TYPES OF ERRORS IN EXPERIMENTAL DATA

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Outline

- Types of Errors in Experimental Data
- Instrumental errors
- Method errors
- Personal errors

Objectives

The students will be able to:

- Have knowledge about the types of errors in analytical methods.
- Discuss the types and source of errors and try to solve the error.

Types of Errors in Experimental Data

Random errors or **indeterminate errors** affect measurement **precision**.

- They arise from experimental variables that cannot be controlled or determined.
- Examples include random fluctuations in electrical noise, random inconsistencies in measurement readings, or random changes in laboratory temperature.

Systematic errors or **determinate errors** affect the **accuracy** of results.

- These errors often occur when instruments or measuring devices are uncalibrated or are calibrated improperly.
- They have the same effect on all samples.
- Systematic errors can be very subtle and difficult to detect, but finding and eliminating them is an integral part of the measurement process.

Gross errors

- Occur infrequently and often result from an experimental blunder such as misreading a scale or interpreting a number incorrectly.
- If you mistakenly read a 9 as 4 or 3 as 8, you have made a gross error.

Systematic Errors

Systematic errors have a definite value, an assignable cause, and are of the same magnitude for replicate measurements made in the same way. They lead to bias in measurement results.

There are three types of systematic errors:

- **Instrumental errors** are caused by nonideal instrument behavior, by faulty calibrations, or by use under inappropriate conditions.
- **Method errors** arise from nonideal chemical or physical behavior of analytical systems.
- **Personal errors** result from the carelessness, inattention, or personal limitations of the experimenter.

Instrumental errors

- All measuring devices are potential sources of systematic errors. For example, pipets, burets, and volumetric flasks may hold or deliver volumes slightly different from those indicated by their graduations.
- **Calibration** eliminates most systematic errors of this type.
- Electronic instruments are also subject to systematic errors. These can arise from several sources. For example, errors may emerge as the voltage of a battery-operated power supply decreases with use. Errors can also occur if instruments are not calibrated frequently or if they are calibrated incorrectly.

Calibration is the activity of checking by comparison with the standard. The accuracy of measuring any instrument. It may also include adjustment of the instrument to bring with standard alignment.

Method errors

- The non-ideal chemical or physical behavior of the reagents and reactions on which an analysis is based often introduce systematic method errors.

- Such sources of non-ideality might be because of one or more of the followings:
  - **Slow reactions**
  - **Incompleteness reactions**
  - **Instable species**
  - **Lack of specificity of most reagents**
  - **Possible occurrence of side reactions**

Method errors are usually the most difficult to identify and correct.

- Some compounds are incompletely decomposed by the sulfuric acid. With such compounds, potassium sulfate is used to raise the boiling temperature.

■ *Personal errors*

- Many measurements require personal judgments. Examples include estimating the position of a pointer between two scale divisions, the color of a solution at the end point in a titration, or the level of a liquid with respect to a graduation in a pipet or burette.

- Color blindness is a good example of a limitation that could cause a personal error in a volumetric analysis

- Automated and computerized instruments can eliminate this form of bias.

Reference(s)

- Skoog, D. A., West, D. M., Holler, F. J., and Crouch, S. R. (2022). *Fundamentals of Analytical Chemistry*. 10th Ed. Cengage, Inc. Student Edition ISBN: 9780357450390.