2.

$$\Delta T = T_{final} - T_{initial}$$

$$\Delta T = 35^{\circ}\text{C} - 20^{\circ}\text{C} = 15^{\circ}\text{C}$$

Step 2: Calculate the increase in the speed of sound

Next, use the given rate of increase to determine the total increase in speed.

$$\text{Speed increase} = (\Delta T) \times (0.6\ \frac{\text{m/s}}{^{\circ}\text{C}})$$

$$\text{Speed increase} = (15^{\circ}\text{C}) \times (0.6\ \frac{\text{m/s}}{^{\circ}\text{C}}) = 9\ \text{m/s}$$

Step 3: Calculate the final speed of sound

Finally, add the speed increase to the initial speed of sound at 20°C.

$$v_{35^{\circ}\text{C}} = v_{20^{\circ}\text{C}} + \text{Speed increase}$$

$$v_{35^{\circ}\text{C}} = 343\ \text{m/s} + 9\ \text{m/s} = 352\ \text{m/s}$$

3..

The total distance traveled by the sonar signal is the speed of sound in water multiplied by the time it took for the echo to return.

$$d_{total} = v \times t$$

$$d_{total} = 1480 \text{ m/s} \times 4 \text{ s} = 5920 \text{ m}$$

Step 2: Determine the depth of the water

The total distance calculated is the round trip (down to the bottom and back up). To find the depth of the water, you need to divide the total distance by 2.

$$d_{water} = \frac{d_{total}}{2}$$

$$d_{water} = \frac{5920 \text{ m}}{2} = 2960 \text{ m}$$

4.

The speed of a wave can be calculated by dividing the distance it travels by the time it takes. The formula is:

$$v = \frac{d}{t}$$

where v is speed, d is distance, and t is time.

Step 2: Substitute and calculate

Given that the distance (d) is 200 meters and the time (t) is 0.05 seconds, you can substitute these values into the formula:

$$v = \frac{200 \text{ m}}{0.05 \text{ s}}$$

$$v = 4000 \text{ m/s}$$

5.

Substitute the given and assumed values into the formula:

$$v = \sqrt{\frac{(1.66)\left(8.314\ \frac{\mathrm{J}}{\mathrm{mol{\cdot}K}}\right)(273.15\ \mathrm{K})}{0.004\ \frac{\mathrm{kg}}{\mathrm{mol}}}}$$

$$v = \sqrt{\frac{3769.96\ \frac{\mathrm{J}}{\mathrm{mol}}}{0.004\ \frac{\mathrm{kg}}{\mathrm{mol}}}}$$

$$v = \sqrt{942490\ \frac{\mathrm{m}^2}{\mathrm{s}^2}}$$

$$v \approx 970.82\ \frac{\mathrm{m}}{\mathrm{s}}$$

The speed of sound (v) in an ideal gas is given by the formula:

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

6.

The ratio of the speed of sound in hydrogen (v_{H_2}) to the speed of sound in oxygen (v_{O_2}) is:

$$\frac{v_{H_2}}{v_{O_2}} = \frac{\sqrt{\frac{\gamma_{H_2} RT}{M_{H_2}}}}{\sqrt{\frac{\gamma_{O_2} RT}{M_{O_2}}}}$$

Since γ, R, and T are the same for both gases (assuming they are at the same temperature), they cancel out, simplifying the equation to:

$$\frac{v_{H_2}}{v_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}}$$

Step 4: Substitute the molar masses and calculate the ratio

Using the given molar masses:

- $M_{H_2} = 0.002 \text{ kg/mol}$
- $M_{O_2} = 0.032 \text{ kg/mol}$
  $\frac{v_{H_2}}{v_{O_2}} = \sqrt{\frac{0.032}{0.002}} = \sqrt{16} = 4$

(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

∴ in °c $t = 294.67 - 273 = 21.6$ °c

(8)

Given $B = 1.4 \times 10^{09}$ 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

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Thapt

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

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

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

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

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

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

$= 225\ kg/m^3$

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Advanced

(16)

Given that $B = 220$ kg wt / mm2

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

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

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

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

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

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

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

(17).

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

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

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

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

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

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

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

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L Task

1. Given $t = 20^\circ C$; $v_0 = 331$ 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 $v_t = v_0 \left[1 + \frac{t}{546}\right]$

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

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

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

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

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

$\Rightarrow t = 31^\circ C$.

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(3.)

Given $t = -10^\circ C.$

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

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

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

$V_t \simeq 325.3 \ m/s$

(4)

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

$\rho = 1.2$ kg/m3

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/m3

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(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 $V = \sqrt{\frac{\gamma RT}{M}}$

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

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

$\Rightarrow V = 347 \, m/s$

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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.

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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 $V = \sqrt{\frac{8RT}{M}}$

$T =$ constant

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

$M_O = 32$

$M_{H_2} = 2$

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

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

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

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