DPP – Thermal Expansion

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Q 1. The co-efficient of linear expansion of iron is 11/180 of volume coefficient of expansion of mercury which is 18×10^{-5} /°C. An iron rod is 10m long at 27 °C. The length of the rod will be decreased by 1.1mm then the temperature of the rod changes by:

(a) 0 °C (b) 10 °C
(c) 20 °C (d) 170 °C

Q 2. At 50 °C, a brass rod has a length 50 cm and a diameter 2 mm. It is joined to a steel rod of the same length and diameter at the same temperature. The change in the length of the composite rod when it is heated to 250 °C is: (Coefficient of linear expansion of brass = 2×10^{-5} /°C, coefficient of linear expansion of steel = 1.2×10^{-5} /°C)

(a) 0.28 cm (b) 0.30 cm
(c) 0.32 cm (d) 0.34 cm

Q 3. A rod of length 2 m is at a temperature of 20 °C. find the free expansion of the rod, if the temperature is increased to 50 °C:
($\alpha = 15 \times 10^{-6}$ /°C)

(a) 0.9 mm (b) 9 mm
(c) 9 cm (d) 1.9 mm

Q 4. Density of substance at 0 °C is 10 gm/cc and at 100°C, its density is 9.7 gm/cc. The coefficient of linear expansion of the substance will be:

(a) 10^{2} (b) 10^{-2}
(c) 10^{-3} (d) 10^{-4}

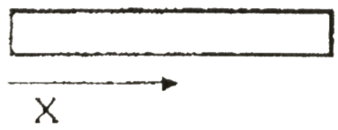
Q 5. The coefficient of volume expansion of a liquid is 4.9×10^{-4} /K. Calculate the fractional change in its density when the temperature is raised by 30 °C:

(a) 1.5×10^{2} (b) 1.5×10^{-2}
(c) 1.5×10^{-3} (d) 1.5×10^{-4}

Q 6. A steel tape 1m long is correctly calibrated for a temperature of 27 °C. The length of a steel rod measured by this tape is found to be 63.0 cm on a hot day when the temperature is 45 °C. Coefficient of linear expansion of steel = 1.20×10^{-5} /K. what is the actual length of the steel rod on that day?

(a) 63.0136cm (b) 63.2134cm
(c) 63.1526cm (d) 63.3136cm

Q 7. A rod has variable co-efficient of linear expansion $\alpha = \frac{x}{5000}$ (x is in metre). If length of the rod is 1m. Determine increase in length of the rod in (cm) on increasing temperature of the rod by 100 °C:



(a) 1.01 (b) 0.1
(c) 0.01 (d) 1

Q 8. The coefficient of linear expansion of a crystal in one direction is α_1 and hat in every direction perpendicular to it is α_2. The coefficient of cubical expansion is:
(a) $\alpha_1 + \alpha_2$ (b) $2\alpha_1 + \alpha_2$
(c) $\alpha_1 + 2\alpha_2$ (d) None of above

Q 9. Coefficient of volume expansion of mercury is 0.18×10^{-3}/°C. If the density of mercury at 0 °C is 13.6 g/cc then its density at 200 °C is:
(a) 13.11 g/cc (b) 52.11 g/cc
(c) 16.11 g/cc (d) 26.11 g/cc

Q 10. The real coefficient of volume expansion of glycerin is 0.000597 /°C and linear coefficient of expansion of glass is 0.000009 /°C. Then the apparent volume coefficient of expansion of glycerin in a container of glass is:
(a) 0.000558 /°C (b) 0.00057 /°C
(c) 0.00027 /°C (d) 0.00066 /°C

Q 11. The coefficient of linear expansion of a metal is 1×10^{-5}/°C. The percentage increase in area of a square plate of that metal when it is heated through 100 °C is:
(a) 0.02% (b) 0.1%
(c) 0.001% (d) 0.2%

Q 12. A metal plate of area 1.2 m^2 increases its area by 2.4×10^{-4} m^2 when it is heated from 0 °C to 100 °C. The coefficient of cubical expansion of the metal expressed in per °C is:
(a) 2×10^{-6} (b) 4×10^{-6}
(c) 6×10^{-6} (d) 3×10^{-6}

Q 13. The length of a metal rod at 0 °C is 0.5 m. When it is heated, its length increases by 2.7mm. The final temperature of rod is (coeff. Of linear expansion of metal = 90×10^{-6}/°C):
(a) 20 °C (b) 30 °C
(c) 40 °C (d) 60 °C

Q 14. A liquid with coefficient of volume expansion γ is filled in a container of a material having coefficient of linear expansion α. If the liquid overflows on heating, then:
(a) γ = 3α (b) γ > 3α

(c) $\gamma < 3\alpha$ (d) $\gamma = \alpha^3$

Q 15. At 20 °C a liquid is filled upto 10 cm height in a container of glass of length 20cm and cross-sectional area 100 cm^2. Scale is marked on the surface of container. This scale gives correct reading at 20 °C. Given $\gamma_L = 5 \times 10^{-5}$ /K, $\alpha_g = 1 \times 10^{-5}$/°C. The actual height of liquid at 40°C is:

(a) 10.01 cm (b) 10.006 cm

(c) 10.6 cm (d) 10.1 cm

Q 16. A uniform metal rod is used as a bar pendulum. If the room temperature rises by 10°C, and the coefficient of linear expansion of the metal of the rod is 2×10^{-6} per °C, the period of the pendulum will have percentage increase of:

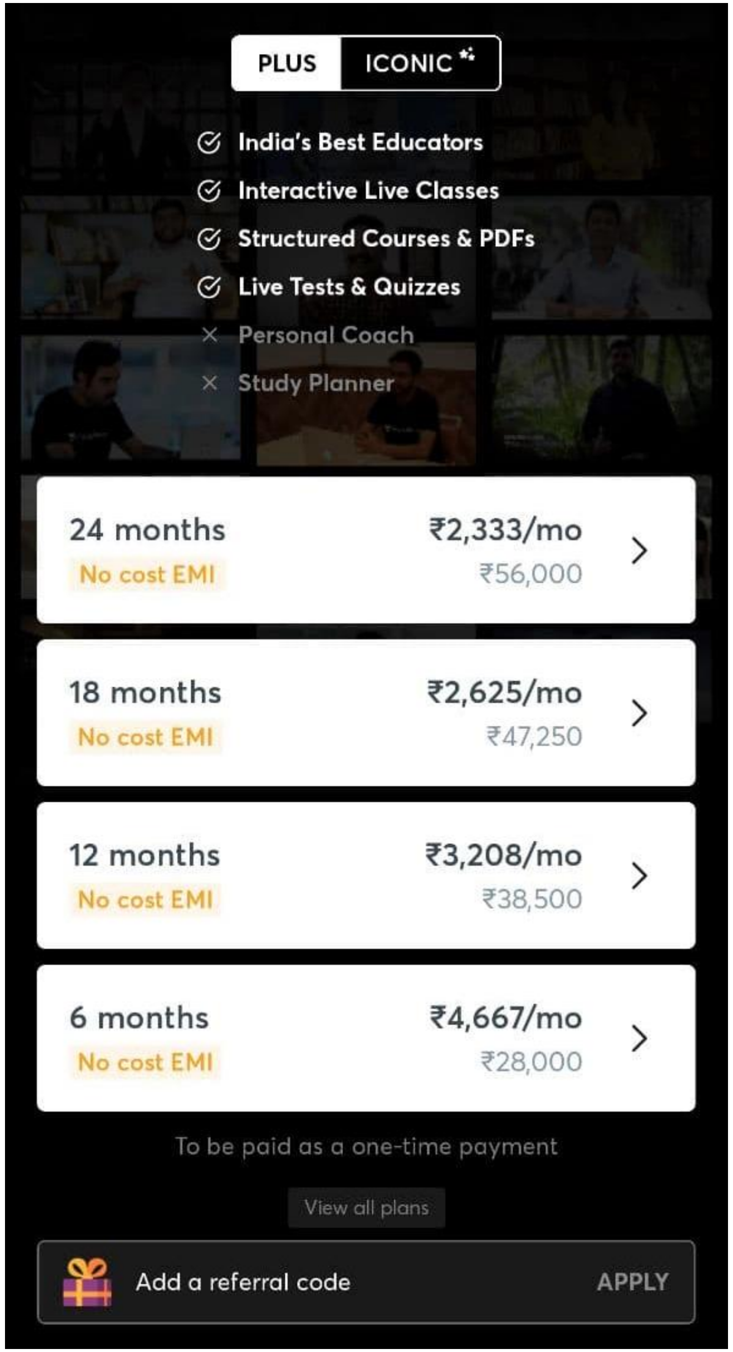
time period of pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$

(a) -2×10^{-3} (b) 1×10^{-3}

(c) -1×10^{-3} (d) 2×10^{-3}

Answer Key

Q.1 b	Q.2 c	Q.3 a	Q.4 d	Q.5 b
Q.6 a	Q.7 d	Q.8 c	Q.9 a	Q.10 b
Q.11 d	Q.12 d	Q.13 d	Q.14 b	Q.15 b
Q.16 b				



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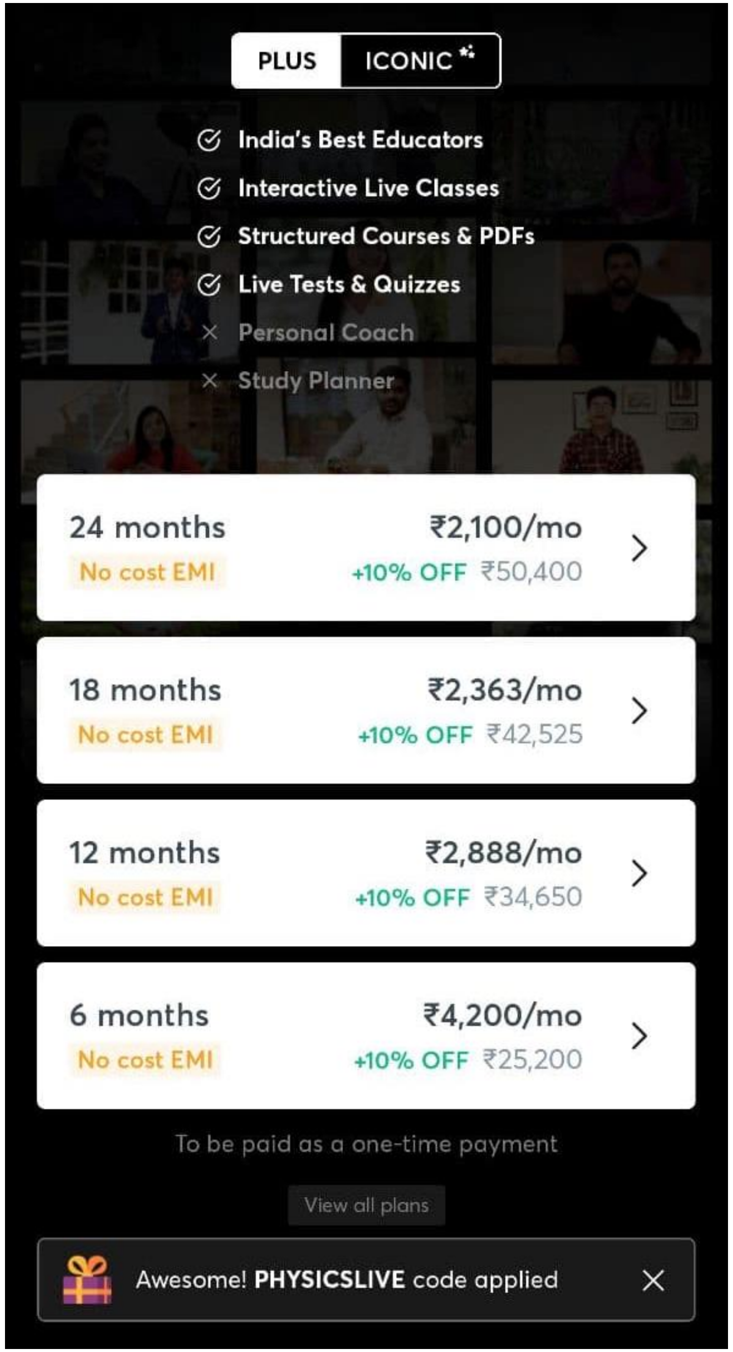

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NEET & JEE Main
Physics DPP – Written Solution

DPP- Thermal Expansion

By Physicsaholics Team

Solution: 1

$\alpha_i = \frac{11}{180}$ γ_m

$\alpha_i = \frac{11}{180} \times 18 \times 10^{-5}$

$\alpha_i = 11 \times 10^{-6}$ /°C

↳ Coefficient of linear expansion of Iron.

$T_1 = 27°C$

$l_1 = 10\,m$

at $T_2 = ?$

$\Delta l_0 = 1.1\,mm$ (decreases)

$\Delta l = l \alpha \Delta t$

$\Delta t = \frac{\Delta l}{l\alpha} = \frac{1.1 \times 10^{-3}}{10 \times 11 \times 10^{-6}}$

$\boxed{\Delta t = 10°C}$

(or)

$l_1 = 10\,m$

at $T = 27° = 300\,K$

$\therefore l_1 = l_0 (1 + \alpha \Delta T)$

$l_0 = \frac{l_1}{1 + \alpha \Delta T} = \frac{10}{1 + 11 \times 10^{-6} \times 300}$

$l_0 = \frac{10}{1 + 33 \times 10^{-4}} = \frac{10}{1.0.0033}$

$l_0 \simeq 10$

Now; $\Delta l = l_0 \alpha \Delta T$

$\Delta l = 1.1\,mm$

$1.1 \times 10^{-3} = 10 \times 11 \times 10^{-6} \Delta T$

$\Delta T = \frac{1.1 \times 10^{-3}}{10 \times 11 \times 10^{-6}}$

$\boxed{\Delta T = 10°C}$

Ans. b

Solution: 2

at $50^\circ C$

Brass; $l_B = 50 cm$ $d_B = 2 mm$; $r_B = 1 mm$

Steel; $l_S = 50 cm$ $d_S = 2 mm$; $r_S = 1 mm$

$\alpha_B = 2 \times 10^{-5} /^\circ C$ $\alpha_S = 1.2 \times 10^{-5} /^\circ C$

$\Delta l_B = l_B \alpha_B \Delta T$

$= 50 \times 2 \times 10^{-5} \times (250 - 50)$

$= 50 \times 2 \times 10^{-5} \times 200$

$= 100 \times 200 \times 10^{-5}$

$\Delta l_B = 0.2 cm$.

$\Delta l_S = l_S \alpha_S \Delta T$

$= 50 \times 1.2 \times 10^{-5} (250 - 50)$

$= 50 \times 1.2 \times 10^{-5} \times 200$

$= 1.2 \times 10000 \times 10^{-5}$

$= 0.012 \times 10$

$\Delta l_S = 0.12 cm$

$\Delta l = \Delta l_B + \Delta l_S$

$\Delta l = 0.2 + 0.12$

$\boxed{\Delta l = 0.32 cm}$

Ans. c

Solution: 3

$$\Delta l = l \alpha \Delta T$$

$$\Delta l = 2 \times 15 \times 10^{-6} \times (50 - 20)$$

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

$$= 900 \times 10^{-6}$$

$$\Delta l = 0.9 \times 10^{-3}\ m$$

$$\boxed{\Delta l = 0.9\ mm}$$

Ans. a

Solution: 4

$T_1 = 0^\circ C \qquad T_2 = 100^\circ C$

$\rho_1 = 10\, g/cc \qquad \rho_2 = 9.7\, g/cc$

$\Delta \rho = \rho_1 \gamma \Delta T$

$0.3 = 10\, \gamma\, (100)$

$\gamma = 0.3 \times 10^{-3}$

$\gamma = 3 \times 10^{-4} /^\circ C$

$\alpha = \frac{\gamma}{3}$

$\boxed{\alpha = 10^{-4} /^\circ C}$

Ans. d

Solution: 5

$$\gamma = 4.9 \times 10^{-4} /K$$

$$\Delta\rho = \rho \gamma \Delta T$$

$$\frac{\Delta\rho}{\rho} = \gamma \Delta T$$

$\frac{\Delta\rho}{\rho}$ = fractional change in density

$$\frac{\Delta\rho}{\rho} = 4.9 \times 10^{-4} \times 30$$

$$\frac{\Delta\rho}{\rho} = 14.7 \times 10^{-3} = 1.47 \times 10^{-2}$$

$$\frac{\Delta\rho}{\rho} \simeq 1.5 \times 10^{-2}$$

Ans. b

Solution: 6

$\Delta T = 45°C - 27°C = 18°C$

$\Delta l = L \alpha \Delta T$

for $L = 63$ cm,

$\Delta l = 63 \times 1.2 \times 10^{-5} \times 18$

$\Delta l = 0.0136$ cm.

$45°C \rightarrow 27°C$ as temp decreases

so, length of steel tape will decrease by 0.0136 cm

$\therefore$ actual length

$l = 63 + \Delta l$

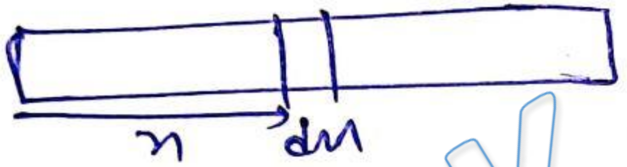
$l = 63 + 0.0136$ cm

$l = 63.0136$ cm

Ans. a

Solution: 7

$$\alpha = \frac{x}{5000}$$



Let increased length of element dx is dl $\therefore$ $dl = dx(1+\alpha\Delta T)$

$$\int_0^l dl = \int_0^1 (1+\alpha\Delta T)\,dx = \int_0^1 \left(1 + \frac{x}{5000}\times 100\right) dx$$

$$l = \left(x + \frac{x^2}{2\times 50}\right)_0^1 = \left(1+\frac{1}{100}\right) - 0$$

$$l = 1 + 0.01$$

$$\boxed{l = 1.01\ m} \qquad \boxed{\Delta l = 0.01\ m = 1\ cm}$$

Ans. d

Solution: 8

$\because \quad r = \alpha_x + \alpha_y + \alpha_z$

$r = \alpha_1 + \alpha_2 + \alpha_2$

$$\boxed{r = \alpha_1 + 2\alpha_2}$$

Ans. c

Solution: 9

$$\because \quad \gamma = \alpha_x + \alpha_y + \alpha_z$$

$$\gamma = \alpha_1 + \alpha_2 + \alpha_2$$

$$\boxed{\gamma = \alpha_1 + 2\alpha_2}$$

$$\gamma = 0.18 \times 10^{-3} /°C$$

$$\rho_0 = 13.6 \ g/cc$$

$$\rho = \rho_0 (1 - \gamma \Delta T)$$

$$\rho = 13.6(1 - 0.18 \times 10^{-3} \times 200)$$

$$= 13.6(1 - 36 \times 10^{-3})$$

$$= 13.6 \ (1 - 0.036)$$

$$= 13.6 \times 0.964$$

$$\boxed{\rho = 13.11 \ g/cc}$$

Ans. a

Solution: 10

$$\gamma_{gly} = 0.000597\ /^\circ C$$

$$\alpha_{glass} = 0.000009\ /^\circ C$$

$$\gamma_{glass} = 3\alpha_{glass} = 3 \times 0.000009$$

$$\gamma_{glass} = 0.000027\ /^\circ C$$

$$\therefore \gamma_{app} = \gamma_{gly} - \gamma_{glass}$$

$$= 0.000597 - 0.000027$$

$$= 0.000570$$

$$\boxed{\gamma_{app} = 0.00057\ /^\circ C}$$

Ans. b

Solution: 11

$\alpha = 1 \times 10^{-5} /°C$

$\beta = 2\alpha = 2 \times 10^{-5} /°C$

let initial Area area is A

then

$\Delta A = A \beta \Delta T$

$\frac{\Delta A}{A} = \beta \Delta T$

$\frac{\Delta A}{A} = 2 \times 10^{-5} \times 100 = 2 \times 10^{-3}$

% increase in Area $= \frac{\Delta A}{A} \times 100 = 2 \times 10^{-3} \times 100 = 2 \times 10^{-1}$

$\boxed{\Delta A\% = 0.2\%}$

Ans. d

Solution: 12

$A_0 = 1.2\ m^2$ at $0°C$

$\Delta A = 2.4 \times 10^{-4}\ m^2$

when $\Delta T = 100°C$

$$\frac{\Delta A}{A_0} = \beta \Delta T$$

$$\beta = \frac{2.4 \times 10^{-4}}{1.2 \times 100}$$

$$\beta = 2 \times 10^{-6} /°C$$

$$\therefore \alpha = \frac{\beta}{2} = 10^{-6} /°C$$

$$\& \gamma = 3\alpha = 3 \times 10^{-6} /°C$$

$$\boxed{\gamma = 3 \times 10^{-6} /°C}$$

Ans. d

Solution: 13

$$l = l_0 (1 + \alpha \Delta T)$$

$$\Delta l = l_0 \alpha \Delta T$$

$$2.7 \times 10^{-3} = 0.5 (90 \times 10^{-6}) \Delta T$$

$$\Delta T = \frac{2.7 \times 10^{-3}}{0.5 \times 90 \times 10^{-6}}$$

$$\Delta T = \frac{2.7}{0.5 \times 90} \times 10^{3} = 0.06 \times 10^{3}$$

$$\Delta T = 60$$

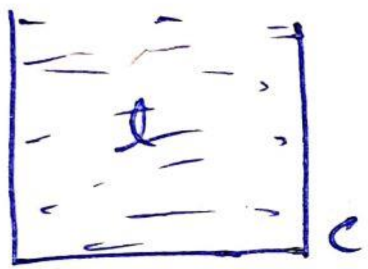
$$T_f - T_i = 60^\circ C \qquad (\because T_i = 0^\circ C)$$

$$\boxed{T_f = 60^\circ C}$$

Ans. d

Solution: 14

for over flow



Co. of Vol. ex. for liquid = γ

linear exp. coeff. for container = α

so, Vol. exp. coeff = 3α

initially:

$V_c = V_l = V$

Now for over flow

$(\Delta V)_c < (\Delta V)_l$

$V(1+3\alpha\Delta T) < V(1+\gamma\Delta T)$

$1+3\alpha\Delta T < 1+\gamma\Delta T$

$3\alpha\Delta T < \gamma\Delta T$

$3\alpha < \gamma$

$\Rightarrow \boxed{\gamma > 3\alpha}$

Ans. b

Solution: 15

$\alpha_g = 1\times10^{-5}\,/^\circ C$

$\beta_g = 2\times10^{-5}\,/^\circ C$

Cross-section Area of container at Temp $40^\circ C$, $A = ?$

$\Delta A = A(\beta)\Delta T = 100\times2\times10^{-5}\times20$

$\Delta A = 4\times10^{3}\times10^{-5}$

$\Delta A = 0.04\ cm^2$

final Area

$\therefore A = 100.04\ cm^2$

For liquid.

initial Volume $= V_0 = 100\times10 = 1000\ cm^3$

final volume

$V = V_0(1+\gamma\Delta T)$

$V = 1000\ cm^3(1+5\times10^{-5}\times20)$

$V = 1000\,(1+10^{-3})$

$V = 1000\,(1.001)$

$V = 1001\ cm^3$

so, $V = A h'$

$1001 = 100.04\,h'$

$h' = \dfrac{1001}{100.04} = 10.0059\ cm$

$\therefore \boxed{h' = 10.006\ cm}$

Ans. b

Solution: 16

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

g is constant

$\therefore T \propto \sqrt{l}$

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta l}{l} \quad \text{—(1)}$$

given; $\alpha = 2\times10^{-6}$

$\Delta t = 10^\circ C$

$$\frac{\Delta l}{l} = \alpha\Delta t = 2\times10^{-6}\times10$$

$$\frac{\Delta l}{l} = 2\times10^{-5}$$

$$\therefore \frac{\Delta T}{T} = \frac{1}{2}(2\times10^{-5})$$

$$\frac{\Delta T}{T} = 10^{-5}$$

$$\frac{\Delta T}{T}\times100 = 10^{-5}\times100$$

$$\boxed{\frac{\Delta T}{T}\% = 10^{-3}}$$

or

from formula of $\frac{\Delta T}{T}$

$$\frac{\Delta T}{T} = \frac{1}{2}\alpha\Delta\theta = \frac{1}{2}\times2\times10^{-6}\times10 = 10^{-5}$$

$$\frac{\Delta T}{T}\% = 10^{-5}\times100 = 10^{-3}$$

Ans. b

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