Scientific Recording and Reporting

Significant figures

They are scientifically meaningful digits of a number that are used to express it to the required degree of accuracy. The level of measurement uncertainty and accuracy is considered acceptable based on this. Digits that can make a measurement decision.

Some rules:

- Non-zero digits are always significant
  23.8 and 3.98 three significant figures

- Trailing zeros are not significant
  200 one significant
  3400 two significant

- Zeros within a number are always significant.
  305 and 20.4 Both have three significant figures.

- Zeros to the left of the first non-zero digit serve only to fix the position of the decimal point are not significant.
  0.54 two significant figures
  0.00047 two significant figures
  0.896 three significant figures

- Scientific notification
  4×10^{-4} one significant figures
  4.0×10^{-4} two significant figures
  4.00×10^{-4} tree significant figures

Calculation with Significant Figures

Addition and Subtraction:

For addition and subtraction, **look at the decimal portion** (i.e., to the right of the decimal point) of the numbers **ONLY**. Here is what to do:

1) Count the number of significant figures in the decimal portion of each number in the problem. (The digits to the left of the decimal place are not used to determine the number of decimal places in the final answer.)

2) Add or subtract in the normal fashion.

3) <u>Round the answer to **the LEAST number of places in the decimal portion** of any number in the problem.</u>

Ex.1)

4.894

+23.15

+349.3

____

349.344

→349.3

Ex. 2) 345.293-215.15 =130.143 → 130.14

Multiplication and Division:

The following rule applies for multiplication and division:

<u>**The LEAST number of significant figures** in any number of the problem</u> determines the number of significant figures in the answer.

Ex.3) 2.5 x 3.42 = 8.55 →8.6

Ex.4) 2.5 x 3.42 x 50.2= 429.21 → 430

Ex. 5) 17.612 ÷ 1.258 = 14 →14.00

Unit

All measurements done in lab must be expressed using appropriate units. During measurement and later in calculations, all data should be kept in their proper units. And all final results must be provided with appropriate units. Only units of the SI and those units recognized for use with the SI are used to express the values of quantities. Correctness and accuracy of the analysis for measured data are based on and confirmed by scientific units. Use of units should be strongly examined by instructor.

Some of SI units

meter **m**	millisecond **ms**
gram **g**	second **s**

kilogram **kg**	milliliter **ml**
mole **mol**	force **N**
liter **L** (not l)	

ERROR ANALYSIS

Collecting your data

Four definition related collecting and analyzing data

Accuracy: agreement to some known or true value. For example, if in lab you obtain a weight measurement of 3.2 kg for a given substance, but the actual or known weight is 10 kg, then your measurement is not accurate. In this case, your measurement is not close to the known value.

Precision: measure of how well reproducible the value is. Using the example above, if you weigh a given substance five times, and get 3.2 kg each time, then your measurement is very precise.

Resolution: the limit or smallest value that can be reasonably read on the instrument scale. Resolution is typically limited by the smallest markings or gradation of the instrument.

Sensitivity: the limit or range of values in which instruments can reasonably be expected to give accurate results. Measuring the thickness of a piece of paper with a meter stick will always give poor results. Measuring the time it takes to blink an eye using a wrist watch is extremely difficult since the event takes place much quicker than the sensitivity of the watch.

Source of Error

It is important to be aware of some of the sources of experimental error and some basic statistical methods of determining the value or values that best represent the system in question. Sources of error that affect the outcome and results of your lab normally result from one of two general categories: systematic error that you either can control, minimize or measure, and random error that you have little control over but which can be addressed using statistics.

Systematic Error: this type of error occur in the same direction in repeated measurements. These can be hard to detect but can be minimized by choosing appropriate testing conditions. An example would be a stopwatch running slow. This could be minimized by replacing the battery (to get it to run at the appropriate speed again) or further reduced by purchasing a better timer suited for the experiment or conditions.

Random Error: the error that occurs at the limit of the resolution of instruments and may occur in any direction. To reduce this type of errors of, you must repeat the experiment creating a mean or average value. This mean value is considered the best or most reliable value. The standard deviation of your values will determine how well your measured data are reliable.

Uncertainty of multiple error sources (this part is only referred to calculus based courses)

Typically in lab, we measure more than one variable at a time or more than one variable is used at a time. This can lead to sources of error propagating or spreading to other variables more than one may realize.

Suppose that x, y, z are measured with uncertainties (errors) Δx, Δy, Δz and the measured values are used to express the combined result q (x, y, z). The uncertainties in q is

$$\Delta q = \sqrt{\left(\frac{\partial q}{\partial x}\Delta x\right)^2 + \cdots + \left(\frac{\partial q}{\partial z}\Delta z\right)^2}$$

Note: in order to obtain the resultant uncertainty, it should take a functional relationship with independent variables such as x, y, z.