Chemistry BC2001x:
Lab Week 5
Gases

"She was beautiful but volatile. Her blood was gasoline."

Important vocabulary:

PRECISION

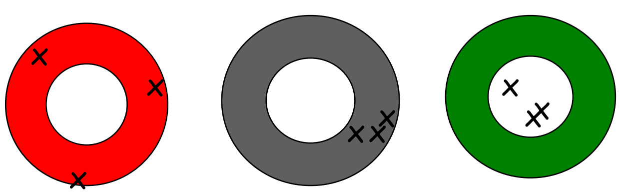
How close a series of measurements are to each other.

ACCURACY

How close a series of measurements are to the correct value.

Precision and Accuracy

- **Results can be precise but not accurate, accurate but not precise.**
- **Naturally, we want them to be both precise and accurate!**



Determining precision

- **Carry our a measurement several times, and compare! --- replicate measurements**
- **How do we measure precision?**
- **Look at deviations among measured values.**

Determining precision: example

Example: measure mass of an object

Trial	mass (g)
1	32.3
2	31.8
3	31.9
mean	32.0

The average or mean is the best estimate of the true value.

Determining precision: example

Deviations from the mean (32.0 g):

Trial	mass (g)	Deviation (g)
1	32.3	+0.3
2	31.8	-0.2
3	31.9	-0.1

Deviations have signs (+ or −)

Mathematically, their average value is zero!

But the average of the absolute values

gives a useful estimated measure of precision:

$(0.3 + 0.2 + 0.1)/3 = 0.6/3 = 0.2$

called "average deviation"

equal to half the difference, for two values

Reporting precision

- Report the result as 32.0 ± 0.2 g
- The average deviation is written with one digit (since it represents the uncertainty).
- The value with which it is associated is written to the same decimal place as the deviation (here, to the nearest tenth).
- The average deviation is an experimental measure of precision: a smaller average deviation means a more precise result.

Assessing precision

How do we know whether precision is good?

It depends on the experiment!

This is why we do uncertainty analysis:
estimation of maximum uncertainty

Make reasonable guesses about uncertainties in each step of the procedure

Combine them to obtain the estimated uncertainty of final result

Compare this estimate with the experimental deviation.

Example for today's experiment later ..

Assessing accuracy

How do we know whether accuracy is good?

IN GENERAL, MUCH HARDER

We would need to know the right answer, but then would this be an "experiment"?

(However it might be a good exercise to learn or test a technique.)

Two possible ways to assess accuracy:

measure the quantity using different methods

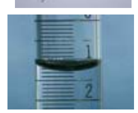
calibrate the method with a known, then use for the unknown.

What influences precision and accuracy?

- Sources of uncertainty can be divided into two classes: systematic and random
- Random errors will make result too high or too low with same average frequency
- Systematic errors cause deviations in the same direction each time.

Random errors: examples

- reading a length from a ruler
- reading the mensicus of a buret
- reading the hands of a clock
- reading a thermometer



Random errors

Random sources of uncertainty cannot be avoided!

Random errors will cancel each other, on average, with repeated measurements.

Random errors influence precision not accuracy, when enough measurements are done.

This is the main reason we repeat experiments!

The average result is more reliable than any one measurement because of some cancellation of random errors.

Systematic errors: examples

- Taking readings with a stretched tape measure
- Using a badly manufactured 10.00 mL pipet: Class A glassware has tolerance 10.00 ± 0.02 mL even used correctly, one might deliver 9.98 mL (class B glassware can be off by more!)
- Poor technique: using a good pipet, but not letting it drain sufficiently, or blowing out the last drop

Systematic errors

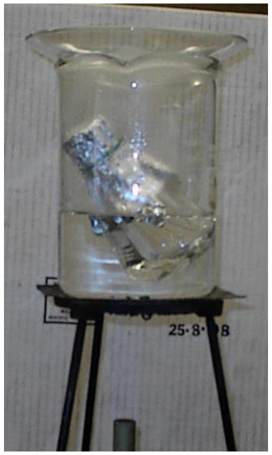
- Systematic errors cause deviations in the same direction each time.
- They do not cancel out in repeated measurements
- Systematic errors influence the accuracy of results.
- Careful calibration of equipment may help minimize systematic errors.
- Some steps in a procedure may be subject to both systematic and random errors.

MOLECULAR WEIGHT OF A VOLATILE LIQUID: PROCEDURE

- Weigh empty flask and sealing material (Al foil, Cu wire).
- Add unknown liquid (from vial) to flask.
- Seal flask. [Seal keeps liquid from escaping, but allows outflow of gas under pressure.]
- Put flask in boiling water until all liquid in flask vaporizes.

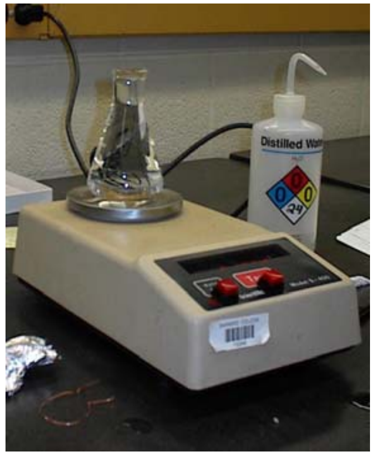
MOLECULAR WEIGHT OF A VOLATILE LIQUID: PROCEDURE

- Most gas escapes. [For gas that remains, P(gas) = P(room).]
- Record the temperature of the boiling water.
- Record the room pressure, with the barometer correction.
- Remove the flask and let it cool. [Vapors of the unknown substance will recondense to liquid.] Weigh flask + liquid.



MOLECULAR WEIGHT OF A VOLATILE LIQUID: PROCEDURE

- Empty the flask.
- Fill it to the rim with water and reweigh it, including the foil and the wire.
- Has this person done the correct thing?
- NO: the foil and wire are not being weighed.
- Look up and record density of water at room temperature



MOLECULAR WEIGHT OF A VOLATILE LIQUID
Calculations and discussion of results

SAMPLE DATA (for one of two determinations):

w = 0.4808 g   T = 100.5°C

P = 758.4 mmHg   V = 125.1 mL

EQUATIONS:

Molecular weight $M = w/n$ and $PV = nRT$

$n = PV/RT$, so $M = w/(PV/RT)$

thus $M = wRT/PV$

RESULTS for two runs (with average deviation)

$M = 118.1 \pm 0.4$ g/mole

MOLECULAR WEIGHT OF A VOLATILE LIQUID
Calculations and discussion of results

Results from two runs: $M = 118.1 \pm 0.4$ g/mole

Suppose the estimated uncertainty is ± 0.7 g/mole

The precision is quite good:
average deviation 0.4 < estimated unc. 0.7

Suppose the liquid is chloroform: $CHCl_3$
from the formula, $M = 119.378$ g/mole.

What is the experimental error or discrepancy?

Error = (exptl value) – (true value)
= 118.1 – 119.378 = –1.3 g/mol

MOLECULAR WEIGHT OF A VOLATILE LIQUID
Calculations and discussion of results

Error = (exptl value) – (true value)
= 118.1 – 119.378 = –1.3 g/mol

The sign indicates that this answer is too small.

The magnitude of this error is larger than the estimated uncertainty (1.3 > 0.7) so the accuracy is not very good.

Why?
What are possible sources of systematic error?