CHEM 205 section 03

LECTURE #3 Thurs. Jan.10, 2008

ASSIGNED READINGS:

TODAY'S CLASS: finish Ch.1

NEXT CLASS: most of Ch.2

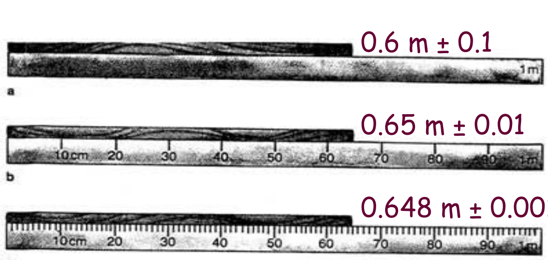
http://artsandscience.concordia.ca/facstaff/P-R/rogers

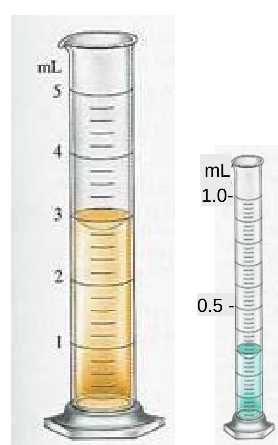
(1)

Quantitative observations continued - **All measurements are somewhat UNCERTAIN…**

- Digits unambiguously read off a scale are ***certain*** (= ***known exactly***)
- The last digit reported is always ***estimated*** & is called ***uncertain***.
  - Important: the estimated digit is not certain, but it is ***significant***.
    - Digital scale: machine estimates last digit
    - Analog scale: you estimate by reading between gradations

Using scales of differing precision





(2) From Addison-Wesley's *Chemistry* (highschool text…) & Zumdahl's *Chemistry*, 7th Ed.

Where does uncertainty come from?
"SOURCES OF ERROR"

- **Random Error**
  (Indeterminate Error)
  - Measurement has an equal probability of being high or low.
  - Usually unavoidable.

  Magnitude determined by:
  - size of scale's divisions

  Direction determined by:
  - random: varies each time
    last digit is estimated

e.g., uncertainties in lengths & volumes on last slide…

- **Systematic Error**
  (Determinate Error)
  - Occurs in the same direction each time (too high, too low).
  - Often results from poor technique or poor expt design

  Magnitude determined by:
  - size of scale's divisions
  - worker's attention to detail

  Direction determined by:
  - calibration of instrument

e.g., bathroom scale offset…

(3)

Accuracy *vs.* precision: describing your data

- Accuracy: refers to the agreement of a particular value with the true value (or accepted value)

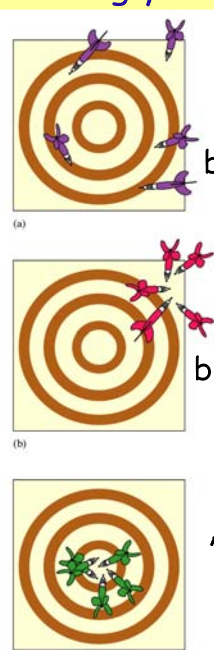
Error (*or* x100 for % error) =

$$\frac{\text{Average exp'tal value} - \text{true value}}{\text{true value}}$$

- Precision: refers to the degree of agreement among several measurements of the same quantity.

Deviation (for each measurement) =
Exp'tal measurement – average value

Standard deviation? see Kotz p.33



ACCURATE
but imprecise

PRECISE
but inaccurate

ACCURATE
and
PRECISE

Rules for Counting Significant Figures p.33-34

- Non-zero integers always count as significant figures.
  345 m has 3 SF (the last is uncertain, but still significant).
- ZEROS:
  - Leading zeros do NOT count as significant figures.
    0.0486 g has 3 SF
  - Trailing zeros are significant **only if** the number contains a decimal point.
    9.300 L has 4 SF
    9300 L = 9.3×10^3 has 2 SF
    9300. L = 9.300×10^3 has 4 SF
  - Captive zeros DO count as significant figures.
    16.07 mL has 4 SF
    203 °C has 3 SF
- Exact numbers (defined quantities, reference values, # counted):
  infinite # of SF: oxygen 16.00 g/mol, 73 students…

THE GOAL: to make sure our numerical data **honestly reflect** the level of uncertainty provided by our instrument/method

Rules for Sig. Fig's in Mathematical Operations

- Rounding: Round up if 1st non-significant figure is ≥ 5
- Addition and Subtraction: # sig figs in the result **is limited by** the number of decimal places in the least precise measurement (piece of data) used in calculation
  ⇨ keep *lowest* # decimal places in answer

$$\begin{array}{r} 6.8 \\ +\ 11.954 \\ \hline 18.754 \end{array}$$?

✓ = 18.8 (3 SF)

- Multiplication and Division: # sig figs in the result **is same as** the number of sig figs in the least precise measurement:
  $6.38 \times 2.0 = 12.76$? ✓ = 13 (2 SF)

THE GOAL: to make sure our numerical results **honestly reflect** the level of uncertainty in the raw data used…

Drawing reasonable conclusions (according to data's SF…)

There are 5 hydrocarbons (compounds containing carbon & hydrogen) with formula C_6H_{14}, with a different "connectivity" of atoms. All 5 are liquids at room temperatures, but they have slightly different densities.

Hydrocarbon isomer	Density (g/cm^3)
2,2-dimethylbutane	0.6600
2-methylpentane	0.6532
1-methylpentane	0.6645
hexane	0.6616
3,3-dimethylbutane	0.6485

Data for your pure sample	
Volume	5.0 cm^3
uncertainty	
Mass	3.2745 g
uncertainty	
Density	
uncertainty	

You have a pure sample of one of these isomers, and you hope to identify it by its density. You measure the volume of your sample using a graduated cylinder, and its mass using an analytical balance.

1.) What is the density of the liquid?

2.) Can you conclude its identity within the limits of your exp'tal error?

(7) 3.) If you make a more accurate volume measurement of 4.93 cm^3, how does your conclusion change?

Multistep calculations: avoiding rounding error

- Follow order of operations: ( ) 1st, then ×/÷, then +/-
- For EACH operation: apply matching SF rule… BUT… keep 1-2 extra SFs for next step
- At very end: round off to appropriate # SFs for last step

Ex.: how many SFs should this density value have?

$$\frac{\text{Mass (by difference)}}{\text{Volume (of spherical sample)}} = \frac{18.32\times10^2\text{ g} - 9.262\times10^2\text{ g}}{{}^4/_3\ \pi\ (3.051\text{ cm})^3}$$

After 1st 2 steps: (not yet rounded)

$$= \frac{9.058\times10^2\text{ g}}{{}^4/_3\ (3.141593\ldots)(28.4005\text{ cm}^3)}$$

SF? SF?

After rest of steps: (not yet rounded) $= 7.61407\text{ g/cm}^3$

(8) **Possible values: (choose 1…)**

a) 7.6141 g/cm^3 b) 7.614 g/cm^3 c) 7.61 g/cm^3 d) 7.6 g/cm^3

1.8 Problem solving – *interpret, plan, execute.*

1. **Interpret** the question
   - Determine what the problem is asking.
2. Develop a **plan** of attack.
   - *Identify key principles*
   - *Sketch diagram / write chemical equation*
   - *Organize information: known vs. unknown; + units.*
   - *Break problem into simpler ones…*
3. **Execute** the plan.
   - *Include all units…do they give desired units at end?*
   - *Don't skip steps.*
4. **Check** your answer.
   - *Common sense – is it a reasonable number ?*
   - *Verify number of significant figures.*

(9)

ASSIGNED READINGS

- BEFORE NEXT CLASS:

Read Ch. 1 (all)
including "math of chemistry" section
& work on exercises from Ch.1 (including math!)

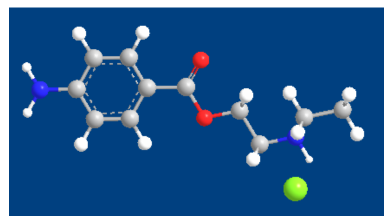
- **LABS & TUTORIALS START THIS WEEK.**
  ARRIVE PREPARED: lab coat, safety glasses
  lab manual
  completed Expt. #1 prelab.
- **CHEM 101 SEMINARS ARE THIS & NEXT WEEK.**
  SIGN UP AT CHEMISTY MAIN OFFICE: SP-201.01

(10)

What drug dose was given?

Ch.1 #43: The anesthetic **procaine hydrochloride (novocaine)** is often used to deaden pain during dental surgery.

The compound is packaged as a 10.% solution (by mass; *d* = 1.0 g/mL) in water. If your dentist injects 0.50 mL of this solution, **what mass of procaine hydrochloride (in mg) is injected?**



(11) *ANS: 50. mg = 5.0×10^1 mg (2 SF)*

Sterling silver: what is its composition?

Sterling silver is a solid solution or "alloy" of silver (Ag) and copper (Cu). If a piece of a sterling silver necklace has a mass of 105.0 g and a volume of 10.12 mL, calculate the mass percent of silver in the necklace.

Assume that the volume of silver present plus the volume of copper present equals the total volume.

DATA: d_{Ag} = 10.5 g/cm^3 d_{Cu} = 8.96 g/cm^3

Hint: find a set of 2 equations & 2 unknowns

Zumdahl's Chemistry, 7th Ed., Ch.1 #87 ANS: 93.0% Ag (& rest Cu)