

SIGNIFICANT FIGURES

Many operations in the chemistry laboratory involve measurements of some kind. Weighing yourself on a bathroom scale is an example of taking a measurement. In the chemistry lab examples include weighing a compound, measuring the volume of a liquid, recording the temperature, etc.

In the chemistry lab not only is the numerical value of a measurement important but also the accuracy and precision. Accuracy refers to how close a measured quantity is to the true value. Precision refers to the degree of reproducibility, how a number of independent measurements agree with one another. A method of measurement is precise if a series of measurements deviates only a small amount from the average.

The number of figures recorded for a measured quantity must reflect the precision with which the measurement has been made. Significant figures in a measured quantity refers to all those figures that are known with complete certainty and one figure that is estimated.

Consider the recorded mass of an object to be 12.346 g. In this case, this result was weighed to the nearest thousandth (0.001 g) of a gram. There are 5 significant figures with the last digit representing a degree of uncertainty. This means that the last digit has been estimated and the exact mass is between 12.345 and 12.347 g.

For example, we can measure the volume of a liquid using a 100 mL graduated cylinder marked in 1-mL divisions. The volume can be estimated to the nearest 0.1 mL. Suppose that we estimate a volume that lies between 72 mL and 73 mL to be 72.4 mL. The first two digits (7 and 2) are known with certainty, and the last digit (4) has been estimated. This measurement has three significant figures.

To determine the number of significant digits in most numbers, you simply count the number of digits in the number. For example, there are five significant digits in 12.346. However many numbers require the use of zeros to hold the decimal place. For example the mass 12.3 g has three significant figures but what if we convert the mass into kilograms. In kilograms this measurement is expressed as 0.0123 kg. The zeros must be present to hold the decimal place. They are not actually measured. Only the 1, 2 and 3 are significant. So, this number has three significant figures.

Zeros that appear at the end of a number such as 500, 2000 and 37, 500 may be part of the measurement or may be present strictly to locate the decimal. To avoid ambiguity, these measurements should be written in scientific notation. See below.

SCIENTIFIC NOTATION

Scientific notation is the way that scientists easily handle very large or very small numbers. For example, instead of writing 0.000000005, we write 5×10^{-9} . Think of 5×10^{-9} as the product of two numbers: 5 (the digit term) and 10^{-9} (the exponential term).

Since the exponential term only locates the decimal place, it is not used in determining the number of significant figures. Consider the examples below.

Number	Number of Significant Figures
1×10^5	1
1.00×10^5	3
1.0×10^{-6}	2

On your scientific calculator:

Make sure that the number in scientific notation is put into your calculator correctly.

Read the directions for your particular calculator. For inexpensive scientific calculators:

1. Punch the number (the digit number) into your calculator.
2. Push the EE or EXP button. Do **NOT** use the \times (times) button!!
3. Enter the exponent number. Use the +/- button to change its sign.
4. Treat any number in scientific notation as a normal number in all subsequent calculations.

To check yourself, multiply 6.0×10^5 times 4.0×10^3 on your calculator. Your answer should be 2.4×10^9 .

Summary

1. Every nonzero digit is significant; the numbers 12.6 and 391 each have three significant figures.
2. Zeros appearing between nonzero digits are significant; the numbers 12.01 and 1008 each have four significant figures.
3. Zeros appearing in front of all the nonzero digits are never significant; the numbers 0.023 and 0.000057 have two significant figures.
4. Zeros to the right of the last nonzero digit but to the left of the decimal point may be significant; the number 200 may have one, two or three significant figures. The number 0.720 has three significant figures.

Examples: 0.0001234 has 4 significant figures
0.00012340 has 5 significant figures
600 has 1 significant figure but if written as 6.00×10^2 , it has 3 significant figures.

If one measures 250 mL to the nearest millilitre, it is more informative to write this volume as 250. mL, 0.250 L, or 2.50×10^2 mL; making all three digits significant. Calculations must also be reported with the correct number of significant figures required to indicate the precision of the experiment.

Integers, such as stoichiometric ratios, counting numbers and other “whole numbers” have infinite significant figures.

EXAMPLES OF SIGNIFICANT FIGURES

Measurement Using	PLACES AFTER THE DECIMAL THAT ARE SIGNIFICANT	EXAMPLE
Volumetric Flask	2	50.00 mL
Volumetric Pipet	2	5.00 mL
Buret	2	23.28 mL
Analytical Balance	4	12.3652 g
Top Loading Balance	1	5.1 g
Thermometer	2	12.36° C
Graduated Cylinder	1	23.4 mL
pH Meter	2	8.32

CALCULATIONS WITH SIGNIFICANT FIGURES

When performing calculations an important requirement is that the precision can be neither gained nor lost in calculations involving measured quantities.

Using measurements in calculations does not make them any more or less precise or accurate. The uncertainty in the results of adding, subtracting, multiplying and dividing measurements depends on the uncertainty of the measurements as discussed on the previous page. The results of the calculations should *always* be rounded to the correct number of significant figures. *Digits that are not significant should be removed.*

ROUNDING

In rounding numbers to the correct number of significant digits the following rules should be applied:

- ← If the digit to be removed is less than 5, simply remove the unwanted digits. For example 6.7495 rounded to two digits is 6.7 because the 4 is less than 5.

- ↑ If the first digit to be removed is 5 or more, increase the preceding digit by one. For example 3.350 rounded to two digits is 3.4 because the first digit to be removed is a 5 and 6.7938 rounded to two digits is 6.8 because 9 is greater than 5.

ADDITION AND SUBTRACTION

To find the number of significant figures in the answer to addition and subtraction, the answer should have the same number of digits to the right of the decimal point as the number having the fewest digits to the right of the decimal point:

$$\begin{array}{r} 78.01216 \\ + 2.96 \\ \hline 80.97 \end{array}$$

- 5 places after decimal
- 2 places after the decimal
- 2 places after the decimal

$$\begin{array}{r} 58.0128 \\ - 32.0015 \\ \hline 26.0113 \end{array}$$

- 4 places after decimal
- 4 places after decimal
- 4 places after decimal

