ws-3. 8th integrated +

T task

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

$\gamma = 1.4$

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

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

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

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

$= 3.765 \times 10^2 = 376.5\ m/s$

2. Distance between Earth and cloud = 660 m

Time of hearing thunder t = 2 sec

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

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

3. length of metal rod = distance travelled by sound in metal = 2000 m.

$V_{air} = 340$ m/s

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

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

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

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

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

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

By solving we get $V_{metal} = 2266.6$ m/s

4. we know $V \propto \sqrt{T}$ ie, $\frac{V_t}{V_0} = \sqrt{\frac{T_t}{T_0}}$

Given $V_t = \sqrt{2}\, V_0$; $T_t = T_0 + 300$.

$$\therefore \frac{\sqrt{2}\, \cancel{V_0}}{\cancel{V_0}} = \sqrt{\frac{T_0+300}{T_0}} \quad \text{s.o.b.s}$$

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

$$\Rightarrow T_0 = 300$$

$\Rightarrow T_0 = 273 + 27°c$

$\therefore T_0 = 27°c$

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(5) Given $v_{air} = 330$ m/s ; $v_{H_2} = ?$

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

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

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

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

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

$v_{H_2} = 1320$ m/s

(6)

Given $M_{H_2} = 0.002$ kg/mo

$M_{O_2} = 0.032$ kg/mo.

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

$\Rightarrow \frac{v_{H_2}}{v_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}} = \sqrt{\frac{0.032}{0.002}}$

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

(7)

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

$V = 350$ m/s

We know $V = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{1.4 \times 8.3 \times T}{\frac{\cancel{28} \times 10^{-3}}{2}}}$

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

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

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

$\therefore$ in °C $t = 294.67 - 273 = 21.6$ °C

(8)

Given $B = 1.4 \times 10^{9}$ pa ; $\rho = 1200$ kg/m3

We know $V = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{1.4 \times 10^9}{1200}}$

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

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

$= 1080.12$ m/s

Theory

(9)

Given $v_m = 1500\, m/s$; $\rho = 2500\, kg/m^3$

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

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

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

$\Rightarrow B = 5.625 \times 10^9\, P$

10.

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

Given $v_A = 600\, m/s$; $\rho_A = 900\, kg/m^3$

$v_B = 1200\, m/s$; $\rho_B = ?$

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

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

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

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

$= 225\, kg/m^3$

Advanced

(16)

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

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

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

density $\rho = 1.1 \ gm/cc = 1.1 \times 10^{3} \ kg/m^3$

$\Rightarrow$ $\therefore$ we know $v = \sqrt{\dfrac{B}{\rho}}$

$$\Rightarrow v = \sqrt{\frac{220 \times 9.8 \times 10^{6}}{1.1 \times 10^{3}}}$$

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

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

(17).

For Helium $\gamma_{He} = \dfrac{5}{3}$; $M_{He} = 4$

Hydrogen $\gamma_{H_2} = \dfrac{7}{5}$; $M_{H_2} = 2$

we know $v = \sqrt{\dfrac{\gamma RT}{M}}$

$$\Rightarrow \frac{v_{He}}{v_{H_2}} = \sqrt{\frac{\gamma_{He}}{\gamma_{H_2}} \times \frac{M_{H_2}}{M_{He}}}$$

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

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

$$\therefore \frac{v_{H_2}}{v_{He}} = \sqrt{\frac{42}{25}} \simeq \sqrt{2} : 1.$$

L Task

1.

Given $t = 20°C.$; $V_0 = 331$ m/se

We know $V_t = V_0 \left[1 + \frac{t}{546}\right]$

$V_t = 331 \left[1 + \frac{20}{546}\right]$

$\Rightarrow V_t = 331 \left[1 + \frac{1}{54.6}\right]$

$= 343.4$ m/s

2.

Given $V_t = 350$ m/s

speed of sound in air $V_0 = 331$ m/s

We know $V_t = V_0 \left[1 + \frac{t}{546}\right]$

$\Rightarrow 350 = 331 \left[1 + \frac{t}{546}\right]$

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

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

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

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

$\Rightarrow t = 31°C.$

(3.)

Given $t = -10°C.$

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

We know $V_t = V_0 \left[1 + \frac{t}{546}\right]$

$= 331 \left[1 - \frac{10}{546}\right]$

$V_t \simeq 325.3 \ m/s$

(4)

Given $B = 1.4 \times 10^9$ Pa

$\rho = 1.2 \ kg/m^3$

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

$\Rightarrow V_1 = \sqrt{1.1666 \times 10^9}$

$\simeq 341.7 \ m/s$

5. Given $V_{medium} = 1500 \ m/s$

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

using $V_{medium} = \sqrt{\frac{B}{\rho}}$

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

$\Rightarrow (1500)^2 = \frac{225 \times 10^8}{\rho}$

$\Rightarrow \rho = \frac{225 \times 10^8}{(1500)^2} = 10^4 \ kg/m^3$

(6)

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

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

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

$= (1200)^2 (950)$

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

$= 1.368 \times 10^9\ Pa$

(7)

Given $M = 0.029\ kg/mole$; $\gamma = 1.4$

$T = 300\ k$; $R = 8.314\ J/molele$

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

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

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

$\Rightarrow V = 347\ m/s$

8.

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

$T = 300$ k.

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

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

$\Rightarrow v \simeq 1017$ m/s

9.

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

$T = 273$ K ; $R = 8.314$ J/mole k

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

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

$\simeq 0.029$ kg/mole

10.

Given $\gamma = 1.4$; $M = 0.044$ kg/mole

$R = 8.314$ J/mol k. ; $V = 400$ m/s

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

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

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

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

$\Rightarrow T = 366$ K.

L Task advanced

(16) Given $Y = 2 \times 10^{11}$ N/m^2

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

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

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

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

(17)

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

$T =$ constant

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

$M_O = 32$

$M_{H_2} = 2$

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

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

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