Important Mathematical tips and tricks to remember:

Exponent Rules

For nonzero real numbers a and b and integers (positive, whole numbers) m and n:

$$b^0 = 1$$
$$b^{-n} = \frac{1}{b^n}$$
$$\frac{1}{b^{-n}} = b^n$$
$$b^m b^n = b^{m+n}$$
$$\frac{b^m}{b^n} = b^{m-n}$$
$$(b^m)^n = b^{mn}$$
$$(ab)^m = a^m b^m$$
$$\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$$
$$b^{1/n} = \sqrt[n]{b}$$

Log Rules

b, m, and n must all be positive.
Reminder that ln is log base e ($b = e$).
The rules hold as long as and b is > 1, but typically $b = 10$ or e

$$log_b(mn) = log_b m + log_b n$$
$$log_b\left(\frac{m}{n}\right) = log_b m - log_b n$$
$$log_b(m^k) = k \cdot log_b m$$
$$log_b(1) = 0$$
$$log_b(b) = 1$$
$$log_b(b^k) = k$$
$$b^{log_b(k)} = k$$

Algebra insights

Multiply by "1", but use a creative definition of 1. Anything times one is the same value.

ex $1 = \frac{a}{a}$

$y = \frac{z}{a}$

$\left(\frac{a}{a}\right) y = \frac{z}{a}$

$\frac{ay}{a} = \frac{z}{a}$

Multiply all terms by the same value

$\left(\frac{ay}{a} = \frac{z}{a}\right) a$ ← distribute

$ay = z$

Add something to both sides.

$y = mx - b$

$y + b = mx - b + b$

$y + b = mx$

Combine like terms

Constants - a, b, c, d, e
variables/unknowns - x, y, z

$ax^2 + by + c = bx + d + ey$

$(ax - b)x + (c - d) = (e - b)y$

sometimes you may want the x^2 and x separate

get all vars of same power w/ single coeff

Multiplying and dividing are interchangeable if you multiply by a fraction. Same for addition and subtraction with negatives.

$\frac{ab}{c} \rightarrow \frac{ab}{c}(c) = ab$

$\frac{ab}{c} \rightarrow \frac{ab}{c}\left(\frac{1}{b}\right) = \frac{a}{c}$

$\alpha \rightarrow \alpha + \beta$

$\alpha \rightarrow \alpha + (-\beta) = \alpha - \beta$

Distribute

$\alpha(\beta + \gamma) = \alpha\beta + \alpha\gamma$

System of equations

Use the equations to define one variable interms of another and reduce # of unknowns until you can solve

Quadratic equation

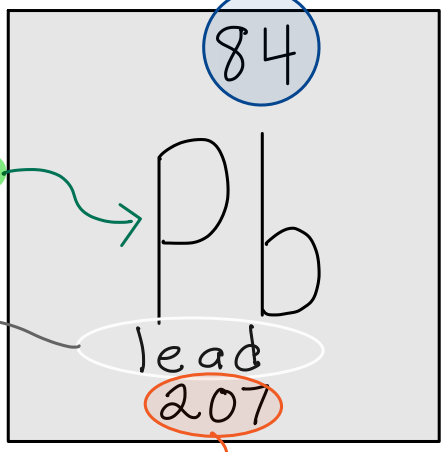
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

when $ax^2 + bx + c = 0$

The periodic table tells you about atoms

Atomic charge / mass / location in chart — tell you about the properties of the element and its interactions with other elements

Atomic properties are determined by (or determine) what element an atom is



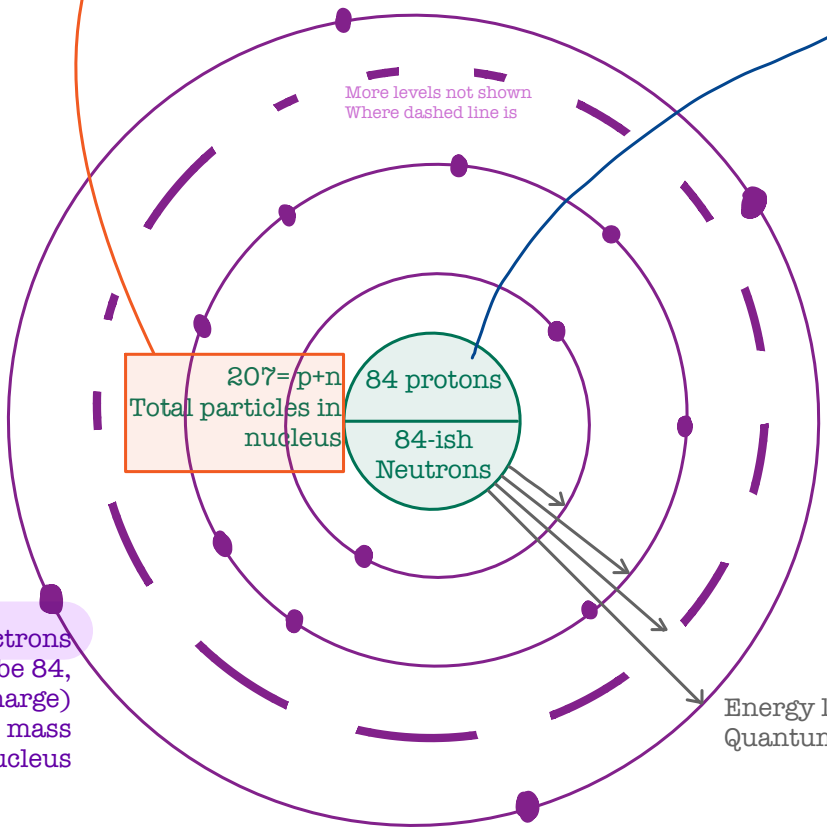
Atomic number
# of protons

Symbol
Use in chemical reactions, equations

Plumbum (in Latin)
When the symbol doesn't match the name, it probably relates to an older name

Name
How you read aloud

Mass
In grams per g-mole
This is an average value. Isotopes (different versions of the element) have different numbers of neutrons so the total mass of an individual atom varies.



Protons have mass and a positive charge

Neutrons have mass but no/neutral charge

Electrons
(There will be 84, or atomic number -charge)
Negative charge and almost no mass
Orbit at known distances from nucleus

Periodic Table

Organizes elements based on their subatomic structure, which defines their properties

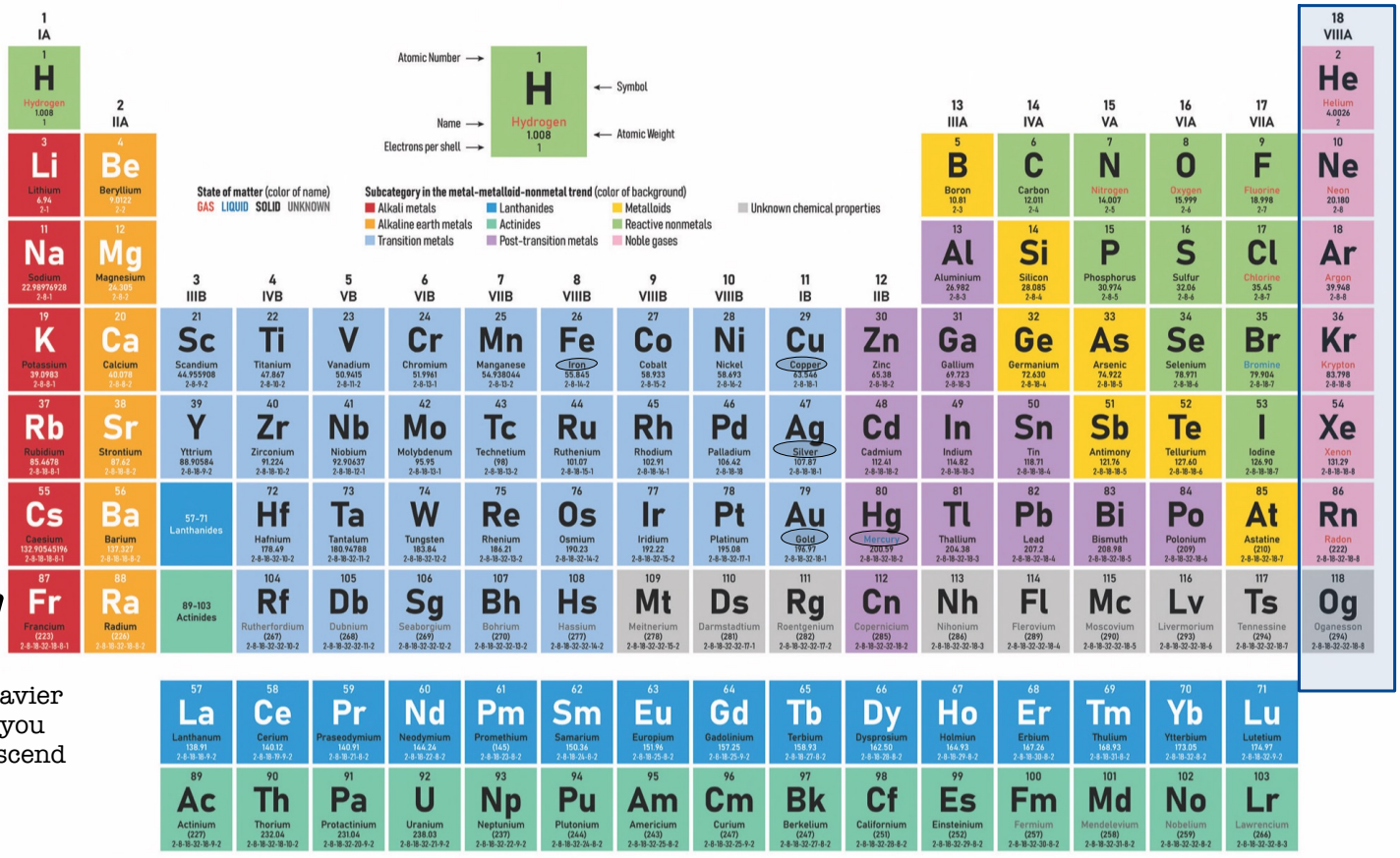
cation (+)

Positively charged
Donate an e-

anion (negative)

Negatively charged

Noble gasses
Not + or -
Unlikely to react
Inert



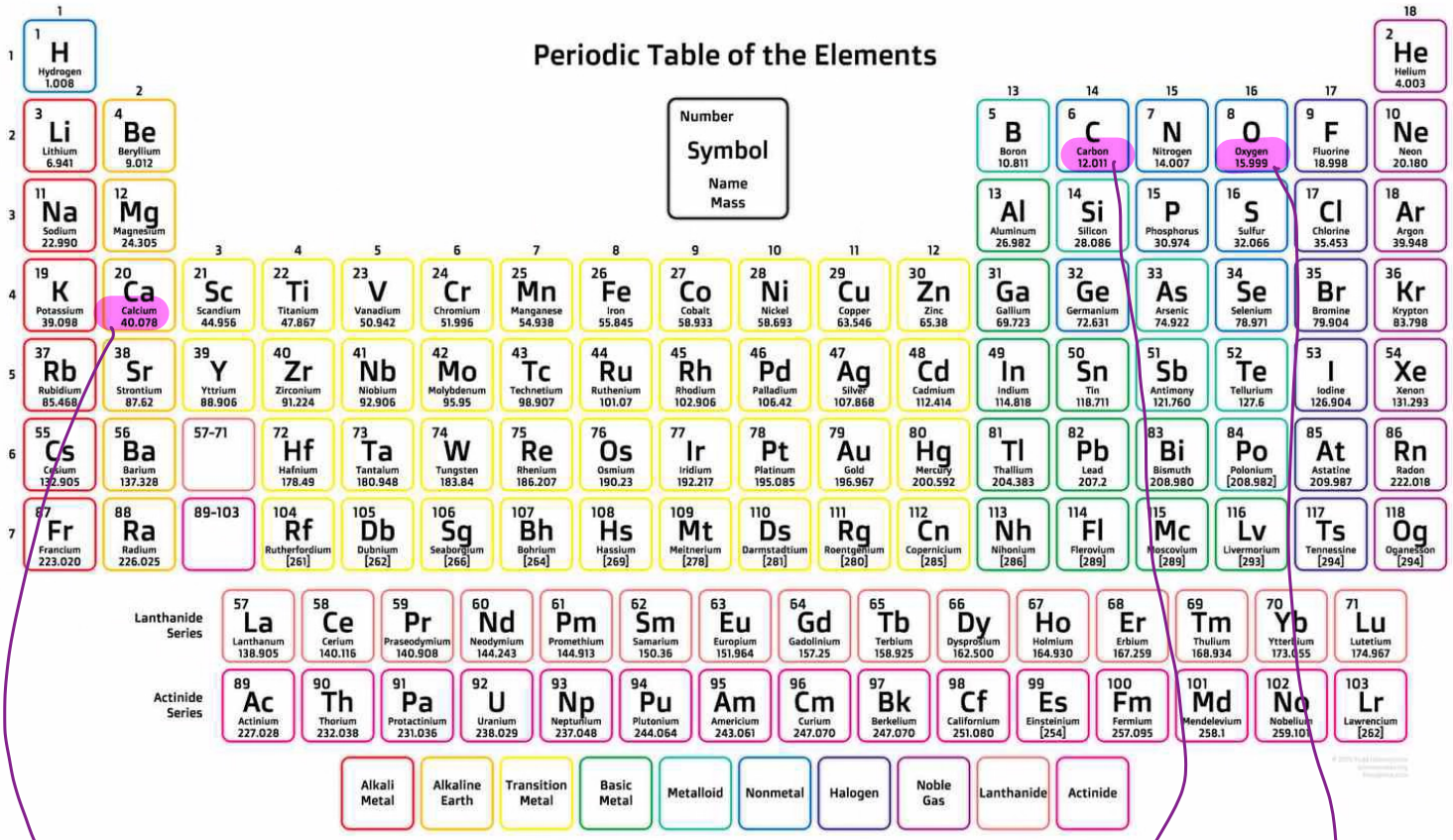
Heavier as you descend

Each column will react (combine) similarly

Commonly referenced elements with “weird” symbols & mnemonics
Fe = iron (think iron man is Fe-male)
Ag = silver (if you win 2nd place you might think “ahh gee”)
Au = gold (if someone steals your gold, you’ll say “Hey you!”)
Hg = mercury (He’s a God)
Pb = lead (the lumps are leading you the same direction)

Molecular Mass
(Sometimes called Molecular weight)

$MW = \sum$ atomic weights



Atomic mass is the non-whole number

$$MW(CaCO_3) = MW(Ca) + MW(C) + 3 \times (O)$$ (O) = 16

$$= 40.08 + 12.01 + 3 \times 16$$ (3 × 16 ≈ 48)

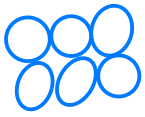
$$= 100.09 \text{ g/mol}$$

Phases of Matter

at a molecular level

solid

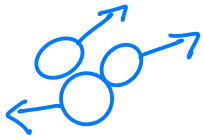
rigid



Relative molecular position constant

liquid

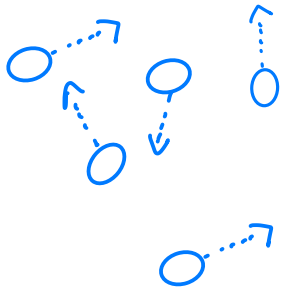
flowy



Constant distance between molecules
Relative positions change

gas

bouncy



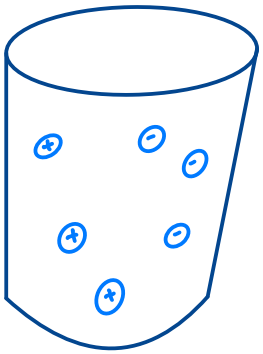
Expands to fill container

Plasma - not used here

solution*

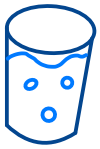
* Technically not a phase

chemical solution



Solute dissociates to ions
I.e. changes at a molecular level

colloidal mixture



No chemistry
(small solids suspended in liquid)
Acts like a solution

Dimensional Analysis

Problem: Your roommate is using your milk for their cereal every morning. They add 1/4 cup of milk each morning, and you buy gallons of milk for $4. During a 15 week semester, how much money have you lost due to stolen milk?

1. Create a "word bank" of fractions

$\frac{0.25c\ milk}{day}$ $\frac{\$4}{gallon}$ $\frac{15\ weeks}{semester}$

1.a) Look for any implicit fractions from standard conversion factors or stoichiometry

$\frac{16cups}{gallon}$ $\frac{7\ days}{week}$

2. Determine your starting and ending points

start → already know → $\frac{1/4\,c}{day}$

end → what you want → $/semester

3. Fill in the middle to create a bridge from your starting point to your ending point

$\frac{1/4\,c\ milk}{day}$	$\frac{7\ days}{week}$	$\frac{15\ weeks}{semester}$	$\frac{gallon}{16\ cups}$	$\frac{\$4}{gallon}$

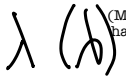
4. Multiply across the top and bottom *separately*. Then divide the product of the top by the product of the bottom. Now you're done!

$$\frac{0.25 \times 7 \times 15 \times 4}{16} = \frac{105}{16} = 6\frac{9}{16}$$

$\frac{\$6.56}{Semester}$

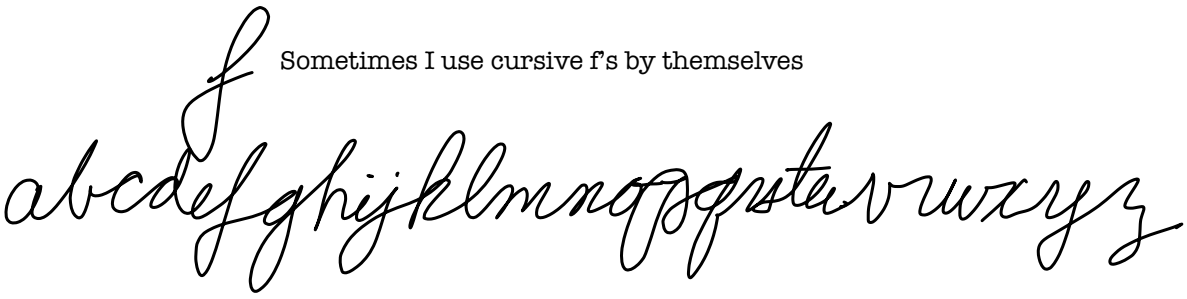
The Greek Alphabet

In engineering, we often use the Greek alphabet for variables, so it's good to know which letters are which for discussing with others. In addition, many of the letters will often represent the same variable, in the same way that we typically use 'x' to represent the horizontal axis. I'm handwriting the letters so you can correlate my handwriting to the variables.

Name	Lower case	Upper case.	common use
Alpha			Common coefficient/unknown variable reference, similar to x
Beta			
Gamma			We'll get to an atmospheric property that uses this
Delta			Change (think derivatives)
Epsilon			
Zeta			
Eta			Efficiency
Theta			Angles
Iota			
Kappa			Rate constants or other unit-less exponential terms
Lambda	 (Messier handwriting)		Wavelengths of light
Mu			Micro- (SI prefix)
Nu			Light, photon energy
Xi			
Omicron			
Pi			3.14159.....
Rho			Density
Sigma			LC is frequently used, but common definition varies by field. UC represents summation
Tau			
Upsilon			
Phi			
Chi			Sometimes refers to an unknown function, not a single variable, e.g. X(x)
Psi			
Omega			

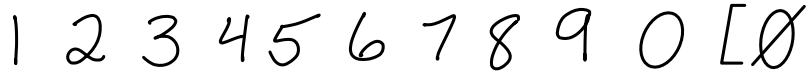
Handwriting

Here's how I write the Latin (English) alphabet as well, in case you are finding something difficult to decipher



Sometimes I use cursive f's by themselves

And here's how I write a few common mathematical symbols



Sometimes I'll strike through a zero if it's likely to be confused for an oh

Plus minus divide multiply. Parenthesis. And