10

THERMAL PROPERTIES OF MATTER

MCQs with One Correct Answer

1. 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 $\ell_1 + \ell_2$. 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 $\ell_1/(\ell_1 + \ell_2)$.

(a) α_s/α_a (b) α_a/α_s

(c) $\alpha_s/(\alpha_a+\alpha_s)$ (d) $\alpha_a/(\alpha_a+\alpha_s)$

2. If a graph is plotted taking the temperature in Fahrenheit along Y-axis and the corresponding temperature in Celsius along the X-axis, it will be a straight line

(a) having a + ve intercept on Y-axis

(b) having a + ve intercept on X-axis

(c) passing through the origin

(d) having a – ve intercepts on both the axis

3. A steel rail of length 5 m and area of cross-section 40 cm^2 is prevented from expanding along its length while the temperature rises by 10°C. If coefficient of linear expansion and Young's modulus of steel are $1.2 \times 10^{-5}\ K^{-1}$ and $2 \times 10^{11}\ Nm^{-2}$ respectively, the force developed in the rail is approximately:

(a) 2×10^7 N (b) 1×10^5 N

(c) 2×10^9 N (d) 3×10^{-5} N

4. A glass flask of volume one litre at 0°C is filled full with mercury at this temperature. The flask and mercury are now heated to 100°C. How much mercury will spill out, if coefficient of volume expansion of mercury is 1.82×10^{-4}/°C and linear expansion of glass is 0.1×10^{-4} /°C respectively?

(a) 21.2 cc (b) 15.2 cc

(c) 1.52 cc (d) 2.12 cc

5. The coefficient of linear expansion of crystal in one direction is α_1 and that in every direction perpendicular to it is α_2 . The coefficient of cubical expansion is

(a) $\alpha_1 + \alpha_2$ (b) $\alpha_1 + 2\alpha_2$

(c) $2\alpha_1 + \alpha_2$ (d) $\alpha_1 + \alpha_2/2$

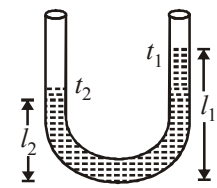
6. In a vertical U-tube containing a liquid, the two arms are maintained at different temperatures t_1 and t_2. The liquid columns in the two arms have heights l_1 and l_2 respectively. The coefficient of volume expansion of the liquid is equal to

(a) $\dfrac{l_1 - l_2}{l_2 t_1 - l_1 t_2}$

(b) $\dfrac{l_1 - l_2}{l_1 t_1 - l_2 t_2}$

(c) $\dfrac{l_1 + l_2}{l_2 t_1 + l_1 t_2}$

(d) $\dfrac{l_1 + l_2}{l_1 t_1 + l_2 t_2}$



7. In an experiment a sphere of aluminium of mass 0.20 kg is heated upto 150°C. Immediately, it is put into water of volume 150 cc at 27°C kept in a calorimeter of water equivalent to 0.025 kg. Final temperature of the system is 40°C. The specific heat of aluminium is :

(take 4.2 joule=1 calorie)

(a) 378 J/kg – °C (b) 315 J/kg – °C

(c) 476 J/kg – °C (d) 434 J/kg – °C

8. A black body at 1227°C emits radiations with maximum intensity at a wavelength of 5000Å. If the temperature of the body is increased by 1000°C, the maximum intensity will be observed at

(a) 5000Å (b) 6000Å

(c) 3000Å (d) 4000Å

9. Two rods of same length transfer a given amount of heat in 12 second, when they are joined as shown in figure (i). But when they are joined as shown in figure (ii), then they will transfer same heat in same conditions in

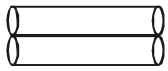


Fig. (i)

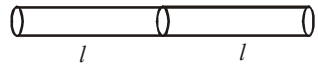


Fig. (ii)

(a) 24 s (b) 13 s

(c) 15 s (d) 48 s

10. Two rigid boxes containing different ideal gases are placed on a table. Box A contains one mole of nitrogen at temperature T_0, while Box B contains one mole of helium at temperature $\left(\frac{7}{3}\right)T_0$. The boxes are then put into thermal contact with each other, and heat flows between them until the gases reach a common final temperature (ignore the heat capacity of boxes). Then, the final temperature of the gases, T_f in terms of T_0 is

(a) $T_f = \frac{3}{7}T_0$ (b) $T_f = \frac{7}{3}T_0$

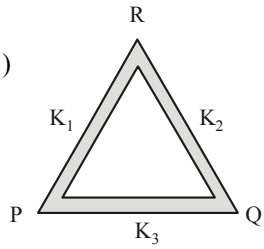
(c) $T_f = \frac{3}{2}T_0$ (d) $T_f = \frac{5}{2}T_0$

11. A bullet of mass 10gm moving with a speed of 20 m/s hits an ice block of mass 990gm kept on a frictionless floor and gets stuck in it. How much ice will melt if 50% of the lost KE goes to ice ? (Initial temperature of the ice block = 0°C, J = 4.2 J/cal and latent heat of ice = 80 cal/g)

(a) 0.001 gm (b) 0.002 gm

(c) 0.003 gm (d) None of these

12. Three rods of same dimensions are arranged as shown in figure. They have thermal conductivities K_1, K_2 and K_3. The points P and Q are maintained at different temperatures for the heat to flow at the same rate along PRQ and PQ then which of the following option is correct?



(a) $K_3 = \frac{1}{2}(K_1 + K_2)$

(b) $K_3 = K_1 + K_2$

(c) $K_3 = \frac{K_1 K_2}{K_1 + K_2}$

(d) $K_3 = 2(K_1 + K_2)$

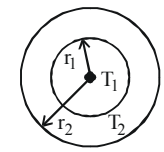
13. A copper sphere cools from 62°C to 50°C in 10 minutes and to 42°C in the next 10 minutes. Calculate the temperature of the surroundings.

(a) 28°C (b) 26°C

(c) 32°C (d) 62°C

14. 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

(a) $\ell n\left(\frac{r_2}{r_1}\right)$



(b) $\frac{(r_2 - r_1)}{(r_1 r_2)}$

(c) $(r_2 - r_1)$

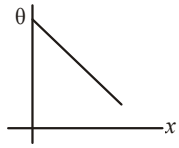
(d) $\frac{r_1 r_2}{(r_2 - r_1)}$

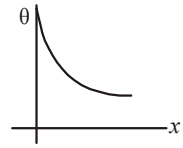
15. A thermometer graduated according to a linear scale reads a value x_0 when in contact with boiling water, and $x_0/3$ when in contact with ice. What is the temperature of an object in °C, if this thermometer in the contact with the object reads $x_0/2$?

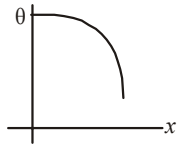
(a) 25 (b) 60

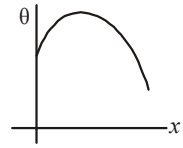
(c) 40 (d) 35

16. 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?

(a) 

(b) 

(c) 

(d) 

17. 500 g of water and 100 g of ice at 0°C are in a calorimeter whose water equivalent is 40 g. 10 g of steam at 100°C is added to it. Then water in the calorimeter is : (Latent heat of ice = 80 cal/g, Latent heat of steam = 540 cal/ g)

(a) 580 g (b) 590 g

(c) 600 g (d) 610 g

18. 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 :

(a) 230°C (b) 270°C

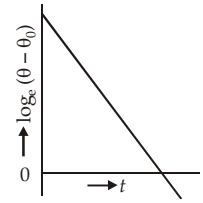
(c) 200°C (d) 250°C

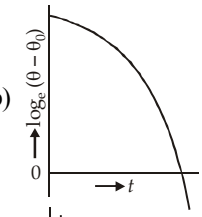
19. A large cylindrical rod of length L is made by joining two identical rods of copper and steel of length $\left(\frac{L}{2}\right)$ each. The rods are completely insulated from the surroundings. If the free end of copper rod is maintained at 100°C and that of steel at 0°C then the temperature of junction is (Thermal conductivity of copper is 9 times that of steel)

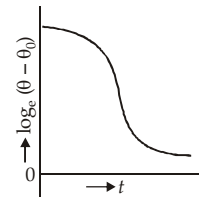
(a) 90°C (b) 50°C

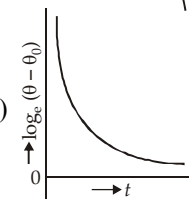
(c) 10°C (d) 67°C

20. 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 :

(a) 

(b) 

(c) 

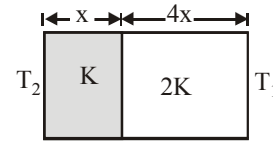
(d) 

Numeric Value Answer

21. The coefficient of apparent expansion of mercury in a glass vessel is 153×10^{-6}/°C and in a steel vessel is 144×10^{-6}/°C. If α for steel is 12×10^{-6}/°C, then that of glass (in /°C) is

22. 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 (in °C) at which the clock will show correct time is

23. The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficient 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 with f equal to



24. A body cools from 50.0°C to 48°C in 5s. How long (in s) will it take to cool from 40.0°C to 39°C? Assume the temperature of surroundings to be 30.0°C and Newton's law of cooling to be valid.

25. 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 _____.

26. 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 (in g) is _____.

27. 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 surroundings, and n is equal to

28. 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 earth to what it was previously will be

29. 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

30. 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 (in kg) 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})

ANSWER KEY																			
1	(c)	**4**	(b)	**7**	(d)	**10**	(c)	**13**	(b)	**16**	(a)	**19**	(a)	**22**	(25)	**25**	(20)	**28**	(64)
2	(a)	**5**	(b)	**8**	(c)	**11**	(c)	**14**	(d)	**17**	(b)	**20**	(a)	**23**	(0.33)	**26**	(40)	**29**	(1)
3	(b)	**6**	(a)	**9**	(d)	**12**	(c)	**15**	(a)	**18**	(a)	**21**	(9×10^{-6})	**24**	(10)	**27**	(1)	**30**	(6.28)