AQA Examination-style questions

1 The escape velocity v_{esc} of an object from a planet or moon is the minimum velocity the object must have to escape from the planet. For a planet or moon of radius R, it can be shown that $v_{esc} = (2gR)^{\frac{1}{2}}$, where g is the gravitational field strength at the surface of the planet or moon.

(a) The radius of the Earth's moon is 1740 km and its surface gravitational field strength is $1.62\,N\,kg^{-1}$. Calculate the escape velocity from the Earth's moon. *(2 marks)*

(b) The average temperature of the lunar surface during the lunar day is about 400 K.

(i) Calculate the mean kinetic energy of a molecule of an ideal gas at 400 K.

(ii) Show that the root mean square speed of a molecule of oxygen gas at this temperature is $560\,m\,s^{-1}$.

(iii) Explain why gas molecules released on the lunar surface escape into space. *(8 marks)*

(c) Astronomers have discovered the existence of water vapour in a giant gas planet orbiting a star 64 light years from Earth. The astronomers observed the spectrum of infrared light from the star and discovered absorption lines due to water vapour which are present only when the planet passes across the face of the star.

(i) Why did astronomers conclude that the absorption lines were due to the planet rather than the star?

(ii) Give **one** reason why it might not have been possible to detect such absorption lines if the planet's surface had been at the same temperature but the planet had been much smaller in diameter and in mass. *(6 marks)*

2 (a) (i) Sketch a graph of pressure against volume for a fixed mass of ideal gas at constant temperature. Label this graph O.

On the *same axes* sketch **two** additional curves A and B, if the following changes are made:

(ii) The same mass of gas at a lower constant temperature (label this A).

(iii) A greater mass of gas at the original constant temperature (label this B). *(3 marks)*

(b) A cylinder of volume $0.20\,m^3$ contains an ideal gas at a pressure of 130 kPa and a temperature of 290 K. Calculate:

(i) the amount of gas, in moles, in the cylinder,

(ii) the total kinetic energy of a molecule of gas in the cylinder,

(iii) the total kinetic energy of the molecules in the cylinder. *(5 marks)*

AQA, 2005

3 (a) State the equation of state for an ideal gas. *(1 mark)*

(b) A fixed mass of an ideal gas is heated while its volume is kept constant. Sketch a graph to show how the pressure, p, of the gas varies with the absolute temperature, T, of the gas. *(2 marks)*

(c) Explain in terms of molecular motion, why the pressure of the gas in part (b) varies with the absolute temperature. *(4 marks)*

(d) Calculate the average kinetic energy of the gas molecules at a temperature of 300 K. *(2 marks)*

AQA, 2004

4 (a) The molecular theory model of an ideal gas leads to the derivation of the equation

$$pV = \frac{1}{3}Nmc_{rms}^2$$

Explain what each symbol in the equation represents. *(4 marks)*

(b) One assumption used in the derivation of the equation stated in part (a) is that molecules are in a state of random motion.

(i) Explain what is meant by random motion.

(ii) State **two** more assumptions used in this derivation. *(4 marks)*

(c) Describe how the motion of gas molecules can be used to explain the pressure exerted by a gas on the walls of its container. *(4 marks)*

AQA, 2002

5 The number of molecules in one cubic metre of air decreases as altitude increases. The table shows how the pressure and temperature of air compare at sea-level and at an altitude of 10 000 m.

altitude	pressure/Pa	temperature/K
sea-level	1.0×10^5	300
10 000 m	2.2×10^4	270

(a) Calculate the number of moles of air in a cubic metre of air at:

(i) sea-level,

(ii) 10 000 m. *(3 marks)*

(b) In air, 23% of the molecules are oxygen molecules. Calculate the number of extra oxygen molecules there are per cubic metre at sea-level compared with a cubic metre of air at an altitude of 10 000 m. *(2 marks)*

AQA, 2006

6 (a) **Figure 1** shows a helium atom of mass 6.8×10^{-27} kg about to strike the wall of a container. It rebounds with the same speed.

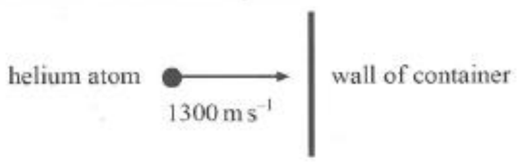

Figure 1

(i) Calculate the momentum change of the helium atom.

(ii) Calculate the number of collisions per second on each cm^2 of the container wall that will produce a pressure of 1.5×10^5 Pa. *(5 marks)*

(b) The molar mass of gaseous nitrogen is 0.028 kg mol^{-1}. The average kinetic energy for nitrogen molecules in a sample is 8.6×10^{-21} J.

(i) Calculate the temperature of the sample.

(ii) Calculate the mean square speed of the nitrogen molecules. *(5 marks)*

AQA, 2006 and 2007

7 The graph in **Figure 2** shows the best fit line for the results of an experiment in which the volume of a fixed mass of gas was measured over a temperature range from 20 °C to 100 °C. The pressure of the gas remained constant throughout the experiment.

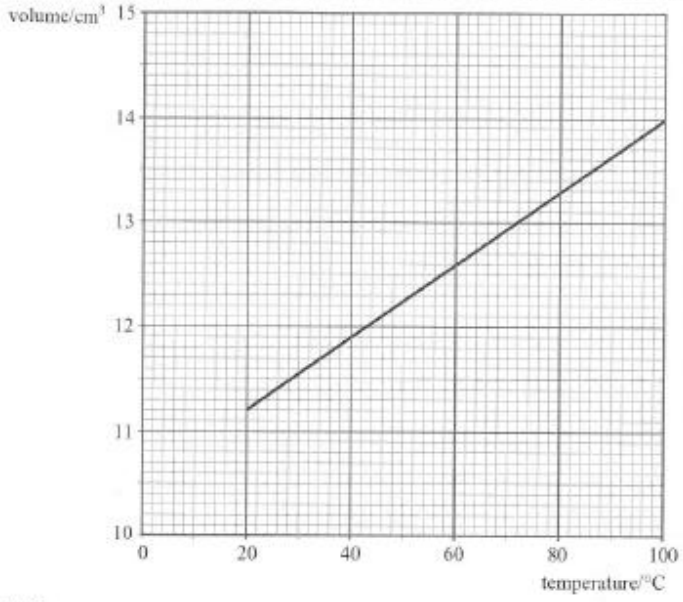

Figure 2

(a) Use the graph in **Figure 2** to calculate a value for the absolute zero of temperature in °C. Show clearly your method of working. *(4 marks)*

(b) Use data from the graph to calculate the mass of gas used in the experiment. You may assume that the gas behaved like an ideal gas throughout the experiment.
gas pressure throughout the experiment = 1.0×10^5 Pa
molar mass of the gas used = $0.044\,kg\,mol^{-1}$ *(5 marks)*

(c) Use the kinetic theory of gases to explain why the pressure of an ideal gas decreases
(i) when it is expanded at constant temperature,
(ii) when its temperature is lowered at constant volume. *(5 marks)*

AQA, 2005 and 2006

8 (a) A cylinder of fixed volume contains 15 mol of an ideal gas at a pressure of 500 kPa and a temperature of 290 K.
(i) Show that the volume of the cylinder is $7.2 \times 10^{-2}\,m^3$.
(ii) Calculate the average kinetic energy of a gas molecule in the cylinder. *(4 marks)*

(b) A quantity of gas is removed from the cylinder and the pressure of the remaining gas falls to 420 kPa. If the temperature of the gas is unchanged, calculate the amount, in mol, of gas remaining in the cylinder. *(2 marks)*

(c) Explain in terms of the kinetic theory why the pressure of the gas in the cylinder falls when gas is removed from the cylinder. *(4 marks)*

AQA, 2003