Chapter 1: Sharpening the Math Toolbox

August 22, 2022

Chemistry Department, Cypress College

Outline

Introduction: Who Am I?

Review: Syllabus

Math Review for Chemist

Introduction: Who am I?

- Last June, graduated from University of California, Irvine, receiving my PhD in Computational and Theoretical Chemistry
- May refer me as Dr. Prof. Brian D. Nguyen
- Exercising, driving, hiking, learning new languages, and gaming

Teaching Philosophy

Humanist-inspired pedagogy:

- Student-teacher relationship is central
    - Mutual respect and growth
    - "Unconditional positive regard"
    - Awareness of the other and their thoughts/emotions
    - Teacher is coach/supporter/mentor rather than supervisor/boss
- Focus on attitude and approach rather than content
- Learning to fail
- Collaboration rather than competition
- Explore and experience something new together, learn about chemistry and ourselves

Making the Most of It

Questions to consider:

- Why am I taking this course?
- What would I like to achieve?
- What methods/tools/resources work for me?

Your feedback, questions, participation are vital:

- Attend lectures and discussions, if possible
- Give on-going feedback to instructors through facial expression, emojis, chat, email, during office hours etc.
- Fill out evaluations
- Own your education
- Be proactive, do not hesitate to speak up or get help

Introduction: Your Turn

With your notecard:

- Take 2-3 mins and write down your name on one side
- On the other side, write down something that I can remember you by

Outline

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Chemistry is necessarily an experimental science: its conclusions are drawn from data, and its principles supported by evidence from facts. - Michael Faraday

Scientific Notation

The scientific notation is expressed

$$N = C \times 10^m \tag{1}$$

where N is a large number, C is the coefficient (a number between $1 - 9$) and m is the exponent (a positive or negative integer)

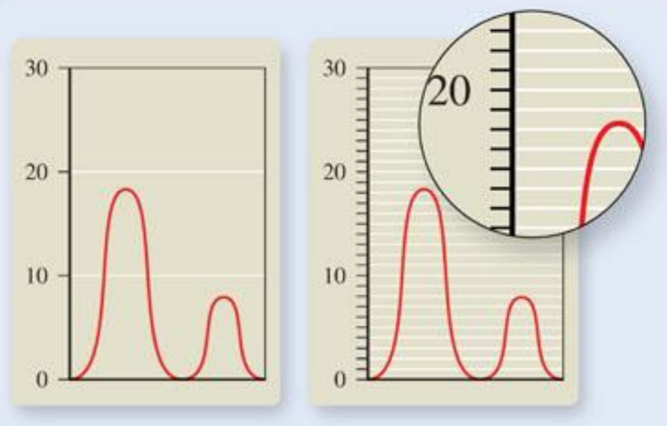
Example: $0.00363246 = 3.63246 \times 10^{-3}$

Significant Figures

- The meaningful digits in a measured or calculated quantity
- Example: $0.00363246 \simeq 3.63 \times 10^{-3}$ to three sig figures
- Implies relative accuracy of 10^{-m}, e.g. 0.1% for $m = 3$

- For practice, what is the measured volume for the liquid above?

Significant Figures - More Practice!



Which is relatively more accurate? What is the approximate measurement for each graph? What is missing?

Counting Significant Figures

All **non-zero** numbers in a measured number are significant

Practice: What is the number of significant figures?

- 36.1 ft
- 1 dozen eggs
- 155.6 lbs

Leading, Sandwiched and Trailing Zeroes

Leading zeroes: Precede non-zero digits in a decimal number are **not** significant

Sandwiched zeroes: Occur between nonzero numbers are significant

Trailing zeroes: Following non-zero numbers are significant in numbers with a decimal point

Leading, Sandwiched and Trailing Zeroes

Practice: What is the number of significant figures?

- 0.0702 lb
- 48600 L
- 100.000 g
- 1.020 atm
- 9.01×10^5 m

Calculated Answers

- Answers must have the same number of significant figures as the least precise measured number(s)
- Calculator answers must often be **rounded off**
- **Rounding rules** are used to obtain the correct number of significant figures

Practice: Round to four significant figures.

- 824.75143 cm
- 0.112544 g

Calculation: Rules for Rounding

Rule 1: In carrying out a multiplication or division, the answer cannot have more significant figures than either of the original numbers.

Example:

$$\frac{278\text{mi}}{11.70\text{gal}} = 23.8\text{mi/gal} \tag{2}$$

Calculation: Rules for Rounding

Rule 2: In carrying out an addition or subtraction, the answer cannot have more digits after the decimal point than either of the original numbers or more digits after the leftmost uncertain digit than either of the original numbers.

Example:

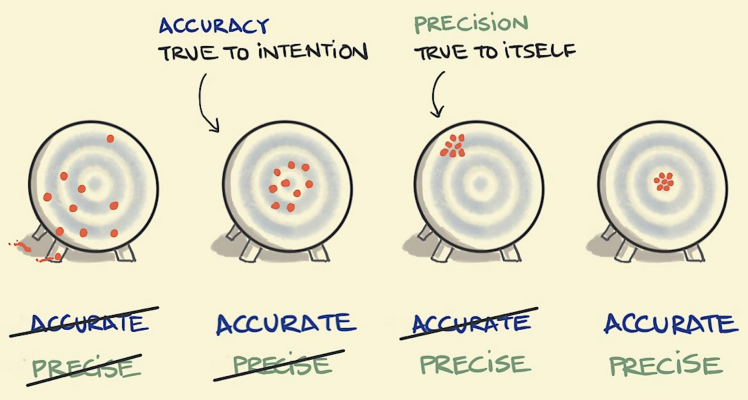
$$3.18\text{L} + 0.01315\text{L} = 3.19\text{L} \tag{3}$$

TIPS: Avoid Rounding Errors

- Carry at least 2 extra significant figures in intermediate results!
- You will need to report your results *exactly* to a given precision
- Round at the very end

Accuracy vs. Precision

What is the difference between accuracy and precision?



Accuracy vs. Precision

Accuracy

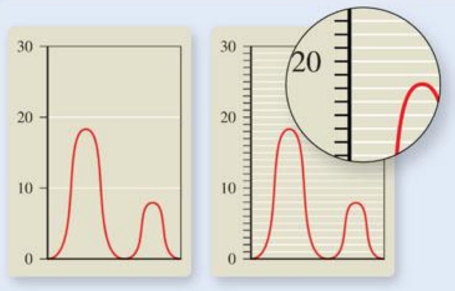
- How close you are to the actual value
- Calculated by the forumula

$$\%\text{Error} = \frac{\text{measured} - \text{actual}}{\text{actual}} \tag{4}$$

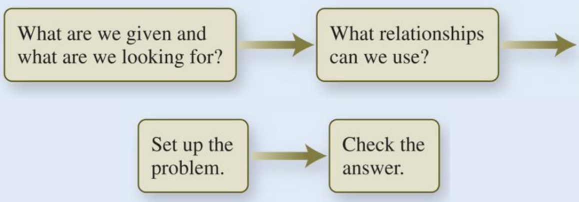
Precision

- How finely tuned your measurements are or how close they can be to each other
- Depends on the measuring tool
- Implied by the number of significant figures

Importance of Units



- Numbers with no units have **no** meaning
- As scientists, we look at the following



Prefixes of Metric System

Giga (G)	Mega (M)	kilo (k)	hecto (h)	deca (da)
$\left(\frac{1\ \text{Gm}}{1\times10^{9}\ \text{m}}\right)$	$\left(\frac{1\ \text{Mm}}{1\times10^{6}\ \text{m}}\right)$	$\left(\frac{1\ \text{km}}{1000\ \text{m}}\right)$	$\left(\frac{1\ \text{hm}}{100\ \text{m}}\right)$	$\left(\frac{1\ \text{dam}}{10\ \text{m}}\right)$
$\left(\frac{1\times10^{9}\ \text{m}}{1\ \text{Gm}}\right)$	$\left(\frac{1\times10^{6}\ \text{m}}{1\ \text{Mm}}\right)$	$\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)$	$\left(\frac{100\ \text{m}}{1\ \text{hm}}\right)$	$\left(\frac{10\ \text{m}}{1\ \text{dam}}\right)$

Basic Units

- meter (m)
- gram (g)
- Liter (L)
- second (s)
- mole (mol)
- calorie (cal)
- Joule (J)

deci (d)	centi (c)	milli (m)	micro (μ)	nano (n)
$\left(\frac{10\ \text{dm}}{1\ \text{m}}\right)$	$\left(\frac{100\ \text{cm}}{1\ \text{m}}\right)$	$\left(\frac{1000\ \text{mm}}{1\ \text{m}}\right)$	$\left(\frac{1\times10^{6}\ \mu\text{m}}{1\ \text{m}}\right)$	$\left(\frac{1\times10^{9}\ \text{nm}}{1\ \text{m}}\right)$
$\left(\frac{1\ \text{m}}{10\ \text{dm}}\right)$	$\left(\frac{1\ \text{m}}{100\ \text{cm}}\right)$	$\left(\frac{1\ \text{m}}{1000\ \text{mm}}\right)$	$\left(\frac{1\ \text{m}}{1\times10^{6}\ \mu\text{m}}\right)$	$\left(\frac{1\ \text{m}}{1\times10^{9}\ \text{nm}}\right)$

Unit Conversion

Dimensional Analysis: A quantity in one unit is converted to an equivalent quantity in a different unit by using conversion factors that express the relationship between units.

$$\text{(Starting quantity)} \times \text{(Conversion factor)} = \text{Equivalent quantity} \tag{5}$$

Examples:

- 1 min = 60 secs
- 1 lb = 16 oz
- 2.20 lb = 1 kg
- 2.54 cm = 1 in

Relating Mass and Volume

- Density (D) is a convenient means of obtaining the mass (M) from its volume (V) or vice versa

$$D = M/V \tag{6}$$

Strategy for Dimensional Analysis

1. Identify the information given and the information needed to answer.
2. Find the relationship(s) between the known information and unknown answer, and plan a series of steps, including conversion factors, for getting from one to the other.
3. Solve the problem by canceling units.
4. Check the answer to make sure it makes sense, both in magnitude and units.

Whiteboard: Dimensional Analysis