

AQA AS Uncertainties, Error Bars and Estimation worksheet

35-40 minutes independent practice + 15-20 minutes review | 36 marks

Specification points covered

- 3.1.2(c) Use absolute, fractional and percentage uncertainties to represent uncertainty in a final answer.
- 3.1.2(d) Combine uncertainties for quantities found by addition, subtraction, multiplication, division or powers.
- 3.1.2(e) Represent uncertainty in a graph data point using error bars.
- 3.1.2(f) Determine uncertainty in the gradient and intercept of a straight-line graph using best and worst acceptable lines.
- 3.1.2(g) Link the significant figures in a measured value to its associated uncertainty.
- 3.1.3(a-b) Make order-of-magnitude estimates and use physics knowledge to make derived estimates.

Mars sample and habitat validation

A team is checking a meteorite fragment, solar-panel data and life-support estimates before committing hardware to a Mars habitat.

State the uncertainty rule used at every stage and report final values at a precision justified by the uncertainty.

1. Reporting uncertainty

1. A length is recorded as (12.4 ± 0.2) cm. State its absolute uncertainty and calculate its fractional and percentage uncertainties. [3 marks]

2. A voltmeter result is initially written as (8.347 ± 0.19) V. Rewrite the result using suitable decimal places and explain your choice. [2 marks]

3. A meteorite fragment displaces water from (54.0 ± 0.5) cm³ to (71.0 ± 0.5) cm³. Calculate its volume and absolute uncertainty. [2 marks]

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2. Combining uncertainties

4. The fragment in Question 3 has mass (146.2 ± 0.1) g. Calculate its density, the percentage uncertainty in the density and a suitable absolute uncertainty for the density. [4 marks]

5. A spherical sensor has diameter (24.0 ± 0.2) mm. Its volume is proportional to d^3 . Calculate the percentage uncertainty in its volume. [2 marks]

6. A thermal store receives (142 ± 4) J and delivers (85 ± 3) J. Calculate the energy lost and its absolute uncertainty. [2 marks]

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3. Products, quotients and error bars

7. A component has potential difference (5.00 ± 0.05) V and current (0.240 ± 0.006) A. Calculate its resistance and the percentage and absolute uncertainties in the resistance. [3 marks]

8. A graph point has coordinates $x = 4.0 \pm 0.2$ and $y = 12.0 \pm 0.8$. State the two endpoints of its horizontal error bar and the two endpoints of its vertical error bar. [2 marks]

9. For a solar-panel graph, the maximum acceptable line passes through (1.0, 2.0) and (6.0, 17.5). The minimum acceptable line passes through (1.0, 3.0) and (6.0, 16.0). Calculate $G_{\max}$, $G_{\min}$, the best estimate of the gradient, its absolute uncertainty and its percentage uncertainty. [5 marks]

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4. Gradient, intercept and presentation

10. The acceptable intercepts from the graph are -0.6 and $+0.2$. Calculate the best estimate of the intercept and its absolute uncertainty. [2 marks]

11. A measured distance is reported as (2.483 ± 0.071) m. Give a more appropriate presentation of the value and uncertainty, and state the rule you used. [2 marks]

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5. Estimation in an unfamiliar context

12. A Mars habitat contains 75 m^3 of air of density 1.2 kg m^{-3} . Take the mean mass of one air molecule as $4.8 \times 10^{-26} \text{ kg}$. Estimate the order of magnitude of the number of molecules in the habitat. [3 marks]

13. A 12 m^2 solar array receives an average intensity of 600 W m^{-2} for 7.0 h and is 20% efficient. Estimate the electrical energy produced and give its nearest order of magnitude. Assess a claim that it produces $5 \times 10^9 \text{ J}$ each day. [4 marks]

Review and improve

- ☐ I select the correct uncertainty rule for each mathematical operation.
- ☐ I can use limiting gradients and intercepts to state a result with uncertainty.
- ☐ I can build and test an order-of-magnitude estimate from physical assumptions.

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