12

Thermal Properties of Matter
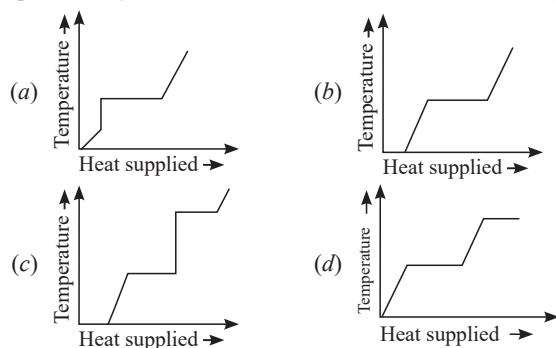
JEE-Main

Temperature, Thermal Expansion

1. With rise in temperature, the Young's modulus of elasticity
   [1 Feb, 2024 (Shift-I)]
   (a) changes erratically   (b) decreases
   (c) increases   (d) remains unchanged

2. A block of ice at –10°C is slowly heated and converted to steam at 100°C. Which of the following curves represent the phenomenon qualitatively: **[30 Jan, 2024 (Shift-II)]**


3. On celcius scale the temperature of body increases by 40°C. The increase in temperature on Fahrenheit scale is:
   [04 April, 2024 (Shift-I)]
   (a) 70°F   (b) 68°F   (c) 72°F   (d) 75°F

4. A hole is drilled in a metal sheet. At 27°C, the diameter of hole is 5 cm. When the sheet is heated to 177°C, the change in the diameter of hole is $d \times 10^{-3}$ cm. The value of d will be ____ if coefficient of linear expansion of the metal is 1.6×10^{-5}/°C. **[24 Jan, 2023 (Shift-I)]**

5. The graph between two temperature scales P and Q is shown in the figure. Between upper fixed point and lower fixed point there are 150 equal divisions of scale P and 100 divisions on scale Q. The relationship for conversion between the two scales is given by:
   [25 Jan, 2023 (Shift-II)]
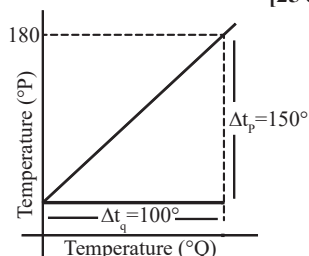
(a) $\dfrac{t_Q}{150} = \dfrac{t_P - 180}{100}$ (b) $\dfrac{t_Q}{100} = \dfrac{t_P - 30}{150}$

(c) $\dfrac{t_p}{180} = \dfrac{t_Q - 40}{100}$ (d) $\dfrac{t_P}{100} = \dfrac{t_Q - 180}{150}$

6. A thin rod having a length of 1m and area of cross-section 3×10^{-6} m^2 is suspended vertically from one end. The rod is cooled from 210°C to 160°C. After cooling, a mass M is attached at the lower end of the rod such that the length of rod again becomes 1m. Young's modulus and coefficient of linear expansion of the rod are 2×10^{11} Nm^{-2} and 2×10^{-5} K^{-1}, respectively. The value of M is ____ kg. (Take $g = 10$ ms^{-2}) **[31 Jan, 2023 (Shift-I)]**

7. On a temperature scale 'X'. The boiling point of water is 65º X and the freezing point is –15ºX. Assume that the X scale is linear. The equivalent temperature corresponding to –95ºX on the Farenheit scale would be: **[11 Apr, 2023 (Shift-I)]**
   (a) –63ºF   (b) –112ºF   (c) –48ºF   (d) –148º

8. A steel rod of length 1 m and cross sectional area 10^{-4} m^2 is heated from 0°C to 200°C without being allowed to extend or bend. The compressive tension produced in the rod is ____ $\times 10^4$ N (Given Young's modulus of steel = 2×10^{11} Nm^{-2}, coefficient of linear expansion = 10^{-5}K^{-1}. **[8 April, 2023 (Shift-II)]**

9. A faulty thermometer reads 5ºC in melting ice and 95ºC in steam. The correct temperature on absolute scale will be ____ K when the faulty thermometer reads 41ºC. **[30 Jan, 2023 (Shift-II)]**

10. At what temperature a gold ring of diameter 6.230 cm be heated so that it can be fitted on a wooden bangle of diameter. 6.241 cm? Both the diameters have been measured at room temperature (27ºC).
    (Given: coefficient of linear thermal expansion of gold $\alpha_L = 1.4 \times 10^{-5}$ K^{-1}) **[29 June, 2022 (Shift-II)]**
    (a) 125.7ºC   (b) 91.7ºC   (c) 425.7ºC   (d) 152.7ºC

11. A solid metallic cube having total surface area 24 m^2 is uniformly heated. If its temperature is increased by 10°C, calculate the increase in volume of the cube (Given: $\alpha = 5.0 \times 10^{-4}$ °C^{-1})
    [25 June, 2022 (Shift-II)]
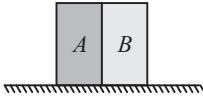   (a) 2.4×10^6 cm^3 (b) 1.2×10^5 cm^3
    (c) 6.0×10^4 cm^3 (d) 4.8×10^5 cm^3

12. A unit scale is to be prepared whose length does not change with temperature and remains 20cm, using a bimetallic strip made of brass and iron each of different length. The length of both components would change in such a way that difference between their length remains constant. If length of brass is 40 cm and length of iron will be ____ cm. **[25 July, 2022 (Shift-I)]**
    ($\alpha_{iron} = 1.2 \times 10^{-5}$K^{-1} and $\alpha_{brass} = 1.8 \times 10^{-5}$K^{-1}).

13. Given below are two statements: one is labelled as **Assertion A** and the other is labelled as **Reason R**.
Assertion A: When a rod lying freely is heated, no thermal stress is developed in it.
Reason R: On heating, the length of the rod increases.
In the light of the above statements, choose the correct answer from the options given below **[25 Feb, 2021 (Shift-I)]**
(*a*) Both A and R are true and R is the correct explanation of A
(*b*) A is false but R is true
(*c*) A is true but R is false
(*d*) Both A and R are true but R is NOT the correct explanation of A

14. Each side of a box made of metal sheet in cubic shape is 'a' at room temperature 'T', the coefficient of linear expansion of the metal sheet is 'α'. The metal sheet is heated uniformly, by a small temperature ΔT, so that its new temperature is $T + \Delta T$. Calculate the increase in the volume of the metal box. **[24 Feb, 2021 (Shift-I)]**
(*a*) $\frac{4}{3}\pi a^3 \alpha \Delta T$ (*b*) $3a^3 \alpha \Delta T$ (*c*) $4\pi a^3 \alpha \Delta T$ (*d*) $4a^3 \alpha \Delta T$

15. A bimetallic strip consists of metals A and B. It is mounted rigidly as shown. The metal A has higher coefficient of expansion compared to that metal B. When bimetallic strip is placed in a cold bath, it will **[16 March, 2021 (Shift-II)]**
(*a*) Neither bend nor shrink
(*b*) Not bend but shrink
(*c*) Bend towards the left
(*d*) Bend towards the right

A	B

16. A steel rod with $Y = 2.0 \times 10^{11}$ Nm^{-2} and $\alpha = 10^{-5}$ °C^{-1} of length 4 m and area of cross-section 10 cm^2 is heated from 0°C to 400°C without being allowed to extend. The tension produced in the rod is $x \times 10^5$ N where the value of x is ___. **[1 Sep, 2021 (Shift-II)]**

17. The area of cross-section of a railway track is 0.01 m^2. The temperature variation is 10°C. Coefficient of linear expansion of material of track is 10^{-5}/°C. The energy stored per meter in the track is J/m. (Young's modulus of material of track is 10^{11} Nm^{-2}) **[22 July, 2021 (Shift-II)]**

18. When the temperature of metal wire is increase from 0°C to 10°C, its length increase by 0.02%. The percentage change in its mass density will be closed to: **[2 Sep, 2020 (Shift-II)]**
(*a*) 0.008 (*b*) 0.8 (*c*) 0.06 (*d*) 2.3

19. Two different wires having lengths L_1 and L_2, and respective temperature coefficient of linear expansion α_1 and α_2, are joined end-to-end. Then the effective temperature coefficient of linear expansion is **[5 Sep, 2020 (Shift-II)]**
(*a*) $\sqrt[2]{\alpha_1 \alpha_2}$
(*b*) $\frac{4\alpha_1\alpha_2}{\alpha_1 + \alpha_2} \frac{L_2 L_1}{(L_2 + L_1)^2}$
(*c*) $\frac{\alpha_1 + \alpha_2}{2}$
(*d*) $\frac{\alpha_1 L_1 + \alpha_2 L_2}{L_1 + L_2}$

20. A non-isotropic solid metal cube has coefficients of linear expansion as: 5×10^{-5} /°C along the x-axis and 5×10^{-6} /°C along the y and the z-axis. If the coefficient of volume expansion of the solid is $C \times 10^{-6}$ /°C then the value of C is **[7 Jan, 2020 (Shift-I)]**

21. A bakelite beaker has volume capacity of 500 cc at 30°C. When it is partially filled with Vm volume (at 30°C) of mercury, it is found that the unfilled volume of the beaker remains constant as temperature is varied. If $\gamma_{beaker} = 6 \times 10^{-6}$ °C^{-1} and $\gamma_{mercury} = 1.5 \times 10^{-4}$ °C^{-1}, where γ is the coefficient of volume expansion, then Vm (in cc) is close to ___. **[3 Sep, 2020 (Shift-I)]**

22. A leak proof cylinder of length 1m, made of a metal which has very low coefficient of expansion is floating vertically in water at 0°C such that its height above the water surface is 20 cm. When the temperature of water is increased to 4°C, the height of the cylinder above the water surface becomes 21 cm. The density of water at $T = 4$°C, relative to the density at $T = 0$°C is close to: **[8 Jan, 2020 (Shift-I)]**
(*a*) 1.0 (*b*) 1.04 (*c*) 1.26 (*d*) 1.01

23. At 40°C, a brass wire of 1mm is hung from the ceiling. A small mass, M is hung from the free end of the wire. When the wire is cooled down from 40°C to 20°C it regains its original length of 0.2 m. The value of M is close to:
(Coefficient of linear expansion and Young's modulus of brass are 10^{-5}/°C and 10^{11} N/m^2, respectively; $g = 10$ ms^{-2}) **[12 April, 2019 (Shift-I)]**
(*a*) 0.5 kg (*b*) 9 kg (*c*) 0.9 kg (*d*) 1.5 kg

24. Two rods A and B of identical dimensions are at temperature 30°C. If a heated upto 180°C and B upto T°C, then the new lengths are the same. If the ratio of the coefficients of linear expansion of A and B is 4 : 3, then the value of T is: **[11 Jan, 2019 (Shift-II)]**
(*a*) 230°C (*b*) 270°C (*c*) 200°C (*d*) 250°C

25. A thermometer graduated according to a linear scale reads a value x_0 when in contact with boiling water, and $x_0/3$ when in contact with ice. What is the temperature of an object in °C, if this thermometer in the contact with the object reads $x_0/2$? **[11 Jan, 2019 (Shift-II)]**
(*a*) 25 (*b*) 60 (*c*) 40 (*d*) 45

Calorimetry, Heat Capacity

26. Heat energy of 184 kJ is given to a block of ice of mass 600g at –12°C, Specific heat of ice is $2222.3\,J\,kg^{-1}\,°C^{-1}$ and latent heat of ice in 336 kJ/kg^{-1} **[29 Jan, 2023 (Shift-II)]**
A. Final temperature of the system will be 0°C.
B. Final temperature of the system will be greater than 0°C.
C. The final system will have a mixture of ice and water in the ratio of 5 : 1.
D. The final system will have a mixture of ice and water in the ratio of 1 : 5.
E. The final system will have water only.
Choose the correct answer from the options given below:
(*a*) A and D only (*b*) B and D only
(*b*) A and E only (*d*) A and C only

27. A water heater of power 2000 W is used to heat water. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}. The efficiency of heater is 70%. Time required to heat 2 kg of water from 10°C to 60°C is _____ s.
(Assume that the specific heat capacity of water remains constant over the temperature range of the water). **[31 Jan, 2023 (Shift-II)]**

28. A copper block of mass 5.0 kg is heated to a temperature of 500°C and is placed on a large ice block. What is the maximum amount of ice that can melt? [Specific heat of copper: 0.39 J g^{-1} °C^{-1} and latent heat of fusion of water: 335 J g^{-1} °C^{-1}] **[25 June, 2022 (Shift-II)]**
(*a*) 1.5 kg (*b*) 5.8 kg (*c*) 2.9 kg (*d*) 3.8 kg

29. A lead bullet penetrates into a solid object and melts. Assuming that 40% of its kinetic energy is used to heat it, the initial speed of bullet is: **[27 June, 2022 (Shift-II)]**
(Given, initial temperature of the bullet = 127°C,
Melting point of the bullet = 327°C,
Latent heat of fusion of lead = 2.5×10^4 Jkg^{-1},
Specific heat capacity of lead= 125 J/kg K)
   (a) 125 ms^{-1} (b) 500 ms^{-1} (c) 250 ms^{-1} (d) 600 ms^{-1}

30. An ice cube of dimensions 60cm × 50cm × 20cm is placed in an insulation box of wall thickness 1cm. The box keeping the ice cube at 0ºC of temperature is brought to a room of temperature 40ºC. The rate of melting of ice is approximately: **[26 July, 2022 (Shift-II)]**
(Latent heat of fusion of ice is 3.4×10^5 J kg^{-1} and thermal conducting of insulation wall is 0.05 Wm^{-1}ºC^{-1})
   (a) 61×10^{-3} kg s^{-1} (b) 61×10^{-5} kg s^{-1}
   (c) 208 kg s^{-1} (d) 30×10^{-3} kg s^{-1}

31. A 100g of iron nail is hit by a 1.5 kg hammer striking at a velocity of 60ms^{-1}. What will be the rise in the temperature of the nail if one fourth of energy of the hammer goes into heating the nail?
[24 June, 2022 (Shift-II)]
[Specific heat capacity of iron = 0.42Jg^{-1} –C^{-1}]
   (a) 675ºC (b) 1600ºC (c) 16.07ºC (d) 6.75ºC

32. A block of ice of mass 120 g at temperature 0ºC is put in 300 g of water at 25ºC. The xg of ice melts as the temperature of the water reaches 0ºC. The value of x is _____.
[Use specific heat capacity of water = 4200 Jkg^{-1}K^{-1}, Latent heat of ice = 3.5×10^5 Jk g^{-1}] **[25 July, 2022 (Shift-II)]**

33. A geyser heats water flowing at a rate of 2.0 kg per minute from 30°C to 70°C. If geyser operates on a gas burner, the rate of combustion of fuel will be _____ g min^{-1}.
[Heat of combustion = 8×10^3 Jg^{-1}, Specific heat of water = 4.2 $Jg^{-1}C^{-1}$] **[26 June, 2022 (Shift-II)]**

34. The temperature of equal masses of three different liquids x, y and z are 10°C, 20°C and 30°C respectively. The temperature of mixture when x is mixed with y is 16°C and that when y is mixed with z is 26°C. The temperature of mixture when x and z are mixed will be:
[26 Aug, 2021 (Shift-II)]
   (a) 28.32°C (b) 23.84°C (c) 25.62°C (d) 20.28°C

35. The height of victoria falls is 63 m. What is the difference in temperature of water at the top and at the bottom of fall?
[Given 1 cal = 4.2 J and specific heat of water = 1calg^{-1} °C^{-1}]
[27 Aug, 2021 (Shift-II)]
   (a) 0.147 ºC (b) 14.76 ºC (c) 1.476 ºC (d) 0.014 ºC

36. Due to cold weather a 1 m water pipe of cross–sectional area 1 cm^2 is filled with ice at –10°C. Resistive heating is used to melt the ice. Current of 0.5 A is passed through 4 k Ω resistance. Assuming that all the heat produced is used for melting, what is the minimum time required?
(Given latent heat of fusion for water/ice = 3.33×10^5 J kg^{-1}, specific heat of ice = 2×10^3 J kg^{-1} and density of ice = 10^3 kg / m^3)
[1 Sep, 2021 (Shift-II)]
   (a) 3.53 s (b) 0.353 s (c) 35.3 s (d) 70.6 s

37. A calorimeter of water equivalent 20 g contains 180 g of water at 25°C. 'm' grams of steam at 100°C is mixed in it till the temperature of the mixture is 31°C. The value of 'm' is close to
(Latent heat of water = 540 cal g^{-1}, Specific heat of water = 1 cal g^{-1} °C^{-1}]
[3 Sep, 2020 (Shift-II)]
   (a) 2 (b) 3.2 (c) 2.6 (d) 4

38. The specific heat of water = 4200 J kg^{-1}K^{-1} and the latent heat of ice = 3.4×10^5 J kg^{-1}. 100 grams of ice at 0°C is placed in 200 g of water at 25°C. The amount of ice that will melt as the temperature of water reaches 0°C is close to (in grams) **[4 Sep, 2020 (Shift-I)]**
   (a) 69.3 (b) 63.8
   (c) 64.6 (d) 61.7

39. M grams of steam at 100°C is mixed with 200g of ice at its melting point in a thermally insulated container. If it produces liquid water at 40°C [heat of vaporization of water is 540 cal/g and heat of fusion of ice is 80 cal/g], the value of M is ____. **[7 Jan, 2020 (Shift-II)]**

40. A bullet of mass 5g, traveling with a speed of 210 m/s, strikes a fixed wooden target. One half of its kinetic energy is converted into heat in the bullet while the other half is converted into heat in the wood. The rise of temperature of the bullet if the specific heat of its material is 0.030 cal gm^{-1}°C^{-1}) (1 cal = 4.2×10^7 ergs) close to: **[5 Sep, 2020 (Shift-I)]**
   (a) 83.3°C (b) 38.4°C (c) 87.5°C (d) 119.2°C

41. Three containers C_1, C_2 and C_3 have water at different temperatures. The table below shows the final temperature T when different amounts of water (given in liters) are taken from each container and mixed (assume no loss of heat during the process)
[8 Jan, 2020 (Shift-II)]

C_1	C_2	C_3	T
1ℓ	2ℓ	–	$60°C$
–	1ℓ	2ℓ	$30°C$
2ℓ	–	1ℓ	$60°C$
1ℓ	1ℓ	1ℓ	θ

The value of θ (in ºC to the nearest integer) is _____.

42. When M_1 gram of ice at –10º C (specific heat = 0.5 cal g^{-1} °C^{-1}) is added to M_2 gram of water at 50ºC, finally no ice is left and the water is at 0ºC. The value of latent heat of ice, in cal g^{-1} is:
[12 April, 2019 (Shift-I)]
   (a) $\dfrac{5M_1}{M_2} - 50$ (b) $\dfrac{50M_2}{M_1}$ (c) $\dfrac{50M_2}{M_1} - 5$ (d) $\dfrac{5M_2}{M_1} - 5$

43. A liquid at 30°C is poured very slowly into a Calorimeter that is at temperature of 110°C. The boiling temperature of the liquid is 80°C. It is found that the first 5 gm of the liquid completely evaporates. After pouring another 80 gm of the liquid the equilibrium temperature is found to be 50°C. The ratio of the Latent heat of the liquid to its specific heat will be _____ °C. **[JEE Adv, 2019]**
[Neglect the heat exchange with surrounding]

44. A current carrying wire heats a metal rod. The wire provides a constant power (P) to the rod. The metal rod is enclosed in an insulated container. It is observed that the temperature (T) in the metal rod changes with time (t) as: **[JEE Adv, 2019]**
$T(t) = T_0(1 + \beta t^{1/4})$

Where β is a constant with appropriate dimension while T_0 is a constant with dimension of temperature.
The heat capacity of the metal is :
   (a) $\dfrac{4P(T(t)-T_0)^3}{\beta^4 T_0^4}$ (b) $\dfrac{4P(T(t)-T_0)}{\beta^4 T_0^2}$
   (c) $\dfrac{4P(T(t)-T_0)^4}{\beta^4 T_0^5}$ (d) $\dfrac{4P(T(t)-T_0)^2}{\beta^4 T_0^3}$

45. Ice at $-20°C$ is added to 50 g of water at 40°C. When the temperature of the mixture reaches 0°C, it is found that 20 g of ice is still unmelted. The amount of ice added to the water was close to (Specific heat of water = 4.2 J/g/°C, Heat of fusion of water at 0°C = 334 J/g and Specific heat of ice = 2.1 J/g/°C)

[11 Jan, 2019 (Shift-I)]

(a) 50 g　　(b) 100 g　　(c) 60 g　　(d) 40 g

46. When 100g of a liquid A at 100°C is added to 50g of a liquid B at temperature 75°C, the temperature of the mixture becomes 90°C. The temperature of the mixture, if 100g of liquid A at 100°C is added to 50g of liquid B at 50°C, will be: **[11 Jan, 2019 (Shift-II)]**

(a) 85°C　　(b) 60°C　　(c) 80°C　　(d) 70°C

47. A metal ball of mass 0.1 kg is heated upto 500ºC and dropped into a vessel of heat capacity 800 JK^{-1} and containing 0.5 kg water. The initial temperature of water and vessel is 30ºC. What is the approximate percentage increment in the temperature of the water? [Specific heat Capacities of water and metal are, respectively 4200 $Jkg^{-1}K^{-1}$ and 400 $Jkg^{-1}K^{-1}$] **[11 Jan, 2019 (Shift-II)]**

(a) 15%　　(b) 30%　　(c) 25%　　(d) 20%

Heat Transfer, Conduction

48. Two plates A and B have thermal conductivities 84 $Wm^{-1}K^{-1}$ and 126 $Wm^{-1}K^{-1}$ respectively. They have same surface area and same thickness. They are placed in contact along their surfaces. If the temperatures of the outer surfaces of A and B are kept at 100° C and 0°C respectively, then the temperature of the surface of contact in steady state is _____°C. **[13 April, 2023 (Shift-II)]**

49. Two coils require 20 minutes and 60 minutes respectively to produce same amount of heat energy when connected separately to the same source. If they are connected in parallel arrangement to the same source; the time required to produce same amount of heat by the combination of coils, will be _____ min. **[29 June, 2022 (Shift-I)]**

50. An ice cube of dimensions 60cm × 50cm × 20cm is placed in an insulation box of wall thickness 1cm. The box keeping the ice cube at 0ºC of temperature is brought to a room of temperature 40ºC. The rate of melting of ice is approximately: **[26 July, 2022 (Shift-II)]** (Latent heat of fusion of ice is 3.4×10^5 J kg^{-1} and thermal conducting of insulation wall is 0.05 $Wm^{-1}ºC^{-1}$)

(a) 61×10^{-3} kg s^{-1}　　(b) 61×10^{-5} kg s^{-1}
(c) 208 kg s^{-1}　　(d) 30×10^{-3} kg s^{-1}

51. As per the given figure, two plates A and B of thermal conductivity K and $2K$ are joined together of form a compound plate. The thickness of plates are 4.0 cm and 2.5 cm respectively and the area of cross-section is 120 cm² for each plate. The equivalent thermal conductivity of the compound plate is $\left(1+\dfrac{5}{\alpha}\right)K$, then the value of α will be _____ . **[29 June, 2022 (Shift-I)]**
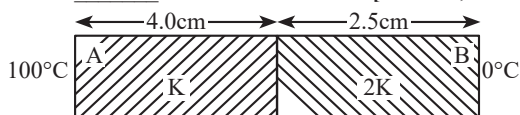
52. Two thin metallic spherical shells of radii r_1 and $r_2(r_1 < r_2)$ are placed with their centres coinciding. A material of thermal conductivity K is filled in the space between the shells. The inner shell is maintained at temperature θ_1 and the outer shell at temperature $\theta_2(\theta_1 < \theta_2)$. The rate at which heat flows radially through the material is: **[31 Aug, 2021 (Shift-II)]**

(a) $\dfrac{\pi r_1 r_2 (\theta_2 - \theta_1)}{r_2 - r_1}$　　(b) $\dfrac{K(\theta_2 - \theta_1)(r_2 - r_1)}{4\pi r_1 r_2}$

(c) $\dfrac{K(\theta_2 - \theta_1)}{r_2 - r_1}$　　(d) $\dfrac{4\pi K r_1 r_2 (\theta_2 - \theta_1)}{r_2 - r_1}$

53. Two identical metal of thermal conductivities K_1 and K_2 respectively are connected in series. The effective thermal conductivity of the combination is: **[17 March, 2021 (Shift-I)]**

(a) $\dfrac{K_1 + K_2}{K_1 K_2}$　(b) $\dfrac{K_1 + K_2}{2 K_1 K_2}$　(c) $\dfrac{2 K_1 K_2}{K_1 + K_2}$　(d) $\dfrac{K_1 K_2}{K_1 + K_2}$

54. A rod CD of thermal resistance 10.0 kW^{-1} is joined at the middle of an identical rod AB as shown in figure, The end A, B and D are maintained at 200°C, 100°C and 125°C respectively. The heat current in CD is P watt. The value of P is **[27 Aug, 2021 (Shift-I)]**
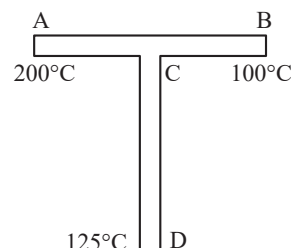
55. Three rods of identical cross-section and lengths are made of three different materials of thermal conductivity K_1, K_2 and K_3, respectively. They are joined together at their ends to make a long rod (see figure). One end of the long rod is maintained at 100°C and the other at 0°C (see figure). If the joints of the rod are at 70°C and 20°C in steady state and there is no loss of energy from the surface of the rod, the correct relationship between K_1, K_2 and K_3 is

[6 Sep, 2020 (Shift-II)]
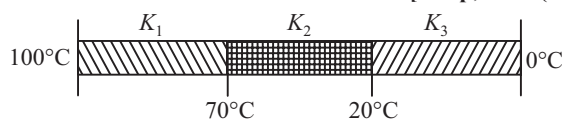
(a) $K_1 : K_3 = 2 : 3$　；　$K_2 : K_3 = 2 : 5$sss
(b) $K_1 < K_2 < K_3$
(c) $K_1 : K_2 = 5 : 2$　；　$K_1 : K_3 = 3 : 5$
(d) $K_1 > K_2 > K_3$

56. A heat source at $T = 10^3$ K is connected to another heat reservoir at $T = 10^2$ K by a copper slab which is 1 m thick. Given that the thermal conductivity of copper is 0.1 W $K^{-1}m^{-1}$, the energy flux through it in the steady state is: **[10 Jan, 2019 (Shift-I)]**

(a) 90 Wm^{-2}　(b) 120 Wm^{-2}　(c) 65 Wm^{-2}　(d) 200 Wm^{-2}

57. A cylinder of radius R is surrounded by a cylindrical shell of inner radius R and outer radius 2R. The thermal conductivity of the material of the inner cylinder is K_1 and that of the outer cylinder is K_2. Assuming no loss of heat, the effective thermal conductivity of the system for heat flowing along the length of the cylinder is: **[12 Jan, 2019 (Shift-I)]**
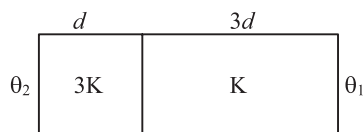
(a) $\dfrac{K_1 + K_2}{2}$　　(b) $K_1 + K_2$

(c) $\dfrac{2K_1 + 3K_2}{5}$　　(d) $\dfrac{K_1 + 3K_2}{4}$

58. Two materials having coefficients of thermal conductivity '3K' and 'K' and thickness 'd' and '$3d$', respectively, are joined to form a slab as shown in the figure. The temperatures of the outer surfaces are 'θ_2' and 'θ_1' respectively, ($\theta_2 > \theta_1$). The temperature at the interface is: **[9 April, 2019 (Shift-II)]**

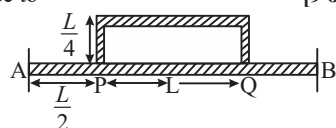| d	$3d$
θ_2 3K	K θ_1

(a) $\dfrac{\theta_2 + \theta_1}{2}$ (b) $\dfrac{\theta_1}{10} + \dfrac{9\theta_2}{10}$ (c) $\dfrac{\theta_1}{3} + \dfrac{2\theta_2}{3}$ (d) $\dfrac{\theta_1}{6} + \dfrac{5\theta_2}{6}$

59. Temperature difference of 120°C is maintained between two ends of a uniform rod AB of length 2L. Another bent rod PQ, of same cross-section as AB and length $\dfrac{3L}{2}$, is connected across AB (See figure). In steady state, temperature difference between P and Q will be close to **[9 Jan, 2019 (Shift-I)]**

A — $\dfrac{L}{4}$ — B, P — L — Q, $\dfrac{L}{2}$

(a) 45°C (b) 75°C (c) 60°C (d) 35°C

Radiation Stefan's Law and Wein's Law

60. Match the temperature of a black body given in List-I with an appropriate statement in List-II, and choose the correct option. **[JEE Adv, 2023]**

[Given: Wien's constant as 2.9×10^{-3} m-K and $\dfrac{hc}{e} = 1.24 \times 10^{-6}$ V-m]

| List-I		List-II
(p) 2000 K	(i)	The radiation at peak wavelength can lead to emission of photoelectrons from a metal of work function 4 eV
(q) 3000 K	(ii)	The radiation at peak wavelength is visible to human eye.
(r) 5000 K	(iii)	The radiation at peak emission wavelength will result in the widest central maximum of a single slit diffraction.
(s) 10000 K	(iv)	The power emitted per unit area is 1/16 of that emitted by a black body at temperature 6000 K.
	(v)	The radiation at peak emission wavelength can be used to image human bones.

(a) $p \to (iii), q \to (v), r \to (ii), s \to (iii)$
(b) $p \to (iii), q \to (ii), r \to (iv), s \to (i)$
(c) $p \to (iii), q \to (iv), r \to (ii), s \to (i)$
(d) $p \to (i), q \to (ii), r \to (v), s \to (iii)$

61. A container with 1 kg of water in it is kept in sunlight, which causes the water to get warmer than the surroundings. The average energy per unit time per unit area received due to the sunlight is 700 Wm^{-2} and it is absorbed by the water over an effective area of 0.05 m^2. Assuming that the heat loss from the water to the surroundings is governed by Newton's law of cooling, the difference (in ºC) in the temperature of water and the surroundings after a long time will be _____. (Ignore effect of the container, and take constant for Newton's law of cooling = 0.001 s^{-1}, Heat capacity of water = 4200 J kg^{-1} K^{-1}) **[JEE Adv, 2020]**

62. Two identical breakers A and B contain equal volumes of two different liquids at 60ºC each and left to cool down. Liquid in A has density of 8×10^2 kg/m^3 and specific heat of 2000 J kg^{-1} K^{-1} while liquid in B has density of 10^3 kg m^{-3} and specific heat of 4000 J kg^{-1} K^{-1}. Which of the following best describes their temperature versus time graph schematically? (assume the emissivity of both the beakers to be the same) **[8 Asst-I)]**

(a) 60ºC, T, B, A, t
(b) 60ºC, T, A, B, t
(c) 60ºC, T, A and B, t
(d) 60ºC, T, A, B, t
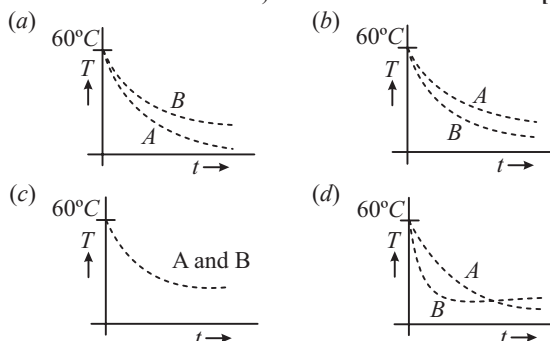
Thermal Expansion

Single Correct

1. The ends Q and R of two thin wires, PQ and RS, are soldered (joined) together. Initially, each of the wire has a length of 1 m at 10°C. Now, the end P is maintained at 10°C, while the end S is heated and maintained at 400°C. The system is thermally insulated from its surroundings. If the thermal conductivity of wire PQ is twice that of the wire RS and the coefficient of linear thermal expansion of PQ is $1.2 \times 10^{-5}\ K^{-1}$, the change in length of the wire PQ is

   C-9.19, W-48.02, UA-42.79 (JEE Adv. 2016)

   (*a*) 0.78 mm   (*b*) 0.90 mm   (*c*) 1.56 mm   (*d*) 2.34 mm

2. Two identical conducting rods are first connected independently to two vessels, one containing water at 100°C and the other containing ice at 0°C. In the second case, the rods are joined end to end and connected to the same vessels. Let q_1 and q_2 gram per second be the rate of melting of ice in the two cases respectively. The ratio $\dfrac{q_1}{q_2}$ is

   (IIT-JEE 2004)

   (*a*) $\dfrac{1}{2}$ (*b*) $\dfrac{2}{1}$

   (*c*) $\dfrac{4}{1}$ (*d*) $\dfrac{1}{4}$

3. Two rods, one of aluminum and the other made of steel, having initial length l_1 and l_2 are connected together to form a single rod of length $l_1 + l_2$. The coefficients of linear expansion for aluminum and steel are α_a and α_s respectively. If the length of each rod increases by the same amount when their temperature are raised by $t°C$, then find the ratio $\dfrac{l_1}{l_1 + l_2}$ **(IIT-JEE 2003)**

   (*a*) $\dfrac{\alpha_s}{\alpha_a}$ (*b*) $\dfrac{\alpha_a}{\alpha_s}$

   (*c*) $\dfrac{\alpha_s}{(\alpha_a + \alpha_s)}$ (*d*) $\dfrac{\alpha_{as}}{(\alpha_a + \alpha_s)}$

Multiple Correct

4. A bimetallic strip is formed out of two identical strips-one of copper and the other of brass. The coefficients of linear expansion of the two metals are α_C and α_B. On heating, the temperature of the strip goes up by ΔT and the strip bends to form an arc of radius of curvature R. Then, R is   **(IIT-JEE 1993)**

   (*a*) proportional to ΔT

   (*b*) inversely proportional to ΔT

   (*c*) proportional to $|\alpha_B - \alpha_C|$

   (*d*) inversely proportional to $|\alpha_B - \alpha_C|$

Match the Column

5. Column-I gives some devices and Column-II gives some processes on which the functioning of these devices depend. Match the devices in Column-I with the processes in Column-II.   **(IIT-JEE 2007)**

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 fuse	(s)	Thermal expansion of solids

   (*a*) A → q; B → r; C → s; D → p

   (*b*) A → s; B → q; C → p, q; D → q, r

   (*c*) A → p; B → r; C → q; D → s

   (*d*) A → s; B → p; C → q; D → r

Numerical Types/Integer Types

6. Steel wire of length L at 40°C is suspended from the ceiling and then a mass m is hung from its free end. The wire is cooled down from 40°C to 30°C to regain its original length L. The coefficient of linear thermal expansion of the steel is $10^{-5}/°C$, Young's modulus of steel is $10^{11}\ N/m^2$ and radius of the wire is 1 mm. Assume that $L \gg$ diameter of the wire. Then the value of m in kg is nearly.

   (IIT-JEE 2011)

7. The apparatus shown in figure consists of four glass columns connected by horizontal sections. The height of two central columns B and C are 49cm each. The two outer columns A and D are open to the atmosphere. A and C are maintained at a temperature of 95°C while the columns B and D are maintained at 5°C. The height of the liquid in A and D measured from the base line are 52.8 cm and 51 cm respectively. Determine the linear coefficient of thermal expansion of the liquid.   **(IIT-JEE 1997)**
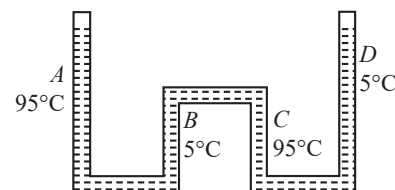
Subjective

8. A cube of coefficient of linear expansion α_s is floating in a bath containing a liquid of coefficient of volume expansion γ_L. When the temperature is raised by ΔT, the depth upto which the cube is submerged in the liquid remains the same. Find the relation between α_s and γ_L showing all the steps.   **(IIT-JEE 2005)**

9. A composite rod is made by joining a copper rod, end to end, with a second rod of different material but of the same cross-section. At 25°C, the composite rod is 1 m in length, of which the length of the copper rod is 30 cm. At 125°C the length of the composite rod increases by 1.91 mm.

   When the composite rod is not allowed to expand by holding it between two rigid walls, it is found that the length of the two constituents do not change with the rise of temperature. Find the

Young's modulus and the coefficient of linear expansion of the second rod. (Given, Coefficient of linear expansion of copper = 1.7×10^{-5} per °C, Young's modulus of copper = 1.3×10^{11} N/m²)

(IIT-JEE 1979)

10. A sinker of weight w_0 has an apparent weight w_1 when placed in a liquid at a temperature T_0 and w_2 when weighed in the same liquid at a temperature T_2. The coefficient of cubical expansion of the material of the sinker is β. What is the coefficient of volume expansion of the liquid?

(IIT-JEE 1978)

Calorimetry

Single Correct

11. A current carrying wire heats a metal rod. The wire provides a constant power (P) to the rod. The metal rod is enclosed in an insulated container. It is observed that the temperature (T) in the metal rod changes with time (t) as:

C-20 W-29 UA-51 (JEE Adv, 2019)

$T(t) = T_0(1 + \beta t^{1/4})$

Where β is a constant with appropriate dimension while T_0 is a constant with dimension of temperature.

The heat capacity of the metal is:

(a) $\dfrac{4P(T(t) - T_0)^3}{\beta^4 T_0^4}$

(b) $\dfrac{4P(T(t) - T_0)}{\beta^4 T_0^2}$

(c) $\dfrac{4P(T(t) - T_0)^4}{\beta^4 T_0^5}$

(d) $\dfrac{4P(T(t) - T_0)^2}{\beta^4 T_0^3}$

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

(IIT-JEE 2005)

(a) From 14.5°C to 15.5°C at 760mm of Hg

(b) From 98.5°C to 99.5°C at 760mm of Hg

(c) From 13.5°C to 14.5°C at 76mm of Hg

(d) From 3.5°C to 4.5°C at 76mm of Hg

13. An ice cube of mass 0.1 kg at $0°C$ is placed in an isolated container which is at 227°C. The specific heat S of the container varies with temperature T according to the empirical relation $S = A + BT$, where $A = 100$ cal/kg–K and $B = 2 \times 10^{-1}$ cal/kg – K^2. If the final temperature of the container is 27°C, determine the mass of the container.

(Latent heat of fusion for water = 8×10^4 cal/kg, specific heat of water = 10^3 cal/kg – K).

(IIT-JEE 2001)

(a) 0.30kg

(b) 0.78kg

(c) 0.93kg

(d) 0.495kg

14. 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 till the temperature of the calorimeter and its contents rises to 80°C. The mass of the steam condensed in kg is

(IIT-JEE 1986)

(a) 0.130

(b) 0.065

(c) 0.260

(d) 0.135

Numerical Types/Integer Types

15. In an insulated vessel, 0.05 kg steam at 373 K and 0.45 kg of ice at 253 K are mixed. Find the final temperature of the mixture (in kelvin).

Given, $L_{\text{fusion}} = 80$ cal/g = 336 J/g, $L_{\text{vaporisation}}$ = 540 cal/g = 2268 J/g,

$S_{\text{ice}} = 2100$ J/kg, $K = 0.5$ cal/g – K and S_{water} = 4200 = 1 cal/g–K.

(IIT-JEE 2006)

16. Earth receives 1400 W/m² of solar power. If all the solar energy falling on a lens of area 0.2 m² is focused onto a block of ice of mass 280 g, the time taken to melt the ice will be ...minutes. (Latent heat of fusion of ice = 3.3×10^5 J/kg)

(IIT-JEE 1997)

Fill in the Blank

17. A liquid at 30°C is poured very slowly into a Calorimeter that is at temperature of 110°C. The boiling temperature of the liquid is 80°C. It is found that the first 5 gm of the liquid completely evaporates. After pouring another 80 gm of the liquid the equilibrium temperature is found to be 50°C. The ratio of the Latent heat of the liquid to its specific heat will be _____ °C.

[Neglect the heat exchange with surrounding]

C-4 W-66 UA-30 (JEE Adv, 2019)

Heat Transfer and Thermal Conductivity

Single Correct

18. Two rectangular blocks, having identical dimensions, can be arranged either in configuration I or in configuration II as shown in the figure. One of the blocks has thermal conductivity K and the other $2K$. The temperature difference between the ends along the X-axis is the same in both the configurations. It takes $9s$ to transport a certain amount of heat from the hot end to the cold end in the configuration I. The time to transport the same amount of heat in the configuration II is

C-43.52, W-53.25, UA-3.23 (JEE Adv. 2013)
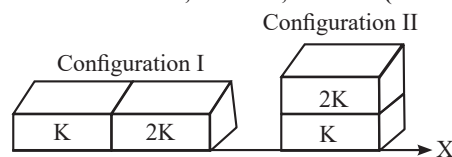
(a) 2.0 s

(b) 3.0 s

(c) 4.5 s

(d) 6.0 s

19. In which of the following processes, convection does not take place primarily?
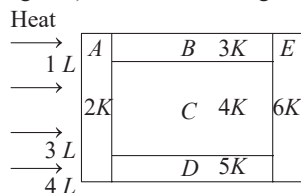
(IIT-JEE 2005)

(a) Sea and land breeze

(b) Boiling of water

(c) Warming of glass bulb due to filament

(d) Heating air around a furnace

20. 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 two different temperatures. There is no loss of heat across the cylindrical surface and the system is in steady state. The effective thermal conductivity of the system is

(IIT-JEE 1988)

(a) $K_1 + K_2$

(b) $K_1 K_2/(K_1 + K_2)$

(c) $(K_1 + 3K_2)/4$

(d) $(3K_1 + K_2)/4$

Multiple Correct

21. A composite block is made of slabs A, B, C, D and E of different thermal conductivities (given in terms of a constant K) and (given in terms of length, L) as shown in the figure.
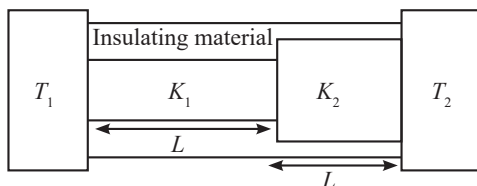
Heat

All slabs are of same width. Heat Q flows only from left to right through the blocks. Then, in steady state **(IIT-JEE 2011)**

(*a*) heat flow through A and E slabs are same

(*b*) heat flow through slab E is maximum

(*c*) temperature difference across slab E is smallest

(*d*) heat flow through C = heat flow through B + heat flow through D

Numerical Types/Integer Types

22. Two conducting cylinders of equal length but different radii are connected in series between two heat baths kept at temperatures $T_1 = 300K$ and $T_2 = 100K$, as shown in the figure. The radius of the bigger cylinder is twice that of the smaller one and the thermal conductivities of the materials of the smaller and the larger cylinders are K_1 and K_2, respectively. If the temperature at the junction of the cylinders in the steady state is $200K$, then K_1/K_2 .... =
**C-37.17, W-49.03, UA-13.8 (JEE Adv. 2018)**

23. The temperature of 100 g of water is to be raised from 24°C to 90°C by adding steam to it. Calculate the mass of the steam required for this purpose. **(IIT-JEE 1996)**

24. An electric heater is used in a room of total wall area 137m^2 to maintain a temperature of +20°C inside it, when the outside temperature is –10°C. The walls have three different layers. The innermost layer is of wood of thickness 2.5cm, the middle layer is of cement of thickness 1.0cm and the outermost layer is of brick of thickness 25.0cm. Find the power of the electric heater. Assume that there is no heat loss through the floor and the ceiling. The thermal conductivities of wood, cement and brick are 0.125, 1.5 and 1.0 W/m/°C respectively. **(IIT-JEE 1986)**

25. A room is maintained at 20°C by a heater of resistance 20Ω connected to 200V mains. The temperature is uniform throughout the room and the heat is transmitted through a glass window of area $1m^2$ and thickness 0.2cm. Calculate the temperature outside. Thermal conductivity of glass is $0.2\text{calm}^{-1}\text{s}^{-1}(°C)^{-1}$ and mechanical equivalent of heat is 4.2Jcal^{-1}. **(IIT-JEE 1978)**

Fill in the Blanks

26. Earth receives 1400 W/m^2 of solar power. If all the solar energy falling on a lens of area 0.2 m^2 is focused onto a block of ice of mass 280 g, the time taken to melt the ice will be _____ minutes. (Latent heat of fusion of ice = 3.3×10^5J /kg) **(IIT-JEE 1997)**

27. The variation of temperature of a material as heat is given to it at a constant rate as shown in the figure. The material is in solid state at the point O. The state of the material at the point P is _____.
**(IIT-JEE 1986)**
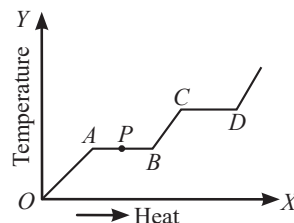
Subjective

28. A double-pane window used for insulating a room thermally from outside consists of two glass sheets each of area 1 m^2 and thickness 0.01 m separated by a 0.05 m thick stagnant air space. In the steady state, the room glass interface and the glass-outdoor interface are at constant temperatures of 27°C and 0°C respectively. Calculate the rate of heat flow through the window pane. Also, find the temperatures of other interfaces. Given, thermal conductivities of glass and air as 0.8 and 0.08W m^{-1}K^{-1} respectively. **(IIT-JEE 1997)**

True/False

29. The volume V versus temperature T graphs for a certain amount of a perfect gas at two pressure p_1 and p_2 are as shown in figure. It follows from the graphs that p_1 is greater than p_2. **(IIT-JEE 1982)**
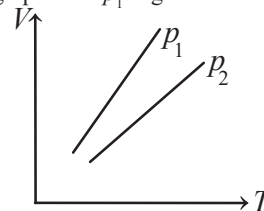
Radiation Stefan's Law and Wien's Law

Single Correct

30. Three very large plates of the 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
C-16.25, W-23.27, UA-60.48 (IIT-JEE 2012)

(*a*) $\left(\dfrac{65}{2}\right)^{\frac{1}{4}}T$ (*b*) $Q_{B+D} = \dfrac{KA\Delta T}{L}$

(*c*) $\left(\dfrac{97}{2}\right)^{\frac{1}{4}}T$ (*d*) $(97)^{\frac{1}{4}}T$

31. A black body of temperature T is inside a chamber of temperature T_0. Now the closed chamber is slightly opened to sun such that temperature of black body (T) and chamber (T_0) remains constant
**(IIT-JEE 2006)**

(*a*) Black body will absorb more radiation

(*b*) Black body will absorb less radiation

(*c*) Black body emit more energy

(*d*) Black body emit energy equal to energy absorbed by it

32. A body with area A and temperature T and emissivity $e = 0.6$ is kept inside a spherical black body. What will be the maximum energy radiated? **(IIT-JEE 2005)**

(*a*) $0.6\ e\sigma AT^4$ (*b*) $0.8\ e\sigma AT^4$ (*c*) $1.0\ e\sigma AT^4$ (*d*) $0.4\ e\sigma AT^4$

33. Variation of radiant energy emitted by sun, filament of tungsten lamp and welding arc as a function of its wavelength is shown in figure. Which of the following option is the correct match?
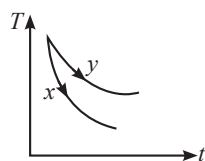
(IIT-JEE 2005)
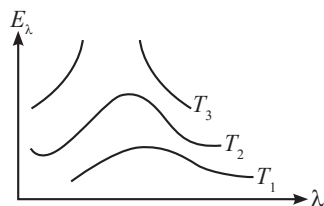
(*a*) Sun- T_1, tungsten filament- T_2, welding arc-T_3

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

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

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

34. Three discs, A, B and C having radii 2 m, 4 m and 6 m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are 300 nm, 400 nm and 500 nm, respectively. The power radiated by them are Q_A, Q_B and Q_C respectively **(IIT-JEE 2004)**

(*a*) Q_A is maximum (*b*) Q_B is maximum

(*c*) Q_C is maximum (*d*) $Q_A = Q_B = Q_C$

35. The graph, shown in the diagram, represents the variation of temperature (T) of the bodies, x and y having same surface area, with time (t) due to the emission of radiation. Find the correct relation between the emissivity and absorptivity power of the two bodies **(IIT-JEE 2003)**


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

(*c*) $E_x > E_y$ and $a_x > a_y$ (*d*) $E_x < E_y$ and $a_x < a_y$

36. An ideal black body at room temperature is thrown into a furnace. It is observed that **(IIT-JEE 2002)**

(*a*) Initially it is the darkest body and at later times the brightest

(*b*) It is the darkest body at all times

(*c*) It cannot be distinguished at all times

(*d*) Initially it is the darkest body and at later times it cannot be distinguished

37. The plots of intensity versus wavelength for three black bodies at temperatures T_1, T_2 and T_3 respectively are as shown. Their temperatures are such that **(IIT-JEE 2000)**
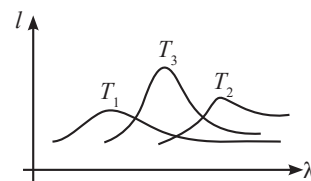
(*a*) $T_1 > T_2 > T_3$ (*b*) $T_1 > T_3 > T_2$

(*c*) $T_2 > T_3 > T_1$ (*d*) $T_3 > T_2 > T_1$

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

(IIT-JEE 1998)
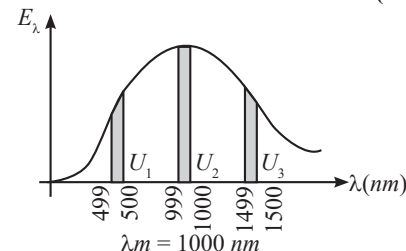
(*a*) $U_1 = 0$ (*b*) $U_3 = 0$ (*c*) $U_1 > U_2$ (*d*) $U_2 > U_1$

39. A spherical black body with a radius of 12 cm radiates 450 W power at 500 K. If the radius were halved and the temperature doubled, the power radiated in watt would be **(IIT-JEE 1997)**

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

40. 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 **(IIT-JEE 1997)**

(*a*) 1.46 (*b*) 0.69 (*c*) 1.21 (*d*) 0.83

41. Two metallic spheres S_1 and S_2 are made of the same material and have got identical surface finish. The mass of S_1 is thrice 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 **(IIT-JEE 1995)**

(*a*) $\dfrac{1}{3}$ (*b*) $\dfrac{1}{\sqrt{3}}$ (*c*) $\dfrac{\sqrt{3}}{1}$ (*d*) $\left(\dfrac{1}{3}\right)^{\frac{1}{3}}$

42. A solid copper sphere (density ρ and specific heat capacity C) of radius r at an initial temperature 200 K is suspended inside a chamber whose walls are at almost 0 K. The time required for the temperature of the sphere to drop to 100 K is **(IIT-JEE 1991)**

(*a*) $\dfrac{7r\rho C}{72 \times 10^6 \sigma}$ (*b*) $\dfrac{r\rho C}{\sigma}$

(*c*) $\dfrac{r\rho C}{\sigma}$ (*d*) None of these

Multiple Correct

43. The filament of a light bulb has surface area 64 mm^2. The filament can be considered as a black body at temperature 2500 K emitting radiation like a point source when viewed from far. At night the light bulb is observed from a distance of 100 m. Assume the pupil of the eyes of the observer to be circular with radius 3 mm. Then (Take Stefan-Boltzmann constant = 5.67×10^{-8}Wm^{-2} K^{-4}, Wien's displacement constant = $2.90 \times 10^{-3}\ m - K$, Planck's constant = 6.63×10^{-34}Js, speed of light in vacuum = 3.00×10^8 ms^{-1})

W C-2.83 W-13.05 UA-60.84 PC-23.28 (JEE Adv. 2020)

(a) power radiated by the filament is in the range 642 W to 645 W
(b) radiated power entering into one eye of the observer is in the range 3.15×10^{-8} W to 3.25×10^{-8} W
(c) the wavelength corresponding to the maximum intensity of light is 1160 nm
(d) taking the average wavelength of emitted radiation to be 1740 nm, the total number of photons entering per second into one eye of the observer is in the range 2.75×10^{11} to 2.85×10^{11}

44. A human body has a surface area of approximately $1 m^2$. The normal body temperature is 10K above the surrounding room temperature T_0. Take the room temperature to be $T_0 = 300K$. For $T_0 = 300K$, the value of $\sigma T_0^4 = 460 Wm^{-2}$(where σ is the Stefan Boltzmann constant). Which of the following options is/are correct?
C-12.24, W-35.32, UA-52.45, PC-0 (JEE Adv. 2017)
(a) If the body temperature rises significantly, then the peak in the spectrum of electromagnetic radiation emitted by the body would shift to longer wavelengths
(b) If the surrounding temperature reduces by a small amount $\Delta T_0 << T_0$, then to maintain the same body temperature the same (living) human being needs to radiate $\Delta W = 4\sigma T_0^3 \Delta T_0$ more energy per unit time
(c) The amount of energy radiated by the body in 1s is close to 60J
(d) Reducing the exposed surface area of the body (e.g. by curling up) allows humans to maintain the same body temperature while reducing the energy lost by radiation

45. Two bodies A and B have thermal emissivities of 0.01 and 0.81 respectively. The outer surface areas of the two bodies are the same. The two bodies emit total radiant power at the same rate. The wavelength λ_B corresponding to maximum spectral radiancy in the radiation from B shifted from the wavelength corresponding to maximum spectral radiancy in the radiation from A, by $1.00\mu m$. If the temperature of A is $5802K$ **(IIT-JEE 1994)**
(a) the temperature of B is 1934 K
(b) $\lambda_B = 1.5\ \mu m$
(c) the temperature of B is 11604 K
(d) the temperature of B is 2901 K

Match the Column

46. Match the temperature of a black body given in List-I with an appropriate statement in List-II, and choose the correct option.
C-24.22 W-23.75 UA-52.03 (JEE Adv, 2023)
[Given: Wien's constant as 2.9×10^{-3} m-K

and $\dfrac{hc}{e} = 1.24 \times 10^{-6}$ V-m]

	List-I		List-II
(p)	2000 K	(i)	The radiation at peak wavelength can lead to emission of photoelectrons from a metal of work function 4 eV
(q)	3000 K	(ii)	The radiation at peak wavelength is visible to human eye.
(r)	5000 K	(iii)	The radiation at peak emission wavelength will result in the widest central maximum of a single slit diffraction.
(s)	10000 K	(iv)	The power emitted per unit area is 1/16 of that emitted by a black body at temperature 6000 K.
		(v)	The radiation at peak emission wavelength can be used to image human bones.

(a) $p \to (iii), q \to (v), r \to (ii), s \to (iii)$
(b) $p \to (iii), q \to (ii), r \to (iv), s \to (i)$
(c) $p \to (iii), q \to (iv), r \to (ii), s \to (i)$
(d) $p \to (i), q \to (ii), r \to (v), s \to (iii)$

Numerical Types/Integer Types

47. A metal is heated in a furnace where a sensor is kept above the metal surface to read the power radiated (P) by the metal. The sensor has a scale that displays $\log_2(P/P_0)$, where P_0 is a constant. When the metal surface is at a temperature of 487°C, the sensor shows a value 1. Assume that the emissivity of the metallic surface remains constant. What is the value displayed by the sensor when the temperature of the metal surface is raised to 2767°C?
C-12.15, W-82.02, UA-5.83 (JEE Adv. 2016)

48. Two spherical stars A and B emit black body radiation. The radius of A is 400 times that of B and emits 10^4 times the power emitted from B. The ratio $\left(\dfrac{\lambda_A}{\lambda_B}\right)$ of their wavelengths λ_A and λ_B at which the peaks occur in their respective radiation curves is
(JEE Adv. 2015)

Fill in the Blanks

49. The earth receives at its surface radiation from the sun at the rate of $1400 Wm^{-2}$. The distance of the center of the sun from the surface of the earth is 1.5×10^{11}m and the radius of the sun is 7×10^8m. Treating the sun as a black body, it follows from the above data that its surface temperature is ...K. **(IIT-JEE 1989)**

True/False

50. Two spheres of the same material have radii 1m and, 4m temperature 4000K and 2000K respectively. The energy radiated per second by the first sphere is greater than that by the second. **(IIT-JEE 1988)**

Subjective

51. One end of a rod of length L and cross-sectional area A is kept in a furnace of temperature T_1. The other end of the rod is kept at a temperature T_2. The thermal conductivity of the material of the rod is K and emissivity of the rod is e.
It is given that $T_2 = T_s + \Delta T$, where $\Delta T << T_s$, T_s being the temperature of the surroundings. If $\Delta T \propto (T_1 - T_s)$, find the proportionality constant. Consider that heat is lost only by radiation at the end where the temperature of the rod is T_2. **(IIT-JEE 2004)**
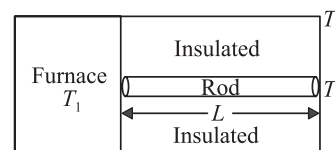
52. The top of an insulated cylindrical container is covered by a disc having emissivity 0.6, conductivity $0.167 WK^{-1}$ m^{-1} and thickness 1 cm. The temperature is maintained by circulating oil as shown.
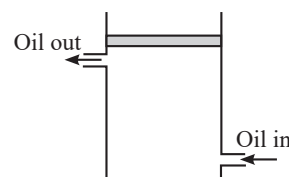
(a) Find the radiation loss to the surroundings in $Jm^{-2}\,s^{-1}$ if temperature of the upper surface of the disc is 127°C and temperature of surroundings is 27°C.

(b) Also find the temperature of the circulating oil. Neglect the heat loss due to convection. **(IIT-JEE 2003)**

53. A solid body X of heat capacity C is kept in an atmosphere whose temperature is $T_A = 300$ K. At time $t = 0$, the temperature of X is $T_0 = 400$ K. It cools according to Newton's law of cooling. At time t_1 its temperature is found to be 350 K.

At this time $(t)_1$ the body X is connected to a large body Y at atmospheric temperature T_A through a conducting rod of length L, cross-sectional area A and thermal conductivity K. The heat capacity of Y is so large that any variation in its temperature may be neglected. The cross-sectional area A of the connecting rod is small compared to the surface area of X. Find the temperature of X at time $t = 3t_1$. **(IIT-JEE 1998)**

Newton's Law of Cooling

Single Correct

54. Three rods of identical cross-sectional area and made from the same metal form the sides of an isosceles triangle ABC, right angled at B.

The points A and B are maintained at temperatures T and $\left(\sqrt{2}\right)T$ respectively. In the steady state, the temperature of the point C is T_c. Assuming that only heat conduction takes place, T_c/T is

(IIT-JEE 1995)

(a) $\dfrac{1}{2(\sqrt{2}-1)}$ (b) $\dfrac{3}{\sqrt{2}+1}$

(c) $\dfrac{1}{\sqrt{3}(\sqrt{2}-1)}$ (d) $\dfrac{1}{(\sqrt{2}+1)}$

Numerical Types/Integer Types

55. Two metal cubes A and B of the same size are arranged as shown in figure. The extreme ends of the combination are maintained at the indicated temperatures. The arrangement is thermally insulated. The coefficients of thermal conductivity of A and B are 300 W/m°C and 200 W/m°C, respectively. After steady state is reached the temperature T of the interface will be **(IIT-JEE 1996)**
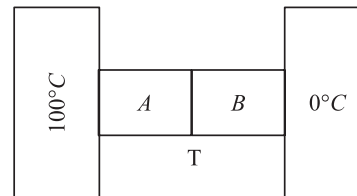
56. A cylindrical block of length 0.4m and area of cross-section $0.04m^2$ is placed coaxially on a thin metal disc of mass 0.4kg and of the same cross-section. The upper face of the cylinder is maintained at a constant temperature of 400K and the initial temperature of the disc is 300K. If the thermal conductivity of the material of the cylinder is 10 watt/mK and the specific heat capacity of the material of the disc is 600J/kg – K, how long will it take for the temperature of the disc to increase to 350K? Assume, for purposes of calculation, the thermal conductivity of the disc to be very high and the system to be thermally insulated except for the upper face of the cylinder. **(IIT-JEE 1992)**

Fill in the Blanks

57. A container with 1 kg of water in it is kept in sunlight, which causes the water to get warmer than the surroundings. The average energy per unit time per unit area received due to the sunlight is 700 Wm^{-2} and it is absorbed by the water over an effective area of 0.05 m^2. Assuming that the heat loss from the water to the surroundings is governed by Newton's law of cooling, the difference (in °C) in the temperature of water and the surroundings after a long time will be _____. (Ignore effect of the container, and take constant for Newton's law of cooling = 0.001 s^{-1}, Heat capacity of water = 4200 J $kg^{-1}\,K^{-1}$) **C-8.53 W-60.73 UA-30.73 (JEE Adv, 2020)**

ANSWER KEY

JEE-Main

1. (b)	2. (d)	3. (3)	4. [12]	5. (b)	6. [60]	7. (d)	8. [4]	9. [313]	10. (d)
11. (b)	12. [60]	13. (b)	14. (b)	15. (c)	16. [8]	17. [5]	18. (c)	19. (d)	20. [60]
21. [20.00]	22. (d)	23. (b)	24. (a)	25. (a)	26. (a)	27. [300]	28. (c)	29. (b)	30. (b)
31. (c)	32. [90]	33. [42]	34. (b)	35. (a)	36. (c)	37. (a)	38. (d)	39. [40]	40. (c)
41. [50]	42. (c)	43. [270.00]	44. (a)	45. (d)	46. (c)	47. (d)	48. [40]	49. [15]	50. (b)
51. [21]	52. (d)	53. (c)	54. [2]	55. (a)	56. (a)	57. (d)	58. (b)	59. (a)	60. (c)
61. [8.33]	62. (a)								

JEE-Advanced

1. (a)	2. (c)	3. (c)	4. (b, d)	5. (b)	6. [3]	7. [0.67 × 10⁻⁴]		11. (a)	12. (a)
13. (d)	14. (a)	15. [273]	16. [5.5]	17. [270]	18. (a)	19. (c)	20. (c)	21. (a,c,d)	22. [4]
23. [12]	24. [9000]	25. [15.24]	29. [False]	30. (c)	31. (d)	32. (c)	33. (c)	34. (b)	35. (c)
36. (a)	37. (b)	38. (d)	39. (d)	40. (b)	41. (d)	42. (a)	43. (b, c, d)	44. (c)	45. (a, b)
46. (c)	47. [9]	48. [2]	49. [5803]	50. [False]	54. (b)	55. [60]	56. [166.3]	57. [8.33]	