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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

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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 ($R = 8.31\ J\ mol^{-1}\ K^{-1}$). [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 1.01×10^5 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]

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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 1.0×10^5 Pa. Calculate the final pressure. [3]

B2 Calculate the volume occupied by 0.50 mol of an ideal gas at a pressure of 2.0×10^5 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 $pV = NkT$ ($k = 1.38 \times 10^{-23}$ J K^{-1}). [3]

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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 kg mol^{-1} (R = 8.31 J mol^{-1} K^{-1}). Calculate the pressure in the cylinder. [3]

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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 × 10^5 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 × 10^5 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 × 10^{23} mol^{-1}). [4]

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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 1.05×10^5 Pa and a temperature of 293 K. The supplier offers a cylinder of internal volume 0.040 m^3 containing helium at 1.5×10^7 Pa, also at 293 K. Helium stops flowing out of the cylinder once its pressure falls to the balloon pressure ($R = 8.31$ J mol^{-1} 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 1.4×10^5 Pa and a temperature of 300 K. The molar mass of nitrogen is 0.028 kg mol^{-1} ($R = 8.31$ J mol^{-1} K^{-1}, $N_A = 6.02 \times 10^{23}$ mol^{-1}). Calculate the density of the nitrogen and the mass of one nitrogen molecule. [4]

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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]

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