General Chemistry I, CHEM 103

Lecture 1: Measurements, mathematical treatment of measurements and dimensional analysis I

(aka the math you need to know for Gen Chem)

Chapter 1 from textbook

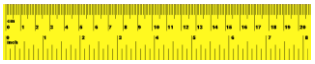
Units 1.4-1.6

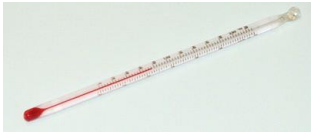
Math you need to know in Chem 103

- Metric system and unit conversion
- Significant figures
- Scientific notation and exponents
- Dimensional analysis

Metric system: base and derived units (SI units)

Base Units		
Length	meter	m
Mass	kilogram	kg
	gram	g
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
Amount of substance	mole	mol
Luminous intensity	candela	cd
Some Derived Units		
Area	square meter	m^2
Volume	cubic meter	m^3
	liter	L (= dm^3)





Metric system: prefixes

Most commonly used in genchem (memorize these):

Kilo	k	10^{3}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	μ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}

List of Prefixes in the Metric System

Prefix	Symbol	Numerical Value	Exponential Value
quetta	Q	1,000,000,000,000,000,000,000,000,000,000	10^{30}
ronna	R	1,000,000,000,000,000,000,000,000,000	10^{27}
yotta	Y	1,000,000,000,000,000,000,000,000	10^{24}
zetta	Z	1,000,000,000,000,000,000,000	10^{21}
exa	E	1,000,000,000,000,000,000	10^{18}
peta	P	1,000,000,000,000,000	10^{15}
tera	T	1,000,000,000,000	10^{12}
giga	G	1,000,000,000	10^{9}
mega	M	1,000,000	10^{6}
kilo	k	1,000	10^{3}
hecto	h	100	10^{2}
deka	da	10	10^{1}
no prefix		1	10^{0}
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	μ	0.000001	10^{-6}
nano	n	0.000000001	10^{-9}
pico	p	0.000000000001	10^{-12}
femto	f	0.000000000000001	10^{-15}
atto	a	0.000000000000000001	10^{-18}
zepto	z	0.000000000000000000001	10^{-21}
yocto	y	0.000000000000000000000001	10^{-24}
ronto	r	0.000000000000000000000000001	10^{-27}
quecto	q	0.000000000000000000000000000001	10^{-30}

Practice unit conversions

- The length of the bond between two hydrogen atoms in a H_2 molecule is 74 pm. How much is that in meters?
- A wavelength corresponding to blue light is 475 nm. How much is that in cm?
- A drop of water has a volume of 50 µL. How much is that in mL?

$m = 10^9\ nm$

- $74\ pm = 74\ pm \dfrac{1\ m}{10^{12}\ pm} = 74 \cdot 10^{-12}\ m$

- $475\ nm = 475\ nm \dfrac{1\ m}{10^9\ nm} \dfrac{100\ cm}{1\ m} = 475 \cdot 10^{-9} \cdot 10^2\ cm$

$= 475\ 10^{-7}\ cm$

$= 4.75 \cdot 10^{-5}\ cm$ scientific notation

- $50\ \mu L = 50\ \mu L \dfrac{1\ L}{10^6\ \mu L} \dfrac{10^3\ mL}{1\ L}$

$= 50 \cdot 10^{-3}\ mL = 0.05\ mL$

Metric system/SI units practice

Give the derived SI units for each of the following quantities in base SI units:

- Acceleration = distance/time^2
- Force = (mass)(acceleration)
- Work =(force)(distance)
- Pressure = force/area
- Power = work/time
- Velocity = distance/time
- Energy = (mass)(velocity)^2

Some useful exponent rules

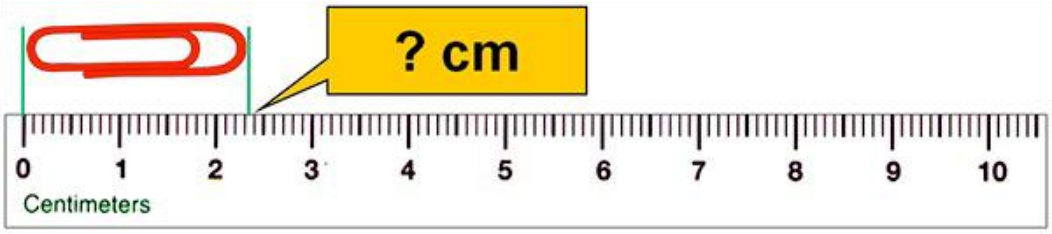
For $a > 0$, $b > 0$, x, y, *and* n *Real Numbers*

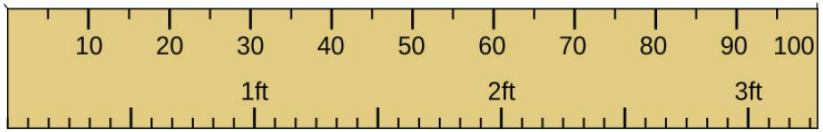
1. $a^x = a^y \iff x = y$
2. $a^x a^y = a^{x+y}$
3. $\frac{a^x}{a^y} = a^{x-y}$
4. $a^{-x} = \frac{1}{a^x}$
5. $(a^x)^y = a^{xy}$
6. $a^x b^x = (ab)^x$
7. $a^{\frac{x}{y}} = \sqrt[y]{a^x} = (\sqrt[y]{a})^x$ for x and y integers > 1
8. $a^0 = 1$
9. $a^1 = a$
10. $1^x = 1$

Exact vs. inexact numbers

- Exact numbers
  - Counted objects (so we know the number exactly by counting)
    - 5 beakers
  - Conversion factors that are exact by definition
    - Metric multiples and submultiples of a unit (e.g., 1 m = 100 cm)
    - 1 in = exactly 2.54 cm
  - Many physical constants
    - Avogadro constant, ideal gas constant, Planck constant, speed of light…

- Inexact numbers
  - Numbers obtained through measurement (using human made tools that by their nature have a precision limit) directly or indirectly





Significant figures

- Significant figures are the digits in a number that carry meaningful information about its precision. In science and engineering, no measurement is perfect. Significant figures prevent you from claiming your data is more precise than it actually is.

$200

- Are these numbers the same?

  0.35 g vs. 0.3500 g

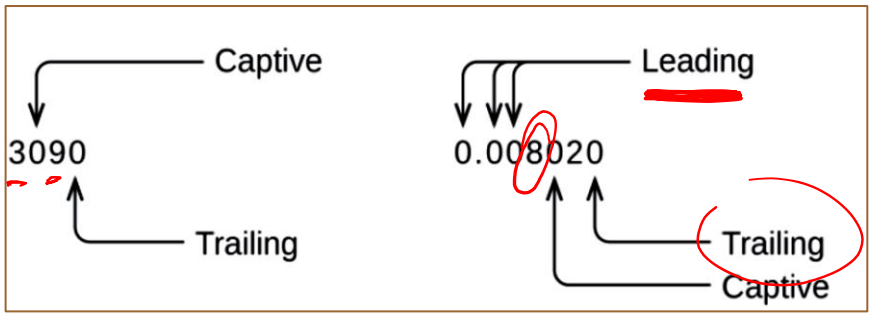
more precise
more sig fig

$5000

- No – 0.3500 g is 100x more precisely known!
  - 0.35 g: uncertain about the hundredths (10^{-2}) position; certain about all positions > 10^{-2}
- 0.3500 g: uncertain about the 10^{-4} position
- The value conveys knowledge about the instrument with which it was measured

Significant figure rules

- All exact numbers have infinite significant figures
- Rest: all figures are significant, except for leading zeros and trailing zeros when there is no decimal point
  - 45.503
  - 0.406
  - 0.400
  - 0.0047
- Certain ambiguities exist, some of which can only be addressed by scientific notation
  - 7500 m
  - 7500. m
  - 7.50 x 10^3 m
- When in doubt – convert number to scientific notation
  - Perhaps the easiest way to see the # of SF!



Significant figure rules

1. Non-zero digits are always significant
2. Zeros between non-zero digits are always significant
3. Leading zeros are never significant
4. Trailing zeros are only significant if the number contains a decimal point