ANSWERS TO CALCULATING THE UNCERTAINTY OF A DERIVED UNIT

1. Initial calculation: Rate = $\frac{14.52\ \text{g}}{38.6\ \text{s}}$ = 0.376 g/s

   percentage uncertainty in mass = $\frac{0.01}{14.52}$ x 100 % = 0.069 %

   percentage uncertainty in time = $\frac{0.5}{38.6}$ x 100 % = 1.30 %

   total percentage uncertainty = 0.069 % + 1.30 % = 1.37 %, which rounds to 1 %

   Therefore: **Rate = 0.376 g/s ± 1%**

2. Initial calculation: distance = 58.6 km/s x 18.6 s = 1.09 x 10^3 km

   percentage uncertainty in velocity = $\frac{0.9}{58.6}$ x 100 % = 1.54 %

   percentage uncertainty in time = $\frac{0.2}{18.6}$ x 100 % = 1.08 %

   total percentage uncertainty = 1.54 % + 1.08 % = 2.62 %, which rounds to 3 %

   Absolute uncertainty = $\frac{3}{100}$ x 1.09 x 10^3 km = 0.033 x 10^3 km

   Therefore: **Distance = 1.09 x 10^3 ± 0.03 x 10^3 km**

3. Initial calculation: Rate = $\frac{32.6\ \text{L}}{435\ \text{km}}$ = 0.0749 L/km

   percentage uncertainty in volume = $\frac{0.4}{32.6}$ x 100 % = 1.23 %

   percentage uncertainty in distance = $\frac{1}{435}$ x 100 % = 0.23 %

   total percentage uncertainty = 1.23 % + 0.23 % = 1.46 %, which rounds to 1 %

   Absolute uncertainty = $\frac{1}{100}$ x 0.0749 = 0.0007

   Therefore: **Rate = 0.0749 ± 0.0007 L/km**

4. Initial calculation: mass of track = $\frac{64.5\ \text{kg}}{1\ \text{m}}$ x 15.0 x 10^{-2} m = 9.68 kg

   percentage uncertainty in mass to length ratio = $\frac{0.5}{64.5}$ x 100 % = 0.78 %

   percentage uncertainty in length = $\frac{0.2}{15.0}$ x 100 % = 1.33 %

   total percentage uncertainty = 0.78 % + 1.33 % = 2.11 %, which rounds to 2 %.

   Absolute uncertainty = $\frac{2}{100}$ x 9.68 = 0.2

   Since the calculated value for the mass has an absolute uncertainty of 0.2, it makes no sense to claim the calculated mass is meaningful in the second decimal place, so:

   mass of track = 9.7 ± 0.2 kg

5. Initial calculation: concentration = $\frac{15\ \text{g}}{0.500\ \text{L}} = 3.0 \times 10^{1}$ g/L

   percentage uncertainty in mass = $\frac{1}{15} \times 100\ \% = 6.67\ \%$

   percentage uncertainty in volume = $\frac{5}{500} \times 100\ \% = 1.00\ \%$

   total percentage uncertainty = 6.67 % + 1.00 % = 7.67 %, which rounds to 8 %

   Absolute uncertainty = $\frac{8}{100} \times 3.0 \times 10^{1} = 0.2 \times 10^{1}$

   Therefore: **concentration = $3.0 \pm 0.2 \times 10^{1}$ g/L**

6. First: calculations for 100 cm length of ribbon

   Initial calculation of mass/length ratio = $\frac{3.84\ \text{g}}{100.0\ \text{cm}} = 0.0384$ g/cm

   percentage uncertainty of mass = $\frac{0.01}{3.84} \times 100\ \% = 0.26\ \%$

   percentage uncertainty of length = $\frac{0.1}{100.0} \times 100\ \% = 0.10\ \%$

   total percentage uncertainty = 0.26 % + 0.10 % = 0.36 %, which rounds to 0.4 %

   Absolute uncertainty = $\frac{0.4}{100} \times 0.0384 = 0.0002$

   So: mass/length ratio for 100 piece = 0.0384 ± 0.0002 g/cm

   Next: calculations for short piece of ribbon

   Initial calculation: mass = 0.0384 g/cm x 2.50 cm = 0.096 g

   percentage uncertainty of length = $\frac{0.02}{2.50} \times 100\ \% = 0.80\ \%$

   percentage uncertainty in mass/length ratio = 0.36 % (from first set of calculations, above)

   total percentage uncertainty = 0.80 % + 0.36 % = 1.16 %, which rounds to 1%

   absolute uncertainty = $\frac{1}{100} \times 0.096 = 0.00096$, which rounds to 0.001

   so: **mass = 0.096 ± 0.001 g**