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

76.070 g

5

85000. mm

5

decimal point

0.001030 kg

4

156.0002 g

7

0.10 s

2

17000000 mg

2

$120\bar{0}00$ km

4

1350 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!

$$
\begin{array}{r}
14.20\underline{6} \\
154.7\underline{2} \\
1.\underline{6} \\
+\ 0.22\underline{2} \\
\hline
170.\underline{748}
\end{array}
$$

Round so that there's only one uncertain digit in the answer!

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!

$$\overset{4}{\underline{15.62}} \times 0.0\overset{3}{\underline{667}} \times \overset{3}{\underline{35.0}} = 36.4|6489$$

How should we report this answer?

$$\boxed{36.5}$$

$$\overset{3}{\underline{25.4}} \times 0.000\overset{2}{\underline{23}} \times \overset{5}{\underline{15.201}} = 0.088|804242$$

How should we report this answer?

$$\boxed{0.089}$$

A few more math with significant figures examples:

$$\overset{5}{15047} \times \overset{2}{11} \times \overset{4}{0.9876} = 163464.5892$$

$\cancel{16}$

$\boxed{160000}$

(1.6×10^5)

Placeholder zeros, even though they aren't SIGNIFICANT, still need to be included, so we know how big the number is!

Addition:

```
   147.3
  2432
     0.97
+  111.6
 2691.87
```

$\boxed{2692}$

DENSITY CALCULATION

$$\frac{\overset{6}{14.7068\ g}}{\underset{2}{2.7\ mL}} = 5.446962963\ g/mL$$

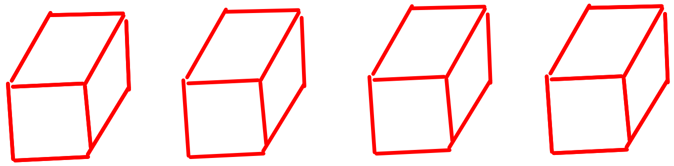
$\boxed{5.4\ g/mL}$

To improve (make more precise) this calculated density, we must improve the poorest measurement. We must use a more precise device to measure the VOLUME (which only has two significant figures in this example)!

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 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!

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

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

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

3   ∞ ∞

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!)

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!

Another look at chemical reactions

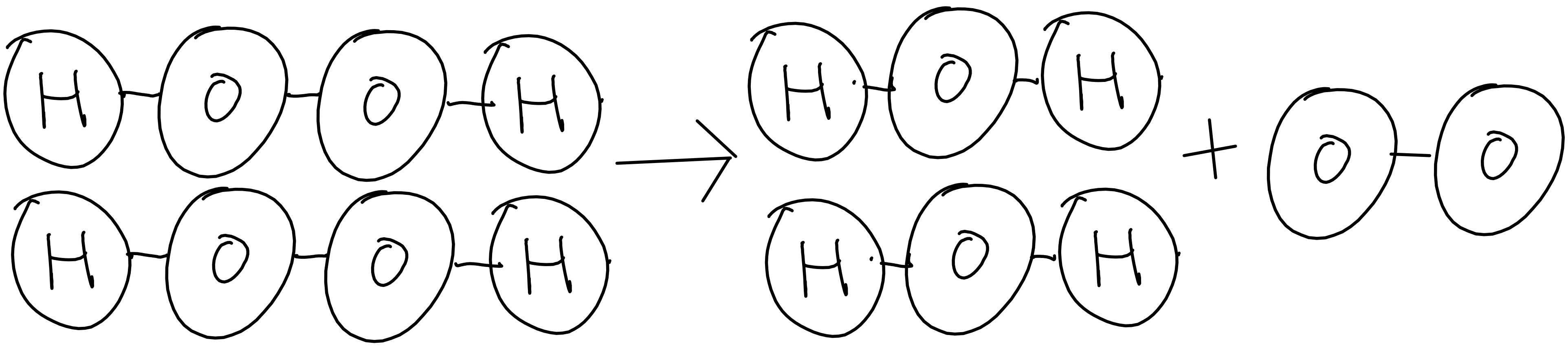
The decomposition of hydrogen peroxide over time (or when poured over a cut) works like this:

HYDROGEN PEROXIDE $\longrightarrow$ WATER + OXYGEN GAS

implying:... $H_2O_2 \longrightarrow H_2O + O_2$

... but wouldn't this mean that somehow an extra oxygen atom would form?

Not according to Dalton's theory. Dalton's theory would predict a different RATIO of water and oxygen would form:



$$\boxed{2\,H_2O_2 \longrightarrow 2\,H_2O + O_2}$$

- Dalton's theory sets LIMITS on what can be done with chemistry. For example:

1. Chemistry can't convert lead (an element) into gold (another element). Sorry, alchemists!

2. You can't have a compound form in a chemical reaction that contains an element that was not in your starting materials.

3. You can only make a certain amount of desired product from a fixed amount of starting material.

Atomic structure

- Until the early 20th century, chemists considered atoms to be indivisible particles.
- The discovery of SUBATOMIC PARTICLES changed the way we view atoms!

The subatomic particles

PROTON

- a small, but relatively massive particle that carres an overall unit POSITIVE CHARGE

NEUTRON

- a small, but relatively massive, particle that carries NO CHARGE
- slightly more massive than the proton

ELECTRON

- a small particle that carries an overall unit NEGATIVE CHARGE
- about 2000 times LESS massive than either protons or neutrons