

Significant Figures – A Summary

1. Exact numbers express a counted value or a definition

- a) Counted quantities, such as 22 students, 15 cars, or 12 oranges are exact numbers.
- b) Definitions, such as one kilometer is exactly 1000 meters, or one dozen eggs is 12 eggs are exact numbers.

In calculations, exact numbers do not affect the number of significant figures. They are treated as if they have an infinite amount of significant digits.

2. Measurements and Significant figures

In any measurement, the last digit of the measurement is considered to be an estimated value and has an uncertainty associated with it. Generally, the uncertainty is expressed as plus or minus one unit in the last place of the measurement. For example a measurement of 25.3 cm has an uncertainty of ± 0.1 cm, or a mass of 45.342 g has an uncertainty of ± 0.001 g.

The rules for writing and identifying significant figures are:

- a) All nonzero digits (digits from 1 to 9) are significant. Thus, the number 129.454 contains **six** significant figures.
- b) Zero digits that occur between nonzero digits are significant. The number 390.02 contains **five** significant figures. (Note: The decimal point does not affect the number of significant digits.)
- c) Zeros at the beginning of a number (i.e., on the left-hand side) are considered to be placeholders and are not significant. The number 0.00078 contains **two** significant figures and 0.302 contains **three** significant figures. (Note: It is common practice to place a zero in front of the decimal point preceding a decimal fraction. It acts as a placeholder only.)
- d) Zeros that occur at the end of a number (i.e., on the right-hand side) that include an expressed decimal point are significant. The presence of the decimal point is taken as an indication that the measurement is exact to the places indicated. The number 57500. contains **five** significant figures and 34.00 contains **four** significant figures.
- e) Zeros that occur at the end of a number (i.e., on the right-hand side) **without an expressed decimal point** are ambiguous (i.e., we have no information on whether they are significant or not) and are **not** considered to be significant. The number 575000 contains three significant figures and 2000 contains one significant figure.

One way of indicating that some or all the zeros are significant is to write the number in scientific notation form (See Section 6). For example, a number such as 2000 would be written as 2×10^3 if it contains one significant figure, and as 2.0×10^3 if it contains two significant figures.

3. Rounding-off Numbers

When dealing with significant figures, it is often necessary to round-off numbers in order to keep the results of calculations significant.

- a) If the first digit to be dropped is less than 5, the last digit kept remains the same. To round-off a number such as 64.826 to three significant figures means to express it as the nearest three digit number, which will be 64.8.
- b) If the first digit to be dropped is greater than 5, the last digit kept is increased by 1. Rounding-off the number 26.472 to three significant figures will result in the value 26.5

- c) If the first digit to be dropped is 5, then two rules apply:

If the five precedes one or more additional digits, the last digit kept is increased by 1. Rounding-off the number 42.4502 to three significant figures will result in the value 42.5

If the only digit to be dropped is a five, and **the last digit kept is odd**, increase it by 1 to an even number. Rounding-off the number 53.75 to three significant figures will result in the value 53.8 However, if **the last digit kept is even**, do not change its value. Rounding-off the number 53.65 to three significant figures will result in the value 53.6.

4. Numerical Operations with Significant Figures

a) Addition and subtraction

When adding (or subtracting) approximate numbers, round off the sum (or difference) to the last column in which each number has a significant figure.

Example $67.25 + 721.2 + 30.006 + 2.43 = 820.886$ which would be rounded off to 820.9

b) Multiplication and division

When multiplying (or dividing) approximate numbers, round off the product (or quotient) so that the final answer contains only as many significant figures as the least approximate number involved in the calculation.

Example: $3.01 \times 1.4 \times 725.1 = 3055.5714$ which would be rounded off to 3100 (based on the 1.4 which contains two significant figures)

NOTE: When performing a series of calculations, keep at least 3 to 4 digits in the answers to each intermediate step and only **round off your final answer** to the correct number of significant figures.