Math for Chemistry Cheat Sheet

This quick math review outlines the basic rules (left) and chemistry applications (right) of each term.

Unit Conversion – *The rocess of converting a given unit to a desired unit using conversion factors.*

Using Conversion Factor:
DesiredUnit=*Factor x GivenUnit*

$= \frac{DesiredUnit}{GivenUnit} xGivenUnit$

<u>Common Conversion Factors</u>:
1 cal = 4.184 J; 1Å = 10^{-10}m
1 atm = 760 mmHg; 1kg=2.2lb
K = °C + 273.15
°F = (9/5) x°C + 32
1 L = 1 dm^3 = 10^{-3} m^3
1 in^3 = 1.6387 x 10^{-6} m^3

<u>Metric Conversion</u>: Uses multipliers to convert from one sized unit to another .

mega-	M	10^6
kilo-	k	10^3
deci-	d	10^{-1}
centi-	c	10^{-2}
milli-	m	10^{-3}
micro-	μ	10^{-6}
nano-	n	10^{-9}
pico-	p	10^{-12}

Unit Conversion is used in every aspect of chemistry.
Example 1: How many meters (m) in 123 ft?

$$?m = 123ft(\frac{12in}{1ft})(\frac{2.54cm}{1in})(\frac{1m}{100cm}) = 37.4904 = 37.5m$$

Example 2: What is the Fahrenheit at 25 degrees of Celsius?
?°F = 32 + (9/5) x °C = 32 + 9x25/5 = 77°F
Example 3: What is the volume in L of 100 grams of motor oil with a density of 0.971 g/cm^3?

$$?L = \frac{100g}{0.971g/cm^3} = 102.987 = 103cm^3 x \frac{1L}{1000cm^3} = 0.103L$$

Significant Figures – *The digits in a measurement that are reliable, irrespective of the decimal place's location.*

Exponents - *The number that gives reference to the repeated multiplication required, that is, in x^n, n is the exponent.*

<u>Rule of 1</u>: (a) Any number raised to the power of one equals itself, x^1=x. (b) One raised to any power is one, 1^n=1.
<u>Product Rule</u>: When multipling two powers with the same base, just add the exponents, $x^m \cdot x^n = x^{m+n}$.
<u>Power Rule</u>: To raise a power to a power, just multiply the exponents, $(x^m)^n = x^{mxn}$.
<u>Quotient Rule</u>: To divide two powers with the same base, just subtract their exponents, $(x^m) \div x^n = x^{m-n}$.
<u>Zero Rule</u>: Any nonzero numbers raised to the power of zero equals 1, x^0 = 1; x ≠ 0.
<u>Nagative Rule</u>: Any nonzero number raised to a negative power equals its reciprocal raised to the oppositive positive power, $x^{-n} = 1/x^n$; x ≠ 0.

Exponents is being used everywhere in chemistry, most noticeably in metric unit conversions and exponential notations.
<u>Rule of 1</u>: 12.3^1=12.3; 1^3=1
<u>Product Rule</u>: $10^{-12} \cdot 10^{-4} = 10^{(-12)+(-4)} = 10^{-16}$
<u>Power Rule</u>: $(10^{-12})^2 = 10^{(-12)x2} = 10^{-24}$
<u>Quotient Rule</u>: $10^8 \div 10^3 = x^{8-3} = 10^5$
<u>Zero Rule</u>: 10^0 = 1
<u>Negative Rule</u>: $10^{-2} = 1/10^2$ = 1/100 = 0.01

Common Student Errors:
#1: $-10^2 \neq (-10)^2$. The square of any negative is positive.
#2: $2^2 \cdot 8^3 \neq (2x8)^{2+3}$. Product rule applies to same base only.
#3: $10^2 + 10^3 \neq (10)^{2+3}$. Product rule does not apply to the sum.

Scientific (Exponential) Notations – A exponential form with a number (1-10) times some power of 10, n x 10^m

<u>Addition</u>: (M x 10^n) + (N x 10^n) = (M + N) x 10^n
<u>Subtraction</u>: (M x 10^n) - (N x 10^n) = (M - N) x 10^n
<u>Multiplication</u>: (M x 10^m) x (N x 10^n) = (M x N) x 10^{m+n}
<u>Division</u>: (M x 10^m) ÷ (N x 10^n) = (M x N) x 10^{m-n}
<u>Power</u>: $(N \times 10^n)^m = (N)^m \times 10^{n \cdot m}$
<u>Root</u>: $\sqrt{Nx10^n} = (Nx10^n)^{1/2} = \sqrt{N}x10^{n/2}$

#1: (1.23x10^{-5}) + (0.21x10^{-5}) = (1.23 + 0.21)x10^{-5} =1.44 x10^{-5}
#2: (5.13x10^{-3}) + (1.41x10^{-3}) = (5.13 – 1.41)x10^{-3} =3.72 x10^{-3}
#3: (2.5x10^{-3}) x (0.43x10^7) = (2.5x0.43)x10^{-3+7} =1.1 x10^3
#4: (2.5x10^{-3}) ÷ (0.43x10^7) = (2.5÷0.43)x$10^{(-3)-(+7)}$ =5.8 x10^{-10}
#5: $(1.23 \times 10^{-3})^2 = (1.23)^2 \times 10^{-3x2}$ = 1.51x 10^{-6}
#6: $\sqrt{1.2x10^4} = (1.2x10^4)^{1/2} = \sqrt{1.2}x10^{4/2} = 1.1x10^2$

Logarithm - *The logarithm of **y** with respect to a base **b** is the exponent to which we have to raise **b** to obtain **y**.*

<u>Definition</u>: x = $\log_b y$ <-> b^x = y (Logarithm <->Exponent)
<u>Operations</u>: log(x·y) = log x + log y
log(x/y) = log x – log y
log(x^n) = n·log x
<u>Natural Logarithm</u>: ln x = $\log_e x$, where e = 2.718
<u>Sigficant Figures in logarithm</u>: Only the resulting numbers to the right of the decimal place are signficant.
e.g. log (<u>3.123</u>x10^5) = 5.<u>5092</u>

<u>Applications</u>: pH = -log[H^+], pKa, ΔG=ΔG°+RTln(Q)
<u>Example</u>: What is the H^+ concentration in pH=3.00?
<u>Solution</u>: (Illustrated by the KUDOS method)
Step 1 - Known: pH=3.00
Step 2 – Unknown: [H^+]=?M
Step 3 – Definition: pH = -log[H^+], that is, [H^+]=$10^{-(pH)}$
Step 4 – Output: [H^+]=$10^{-(pH}$ = 1.0x10^{-3}M
Step 5 – Substantiation: Unit, S.F. and value are reasonable.

Quadratic Equation - *A polynomial equation of the second degree in the form of $ax^2 + bx + c = 0$*

<u>Equation</u>: $ax^2+bx+c=0$ <u>Roots</u>: $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

- It always has two roots (or solutions) x_1 & x_2
- For most chemical problems (mass, temperature, concentration etc.), ignore the negative root.

<u>Example</u>: equilibrum concentration equation $x^2 + 3x - 10 = 0$.
Solution:

$$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{-3 \pm \sqrt{3^2 - 4x1x(-10)}}{2x(1)} = \frac{-3 \pm \sqrt{49}}{2}$$

x_1=2 and x_2=-5, ignore the negative root, so the answer x=2

