

ws-3. 8th integrated +

Task

1. Given $\rho_{\text{gas}} = 1 \text{ kg/m}^3$

$$\gamma = 1.4$$

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

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

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

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

$$= 30765 \times 10^2 = 3765 \text{ m/s}$$

2.

Distance between Earth and cloud = 660 m

Time of hearing thunder $t = 2 \text{ sec}$

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

$$= \frac{660}{2} = 330 \text{ m/s}$$

3. length of metal rod = distance travelled by

sound in metal = 2000 m.

$$v_{\text{air}} = 340 \text{ m/s}$$

let t_{air} , t_{metal} are the time taken by the

sound to travel in air and metal

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

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

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

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

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

By solving we get $v_{\text{metal}} = 2266.6 \text{ m/s}$

Ans

$$\text{we know } v \propto \sqrt{T} \quad (\text{i.e.}) \quad \frac{v_T}{v_0} = \sqrt{\frac{T_T}{T_0}}$$

$$\text{Given } v_T = \sqrt{2} v_0 \quad ; \quad T_T = T_0 + 300.$$

$$\therefore \frac{\sqrt{2} v_0}{v_0} = \sqrt{\frac{T_0 + 300}{T_0}} \quad \text{s.o.b.}$$

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

$$\Rightarrow T_0 = 273 + 27^\circ \text{C}$$

$$\therefore T_0 = 27^\circ \text{C}$$

$$\Rightarrow T_0 = 300$$

5

Given

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

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

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

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

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

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

$$V_{\text{H}_2} = 1320 \text{ m/s}$$

6

Given

$$M_{\text{H}_2} = 0.002 \text{ kg/mol}$$

$$M_{\text{O}_2} = 0.032 \text{ kg/mol}$$

we know $V \propto \frac{1}{\sqrt{M}}$

$$\Rightarrow \frac{V_{\text{H}_2}}{V_{\text{O}_2}} = \sqrt{\frac{M_{\text{O}_2}}{M_{\text{H}_2}}} = \sqrt{\frac{0.032}{0.002}}$$

$$= \sqrt{\frac{32}{2}} = \sqrt{16} = 4$$



7

Given $\gamma = 1.4$; $M = 28 \times 10^{-3} \text{ kg/mol}$.

$$V = 350 \text{ m/s}$$

We know

$$V = \sqrt{\frac{\gamma R T}{M}} = \sqrt{\frac{1.4 \times 8.3 \times T}{28 \times 10^{-3}}}$$

$$\Rightarrow 350 = \sqrt{\frac{8.3 \times T}{2 \times 10^{-2}}}$$

$$\Rightarrow (350)^2 = \frac{8300}{2} \times T$$

$$\Rightarrow T = \frac{(350)^2 \times 2}{8300} = 294.67 \text{ K}$$

21m 8.01x 10^4 in °C

$$t = 294.67 - 273 = 21.6^\circ \text{C}$$

8

Given $B = 1.04 \times 10^9 \text{ Pa}$; $\rho = 1200 \text{ kg/m}^3$

We know

$$V = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{1.04 \times 10^9}{1200}}$$

$$\Rightarrow V = \sqrt{\frac{14}{12} \times 10^6} = \sqrt{\frac{7}{6}} \times 10^3$$

$$\Rightarrow V = 1.08012 \times 10^3 \text{ m/s}$$

$$= 1080.12 \text{ m/s}$$



Thrust

9

Given $v_m = 1500 \text{ m/s}$; $\rho = 2500 \text{ kg/m}^3$

we know $v = \sqrt{\frac{B}{\rho}}$

$$\Rightarrow 1500 = \sqrt{\frac{B}{2500}}$$

$$\Rightarrow (1500)^2 = \frac{B}{2500}$$

$$\Rightarrow B = 5.625 \times 10^9 \text{ P}$$

10.

we know

$$v \propto \frac{1}{\sqrt{\rho}} \Rightarrow v^2 \propto \frac{1}{\rho}$$

Given $v_A = 600 \text{ m/s}$; $\rho_A = 900 \text{ kg/m}^3$

$v_B = 1200 \text{ m/s}$; $\rho_B = ?$

$$\therefore \left(\frac{v_A}{v_B} \right)^2 = \frac{\rho_B}{\rho_A}$$

$$\Rightarrow \rho_B = \left(\frac{v_A}{v_B} \right)^2 \times \rho_A$$

$$\rho_B = \left(\frac{600}{1200} \right)^2 \times 900$$

$$= \frac{1}{4} \times 900$$

$$= 225 \text{ kg/m}^3$$

(16)

Given that $B = 220 \text{ kg wt } 1 \text{ mm}^2$

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

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

$$\text{density } \rho = 1.2 \text{ gm/cc} = 1.2 \times 10^3 \text{ kg/m}^3$$

we know $v = \sqrt{\frac{B}{\rho}}$

$$v = \sqrt{\frac{220 \times 9.8 \times 10^6}{1.2 \times 10^3}}$$

$$= \sqrt{196 \times 10^4} = 14 \times 10^2$$

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

(17)

For Helium

$$\gamma_{\text{He}} = \frac{5}{3}$$

$$M_{\text{He}} = 4$$

Hydrogen

$$\gamma_{\text{H}_2} = \frac{7}{5}$$

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

we know

$$v = \sqrt{\frac{\gamma R T}{M}}$$

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

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

$$= \sqrt{\frac{25}{42}}$$

$$\therefore \frac{v_{\text{H}_2}}{v_{\text{He}}} = \sqrt{\frac{42}{25}} \approx \sqrt{2} \approx 1.41$$

L-Topic

1. Given

$$t = 20^{\circ}\text{C} ; v_0 = 331 \text{ m/s}$$

We know $v_t = v_0 \left(1 + \frac{t}{546} \right)$

$$v_t = 331 \left(1 + \frac{20}{546} \right)$$

$$\Rightarrow v_t = 331 \left(1 + \frac{1}{54.6} \right)$$

$$v_t = 343.4 \text{ m/s}$$

2.

Given

$$v_t = 350 \text{ m/s}$$

speed of sound in air $v_0 = 331 \text{ m/s}$

We know $v_t = v_0 \left(1 + \frac{t}{546} \right)$

$$350 = 331 \left(1 + \frac{t}{546} \right)$$

$$\Rightarrow \frac{350}{331} = 1 + \frac{t}{546}$$

$$\Rightarrow \frac{350}{331} - 1 = \frac{t}{546}$$

$$\Rightarrow \frac{350 - 331}{331} = \frac{t}{546}$$

$$\Rightarrow \frac{19}{331} \times 546 = t$$

$$\Rightarrow t = 31^{\circ}\text{C}$$



3.

Given $t = -10^\circ\text{C}$.

$$V_{\text{air}} = V_0 = 331 \text{ m/s}$$

$$\begin{aligned} \text{We know } V_t &= V_0 \left(1 + \frac{t}{546} \right) \\ &= 331 \left[1 - \frac{10}{546} \right] \end{aligned}$$

$$V_t \approx 325.3 \text{ m/s}$$

4.

Given $B = 1.4 \times 10^9 \text{ Pa}$

$$\rho = 1.2 \text{ kg/m}^3$$

$$\text{We know } V = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{1.4 \times 10^9}{1.2}}$$

$$\begin{aligned} V &= \sqrt{1.1666 \times 10^9} \\ &\approx 341.7 \text{ m/s} \end{aligned}$$

5. Given

$$V_{\text{medium}} = 1500 \text{ m/s}$$

$$B = 2.25 \times 10^{10} \text{ Pa}$$

$$\text{Using } V_{\text{medium}} = \sqrt{\frac{B}{\rho}}$$

$$\Rightarrow 1500 = \sqrt{\frac{2.25 \times 10^{10}}{\rho}}$$

$$\Rightarrow (1500)^2 = \frac{2.25 \times 10^{10}}{\rho}$$

$$\Rightarrow \rho = \frac{2.25 \times 10^{10}}{(1500)^2} = 10^4 \text{ kg/m}^3$$



⑥

Given $v_{\text{liquid}} = 1200 \text{ m/s}$; $\rho = 950 \text{ kg/m}^3$

we know $v = \sqrt{\frac{B}{\rho}}$

$$\therefore B = v^2 \rho$$

$$= (1200)^2 (950)$$

$$= 144 \times 10^4 \times 950$$

$$= 1.368 \times 10^9 \text{ Pa}$$

⑦

Given

$$M = 0.029 \text{ kg/mole} ; \gamma = 1.4$$

$$T = 300 \text{ K} ; R = 8.314 \text{ J/mole K}$$

we know $v = \sqrt{\frac{\gamma R T}{M}}$

$$\Rightarrow v = \sqrt{\frac{1.4 \times 8.314 \times 300}{0.029}}$$

$$\Rightarrow v = \sqrt{\frac{3491.88}{0.029}}$$

$$\Rightarrow v = 347 \text{ m/s}$$



8.

Given $M = 4 \times 10^{-3} \text{ kg/mol}$; $\gamma_{H_2} = 1.66$

$T = 300 \text{ K}$

From $v = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{1.66 \times 8.314 \times 300}{4 \times 10^{-3}}}$

$\Rightarrow v = \sqrt{\frac{4140.67}{0.004}} = \sqrt{1035168}$

$\Rightarrow v \approx 1017 \text{ m/s}$

9.

Given $\gamma = 1.4$; $v = 330 \text{ m/s}$

$T = 273 \text{ K}$; $R = 8.314 \text{ J/mol K}$

From $v = \sqrt{\frac{\gamma RT}{M}} \Rightarrow M = \frac{\gamma RT}{v^2}$

$\Rightarrow M = \frac{1.4 \times 8.314 \times 273}{(330)^2}$

$\approx 0.029 \text{ kg/mol}$

10.

Given $\gamma = 1.4$; $M = 0.044 \text{ kg/mol}$

$R = 8.314 \text{ J/mol K}$; $v = 400 \text{ m/s}$

From $v = \sqrt{\frac{\gamma RT}{M}}$

$\Rightarrow T = \frac{16 \times 10^4 \times 0.044}{1.4 \times 8.314}$

$\Rightarrow (400)^2 = \frac{\gamma R}{M} T$

$\Rightarrow T = \frac{(400)^2 M}{\gamma R}$

$\Rightarrow T = 366 \text{ K}$



L Task advanced

(16)

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

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

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

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

$$\Rightarrow v = \sqrt{\frac{10^8}{4}} = 5000 \text{ m/s}$$

(17)

we know that

$$v = \sqrt{\frac{3RT}{M}}$$

$T = \text{constant}$

$$\Rightarrow v \propto \frac{1}{\sqrt{M}}$$

$$M_O = 32$$

$$M_{H_2} = 2$$

$$\Rightarrow \frac{v_{H_2}}{v_{O_2}} = \sqrt{\frac{M_O}{M_{H_2}}} = \sqrt{\frac{32}{2}}$$

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

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