DPP - Daily Practice Problems

Chapter-wise Sheets

Date : | **Start Time :** | **End Time :**

PHYSICS

CP10

SYLLABUS : Thermal Properties of Matter

Max. Marks : 180 **Marking Scheme :** (+4) for correct & (–1) for incorrect answer **Time : 60 min.**

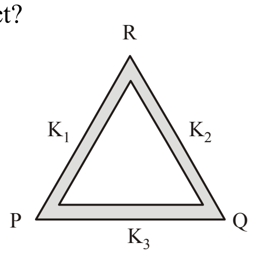
INSTRUCTIONS : This Daily Practice Problem Sheet contains 45 MCQs. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

1. The total radiant energy per unit area, normal to the direction of incidence, received at a distance R from the centre of a star of radius r, whose outer surface radiates as a black body at a temperature T K is given by: (σ is Stefan's constant)

(a) $\frac{\sigma r^2 T^4}{R^2}$ (b) $\frac{\sigma r^2 T^4}{4\pi r^2}$

(c) $\frac{\sigma r^4 T^4}{r^4}$ (d) $\frac{4\pi\sigma r^2 T^4}{R^2}$

2. Three rods of same dimensions are arranged as shown in figure, have thermal conductivities K_1, K_2 and K_3. The points P and Q are maintained at different temeratures 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) $K_3 = -2(K_1 + K_2)$

3. The sprinkling of water slightly reduces the temperature of a closed room because

(a) temperature of water is less than that of the room

(b) specific heat of water is high

(c) water has large latent heat of vaporisation

(d) water is a bad conductor of heat

4. The value of molar heat capacity at constant temperature is

(a) zero (b) infinity

(c) unity (d) 4.2

5. The specific heat capacity of a metal at low temperature (T) is given as

$$C_p(kJK^{-1}\text{kg}^{-1}) = 32\left(\frac{T}{400}\right)^3$$

A 100 gram vessel of this metal is to be cooled from 20ºK to 4ºK by a special refrigerator operating at room temperature (27°C). The amount of work required to cool the vessel is

(a) greater than 0.148 kJ

(b) between 0.148 kJ and 0.028 kJ

(c) less than 0.028 kJ

(d) equal to 0.002 kJ

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ

Space for Rough Work

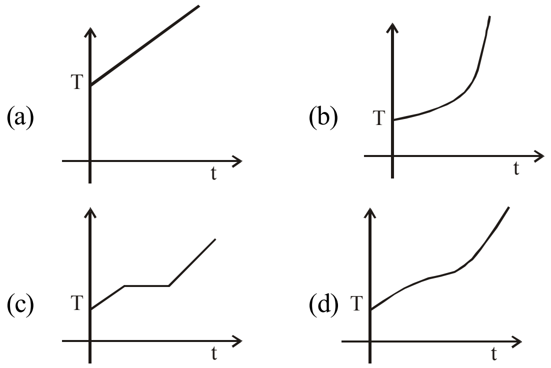
6. The emissive power of a black body at T = 300K is 100 Watt/m^2. Consider a body B of area A = $10m^2$ coefficient of reflectivity r = 0.3 and coefficient of transmission t = 0.5. Its temperature is 300K. Then which of the following is incorrect?
(a) The emissive power of B is 20 W/m^2
(b) The emissive power of B is 200 W/m^2
(c) The power emitted by B is 200 Watts
(d) The emissivity of B is 0.2

7. A solid cube and a solid sphere of the same material have equal surface area. Both are at the same temperture 120°C, then
(a) both the cube and the sphere cool down at the same rate
(b) the cube cools down faster than the sphere
(c) the sphere cools down faster than the cube
(d) whichever is having more mass will cool down faster

8. The density of water at 20°C is 998 kg/m^3 and at 40°C 992 kg/m^3. The coefficient of volume expansion of water is
(a) 10^{-4}/°C (b) 3×10^{-4}/°C
(c) 2×10^{-4}/°C (d) 6×10^{-4}/°C

9. A metallic rod ℓ cm long, A square cm in cross-section is heated through t°C. If Young's modulus of elasticity of the metal is E and the mean coefficient of linear expansion is α per degree celsius, then the compressional force required to prevent the rod from expanding along its length is
(a) $E A \alpha t$ (b) $E A \alpha t/(1 + \alpha t)$
(c) $E A \alpha t/(1 - \alpha t)$ (d) $E \ell \alpha t$

10. If liquefied oxygen at 1 atmospheric pressure is heated from 50 K to 300 K by supplying heat at constant rate. The graph of temperature vs time will be



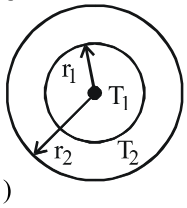
11. If a bar is made of copper whose coefficient of linear expansion is one and a half times that of iron, the ratio of force developed in the copper bar to the iron bar of identical lengths and cross-sections, when heated through the same temperature range (Young's modulus of copper may be taken to be equal to that of iron) is
(a) 3/2 (b) 2/3 (c) 9/4 (d) 4/9

12. A piece of ice falls from a height h so that it melts completely. Only one-quarter of the heat produced is absorbed by the ice and all energy of ice gets converted into heat during its fall. The value of h is :
[Latent heat of ice is 3.4×10^5 J/kg and g = 10 N/kg]
(a) 34 km (b) 544 km (c) 136 km (d) 68 km

13. A body of mass 5 kg falls from a height of 20 metres on the ground and it rebounds to a height of 0.2 m. If the loss in potential energy is used up by the body, then what will be the temperature rise?
(specific heat of material = 0.09 cal gm^{-1} $°C^{-1}$)
(a) 0°C (b) 4°C (c) 8°C (d) None of these

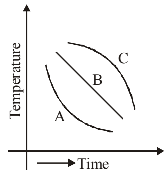
14. Two straight metallic strips each of thickness t and length ℓ are rivetted together. Their coefficients of linear expansions are α_1 and α_2. If they are heated through temperature ΔT, the bimetallic strip will bend to form an arc of radius
(a) $t/\{\alpha_1 + \alpha_2)\Delta T\}$ (b) $t/\{(\alpha_2 - \alpha_1)\Delta T\}$
(c) $t(\alpha_1 - \alpha_2)\Delta T$ (d) $t(\alpha_2 - \alpha_1)\Delta T$

15. The figure shows a system of two concentric spheres of radii r_1 and r_2 are 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) $\ln\left(\frac{r_2}{r_1}\right)$ (b) $\frac{(r_2 - r_1)}{(r_1 r_2)}$
(c) $(r_2 - r_1)$ (d) $\frac{r_1 r_2}{(r_2 - r_1)}$

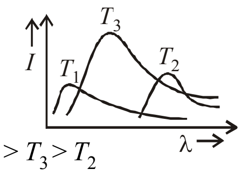
16. A block of steel heated to 100°C is left in a room to cool. Which of the curves shown in fig., represents the correct behaviour?



(a) A (b) B (c) C (d) None of these

17. Which of the following will expand the most for same rise in temperature?
(a) Aluminium (b) Glass
(c) Wood (d) All will expand same

18. The plots of intensity versus wavelength for three black bodies at temperatures T_1, T_2 and T_3 respectively are as shown. Their temperature are such that



(a) $T_1 > T_2 > T_3$ (b) $T_1 > T_3 > T_2$
(c) $T_2 > T_3 > T_1$ (d) $T_3 > T_2 > T_1$

19. When the temperature of a rod increases from t to t + Δt, its moment of inertia increases from I to I + ΔI. If α be the coefficient of linear expansion of the rod, then the value of $\frac{\Delta I}{I}$ is
(a) $2\alpha\Delta t$ (b) $\alpha\Delta T$ (c) $\frac{\alpha\Delta t}{2}$ (d) $\frac{\Delta t}{\alpha}$

20. 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 and respectively. If the length of each rod increases by the same amount when their temperature are raised by t^0C, 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) $\alpha_a/(\alpha_a + \alpha_s)$

RESPONSE GRID					
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ

Space for Rough Work

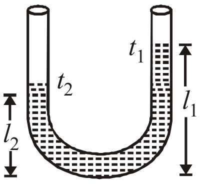
21. A polished metal plate with a rough black spot on it is heated to about 1400 K and quickly taken into a dark room. Which one of the following statements will be true?
(a) The spot will appear brighter than the plate
(b) The spot will appear darker than the plate
(c) The spot and plate will appear equally bright
(d) The spot and the plate will not be visible in the dark room

22. On observing light from three different stars P, Q and R, it was found that intensity of violet colour is maximum in the spectrum of P, the intensity of green colour is maximum in the spectrum of R and the intensity of red colour is maximum in the spectrum of Q. If T_P, T_Q and T_R are the respective absolute temperature of P, Q and R, then it can be concluded from the above observations that
(a) $T_P > T_R > T_Q$ (b) $T_P < T_R < T_Q$
(c) $T_P < T_Q < T_R$ (d) $T_P > T_Q > T_R$

23. A partition wall has two layers of different materials A and B in contact with each other. They have the same thickness but the thermal conductivity of layer A is twice that of layer B. At steady state the temperature difference across the layer B is 50 K, then the corresponding difference across the layer A is
(a) 50 K (b) 12.5 K (c) 25 K (d) 60 K

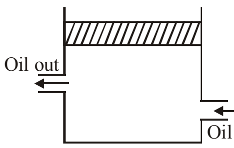
24. Which of the following statements is/are false about mode of heat transfer?
(a) In radiation, heat is transfered from one medium to another without affecting the intervening medium
(b) Radiation and convection are possible in vaccum while conduction requires material medium.
(c) Conduction is possible in solids while convection occurs in liquids and gases.
(d) All are correct

25. 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) $\frac{l_1 - l_2}{l_2 t_1 - l_1 t_2}$ (b) $\frac{l_1 - l_2}{l_1 t_1 - l_2 t_2}$ (c) $\frac{l_1 + l_2}{l_2 t_1 + l_1 t_2}$ (d) $\frac{l_1 + l_2}{l_1 t_1 + l_2 t_2}$

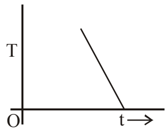
26. The top of an insulated cylindrical container is covered by a disc having emissivity 0.6 and conductivity 0.167 $WK^{-1}m^{-1}$ and thickness 1 cm. The temperature is maintained by circulating oil as shown in figure. Find the radiation loss to the surrounding in $Jm^{-2}s^{-1}$ if temperature of the upper surface of the disc is 27°C and temperature of the surrounding is 27°C.

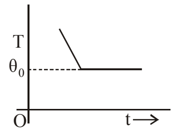


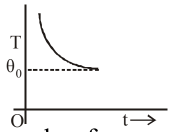
(a) 595 $Jm^{-2}s^{-1}$ (b) 545 $Jm^{-2}s^{-1}$
(c) 495 $Jm^{-2}s^{-1}$ (d) None of these

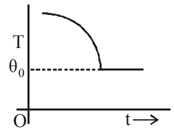
27. Wien's law is concerned with
(a) relation between emissivity and absorptivity of a radiating surface
(b) total radiation, emitted by a hot surface
(c) an expression for spectral distribution of energy of a radiation from any source
(d) a relation between the temperature of a black body and the wavelength at which there is maximum radiant energy per unit wavelength

28. 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

(a) 

(b) 

(c) 

(d) 

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

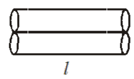


Fig. (i)

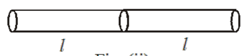


Fig. (ii)

(a) 24 s (b) 13 s (c) 15 s (d) 48 s

30. Consider a compound slab consisting of two different materials having equal thicknesses and thermal conductivities *K* and 2*K*, respectively. The equivalent thermal conductivity of the slab is
(a) $\frac{4}{3}K$ (b) $\frac{2}{3}K$ (c) $\sqrt{3}\,K$ (d) $3K$

31. The coefficient of thermal conductivity of copper, mercury and glass are respectively K_c, K_m and K_g such that $K_c > K_m > K_g$. If the same quantity of heat is to flow per sec per unit area of each and corresponding temperature gradients are X_c, X_m and X_g then
(a) $X_c = X_m = X_g$ (b) $X_c > X_m > X_g$
(c) $X_c < X_m < X_g$ (d) $X_m < X_c < X_g$

32. The radiation energy density per unit wavelength at a temperature T has a maximum at a wavelength λ_0. At temperature 2T, it will have a maximum wavelength
(a) $4\lambda_0$ (b) $2\lambda_0$ (c) $\frac{\lambda_0}{2}$ (d) $\frac{\lambda_0}{4}$

33. Assuming the Sun to be a spherical body of radius *R* at a temperature of *TK*, evaluate the total radiant powerd incident of Earth at a distance *r* from the Sun
(a) $4\pi r_0^2 R^2 \sigma \frac{T^4}{r^2}$ (b) $\pi r_0^2 R^2 \sigma \frac{T^4}{r^2}$
(c) $r_0^2 R^2 \sigma \frac{T^4}{4\pi r^2}$ (d) $R^2 \sigma \frac{T^4}{r^2}$

RESPONSE GRID					
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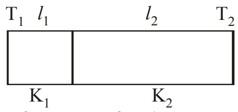
	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ
	31. ⓐⓑⓒⓓ	32. ⓐⓑⓒⓓ	33. ⓐⓑⓒⓓ		

Space for Rough Work

34. A metal ball immersed in alcohol weighs W_1 at 0ºC and W_2 at 59ºC. The coefficient of cubical expansion of the metal is less than that of alcohol. Assuming that the density of the metal is large compared to that of alcohol, it can be shown that

(a) $W_1 > W_2$ (b) $W_1 = W_2$
(c) $W_1 < W_2$ (d) $W_1 = (W_2/2)$

35. 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 length l_1 and l_2 and thermal conductivities K_1 and K_2 respectively. The temperature at the interface of the two sections is



(a) $\frac{(K_1l_1T_1+K_2l_2T_2)}{(K_1l_1+K_2l_2)}$ (b) $\frac{(K_2l_2T_1+K_1l_1T_2)}{(K_1l_1+K_2l_2)}$

(c) $\frac{(K_2l_1T_1+K_1l_2T_2)}{(K_2l_1+K_1l_2)}$ (d) $\frac{(K_1l_2T_1+K_2l_1T_2)}{(K_1l_2+K_2l_1)}$

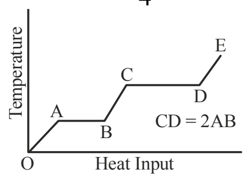
36. Two spheres of different materials one with double the radius and one-fourth wall thickness of the other are filled with ice. If the time taken for complete melting of ice in the larger sphere is 25 minute and for smaller one is 16 minute, the ratio of thermal conductivities of the materials of larger spheres to that of smaller sphere is

(a) 4 : 5 (b) 5 : 4 (c) 25 : 8 (d) 8 : 25

37. A black body has maximum wavelength λ_m at temperature 2000 K. Its corresponding wavelength at temperature 3000 K will be

(a) $\frac{3}{2}\lambda_m$ (b) $\frac{2}{3}\lambda_m$ (c) $\frac{4}{9}\lambda_m$ (d) $\frac{9}{4}\lambda_m$

38. A solid material is supplied with heat at constant rate and the temperature of the material changes as shown. From the graph, the FALSE conclusion drawn is



(a) AB and CD of the graph represent phase changes
(b) AB represents the change of state from solid to liquid
(c) latent heat of fusion is twice the latent heat of vaporization
(d) CD represents change of state from liquid to vapour

39. 10 gm of ice cubes at 0°C are released in a tumbler (water equivalent 55 g) at 40°C. Assuming that negligible heat is taken from the surroundings, the temperature of water in the tumbler becomes nearly (L = 80 cal/g)

(a) 31ºC (b) 22ºC (c) 19ºC (d) 15ºC

40. In a surrounding medium of temperature 10°C, a body takes 7 min for a fall of temperature from 60°C to 40°C. In what time the temperature of the body will fall from 40°C to 28°C?

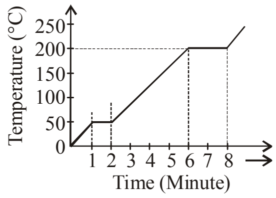
(a) 7 min (b) 11 min (c) 14 min (d) 21 min

41. Two rods of same length and area of cross-section A_1 and A_2 have their ends at the same temperature. If K_1 and K_2 are their thermal conductivities, c_1 and c_2 are their specific heats and d_1 and d_2 are their densities, then the rate of flow of heat is the same in both the rods if

(a) $\frac{A_1}{A_2}=\frac{-k_1}{k_2}$ (b) $\frac{A_1}{A_2}=\frac{k_1 c_1 d_1}{k_2 c_2 d_2}$

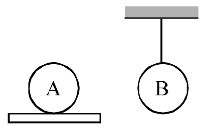
(c) $\frac{A_1}{A_2}=\frac{k_2 c_1 d_1}{c_2 d_2 k_1}$ (d) $\frac{A_1}{A_2}=\frac{k_2}{k_1}$

42. A student takes 50gm wax (specific heat = 0.6 kcal/kg°C) and heats it till it boils. The graph between temperature and time is as follows. Heat supplied to the wax per minute and boiling point are respectively



(a) 500 cal, 50°C (b) 1000 cal, 100°C
(c) 1500 cal, 200°C (d) 1000 cal, 200°C

43. Consider two identical iron spheres, one which lie on a thermally insulating plate, while the other hangs from an insulatory thread. Equal amount of heat is supplied to the two spheres, then



(a) temperature of A will be greater than B
(b) temperature of B will be greater than A
(c) their temperature will be equal
(d) can't be predicted

44. Steam at 100°C is passed into 20 g of water at 10°C. When water acquires a temperature of 80°C, the mass of water present will be: [Take specific heat of water = 1 cal g^{-1} °C^{-1} and latent heat of steam = 540 cal g^{-1}]

(a) 24 g (b) 31.5 g (c) 42.5 g (d) 22.5 g

45. Two solid spheres, of radii R_1 and R_2 are made of the same material and have similar surfaces. The spheres are raised to the same temperature and then allowed to cool under identical conditions. Assuming spheres to be perfect conductors of heat, their initial rates of loss of heat are

(a) R_1^2/R_2^2 (b) R_1/R_2 (c) R_2/R_1 (d) R_2^2/R_1^2

RESPONSE GRID					
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	39. ⓐⓑⓒⓓ	40. ⓐⓑⓒⓓ	41. ⓐⓑⓒⓓ	42. ⓐⓑⓒⓓ	43. ⓐⓑⓒⓓ
	44. ⓐⓑⓒⓓ	45. ⓐⓑⓒⓓ			

DAILY PRACTICE PROBLEM DPP CHAPTERWISE CP10 - PHYSICS

Total Questions	45	Total Marks	180
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	45	Qualifying Score	60
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

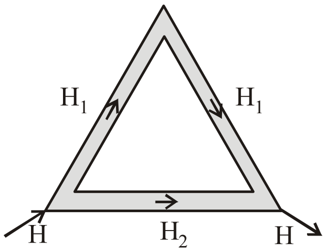
PHYSICS SOLUTIONS

DPP/CP10

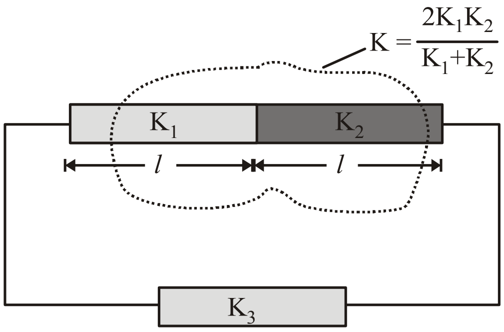
1. **(a)** $E = \frac{S}{S_0}\sigma T^4 = \frac{4\pi r^2}{4\pi R^2}\sigma T^4$

$= \sigma \frac{r^2}{R^2} T^4$

2. **(c)**



The given arrangement of rods can be redrawn as follows



It is given that $H_1 = H_2$

$\Rightarrow \frac{KA(\theta_1 - \theta_2)}{2l} = \frac{K_3 A(\theta_1 - \theta_2)}{l} \Rightarrow K_3 = \frac{K}{2} = \frac{K_1 K_2}{K_1 + K_2}$

3. **(c)** $Q = mc\Delta T$

$Q = mc\,(T - T_0)$ ......(i)

$Q = Kt$ whereas K is heating rate

$\therefore$ from 50 to boiling temperature, T increases linearly.

At vaporization, equation is $Q = mL$

so, temperature remains constant till vaporisation is complete

After that, again Eqn (i) is followed and temperature increases linearly

4. **(b)** At constant temperature molar heat capacity

$C_T = \frac{\Delta Q}{n\Delta T}$

T is const. $\Rightarrow \Delta T = 0$

$\therefore \quad C_T = \frac{\Delta Q}{0} = \infty$

5. **(d)** Required work = energy released

Here, $Q = \int mc\,dT$

$= \int_{20}^{4} 0.1 \times 32 \times \left(\frac{T^3}{400^3}\right) dT \approx 0.002$ kJ.

Therefore, required work = 0.002 kJ

6. **(b)** Since, e = a = 0.2

Since a = (1 – r – t) = 0.2 for the body B

Thus emissive power of B is given by,

$E = a E_b = (100)(0.2) = 20\ W/m^2$

7. **(b)** Rate of cooling of a body $R = \frac{\Delta\theta}{t} = \frac{A\varepsilon\sigma(T^4 - T_0^4)}{mc}$

$\Rightarrow R \propto \frac{A}{m} \propto \frac{\text{Area}}{\text{Volume}}$ $[m = \rho \times V]$

$\Rightarrow$ For the same surface area. $R \propto \frac{1}{\text{Volume}}$

$\because$ Volume of cube < Volume of sphere

$\Rightarrow R_{cube} > R_{Sphere}$ i.e., cube, cools down with faster rate.

8. **(b)** From question,

$\Delta\rho = (998 - 992)\ kg/m^3 = 6\ kg/m^3$

$\rho = \frac{998 + 992}{2}\ kg/m^3 = 995\ kg/m^3$

$\rho = \frac{m}{V}$

$\Rightarrow \frac{\Delta\rho}{\rho} = -\frac{\Delta V}{V} \Rightarrow \left|\frac{\Delta\rho}{\rho}\right| = \left|\frac{\Delta V}{V}\right|$

$\therefore$ Coefficient of volume expansion of water,

$\frac{1}{V}\frac{\Delta V}{\Delta t} = \frac{1}{\rho}\frac{\Delta\rho}{\Delta t} = \frac{6}{995 \times 20} \approx 3 \times 10^{-4}/°C$

9. **(a)** $E = \frac{F/A}{\Delta l / l} = \frac{\text{stress}}{\text{strain}}$ where $\Delta\ell = (\ell' - \ell) = \ell\alpha t$ so $F = EA\alpha t$

10. **(c)**

11. **(a)** $F = Y\alpha t A$ or $F \propto \alpha$

($\because$ Y t A is same for both copper and iron)

or $F_C \propto \alpha_C$ and $F_I \propto \alpha_I$

$\therefore \frac{F_C}{F_I} = \frac{3/2}{1} = \frac{3}{2}$

12. **(c)** According to question only one-quarter of the heat produced by falling piece of ice is absorbed in the melting of ice.

i.e., $\frac{mgh}{4} = mL$

$\Rightarrow \quad h = \frac{4L}{g} = \frac{4 \times 3.4 \times 10^5}{10} = 136$ km.

13. **(d)** $W = W_1 - W_2 = mgh - mgh' = mg\,(h - h')$

$= 5 \times 10\ (20 - 0.2) = 5 \times 10 \times 19.8$

$= 5 \times 198 = 990$ joule

This energy is converted into heat when the ball strikes the earth. Heat produced is

$$Q = \frac{990}{4.2} \text{calorie}$$

$$\Delta T = \frac{Q}{mc} = \frac{99 \times 100}{42 \times 5000 \times 0.09} = \frac{11}{32}\ ^\circ C$$

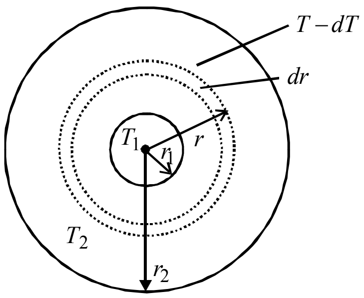
14. (b) Let the angle subtended by the arc formed be θ. Then

$$\theta = \frac{\ell}{r} \text{ or } \theta = \frac{\Delta\ell}{\Delta r} = \frac{\ell_2 - \ell_1}{r_1 - r_2}$$

$$\therefore \quad \theta = \frac{\ell(\alpha_2 - \alpha_1)\Delta T}{t} \text{ or } \frac{\ell}{r} = \frac{\ell(\alpha_2 - \alpha_1)\Delta T}{t}$$

So, $r = \dfrac{t}{(\alpha_2 - \alpha_1)\Delta T}$

15. (d)



Consider a shell of thickness (dr) and of radius (r) and let the temperature of inner and outer surfaces of this shell be T and $(T - dT)$ respectively.

$\frac{dQ}{dt}$ = rate of flow of heat through it

$$= \frac{KA[(T - dT) - T]}{dr} = \frac{-KAdT}{dr}$$

$$= -4\pi K r^2 \frac{dT}{dr} \qquad (\because\ A = 4\pi r^2)$$

To measure the radial rate of heat flow, integration technique is used, since the area of the surface through which heat will flow is not constant.

Then, $\left(\frac{dQ}{dt}\right)\int_{r_1}^{r_2} \frac{1}{r^2} dr = -4\pi K \int_{T_1}^{T_2} dT$

$$\frac{dQ}{dt}\left[\frac{1}{r_1} - \frac{1}{r_2}\right] = -4\pi K\left[T_2 - T_1\right]$$

or $\dfrac{dQ}{dt} = \dfrac{-4\pi K r_1 r_2 (T_2 - T_1)}{(r_2 - r_1)}$

$$\therefore \quad \frac{dQ}{dt} \propto \frac{r_1 r_2}{(r_2 - r_1)}$$

16. (a) According to Newton's law of cooling if temperature difference between body & surrounding is large, then rate of cooling is also fast hence curve A shows correct behaviour.

17. (a) Among glass, wood and metals, metals expand more for same rise in temperature.

18. (b) According to Wein's law $\lambda_m \propto \frac{1}{T}$ and from the figure $(\lambda_m)_1 < (\lambda_m)_3 < (\lambda_m)_2$ therefore $T_1 > T_3 > T_2$.

19. (a) Moment of inertia of a rod,

$$I = \frac{1}{12} ML^2$$

Differentiating w.r.t. to ΔL, we get

$$\frac{\Delta I}{\Delta L} = \frac{1}{12} \times 2ML$$

$$\Delta I = \frac{1}{12} 2ML\Delta L \qquad \therefore \frac{\Delta I}{I} = 2\frac{\Delta L}{L}$$

As we know, $\Delta L = L\alpha\Delta t$ or $\dfrac{\Delta L}{L} = \alpha\Delta t$

Substituting the value $\dfrac{\Delta L}{L}$, we get

$$\frac{\Delta I}{I} = 2\alpha\Delta t$$

20. (c) The lengths of each rod increases by the same amount

$$\therefore \quad \Delta\ell_a = \Delta\ell_s \Rightarrow \ell_1\alpha_a t = \ell_2\alpha_s t$$

$$\Rightarrow \frac{\ell_2}{\ell_1} = \frac{\alpha_a}{\alpha_s} \Rightarrow \frac{\ell_2}{\ell_1} + 1 = \frac{\alpha_a}{\alpha_s} + 1$$

$$\Rightarrow \frac{\ell_2 + \ell_1}{\ell_1} = \frac{\alpha_a + \alpha_s}{\alpha_s} \Rightarrow \frac{\ell_1}{\ell_1 + \ell_2} = \frac{\alpha_s}{\alpha_a + \alpha_s}$$

21. (a) According to Kirchhoff law, good absorbers are good emitters. Since black spot is good absorber so it is also a good emitter & will be brighter than plate.

22. (a) From Wein's displacement law

$\lambda_m \times T$ = constant

P – max. intensity is at violet

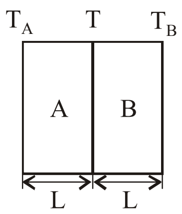
$\Rightarrow \lambda_m$ is minimum $\Rightarrow$ temp maximum

R – max. intensity is at green

$\Rightarrow \lambda_m$ is moderate $\Rightarrow$ temp moderate

Q – max. intensity is at red $\Rightarrow \lambda_m$ is maximum $\Rightarrow$ temp. minimum i.e., $T_p > T_R > T_Q$

23. (c)



Let T be temperature of the junction

Here, $K_A = 2K_B$, $T - T_B = 50K$

At the steady state,

$$H_A = H_B$$

$$\therefore \frac{K_A A(T_A - T)}{L} = \frac{K_B A(T - T_B)}{L}$$

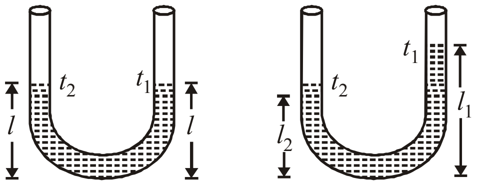
$2K_B(T_A - T) = K_B(T - T_B)$

$T_A - T = \frac{T - T_B}{2}$

$= \frac{50K}{2} = 25K$

24. **(b)**

25. **(a)** Suppose, height of liquid in each arm before rising the temperature is l.



With temperature rise height of liquid in each arm increases *i.e.* $l_1 > l$ and $l_2 > l$

Also $l = \frac{l_1}{1+\gamma t_1} = \frac{l_2}{1+\gamma t_2}$

$\Rightarrow l_1 + \gamma l_1 t_2 = l_2 + \gamma l_2 t_1 \Rightarrow \gamma = \frac{l_1 - l_2}{l_2 t_1 - l_1 t_2}$.

26. **(a)** The rate of heat loss per unit area due to radiation $= \in\sigma(T^4 - T_0^4)$
$= 0.6 \times 5.67 \times 10^{-8} [(400)^4 - (300)^4] = 595\ Jm^{-2}s^{-1}$.

27. **(d)** According to Wein's displacement law, product of wavelength belonging to maximum intensity and temperature is constant i.e., $\lambda_m T$ = constant.

28. **(c)** According to Newton's law of cooling, the temperature goes on decreasing with time non-linearly.

29. **(d)** $t \propto \frac{\ell}{A}, t' \propto \frac{2\ell}{A/2}$

$\frac{t'}{t} = 4\frac{\ell/A}{\ell/A}$

$t' = 4 \times t$

$3/t' = 48s$

30. **(a)** In series, equivalent thermal conductivity

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

or, $K_{eq} = \frac{2 \times K \times 2K}{K + 2K} = \frac{4}{3}K$

31. **(c)** $Q = -KA\left(\frac{d\theta}{dx}\right) \times t$

32. **(c)** Using Wein's law, $\lambda_m T$ = constant

$\lambda_1 T_1 = \lambda_2 T_2$

$\lambda_2 = \lambda_1 \frac{T_1}{T_2}$

$\lambda_2 = \frac{\lambda_0 T}{2T} = \frac{\lambda_0}{2}$

33. **(b)** Total power radiated by Sun $= \sigma T^4 \times 4\pi R^2$
The intensity of power at earth's surface

$= \frac{\sigma T^4 \times 4\pi R^2}{4\pi r^2}$

Total power received by Earth

$= \frac{\sigma T^4 R^2}{r^2}(\pi r_0^2)$

34. **(c)** The upthrust is given by $\frac{4}{3}\pi R_t^3 \rho g$

Here $R_t^3 = R_0^3(1+\gamma_m t)$ and $\rho_t = \rho_0/(1+\gamma_a t)$

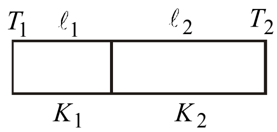
So, the upthrust at t°C is given by

$= \frac{4}{3}\pi R_0^3 (1+\gamma_m t) \times \{\rho_0/(1+\gamma_a t)\} g$

As $\gamma_m < \gamma_a$, hence upthrust at t°C < upthrust at 0°C

So, the upthrust is decreased. Hence weight in liquid gets increased.

35. **(d)** Let T be the temperature of the interface. As the two sections are in series, the rate of flow of heat in them will be equal.



$\therefore \frac{K_1 A(T_1 - T)}{\ell_1} = \frac{K_2 A(T - T_2)}{\ell_2}$,

where A is the area of cross-section.

or, $K_1 A(T_1 - T)\ell_2 = K_2 A(T - T_2)\ell_1$

or, $K_1 T_1 \ell_2 - K_1 T \ell_2 = K_2 T \ell_1 - K_2 T_2 \ell_1$

or, $(K_2\ell_1 + K_1\ell_2)T = K_1 T_1 \ell_2 + K_2 T_2 \ell_1$

$\therefore T = \frac{K_1 T_1 \ell_2 + K_2 T_2 \ell_1}{K_2 \ell_1 + K_1 \ell_2} = \frac{K_1 \ell_2 T_1 + K_2 \ell_1 T_2}{K_1 \ell_2 + K_2 \ell_1}$.

36. **(d)** Radius of small sphere = r
Thickness of small sphere = t
Radius of bigger sphere = 2r
Thickness of bigger sphere = t/4
Mass of ice melted = (volume of sphere) × (density of ice)
Let K_1 and K_2 be the thermal conductivities of larger and smaller sphere.
For bigger sphere,

$\frac{K_1 4\pi (2r)^2 \times 100}{t/4} = \frac{\frac{4}{3}\pi(2r)^3 \rho L}{25 \times 60}$

For smaller sphere,

$\frac{K_2 \times 4\pi r^2 \times 100}{t} = \frac{\frac{4}{3}\pi r^3 \rho L}{16 \times 60}$

$\therefore \frac{K_1}{K_2} = \frac{8}{25}$

37. **(b)** According to Wein's displacement law,
$\lambda_m T = 2.88 \times 10^{-3}$
When T = 2000 K,
$\lambda_m (2000) = 2.88 \times 10^{-3}$ ....(1)
When T = 3000 K,
$\lambda'_m (3000) = 2.88 \times 10^{-3}$ ....(2)
Dividing (1) by (2),

$$\frac{2}{3}\frac{\lambda_m}{\lambda'_m} = 1 \Rightarrow \frac{\lambda_m}{\lambda'_m} = \frac{3}{2} \Rightarrow \lambda'_m = \frac{2}{3}\lambda_m$$

38. **(c)** AB represents latent heat of fusion
$Q_1 = mL_F$
Here, $L_F \propto$ length of line AB
CD represents latent heat of vaporization $Q_2 = mL_V$
Here, $L_V \propto$ length of line CD
$\therefore\ Q_2 = 2Q_1$ [$\because$ As CD = 2AB]

39. **(b)** Let the final temperature be T

Heat gained by ice $= mL + m \times s \times (T - 0)$

$= 10 \times 80 + 10 \times 1 \times T$

Heat lost by water $= 55 \times 1 \times (40 - T)$

By using law of calorimetery,

$800 + 10\,T = 55 \times (40 - T)$

$\Rightarrow T = 21.54°C = 22°C$

40. **(a)** According to Newton's law of cooling,

$$\frac{\theta_1 - \theta_2}{t} = K\left[\frac{\theta_1 + \theta_2}{2} - \theta_0\right]$$

where θ_0 is the surrounding temperature.

$$\therefore\ \frac{60 - 40}{7} = K\left(\frac{60 + 40}{2} - 10\right)$$

$$\Rightarrow \frac{20}{7} = 40K \Rightarrow K = \frac{1}{14}$$

$$\therefore\ \frac{40 - 28}{t} = K\left[\frac{40 + 28}{2} - 10\right] \Rightarrow \frac{12}{t} = 24K$$

$$\text{or}\ \ t = \frac{12}{24K} = \frac{12 \times 14}{24} = 7\ \text{min}$$

41. **(d)** $\dfrac{Q}{t} = K_1 A_1 \dfrac{d\theta}{dx} = K_2 A_2 \dfrac{d\theta}{dx}$

42. **(c)** Since specific heat = 0.6 *kcal*/*g* × °C = 0.6 *cal*/*g* × °C
From graph it is clear that in a minute, the temperature is raised from 0°C to 50°C.
$\Rightarrow$ Heat required for a minute = 50 × 0.6 × 50 = 1500 *cal*.
Also from graph, Boiling point of wax is 200°C.

43. **(b)** Temperature of B will be higher because, due to expansion centre of mass B will come down same heat is supplied but in B, potential energy is decreased therefore internal energy gain will be more.

44. **(d)** According to the principle of calorimetry.
Heat lost = Heat gained
$mL_v + ms_w\Delta\theta = m_w s_w \Delta\theta$
$\Rightarrow\ m \times 540 + m \times 1 \times (100 - 80)$
$= 20 \times 1 \times (80 - 10)$
$\Rightarrow\ m = 2.5$ g
Therefore total mass of water at 80°C
$= (20 + 2.5)$ g $= 22.5$ g

45. **(a)** Initial rate of loss of heat $= \dfrac{\sigma T^4 \times A_1 \times e}{\sigma T^4 \times A_2 \times e} = \dfrac{R_1^2}{R_2^2}$