

## Data Analysis

### A. Units and Conversion Factors\*

All measured quantities in your chemistry lab consist of a number and a unit. Therefore, you must include units in all your measurements and calculations. To convert units we use equivalent units, for example

$$\begin{aligned}1 \text{ mi} &= 5280 \text{ ft} \\1 \text{ g} &= 1000 \text{ mg} \\1 \text{ hr} &= 60 \text{ s}\end{aligned}$$

For the first example we can construct two conversion factors. One conversion factor (in red) can be obtained by dividing both sides by 5280 ft,

$$\frac{1 \text{ mi}}{5280 \text{ ft}} = \frac{5280 \text{ ft}}{5280 \text{ ft}} = 1$$

The other conversion factor can be constructed by dividing both sides by 1 mi,

$$\frac{1 \text{ mi}}{1 \text{ mi}} = \frac{5280 \text{ ft}}{1 \text{ mi}} = 1$$

Conversion factors are ratios used to express a quantity in different units. It is very easy to convert units. First, set the unit you are converting from (beginning unit) in the opposite position in the conversion factor so that it cancels and you are left with the unit you are converting to (final unit),

$$\text{beginning unit} \times \frac{\text{final unit}}{\text{beginning unit}} = \text{final unit}$$

For example, to convert the distance (e.g. 150 miles) from miles to feet, we use the conversion factor with miles in the denominator,

$$\text{Distance (ft)} = 150 \text{ mi} \times \frac{5280 \text{ ft}}{1 \text{ mi}} = 792,000 \text{ ft}$$

### B. Accuracy and Precision

A very important aspect of any experiment is to learn to apply the measures of *accuracy* and *precision* to **all** quantitative laboratory measurements. Accuracy is a measure of the agreement of a measurement with its **accepted** value. Usually, it is expressed as a percent error, which is defined by the equation:

$$\% \text{ error} = \frac{\text{measured value} - \text{accepted value}}{\text{accepted value}} \times 100$$

Accepted values for many properties are found in the *Handbook of Chemistry and Physics* or published in some other reputable source, such as textbooks or online. Any accepted value used in your report must be accompanied by a proper citation to the reference. The precision of a measurement is a measure of the mutual agreement of repeated determinations; it is a measure of the reproducibility of an experimental value. The most useful measure of precision is the

standard deviation (*std*). This is the range of values within which 68% of all measured values are likely to fall. The smaller this range, the more precise are the results. Standard deviation is given by the following formula:

$$std = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1}}$$

where  $N$  is the number of measurements and  $\bar{x}$  is their average. An example is shown below:

- For example, a student makes four measurements of the density of an object and obtains the values

10.10 g/cm<sup>3</sup>, 10.20 g/cm<sup>3</sup>, 10.12 g/cm<sup>3</sup>, and 10.15 g/cm<sup>3</sup>.

$i$	$x_i$ (g/cm <sup>3</sup> )	$x_i - \bar{x}$ (g/cm <sup>3</sup> )	$(x_i - \bar{x})^2$ (g/cm <sup>3</sup> ) <sup>2</sup>
1	10.10	0.04	$16 \times 10^{-4}$
2	10.20	0.06	$36 \times 10^{-4}$
3	10.12	0.02	$4 \times 10^{-4}$
4	10.15	0.01	$1 \times 10^{-4}$
	$\bar{x} = 10.14$		sum = $57 \times 10^{-4}$

$$std = \sqrt{\frac{57 \times 10^{-4}}{4 - 1}} = 0.04 \text{ g/cm}^3$$

These results would be reported as  $10.14 \pm 0.04 \text{ g/cm}^3$ . The smaller the standard deviation, the more closely each individual measurement agrees with the average value and the better the precision.

Remember, all entries in your lab book must be made, in ink, directly in your tables, in your book, before you leave the lab. All measurements made in the laboratory must be reported with an appropriate number of significant figures and with the correct units. This is a very important part of this experiment and all of the experiments which follow. It will always be a factor in the grade you receive for your lab report! It is not unusual to make measurements that give very suspicious results. A suspicious measurement can be ignored, if there are other good measurements and if there is reason to believe it is bogus. However, you must not remove or delete it from your report; simply draw a line through it and indicate why you are not using it for your average value. Just because it is not the result you think you should get is not a sufficient reason. You might consider putting a copy of this paragraph at the top of each experiment in your notebook. It is that important.

## Graphing Data in Microsoft Excel 2013 – The Basics

### A. Open Excel

**Start** → **Programs** → **Microsoft Office 2013** → **Excel 2013**

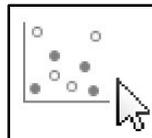
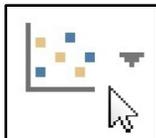
### B. Enter Data

1. In a single vertical column, enter all data to be plotted on the x-axis.
2. In the column immediately to the right, enter all data to be plotted on the y-axis.
3. Label your columns by placing a label at the top of each column.

volume (mL)	mass (g)
4.0	10.125
9.3	27.684
13.8	38.145
17.5	47.751

### C. Generating the Graph

1. Select all numerical data to be plotted.
2. Click the **INSERT** menu tab at the top → in the **Charts** category click **Insert Scatter (X, Y) or Bubble Chart** → click **Scatter** with no line (1<sup>st</sup> choice)



### D. Label Chart and Axes

#### A. Chart Title

1. Click on the default title, click again to get a cursor, then edit appropriately.

#### B. Axis Titles

1. Click on the chart and click the **Chart Elements** button.
2. Check **Axis Titles**.
3. Edit axis titles similarly to the chart title.



### E. Add a Trendline with Equation

1. Right-click on any data point in your graph → **Add Trendline...**
2. Under **TRENDLINE OPTIONS**, click: **Linear**  
**Display Equation on chart**  
**Display R-squared value on chart**

When done correctly, a plot of the data above should look like the graph on the next page.

### F. Printing Your Graph

#### A. To fill an entire page with one graph

1. Click on the graph → click **FILE** (top left corner) → **Print**
2. Inspect to make sure it is correct, select **Print** icon.

#### B. To place multiple small graphs on one page

1. If page borders are not visible, click the **PAGE LAYOUT** menu tab → in the **Gridlines** section of the **Sheet Options** category, check **Print**.
2. Arrange each graph to fill up one page, go to **FILE** → **Print** and preview to make sure it is correct, select **Print** icon.

## Part 2: Density of Aluminum Rods

