Solutions

Each answer shows the steps, then the **result**.

2.1

- a gas that obeys $pV \propto T$ (i.e. $pV = nRT$) exactly, at all p and T

2.2

- $pV = nRT$
- $pV = NkT$

2.3

- $R = 8.31\ \text{J mol}^{-1}\,\text{K}^{-1}$

2.4

- Nk (the number of molecules × the Boltzmann constant)

3.1 B

- T in $pV = nRT$ must be in **kelvin**
- **A** is Celsius; **C** is energy; **D** is amount of substance

3.2

- $p = nRT/V$

$$p = \frac{(0.50\ \text{mol})(8.31\ \text{J mol}^{-1}\,\text{K}^{-1})(300\ \text{K})}{0.020\ \text{m}^3} = \mathbf{6.2 \times 10^4}\ \text{Pa}$$

3.3

(a) it is an **ideal gas**: $pV \propto T$ (the line is straight and passes through the origin)

(b) gradient $= 600\ \text{J}/300\ \text{K} = 2.0\ \text{J K}^{-1}$

- this equals Nk

$$N = \frac{2.0\ \text{J K}^{-1}}{1.38 \times 10^{-23}\ \text{J K}^{-1}} = \mathbf{1.4 \times 10^{23}}$$

3.4

- at constant temperature (and amount of gas), the pressure is **inversely proportional** to the volume (pV = constant)

3.5

(a) T is the **thermodynamic (absolute) temperature**, measured in kelvin

- k is the **Boltzmann constant**

(b) m is the mass of **one molecule**

- $\langle c^2 \rangle$ is the **mean square speed** — the average of the squares of the molecular speeds, not the square of the average

(c) set the two right-hand sides equal: $NkT = \frac{1}{3}Nm\langle c^2 \rangle$

- so $\frac{1}{3}m\langle c^2 \rangle = kT$
- the mean kinetic energy of one molecule is $E_K = \frac{1}{2}m\langle c^2 \rangle$
- which is $\frac{3}{2}$ times the previous line, so $E_K = \frac{3}{2}kT$

(d) $\frac{1}{2}m\langle c^2 \rangle \propto T$, so $\langle c^2 \rangle \propto T$ and $c_{\text{r.m.s.}} \propto \sqrt{T}$

- quadrupling T therefore **doubles** the r.m.s. speed