(4)

Give

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 $\text{time} = \dfrac{\text{distance}}{\text{velocity}}$

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

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

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

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

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

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

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

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

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

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

(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 $V = \sqrt{\frac{\gamma P}{\rho}}$

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

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

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

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

perature

(7)

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

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

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

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

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

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

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

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

(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 $\gamma_N = \frac{7}{5}$

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

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

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

I task

10.

we know that velocity of sound in a gas $V = \sqrt{\frac{\gamma RT}{M}}$

where $\gamma \rightarrow$ Adiabatic constant

$R \rightarrow$ Gas constant, $M \rightarrow$ Molecular weight

clearly velocity of sound does not depends on pressure.

so As Pressure doubled, the velocity of sound in air remains same (ie) 300 m/s

(16) Advanced level

Given $t = 15°c$; Humidity $H = 80\% = 0.8$

$T = 273 + 15$

$= 288 k.$

$V_{dry} = \sqrt{\frac{\gamma RT}{M}}$

For air $\gamma = 1.4$; $M = 29 \times 10^{-3}$ kg/mole

$R = 8.314$

$\therefore V_{dry} = \sqrt{\frac{1.4 \times 8.314 \times 288}{29 \times 10^{-3}}}$

$= 339$ m/s

$\therefore V_{Humid} = V_{dry}[1 + 0.5 \times H] = 339[1 + 0.5 \times 0.8]$

$= 339[1.4]$

$= 474.69$ m/s

(17)

Given speed of sound in air $V_{air} = 343$ m/s.

Time for echo = 5 sec.

$\therefore$ Total distance travelled $= V_{air} \times T$

$= 343 \times 5 = 1715$ m

since the total distance represents a round trip (to the reflector and back). The distance to the reflecting surface is half of the total distance.

Distance to surface $= \frac{1715}{2} = 857.5$ m.

SAQ'

(1)

Variation of velocity with temperature

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

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

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

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

$$V_t = 330 \cdot 60 \text{ m/s}$$

$\therefore$ increase in velocity $V_t - V_0 = 330{\cdot}60 - 330$

$= 0{\cdot}60$ 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 ; $\rho_{gas} = 1{\cdot}4\times10^{-3}$ gm/cm^3

Ratio of specific heats $= \gamma = 1{\cdot}4$. $= 1{\cdot}4$ kg/m3

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

$$\Rightarrow V = \sqrt{\frac{1{\cdot}4\times10}{1{\cdot}4}} = \sqrt{10} \text{ m/s}$$

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 $V \propto \sqrt{T}$

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

$$\Rightarrow \frac{\cancel{332}}{_2\cancel{664}} = \sqrt{\frac{273}{T_2}} \Rightarrow \frac{1}{2} = \sqrt{\frac{273}{T_2}}$$

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

$$\Rightarrow t_2 = 1092 - 273$$

$$= 819°c.$$

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

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

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

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

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

(10)

If $t_1 = 51^\circ c \longrightarrow T_1 = 273 + 51 = 324\ K \rightarrow V_1 = V$

$t_2 = 303^\circ c \rightarrow T_2 = 273 + 303 = 576\ K \rightarrow V_2 = ?$

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

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

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

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

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

Advanced For LTask

(16)

Given $t = 25°$; Humidity $H = 50\% = \frac{1}{2}$

~~T = 273~~ $V_0 = 330\ m/s$

we know $V_t = V_{0}\left[1 + \frac{t}{546}\right]$

$= 330\left[1 + \frac{25}{546}\right]$

$= 345\ m/s$

$V_{Humid} = V_{dry}\left[1 + 0.5H\right]$

$= 345\left[1 + 0.5 \times \frac{1}{2}\right]$

$= 345\left[1 + 0.25\right] = 345 \times 1.25$

$= 431\ m/s$

(17)

Given distance of cliff $d = 500\ m$

speed of sound $= 343\ m/s$

Time taken to hear an echo $= \frac{2d}{v} = \frac{2 \times 500}{343}$

$= 2.915\ sec$