WS-14 → T task → 9th foundation

(2)

Given density of the gas $\rho = 1$ kg/m3

$\gamma = 1.4$

At STP Pressure $P = 1$ atm $= 10^5$ Pa.

Velocity of the gas $v = \sqrt{\frac{\gamma P}{\rho}}$

$= \sqrt{\frac{1.4 \times 10^5}{1}}$

$= \sqrt{14} \times 10^2$

$= 3.765 \times 10^2$

$= 376.5$ m/s

(3)

Distance between cloud and Earth $d = 660$m

Time of hearing thunder $t = 2$ sec.

$\therefore$ Velocity of sound $= \frac{\text{Distance travelled}}{\text{Time}}$

$= \frac{660}{2}$

$= 330$ m/s

(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_{metal} = 2000 m.

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

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

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

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

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

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

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

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

$$= \frac{1}{340} - \frac{1}{V_{metal}} = \frac{1}{400}$$

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

$$\Rightarrow \cancel{\frac{1}{V_{metal}} = \frac{40-34}{1200} = \frac{4}{1200}} \quad 6$$

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

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

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

(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

$$B = -\frac{dP}{\frac{dV}{V}} = \frac{\cancel{-}2\alpha V^{-3}\cancel{dV}}{\cancel{-}\frac{\cancel{dV}}{V}}$$

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

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

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

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

$$\therefore B = 2P$$

We know that Acc to laplace formula

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

$$V = \sqrt{\frac{2P}{\rho}}$$

(5)

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

$\therefore \frac{V_t}{V_0} = \sqrt{\frac{T_t}{T_0}}$; where

T_0 = initial temperature

$V_0 \Rightarrow$ initial velocity

$V_t = \sqrt{2}\ V_0$

$T_t = T_0 + 300$

$\Rightarrow \frac{\sqrt{2}\ \cancel{V_0}}{\cancel{V_0}} = \sqrt{\frac{T_0+300}{T_0}}$

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

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

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

$\Rightarrow T_0 = 300\,K$

$= 273 + 27^\circ C$

$\therefore$ initial temperature in $^\circ C = 27^\circ C$

(6)

Given $V_{air} = 330\ m/s$; $V_{H_2} = ?$

$\rho_{air} = 16\ \rho_{H_2}$

Acc to the relation $V = \sqrt{\frac{\gamma P}{\rho}}$

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

$\Rightarrow \frac{V_{H_2}}{V_{air}} = \sqrt{\frac{\rho_{air}}{\rho_{H_2}}}$

$\Rightarrow \frac{V_{H_2}}{330} = \sqrt{\frac{16\ \cancel{\rho_{H_2}}}{\cancel{\rho_{H_2}}}} = \sqrt{16} = 4$

$\Rightarrow V_{H_2} = 4 \times 330 = 1320\ m/s$

7

At $t_1 = 0°C$, velocity $V_1 = 320$ m/s

$t_2 = ?$ $\quad V_2 = \frac{V_1}{2}$

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

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

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

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

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

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

9

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

helium is mono atomic $\therefore \gamma_{He} = \frac{5}{3}$

Nitrogen is diatomic $\gamma_N = \frac{7}{5}$

$$\therefore \frac{V_{N_2}}{V_{He}} = \sqrt{\frac{\gamma_{He}}{\gamma_N} \times \frac{M_{He}}{M_{N}}}$$

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

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

(16)

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

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

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

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

density $\rho = 1.1\ g/cm^3$

$$\rho = 1.1 \times 10^3\ kg/m^3$$

$$V = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{220 \times 9.8 \times 10^6}{1.1 \times 10^3}} = \sqrt{196 \times 10^4}$$

$$= 14 \times 10^2$$

$$u = 1.4 \times 10^3\ m/s$$

(17)

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

Helium is mono atomic. $\gamma_{He} = \frac{5}{3}$; $M_{He} = 4$

Hydrogen is Diatomic $\gamma_{H_2} = \frac{7}{5}$; $M_{H_2} = 2$

$$\therefore \frac{V_{He}}{V_{H_2}} = \sqrt{\frac{\gamma_{He}}{\gamma_{H_2}} \times \frac{M_{H_2}}{M_{He}}}$$

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

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

$$\frac{V_{He}}{V_{H_2}} = \sqrt{\frac{25}{42}} \Rightarrow \frac{V_{H_2}}{V_{He}} = \sqrt{\frac{42}{25}} \simeq \sqrt{2} : 1$$

LTask

SAQ'

(1)

variation of velocity with temperature

$$V_t = V_0 \left(1 + \frac{t^\circ c}{546}\right] m/s$$

where $V_0 = 330$ m/s ; $t = 1^\circ c$

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

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

$$V_t = 330.60 \ m/s$$

$\therefore$ increase in velocity $V_t - V_0 = 330.60 - 330$

$= 0.60$ m/s

(2)

Given $V_{sound} = 330$ m/s

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

$$\therefore \frac{V_{sound}}{V_{light}} = \frac{330}{3\times10^8} \simeq \frac{330}{300\times10^6} \simeq \frac{1}{10^6}$$

(3)

Given Pressure $P = 10$ Pa ; $\rho_{gas} = 1.4\times10^{-3}$ gm/cm^3

Ratio of specific heats $= \gamma = 1.4$. $= 1.4$ kg/m3

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

$$\Rightarrow V = \sqrt{\frac{\cancel{1.4}\times10}{\cancel{1.4}}} = \sqrt{10} \ m/s$$

(4)

Temperature at NTP $T_1 = 273k$

velocity $V_1 = V$.

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

$= 4V$.

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

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

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

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

$$\Rightarrow T_2 = 16 \times 273 = 4368\,k.$$

(5)

At $t_1 = 0°c \rightarrow T_1 = 273 + t_1 = 273\,k$.

velocity $V_1 = 332$ m/s.

$V_2 = 664$ m/s Then $t_2 = ?$

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

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

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

$$\Rightarrow \frac{1}{4} = \frac{273}{T_2} \Rightarrow T_2 = 1092\,k$$

$$\Rightarrow t_2 = 1092 - 273$$

$$= 819\,°c.$$

(6)

Given $T_2 = 2T_1$

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

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

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

(7)

Given density is tripled (ie) $d_2 = 3d_1$

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

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

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

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

(9)

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

$\gamma_N = \frac{7}{5}$; $M_N = 28$

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

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

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

(8)

We know that $V = \sqrt{\frac{\gamma RT}{M}}$

Given that $V_N = V_O$ [Here both are diatomic]

$\Rightarrow \sqrt{\frac{\cancel{\gamma R} T_N}{M_N}} = \sqrt{\frac{\cancel{\gamma R} T_O}{M_O}}$ [$M_N = 28$; $M_O = 32$]

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

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

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

$\Rightarrow T_O = \frac{8}{7} \times 292 = 333.7\,k$

$\Rightarrow t$ in $°c = 333-273 \simeq 60°c$

(10)

If $t_1 = 51°c \rightarrow T_1 = 273+51 = 324\,k \rightarrow V_1 = V$

$t_2 = 303°c \rightarrow T_2 = 273+303 = 576\,k \rightarrow V_2 = ?$

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

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

$\Rightarrow \frac{V}{V_2} = \sqrt{\frac{\cancel{324}\,81}{\cancel{576}\,144}}$

$\Rightarrow \frac{V}{V_2} = \sqrt{\frac{81}{144}} = \frac{9}{12} = \frac{3}{4}$

$\Rightarrow V_2 = \frac{4}{3} V.$

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(16)

Given Young's modulus $Y = 2\times10^{11}\ N/m^2$

density $\rho = 8\times10^3\ kg/m^3$

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

$$V = \sqrt{\frac{2\times10^{11}}{8\times10^3}}$$

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

$$\Rightarrow V = 5\times10^3\ m/s$$

(17)

we know that $V = \sqrt{\frac{8RT}{M}}$

Here both O_2 and H_2 are diatomic ; $T =$ constant

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

$M_O = 32$

$M_{H_2} = 2$

$$\Rightarrow \frac{V_{H_2}}{V_{O_2}} = \sqrt{\frac{M_O}{M_{H_2}}} = $$

$$= \sqrt{\frac{32}{2}} = \sqrt{\frac{16}{1}}$$

$$\Rightarrow \frac{V_{H_2}}{V_{O_2}} = \frac{4}{1}$$