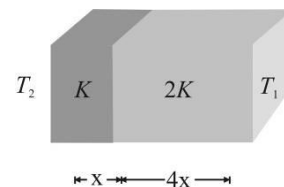


Properties of Matter

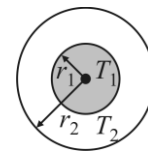
JEE Main (Archive)

Level - 1

- Two spheres of the same material have radii 1 m and 4 m and temperatures 4000 K and 2000 K respectively. The ratio of the energy radiated per second by the first sphere to that by the second is : **[2002]**
(A) $1 : 1$ (B) $16 : 1$ (C) $4 : 1$ (D) $1 : 9$
- Amount of heat required to raise the temperature of a body through 1 K is called its : **[2002]**
(A) Water equivalent (B) Thermal capacity
(C) Entropy (D) specific heat
- Which of the following is an example of ideal black body? **[2002]**
(A) Kajal (B) Black board
(C) A pin hole in a box (D) None of these
- According to Newton's law of cooling, the rate of cooling of a body is proportional to $(\Delta\theta)^n$, where $\Delta\theta$ is the difference of the temperature of the body and the surrounding, and n is equal to : **[2003]**
(A) One (B) two (C) three (D) four
- The earth radiates in the infrared region of the spectrum. The spectrum is correctly given by : **[2003]**
(A) Wien's law (B) Rayleigh-Jeans law
(C) Planck's law of radiation (D) Stefan's law of radiation
- A wire suspended vertically from one of its ends is stretched by attaching a weight of 200 N to the lower end. The weight stretches the wire by 1 mm . Then, the elastic energy stored in the wire is : **[2003]**
(A) 0.2 J (B) 10 J (C) 20 J (D) 0.1 J
- A wire fixed at the upper end stretches by length l by applying a force F . The work done in stretching is : **[2004]**
(A) $\frac{F}{2l}$ (B) $F l$ (C) $2 F l$ (D) $\frac{F l}{2}$
- The temperatures 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 $\left[\frac{A(T_2 - T_1)K}{x} \right] f$, where f is equal to: **[2004]**
(A) 1 (B) $\frac{1}{2}$ (C) $\frac{2}{3}$ (D) $\frac{1}{3}$
- If the temperature of the sun were to increase from T to $2T$ and its radius from R to $2R$, then the ratio of the radiant energy received on the earth to what it was previously will be: **[2004]**
(A) 4 (B) 16 (C) 32 (D) 64



10. The figure shows a system of two concentric spheres of radii r_1 and r_2 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: [2005]



(A) $\frac{r_1 r_2}{(r_2 - r_1)}$ (B) $(r_2 - r_1)$ (C) $(r_2 - r_1)(r_1 r_2)$ (D) $\ln\left(\frac{r_2}{r_1}\right)$

11. Assuming the sun to be a spherical body of radius R at a temperature of T Kelvin. Evaluate the total radiant power incident on the earth at a distance r from the sun, if radius of earth is r_0 . [2006]



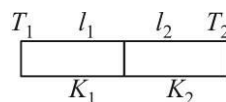
(A) $r_0^2 R^2 \sigma \frac{T^4}{4\pi r^2}$ (B) $R^2 \frac{\sigma T^4}{r^2}$ (C) $4\pi r_0^2 R^2 \frac{\sigma T^4}{r^2}$ (D) $\pi r_0^2 R^2 \frac{\sigma T^4}{r^2}$

12. A wire elongates by ℓ mm when a load w is hanged from it. If the wire goes over a pulley and two weights w each are hung at the two ends, the elongation of the wire will be (in mm): [2006]

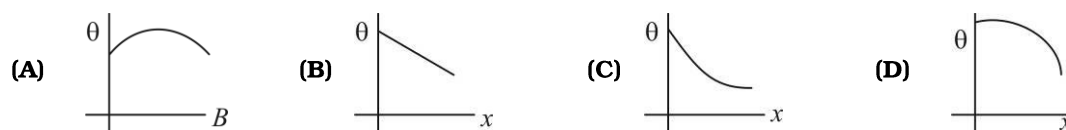
(A) ℓ (B) 2ℓ (C) zero (D) $\frac{\ell}{2}$

13. One end of a thermally insulated rod is kept at a temperature T_1 and the 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: [2007]

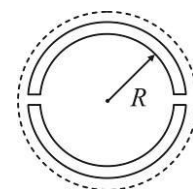
(A) $(K_2 l_2 T_1 + K_1 l_1 T_2) / (K_1 l_1 + K_2 l_2)$ (B) $(K_2 l_1 T_1 + K_1 l_2 T_2) / (K_2 l_1 + K_1 l_2)$ (C) $(K_1 l_2 T_1 + K_2 l_1 T_2) / (K_1 l_2 + K_2 l_1)$ (D) $(K_1 l_1 T_1 + K_2 l_2 T_2) / (K_1 l_1 + K_2 l_2)$



14. 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 figures. [2009]

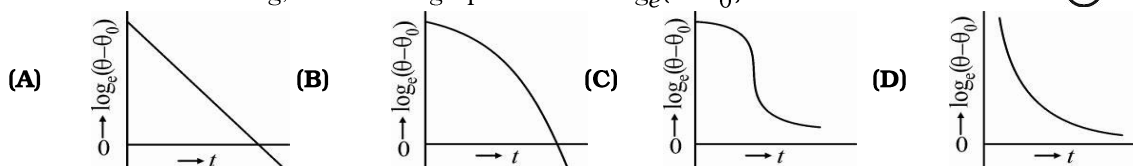


15. A wooden wheel of radius R is made of two semi-circular parts (see figure). The two parts are held together by a ring made of a metal strip of cross sectional area S and length L . L is slightly less than $2\pi R$. To fit the ring on the wheel, it is heated so that its temperature rises by ΔT and it just steps over the wheel. As it cools down to surrounding temperature, it presses the semi-circular parts together. If the coefficient of linear expansion of the metal is α , and its Young's modulus is Y , the force that one part of the wheel applies on the other part is: [2012]

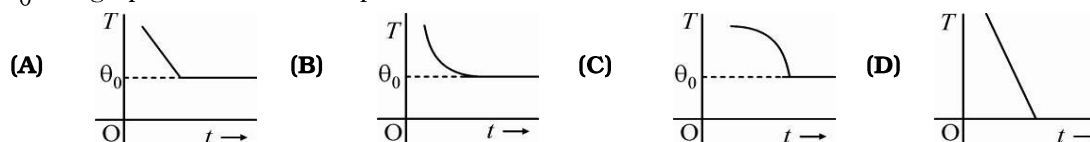


(A) $2\pi S y \alpha \Delta T$ (B) $S Y \alpha \Delta T$ (C) $\pi S Y \alpha \Delta T$ (D) $2 S Y \alpha \Delta T$

16. A liquid in a beaker has temperature $\theta(t)$ at time t and θ_0 is temperature of surroundings, then according to Newton's law of cooling, the correct graph between $\log_e(\theta - \theta_0)$ and t is: ▶ [2012]



17. If a piece of metal is heated to temperature θ and then allowed to cool in a room which is at temperature θ_0 , the graph between the temperature T of the metal and time t will be closest to: [2013]



18. Assume that a drop of liquid evaporates by decrease in its surface energy, so that its temperature remains unchanged, what should be the minimum radius of the drop for this to be possible? The surface tension is T , density of liquid is ρ and L is its latent heat of vaporisation. ▶ [2013]

- (A) $\rho L / T$ (B) $\sqrt{T / \rho L}$ (C) $T / \rho L$ (D) $2T / \rho L$

19. Three rods of copper, brass and steel are welded together to form a Y-shaped structure. Area of cross-section of each rod = 4 cm^2 . The end of copper rod is maintained at 100°C where as ends of brass and steel are kept at 0°C . Lengths of the copper, brass and steel rods are 46, 13 and 12 cm respectively. The rods are thermally insulated from surroundings except at ends. Thermal conductivities of copper, brass and steel are 0.92, 0.26 and 0.12 CGS units respectively. The rate of heat flow through copper rod is: ▶ [2014]

- (A) 4.8 cal/s (B) 6.0 cal/s (C) 1.2 cal/s (D) 2.4 cal/s

20. The pressure that has to be applied to the ends of a steel wire of length 10 cm to keep its length constant when its temperature is raised by 100°C is: (For steel Young's modulus is $2 \times 10^{11} \text{ Nm}^{-2}$ and coefficient of thermal expansion is $1.1 \times 10^{-5} \text{ K}^{-1}$) [2014]

- (A) $2.2 \times 10^7 \text{ Pa}$ (B) $2.2 \times 10^9 \text{ Pa}$ (C) $2.2 \times 10^8 \text{ Pa}$ (D) $2.2 \times 10^6 \text{ Pa}$

21. A pendulum made of uniform wire of cross-sectional area A has time period T . When an additional mass M is added to its bob, the time period changes T_M . If the Young's modulus of the material of the wire is Y , then

$\frac{1}{Y}$ is equal to (g = gravitational acceleration): ▶ [2015]

- (A) $\left[\left(\frac{T_M}{T} \right)^2 - 1 \right] \frac{A}{Mg}$ (B) $\left[\left(\frac{T_M}{T} \right)^2 - 1 \right] \frac{Mg}{A}$ (C) $\left[1 - \left(\frac{T_M}{T} \right)^2 \right] \frac{A}{Mg}$ (D) $\left[1 - \left(\frac{T}{T_M} \right)^2 \right] \frac{A}{Mg}$

22. A pendulum clock loses 12 s a day if the temperature is 40°C and gains 4 s in a day if the temperature is 20°C . The temperature at which the clock will show correct time, and the coefficient of linear expansion (α) of the metal of the pendulum shaft are, respectively: [2016]

- (A) 25°C , $\alpha = 1.85 \times 10^{-5} / ^\circ\text{C}$ (B) 60°C , $\alpha = 1.85 \times 10^{-4} / ^\circ\text{C}$
(C) 30°C , $\alpha = 1.85 \times 10^{-3} / ^\circ\text{C}$ (D) 55°C , $\alpha = 1.85 \times 10^{-2} / ^\circ\text{C}$

23. An external pressure p is applied on a cube at 0°C so that it is equally compressed from all sides. K is the bulk modulus of the material of the cube and α is its coefficient of linear expansion. Suppose we want to bring the cube to its original size by heating. The temperature should be raised by :  [2017]

(A) $\frac{p}{\alpha K}$ (B) $\frac{3\alpha}{pK}$ (C) $3pK\alpha$ (D) $\frac{p}{3\alpha K}$

24. A man grows into a giant such that his linear dimensions increase by a factor of 9. Assuming that his density remains same, the stress in the leg will change by a factor of :  [2017]

(A) $\frac{1}{9}$ (B) 81 (C) $\frac{1}{81}$ (D) 9

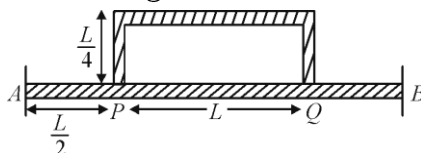
25. A solid sphere of radius r made of a soft material of bulk modulus K is surrounded by a liquid in cylindrical container. A massless piston of area a floats on the surface of the liquid covering entire cross-section of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere, $\left(\frac{dr}{r}\right)$ is:  [2018]

(A) $\frac{Ka}{mg}$ (B) $\frac{Ka}{3mg}$ (C) $\frac{mg}{3Ka}$ (D) $\frac{mg}{Ka}$

26. A rod, of length L at room temperature and uniform area of cross section A , is made of a metal having coefficient of linear expansion $\alpha/^\circ\text{C}$. It is observed that an external compressive force F , is applied on each of its ends, prevents any change in the length of the rod, when its temperature rises by ΔT . Young's modulus, Y , for this metal is : [2019]

(A) $\frac{F}{2A\alpha\Delta T}$ (B) $\frac{F}{A\alpha(\Delta T - 273)}$ (C) $\frac{F}{A\alpha\Delta T}$ (D) $\frac{2F}{A\alpha\Delta T}$

27. 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 $\frac{3L}{2}$, is connected across AB (See figure). In steady state, temperature difference between P and Q will be close to:  [2019]



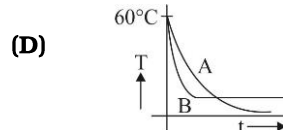
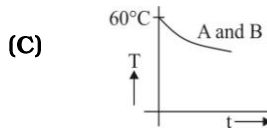
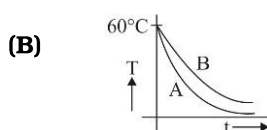
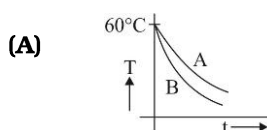
(A) 45°C (B) 60°C (C) 35°C (D) 75°C

28. In an experiment, brass and steel wires of length 1 m each with areas of cross section 1 mm^2 are used. The wires are connected in series and one end of the combined wire is connected to a rigid support and other end is subjected to elongation. The stress required to produce a net elongation of 0.2 mm is,  [2019]
[Given, the Young's Modulus for steel and brass are, respectively, $120 \times 10^9\text{ N/m}^2$ and $60 \times 10^9\text{ N/m}^2$]

(A) $1.8 \times 10^6\text{ N/m}^2$ (B) $1.2 \times 10^6\text{ N/m}^2$ (C) $4.0 \times 10^6\text{ N/m}^2$ (D) $0.2 \times 10^6\text{ N/m}^2$

- 29.** An unknown metal of mass 192 g heated to a temperature of 100°C was immersed into a brass calorimeter of mass 128 g containing 240 g of water at a temperature of 8.4°C . Calculate the specific heat of the unknown metal if water temperature stabilizes at 21.5°C . (Specific heat of brass is $394 \text{ J kg}^{-1} \text{ K}^{-1}$) 
- (A) $916 \text{ J kg}^{-1} \text{ K}^{-1}$ (B) $654 \text{ J kg}^{-1} \text{ K}^{-1}$ (C) $1232 \text{ J kg}^{-1} \text{ K}^{-1}$ (D) $458 \text{ J kg}^{-1} \text{ K}^{-1}$ [2019]
- 30.** A heat source at $T = 10^3 \text{ K}$ is connected to another heat reservoir at $T = 10^2 \text{ K}$ by a copper slab which is 1 m thick. Given that the thermal conductivity of copper is $0.1 \text{ WK}^{-1} \text{ m}^{-1}$, the energy flux through it in the steady state is: [2019]
- (A) 200 Wm^{-2} (B) 120 Wm^{-2} (C) 65 Wm^{-2} (D) 90 Wm^{-2}
- 31.** Two rods A and B of identical dimensions are at temperature 30°C . If A is heated upto 180°C and B upto $T^{\circ}\text{C}$, 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: [2019]
- (A) 270°C (B) 200°C (C) 230°C (D) 250°C
- 32.** A thermometer graduated according to a linear scale reads a value x_0 when in contact with ice. What is the temperature of an object in $^{\circ}\text{C}$, if this thermometer in the contact with the object reads $x_0 / 2$? 
- (A) 35 (B) 40 (C) 60 (D) 25 [2019]
- 33.** When 100 g of a liquid A at 100°C is added to 50 g of a liquid B at temperature 75°C , the temperature of the mixture becomes 90°C . The temperature of the mixture, if 100 g of liquid A at 100°C is added to 50 g of liquid B at 50°C , will be: [2019]
- (A) 60°C (B) 70°C (C) 85°C (D) 80°C
- 34.** A metal ball of mass 0.1 kg is heated upto 500°C 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 30°C . What is the approximate percentage increment in the temperature of the water? [Specific Heat Capacities of water and metal are, respectively, $4200 \text{ J kg}^{-1} \text{ K}^{-1}$ and $400 \text{ J kg}^{-1} \text{ K}^{-1}$] [2019]
- (A) 25% (B) 15% (C) 30% (D) 20%
- 35.** If speed (V), acceleration (A) and force (F) are considered as fundamental units, the dimension of Young's modulus will be: [2019]
- (A) $V^{-4} A^2 F$ (B) $V^{-2} A^2 F^{-2}$ (C) $V^{-2} A^2 F^2$ (D) $V^{-4} A^{-2} F$
- 36.** 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 = $4.2 \text{ J/g/}^{\circ}\text{C}$ Specific heat of Ice = $2.1 \text{ J/g/}^{\circ}\text{C}$ Heat of fusion of water at $0^{\circ}\text{C} = 334 \text{ J/g}$) [2019]
- (A) 40 g (B) 60 g (C) 50 g (D) 100 g

37. A load of mass M kg is suspended from a steel wire of length 2 m and radius 1.0 mm in Searle's apparatus experiment. The increase in length produced in the wire is 4.0 mm. Now the load is fully immersed in a liquid of relative density 2. The relative density of the material of load is 8. The new value of increase in length of the steel wire is: ▶ [2019]
(A) zero (B) 4.0 mm (C) 3.0 mm (D) 5.0 mm
38. 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: ▶ [2019]
(A) $\frac{2K_1 + 3K_2}{5}$ (B) $\frac{K_1 + 3K_2}{4}$ (C) $K_1 + K_2$ (D) $\frac{K_1 + K_2}{2}$
39. A thermally insulated vessel contains 150 g of water at 0°C . Then the air from the vessel is pumped out adiabatically. A fraction of water turns into ice and the rest evaporates at 0°C itself. The mass of evaporated water will be closest to:
(Latent heat of vaporization of water $= 2.10 \times 10^6 \text{ J kg}^{-1}$ and Latent heat of Fusion of water $= 3.36 \times 10^5 \text{ J kg}^{-1}$) ▶ [2019]
(A) 20 g (B) 150 g (C) 130 g (D) 35 g
40. A boy's catapult is made of rubber cord which is 42 cm long, with 6 mm diameter of cross-section and of negligible mass. The boy keeps a stone weighing 0.02 kg on it and stretches the cord by 20 cm by applying a constant force. When released, the stone flies off with a velocity of 20 ms^{-1} . Neglect the change in the area of cross-section of the cord while stretched. The Young's modulus of rubber is closest to : ▶ [2019]
(A) 10^6 Nm^{-2} (B) 10^3 Nm^{-2} (C) 10^8 Nm^{-2} (D) 10^4 Nm^{-2}
41. A steel wire having a radius of 2.0 mm, carrying a load of 4 kg, is hanging from a ceiling. Given that $g = 3.1 \pi \text{ ms}^{-2}$, what will be the tensile stress that would be developed the wire? ▶ [2019]
(A) $3.1 \times 10^6 \text{ Nm}^{-2}$ (B) $4.8 \times 10^6 \text{ Nm}^{-2}$ (C) $5.2 \times 10^6 \text{ Nm}^{-2}$ (D) $6.2 \times 10^6 \text{ Nm}^{-2}$
42. Two identical beakers A and B contain equal volumes of two different liquids at 60°C each and left to cool down. Liquid in A has density of $8 \times 10^2 \text{ kg/m}^3$ and specific heat of $2000 \text{ J kg}^{-1} \text{ K}^{-1}$ while liquid in B has density of 10^3 kg/m^3 and specific heat of $4000 \text{ J kg}^{-1} \text{ K}^{-1}$. Which of the following best describes their temperature versus time graph schematically? (assume the emissivity of both the beakers to be the same) ▶ [2019]



43. Young's moduli of two wires A and B are in the ratio 7 : 4. Wire A is 2 m long and has radius R. Wire B is 1.5 m long and has radius 2 mm. If the two wires stretch by the same length for a given load, then the value of R is close to: [2019]
(A) 1.5 mm (B) 1.3 mm (C) 1.7 mm (D) 1.9 mm
44. Two materials having coefficients of thermal conductivity '3 K' and 'K' and thickness 'd' and '3 d', 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: [2019]
(A) $\frac{\theta_1}{6} + \frac{5\theta_2}{6}$ (B) $\frac{\theta_1}{10} + \frac{9\theta_2}{10}$ (C) $\frac{\theta_2 + \theta_1}{2}$ (D) $\frac{\theta_1}{3} + \frac{2\theta_2}{3}$
45. The elastic limit of brass is 379 MPa. What should be the minimum diameter of a brass rod if it is to support a 400 N load without exceeding its elastic limit? [2019]
(A) 1.00 mm (B) 0.90 mm (C) 1.36 mm (D) 1.16 mm
46. A uniform cylindrical rod of length L and radius r, is made from a material whose Young's modulus of elasticity equals Y. When this rod is heated by temperature T and simultaneously subjected to a net longitudinal compressional force F, its length remains unchanged. The coefficient of volume expansion, of the material of the rod, is (nearly) equal to: [2019]
(A) $3F / (\pi r^2 Y T)$ (B) $6F / (\pi r^2 Y T)$ (C) $F / (3\pi r^2 Y T)$ (D) $9F / (\pi r^2 Y T)$
47. When M_1 gram of ice at -10°C (specific heat = $0.5 \text{ cal } g^{-1}^\circ\text{C}^{-1}$) is added to M_2 gram of water at 50°C , finally no ice is left and the water is at 0°C . The value of latent heat of ice, in $\text{cal } g^{-1}$ is: [2019]
(A) $\frac{50M_2}{M_1}$ (B) $\frac{5M_2}{M_1} - 5$ (C) $\frac{5M_1}{M_2} - 50$ (D) $\frac{50M_2}{M_1} - 5$
48. At 40°C , a brass wire of 1 mm radius 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 $10^{-5} / ^\circ\text{C}$ and 10^{11} N/m^2 , respectively; $g = 10 \text{ ms}^{-2}$) [2019]
(A) 9 kg (B) 1.5 kg (C) 0.5 kg (D) 0.9 kg