Exercise - I (OBJECTIVE PROBLEMS)

1. 10 gm of ice at 0°C is kept in a calorimeter of water equivalent 10 gm. How much heat should be supplied to the apparatus to evaporate the water thus formed? (Neglect loss of heat)
(A) 6200 cal (B) 7200 cal
(C) 13600 cal (D) 8200 cal

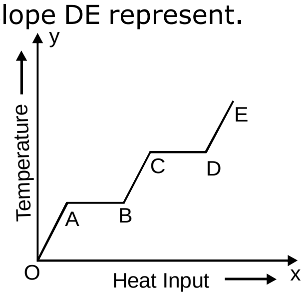
2. Heat is being supplied at a constant rate to a sphere of ice which is melting at the rate of 0.1 gm/sec. It melts completely in 100 sec. The rate of rise of temperature thereafter will be (Assume no loss of heat)
(A) 0.8 °C/sec (B) 5.4 °C/sec
(C) 3.6 °C/sec (D) will change with time

3. A 2100 W continuous flow geyser (instant geyser) has water inlet temperature = 10°C while the water flows out at the rate of 20 g/sec. The outlet temperature of water must be about
(A) 20°C (B) 30°C
(C) 35°C (D) 40°C

4. A continuous flow water heater (geyser) has an electrical power rating = 2 k W and efficienty of conversion of electrical power into heat = 80%. If water is flowing through the device at the rate of 100 cc/sec, and the inlet temperature is 10 °C, the oulet temperature will be
(A) 12.2 °C (B) 13.8 °C
(C) 20 °C (D) 16.5 °C

5. Ice at 0°C is added to 200 g of water initially at 70°C in a vacuum flask. When 50 g of ice has been added and has all melted the temperature of the flask and contents is 40°C. When a further 80 g of ice has been added and has all metled, the temperature of the whole is 10°C. Calculate the specific latent heat of fusion of ice.
[Take S_w = 1 cal/gm °C]
(A) 3.8×10^5 J/kg (B) 1.2×10^5 J/kg
(C) 2.4×10^5 J/kg (D) 3.0×10^5 J/kg

6. A solid material is supplied with heat at a constant rate. The temperature of material is changing with heat input as shown in the figure. What does slope DE represent.

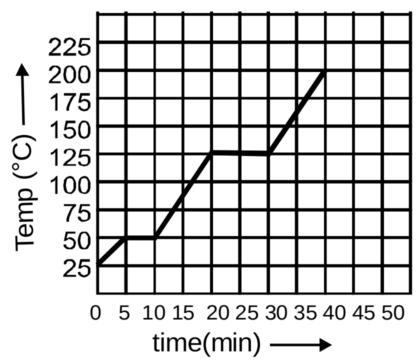


(A) latent heat of liquid
(B) latent heat of vapour
(C) heat capacity of vapour
(D) inverse of heat capacity of vapour

7. A block of ice with mass m falls into a lake. After impact, a mass of ice m/5 melts. Both the block of ice and the lake have a temperature of 0°C. If L represents the heat of fusion, the minimum distance the ice fell before striking the surface is
(A) $\frac{L}{5g}$ (B) $\frac{5L}{g}$ (C) $\frac{gL}{5m}$ (D) $\frac{mL}{5g}$

8. The specific heat of a metal at low temperatures varies according to $S = aT^3$ where a is a constant and T is absolute temperature. The heat energy needed to raise unit mass of the metal from T = 1 K to T = 2 K is
(A) 3a (B) $\frac{15a}{4}$ (C) $\frac{2a}{3}$ (D) $\frac{12a}{5}$

9. The graph shown in the figure represent change in the temperature of 5 kg of a substance as it abosrbs heat at a constant rate of 42 kJ min^{-1}. The latent heat of vapourization of the substance is :



(A) 630 kJ kg^{-1} (B) 126 kJ kg^{-1}
(C) 84 kJ kg^{-1} (D) 12.6 kJ kg^{-1}

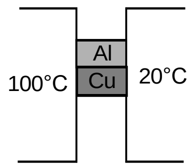
10. The density of a material A is 1500 kg/m^3 and that of another mateial B is 2000 kg/m^3. It is found that the heat capacity of 8 volumes of A is equal to heat capacity of 12 volumes of B. The ratio of specific heats of A and B will be
(A) 1 : 2 (B) 3 : 1
(C) 3 : 2 (D) 2 : 1

11. Find the amount of heat supplied to decrease the volume of an ice water mixture by 1 cm^3 without any change in temperature. (ρ_{ice}= 0.9 ρ_{water}, L_{ice} = 80 cal/gm)
(A) 360 cal (B) 500 cal
(C) 720 cal (D) none of these

12. Some steam at 100°C is passed into 1.1 kg of water contained in a calorimeter of water equivalent 0.02 kg at 15°C so that the temperature of the calorimeter and its contents rises to 80°C. What is the mass of steam condensing. (in kg)
(A) 0.130 (B) 0.065
(C) 0.260 (D) 0.135

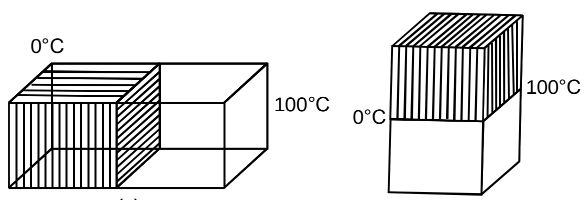
13. A wall has two layers A and B, each made of different material. Both the layers have the same thickness. The thermal conductivity for A is twice that of B. Under steady state, the temperature difference across the whole wall is 36°C. Then the temperature difference across the layer A is
(A) 6°C (B) 12°C
(C) 18°C (D) 24°C

14. Two metal cubes with 3 cm-edges of copper and aluminium are arranged as shown in figure.
(K_{CU} = 385 W/m-K, K_{AL} = 209 W/m-K) (K_{CU} = 385 W/m-K, K_{AL} = 209 W/m-K)
(a) The total thermal current from one reservoir to the other is :



(A) 1.43×10^3 W (B) 2.53×10^3 W
(C) 1.53×10^4 W (D) 2.53×10^4 W
(b) The ratio of the thermal current carried by the copper cube to that carried by the aluminium cube is -
(A) 1.79 (B) 1.69
(C) 1.54 (D) 1.84

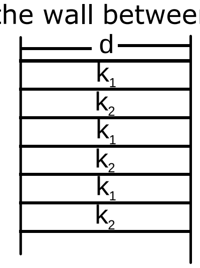
15. Two identical square rods of metal are welded end to end as shown in figure (a). Assume that 10 cal of heat flows through the rods in 2 min. Now the rods are welded as shown in figure. (b) The time it would take for 10 cal to flow through the rods now, is : -



(a) (b)

(A) 0.75 min (B) 0.5 min
(C) 1.5 min (D) 1 min

16. A wall consists of alternating blocks with length 'd' and coefficint of thermal conductivity k_1 and k_2. The cross sectional area of the blocks are the same. The equivalent coefficient of thermal conductivity of the wall between left and right is



(A) $K_1 + K_2$ (B) $\frac{(K_1+K_2)}{2}$
(C) $\frac{K_1K_2}{K_1+K_2}$ (D) $\frac{2K_1K_2}{K_1+K_2}$

17. A pot with a steel bottom 1.2 cm thick rests on a hot stove. The area of the bottom of the pot is 0.150 m^2. The water inside the pot is at 100°C and 0.440 kg vapourise in every 5 minutes. The temperature of the lower surface of the pot, which is in contact with the stove is (Given : L_v = 2.256×10^6 J/kg and K_{steel} = 50.2 W/m-K)
(A) 105.3 °C (B) 205.3 °C
(C) 185.3 °C (D) 115.3 °C

18. A lake surface is exposed to an atmosphere where the temperature is < 0°C. If the thickness of the ice layer formed on the surface grows from 2 cm to 4 cm in 1 hour, The atmospheric temperature, T_a will be -
(Thermal conductivity of ice K = 4×10^{-3} cal/cm/s/°C; density of ice = 0.9 gm/cc. Latent heat of fusion of ice = 80 cal/gm. Neglect the change of density during the state change. Assume that the water below the ice has 0°c temperature every where) -
(A) –20°C (B) 0°C
(C) –30°C (D) –15°C

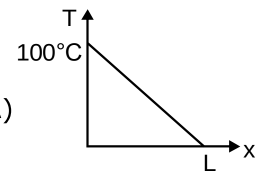
19. One end of a 2.35m long and 2.0cm radius aluminium rod (K = 235 $W.m^{-1}K^{-1}$) is held at 20°C. The other end of the rod is in contact with a block of ice at its melting point. The rate in kg. s^{-1} at which ice melts is
(A) $48\pi \times 10^{-6}$ (B) $24\pi \times 10^{-6}$
(C) $2.4\pi \times 10^{-6}$ (D) $4.8\pi \times 10^{-6}$

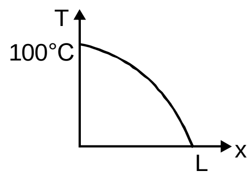
[Take latent heat of fusion for ice as $\frac{10}{3} \times 10^5$ $J.kg^{-1}$]

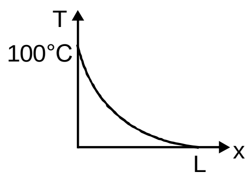
20. Four rods of same material with different radii r and length *l* are used to connect two reservoirs of heat at different temperatures. Which one will conduct most heat ?
(A) r = 2cm, *l* =0.5m (B) r=2cm, *l* =2m
(C) r=0.5cm, *l* =0.5m (D) r =1cm, *l* = 1 m

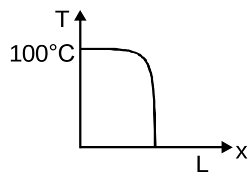
21. A cylinder of radius R made of a material of thermal conductivity k_1 is surrounded by a cylindrical shell of inner radius R and outer radius 2R made of a material of thermal conductivity k_2. The two ends of the combined system are maintained at different temperatures. There is no loss of heat from the cylindrical surface and the system is in steady state. The effective thermal conductivity of the system is
(A) $k_1 + k_2$ (B) $\frac{k_1k_2}{k_1+k_2}$
(C) $\frac{1}{4}(k_1+3k_2)$ (D) $\frac{1}{4}(3k+k_2)$

22. A rod of length L and uniform cross-sectional area has varying thermal conductivity which changes linearly from 2K at end A to K at the other end B. The ends A and B of the rod are maintained at constant temperature 100°C and 0°C, respectively. At steady state, the graph of temperature : T = T(x) where x = distance from end A will be

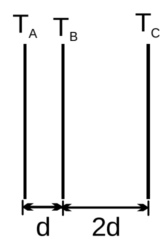
(A) 

(B) 

(C) 

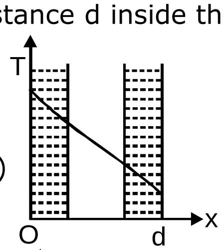
(D) 

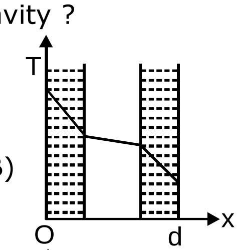
23. Two sheets of thickness d and 2d and same area are touching each other on their face. Temperature T_A, T_B, T_C shown are in geometric progression with common ratio r = 2. Then ratio of thermal conductivity of thinner and thicker sheet are

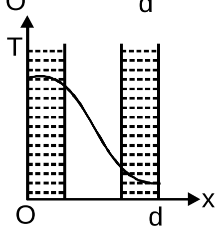


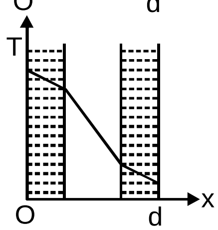
(A) 1 (B) 2 (C) 3 (D) 4

24. The wall with a cavity consists of two layers of brick separated by a layer of air. All three layers have the same thickness and the thermal conductivity of the brick is much greater than that of air. The left layer is at a higher temperature than the right layer and steady state condition exists. Which of the following graphs predicts correctly the variation of temperature T with distance d inside the cavity ?

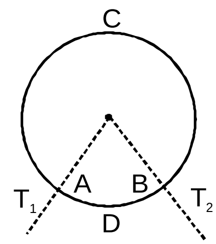
(A) 

(B) 

(C) 

(D) 

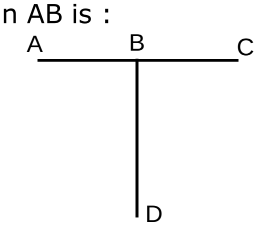
25. A ring consisting of two parts ADB and ACB of same conductivity k carries an amount of heat H. The ADB part is now replaced with another metal keeping the temperatures T_1 and T_2 constant. The heat carried increases to 2H. What should be the conductivity of the new ADB part? Given $\frac{ACB}{ADB} = 3$:



(A) $\frac{7}{3}k$ (B) 2 k

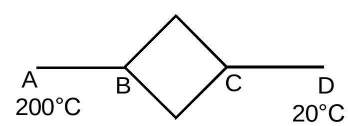
(C) $\frac{5}{2}k$ (D) 3 k

26. Three conducting rods of same material and cross-section are shown in figure. Temperatures of A, D and C are maintained at 20°C, 90°C and 0°C. The ratio of lengths of BD and BC if there is no heat flow in AB is :



(A) 2/7 (B) 7/2
(C) 9/2 (D) 2/9

27. Six identical conducting rods are joined as shown in figure. Points A and D are maintained at temperature of 200°C and 20°C respectively. The temperature of junction B will be :



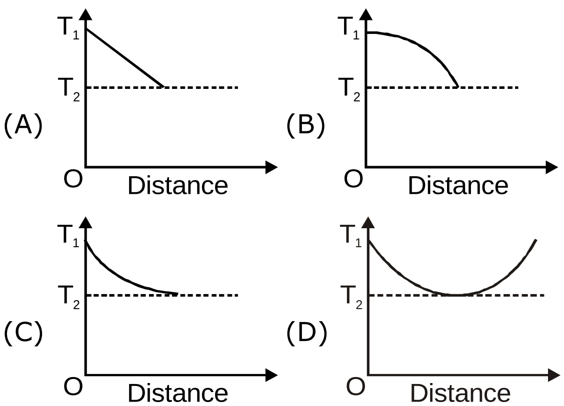
(A) 120° C (B) 100°C
(C) 140°C (D) 80°C

28. A metallic rod of cross-sectional area 9.0 cm^2 and length 0.54 m, with the surface insulated to prevent heat loss, has one end immersed in boiling water and the other in ice-water mixture. The heat conducted through the rod melts the ice at the rate of 1 gm for every 33 sec. The thermal conductivity of the rod is
(A) 330 $Wm^{-1}K^{-1}$ (B) 60 $Wm^{-1}K^{-1}$
(C) 600 $Wm^{-1}K^{-1}$ (D) 33 $Wm^{-1}K^{-1}$

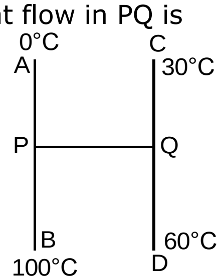
29. A hollow sphere of inner radius R and outer radius 2R is made of a material of thermal conductivity K. It is surrounded by another hollow sphere of inner radius 2R and outer radius 3R made of same material of thermal conductivity K. The inside of smaller sphere is maintained at 0°C and the outside of bigger sphere at 100°C. The system is in steady state. The temperature of the interface will be :

(A) 50°C (B) 70°C
(C) 75°C (D) 45°C

30. The ends of a metal bar of constant cross-sectional area are maintained at temperatures T_1 and T_2 which are both higher than the temperature of the surroundings. If the bar is unlagged, which one of the following sketches best represents the variation of temperature with distance along the bar?

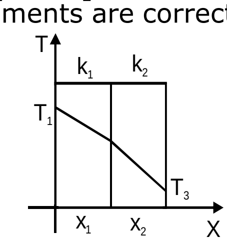


31. Three identical rods AB, CD and PQ are joined as shown. P an Q are mid points of AB and CD respectively. Ends A, B, C and D are maintained at 0°C, 100°C, 30°C and 60°C respectively. The direction of heat flow in PQ is



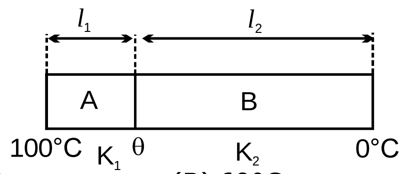
(A) from P to Q
(B) from Q to P
(C) heat does not flow in PQ
(D) data not sufficient

32. The temperature drop through each layer of two layer furnace wall is shown in figure. Assume that the external temperature T_1 and T_3 are maintained constant and $T_1 > T_3$. If the thickness of the layers x_1 and x_2 are the same, which of the following statements are correct.



(A) $k_1 > k_2$ (B) $k_1 < k_2$
(C) $k_1 = k_2$ but heat flow through material (1) is larger then through (2)
(D) $k_1 = k_2$ but heat flow through material (1) is less than that through (2)

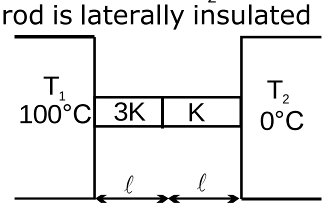
33. Two rods A and B of different materials but same cross section are joined as in figure. The free end of A is maintained at 100°C and the free end of B is maintained at 0°C. If $l_2 = 2l_1$, $K_1 = 2K_2$ and rods are thermally insulated from sides to prevent heat losses then the temperature θ of the junction of the two rods is



(A) 80°C (B) 60°C
(C) 40°C (D) 20°C

Question No. 34. to 36 (3 questions)

Two rods A and B of same cross-sectional are A and length l connected in series between a source (T_1 = 100°C) and a sink (T_2 = 0°C) as shown in figure. The rod is laterally insulated



34. The ratio of the thermal resistance of the rod is

(A) $\frac{R_A}{R_B} = \frac{1}{3}$ (B) $\frac{R_A}{R_B} = 3$

(C) $\frac{R_A}{R_B} = \frac{3}{4}$ (D) $\frac{4}{3}$

35. If T_A and T_B are the temperature drops across the rod A and B, then

(A) $\frac{T_A}{T_B} = \frac{3}{1}$ (B) $\frac{T_A}{T_B} = \frac{1}{3}$

(C) $\frac{T_A}{T_B} = \frac{3}{4}$ (D) $\frac{T_A}{T_B} = \frac{4}{3}$

36. If G_A and G_B are the temperature gradients across the rod A and B, then

(A) $\frac{G_A}{G_B} = \frac{3}{1}$ (B) $\frac{G_A}{G_B} = \frac{1}{3}$

(C) $\frac{G_A}{G_B} = \frac{3}{4}$ (D) $\frac{G_A}{G_B} = \frac{4}{3}$

37. Two sheets of thickness d and 3d, are touching each other. The temperature just outside the thinner sheet side is A, and on the side of the thicker sheet is C. The interface temperature is B. A, B and C are in arithmetic progressing, the ratio of thermal conductivity of thinner sheet and thicker sheet is

(A) 1 : 3 (B) 3 : 1
(C) 2 : 3 (D) 1 : 9

38. A cylindrical rod with one end in a steam chamber and the outer end in ice results in melting of 0.1 gm of ice per second. If the rod is replaced by another with half the length and double the radius of the first and if the thermal conductivity of material of second rod is 1/4 that of first, the rate at which ice melts is gm/sec will be
(A) 3.2 (B) 1.6
(C) 0.2 (D) 0.1

39. A composite rod made of three rods of equal length and cross-section as shown in the fig. The thermal conductivities of the materials of the rods are K/2, 5K and K respectively. The end A and end B are at constant temperatures. All heat entering the face A goes out of the end B there being no loss of heat from the sides of the bar. The effective thermal conductivity of the bar is

(A) 15K/16 (B) 6K/13
(C) 5K/16 (D) 2K/13.

40. A rod of length L with sides fully insulated is of a material whose thermal conductivity varies with temperature as $K = \frac{\alpha}{T}$, where α is a constant. The ends of the rod are kept at temperature T_1 and T_2. The temperature T at x, where x is the distance from the end whose temperature is T_1 is

(A) $T_1\left(\frac{T_2}{T_1}\right)^{\frac{x}{L}}$ (B) $\frac{x}{L}\ln\frac{T_2}{T_1}$

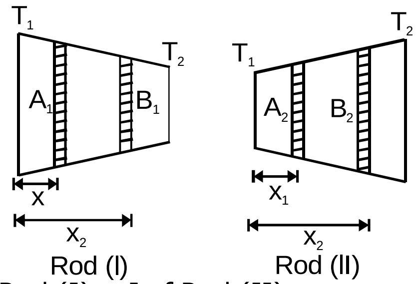
(C) $T_1 e^{\frac{T_2 x}{T_1 L}}$ (D) $T_1 + \frac{T_2 - T_1}{L}x$

41. Heat flows radially outward through a spherical shell of outside radius R_2 and inner radius R_1. The temperature of inner surface of shell is θ_1 and that of outer is θ_2. The radial distance from centre of shell where the temperature is just half way between θ_1 and θ_2 is :

(A) $\frac{R_1 + R_2}{2}$ (B) $\frac{R_1 R_2}{R_1 + R_2}$

(C) $\frac{2R_1 R_2}{R_1 + R_2}$ (D) $R_1 + \frac{R_2}{2}$

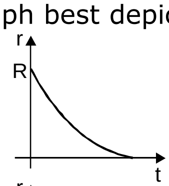
42. The two ends of two similar non-uniform rods of length ℓ each and thermal conductivity 'K' are maintained at different but constant temperature. The temperature gradient at any point on the rod is $\frac{\Delta T}{\Delta \ell}$. The heat flow per unit time through the rod is I : Given $T_1 > T_2$. Then which of the following is true:

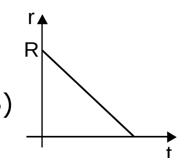


(A) I of Rod (I) = I of Rod (II)
(B) I of Rod (I) > I of Rod (II)
(C) I of Rod (I) < I of Rod (II)
(D) data is insufficient

43. A system S receives heat continuously from an electrical heater of power 10 W. The temperature of S becomes constant at 50°C when the surrounding temperature is 20°C. After the heater is switched off, S cools from 35.1 °C to 34.9 °C in 1 minute. The heat capacity of S is
(A) 100 J/°C (B) 300 J/°C
(C) 750 J/°C (D) 1500 J/°C

44. A sphere of ice at 0°C having initial radius R is placed in an environment having ambient temperature > 0°C. The ice melts uniformly, such that shape remains spherical. After a time 't' the radius of the sphere has reduced to r. Assuming the rate of heat absorption is proportional to the surface area of the sphere at any moment, which graph best depicts r(t).

(A)


(B)


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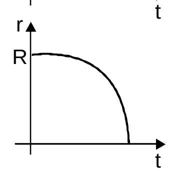
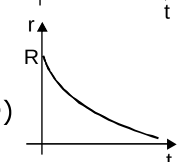


(D)


45. The power radiated by a black body is P and it radiates maximum energy around the wavelength λ_0. If the temperature of the black body is now changed so that it radiates maximum energy around wavelength $3/4\lambda_0$, the power radiated by it will increase by a factor of
(A) 4/3 (B) 16/9
(C) 64/27 (D) 256/81

46. A black metal foil is warmed by radiation from a small sphere at temperature 'T' and at a distance 'd'. It is found that the power received by the foil is P. If both the temperature and distance are doubled, the power received by the foil will be :
(A) 16 P (B) 4P
(C) 2 P (D) P

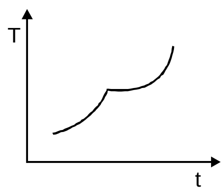
47. Star S_1 emits maximum radiation of wavelength 420 nm and the star S_2 emits maximum radiation of wavelength 560 nm, what is the ratio of the temperature of S_1 and S_2 :

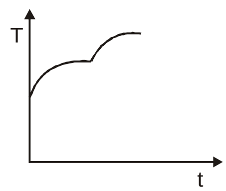
(A) 4/3 (B) $(4/3)^{1/4}$
(C) 3/4 (D) $(3/4)^{1/2}$

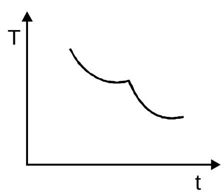
48. Spheres P and Q are uniformly constructed from the same material which is a good conductor of heat and the radius of Q is thrice the radius of P. The rate of fall of temperature of P is x times that of Q when both are at the same surface temperature. The value of x is :

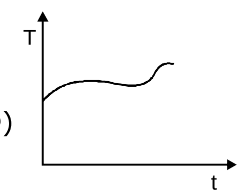
(A) 1/4 (B) 1/3
(C) 3 (D) 4

49. An ice cube at temperature –20°C is kept in a room at temperature 20°C. The variation of temperature of the body with time is given by

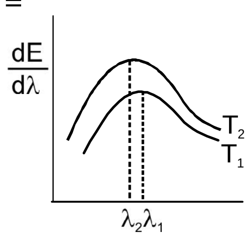
(A) 

(B) 

(C) 

(D) 

50. The spectral emissive power E_λ for a body at temperature T_1 is plotted against the wavelength and area under the curve is found to be A. At a different temperature T_2 the area is found to be 9A. Then λ_1/λ_2 =



(A) 3 (B) 1/3
(C) $1/\sqrt{3}$ (D) $\sqrt{3}$

51. The intensity of radiation emitted by the Sun has its maximum value at a wavelength of 510 nm and that emitted by the North Star has the maximum value at 350 nm. If these stars behave like black bodies then the ratio of the surface temperature of the Sun and the North Star is

(A) 1.46 (B) 0.69
(C) 1.21 (D) 0.83

52. Two bodies P and Q have thermal emissivities of ε_p and ε_Q respectively. Surface areas of these bodies are same and the total radiant power is also emitted at the same rate. If temperature of P is θ_P kelvin then temperature of Q i.e. θ_Q is

(A) $\left(\frac{\varepsilon_Q}{\varepsilon_P}\right)^{1/4}\theta_P$ (B) $\left(\frac{\varepsilon_P}{\varepsilon_Q}\right)^{1/4}\theta_P$

(C) $\left(\frac{\varepsilon_Q}{\varepsilon_P}\right)^{1/4}\times\frac{1}{\theta_P}$ (D) $\left(\frac{\varepsilon_Q}{\varepsilon_P}\right)^{4}\theta_P$

53. A black body calorimeter filled with hot water cools from 60ºC to 50ºC in 4 min and 40ºC to 30ºC in 8 min. The approximate temperature of surrounding is

(A) 10ºC (B) 15ºC
(C) 20ºC (D) 25ºC

54. The rate of emission of radiation of a black body at 273ºC is E, then the rate of emission of radiation of this body at 0ºC will be

(A) $\frac{E}{16}$ (B) $\frac{E}{4}$

(C) $\frac{E}{8}$ (D) 0

55. A body cools from 75°C to 65°C in 5 minutes. If the room temperature is 25°, then the temperature of the body at the end of next 5 minutes is :

(A) 57°C (B) 55°C
(C) 54°C (D) 53°

56. The temperature of a body falls from 40°C to 36°C in 5 minutes. when placed in a surrounding of constant temperature 16°C. Then the time taken for the temperature of the body to become 32°C is -

(A) 5 min (B) 4.3 min
(C) 6.1 min (D) 10.2 min.