

Calculate the stress developed inside a tooth cavity filled with copper when hot tea at temperature of  $57^{\circ}\text{C}$  is drunk. You can take body (tooth) temperature to be  $37^{\circ}\text{C}$  and  $\alpha = 1.7 \times 10^{-5}/^{\circ}\text{C}$ , bulk modulus for copper =  $140 \times 10^9 \text{ N/m}^2$ .

Temperature of tea =  $57^{\circ}\text{C}$

Temperature of body =  $37^{\circ}\text{C}$

$$\therefore \Delta T = 57 - 37$$

$$\boxed{\Delta T = 20^{\circ}\text{C}}$$

Bulk modulus ( $B$ ) =  $140 \times 10^9 \text{ N/m}^2$

Also,  $\alpha = 1.7 \times 10^{-5} / \text{K}$

$$\therefore \gamma = 3\alpha \Rightarrow 3 \times 1.7 \times 10^{-5} / \text{K}$$

$$\boxed{\gamma \Rightarrow 5.1 \times 10^{-5} / \text{K}}$$

Let ' $V$ ' be the volume of cavity and ' $\Delta V$ ' be the increased volume on increasing temperature ' $\Delta T$ '.

$$\therefore \Delta V = (V\gamma)\Delta T$$

$$\Rightarrow \frac{\Delta V}{V} = \gamma \Delta T$$

$V$

Hence, thermal stress produced = Bulk modulus  $\times$  Volumetric strain

$$= B \times \frac{\Delta V}{V}$$

$$= 140 \times 10^9 \times 5.1 \times 10^{-5} \times 20$$

$$\boxed{\text{Thermal stress produced} = 1.428 \times 10^8 \text{ N/m}^2}$$