Hence temperature of sun is measured with pyrometer

122 (b)

If the ball is heated then it will expand at free surface, so the ball will expand at outer and inner both surfaces. Hence, the volume of cavity which is inside the ball, decreases.

123 (c)

$$\frac{F-32}{9} = \frac{K-273}{5} \Rightarrow \frac{x-32}{9} = \frac{x-273}{5} \Rightarrow x = 574.25$$

124 (c)

According to Newton's law of cooling

Rate of cooling ∝ mean temperature difference

Initially, mean temperature difference

$$= \left(\frac{70+60}{2} - \theta_0\right) = (65 - \theta_0)$$

Finally, mean temperature difference

$$= \left(\frac{60+50}{2} - \theta_0\right) = (55 - \theta_0)$$

In second case mean temperature difference decreases, so rate of fall of temperature decreases, so it takes more time to cool through the same range

126 (c)

For a black body $\frac{Q}{t} = P = A\sigma T^4$

$$\Rightarrow \frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^4 \Rightarrow \frac{P_2}{20} = \left(\frac{273+727}{273+227}\right)^4$$

$$\Rightarrow \frac{P_2}{20} = (2)^4 \Rightarrow P_2 = 320W$$

127 (d)

In conducting rod given heat transmits so burning temperature does not reach soon. In wooden rod heat doesn't conducts

128 (a)

When the temperature of an object is equal to that of human body, no heat is transferred from the object to body and vice versa. Therefore block of wood and block of metal feel equally cold and hot if they have same temperature as human body

129 (c)

Relative humidity at a given temperature (R)

$$= \frac{\text{Partial pressure of water vapour}}{\text{Vapour pressure of water}}$$

$$= \frac{0.012\times10^5}{0.016\times10^5} = 0.75 = 75\%$$

130 (c)

Energy radiated per unit time

$$E = \sigma A T^4$$

Where σ = Stefan's constant

∴ For sun $E_{\text{sun}} = \sigma A_{\text{sun}} T_{\text{sun}}^4$

According to question

$$E_{\text{star}} = 10000 E_{\text{sun}}$$

$$\sigma A_{\text{star}} \times T_{\text{star}}^4 = 10000 \times \sigma A_{\text{sun}} \times T_{\text{sun}}^4$$

$$\pi R_{\text{star}}^2 T_{\text{star}}^4 = 10000 \times \pi R_{\text{sun}}^2 \times T_{\text{sun}}^4$$

$$\left(\frac{R_{\text{star}}}{R_{\text{sun}}}\right)^2 = 10000 \left(\frac{T_{\text{sun}}}{T_{\text{star}}}\right)^4$$

$$= 10000 \left(\frac{6000}{2000}\right)^4$$

$$\Rightarrow \quad \frac{R_{\text{star}}}{R_{\text{sun}}} = \sqrt{10000 \times (3)^4}$$

$$= 100 \times 3^2 = 900$$

$R_{\text{star}} : R_{\text{sun}} = 900 : 1$

131 **(c)**

According to Stefan's law

$$E = \sigma T^4$$

Where σ is Stefan's constant.

Given, $T = 2T_s$

$\therefore \quad E' = \sigma (2T_s)^4 = 16 \sigma T_s^4 = 16 E_s$

Hence, total energy radiated by star is sixteen times as that of the sun.

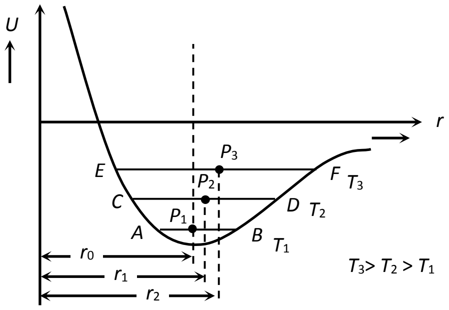
132 **(b)**

For a black body rate of energy $\frac{Q}{t} = P = A\sigma T^4$

$$\Rightarrow P \propto T^4 \Rightarrow \frac{P_1}{P_2} = \left(\frac{T_1}{T_2}\right)^4 = \left\{\frac{(273+7)}{(273+287)}\right\}^4 = \frac{1}{16}$$

133 **(d)**

The expansion of solids can be well understood by potential energy curve for two adjacent atoms in a crystalline solid as a function of their intermolecular separation (r).



At ordinary temperature: Each molecule of the solid vibrates about it's equilibrium position P_1 between A and B (r_0 is the equilibrium distance of it from some other molecule)

At high temperature: Amplitude of vibration increases ($C \leftrightarrow D$ and $E \leftrightarrow F$). Due to asymmetry of the curve, the equilibrium positions (P_2 and P_3) of molecule is displaced. Hence it's distance from other molecules increses ($r_2 > r_1 > r_0$).

Thus, on raising the temperature, the average equilibrium between the molecules increases and the solid as a whole expands

134 **(b)**

$$\frac{C}{5} = \frac{F-32}{9} \Rightarrow \frac{25}{5} = \frac{F-32}{9} = F = 77^{\circ}F$$

135 **(d)**

$n = 8\, mole, \Delta t = 30°\text{C}$

$\theta = nc_p \Delta t$

$\theta = 8 \times \frac{5}{2} \times 8.31 \times 30 = 5000$

136 **(b)**

We know that $\frac{dQ}{dt} = kA\frac{d\theta}{dx}$

In steady state flow of heat

$$d\theta = \frac{dQ}{dt} \cdot \frac{1}{kA} dx$$

$\Rightarrow \quad \theta_H - \theta = k'x$

$\Rightarrow \quad \theta = \theta_H - k'x$

Equation $\theta = \theta_H - k'x$ represents a straight line.

137 **(b)**

When salt crystals dissolve, crystal lattice is destroyed. The process requires a certain amount of energy (latent heat) which is taken from the water.

In vessel (B), a part of intermolecular bonds has already been destroyed in crushing the crystal. Hence less energy is required to dissolve the powder and the water will be at higher temperature

139 **(c)**

A lake cools from the surface to bottom. Above 4°C the cooled water at the surface flows to the bottom because of it's greater density. But when the surface temperature drops below 4°C (here it is 2°C), the water near the surface is less dense than the warmer water below. Hence the downward flow ceases, the water at the bottom remains at 4°C until nearly the entire lake, is frozen

Assertion - Reasoning Type

This section contain(s)30 questions numbered 1 to 30. 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

1 **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

2 **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

3 **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

4 **Statement 1:** Radiation is the speediest mode of heat transfer
Statement 2: Radiation can be transmitted in zig-zag motion

5 **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
$$\frac{1}{K}=\frac{1}{K_1}+\frac{1}{K_2}$$

6 **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

7 **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

8 **Statement 1:** Animals curl into a ball, when they feel very cold
Statement 2: Animals by curling their body reduce the surface area

9 **Statement 1:** The melting point of ice decreases with increase of pressure
Statement 2: Ice contracts on melting

10 **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.

11 **Statement 1:** Blue star is at high temperature than red star
Statement 2: Wien's displacement law states that $T \propto (1/\lambda_m)$

12 **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

13 **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

14 **Statement 1:** Like light radiations, thermal radiation are also electromagnetic radiation
Statement 2: The thermal radiations require no medium for propagation

15	**Statement 1:**	All black coloured objects are considered black bodies
	Statement 2:	Black colour is a good absorber of heat
16	**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
17	**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
18	**Statement 1:**	Temperatures near the sea coast are moderate
	Statement 2:	Water has a high thermal conductivity
19	**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
20	**Statement 1:**	Bodies radiate heat at all temperatures
	Statement 2:	Rate of radiation of heat is proportional to the fourth power of absolute temperature
21	**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
22	**Statement 1:**	Woolen clothes keep the body warm in winter
	Statement 2:	Air is a bad conductor of heat
23	**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
24	**Statement 1:**	Perspiration from human body helps in cooling the body
	Statement 2:	A thin layer of water on the skin enhances its emissivity
25	**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
26	**Statement 1:**	Snow is better insulator than ice
	Statement 2:	Snow contains air packet and air is good insulator of heat
27	**Statement 1:**	Fahrenheit is the smallest unit measuring temperature
	Statement 2:	Fahrenheit was the first temperature scale used for measuring temperature
28	**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
29	**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
30	**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

: ANSWER KEY :

1)	c	2)	c	3)	a	4)	c	5)	d
6)	b	7)	c	8)	a	9)	a	10)	a
11)	a	12)	d	13)	c	14)	b	15)	d
16)	d	17)	a	18)	b	19)	c	20)	d
21)	a	22)	a	23)	c	24)	c	25)	c
26)	a	27)	c	28)	b	29)	d	30)	c

: HINTS AND SOLUTIONS :

1 **(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

2 **(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

3 **(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

4 **(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

5 **(d)**

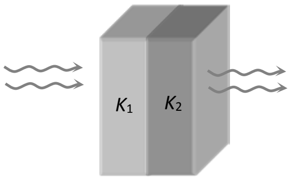
Equivalent thermal conductivity of two equally thick plates in series combination is given by

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

If $K_1 > K_2$

Then $K_1 < K < K_2$

Hence assertion and reason both are false



6 **(b)**

Both assertion and reason are true but reason is not correctly explaining the assertion

7 **(c)**

The relation between F and C scale is, $\frac{C}{5} = \frac{F-32}{9}$. If $F = C \Rightarrow C = -40°C$, $i.e.$, at -40^{o} the Centigrade and Fahrenheit thermometers reads the same

8 **(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

9 **(a)**

With rise in pressure melting point of ice decreases. Also ice contracts on melting

10 **(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

11 **(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

12 **(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

13 **(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

14 **(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

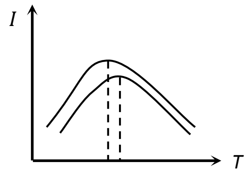
15 **(d)**
It is not necessary that all black coloured objects are black bodies. For example, if we take a black surface which is highly polished, it will not behave as a perfect black body
A perfectly black body absorbs all the radiations incident on it

16 **(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

17 **(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

18 **(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

19 **(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



20 **(d)**
Assertion is false because at absolute zero ($0\ K$), heat is neither radiated nor absorbed. Reason is the statement of Stefan's law, as $E \propto T^4$

21 **(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

22 **(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

23 **(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

24 **(c)**
When water leaves the body through perspiration energy content of molecules remained in body decreases, therefore temperature also decreases

25 **(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 $E = \sigma T^4$

26 **(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

27 **(c)**
Celsius scale was the first temperature scale and Fahrenheit is the smallest unit measuring temperature

28 **(b)**
This is in accordance with the Stefan's law $E \propto T^4$

29 **(d)**
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

30 **(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

Matrix - Match Type

This section contain(s) 1 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**.

1. 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

: ANSWER KEY :

1)	a