Chem 111-Packet

PRECISION AND ACCURACY

PRECISION AND STANDARD DEVIATION

Precision describes the reproducibility of a result. If an experiment is repeated many times, and if the error is random, then the results tend to cluster symmetrically about the average value. If you measure a quantity several times and the values agree closely with one another, your measurements are precise. If the values vary widely, your measurements are not precise. You will regularly report on your precision as standard deviation and percent deviation.

MEAN VALUE AND STANDARD DEVIATION

The arithmetic mean, $\overline{x}$ (also called average) is the sum of the measured values divided by n, the number of measurements.

Mean: $$\bar{x} = \frac{\sum_i x_i}{n}$$

Where x_i is the individual measured value.
The standard deviation, s, measures how closely the data are clustered about the mean. The smaller the standard deviation, the more closely the data are clustered about the mean.
Standard deviation:

$$s = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{n-1}}$$

You will express your experimental results in the form:

Mean ± standard deviation

ACCURACY AND PERCENT ERROR

Accuracy refers to how close your result is to the true correct value. Sometimes the true value could be the theoretical value. Accuracy is expressed as % error. It is the % difference between the measured and the known true value.

$$\% \text{ Error} = \frac{\text{Error}}{\text{True value}} \times 100$$

$$= \left| \frac{\text{Experimental value - True value}}{\text{True value}} \right| \times 100$$

Example: A student, in three titrations, used 18.00 ml, 17.80 ml, and 18.90 ml of base to neutralize 10.00 ml acid.

a. What is the precision?

1. First, we will find the mean (average value) by adding all the measured values and divide by 3.

$$\overline{x} = \frac{18.00 \text{ ml} + 17.80 \text{ ml} + 18.90 \text{ ml}}{3} = \mathbf{18.23} \text{ ml}$$

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2. Second, we will find the deviation of each measurement.

   i. Deviation of the first measurement:

   (18.00– 18.23) ml = - 0.23 ml

   ii. Deviation of the second measurement:

   (17.80 – 18.23) ml = - 0.43 ml

   iii. Deviation of the third measurement:

   (18.90 – 18.23) ml = + 0.67 ml

3. Next, we will find standard deviation:

$$S = \sqrt{\frac{(-0.23)^2 + (-0.43)^2 + (+0.67)^2}{2}}$$

$$S = 0.59$$

The answer is 18.23 ± 0.59 ml

4. To calculate % deviation:

$$\% \text{ deviation} = \frac{\text{standard deviation}}{\text{mean value}} \times 100$$

$$\% \text{ deviation} = \frac{0.59 \text{ ml}}{18.23 \text{ ml}} \times 100$$

= 3.2 % **(the answer has 2 sig. figures)**

The answer is 18.23 ml ± 3.2 %

b. If the true value is 15.77 ml, calculate the accuracy of the experiment.

$$\% \text{ error} = \frac{|15.77 \text{ ml} - 18.23 \text{ ml}|}{15.77 \text{ ml}} \times 100 = \frac{2.46 \text{ ml}}{15.77 \text{ ml}} \times 100 = 15.6 \%$$

Exercise 1:
A chemist reports the following experimental values for the molar mass of an acid: 181.5, 188.0, 182.4, and 183.8g/mole. The correct molar mass of the acid is 181.2 g/mole.

a. Calculate the mean of the experimental results.
Setup:

b. Find the precision of the experiment expressed as standard deviation.
Setup:

_____g/mole ± _____g/mole

c. Find the precision expressed as % deviation.
Setup:

_____g/mole ± _____%

d. Find the accuracy of the experiment.
Setup:

% error = _____%

Exercise 2:

Ten samples of fertilizers were analyzed for the amount of phosphorus present expressed as milligrams per kg of fertilizer. The measurements were reported as follows:
6.62, 22.72, 6.02, 17.88, 6.72, 15.12, 11.08, 23.08, 21.58, 16.42
a. Calculate the precision as standard deviation.
Setup:

Standard deviation = $\pm$ _____ mg

b. Calculate the precision as % deviation.
Setup:

Percent deviation = $\pm$ _____ %

c. The true value of the mass of phosphorus present is 24.10 mg. Find the accuracy of the experiment.
Setup:

_____ %

Exercise 3:

Nitrite was measured in rainwater as mg/L and the following results were obtained: 0.079, 0.088, 0.073, 0.097, 0.070, and 0.068. The true value of the mass of nitrite present is 0.092 mg/L.

a. Calculate the precision as standard deviation.

Setup:

Standard deviation = $\pm$ _____mg/L

b. Calculate the precision as % deviation.

Setup:

Percent deviation = $\pm$ _____%

c. Find the accuracy of the experiment.

Setup:

_____ %

Exercise 4:

The Manganese content (measured as g/ kg of steel) of five samples of steel was reported by a chemist as follows: 145, 156, 132, 124, and 138. A Standard Reference Material is certified to contain 155 g manganese per kilogram of steel.

a. Calculate the precision as standard deviation.

Setup:

Standard deviation = $\pm$ _____g

b. Calculate the precision as % deviation.

Setup:

Percent deviation = $\pm$ _____%

c. Find the accuracy of the experiment.

Setup:

_____ %