Lecture 2: Measurements (Chapt. 1)

Units

- SI units – most scientist use
- Prefixes - quick way to convey exponential notation
- Conversion – units in same system and different systems

❖ Example

Convert 23 lb_m ft/min^2 to its equivalent in kg cm/s^2 (force)

$$\frac{23\ lb_m\ ft}{min^2}\left|\frac{0.454\ kg}{1\ lb_m}\right|\frac{100\ cm}{3.281\ ft}\left|\frac{1\ min^2}{(60)^2 s^2}\right. = 0.88\ kg\ cm/s^2$$

Prefixes

Factor	Name	Symbol	Factor	Name	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	μ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da	10^{-24}	yocto	y

http://physics.nist.gov/cuu/Units/prefixes.html

Chemical Concentrations

Definitions:

- Solute – minor species in solution
- Solvent – major species in solution
- Concentration – how much solute is in solvent
- Mole – Avagadro's number of particles (6.02×10^{23})
- Molarity – moles per liter
- Molality – moles per 1 kg of solvent
- Atomic mass – grams per mole of element
- Molecular mass - grams per mole of molecular species
- Formal concentration – moles per liter of electrolyte (converted to other species)
- Formula mass – sum of atomic masses of atoms in formula

Example: Determining molarity and molality

A solution with a final volume of 500.0 mL was prepared by dissolving 25.00 mL of methanol (CH_3OH, density = 0.7914 g/mL) in chloroform.

a) Calculate the molarity of methanol in the solution

b) The solution density of 1.454 g/mL. Find the molality of methanol.

Percent composition

$$\text{Weight percent} = \text{wt \%} = \frac{\text{Mass of solute}}{\text{Mass of total solution or mixture}} \times 100$$

$$\text{Volume percent} = \text{v \%} = \frac{\text{Volume of solute}}{\text{Volume of total solution}} \times 100$$

Parts per Million = grams of substance per 10^6 grams of total solution
"ppm"

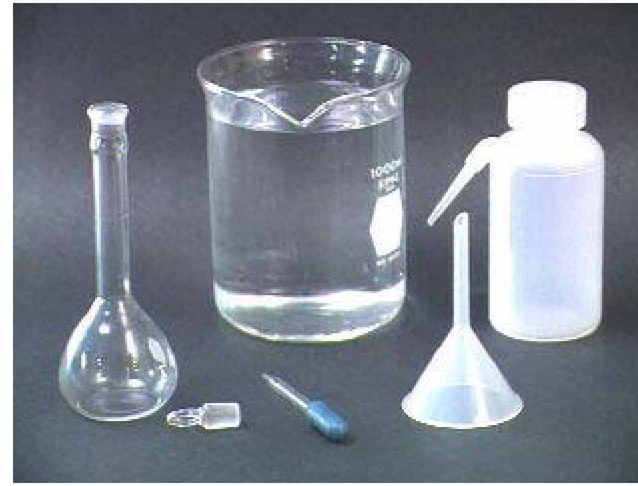
Parts per Billion = grams of substance per 10^9 grams of total solution
"ppb"

The concentration of Pb in water delivered by Dr. K's former favorite drinking fountain is 0.252 mg/L.

- What is the Pb concentration in molarity?
- How many Pb atoms per gallon?
- The lead drinking water standard is currently 15 μg/L. Does this fountain violate the standard?

http://www.epa.gov/safewater/sdwa/sdwa.html

Preparing Solutions



Typically – weigh out desired about of solute and dissolve in solvent using volumetric flask

Dilutions

IMPORTANT FORMULA –

$$C_{conc} \ \text{x} \ V_{conc} = C_{dil} \ \text{x} \ V_{dil}$$

Example: Prepare 300 ml of a 0.100 M HCl solution from conc. HCl (≈ 12. 1 M).

C_{conc} =

V_{conc} =

C_{dil} =

V_{dil} =

Stoichiometry

- Balancing chemical equations
- Calculating equivalent quantities
- Determining excess and limiting reagents
- Determining theoretical and actual yields
- Use of solution concentration units in basic stoichiometric calculations
- Preparing solutions and dilutions

$$Th^{4+} + 4\,F^{-} \rightarrow ThF_4(s)$$

Chapter 2 – Tools of the Trade

Safety

- Primary safety rule (from Harris): to familiarize yourself with the hazards and do nothing that you or your instructor/supervisor would consider to be dangerous.
- Added thoughts: Not only be familiar with hazards, think about how the hazard could be mitigated if an accident or problem arises. Also, be familiar with hazards present in the lab that are not associated with your experiment.

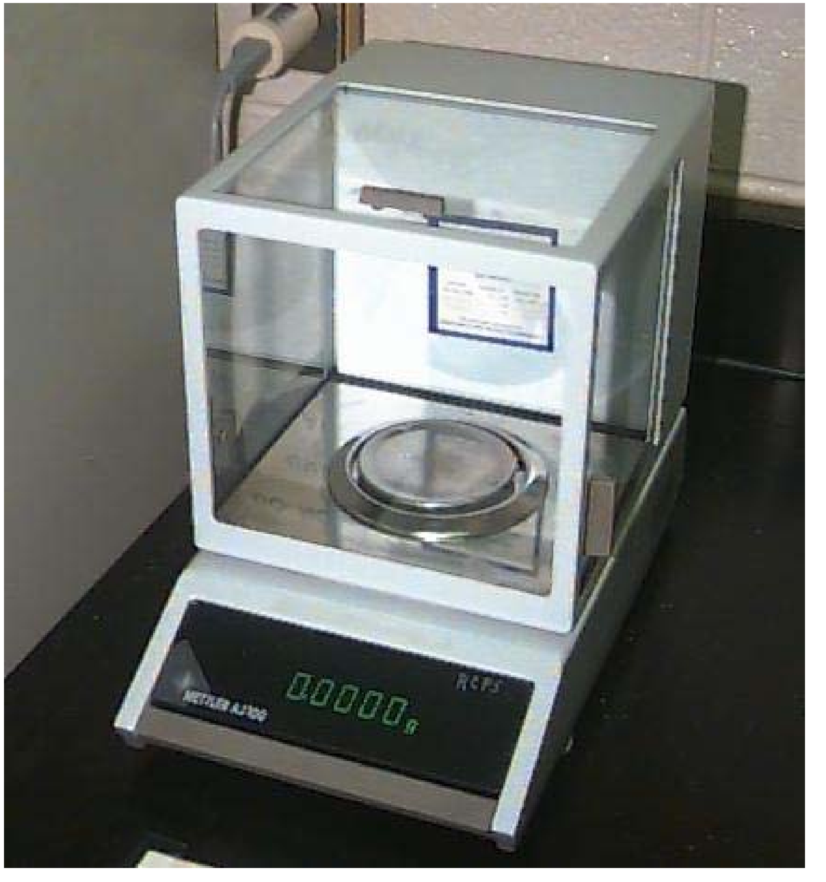
Laboratory Notebook - Purpose

- State what was done.
- State what was observed.
- Be understandable to someone else.

(More detail and notes is the best approach.)

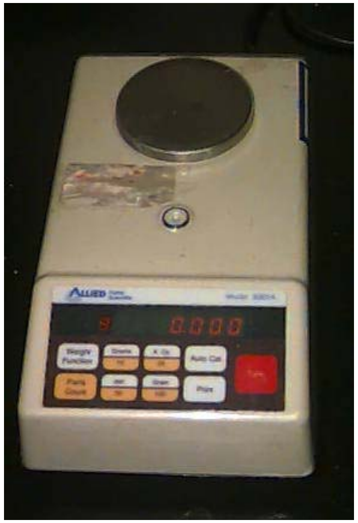
Measuring mass

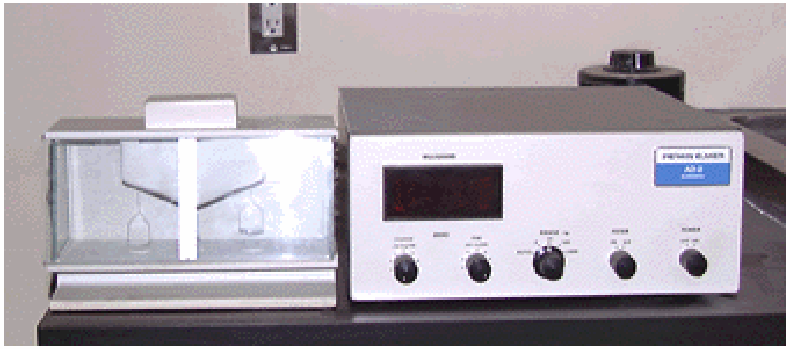
- "Weighing" is a misnomer
- Mass = amount of matter, whereas weight is gravitational force
- Measurement of mass is the most basic measurement in chemistry



Types of balances

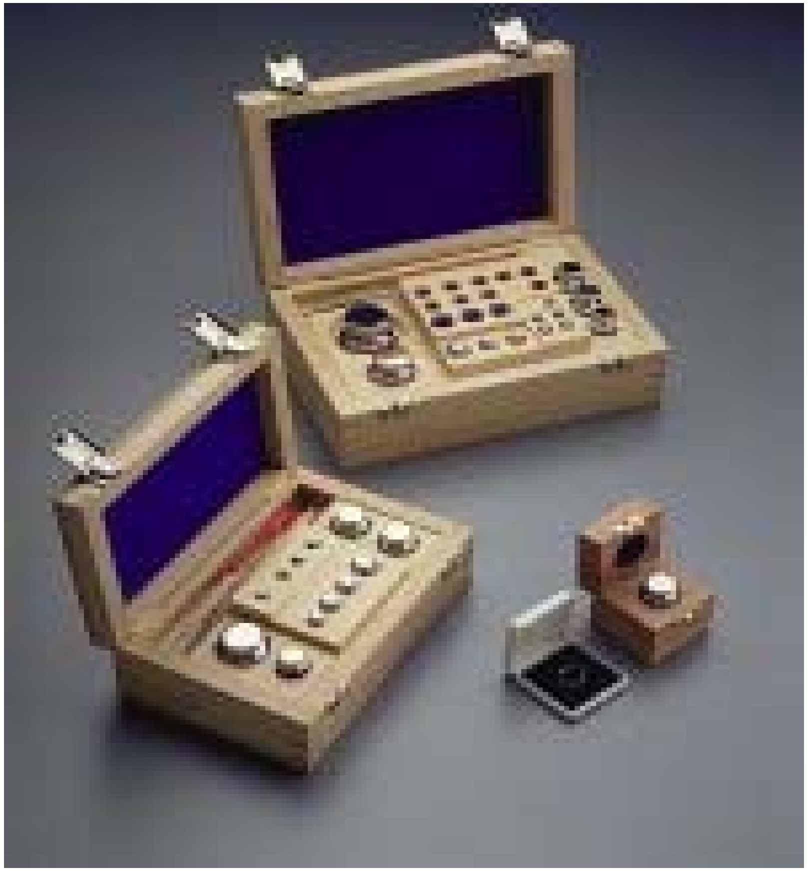
- Toploading balance - reads to nearest 1 g, 0.1 g, 0.01 g, or 0.001 g
- Analytical balance - 0.0001 or 0.00001 g readability
- Microbalance - readability to 1 μg or less





Standard masses

- Balances are calibrated by comparison to mass standards, which are hopefully “traceable” to NIST or equivalently certified standards

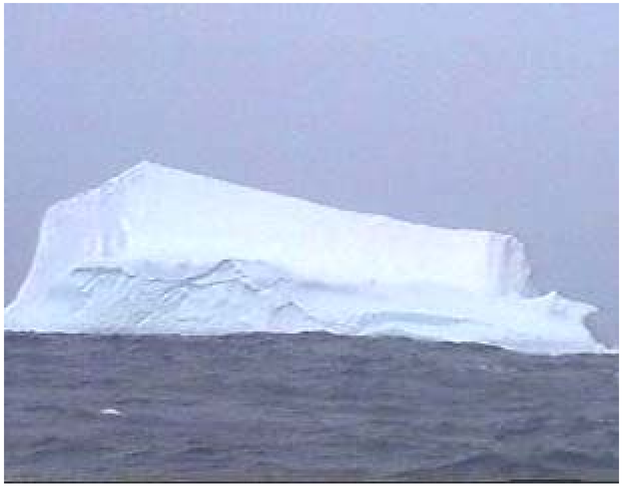


http://www.mt.com/home/products/en/lab/weighing/weigh.asp

The buoyancy problem and its correction

- The measured mass of an object is less than its true mass based upon the mass of the air the object displaces
- Also affects comparison masses (weights)
- The densities of the object and comparison weights are important

See Fig. 2-6 Harris



The buoyancy correction formula

- $M_{true} = \quad M_{meas} (1 - \rho_{air}/\rho_{wts}) / (1 - \rho_{air}/\rho_{obj})$

where

- – M_{true} =true mass of object
- – M_{meas} =measured mass of object
- – ρ_{air} = air density (g/cm^3)
- – ρ_{wts} = density of balance weights (g/cm^3)
- – ρ_{obj} = density of object being weighed (g/cm^3)

http://www.cae.wisc.edu/~pchaopri/set1_2.htm

Calculate the percent error in a pipet calibration with air buoyancy effects

A 25 mL Class A pipet is calibrated by "weighing" the water delivered into a tared open beaker. The measured mass of the water is 24.9326 g. What is the true mass of the water?

ρ_{air} = 0.0012105 g/cm^3

ρ_{water} = 0.99774 g/cm^3

ρ_{wts} = 8.6809 g/cm^3