CH204 Experiment 1

Dr. Brian Anderson
Fall 2009

Are the Densities of Coke and Diet Coke Different?

$$d = \frac{m}{V}$$

Today

- **Error in experimental data**
  - **Random**
  - **Systematic**
  - **Gross**
- **Accuracy and precision**
  - **Accuracy – how close your final answer is to the correct one**
  - **Precision – how close your data points are to each other**

More Today

- **Significant digits**
  - **Count 'em!**
  - **Add and subtract 'em!**
  - **Multiply and divide 'em!**
- **Standard deviation**
  - **A statistical measure of random error**
- **Quick look at Experiment 1**

Significant digits

All non-zero digits are significant.

There are only two cases when zeroes are not significant:

36000
0.0075

All other zeroes are significant.

Significant zeroes

"Captive" zeroes are significant:

36,003
1.0075

Trailing zeroes after a decimal place are also significant:

0.00750

Multiplying and Dividing

Look for the number with the fewest significant digits, and use that many in your answer.

45,398 x 34.5 = 1,566,231
= 1,570,000

Adding and Subtracting

Look for the number with the <u>fewest decimal places</u>, and use that many in your answer.

$$\begin{array}{r} 55.685 \\ +\ \ 1.7 \\ \hline 57.485 \end{array}$$

How much does a quarter weigh?

Weigh a few more...

5.7128	5.6947
5.7085	5.6907
5.6106	5.6339
5.6009	5.7205
5.6466	5.7195

Now what does a quarter weigh?

Average = 5.67387 grams

There's got to be a better way!

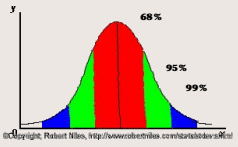
There is. Calculate the average ± standard deviation

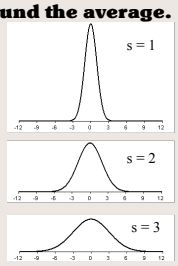
Standard deviation is a measure of the scatter in the data - and it also tells us how many decimal places we should keep in our average.

What is Standard Deviation?

It's a calculation based on a set of data points that tells us how widely the data points are scattered around the average.

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





Calculating Standard Deviation

This is 2009. Don't calculate it by hand. Use a built-in calculator function or use Excel.

Let's head to Excel right now and see how E-Z this is.

So now what does a quarter weigh?

5.67287 ± 0.046377 g

Variability occurs HERE

Report the final answer only up to the first uncertain digit – which is the same decimal place where the standard deviation falls.

Pay attention here

5.67287 ± 0.046377 g

Round the standard deviation to ONE significant digit: 0.05

Report the average only up to that same decimal place: 5.67

Variability (random error) limits your answer

5.67287 ± 0.046377 g

should be reported as

5.67 ± 0.05 g

And that's what a quarter weighs!

What do these numbers mean?

5.67 ± 0.05 g

68% of all quarters should weigh between 5.62 and 5.72 grams.

5.7128	5.6947
5.7085	5.6907
5.6106	5.6339
5.6009	5.7205
5.6466	5.7195

Variability limits significant digits

There were five significant digits in the mass of each quarter, but only three significant digits in the final result.

The last two digits are insignificant because they are less than the variability in the measurement.

"Variability in the measurement" is random error!

Ways of Determining Random Error

For a single reading:

- **Precision of the equipment**
- **Tolerance of the glassware**

For many readings:

- **Statistics**

That's what we're gonna do in lab today.

Std. Dev. = random error

We'll use this same procedure to determine random error and significant digits in Experiment 1.

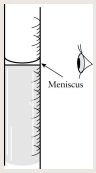
And speaking of Experiment 1...

Equipment

Graduated cylinder 0.1 ml

Volumetric pipette 0.01 ml

Burette 0.01 ml



Analytical balance

0.0001 grams!

Two-Part Lab

Part One:

- **Measure the mass of 5 mL of sample using the analytical balance and three different types of glassware (pipette, burette, and graduated cylinder).**
- **Calculate density. Total of six data points.**
- **Enter your results into the spreadsheet on the computer nearest the printer, and use all the class data in your report.**

Two-Part Lab

Part Two:

- **Dispense your assigned volume using a burette, and measure the mass of the sample on the analytical balance.**
- **Do NOT calculate density.**
- **Enter your mass and volume measurements into the spreadsheet on the computer nearest the door, and use all the class data in your report.**

Important!

You will need <u>all three</u> graphs:

Part One:

1 - Density chart and graph comparing different methods (includes average and standard deviation for each method).

Part Two:

2 - Mass vs volume graph for Coke

3 - Mass vs volume graph for Diet Coke

Handling bad data

If you know it's bad – because you know something went wrong, or because the number is physically impossible - you can discard it.

If you don't like it because it's widely scattered, you can't just toss it, you have to apply the Q-test (see the appendix of the lab manual).

Interpolation

In order to calculate the density of water at the same temperature as your Coke or Diet Coke sample, you will have to interpolate between the density values in the table on page 8 of the lab manual.

Final comments

When entering data, type with your fingerds, not wiht youpr thumbds.

Beakers are not volumetric!

Show your cleaned burette to your TA in order to get your data signed.

Final final comments

Next week: Final Exam, Part 1.

Bring a calculator!

- **Sample quizzes on the Freebies page.**

- **Play with the spreadsheet on the Freebies Page.**

- **Preliminary write-up 2: copy only first column from big table on page 16.**