CHAPTER 1 : MEASUREMENTS

1.1 The scientific method

1.2 Units of measurement

1.3 Uncertainty in measurement –precision and accuracy

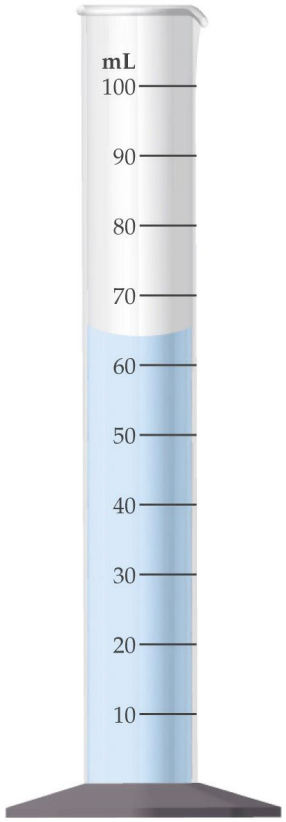
1.4 Significant figures and calculations

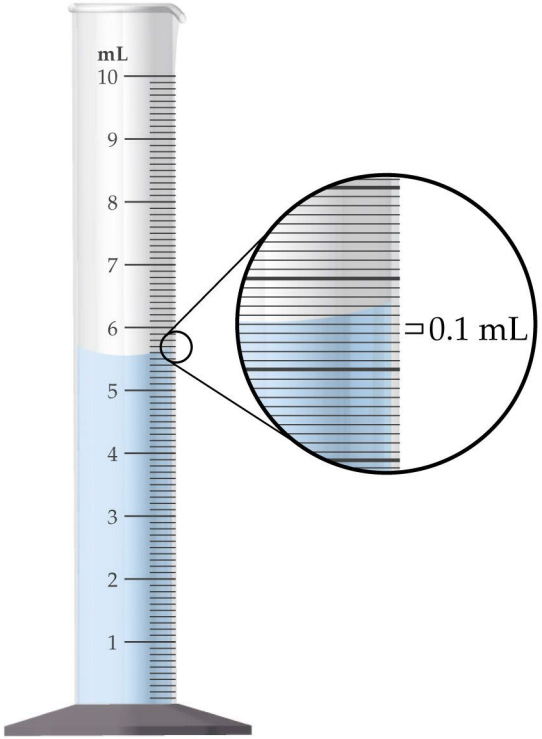
1.5 Dimensional analysis

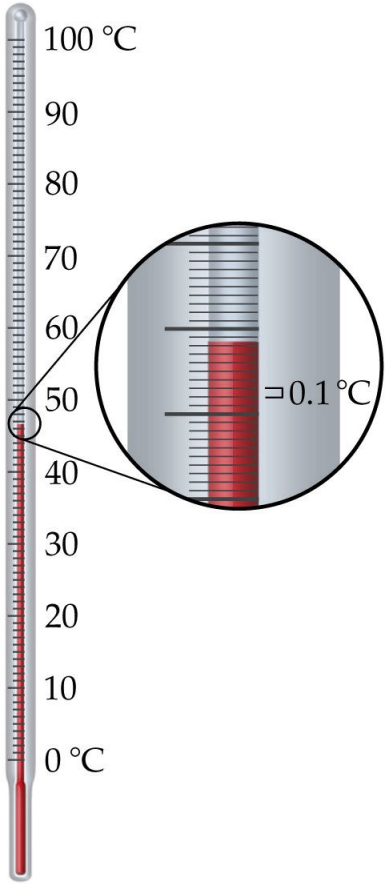
1.4
SIGNIFICANT FIGURES AND CALCULATIONS

1.4
Significant figures and calculations

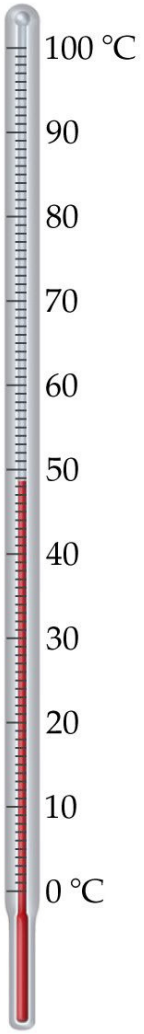
- **All certain digits plus one estimated digit**







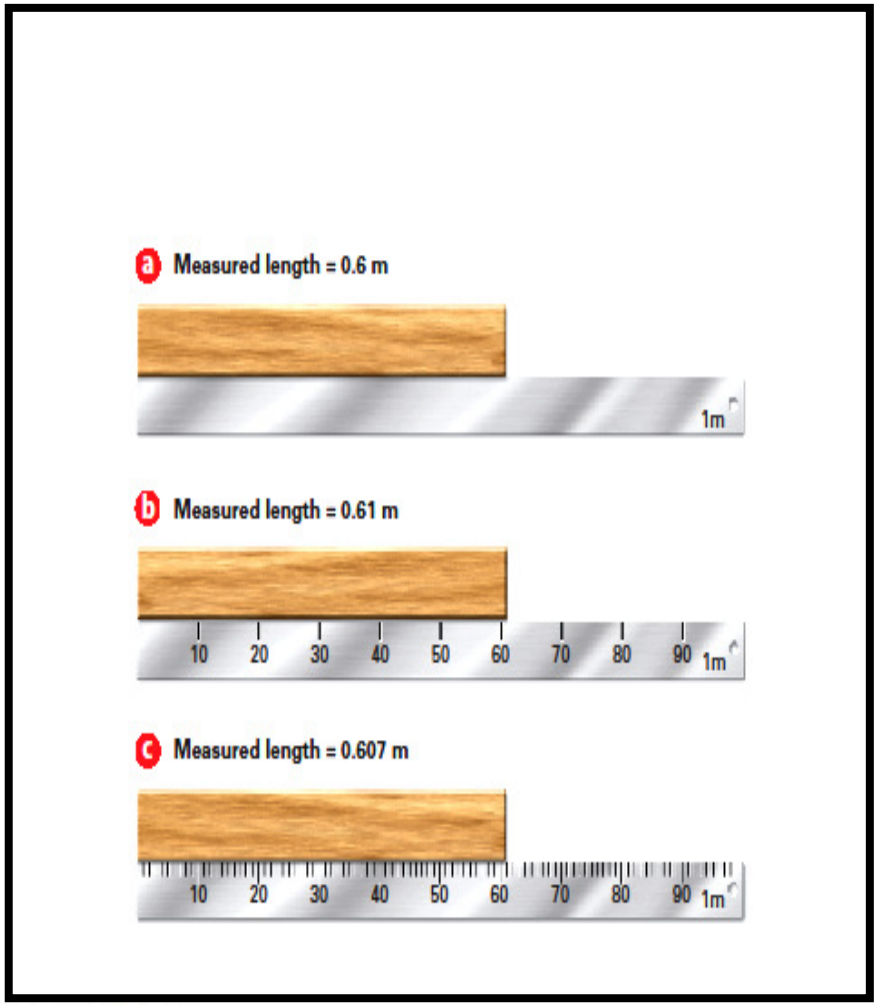
Celsius



Celsius

Significant Figures in Measurements

- Significant figures in a measurement include all of the digits that are known, plus one more digit that is estimated.
- Measurements must be reported to the correct number of significant figures.



Significant Figures

You must be within 1 sig fig – it does not need to be perfect, but sig figs DO count!

- Any digit that is not zero is significant

  2.234 kg 4 significant figures

- Zeros between nonzero digits are significant

  607 m 3 significant figures

- Zeros to the left of the first nonzero digit are **not** significant

  0.07 L 1 significant figure

- If a number is greater than 1, then all zeros to the right of the decimal point are significant

  5.0 mg 2 significant figures

- If a number is less than 1, then only the zeros that are at the end and in the middle of the number are significant

  0.00520 g 3 significant figures

Rules for Counting Significant Figures

Two special situations have an *unlimited* number of significant figures:

1. Counted items
   a) 23 people, or 425 thumbtacks

2 Exactly defined quantities
   b) 60 minutes = 1 hour

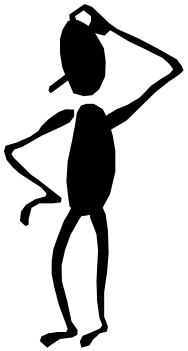
Sig Fig Practice #1

How many significant figures in the following?

1.0070 m →	5 sig figs
17.10 kg →	4 sig figs
100,890 L →	5 sig figs
3.29×10^3 s →	3 sig figs
0.0054 cm →	2 sig figs
3,200,000 mL →	2 sig figs
5 dogs →	unlimited

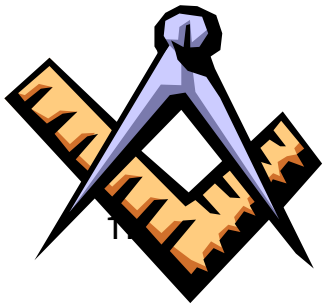
These all come from some measurements

← This is a counted value



How many significant figures are in each of the following measurements?

24 mL	2 significant figures
3001 g	4 significant figures
0.0320 m^3	3 significant figures
6.4 x 10^4 molecules	2 significant figures
560 kg	2 significant figures



Rounding Calculated Answers

- Rounding
  - Decide *how many* significant figures are needed
  - Round to that many digits, counting from the *left*
  - Is the next digit less than 5? Drop it.
  - Next digit 5 or greater? Increase by 1
  - 3.016 rounded to hundredths is 3.02
- 3.013 rounded to hundredths is 3.01
- 3.015 rounded to hundredths is 3.02
- 3.045 rounded to hundredths is 3.04
- 3.04501 rounded to hundredths is 3.05

Rounding Calculated Answers

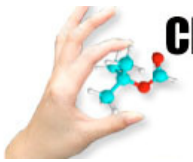
- Addition and Subtraction
  - The answer should be rounded to the same number of decimal places as the *least* number of decimal places in the problem.Examples:

$$\begin{array}{r} 4.8 \\ -\ 3.965 \\ \hline 0.835 \end{array} = 0.8$$

Examples

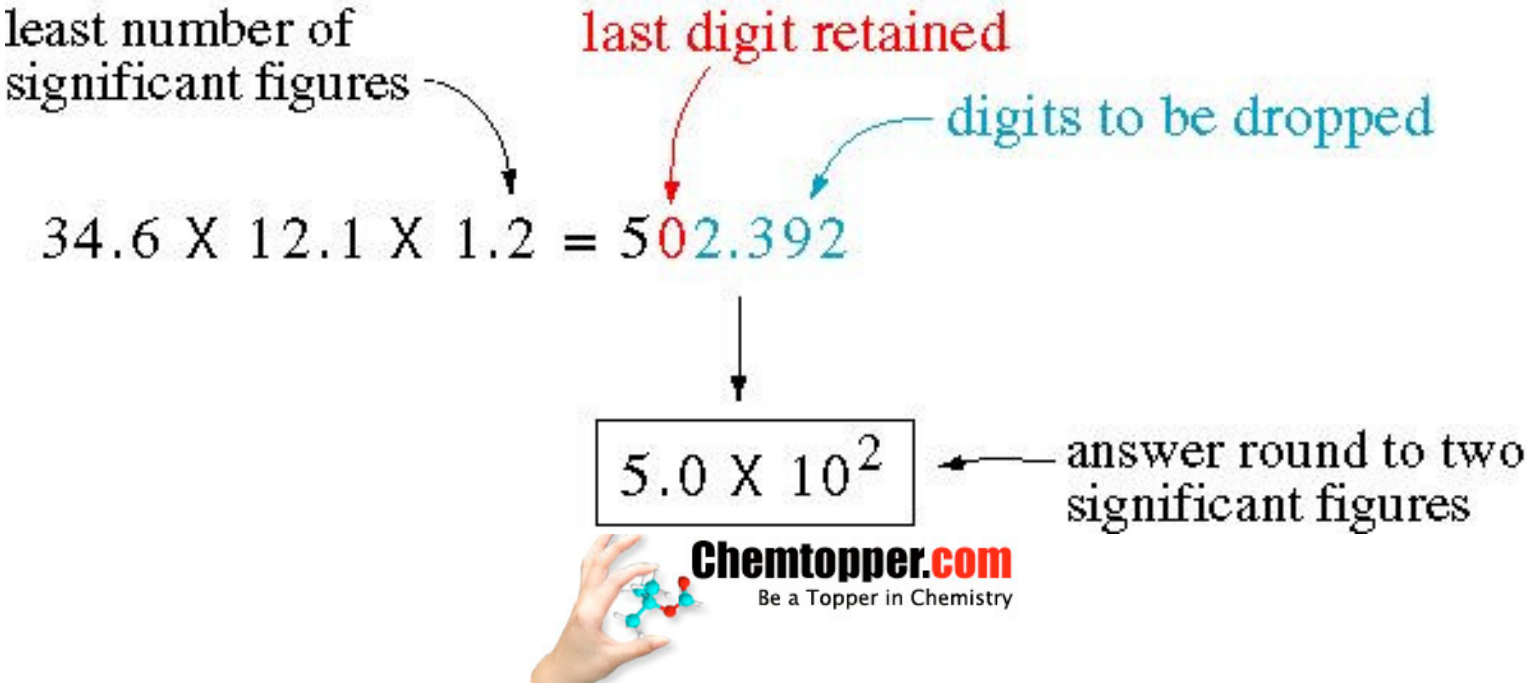
Make the following have 3 sig figs:

- 761.50 → 762
- 14.334 → 14.3
- 10.44 → 10.4
- 10789 → 10800
- 8024.50 → 8020
- 203.514 → 204



Rounding Calculated Answers

- Multiplication and Division
  - Round the answer to the same number of significant figures as the least number of significant figures in the problem.



Rules for Significant Figures in Mathematical Operations

- Multiplication and Division: # sig figs in the result equals the number in the least precise measurement used in the calculation.

$$6.38 \times 2.0 = 12.76 \rightarrow 13 \text{ (2 sig figs)}$$

Three significant figures

Three significant figures

$$\frac{278 \text{ mi}}{11.70 \text{ gal}} = 23.8 \text{ mi/gal}$$

Four significant figures

Significant Figures in Calculations

- In general a calculated answer cannot be more precise than the *least precise* measurement from which it was calculated.
- Ever heard that a chain is only as strong as the weakest link?
- Sometimes, calculated values need to be *rounded off*.

Sig Fig Practice #2

Calculation	Calculator says:	Answer
3.24 m x 7.0 m	22.68 m^2	23 m^2
100.0 g ÷ 23.7 cm^3	4.219409283 g/cm^3	4.22 g/cm^3
0.02 cm x 2.371 cm	0.04742 cm^2	0.05 cm^2
710 m ÷ 3.0 s	236.6666667 m/s	240 m/s
1818.2 lb x 3.23 ft	5872.786 lb·ft	5870 lb·ft
1.030 g ÷ 2.87 mL	2.9561 g/mL	2.96 g/mL

Rules for Significant Figures in Mathematical Operations

- Addition and Subtraction: The number of decimal places in the result equals the number of decimal places in the least precise measurement.

$$6.8 + 11.934 =$$

$$18.734 \rightarrow 18.7 \text{ (3 sig figs)}$$

89.332
+1.1 ← one significant figure after decimal point

90.432 ← round off to 90.4

3.70 ← two significant figures after decimal point
-2.9133

0.7867 ← round off to 0.79

Sig Fig Practice #3

Calculation	Calculator says:	Answer
3.24 m + 7.0 m	10.24 m	10.2 m
100.0 g - 23.73 g	76.27 g	76.3 g
0.02 cm + 2.371 cm	2.391 cm	2.39 cm
713.1 L - 3.872 L	709.228 L	709.2 L
1818.2 lb + 3.37 lb	1821.57 lb	1821.6 lb
2.030 mL - 1.870 mL	0.16 mL	0.160 mL