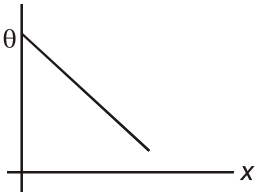
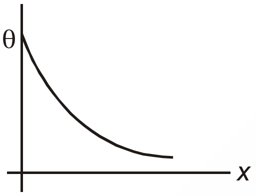
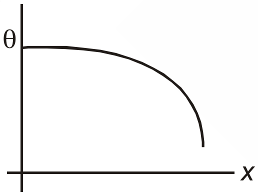
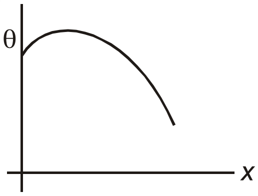
Thermal Properties of Matter

1. 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? **[AIEEE-2009]**

(1)


(2)


(3)


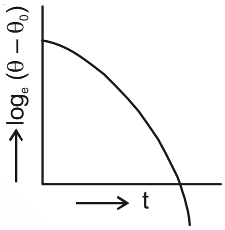
(4)


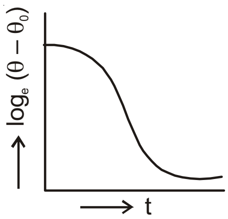
2. An aluminium sphere of 20 cm diameter is heated from 0°C to 100°C. Its volume changes by (given that coefficient of linear expansion for aluminium $\alpha_{Al} = 23 \times 10^{-6}$/°C) **[AIEEE-2011]**

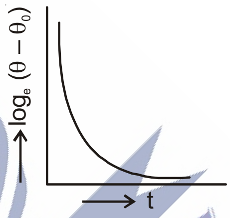
(1) 49.8 cc (2) 28.9 cc

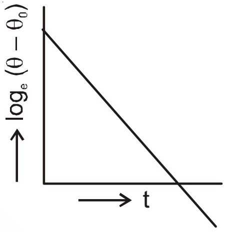
(3) 2.89 cc (4) 9.28 cc

3. 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 **[AIEEE-2012]**

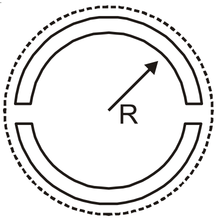
(1)


(2)


(3)


(4)


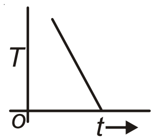
4. A wooden wheel of radius R is made of two semicircular parts (see figure). The two parts are held together by a ring made of a metal strip of cross sectional area S and length L. L is slightly less than $2\pi R$. To fit the ring on the wheel, it is heated so that its temperature rises by ΔT and it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

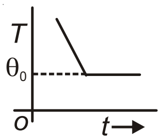


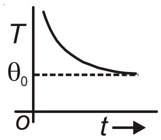
(1) $SY\alpha\Delta T$ (2) $\pi SY\alpha\Delta T$

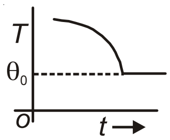
(3) $2SY\alpha\Delta T$ (4) $2\pi SY\alpha\Delta T$

5. 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 : **[JEE (Main)-2013]**

(1) 

(2) 

(3) 

(4) 

6. 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 2×10^{11} Nm^{-2} and coefficient of thermal expansion is 1.1×10^{-5} K^{-1}) **[JEE (Main)-2014]**

(1) 2.2×10^8 Pa (2) 2.2×10^9 Pa

(3) 2.2×10^7 Pa (4) 2.2×10^6 Pa

7. Three rods of copper, brass and steel are welded together to form a Y-shaped structure. Area of cross-seciton of each rod = 4 cm^2. End of copper rod is maintained at 100°C whereas 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. Rate of heat flow through copper rod is **[JEE (Main)-2014]**

(1) 1.2 cal/s (2) 2.4 cal/s

(3) 4.8 cal/s (4) 6.0 cal/s

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

(1) 60°C, $\alpha = 1.85 \times 10^{-4}$/°C

(2) 30°C, $\alpha = 1.85 \times 10^{-3}$/°C

(3) 55°C, $\alpha = 1.85 \times 10^{-2}$/°C

(4) 25°C, $\alpha = 1.85 \times 10^{-5}$/°C

9. A copper ball of mass 100 gm is at a temperature T. It is dropped in a copper calorimeter of mass 100 gm, filled with 170 gm of water at room temperature. Subsequently, the temperature of the system is found to be 75°C. T is given by :

(Given : room temperature = 30°C, specific heat of copper = 0.1 cal/gm°C) **[JEE (Main)-2017]**

(1) 800°C (2) 885°C

(3) 1250°C (4) 825°C

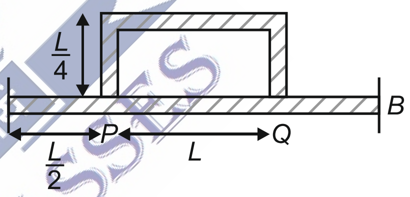
10. An external pressure P is applied on a cube at 0°C so that it is equally compressed from all sides. K is the bulk modulus of the material of the cube and α is its coefficient of linear expansion. Suppose we want to bring the cube to its original size by heating. The temperature should be raised by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

(1) $\dfrac{P}{3\alpha K}$ (2) $\dfrac{P}{\alpha K}$

(3) $\dfrac{3\alpha}{PK}$ (4) $3PK\alpha$

11. 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

[JEE (Main)-2019]



(1) 35°C (2) 45°C

(3) 60°C (4) 75°

12. 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 J $kg^{-1}K^{-1}$) **[JEE (Main)-2019]**

(1) 916 J $kg^{-1}K^{-1}$ (2) 1232 J $kg^{-1}K^{-1}$

(3) 654 J $kg^{-1}K^{-1}$ (4) 458 J $kg^{-1}K^{-1}$

13. 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 off ice added to the water was close to

(Specific heat of water = 4.2 J/g/°C

Specific heat of Ice = 2.1 J/g/°C

Heat of fusion of water at 0°C = 334 J/g)

[JEE (Main)-2019]

(1) 100 g (2) 40 g

(3) 50 g (4) 60 g

14. 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 $Jkg^{-1}K^{-1}$ and 400 $Jkg^{-1}K^{-1}$] **[JEE (Main)-2019]**

(1) 25% (2) 20%

(3) 30% (4) 15%

15. 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

[JEE (Main)-2019]

(1) 85°C (2) 80°C

(3) 70°C (4) 60°C

16. Two rods *A* and *B* of identical dimensions are at temperature 30°C. If *A* is 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

[JEE (Main)-2019]

(1) 270°C (2) 230°C

(3) 250°C (4) 200°C

17. 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 $x_0/2$? **[JEE (Main)-2019]**

(1) 40 (2) 60

(3) 35 (4) 25

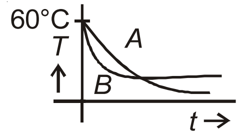
18. A cylinder of radius *R* is surrounded by a cylindrical shell of inner radius *R* and outer radius 2*R*. The thermal conductivity of the material of the inner cylinder is K_1 and that of the outer cylinder is K_2. Assuming no loss of heat, the effective thermal conductivity of the system for heat flowing along the length of the cylinder is **[JEE (Main)-2019]**

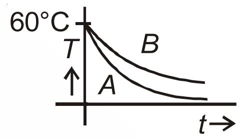
(1) $\dfrac{K_1 + K_2}{2}$ (2) $\dfrac{K_1 + 3K_2}{4}$

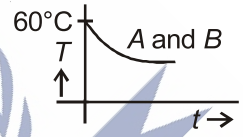
(3) $K_1 + K_2$ (4) $\dfrac{2K_1 + 3K_2}{5}$

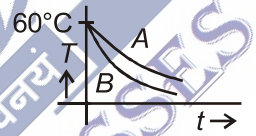
19. Two identical beakers *A* and *B* contain equal volumes of two different liquids at 60°C each and left to cool down. Liquid in *A* has density of 8×10^2 kg/m^3 and specific heat of 2000 $Jkg^{-1}K^{-1}$ while liquid in *B* has density of 10^3 kgm^{-3} and specific heat of 4000 $Jkg^{-1}K^{-1}$. Which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

[JEE (Main)-2019]

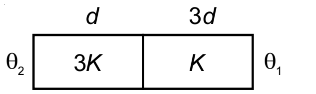
(1) 

(2) 

(3) 

(4) 

20. 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 **[JEE (Main)-2019]**



(1) $\dfrac{\theta_1}{6} + \dfrac{5\theta_2}{6}$ (2) $\dfrac{\theta_1}{10} + \dfrac{9\theta_2}{10}$

(3) $\dfrac{\theta_1}{3} + \dfrac{2\theta_2}{3}$ (4) $\dfrac{\theta_2 + \theta_1}{2}$

21. A massless spring (*k* = 800 N/m), attached with a mass (500 g) is completely immersed in 1 kg of water. The spring is stretched by 2 cm and released so that it starts vibrating. What would be the order of magnitude of the change in the temperature of water when the vibrations stop completely? (Assume that the water container and spring receive negligible heat and specific heat of mass = 400 J/kg K, specific heat of water = 4184 J/kg K) **[JEE (Main)-2019]**

(1) 10^{-5} K (2) 10^{-1} K

(3) 10^{-3} K (4) 10^{-4} K

22. 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}/°C and 10^{11} N/m^2, respectively ; g = 10 ms^{-2}) **[JEE (Main)-2019]**

(1) 0.5 kg (2) 0.9 kg

(3) 1.5 kg (4) 6.28 kg

23. When M_1 gram of ice at –10°C (specific heat = 0.5 cal g^{-1}°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 cal g^{-1} is : **[JEE (Main)-2019]**

(1) $\frac{50M_2}{M_1} - 5$ (2) $\frac{5M_1}{M_2} - 50$

(3) $\frac{50M_2}{M_1}$ (4) $\frac{5M_2}{M_1} - 5$

24. 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: **[JEE (Main)-2019]**

(1) $9F/(\pi r^2 YT)$ (2) $3F/(\pi r^2 YT)$

(3) $F/(3\pi r^2 YT)$ (4) $6F/(\pi r^2 YT)$

25. One kg of water, at 20°C, is heated in an electric kettle whose heating element has a mean (temperature averaged) resistance of 20 Ω. The rms voltage in the mains is 200 V. Ignoring heat loss from the kettle, time taken for water to evaporate fully, is close to **[JEE (Main)-2019]**

[Specific heat of water = 4200 J/(kg °C),

Latent heat of water = 2260 kJ/kg]

(1) 16 minutes (2) 3 minutes

(3) 22 minutes (4) 10 minutes

26. When the temperature of a metal wire is increased from 0°C to 10°C, its length increases by 0.02%. The percentage change in its mass density will be closest to **[JEE (Main)-2020]**

(1) 2.3 (2) 0.06

(3) 0.8 (4) 0.008

27. A metallic sphere cools from 50°C to 40°C in 300 s. If atmospheric temperature around is 20°C, then the sphere's temperature after the next 5 minutes will be close to **[JEE (Main)-2020]**

(1) 28°C (2) 35°C

(3) 33°C (4) 31°C

28. Amount of solar energy received on the earth's surface per unit area per unit time is defined a solar constant. Dimension of solar constant is

[JEE (Main)-2020]

(1) ML^2T^{-2} (2) MLT^{-2}

(3) $M^2L^0T^{-1}$ (4) ML^0T^{-3}

29. 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}) **[JEE (Main)-2020]**

(1) 2 (2) 3.2

(3) 2.6 (4) 4

30. 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) **[JEE (Main)-2020]**

(1) 69.3 (2) 63.8

(3) 64.6 (4) 61.7

31. A bullet of mass 5 g, travelling 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/(g – °C) (1 cal = 4.2 × 10^7 ergs) close to

[JEE (Main)-2020]

(1) 83.3°C (2) 87.5°C

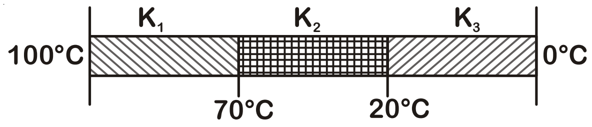
(3) 38.4°C (4) 119.2°C

32. 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 **[JEE (Main)-2020]**

(1) $\sqrt[2]{\alpha_1\alpha_2}$ (2) $4\frac{\alpha_1\alpha_2}{\alpha_1+\alpha_2}\frac{L_2L_1}{(L_2+L_1)^2}$

(3) $\frac{\alpha_1+\alpha_2}{2}$ (4) $\frac{\alpha_1L_1+\alpha_2L_2}{L_1+L_2}$

33. 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 **[JEE (Main)-2020]**



(1) $K_1 : K_3 = 2:3$, $K_2 : K_3 = 2:5$

(2) $K_1 < K_2 < K_3$

(3) $K_1 : K_2 = 5:2$, $K_1 : K_3 = 3:5$

(4) $K_1 > K_2 > K_3$

34. M grams of steam at 100°C is mixed with 200 g 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 _________. **[JEE (Main)-2020]**

35. 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)

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 °C to the nearest integer) is _______. **[JEE (Main)-2020]**

36. 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 coefficent of volume expansion of the solid is $C \times 10^{-6}$/°C then the value of C is ________.

[JEE (Main)-2020]

37. A bakelite beaker has volume capacity of 500 cc at 30°C. When it is partially filled with V_m 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 V_m (in cc) is close to __________. **[JEE (Main)-2020]**

❑ ❑ ❑