

Including Uncertainties in Measurements and Calculations

Absolute uncertainty (i.e., uncertainty in measurements)

i) Analogue scales: +/- half the smallest division.

Example:
A 43.8 mL reading from a 100 mL graduated cylinder (with 1 mL divisions) should be reported as,

$$43.8 \pm 0.5 \text{ mL}$$



ii) Digital scales: +/- the smallest scale division.

Example:
A 25.35 g reading from a digital balance should be reported as,

$$25.35 \pm 0.01 \text{ g}$$



Uncertainty in calculations

i) Addition or Subtraction: The uncertainty is the sum of the absolute uncertainties.

Example:

$$(2.25 \pm 0.01\text{m}) + (5.00 \pm 0.01\text{m}) = \boxed{7.25 \pm 0.02\text{m}}$$

ii) Multiplication or Division: the uncertainty is the sum of the ratios of absolute uncertainties.

That is, if $a \times b = d$
then the uncertainty in d (or Δd) is: $\Delta d = d \left[\frac{\Delta a}{a} + \frac{\Delta b}{b} \right]$

Example:

Dimensions	Uncertainty
mass = 22.10 g	$\pm 0.01\text{g}$
volume = 50.0 mL	$\pm 0.5\text{mL}$

Calculation: $\frac{22.10 \text{ g}}{50.0\text{mL}} = 0.442 \text{ g/mL}$

Uncertainty: $0.442[(0.01/22.10) + (0.5/50.0)] = 0.00462$

Report answer as: $\boxed{0.442 \pm 0.005 \text{ g/mL}}$

Data tables should be well-formatted, allowing information to be easily read and understood.

Bad:

Poorly formatted, difficult to follow, and gives repetitive information.

Beaker (mL)	100	150	250	400
Starting Mass of acetone (+/- 0.01 g)	7.68	7.50	7.67	7.60
1 minute (+/- 0.1 minutes)	7.66	7.48	7.66	7.59
2 minutes (+/- 0.1 minutes)	7.65	7.47	7.64	7.55
3 minutes (+/- 0.1 minutes)	7.63	7.46	7.62	7.54
4 minutes (+/- 0.1 minutes)	7.62	7.44	7.60	7.52

Revised:

Time (+/- 0.1 min)	Beaker (mL)			
	100	150	250	400
	Acetone (+/- 0.01g)			
0	7.68	7.50	7.67	7.60
1.0	7.66	7.48	7.66	7.59
2.0	7.65	7.47	7.64	7.55
3.0	7.63	7.46	7.62	7.54
4.0	7.62	7.44	7.60	7.52