Unit 7 · Mechanical Waves

HARDER PRACTICE QUESTIONS

Full marks 29

Write your answers on separate paper. Show your working. Take R = 8.31 J/(mol K).

1 Spot the error [3]

Find the mistake in the working and correct it.

The speed of sound in air at 17 °C is 342 m/s. Srijana finds it at 47 °C:

"$v = 342\sqrt{\frac{47}{17}} = \mathbf{569\ m/s}$."

2 Show that [3]

The root mean square speed of the molecules of a gas is $c_{\text{rms}} = \sqrt{\frac{3RT}{M}}$. Show that the speed of sound in the gas is $\sqrt{\gamma/3}$ times c_{rms}, and find this fraction for air ($\gamma = 1.4$). Why does it make sense that sound is a little slower than the molecules?

3 Predict, then explain [3]

Write your prediction first, then explain it.

At the same temperature, would sound be faster in helium (monatomic, $\gamma = 1.67$, M = 4 g/mol) or in air ($\gamma = 1.4$, M = 29 g/mol)? Predict first, then find how many times faster.

4 Read the data [4]

Answer from the data.

Ujjwal measures the speed of sound in a gas at different temperatures:

T (K)	250	300	350	400
v (m/s)	317	347	375	401

i. Show that v^2 is proportional to T.

ii. Find the slope of the graph of v^2 against T.

iii. If $\gamma = 1.4$, find the molar mass of the gas. What might the gas be?

5 A real setting [3]

At Everest Base Camp the air may be at −10 °C and less than half the pressure of the air in Kathmandu, which is at 20 °C. The speed of sound in air at 0 °C is 331 m/s. Find the speed of sound in each place. Does the low pressure at Base Camp matter?

6 What if? [3]

On a humid day, 4 molecules in every 100 in the air are water (M = 18 g/mol) instead of dry air (M = 29 g/mol). What would the average molar mass be, and by what percentage would the speed of sound change (same temperature and γ)?

7 Check the claim [2]

Kabir claims that sound is 20% faster on a 40 °C summer day than on a 0 °C winter day. Check the claim.

8 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

> Sunita wrote: “A higher note travels faster than a low one, because its frequency is higher. Sound is fastest in gases, because their molecules move fastest. And sound travels faster in denser materials, since steel is denser than air.”

9 Design it [3]

Plan an experiment to test whether the speed of sound in air depends on temperature, using a long plastic pipe, two phones that record sound, and a source of a sharp click. Say what you would measure, how you would change the temperature, and what result would show that $v \propto \sqrt{T}$.

10 Make your own [2]

Choose a tension and a mass per unit length for a string on which waves travel at 200 m/s.