Chapter 11

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 q along the length x of the bar from its hot end is best described by which of the following figures? **[AIEEE-2009]**

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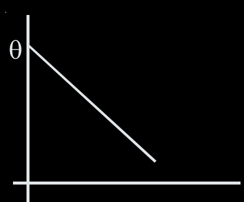

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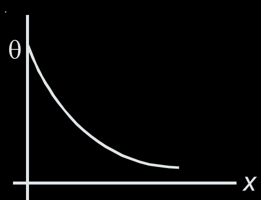

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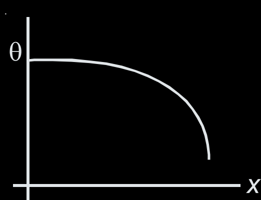

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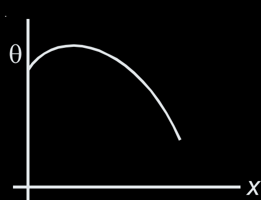
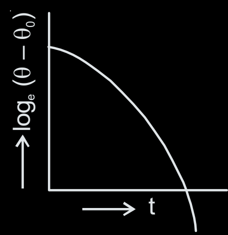


2. An aluminium sphere of 20 cm diameter is heated from 0°C to 100°C. Its volume changes by (given that coefficient of linear expansion for aluminium $a_{Al} = 23 \times 10^{-6}$/°C) **[AIEEE-2011]**

(1) 49.8 cc (2) 28.9 cc

(3) 2.89 cc (4) 9.28 cc

3. A liquid in a beaker has temperature q(t) at time t and q_0 is temperature of surroundings, then according to Newton's law of cooling the correct graph between $\log_e(q - q_0)$ and t is **[AIEEE-2012]**

(1)


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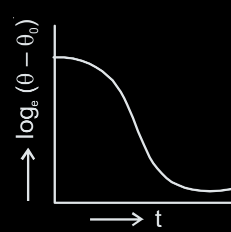

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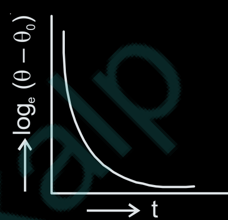

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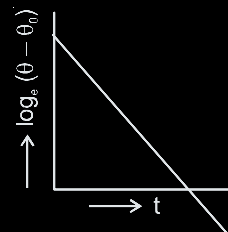
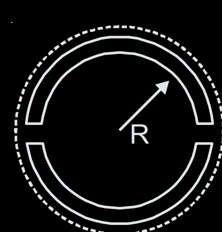


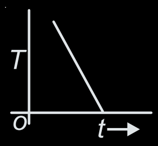
4. A wooden wheel of radius R is made of two semicircular parts (see figure). The two parts are held together by a ring made of a metal strip of cross sectional area S and length L. L is slightly less than 2pR. To fit the ring on the wheel, it is heated so that its temperature rises by DT and it just 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 a, and its Youngs' modulus is Y, the force that one part of the wheel applies on the other part is **[AIEEE-2012]**

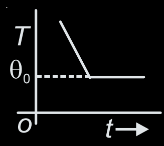


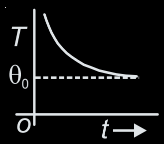
(1) SYa$\text{D}T$ (2) pSYa$\text{D}T$

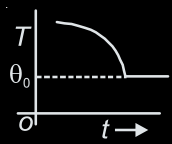
(3) 2SYa$\text{D}T$ (4) 2pSYa$\text{D}T$

5. If a piece of metal is heated to temperature q and then allowed to cool in a room which is at temperature q_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 (a) of the metal of the pendulum shaft are respectively: **[JEE (Main)-2016]**

(1) 60°C, a = 1.85×10^{-4}/°C

(2) 30°C, a = 1.85×10^{-3}/°C

(3) 55°C, a = 1.85×10^{-2}/°C

(4) 25°C, a = 1.85×10^{-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

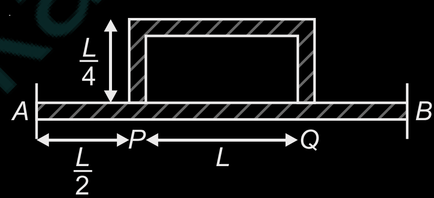
10. An external pressure P is applied on a cube at 0°C so that it is equally compressed from all sides. K is the bulk modulus of the material of the cube and a is its coefficient of linear expansion. Suppose we want to bring the cube to its original size by heating. The temperature should be raised by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

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

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

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

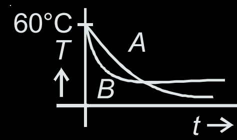
18. A cylinder of radius *R* is surrounded by a cylindrical shell of inner radius *R* and outer radius 2*R*. The thermal conductivity of the material of the inner cylinder is K_1 and that of the outer cylinder is K_2. Assuming no loss of heat, the effective thermal conductivity of the system for heat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

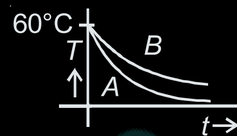
(1) $\frac{K_1 + K_2}{2}$ (2) $\frac{K_1 + 3K_2}{4}$

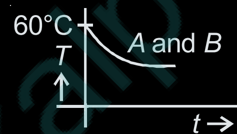
(3) $K_1 + K_2$ (4) $\frac{2K_1 + 3K_2}{5}$

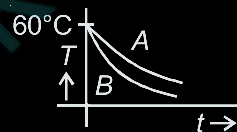
19. Two identical beakers *A* and *B* contain equal volumes of two different liquids at 60°C each and left to cool down. Liquid in *A* has density of 8×10^2 kg/m^3 and specific heat of 2000 $Jkg^{-1}K^{-1}$ while liquid in *B* has density of 10^3 kgm^{-3} and specific heat of 4000 $Jkg^{-1}K^{-1}$. Which 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 ‘q_2’ and ‘q_1’ respectively, ($q_2 > q_1$). The temperature at the interface is **[JEE (Main)-2019]**

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

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

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

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

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) $9F/(pr^2YT)$ (2) $3F/(pr^2YT)$

(3) $F/(3pr^2YT)$ (4) $6F/(pr^2YT)$

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 W. 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

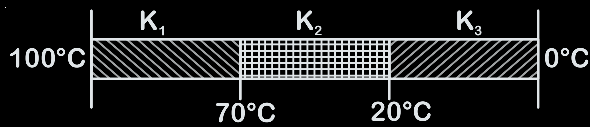
(3) 38.4°C (4) 119.2°C

32. Two different wires having lengths L_1 and L_2, and respective temperature coefficient of linear expansion a_1 and a_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) $4\dfrac{\alpha_1\alpha_2}{\alpha_1+\alpha_2}\dfrac{L_2L_1}{(L_2+L_1)^2}$

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

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 q (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 $g_{(beaker)} = 6 \times 10^{-6}°C^{-1}$ 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]**

38. 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 'a'. The metal sheet is heated uniformly, by a small temperature DT, so that its new temperature is T + DT. Calculate the increase in the volume of the metal box. **[JEE (Main)-2021]**

(1) 4pa^{3}aDT (2) 3a^{3}aDT

(3) $\frac{4}{3}\pi a^3 \alpha \Delta T$ (4) 4a^{3}aDT

39. Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R). **[JEE (Main)-2021]**

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:

(1) A is true but R is false

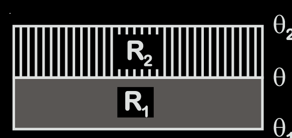
(2) A is false but R is true

(3) Both A and R are true but R is NOT the correct explanation of A

(4) Both A and R are true and R is the correct explanation of A

40. The temperature q at the junction of two insulating sheets, having thermal resistances R_1 and R_2 as well as top and bottom temperatures q$_1$ and q$_2$ (as shown in figure) is given by :

[JEE (Main)-2021]



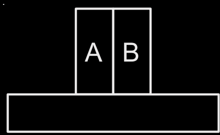
(1) $\frac{\theta_1 R_2 - \theta_2 R_1}{R_2 - R_1}$

(2) $\frac{\theta_2 R_2 - \theta_1 R_1}{R_2 - R_1}$

(3) $\frac{\theta_1 R_1 + \theta_2 R_2}{R_1 + R_2}$

(4) $\frac{\theta_1 R_2 + \theta_2 R_1}{R_1 + R_2}$

41. 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 of metal B. When the bimetallic strip is placed in a cold bath, it will : **[JEE (Main)-2021]**



(1) Bend towards the left

(2) Bend towards the right

(3) Not bend but shrink

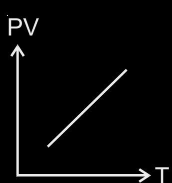
(4) Neither bend nor shrink

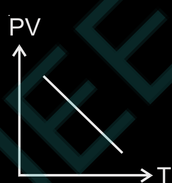
42. Two identical metal wires of thermal conductivities K_1 and K_2 respectively are connected in series. The effective thermal conductivity of the combination is: **[JEE (Main)-2021]**

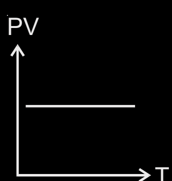
(1) $\dfrac{2K_1K_2}{K_1+K_2}$ (2) $\dfrac{K_1+K_2}{2K_1K_2}$

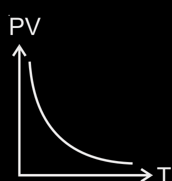
(3) $\dfrac{K_1+K_2}{K_1K_2}$ (4) $\dfrac{K_1K_2}{K_1+K_2}$

43. Which of the following graphs represent the behavior of an ideal gas? Symbols have their usual meaning. **[JEE (Main)-2021]**

(1) 

(2) 

(3) 

(4) 

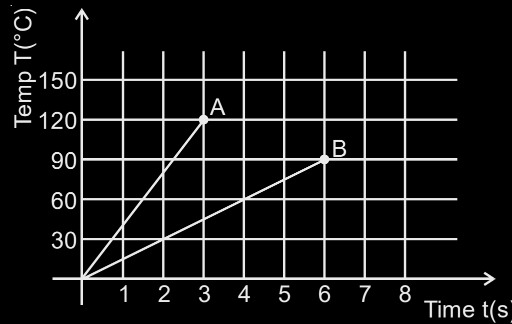
44. In 5 minutes, a body cools from 75°C to 65°C at room temperature of 25°C. The temperature of body at the end of next 5 minutes is ___ °C.

[JEE (Main)-2021]

45. 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}) **[JEE (Main)-2021]**

46. Two different metal bodies A and B of equal mass are heated at a uniform rate under similar conditions. The variation of temperature of the bodies is graphically represented as shown in the figure. The ratio of specific heat capacities is:

[JEE (Main)-2021]



(1) $\dfrac{3}{8}$ (2) $\dfrac{4}{3}$

(3) $\dfrac{3}{4}$ (4) $\dfrac{8}{3}$

47. The number of molecules in one litre of an ideal gas at 300 K and 2 atmospheric pressure with mean kinetic energy 2×10^{-9} J per molecule is

[JEE (Main)-2021]

(1) 0.75×10^{11}

(2) 4.8×10^{22}

(3) 1.5×10^{11}

(4) 3×10^{11}

48. A body takes 4 min. to cool from 61°C to 59°C. If the temperature of the surroundings is 30°C, the time taken by the body to cool from 51°C to 49°C is **[JEE (Main)-2021]**

(1) 8 min.

(2) 3 min.

(3) 6 min.

(4) 4 min.

49. 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: **[JEE (Main)-2021]**

(1) 25.62°C

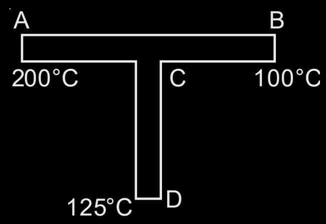
(2) 28.32°C

(3) 23.84°C

(4) 20.28°C

50. 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 ends 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 _____.

[JEE (Main)-2021]



51. 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 = 1 cal $g^{-1°}$ C^{-1}] **[JEE (Main)-2021]**

(1) 0.147°C (2) 1.476°C

(3) 14.76°C (4) 0.014°C

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 q_1 and the outer shell at temperature q_2($q_1 < q_2$). The rate at which heat flows radially through the material is:

[JEE (Main)-2021]

(1) $\dfrac{K(\theta_2-\theta_1)(r_2-r_1)}{4\pi r_1 r_2}$ (2) $\dfrac{4\pi K r_1 r_2(\theta_2-\theta_1)}{r_2-r_1}$

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

53. 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 kW 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)

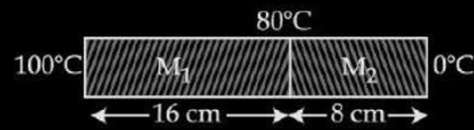
[JEE (Main)-2021]

(1) 35.3 s (2) 0.353 s

(3) 70.6 s (4) 3.53 s

54. Two metallic blocks M_1 and M_2 of same area of cross-section are connected to each other (as shown in figure). If the thermal conductivity of M_2 is K then the thermal conductivity of M_1 will be :

[Assume steady state heat conduction]



[JEE (Main)-2022]

(1) 10K

(2) 8K

(3) 12.5K

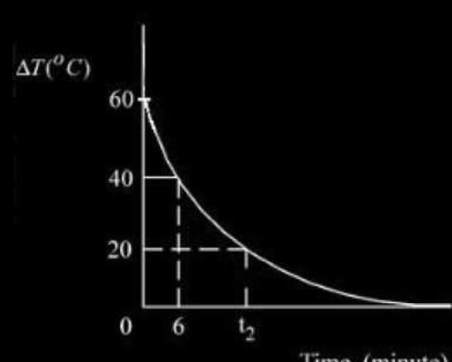
(4) 2K

55. Potential energy as a function of r is given by $U=\dfrac{A}{r^{10}}-\dfrac{B}{r^5}$, where r is the interatomic distance, A and B are positive constants. The equilibrium distance between the two atoms will be: **[JEE (Main)-2022]**

(1) $\left(\dfrac{A}{B}\right)^{\frac{1}{5}}$ (2) $\left(\dfrac{B}{A}\right)^{\frac{1}{5}}$

(3) $\left(\dfrac{2A}{B}\right)^{\frac{1}{5}}$ (4) $\left(\dfrac{B}{2A}\right)^{\frac{1}{5}}$

56. In an experiment to verify Newton's law of cooling, a graph is plotted between, the temperature difference (ΔT) of the water and surroundings and time as shown in figure. The initial temperature of water is taken as 80ºC. The value of t_2 as mentioned in the graph will be _______. **[JEE (Main)-2022]**



57. 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 $\alpha = 5.0 \times 10^{-4}\ °C^{-1}$). **[JEE (Main)-2022]**

(1) $2.4 \times 10^6\ cm^3$ (2) $1.2 \times 10^5\ cm^3$

(3) $6.0 \times 10^4\ cm^3$ (4) $4.8 \times 10^5\ cm^3$

58. 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}]

[JEE (Main)-2022]

(1) 1.5 kg (3) 5.8 kg

(3) 2.9 kg (4) 3.8 kg

59. 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:

(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 J kg^{-1}

Specific heat capacity of lead = 125 J/kg K)

[JEE (Main)-2022]

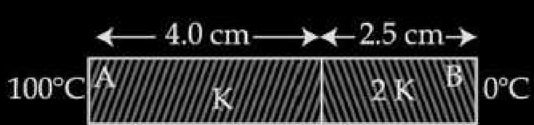
(1) 125 ms^{-1}

(2) 500 ms^{-1}

(3) 250 ms^{-1}

(4) 600 ms^{-1}

60. As per the given figure, two plates *A* and *B* of thermal conductivity *K* and 2 *K* are joined together to 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 cm^2 for each plate. The equivalent thermal conductivity of the compound plate is $\left(1+\frac{5}{\alpha}\right)$ K, then the value of α will be ___.



[JEE (Main)-2022]

61. 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 (27°C).

(Given: coefficient of linear thermal expansion of gold $\alpha_L = 1.4 \times 10^{-5}\ K^{-1}$) **[JEE (Main)-2022]**

(1) 125.7°C

(2) 91.7°C

(3) 425.7°C

(4) 152.7°C

62. A unit scale is to be prepared whose length does not change with temperature and remains 20 cm, 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 lengths remains constant. If length of brass is 40 cm and length of iron will be ___ cm.

($a_{iron} = 1.2 \times 10^{-5}\ K^{-1}$ and $\alpha_{brass} = 1.8 \times 10^{-5}\ K^{-1}$).

[JEE (Main)-2022]

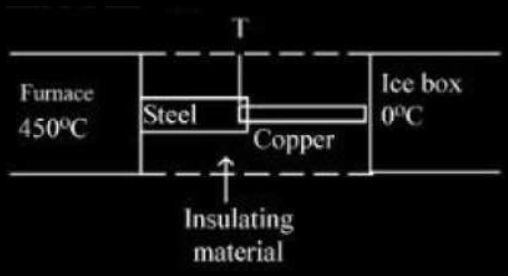
63. A block of ice of mass 120 g at temperature 0°C is put in 300 g of water at 25°C. The *x* g of ice melts as the temperature of the water reaches 0°C. The value of *x* is _______.

[Use specific heat capacity of water = 4200 $Jkg^{-1}K^{-1}$, Latent heat of ice = 3.5×10^5 Jkg^{-1}]

[JEE (Main)-2022]

64. If K_1 and K_2 are the thermal conductivities, L_1 and L_2 are the lengths and A_1 and A_2 are the cross sectional areas of steel and copper rods respectively such that $\frac{K_2}{K_1} = 9, \frac{A_1}{A_2} = 2, \frac{L_1}{L_2} = 2$. Then, for the arrangement as shown in the figure, the value of temperature *T* of the steel-copper junction in the steady state will be

[JEE (Main)-2022]



(1) 18°C

(2) 14°C

(3) 45°C

(4) 150°C

65. A 100 g of iron nail is hit by a 1.5 kg hammer striking at a velocity of 60 ms^{-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?

[Specific heat capacity of iron = 0.42 Jg^{-1} $°C^{-1}$]

[JEE (Main)-2022]

(1) 675°C

(2) 1600°C

(3) 16.07°C

(4) 6.75°C

66. An ice cube of dimensions 60 cm × 50 cm × 20 cm is placed in an insulation box of wall thickness 1 cm. The box keeping the ice cube at 0°C of temperature is brought to a room of temperature 40°C. The rate of melting of ice is approximately.

(Latent heat of fusion of ice is 3.4×10^5 J kg^{-1} and thermal conducting of insulation wall is 0.05 $Wm^{-1}°C^{-1}$) **[JEE (Main)-2022]**

(1) 61×10^{-3} kg s^{-1}

(2) 61×10^{-5} kg s^{-1}

(3) 208 kg s^{-1}

(4) 30×10^{-5} kg s^{-1}

67. 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} $°C^{-1}$] **[JEE (Main)-2022]**

❑ ❑ ❑

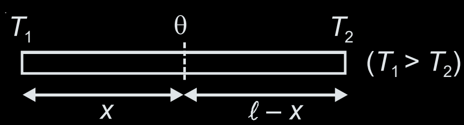
Chapter 11

Thermal Properties of Matter

1. Answer (1)

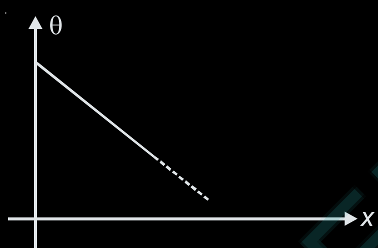
As rate of heat flow through the rod is constant through each section.

$$\frac{T_1-\theta}{\frac{x}{k_0A}}=\frac{\theta-T_2}{\frac{\ell-x}{k_0A}}$$



$$\Rightarrow \quad \theta=-\frac{(T_1-T_2)x}{\ell}+T_1$$

So, graph is



2. Answer (2)

$\Delta V = V(3\alpha)\,\Delta T$

$$=\frac{4}{3}\pi(10)^3\times 3\times 23\times 10^{-6}\times 100$$

$= 28.9$ cc

3. Answer (4)

4. Answer (1)

5. Answer (3)

The temperature will decrease exponentially with time.

6. Answer (1)

As length is constant,

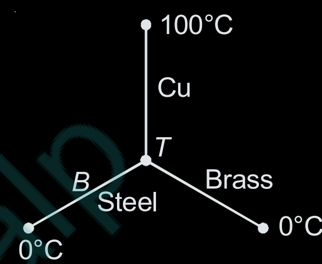
$$\text{Strain} = \frac{\Delta L}{L} = \alpha\Delta Q$$

Now pressure = stress = Y × strain

$= 2 \times 10^{11} \times 1.1 \times 10^{-5} \times 100$

$= 2.2 \times 10^{8}$ Pa

7. Answer (3)



$Q = Q_1 + Q_2$

$$\frac{0.92\times 4(100-T)}{46}=\frac{0.26\times 4\times (T-0)}{13}+\frac{0.12\times 4\times T}{12}$$

$\Rightarrow \quad 200 - 2T = 2T + T$

$\Rightarrow \quad T = 40°C$

$$\Rightarrow \quad Q = \frac{0.92\times 4\times 60}{46} = 4.8 \text{ cal/s}$$

8. Answer (4)

$$\frac{1}{2}\alpha(40-T)\times 86400 = 12\text{s} \qquad \text{...(i)}$$

$$\frac{1}{2}\alpha(T-20)\times 86400 = 4 \qquad \text{...(ii)}$$

On dividing (i) by (ii) and solving

$T = 25°C$

9. Answer (2)

$100 \times 0.1 \times (t - 75)$

$= 100 \times 0.1 \times 45 + 170 \times 1 \times 45$

$10t - 750 = 450 + 7650$

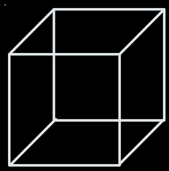
$10t = 1200 + 7650$

$10t = 8850$

$t = 885°C$

10. Answer (1)

$$K = \frac{\Delta P}{\left(-\frac{\Delta V}{V}\right)}$$



$\gamma = 3\alpha$

$$\frac{\Delta V}{V} = \frac{P}{K}$$

$$\therefore\ V = V_0\ (1 + \gamma\Delta t)$$

$$\frac{\Delta V}{V_0} = \gamma\Delta t$$

$$\therefore\ \frac{P}{K} = \gamma\Delta t \Rightarrow \Delta t = \frac{P}{\gamma K} = \frac{P}{3\alpha K}$$

11. Answer (2)

$$\frac{2(T_A - T_P)}{L} = \left(\frac{T_P - T_Q}{L}\right) + \frac{2}{3}\left(\frac{T_P - T_Q}{L}\right)$$

$$2(T_A - T_P) = \frac{5}{3}(T_P - T_Q) \qquad ....(1)$$

$$2(T_Q - T_B) = \frac{5}{3}(T_P - T_Q) \qquad ....(2)$$

From (1) and (2)

$$2(T_A - T_B) = 2(T_P - T_Q) + \frac{10}{3}(T_P - T_Q)$$

$$\Rightarrow\ 2\times 120 = \frac{16}{3}(T_P - T_Q)$$

$$\Rightarrow\ T_P - T_Q = \frac{2\times 120\times 3}{16} = 45°\text{C}$$

12. Answer (1)

$$192 \times s(100 - 21.5) = 128 \times 0.394 \times (21.5 - 8.4) + 240 \times 4.18 \times (21.5 - 8.4)$$

$$\Rightarrow\ s = \frac{660.65 + 13142}{15072}$$

$\Rightarrow$ s $\simeq$ 916 J $\text{kg}^{-1}\text{K}^{-1}$

13. Answer (2)

Heat lost by water = 50 × 40 = 2000 cal.

Let amount of ice be x g.

$$x \times \frac{1}{2} \times 20 + (x - 20) \times 80 = 2000$$

$$90\,x = 3600$$

$$x = 40 \text{ g}$$

14. Answer (2)

Heat lost = Heat gained

Let final temperature be T

$$0.1(500 - T) \times 400 = (800 + 0.5 \times 4200)[T - 30]$$

$$(500 - T) = \frac{2900}{40}[T - 30]$$

$$T = 36.39$$

$$\%\text{ increase} = \frac{36.39 - 30}{30} \simeq 20\%$$

15. Answer (2)

$$100\ S_1\ (100 - 90) = 50\ S_2\ (90 - 75)$$

$$20\ S_1 = 15\ S_2$$

$$4\ S_1 = 3\ S_2$$

Let final temperature be T

$$100\ S_1\ (100 - T) = 50\ S_2\ (T - 50)$$

$$75\ S_2\ (100 - T) = 50\ S_2\ (T - 50)$$

$$3(100 - T) = 2T - 100$$

$$T = 80°\text{C}$$

16. Answer (2)

$$\Delta\ell = \ell_0\ \alpha\ (\Delta T)$$

$$\alpha_A (180 - 30) = \alpha_B (T - 30)$$

$$4(180 - 30) = 3(T - 30)$$

$$T = 230°\text{C}$$

17. Answer (4)

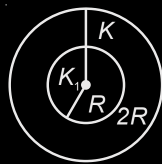
$$\frac{2x_0}{3} = 100°\text{C}$$

$$\frac{x_0}{2} = \frac{x_0}{3} + \frac{x_0}{6}$$

$$= 0° + \frac{1}{6} \times \frac{3\times 100}{2} = 25°\text{C}$$

18. Answer (2)

$$\because \quad K_{eq} = \frac{K_1A_1 + K_2A_2}{A_1 + A_2}$$



$$\Rightarrow \quad K_{eq} = \frac{K_1\pi R^2 + K_2 3\pi R^2}{4\pi R^2}$$

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

19. Answer (2)

$$mS\left(-\frac{dT}{dt}\right) = e\sigma AT^4$$

$$-\frac{dT}{dt} = \frac{e\sigma \times A \times T^4}{\rho \times \text{Vol.} \times S}$$

$$\frac{\left(-\frac{dT}{dt}\right)_A}{\left(-\frac{dT}{dt}\right)_B} = \frac{\rho_B}{\rho_A} \times (2) > 1$$

So, A cools down at faster rate.

20. Answer (2)

$$H = \frac{3KA}{d}(\theta_2 - \theta) = \frac{KA}{3d}(\theta - \theta_1)$$

$$\Rightarrow \quad \theta = \frac{9\theta_2}{10} + \frac{\theta_1}{10}$$

21. Answer (1)

$$\frac{1}{2}k\Delta x^2 = E(\text{dissipated})$$

$$\therefore \quad \frac{1}{2} \times 800 \times \left(\frac{2 \times 2}{100 \times 100}\right) = \frac{16}{100}\ \text{J}$$

$$\frac{16}{100} = \frac{1}{2} \times 400 \times \Delta T + 1 \times 4184 \times \Delta T$$

$$\Rightarrow \quad \frac{16}{100} = (200 + 4184)\Delta T = 4384\ \Delta T$$

$$\therefore \quad \Delta T = \frac{16}{4384 \times 100} = 3.6 \times 10^{-5}\ \text{K}$$

22. Answer (4)

$$\frac{Mgl}{A\,\Delta l} = Y$$

$$\therefore \quad \Delta l_{\text{Mechanical}} = \frac{Mgl}{AY}$$

$$\Delta l_{\text{Thermal}} = l\alpha\Delta T = l\alpha \times 20$$

$$\frac{Mgl}{AY} = 20\ \alpha\ l$$

$$M = \frac{20 \times 10^{-5} \times \pi \times 1 \times 10^{-6} \times 10^{11}}{10} = 6.28\ \text{kg}$$

23. Answer (1)

$M_1 \times 5 + M_1L = M_2\ 50$

$$L = \frac{50M_2}{M_1} - 5$$

24. Answer (2)

$$Y = \frac{FL}{A\,|\Delta L|} \Rightarrow \Delta L = \frac{FL}{AY} = L\ \alpha\ T$$

$$\alpha = \frac{F}{AYT}$$

$$\gamma = 3\alpha = \frac{3F}{\pi r^2 YT}$$

25. Answer (3)

$\Delta Q = 1 \times 4200 \times 80 + 2260 \times 10^3$ J

$= (336 + 2260) \times 10^3$ J $= 2596 \times 10^3$ J

$$\Delta Q = I_{\text{rms}}\ V_{\text{rms}}t = 200 \times \frac{200}{20}t = 2000t$$

$$\Rightarrow \quad t = \frac{2596}{2}\ \text{s} \approx 21.6\ \text{minutes} \approx 22\ \text{minutes}$$

26. Answer (2)

$$\rho = \frac{M}{V} \Rightarrow \left|\frac{\Delta\rho}{\rho} \times 100\right| = \left|\frac{\Delta V}{V} \times 100\right|$$

$$\left|\frac{\Delta\rho}{\rho} \times 100\right| = 3\alpha\Delta T \times 100 \qquad \text{...(i)}$$

Given $\frac{\Delta\ell}{\ell} = 2 \times 10^{-4}$ $\qquad \Rightarrow \alpha\Delta T = 2 \times 10^{-4}$

$\Rightarrow \quad \alpha = 2 \times 10^{-5}$

From (i), $\frac{\Delta\rho}{\rho} \times 100 = 6 \times 10^{-5} \times 10 \times 100$

$= 0.06$

27. Answer (3)

$$\frac{\Delta T}{\Delta t} = -b(T_{av} - T_s)$$

$$\therefore \quad \frac{50-40}{5} = -b[45-20]$$

$$\text{and, } \frac{40-T_3}{5} = -b\left[\frac{40+T_3}{2} - 20\right]$$

$$\Rightarrow \quad T_3 = \frac{200}{6} \approx 33°C$$

28. Answer (4)

$$\text{Solar constant} = \frac{E}{AT}$$

$$= \frac{M^1L^2T^{-2}}{L^2T} = M^1T^{-3}$$

29. Answer (1)

m[540 + (100 – 31)] = 200 × [31 – 25]

$$m = \frac{1200}{609}$$

$$\simeq 2\,\text{gm}$$

30. Answer (4)

$MS\Delta T = mL$

$$\Rightarrow \quad m = \frac{MS\,\Delta T}{L}$$

$$= \frac{(200)\,(4200)\,(25)}{3.4 \times 10^5}\ \text{gm}$$

= 61.7 gm

31. Answer (2)

$$\cancel{M}S\Delta T = \frac{1}{2}\left(\frac{1}{2}\cancel{M}v^2\right)$$

$$\Rightarrow \quad \Delta T = \frac{v^2}{4S}$$

$$= \frac{(210,00)^2}{4 \times 0.030 \times 4.2 \times 10^7}$$

$\simeq 87.5°C$

32. Answer (4)

$(L_1 + L_2)\alpha_{eq} \times \Delta T = L_1\alpha_1\Delta T + L_2\alpha_2\Delta T$

$$\Rightarrow \quad \alpha_{eq} = \frac{L_1\alpha_1 + L_2\alpha_2}{(L_1 + L_2)}$$

33. Answer (1)

$$K_1(100-70) = K_2(50)$$

$$K_3(20) = K_2(50)$$

34. Answer (40)

M 540 + M × 1 × (100 – 40)

= 200 × 80 + 200 × 1 × 40

$\Rightarrow$ 600 M = 24000

$\Rightarrow$ M = 40

35. Answer (50.00)

Let C_1 is at θ_1 ; C_2 is at θ_2 and C_3 is at θ_3 then

$ms(\theta_1 - 60) = 2ms(60 - \theta_2)$

$\Rightarrow \theta_1 - 60 = 120 - 2\theta_2$

$\Rightarrow \theta_1 = 180 - 2\theta_2$ ...(i)

and $ms(\theta_2 - 30) = 2ms(30 - \theta_3)$

$\Rightarrow \theta_2 = 90 - 2\theta_3$ ...(ii)

and $2ms(\theta_1 - 60) = ms(60 - \theta_3)$

$\Rightarrow 2\theta_1 - 120 = 60 - \theta_3$

$\Rightarrow 2\theta_1 + \theta_3 = 180$ ...(iii)

Adding them together $3(\theta_1 + \theta_2 + \theta_3) = 9\theta$

$\Rightarrow \theta = 50°C$

36. Answer (60.00)

$$V = lbh$$

$$\therefore \quad \frac{\Delta V}{V} = \frac{\Delta \ell}{\ell} + \frac{\Delta b}{b} + \frac{\Delta h}{h}$$

$$\Rightarrow \quad \gamma = 5 \times 10^{-5} + 5 \times 10^{-6} + 5 \times 10^{-6}$$

$$= 60 \times 10^{-6}\ /°C$$

37. Answer (20.00)

V_0 = 500 cc

$V_b = V_0 + V_0\,\gamma_{beaker}\,\Delta T$

And for Mercury

$V'_B = V_m + V_m\,\gamma_m\,\Delta T$

Unfilled volume $(V_0 - V_m) = (V_b - V'_m)$

$$\Rightarrow \quad V_0\,\gamma_{beaker} = V_m\,\gamma_M \qquad \therefore\ V_m = \frac{500 \times 6 \times 10^{-6}}{1.5 \times 10^{-4}}$$

$\Rightarrow V_m$ = 20 cc

38. Answer (2)

$V = a^3$, $\gamma = 3\alpha$

$$\therefore \quad \Delta V = V\gamma\Delta T$$

$$= a^3 \times (3\alpha)\Delta T$$

$$= 3a^3\alpha\Delta T$$

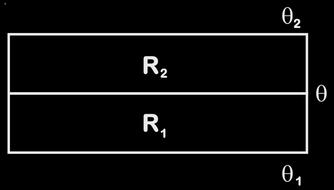
39. Answer (3)

In free expansion, thermal stress = 0

So, statement A is true.

Statement R is also true but it is not correct reason for A.

40. Answer (4)



$$\frac{\theta_2-\theta}{R_2}=\frac{\theta-\theta_1}{R_1}$$

$$\Rightarrow \theta_2R_1-\theta R_1=\theta R_2-\theta_1R_2$$

$$\Rightarrow \theta=\frac{\theta_1R_2+\theta_2R_1}{R_1+R_2}$$

41. Answer (1)

A will contract more than B, so it will bend towards left.

42. Answer (1)

$\because R_{eq} = R_1 + R_2$

$$\Rightarrow \frac{2l}{K_{eq}\times A}=\frac{l}{K_1A}+\frac{l}{K_2A}$$

$$\Rightarrow \frac{2}{K_{eq}}=\frac{K_1+K_2}{K_1K_2}$$

$$\Rightarrow K_{eq}=\frac{2K_1K_2}{K_1+K_2}$$

43. Answer (1)

PV = nRT

$\Rightarrow$ PV $\propto$ T

$\Rightarrow$ straight line with positive slope.

44. Answer (57)

$$\frac{75-65}{5}=k\left(\frac{75+65}{2}-25\right)$$

$$\Rightarrow k=\frac{2}{45}$$

$$\frac{65-T}{5}=k\left(\frac{65+T}{2}-25\right)$$

$$\Rightarrow T=57^\circ C$$

45. Answer (05)

As the tracks won't be allowed to expand linearly, the rise in temperature would lead to developing thermal stress in track.

$$\frac{\text{Stress}(\sigma)}{Y}=\alpha\Delta T \text{ or } \sigma=Y\alpha\Delta T$$

Energy stored per unit volume $=\dfrac{1}{2}\dfrac{\sigma^2}{Y}$

$\Rightarrow$ Energy stored per unit length $=\dfrac{A\sigma^2}{2Y}$

$$=\frac{A}{2}\times Y\alpha^2\Delta T^2$$

$$=\frac{10^{-2}\times10^{11}\times10^{-10}\times100}{2}=5\text{ J/m}$$

46. Answer (1)

$$Q=ms\frac{dT}{dt}$$

$$\frac{S_A}{S_B}\times\frac{120}{3}\times\frac{6}{90}=1$$

$$\frac{S_A}{S_B}\times\frac{8}{3}=1$$

$$\Rightarrow \frac{S_A}{S_B}=\frac{3}{8}$$

47. Answer (2)

$2 \times 10^5 \times 10^{-3} = (n) \times 8.31 \times 300$

$\Rightarrow$ n = 0.08 moles

N = nx N_A

= 4.8×10^{22} molecules

48. Answer (3)

$$-\frac{dT}{dt}=k(T-T_0)$$

$$\frac{(60-30)}{(50-30)}=\frac{t}{4}$$

t = 6 min.

49. Answer (3)

$10S_1 + 20S_2 = 16S_1 + 16S_2$

$\Rightarrow 4S_2 = 6S_1 \Rightarrow 2S_2 = 3S_1$ ...(1)

$20S_2 + 30S_3 = 26S_2 + 26S_3$

$\Rightarrow 6S_2 = 4S_3 \Rightarrow 3S_2 = 2S_3$ ...(2)

$10S_1 + 30S_3 = T(S_1 + S_3)$

$$\Rightarrow T = \frac{10S_1 + 30S_3}{S_1 + S_3} = 23.84°C$$

50. Answer (2)

$$\frac{200 - T}{R/2} + \frac{100 - T}{R/2} = \frac{T - 125}{R}$$

$\Rightarrow T = 145°C$

$$H = \frac{145 - 125}{10} = 2 \text{ W}$$

51. Answer (1)

By principle of calorimetry

$mgh = mc\Delta T$

$10^3 \times 4.2 \times \Delta T = 630$

$\Delta T = 0.147°C$

52. Answer (2)

$$\frac{dQ}{dt} = \frac{\theta_2 - \theta_1}{R_{th}}$$

$$\text{Now, } R_{th} = \int_{r_1}^{r_2} \frac{dx}{K \times 4\pi x^2}$$

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

$$\therefore \frac{dQ}{dt} = \frac{4\pi K r_1 r_2 (\theta_2 - \theta_1)}{(r_2 - r_1)}$$

53. Answer (1)

$ms\Delta t + mL = I^2Rt$

$\Rightarrow 10^3 \times 1 \times 10^{-4} \times 1[2 \times 10^3 \times 10 + 3.33 \times 10^5]$

$= 0.5^2 \times 4 \times 10^3 \times t$

$\Rightarrow t = 35.3$ s

54. Answer (2)

Thermal current is same so

$$\frac{dQ}{dt} = \frac{\Delta T_1}{\frac{l_1}{K_1 A}} = \frac{\Delta T_2}{\frac{l_2}{K_2 A}}$$

$$\text{or } \frac{20}{16} \times K' = \frac{80}{8} \times K$$

$\Rightarrow K' = 8K$

55. Answer (3)

For equilibrium

$$-\frac{dU}{dr} = 0 = \frac{10A}{r^{11}} - \frac{5B}{r^6}$$

$$\Rightarrow r^5 = \frac{2A}{B}$$

$$\text{And } r = \left(\frac{2A}{B}\right)^{1/5}$$

56. Answer (16)

Temperature of surrounding = 20ºC

For 0 $\to$ 6 minutes, average temp. = 70ºC

$\to$ Rate of cooling $\propto$ 70ºC – 20ºC = 50ºC

For 6 $\to$ t_2 minutes, average temp. = 50ºC

$\to$ Rate of cooling $\propto$ 30ºC

$$\Rightarrow t_2 - 6 = \frac{5}{3}(6 \text{ minutes})$$

$\Rightarrow t_2 = 16$ minutes

57. Answer (2)

$6 \times l^2 = 24$

$\Rightarrow l = 2$ m

$$\therefore \frac{\Delta V}{V} = 3 \times \frac{\Delta l}{l}$$

$\Rightarrow \Delta V = 3 \times (\alpha \Delta T) \times V$

$= 3 \times 5 \times 10^{-4} \times 10 \times (8)$

$= 120 \times 10^{-3}$ m^3

$= 120 \times 10^{-3} \times 10^6$ cm^3

$= 1.2 \times 10^5$ cm^3

58. Answer (3)

$mL = \Delta Q = ms\Delta T$

$$\Rightarrow m = \frac{5 \times 0.39 \times 10^3 \times 500}{335}$$

$= 2.9$ kg

59. Answer (2)

$$\frac{2}{5}\times\frac{1}{2}mv^2 = mL + ms\Delta T$$

$$\Rightarrow \frac{v^2}{5} = 2.5\times10^4 + 125 + 200$$

$$\Rightarrow \frac{v^2}{5} = 5\times10^4$$

$\Rightarrow$ v = 500 m/s

60. Answer (21)

$$\frac{L_1}{K_1A_1} + \frac{L_2}{K_2A_2} = \frac{L_1+L_2}{K_{eff}A_{eff}}$$

$$\Rightarrow \frac{4}{K} + \frac{2.5}{2K} = \frac{6.5}{K_{eff}}$$

$$\Rightarrow \frac{10.5}{2K} = \frac{6.5}{K_{eff}}$$

$$\Rightarrow K_{eff} = \frac{13K}{10.5} = \left(1+\frac{5}{21}\right)K$$

$\Rightarrow$ $\alpha = 21$

61. Answer (4)

$\Delta D = D\alpha\Delta T$

$$\Delta T = \frac{0.011}{6.230\times1.4\times10^{-5}}$$

= 126.11°C

$\Rightarrow$ $T_f = T + \Delta T$

= (27 + 126.11)°C

= 153.11°C

$\Rightarrow$ Option (4) is correct

62. Answer (60)

$\Delta L_1 = \alpha_1 L_1 \Delta T$

$\Delta L_2 = \alpha_2 L_2 \Delta T$

$\alpha_1 L_1 = \alpha_2 L_2$

$1.2 \times 10^{-5} \times L_1 = 1.8 \times 10^{-5} L_2$

$$L_1 = \frac{1.8}{1.2}\times 40 = 60 \text{ cm}$$

63. Answer (90)

Heat lost by water = Heat gained by ice

$0.3 \times 4200 \times 25 = x \times 3.5 \times 10^5$

$$x = \frac{0.3\times4200\times25}{3.5\times10^5}$$

$= 90 \times 100 \times 10^5 \times 10^3$ gram = 90 gm

64. Answer (3)

$$450 - T = \frac{dQ}{dt}\times\frac{l_1}{K_1A_1}$$

$$T - 0 = \frac{dQ}{dt}\times\frac{l_2}{K_2A_2}$$

So, $\frac{450-T}{T} = \frac{K_2A_2l_1}{K_1A_1l_2} = 9\times\frac{1}{2}\times2 = 9$

$450 - T = 9T$

$\Rightarrow$ T = 45°C

65. Answer (3)

$$\frac{1}{2} \times 1.5 \times 60^2 \times \frac{1}{4} = 100 \times 0.42 \times \Delta T$$

$$\Delta T = \frac{1.5\times60^2}{8\times100\times0.42} = 16.07°\text{C}$$

66. Answer (2)

$$\frac{\Delta Q}{\Delta t} = \frac{kA(T_1-T_2)}{\ell}$$

$$\Rightarrow \frac{mL}{\Delta t} = \frac{kA(T_1-T_2)}{\ell}$$

$$\Rightarrow \frac{m}{\Delta t} = \frac{kA(T_1-T_2)}{L\ell}$$

$\simeq 61.1 \times 10^{-5}$ kg/s

67. Answer (42)

Q = msΔT

$$\frac{dQ}{dt} = \left(\frac{dm}{dt}\right)_{water} S\Delta T = \left(\frac{dm}{dt}\right)_{oil} C$$

$$\Rightarrow 2\times4.2\times10^3\times40 = \left(\frac{dm}{dt}\right)_{oil}\times8\times10^6$$

$$\Rightarrow \left(\frac{dm}{dt}\right)_{oil} = \frac{8\times4.2\times10^4}{8\times10^6} \text{ kg / minute}$$

= 42 g/min