Parts per Thousand (ppt) Guide

Parts per thousand (ppt), also known as the "relative standard deviation", is useful when comparing the uncertainty between different measurements of varying magnitude (i.e. it is a measure of the ***precision*** within an experiment.) **Parts per thousand can be applied to any set of data** where more than one experimental value has been applied – i.e. volumes, percentages, concentrations, etc. We will use parts per thousand often this year, so knowledge of how it works is critical for the successful student.

For the values x_1, x_2 and x_3:

- Take the **average** of the values

$$\text{average} = \frac{\text{sum}}{\#\ \text{of values}} = \frac{x_1 + x_2 + x_3}{3}$$

- Find the **deviation** of each value relative to the average

$$\text{deviation}_1 = \text{absolute value (average} - x_1) = |\ \text{average} - x_1\ |$$
$$\text{deviation}_2 = |\ \text{average} - x_2\ |$$
$$\text{deviation}_3 = |\ \text{average} - x_3\ |$$

- Find the **average deviation** of the deviations

$$\text{average deviation} = \frac{\text{sum of deviations}}{\#\ \text{of values}} = \frac{\text{deviation}_1 + \text{deviation}_2 + \text{deviation}_3}{3}$$

- Calculate the **parts per thousand (ppt)** for the values

$$\text{ppt} = \frac{\text{average deviation}}{\text{average}} * 1000$$

<u>*Example*</u>*:* Calculate the parts per thousand for the values 35.72%, 35.92% and 36.02%

- Average = $\frac{35.72 + 35.92 + 36.02}{3}$ = **35.89 %**
- $\text{Deviation}_1 = |\ 35.89 - 35.72\ | = 0.17$
- $\text{Deviation}_2 = |\ 35.89 - 35.92\ | = 0.03$
- $\text{Deviation}_3 = |\ 35.89 - 36.02\ | = 0.13$
- average deviation = $\frac{0.17 + 0.03 + 0.13}{3}$ = **0.11 %**
- parts per thousand = $\frac{0.11}{35.89} * 1000$ = **3.1** *unitless*

Parts per thousand relates the deviation to the magnitude of the experimental data. Consider these two sets of data each with an average deviation of ±0.010:

Data set 1: 0.250 ± 0.010, ppt = (0.010/0.250) x 1000 = 40 ppt (not very good precision).

Data set 2: 4.50 ± 0.010, ppt = (0.010/4.50) x 1000 = 2 ppt (excellent precision)

Although both scenarios have the same deviation, the relative deviation compared to the data gives very different results. Patience and focus is a virtue in this lab.