

AP Chemistry/AP Physics- Uncertainties and Significant Figures (sig. figs.)

All measurements always have some uncertainty. We refer to the uncertainty as the error in the measurement. Errors fall into two categories:

- 1. Systematic Error** - Errors resulting from measuring devices being out of calibration. Such measurements will be consistently too small or too large. These errors can be eliminated by pre-calibrating against a known, trusted standard or increasing sample size. Electronic noise in the circuit of an electrical instrument.
- 2. Random Errors** - Errors resulting in the fluctuation of measurements of the same quantity about the average. The measurements are equally probable of being too large or too small. These errors generally result from the fineness of scale division of a measuring device or the instrument is wrongly used by the experimenter.

Physics and chemistry are a quantitative sciences and that means a lot of measurements and calculations. These calculations involve measurements with uncertainties and thus it is essential for the students to learn how to analyze these uncertainties (errors) in any calculation. Systematic errors are generally “simple” to analyze but random errors require a more careful analysis. The term "human error" should also be avoided in error analysis discussions because it is too general to be useful, and because any data acquired under the effects of personal error should be excluded from error analysis. 1). Uncertainty in a scale measuring device is equal to the smallest increment divided by two, and 2). Uncertainty in a digital measuring device is equal to the smallest increment.

Two calculations are generally performed to determine the amount of error:

$$\text{Percent Error} = \frac{|\text{measured} - \text{actual}|}{\text{actual}} * 100\% \quad \text{Percent Difference} = \frac{|\text{measured}_1 - \text{measured}_2|}{\left(\frac{\text{measured}_1 + \text{measured}_2}{2}\right)} * 100\%$$

Significant Figures Rules: Significant Figures are a necessary part of any math based science. Significant figures are the digits in your number that were actually measured plus one estimated digit.

- 1) All nonzero digits are significant.
- 2) Zeros between significant digits are significant.
- 3) Zeros to the left of nonzero digits are not significant.
- 4) Zeroes at the end of a number are significant only if they are to the right of the decimal point.

Number	Significant Figures
70.2	3
0.045	2
70.0	3
4.7	2
100	1
706	3
400.0	4
0.002	1
0.0020	2
0.002047	4
1.0	2
104,020	5
1.20×10^3 (illustrating 1200 with 3 sig figs)	3
2.00×10^{-3} (illustrating 0.002 with 3 sig figs)	3