

Task.

②

Given density of the gas $\rho = 1 \text{ kg/m}^3$

$$\gamma = 1.4$$

At STP Pressure $P = 1 \text{ atm} = 10^5 \text{ Pa}$

$$\begin{aligned} \text{Velocity of the gas } v &= \sqrt{\frac{\gamma P}{\rho}} \\ &= \sqrt{\frac{1.4 \times 10^5}{1}} \\ &= \sqrt{140000} \times 10^2 \\ &= 376.5 \times 10^2 \\ &= 376.5 \text{ m/s} \end{aligned}$$

③

Distance between cloud and earth $d = 660 \text{ m}$ Time of hearing thunder $t = 2 \text{ sec}$

$$\begin{aligned} \therefore \text{Velocity of sound} &= \frac{\text{Distance travelled}}{\text{Time}} \\ &= \frac{660}{2} \\ &= 330 \text{ m/s} \end{aligned}$$

⑩

we know that Velocity of sound in a gas is $\sqrt{\frac{\gamma P}{\rho}}$ $v \propto \sqrt{P}$ But here temperature is constant

There will be no effect of change in Pressure on Velocity

 $\therefore$ As the Pressure is doubled; velocity = constant.

(4)

length of the metal rod = distance travelled by the sound in metal = $d_{\text{metal}} = 2000 \text{ m}$.

velocity of sound in air = $v_{\text{air}} = 340 \text{ m/s}$

Let t_{air} , t_{metal} are the time taken by the sound to travel in air and metal.

Given $t_{\text{air}} \sim t_{\text{metal}} = 5 \text{ sec}$

we know $\text{time} = \frac{\text{distance}}{\text{velocity}}$

$$\Rightarrow \frac{D}{v_{\text{air}}} \sim \frac{D}{v_{\text{metal}}} = 5$$

$$\Rightarrow D \left[\frac{1}{v_{\text{air}}} \sim \frac{1}{v_{\text{metal}}} \right] = 5$$

$$= 2000 \left[\frac{1}{340} - \frac{1}{v_{\text{metal}}} \right] = 5$$

$$\Rightarrow \frac{1}{340} - \frac{1}{v_{\text{metal}}} = \frac{5}{2000}$$

$$= \frac{1}{340} - \frac{1}{v_{\text{metal}}} = \frac{1}{400}$$

$$\Rightarrow \frac{1}{v_{\text{metal}}} = \frac{1}{340} - \frac{1}{400}$$

$$\Rightarrow \frac{1}{v_{\text{metal}}} = \frac{40-34}{1200} = \frac{6}{1200}$$

$$\Rightarrow \cancel{v_{\text{metal}}} = \cancel{1200} \text{ m/s}$$

$$\Rightarrow \frac{1}{v_{\text{metal}}} = \frac{40-34}{34 \times 400} = \frac{6}{34 \times 400}$$

$$\Rightarrow v_{\text{metal}} = 2266.6 \text{ m/s}$$

①

Given relation is $p = \frac{\alpha}{v^2}$

on Differentiating both sides

$$dp = d\left[\frac{\alpha}{v^2}\right]$$

$$\Rightarrow dp = \alpha d[v^{-2}] \quad \left[\because \frac{d}{dx} x^n = nx^{n-1} dx\right]$$

$$\Rightarrow dp = \alpha [-2v^{-2-1}] dv$$

$$\Rightarrow dp = -2\alpha v^{-3} dv$$

The Bulk modulus of Elasticity

$$B = - \frac{dp}{\frac{dv}{v}} = \frac{-2\alpha v^{-3} dv}{\frac{dv}{v}}$$

$$B = 2\alpha \frac{v^{-3}}{\frac{1}{v}}$$

$$B = 2\alpha v^{-3} v$$

$$= 2\alpha v^{-2}$$

$$B = 2 \frac{\alpha}{v^2}$$

$$\therefore B = 2p$$

We know that Acc to Laplace formula

$$\text{Velocity of sound in fluids} = \sqrt{\frac{B}{\rho}}$$

$$v = \sqrt{\frac{2p}{\rho}}$$

5)

we know that $v \propto \sqrt{T}$

$$\therefore \frac{v_t}{v_0} = \sqrt{\frac{T_t}{T_0}} \quad ; \quad \text{where}$$

T_0 = initial temperature

v_0 = initial velocity

$$v_t = \sqrt{2} \quad v_0$$

$$T_t = T_0 + 300$$

$$\Rightarrow \frac{\sqrt{2} v_0}{v_0} = \sqrt{\frac{T_0 + 300}{T_0}}$$

$$\Rightarrow \sqrt{2} = \sqrt{\frac{T_0 + 300}{T_0}} \quad \text{on squaring both sides}$$

$$\Rightarrow 2 = \frac{T_0 + 300}{T_0}$$

$$\Rightarrow 2T_0 = T_0 + 300 \Rightarrow 2T_0 - T_0 = 300$$

$$\Rightarrow T_0 = 300 \text{ K}$$

$$= 273 + 27^\circ \text{C}$$

$\therefore$ initial temperature in $^\circ \text{C} = 27^\circ \text{C}$

6)

Given $v_{\text{air}} = 330 \text{ m/s}$; $v_{\text{H}_2} = ?$

$$\rho_{\text{air}} = 16 \rho_{\text{H}_2}$$

Acc to the relation $v = \sqrt{\frac{3p}{\rho}}$

$$v \propto \frac{1}{\sqrt{\rho}}$$

$$\Rightarrow \frac{v_{\text{H}_2}}{v_{\text{air}}} = \sqrt{\frac{\rho_{\text{air}}}{\rho_{\text{H}_2}}}$$

$$\Rightarrow \frac{v_{\text{H}_2}}{330} = \sqrt{\frac{16 \rho_{\text{H}_2}}{\rho_{\text{H}_2}}} = \sqrt{16} = 4$$

$$\Rightarrow v_{\text{H}_2} = 4 \times 330 = 1320 \text{ m/s}$$

(3)

(7)

At $t_1 = 0^\circ\text{C}$, velocity $V_1 = 320 \text{ m/s}$

$t_2 = ?$

$$V_2 = \frac{V_1}{2}$$

we know that $V \propto \sqrt{T}$

$$\Rightarrow \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{V_1}{\frac{V_1}{2}} = \sqrt{\frac{273}{T_2}} \quad \left[\text{where } T_1 = 273 + t_1 \right]$$

$$\Rightarrow 2 = \sqrt{\frac{273}{T_2}} \quad \text{on squaring both sides}$$

$$\Rightarrow 4 = \frac{273}{T_2}$$

$$\Rightarrow T_2 = \frac{273}{4} = 68.25 \text{ K.}$$

(8)

Velocity of sound in a gas $V = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}}$

helium is monoatomic $\therefore \gamma_{\text{He}} = \frac{5}{3}$

Nitrogen is diatomic $\gamma_{\text{N}} = \frac{7}{5}$

$$\therefore \frac{V_{\text{N}_2}}{V_{\text{He}}} = \sqrt{\frac{\gamma_{\text{He}}}{\gamma_{\text{N}}}} \times \frac{M_{\text{He}}}{M_{\text{N}_2}}$$

$$= \sqrt{\frac{5}{7} \times \frac{3}{5}} \times \frac{4}{28}$$

$$= \sqrt{\frac{3}{25}} = \frac{\sqrt{3}}{5}$$



(16)

Given that Bulk modulus of elasticity $B = 220 \text{ kg wt/mm}^2$

$$\begin{aligned} 1 \text{ kg wt} &= 9.8 \text{ N} \\ 220 \text{ kg wt} &= 220 \times 9.8 \text{ N} \end{aligned}$$

$$B = 220 \times 9.8 \text{ N/10}^{-6} \text{ m}^2$$

$$B = 220 \times 9.8 \times 10^6 \text{ N/m}^2$$

density $\rho = 1028 \text{ g/cm}^3$

$$\rho = 1.028 \times 10^3 \text{ kg/m}^3$$

$$V = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{220 \times 9.8 \times 10^6}{1.028 \times 10^3}} = \sqrt{196 \times 10^4}$$

$$= 14 \times 10^2$$

$$V = 1.4 \times 10^3 \text{ m/s}$$

(17)

$$\text{Velocity of sound} = \sqrt{\frac{\gamma RT}{M}}$$

Helium is monoatomic $\gamma_{\text{He}} = \frac{5}{3}$; $M_{\text{He}} = 4$

Hydrogen is diatomic $\gamma_{\text{H}_2} = \frac{7}{5}$; $M_{\text{H}_2} = 2$

$$\therefore \frac{V_{\text{He}}}{V_{\text{H}_2}} = \sqrt{\frac{\gamma_{\text{He}}}{\gamma_{\text{H}_2}} \times \frac{M_{\text{H}_2}}{M_{\text{He}}}}$$

$$= \sqrt{\frac{\frac{5}{3}}{\frac{7}{5}} \times \frac{2}{4}}$$

$$= \sqrt{\frac{25}{21} \times \frac{1}{2}}$$

$$\frac{V_{\text{He}}}{V_{\text{H}_2}} = \sqrt{\frac{25}{42}} \Rightarrow \frac{V_{\text{H}_2}}{V_{\text{He}}} = \sqrt{\frac{42}{25}} \approx 2:1$$

LTAKK

SAQ'

①

variation of velocity with temperature

$$v_t = v_0 \left(1 + \frac{t^\circ\text{C}}{546} \right) \text{ m/s}$$

where $v_0 = 330 \text{ m/s}$; $t = 1^\circ\text{C}$

$$\Rightarrow v_t = 330 \left[1 + \frac{1}{546} \right]$$

$$= 330 \left[\frac{547}{546} \right]$$

$$v_t = 330.60 \text{ m/s}$$

$$\therefore \text{increase in velocity } v_t - v_0 = 330.60 - 330 \\ = 0.60 \text{ m/s}$$

②

Given $v_{\text{sound}} = 330 \text{ m/s}$

$$v_{\text{light}} = 3 \times 10^8 \text{ m/s}$$

$$\therefore \frac{v_{\text{sound}}}{v_{\text{light}}} = \frac{330}{3 \times 10^8} \approx \frac{330}{300 \times 10^6} \approx \frac{1}{10^6}$$

③

Given Pressure $P = 10 \text{ Pa}$; $\rho_{\text{gas}} = 1.4 \times 10^{-3} \text{ g/cm}^3$

Ratio of specific heats $\gamma = 1.4$. $= 1.4 \text{ kg/m}^3$

$$\therefore \text{The velocity of sound in a gas } v = \sqrt{\frac{\gamma P}{\rho}}$$

$$\Rightarrow v = \sqrt{\frac{1.4 \times 10}{1.4}} = \sqrt{10} \text{ m/s}$$



④

Temperature at NTP $T_1 = 273 \text{ K}$

velocity $V_1 = V$

For what value of T_2 ; $V_2 = 4V_1$
 $= 4V$

∴ According to the relation $V \propto \sqrt{T}$

$$\Rightarrow \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{V}{4V} = \sqrt{\frac{273}{T_2}} \text{ - on squaring both sides}$$

$$\Rightarrow \frac{1}{16} = \frac{273}{T_2}$$

$$\Rightarrow T_2 = 16 \times 273 = 4368 \text{ K}$$

⑤

At $t_1 = 0^\circ \text{C} \rightarrow T_1 = 273 + t_1 = 273 \text{ K}$

velocity $V_1 = 332 \text{ m/s}$

$V_2 = 664 \text{ m/s}$ then $t_2 = ?$

From the relation $V \propto \sqrt{T}$

$$\Rightarrow \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{332}{664} = \sqrt{\frac{273}{T_2}} \Rightarrow \frac{1}{2} = \sqrt{\frac{273}{T_2}}$$

$$\Rightarrow \frac{1}{4} = \frac{273}{T_2} \Rightarrow T_2 = 1092 \text{ K}$$

$$\Rightarrow t_2 = 1092 - 273$$
$$= 819^\circ \text{C}$$

⑥

Given $T_2 = 2T_1$

we know that $v \propto \sqrt{T}$

$$\therefore \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{T_1}{2T_1}} = \frac{1}{\sqrt{2}}$$

⑦

Given density is tripled i.e. $d_2 = 3d_1$

we know that $v \propto \frac{1}{\sqrt{d}}$

$$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{d_2}{d_1}}$$

$$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{3d_1}{d_1}}$$

$$\Rightarrow \frac{v_1}{v_2} = \frac{\sqrt{3}}{1}$$

⑧

we know that $v = \sqrt{\frac{3RT}{M}}$ and $\gamma_{He} = \frac{5}{3}; M_{He} = 4$
 $\gamma_N = \frac{7}{5}; M_N = 28$

$$\therefore \frac{v_{N_2}}{v_{He}} = \sqrt{\frac{\gamma_{N_2}}{\gamma_{He}} \times \frac{M_{He}}{M_{N_2}}}$$

$$= \sqrt{\frac{7}{5} \times \frac{3}{5} \times \frac{4}{28}} = \sqrt{\frac{3}{25}}$$

$$\frac{v_{N_2}}{v_{He}} = \frac{\sqrt{3}}{5}$$

(8)

we know that $v = \sqrt{\frac{3RT}{M}}$

Given that $v_N = v_O$ [Here both are diatomic]

$$\Rightarrow \sqrt{\frac{3RT_N}{M_N}} = \sqrt{\frac{3RT_O}{M_O}} \quad [M_N = 28; M_O = 32]$$

$$\Rightarrow \sqrt{\frac{T_N}{M_N}} = \sqrt{\frac{T_O}{M_O}} \quad \text{on squaring both sides}$$

$$\Rightarrow \frac{T_N}{28} = \frac{T_O}{32}$$

$$\Rightarrow \frac{273+19}{28} = \frac{T_O}{32} \Rightarrow \frac{292}{7} = \frac{T_O}{8}$$

$$\Rightarrow T_O = \frac{8}{7} \times 292 = 333.7 \text{ K}$$

$$\Rightarrow t \text{ in } ^\circ\text{C} = 333 - 273 = 60^\circ\text{C}$$

(10)

$$\text{If } t_1 = 51^\circ\text{C} \rightarrow T_1 = 273 + 51 = 324 \text{ K} \rightarrow v_1 = v$$

$$t_2 = 303^\circ\text{C} \rightarrow T_2 = 273 + 303 = 576 \text{ K} \rightarrow v_2 = ?$$

we know that $v \propto \sqrt{T}$

$$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{v}{v_2} = \sqrt{\frac{324}{576}}$$

$$\Rightarrow \frac{v}{v_2} = \sqrt{\frac{81}{144}} = \frac{9}{12} = \frac{3}{4}$$

$$\Rightarrow v_2 = \frac{4}{3} v$$

(16)

Given Young's modulus $\gamma = 2 \times 10^{11} \text{ N/m}^2$

density $\rho = 8 \times 10^3 \text{ kg/m}^3$

Velocity of sound in a solid $= \sqrt{\frac{\gamma}{\rho}}$

$$V = \sqrt{\frac{2 \times 10^{11}}{8 \times 10^3}}$$

$$\Rightarrow V = \sqrt{\frac{10^8}{4}} = \frac{10^4}{2}$$

$$\Rightarrow V = 5 \times 10^3 \text{ m/s}$$

(17)

we know that $u = \sqrt{\frac{3RT}{M}}$

Here both O_2 and H_2 are diatomic ; $T = \text{constant}$

$$\therefore V \propto \frac{1}{\sqrt{M}}$$

$$M_{\text{O}} = 32$$

$$M_{\text{H}_2} = 2$$

$$\Rightarrow \frac{V_{\text{H}_2}}{V_{\text{O}_2}} = \sqrt{\frac{M_{\text{O}}}{M_{\text{H}_2}}} = \sqrt{\frac{32}{2}} = \sqrt{\frac{16}{1}}$$

$$\Rightarrow \frac{V_{\text{H}_2}}{V_{\text{O}_2}} = \frac{4}{1}$$