InkChemistry

ANSWER BOOK

# Gases and the ideal gas equation

Amount of substance · Unit C02

AQA 3.1.2.3 · OCR A 2.1.3 (f); PAG 1

16 questions · 48 marks

NAVY EDITION

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## SECTION A · Short, 1 to 2 marks

**A1** GI-Q1

**B1** $pV = nRT$, where R is 8.31 J $K^{-1}$ $mol^{-1}$. **B1** p in pascals, V in cubic metres, n in moles and T in kelvin. [2]

**A2** GI-Q8

**B1** in a gas the molecules are far apart, so their own volume is a tiny fraction of the volume of the gas. **B1** the volume therefore depends on the number of molecules, the temperature and the pressure, not on the size or mass of the molecules. [2]

**A3** GI-Q11

**B1** ethanoic acid molecules form hydrogen bonds in pairs, so many exist as dimers in the vapour. **B1** there are fewer particles than expected, so the calculated amount is smaller and the Mr is larger, up to twice 60. [2]

## SECTION B · Standard, 3 to 5 marks

**B1** GI-Q2

**B1** 350 $cm^3$ = 350 × $10^{-6}$ $m^3$ = 3.50 × $10^{-4}$ $m^3$. **B1** 2.50 $dm^3$ = 2.50 × $10^{-3}$ $m^3$. **B1** -23 °C = -23 + 273 = 250 K. [3]

**B2** GI-Q3

**M1** conversions: V = 1.20 × $10^{-3}$ $m^3$, p = 1.01 × $10^5$ Pa, T = 293 K. **M1** n = pV ÷ RT = (1.01 × $10^5$ × 1.20 × $10^{-3}$) ÷ (8.31 × 293). **A1** n = 0.0498 mol, to three significant figures. [3]

**B3** GI-Q4

**M1** V = 10.0 × $10^{-3}$ = 1.00 × $10^{-2}$ $m^3$. **M1** p = nRT ÷ V = 0.500 × 8.31 × 300 ÷ (1.00 × $10^{-2}$) = 1.25 × $10^5$ Pa. **A1** p = 125 kPa, to three significant figures. [3]

**B4** GI-Q5

**M1** n($CaCO_3$) = 2.50 ÷ 100.1 = 0.02498 mol. **M1** one mole of $CaCO_3$ gives one mole of $CO_2$, so V = 0.02498 × 24.0. **A1** V = 0.599 $dm^3$, to three significant figures. [3]

**B5** GI-Q7

**M1** V = 3.00 × $10^{-3}$ $m^3$ and p = 1.00 × $10^5$ Pa. **M1** T = pV ÷ nR = (1.00 × $10^5$ × 3.00 × $10^{-3}$) ÷ (0.100 × 8.31). **A1** T = 361 K, to three significant figures. [3]

**B6** GI-Q9

**B1** the volume of a gas is proportional to its temperature measured from absolute zero. **B1** absolute zero is -273 °C, so the line meets the temperature axis at -273 °C, not at 0 °C; allow -273.15 °C. **B1** the Kelvin scale starts at absolute zero, so only a kelvin temperature is proportional to pV; a Celsius value would give a wrong n, p or V. [3]

**B7** GI-Q10

**B1** all of the injected liquid must vaporise, or the volume measured would be for only part of the mass. **B1** close to its boiling point a vapour is not ideal, because intermolecular forces pull the molecules together. **B1** the volume would then be smaller than pV = nRT predicts, and the calculated Mr would be too high. [3]

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**B8** GI-Q12

**B1** the volume injected is a few tenths of a cubic centimetre, too small to read precisely from the syringe scale. **B1** turning a volume into a mass needs the density, which may be unknown and changes with temperature. **B1** weighing by difference gives the mass that left the syringe, and liquid left in the needle is not counted. [3]

**B9** GI-Q13

**B1** both give the amount of gas from its volume, and both assume the gas behaves ideally. **B1** 24.0 $dm^3\ mol^{-1}$ applies only at room temperature and pressure, whereas $pV = nRT$ works at any temperature and pressure. **B1** $pV = nRT$ needs every quantity in SI units, whereas the molar volume is used with the volume in $dm^3$. [3]

**B10** GI-Q14

**B1** the percentage difference is $(86.0 - 81.7) \div 86.0 \times 100 = 5.0\%$, so the claim of 1% is not supported. **B1** a gas syringe read to the nearest 1 $cm^3$ on about 50 $cm^3$ alone carries an uncertainty of about 2%, so 1% is not achievable with this apparatus. **B1** a low Mr means the amount was overestimated, which points to a systematic error such as a volume reading that is too large, for example from air in the syringe expanding. [3]

**B11** GI-Q16

**M1** at the same temperature and pressure, gas volumes react in the ratio of the coefficients, 1 : 5 : 3. **A1** volume of oxygen = $5 \times 0.500 = 2.50\ dm^3$, to three significant figures. **A1** volume of carbon dioxide = $3 \times 0.500 = 1.50\ dm^3$, to three significant figures. [3]

**B12** GI-Q19

**B1** an ideal gas has no forces between its molecules and molecules of negligible volume. **B1** ammonia molecules are polar and form hydrogen bonds with each other, so the attractions between them are much stronger than the weak induced dipole–dipole forces between helium atoms. **B1** ammonia molecules are also larger than helium atoms, so their own volume is a bigger share of the gas volume. [3]

## SECTION C · Long, 6 marks or more

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**C1** GI-Q15 **Indicative content** [6]

**B1** hold a gas syringe in a heated jacket at a steady temperature well above the boiling point of the liquid, and record its starting reading. **B1** fill a hypodermic syringe with the liquid and weigh it on a balance reading to three decimal places before injecting. **B1** inject a few tenths of a cubic centimetre through the self-sealing cap, then reweigh the hypodermic syringe so the mass injected is found by difference. **B1** record the gas syringe reading once it is steady, the jacket temperature in kelvin and the atmospheric pressure in pascals. **B1** convert the increase in volume to cubic metres, use n = pV ÷ RT to find the amount of vapour, and divide the mass injected by that amount to give Mr. **B1** running well above the boiling point keeps the vapour close to ideal, and weighing rather than reading a volume of liquid avoids needing its density.

**Levels**

**Level 3 (5–6 marks)** the heated gas syringe, weighing the hypodermic syringe before and after injecting, recording volume, temperature in kelvin and pressure in pascals, the use of pV = nRT and the division of mass by amount are all present, and the answer explains why running well above the boiling point and weighing rather than measuring volume keep the result accurate.

**Level 2 (3–4 marks)** the gas syringe method and pV = nRT are right; the mass is not found by weighing by difference, a unit is left unconverted, or nothing is said about what keeps the result accurate.

**Level 1 (1–2 marks)** the liquid is vaporised in a gas syringe or pV = nRT is quoted, usually with the volume left in $cm^3$ or the temperature in °C.

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