On the gas laws

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Questions 2–4 and 6–9 are taken from *Thermal Physics* by C.J. Adkins.

Warm-up problems

1. What kind of motion is *Brownian motion* and how does it provide evidence for the existence of atoms?

2. Give an account of the essential features of the kinetic features of the kinetic theory model of an ideal gas.

3. Why do the molecules of a gas not all move at the same speed? Explain how the probabilities of finding molecules with different speeds varies as temperature varies. You may wish to sketch a graph.

Regular problems

4. (a) The density of air at $0\,°\text{C}$ and $10^5\,\text{Pa}$ is $1.29\,\text{kg m}^{-3}$. What is the molar mass?

   (b) Approximately how many molecules are there in one litre of air?

5. Explain the term *root mean square* and give an example of its use in physics.

6. For nitrogen, one mole occupies $2.24 \times 10^{-2}\,\text{m}^3$ at $0\,°\text{C}$ and $10^5\,\text{Pa}$. The relative molar mass is 28. What are

   (a) the mass of one molecule,

   (b) the mass of one mole,

   (c) the number of molecules in $10^3\,\text{mm}^3$ at this temperature and pressure,

   (d) the root mean square speed at this temperature?

7. Show that
$$\text{thermodynamic temperature} \propto \text{molecular kinetic energy}$$

8. Given that $4\,\text{kg}$ of helium at $0\,°\text{C}$ and $10^5\,\text{Pa}$ occupy $22.4\,\text{m}^3$, calculate the root mean square speed of helium atoms at $15\,°\text{C}$.

Extension problems

9. Molecules of oxygen ($M_r = 32$) escape from the surface of the moon where the surface temperature is $50\,°\mathrm{C}$. [Radius of moon $= 1738\,\mathrm{km}$. Acceleration of free fall at moon's surface $= 1.62\,\mathrm{m\,s^{-1}}$]

   (a) What is their surface temperature?

   (b) What is their mean kinetic energy?

   (c) What is their potential energy at the moon's surface?

   (d) Will their speed be sufficient for them to escape from the gravitational attraction of the moon?

   (e) Why does the moon have no atmosphere?