Unit 13 · Ideal Gas

HARDER PRACTICE QUESTIONS

Full marks 28

Write your answers on separate paper. Show your working. R = 8.31 J/(mol K); $k_B = 1.38 \times 10^{-23}$ J/K; T = θ + 273.

1 Spot the error [3]

Find the mistake and correct it.

A balloon holds 2.0 L of air at 20 °C. It is warmed to 40 °C at constant pressure. Bikash writes: "V ∝ T, and the temperature has doubled, so the volume doubles to **4.0 L**."

2 Read the data [4]

Answer from the table.

A fixed mass of gas is kept at constant volume:

Temperature (°C)	0	50	100
Pressure (kPa)	80.0	94.6	109.3

i. Find the pressure coefficient of the gas.
ii. Compare it with 1/273.15. What does this tell you?
iii. At what temperature would the pressure of this gas fall to zero, if it stayed a gas?

3 Show that [3]

Using $PV = \frac{1}{3} Nmc_{rms}^2$ and the fact that the average kinetic energy of a molecule depends only on the temperature, show that equal volumes of two gases at the same temperature and pressure hold equal numbers of molecules (Avogadro's law).

4 Estimate it [3]

The numbers are rounded.

A classroom is 10 m long, 8 m wide and 3 m high. The air is at 1.0×10^5 Pa and 27 °C. Estimate the number of molecules of air in the room.

5 Why the Moon has no air [4]

Use the numbers given.

The escape speed from the Moon is 2.4 km/s.

i. At what temperature would the rms speed of helium atoms (M = 4.0 g/mol) equal it?
ii. The Moon's sunlit surface reaches about 400 K. Helium is far below the escape speed at that temperature on average. Why does the Moon still lose its helium over time?

6 Predict, then explain [3]

Write your prediction first, then explain it.

A closed, rigid tank of gas is loaded on a train that runs at a steady 100 km/h.

i. Predict: does the temperature of the gas rise?
ii. Explain, using what temperature measures.

7 Correct the misconceptions [3]

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

> Sarita wrote: “At 0 °C the molecules of a gas stop moving. At the same temperature, heavier molecules have more kinetic energy than lighter ones. And heating a gas at constant volume from 10 °C to 20 °C doubles its pressure.”

8 Think [3]

Two identical flasks at the same temperature and pressure hold helium (M = 4 g/mol) and nitrogen (M = 28 g/mol). Compare the two gases’ i. numbers of molecules, ii. masses and iii. rms speeds.

9 Make your own [2]

Choose a gas, and find the temperature at which the rms speed of its molecules is exactly 1000 m/s. Show that it works.