Expansion of Solids

1. The coefficient of volume expansion is

1) Twice the coefficient of linear expansion

2) Twice the coefficient of areal expansion

3) Thrice the coefficient of areal expansion

4) Thrice the co-efficient of linear expansion

2. The variation of density of solid with temperature is given by the formula

1) $d_2 = \frac{d_1}{1+\gamma(t_2 - t_1)}$ 2) $d_2 = \frac{d_1}{1-\gamma(t_2 - t_1)}$

3) $d_2 = \frac{d_1}{1-2\gamma(t_2 - t_1)}$ 4) $d_2 = \frac{d_1}{1+2\gamma(t_2 - t_1)}$

3. A Brass stopper snuggly fits in the hole of steel plate. To remove the stopper easily, the system

1) Should be heated 2) Should be cooled

3) May be heated or cooled 4) Cannot be removed by heating or cooling

4. A metal plate has two holes in it. When the plate is heated the distance between the two holes

1) Decreases 2) Increases

3) Does not change 4) May increase or decrease

5. Among the following solids, the lowest coefficient of expansion is for

1) Concrete 2) Rubber 3) Glass 4) Silicon

6. A metal sphere is heated. Maximum percentage increase occurs in its

1) Density 2) Volume 3) Surface Area 4) Radius

7. Two metal strips that constitute a thermostat must necessarily differ in their

1) Mass
2) Length
3) Resistivity
4) Coefficient of Linear Expansion

8. A bimetallic strip is heated. It

1) Bends towards the metal with lower coefficient of expansion
2) Bends towards the metal with higher coefficient of expansion
3) Twists itself into helix
4) Does not bend

9. A): Metals expand equally in all directions.

R): Metals are isotropic.

1) Both ‘A’ and ‘R’ are true and ‘R’ is the correct explanation of ‘A’.
2) Both ‘A’ and ‘R’ are true and ‘R’ is not the correct explanation of ‘A’.
3) ‘A’ is true and ‘R’ is false.
4) ‘A’ is false and ‘R’ is true.

10. A): If hot liquid is poured in thick glass tumbler it breaks.

R): Temperature distribution is not uniform in thick bodies leading to differential expansion.

1) Both ‘A’ and ‘R’ are true and ‘R’ is the correct explanation of ‘A’.
2) Both ‘A’ and ‘R’ are true and ‘R’ is not the correct explanation of ‘A’.
3) ‘A’ is true and ‘R’ is false.
4) ‘A’ is false and ‘R’ is true.

11. A): Platinum is used to fuse into glass rods.

R): Both platinum and glass have almost same values of coefficient of linear expansion.

1) Both ‘A’ and ‘R’ are true and ‘R’ is the correct explanation of ‘A’.
2) Both ‘A’ and ‘R’ are true and ‘R’ is not the correct explanation of ‘A’.

3) 'A' is true and 'R' is false.

4) 'A' is false and 'R' is true.

12. A): Invar is used in metal tapes, balance wheels and pendulum clocks.

R): The coefficient of linear expansion of invar is very low.

1) Both 'A' and 'R' are true and 'R' is the correct explanation of 'A'.

2)Both 'A' and 'R' are true and 'R' is not the correct explanation of 'A'.

3) 'A' is true and 'R' is false.

4) 'A' is false and 'R' is true.

13. A): In summer, the pendulum clock runs slow.

R): As temperature increases, length of the pendulum decreases and time period decreases.

1) Both 'A' and 'R' are true and 'R' is the correct explanation of 'A'.

2)Both 'A' and 'R' are true and 'R' is not the correct explanation of 'A'.

3) 'A' is true and 'R' is false.

4) 'A' is false and 'R' is true.

14. If coefficient of cubical expansion is x times coefficient of superficial expansion, then the value of x is

1) 1.5 2) 2 3) 2.5 4) 3

15. The ratio of the lengths of two rods is 4:3. The ratio of their coefficients of cubical expansion is 2:3. Then the ratio of their linear expansions when they are heated through same temperature difference is

1) 2:1 2) 1:2 3) 8:9 4) 9:8

16. A metal metre scale gives correct measurement at 0^0C. It is generally used at a temperature of 40^0C. The correction to be made for every metre is **(**$\alpha = 10^{-6}/1^0C$**)**

1) 4 X 10^{-5} m   2) 4 X 10^{-5} m to be added

3) 4 X 10^{-5} m must be deducted   4) none of the above.

17. The temperature of a thin uniform rod increases by Δt . If moment of inertia I about an axis perpendicular to its length, then its moment of increases by

1) 0   2) $\alpha I \Delta t$ 3) $2\alpha I \Delta t$ 4) $\alpha^2 I \Delta t$

18. A metal rod has a length of 1m at 30°C. 'α' of metal is 2.5 x 10^{-5}/°C. The temperature at which it will be shortened by 1mm is

1) –30°C   2) –40°C   3) –10° C   4) 10°C

19. A crystal has linear coefficient of expansion 9×10^{-5}, 12×10^{-5}, 7×10^{-5}/k along three mutually perpendicular directions the volume expansion coefficient is

1) $27\times10^{-5}/k$ 2) $26\times10^{-5}/k$ 3) $21\times10^{-5}/k$ 4) $28\times10^{-5}/k$

20. A steel tape is calibrated at 20°C. When the temperature of the day is –10°C, the percentage error in the measurement with the tape is (α=12 x 10^{-6}/°C)

1) 3.6%   2) 0.36%   3) 0.18%   4) 0.036%

21. A metallic solid sphere is rotating about its diameter as axis of rotation. If the temperature is increased by 200°C, the percentage increase in its moment of inertia is: [Coefficient of linear expansion of the metal = 10^{-5}/°C]

1) 0.1   2) 0.2   3) 0.3   4) 0.4

22. Two marks on a glass rod 10cm apart are found to increase their distance by 0.08mm when the rod is heated from 0^0C to 100^0C. A flask made of the same glass as that rod measures a volume of 1000 c.c at 0^0C. The volume it measures at 100^0C in c.c. is

1) 1002.4   2) 1004.2   3) 1006.4   4) 1008.2

23. If a cylinder of diameter 1.0 cm at 30^0C is to be slide into a hole of diameter 0.9997 cm in a steel plate at the same temperature, then minimum required rise in the temperature of the plate is [coefficient of linear expansion of steel $=12\times10^{-6}/^0C$]

1) 25^0C 2) 35^0C 3) 45^0C 4) 55^0C

24. Two rods of different materials and identical cross sectional areas are joined face to face at one end and their free ends are fixed to the rigid walls. If the temperature of the surroundings is increased by 30°C, the magnitude of the displacement of the joint of the rod is (length of rods $l_1=l_2=1$unit, ratio of their Young's modulii, $y_1/y_2=2$, coefficients of Linear expansion are α_1 and α_2)

1) $5(\alpha_2-\alpha_1)$ 2) $10(\alpha_1-\alpha_2)$ 3) $10(\alpha_2-2\alpha_1)$ 4) $5(2\alpha_1-\alpha_2)$

25. Two uniform metal rods of length L_1 and L_2 and their linear coefficients of expansion α_1 and α_2 respectively, are connected to form a single rod of length (L_1+L_2). When the temperature of the combined rod is raised by "t° c ", the length of each rod increased by the same amount then $\left[\frac{\alpha_2}{\alpha_1+\alpha_2}\right]$ is

1) $\frac{L_1}{L_1+L_2}$ 2) $\frac{L_1+L_2}{L_1}$ 3) $\frac{L_2}{L_1+L_2}$ 4) $\frac{L_1+L_2}{L_2}$

26. A thin brass sheet at 10°C and a thin steel sheet at 20°C have the same surface area. The common temperature at which both would have the same area is (Coefficient of linear expansion for brass and steel are respectively, 19×10^{-6}/°C are 11×10^{-6}/°C)

1) –3.75°C 2) –2.75°C 3) 2.75°C 4) 3.75°C

27. A pendulum clock is 5 seconds fast at a temperature of 15^0C and 10 seconds slow at a temperature of 30^0C. The temperature at which it gives the correct time is

1) 18^0C 2) 20^0C 3) 22^0C 4) 25^0C

28. A pendulum clock gives correct time at 20^0C at a place where g = 10m/s^2. The pendulum consists of a light steel rod connected to a heavy ball. If it is taken to a different place where g = 10.01m/s^2 at what temperature the pendulum gives correct time (α of steel is $10^{-5}/^0$C)

1) 30^0C 2) 60^0C 3) 100^0C 4) 120^0C

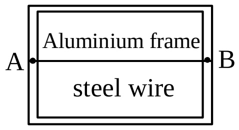
29. A steel meter scale is to be ruled so that millimeter intervals are accurate within about 5 x 10^{-5} mm at a certain temperature. The maximum temperature variation allowable during the ruling is [coefficient of linear expansion of steel = 10 x $10^{-6}k^{-1}$]

1) 2^0C 2) 5^0C 3) 7^0C 4) 10^0C

30. A steel wire AB of length 100 cm is fixed rigidly at points A and B in an aluminum frame as shown in the figure. If the temperature of the system increases through 100^0C, then the excess stress produced in the steel wire relative to the aluminum?

$\alpha_{Al} = 22\times10^{-6}/1^0C$ and $\alpha_{steel} = 11\times10^{-6}/1^0C$

Young's Modulus of steel is 2 X 10^{11} Nm^{-2}.



1) 2.2 X 10^8 Pa 2) 22 X 10^8 Pa 3) 0.2 X 10^8 Pa 4) 220 X 10^8 Pa

Key

1) 4	2) 1	3) 2	4) 2	5) 4	6) 2	7) 4	8) 1	9) 1	10) 1
11)1	12) 1	13) 3	14) 1	15) 3	16) 2	17) 3	18) 3	19) 4	20) 4
21)4	22) 1	23) 1	24) 3	25) 1	26) 1	27) 2	28) 4	29) 2	30) 1

Hints

14. $\gamma = 2\alpha$ $\beta = 2\alpha$

$\frac{\gamma}{\beta} = \frac{3}{2}$ $\gamma = \frac{3}{2}\beta = 1.5\beta$ x = 1.5

15. $\frac{\Delta l_1}{\Delta l_2} = \frac{\alpha_1}{\alpha_2}\frac{l_1}{l_2}$ $= \frac{2}{3}.\frac{4}{3} = \frac{8}{9}$

16. $e = \alpha l \Delta t$

$= 10^{-6}$ x 1 x 40 = 4 x 10^{-5} m to be added

17. I = MR^2

$\Delta I = 2MR\,\Delta R$

$\frac{\Delta I}{I} = \frac{2MR\,\Delta R}{MR^2} = 2\alpha\Delta t \Rightarrow \Delta I = 2\alpha I \Delta t$

18. $\alpha = \frac{\Delta l}{l(t_2 - t_1)}$

$\alpha = \frac{-10^{-3}}{1 \times (t_2 - 30)}$

$25\times10^{-6}=\frac{-10^{-3}}{(t_2-30)}\Rightarrow t_2=-10^0C$

19. $\gamma=\alpha_x+\alpha_y+\alpha_z=28\times10^{-5}$ / K

20. $\frac{e}{l}\times100=(\alpha\Delta t)\times100$

$= 12 \times 10^{-6} \times 30 \times 100$

$= 36 \times 10^{-3} = 0.036$ %

(or)

$\text{Error}=\alpha l(t_1-t_2)$

$\frac{\Delta l}{l}\text{x}100=\alpha(t_1-t_2)\text{x}100$

$\%\text{ error}=12\text{ x }10^{-6}(20+10)\text{ x }100$

$=12\text{ x }10^{-6}\text{ x }30\text{ x }100=0.036\%$

21. $\frac{\Delta I}{I}\times100=(2\alpha\Delta t)\times100$

$= 200 \times 10^{-5} \times 200$

$= 4 \times 10^{-1} = 0.4$

22. $\alpha=\frac{\Delta l}{l\Delta t}=\frac{8\times10^{-5}}{10\times10^{-2}\times100}=8\times10^{06}/^0C$

$V_2=V_1(1+3\alpha\Delta t)$

$= 1000(1 + 24 \times 100 \times 10^{-6}) = 1002.4$ cc

23. $\alpha=\frac{\Delta R}{R\Delta t}$ and $\Delta t=\frac{\Delta R}{R\alpha}$

$=\frac{3\times10^{-4}}{1\times12\times10^{-6}}$ $\quad=\frac{1}{4}\times100=25^0C$

24. $l_1\alpha_1\,\Delta\theta + l_2\alpha_2\Delta\theta = \dfrac{F_1 l_1}{A_1 y_1} + \dfrac{F_2 l_2}{A_2 y_2}$

$1\times\alpha_1\times 30 + 1\times\alpha_2\times 30 = \dfrac{F\times 1}{A\times 2y} + \dfrac{F\times 1}{A\times y}$

$30(\alpha_1+\alpha_2) = \dfrac{F\times 3}{2Ay}$

$10(\alpha_1+\alpha_2) = \dfrac{F}{2Ay}$

Displacement of the joint $= \dfrac{F_1 l_1}{A_1 y_1} - l_1\alpha_1\,\Delta\theta = \dfrac{F\times l_1}{A_1 y_1} - 1\times\alpha_1\times 30 = 10(\alpha_1+\alpha_2) - 30\alpha_1 =$

$10(\alpha_2 - 2\alpha_1)$

25. $l_1\alpha_1 = l_2\alpha_2$

$\dfrac{\alpha_1}{\alpha_2} = \dfrac{l_2}{l_1}$

$\dfrac{\alpha_1}{\alpha_2} + 1 = \dfrac{l_2}{l_1} + 1$

$\dfrac{\alpha_1+\alpha_2}{\alpha_2} = \dfrac{l_2+l_1}{l_1}$

$\dfrac{\alpha_2}{\alpha_1+\alpha_2} = \dfrac{l_1}{l_1+l_2}$

26. $\Delta A = cons\tan t$

$A_1 B_1 (\Delta t)_1 = A_2 B_2 (\Delta t)_2$

$\dfrac{\alpha_1}{\alpha_2} = \dfrac{(\Delta t)_2}{(\Delta t)_1} = \dfrac{19\times 10^{-6}}{11\times 10^{-6}} = \left(\dfrac{t-20}{t-10}\right)$

$t = \dfrac{-30}{8} = -3.75^0 C$

27. $10 = \frac{1}{2}\alpha(30 - t_1) \rightarrow 1$

$\therefore 5 = \frac{1}{2}\alpha(t_1 - 15) \rightarrow 2$

$\frac{1}{2} \Rightarrow 2 = \frac{30 - t_1}{t_1 - 15}$

$\therefore t_1 = 20°C$

28. $T = 2\pi\sqrt{\frac{l}{g}}$

Here T is const

$\therefore l \propto g$

$\therefore \frac{\Delta l}{l} = \frac{\Delta g}{g}$ $\quad\quad$ $\therefore \alpha(t_2 - t_1) = \frac{0.01}{10}$

$\therefore 10^{-5}(t_2 - 20) = 10^{-3}$ $\quad\quad$ $\therefore t_2 = 120^0 C$

29. $\alpha = \frac{l_2 - l_1}{l_1(t_2 - t_1)}$ $\quad\quad$ $10 \text{ x } 10^{-8} = \frac{5 \text{ x } 10^{-5}}{1(t_2 - t_1)}$

$t_2 - t_1 = 5°C$

30. Excess stress in steel relative to Al