



ANSWER BOOK

Uncertainty and error

Measurements · Year 12

AQA 3.1.2 · CIE 1.3 · OCR A 2.2.1

10 questions · 30 marks

NAVY EDITION

SECTION A · Warm-up

- A1** Random errors scatter readings unpredictably above and below the true value (reduced by repeating and averaging). Systematic errors shift all readings the same way (for example a zero error), and are not reduced by repeating. [2]
- A2** Percentage uncertainty = $(0.05/2.50) \times 100 = 2.0\%$. [2]
- A3** Precision is how close repeated readings are to each other (small scatter). Accuracy is how close readings are to the true value. Measurements can be precise but inaccurate if a systematic error is present. [3]

SECTION B · Standard

- B1** When adding, absolute uncertainties add: total = 8.0 ± 0.3 m. [3]
- B2** Percentage uncertainties: length 2%, width 2%. For a product they add: area uncertainty = 4%. Area = $10.0 \times 5.0 = 50 \text{ cm}^2$, so uncertainty = 4% of 50 = $\pm 2 \text{ cm}^2$. [4]
- B3** Percentage uncertainty = $(0.5/45) \times 100 = 1.1\%$. [3]
- B4** Mean = $(20.1 + 20.3 + 20.2 + 20.4)/4 = 20.25 \text{ mm}$. Uncertainty $\approx \text{range}/2 = (20.4 - 20.1)/2 = \pm 0.15 \text{ mm}$. [2]

SECTION C · Stretch

- C1** Percentage uncertainty in $r = (0.1/4.0) \times 100 = 2.5\%$. Since area $\propto r^2$, its percentage uncertainty = $2 \times 2.5\% = 5\%$. Area = $\pi \times 4.0^2 = 50.3 \text{ cm}^2$, so uncertainty = $\pm 2.5 \text{ cm}^2$. [4]
- C2** Percentage uncertainties: mass 1%, volume 5%. For a quotient they add: 6%. $\rho = 0.500/(2.0 \times 10^{-4}) = 2500 \text{ kg m}^{-3}$, so uncertainty = 6% = $\pm 150 \text{ kg m}^{-3}$. [4]
- C3** (a) Reduce random error by repeating readings and taking a mean, and by using instruments of finer resolution. (b) Reduce systematic error by checking for and correcting zero errors, calibrating the instrument, and improving the technique. [3]