How many significant figures are there in each of these measurements?

76.070 g (± 0.001 g)
5

85000. mm (± 1 mm)
decimal point
5

0.001030 kg (± 0.000001 kg)
4

156.0002 g (± 0.0001 g)
7

0.10 s (± 0.01 s)
2

17000000 mg (± 1000000 mg)
2

120$\bar{0}$00 km (± 100 km)
4

1350 ms (± 10 ms)
3

Calculations with measurements

When you calculate something using measured numbers, you should try to make sure the ANSWER reflects the quality of the data used to make the calculation.

An ANSWER is only as good as the POOREST measurement that went into finding that answer!

$$
\begin{array}{rl}
14.206 & \pm 0.001 \\
154.72 & \pm 0.01 \\
1.6 & \pm 0.1 \\
+\ 0.222 & \pm 0.001 \\
\hline
170.748 &
\end{array}
$$

How should we report this answer? How much uncertainty is in this answer?

$\boxed{170.7}$

- If you add an uncertain number to either a certain or an uncertain number, then the result is uncertain!
- If you add certain numbers together, the result is certain!

For addition and subtraction, round FINAL ANSWERS to the same number of decimal places as the measurement with the fewest decimal places. This will give an answer that indicates the proper amount of uncertainty.

For multiplication and division, round FINAL ANSWERS to the same number of SIGNIFICANT FIGURES as the measurement with the fewest SIGNIFICANT FIGURES!

$$\overset{4}{\underline{15.62}} \times \overset{3}{0.0\underline{667}} \times \overset{3}{\underline{35.0}} = 36.46489$$

How should we report this answer?

$$\boxed{36.5}$$

$$\overset{3}{\underline{25.4}} \times \overset{2}{0.000\underline{23}} \times \overset{5}{\underline{15.201}} = 0.088804242$$

How should we report this answer?

$$\boxed{0.089}$$

We're rounding this one to two significant figures. Since the two leading zeros are NOT significant, the first significant figure is the first "8"

A few more math with significant figures examples:

5 2 4

$\underline{15047} \times \underline{11} \times \underline{0.9876} = 163464.5892$ $\boxed{160000}$

1.6×10^5

~~16~~

~~160000.0000~~

Placeholder zeroes (or scientific notation) required here since we need to know where the decimal goes!

Addition:

147.3	± 0.1
2432	± 1
0.97	± 0.01
+ 111.6	± 0.1
2691.87	

$\boxed{2692}$

DENSITY CALCULATION

6

$\dfrac{14.7068 \text{ g}}{2.7 \text{ mL}}$

2

$= 5.446962963 \text{ g/mL}$

$\boxed{5.4 \text{ g/mL}}$

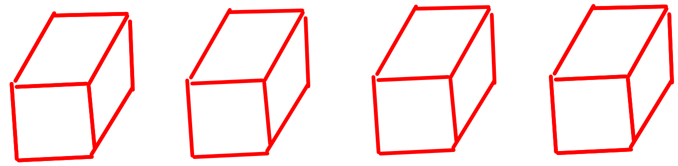
The only way to improve the precision of this density measurement is to improve the precision of the VOLUME measurement, since it limits the precision of the answer.

(We can actually use a LESS precise balance than the one we're currently using and still have the same quality density measurement!)

Exact Numbers

- Some numbers do not have any uncertainty. In other words, they weren't measured!

1) Numbers that were determined by COUNTING!



How many blocks are to the left?

exactly $\underline{4}$

2) Numbers that arise from DEFINITIONS, often involving relationships between units

$12 \text{ in} = 1 \text{ ft}$

$\text{Km} = 10^3 \text{ m}$

* All metric prefixes are exact!

- Treat exact numbers as if they have INFINITE significant figures or decimal places!

Example

You'll need to round the answer to the right number of significant figures!
Convert 4.45 m to in, assuming that 2.54 cm = 1 in

EXACT!

2.54 cm = in $cm = 10^{-2} m$

$$4.45\,\cancel{m} \times \frac{c\cancel{m}}{10^{-2}\,\cancel{m}} \times \frac{in}{2.54\,\cancel{cm}} = 175.1968504\ in$$

3   ∞ ∞

$$= \boxed{175\ in}$$

Usually, in unit conversions the answer will have the same number of significant figures as the original measurement did.

EXCEPTION: Temperature conversions, since these often involve ADDTION (different rule!)

A note on rounding: If possible, try to round only at the END of a multiple-step calculations. Avoid rounding intermediate numbers if possible, since extra rounding introduces ERROR into your calculations.

DALTON'S ATOMIC THEORY

- 1808: Publication of Dalton's "A New System of Chemical Philosophy", which contained the atomic theory

- Dalton's theory attempted to explain two things:

1 CONSERVATION OF MASS

- The total amount of mass remains constant in any process, chemical or physical!

2 LAW OF DEFINITE PROPORTIONS (also called the LAW OF CONSTANT COMPOSITION): All pure samples of a given compound contain the same proportion of elements by mass

The parts of Dalton's theory

1. Matter is composed of small, chemically indivisible ATOMS

2. ELEMENTS are kinds of matter that contain only a single kind of atom. All the atoms of an element have identical chemical properties.

3. COMPOUNDS are kinds of matter that are composed of atoms of two or more ELEMENTS which are combined in simple, whole number ratios.

Most importantly,

4. CHEMICAL REACTIONS are REARRANGEMENTS of atoms to form new compounds.

- Atoms are not gained or lost during a chemical reaction.

- Atoms do not change their identity during a chemical reaction.

- All the atoms that go into a chemical reaction must go out again!