



QUESTION WORKBOOK

Ideal gases and the gas laws

Thermal physics · Year 13

AQA 3.6.2.2 · CIE 14.2.1, 14.2.2, 14.2.3, 14.2.4, 15.1.2, 15.2.1, 15.2.2, 15.2.3
OCR A 5.1.1(b), 5.1.1(c), 5.1.1(d), 5.1.2(e), 5.1.4(a), 5.1.4(d)(i), 5.1.4(g)

20 questions · 61 marks

PRINT EDITION

SECTION A · Warm-up

A1 State Boyle's law for a fixed mass of gas. [2]

A2 A sealed container of volume 0.050 m^3 holds 2.0 mol of an ideal gas at 300 K . Calculate the pressure of the gas ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$). [2]

A3 Explain how extrapolating a graph of pressure against temperature leads to the idea of absolute zero. [2]

A4 A thermometer carried by a weather balloon reads -63°C at high altitude. State this temperature in kelvin. [1]

A5 A rigid sealed flask contains air at a pressure of $1.01 \times 10^5 \text{ Pa}$ and a temperature of 20°C . The flask is placed in a water bath at 77°C . Calculate the new pressure of the air. [2]

A6 The gas laws are described as empirical. State what this means. [1]

SECTION B · Standard

B1 A piston slowly compresses the air in a cylinder from 0.020 m^3 to 0.005 m^3 at constant temperature. The initial pressure is $1.0 \times 10^5 \text{ Pa}$. Calculate the final pressure. [3]

B2 Calculate the volume occupied by 0.50 mol of an ideal gas at a pressure of $2.0 \times 10^5 \text{ Pa}$ and a temperature of 300 K , and state why the temperature must be converted to kelvin in this calculation. [4]

B3 A container of volume 0.010 m^3 holds 3.0×10^{23} gas molecules at 290 K . Calculate the pressure using $pV = NkT$ ($k = 1.38 \times 10^{-23} \text{ J K}^{-1}$). [3]

- B4** A gas of volume 0.010 m^3 at 300 K is heated at constant pressure to 400 K . Calculate its new volume. [3]

- B5** A weather balloon is filled with 12.0 m^3 of helium at ground level, where the pressure is 101 kPa and the temperature is 288 K . It rises to an altitude where the pressure is 22.0 kPa and the temperature is 218 K . Calculate the volume of the balloon at this altitude. [3]

- B6** A cylinder of volume 0.050 m^3 contains 0.72 kg of oxygen at 290 K . The molar mass of oxygen is $0.032 \text{ kg mol}^{-1}$ ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$). Calculate the pressure in the cylinder. [3]

- B7** A student investigating Boyle's law traps a fixed mass of air at constant temperature and records the volume V at four pressures p . p/kPa : 100, 125, 160, 200. V/cm^3 : 40.0, 32.1, 25.0, 20.1. Deduce whether the results are consistent with Boyle's law. [3]

SECTION C · Stretch

- C1** A gas expands from 0.010 m^3 to 0.015 m^3 at a constant pressure of $2.0 \times 10^5 \text{ Pa}$. Calculate the work done by the gas, and state where this energy comes from if the temperature of the gas stays constant. [4]

- C2** A gas occupies 0.024 m^3 at a pressure of $1.0 \times 10^5 \text{ Pa}$ and a temperature of 300 K . Calculate the number of molecules present and the corresponding amount of gas in moles ($N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$). [4]

C3 State the conditions under which a real gas behaves most like an ideal gas.

[3]

C4 A party company must fill 250 balloons with helium. Each filled balloon holds 0.012 m^3 at a pressure of $1.05 \times 10^5 \text{ Pa}$ and a temperature of 293 K . The supplier offers a cylinder of internal volume 0.040 m^3 containing helium at $1.5 \times 10^7 \text{ Pa}$, also at 293 K . Helium stops flowing out of the cylinder once its pressure falls to the balloon pressure ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$). Deduce whether one cylinder is enough to fill all the balloons.

[5]

C5 A rigid vessel of volume 0.080 m^3 holds nitrogen at a pressure of $1.4 \times 10^5 \text{ Pa}$ and a temperature of 300 K . The molar mass of nitrogen is $0.028 \text{ kg mol}^{-1}$ ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$, $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$). Calculate the density of the nitrogen and the mass of one nitrogen molecule.

[4]

- C6** Estimate the number of air molecules in a school laboratory at a pressure of 1.0×10^5 Pa and a temperature of 300 K ($k = 1.38 \times 10^{-23}$ J K⁻¹). State the estimate you make for the volume of the room. [3]

- C7** A student has a rigid flask of air fitted with a pressure sensor, a large water bath, a heater, a thermometer and ice. Describe how the student can use this apparatus to determine a value for absolute zero in °C. Include the measurements taken, the graph to be drawn and how the graph gives the result. [6]