

Moles, formulae, gas volumes and atom economy

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab answers

The model answers use $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ and the partial pressure of butane after subtracting the water vapour pressure. Rounding differences in the last figure are acceptable.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.1.2

Question 1 Pressure of the butane

$$p = 101.3 - 2.5 = 98.8 \text{ kPa} = \mathbf{9.88 \times 10^4 \text{ Pa}}.$$

Question 2 Amount of butane in trial 2

$$V = 100 \text{ cm}^3 = 1.00 \times 10^{-4} \text{ m}^3. n = pV \div RT = (9.88 \times 10^4 \times 1.00 \times 10^{-4}) \div (8.31 \times 294) = 9.88 \div 2443 = \mathbf{4.04 \times 10^{-3} \text{ mol}}.$$

Question 3 Molar mass from trial 2

$$M = 0.24 \div 0.00404 = \mathbf{59.3 \text{ g mol}^{-1}}.$$

Question 4 Mean molar mass

$$\text{Trial 1: } n = 3.24 \times 10^{-3} \text{ mol, } M = 58.7. \text{ Trial 3: } n = 4.85 \times 10^{-3} \text{ mol, } M = 57.7. \text{ Mean} = (58.7 + 59.3 + 57.7) \div 3 = \mathbf{58.6 \text{ g mol}^{-1}}.$$

Question 5 Accuracy

$$\text{True } M = 4 \times 12.0 + 10 \times 1.0 = 58.0 \text{ g mol}^{-1}. \text{ Difference} = (58.6 - 58.0) \div 58.0 \times 100 = \mathbf{1.0 \%}.$$

Question 6 Uncertainty in the mass loss

$$\text{Two readings, each } \pm 0.01 \text{ g, give } \pm 0.02 \text{ g on the loss. Percentage uncertainty} = 0.02 \div 0.24 \times 100 = \mathbf{8.3 \%}.$$

Question 7 Systematic error

Some butane dissolves, so the measured volume of gas is too small. The amount n is too small, and $M = m \div n$ is too large. The calculated molar mass is **too high**.

Question 8 Improvement

Collect a larger volume and mass (for example 250 cm³ with a bigger mass loss) so that the fixed ± 0.02 g uncertainty becomes a smaller percentage, or use a balance reading to 0.001 g.