

Chem 321 Lecture 2 - Analysis, Measurements and Tools

8/29/13

Student Learning Objectives

Analysis

Analytical chemistry is concerned with the determination of what components are present in a sample (**qualitative results**) and how much of a particular component is present (**quantitative results**). The analytes may be major or minor ones (pph or ppth levels), trace (ppm levels) or ultratrace (ppb or ppt levels). Frequently a separation of the components is needed before identification and quantification can be achieved. Chromatography is one of the major means used to separate components. Analytical chemistry is also concerned with the development of methods used to make these separations and determinations. Analytical methods are very important in almost all areas of science, including biochemistry, environmental science, clinical work and materials science.

Analytical methods can be classified as either classical or instrumental. Classical methods (also known as wet chemistry methods) such as gravimetric analysis and titrations tend to rely on mass and volume measurements of bulk materials. Instrumental methods rely on instruments that detect and quantify the amount of an analyte, usually at the trace or ultratrace level, by measuring a property of the analyte such as light absorption. In this course you will use both types of methods to quantitatively analyze your samples.

The validity of any analysis ultimately depends on the quality of the sample being analyzed. As instrumental methods become capable of detecting smaller and smaller amounts of analytes and require smaller and smaller sample sizes, it becomes even more critical that care is taken so that a representative sample is analyzed. In addition, contamination becomes a significant concern. For trace and ultratrace analytes the methods used to obtain and to store a sample are very important. The samples you will analyze in Chem 321L consist of rather simple matrices (to minimize interferences) and have been carefully prepared to ensure that they are very homogeneous. Sampling techniques and proper storage of samples will not be an areas of focus in this course but will be considered in the second-semester analytical chemistry course (Chem 422/L) at CSUN.

Your grade in Chem 321L will depend in large part on how carefully you analyze samples ("unknowns") you are assigned. For example, in the first experiment you are asked to determine the mass percent chloride in a solid. Your grade will be based on the **relative error** associated with your results.

$$\text{Relative Error} = \frac{|\text{reported value} - \text{true value}|}{\text{true value}} \times 10^x$$

If the relative error is to be expressed as a percent, $x = 2$. For **parts per thousand (ppth)** relative errors, $x = 3$.

Notice that relative errors are always positive numbers. The quantity inside the absolute value lines (reported value - true value) is called the **absolute error** and may have a positive or negative sign depending upon whether your result is larger or smaller than the true value, respectively. For some of your unknowns, the true value is the value provided by the commercial supplier of the unknowns based on an extensive analysis of the material using methods of analysis similar to those you will use. In other cases, the unknowns are solutions that have been very carefully prepared to contain a specific amount of analyte.

Example 1.1

Problem

If one determines the mass percent of an analyte to be 30.11%, what is the relative error of this result if the true value is 30.00%?

Solution

Substitute this information into the expression for relative error.

$$\text{Relative Error (ppth)} = \frac{|30.11\% - 30.00\%|}{30.00\%} \times 10^3 = 3.7 \text{ ppth}$$

In Example 1.1 notice that the dimensions associated with the result (in this case, mass percent) do not appear in the expression of the relative error. Relative errors are usually expressed with only one or two significant figures. A result of 3.7 ppt relative error for the gravimetric chloride experiment will earn you a grade of 9/10. This means that you are expected to do very careful work in the lab!

Relative errors can also be associated with measurements. In this case,

$$\text{Relative Error} = \frac{|\text{uncertainty in measurement}|}{\text{measurement}} \times 10^x$$

Example 1.2

Problem

What is the ppt relative error associated with a buret reading of 38.94 mL if the uncertainty in reading your buret is ± 0.02 mL.?

Solution

Substitute this information into the expression for relative error of a measurement.

$$\text{Relative Error (ppt)} = \frac{0.02 \text{ mL}}{38.94 \text{ mL}} \times 10^3 = 0.5_1 \text{ ppt}$$

The subscripted 1 in the answer means that it is not a significant figure. It is given to avoid round-off errors in case this result is used in subsequent calculations.

As we will see, relative errors play an important role in deciding how to properly round off results for reporting. It is essential that you can readily estimate the relative error associated with a measurement. Unless stated otherwise, assume an uncertainty of ± 1 unit in the rightmost digit of a measurement.

Check for Understanding 1.1

Solutions

1. What is the ppth relative error associated with each of the following volume measurements? 25 mL 25.1 mL 25.13 mL