

Essential Tool for Chemistry Concepts, Variables & Equations, Including Sample Problems, Common Pitfalls & Helpful Hints

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Your success in chemistry depends on your ability to solve numerical problems.

BASIC SKILLS

CALCULATOR SURVIVAL

- Become familiar with your calculator.
- Before the exam, make sure you can multiply, divide, add, subtract and use all needed functions.
- Calculators never make mistakes; they take your input (rounded & accidentally) and give an answer.
- Look at the answer; does it make sense?
- Do a quick estimate to check your work.
- Sample:** $4.34 \times 7.68(1.85 \times 9.8)$ is roughly $4 \times 8(1 \times 10)$ or 32; the actual answer 3.24.

HOW TO DO WORD PROBLEMS

- Read and evaluate the question before you start plugging numbers into the calculations.
- Identify the variables, constants and equations.
- Write out units of the variables and constants.
- Work out the unit before the number.
- You may have extra information, or you may need to obtain constants from your text.

HOW TO WORK WITH UNITS

All numerical data has units. In chemistry, we use metric "SI" units.

- Pitfall:** If the unit is wrong, the answer is wrong!
- Unit problem:** Convert powers of "10"

- 1. Unit problem: Convert powers of "10"
- 2. Fundamental Units

- Mass: kilogram (kg)
- Length: meter (m)
- Temperature: Kelvin (K)
- Time: second (s)
- Amount of a substance: mole
- Electric charge: coulomb, (C)

Derived Units

- Area: length squared, m^2
- Volume: length cubed, m^3 ; 1 liter (L) = 1 dm³
- Density: mass/volume; common unit kg/m^3
- Speed: distance/time; common unit m/s
- Electric current: ampere (A) = 1 C/s
- Force: Newton (N) = 1 kg m/s^2
- Energy: Joule (J) = 1 kg m^2/s^2
- Pressure: Pascal (Pa) = 1 kg/m m^2/s^2

Fundamental Constants

Mass	in amu (g/mole)	in kg
electron	9.109×10^{-31}	9.109×10^{-31}
proton	1.6726×10^{-27}	1.6726×10^{-27}
neutron	1.6749×10^{-27}	1.6749×10^{-27}
Electronic charge	1.6022×10^{-19} C	
Avogadro's number, N_A	6.02214×10^{23}	
Ideal gas constant, R		
R, for gas calculations	0.082 L atm/(K mol)	
R, for energy calculations	8.314 J/(K mol)	
Faraday Constant, F	96,485 C/mol	
Planck's Constant, h	6.626×10^{-34} J s	
Speed of light, c	2.9979×10^8 m/s	

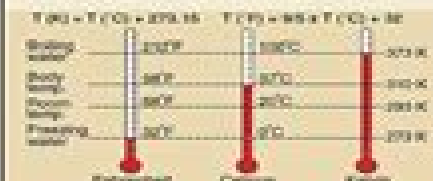
BASIC SKILLS cont.

HOW TO CONVERT DATA

The unit & numerical value are changed using a conversion factor or equation.

HOW TO USE EQUATIONS FOR DATA CONVERSION

- Sample:** Convert a temperature of 47°C to °F and Kelvin.
- Given: $K = ^\circ C + 273.15$
- Calculate: Temperature in K = $47^\circ C + 273.15 = 320.15$ K
- Given: $^\circ F = 9/5 ^\circ C + 32$
- Calculate: Temperature in $^\circ F = 9/5 \times 47^\circ C + 32 = 117^\circ F$



HOW TO USE A CONVERSION FACTOR

- Sample:** "1 hour = 60 minutes" gives two conversion factors.
- 1. Multiply by "1 hour/60 minutes" to convert minutes to hours.
- 2. Multiply by "60 minutes/1 hour" to convert hours to minutes.
- Sample:** Determine the number of hours in 45 minutes.
- Given: Conversion factor is "1 hour/60 minutes"
- Calculate: Time = 45 minutes \times (1 hour/60 minutes) = 0.75 hour (minutes cancel).

Common conversions:

- 1 calorie = 4.184 J, 1 kg = 2.2 lb, 1 m = 3.3 ft
- 1 g = 0.001 kg, 1 angstrom (Å) = 1×10^{-10} m
- 1 atm = 1.01325×10^5 Pa, 1 atm = 760 mm Hg

Pitfall: Equations and conversion factors have units. Review of inserting conversion factors.

MATH REVIEW

HOW TO WORK WITH ALGEBRAIC EQUATIONS

Give equal treatment to each side.

- Add or subtract
- Sample:** Given, $x + y$, then, $x + y = x + y$
- Multiply or divide
- Sample:** Given, $x = y$, then, $4x = 4y$ and $x/2 = y/2$
- Given: $x = y + 4$, then $4x = 4(y + 4) = 4y + 16$, $x \neq 2$
- Pitfall:** Dividing by zero is not allowed.

HOW TO WORK WITH SCIENTIFIC NOTATION

The exponent gives the power of 10.
Sample: $0.00045 = 4.5 \times 10^{-4}$, $0.45 = 4.5 \times 10^{-1}$
Sample chemical applications: Molar masses are 10^{-3} mol; 1 liter of water contains about 1×10^{25} atoms.

MATH REVIEW cont.

HOW TO USE LOGARITHMS & EXPONENTS

- Common logarithm, log₁₀, base "10"**
Denotes number or function in powers of 10.
Sample: Given, $y = 10^4$, then $\log_{10} y = 4$.
- Natural logarithm, ln, base "e"** ($e = 2.718281828$)
Denotes number or function in powers of "e".
Sample: Given, $x = e^5$, then $\ln x = 5$.
- Products:** $\log (xy) = \log x + \log y$
- Powers:** $\log (x^y) = y \log x$
- Multiplication:** Add exponents from each term.
Sample: $10^2 \times 10^3 = 10^{2+3} = 10^5$
- Division:** Subtract denominator exponents from numerator exponents.
Sample: $10^5/10^2 = 10^{5-2} = 10^3$
- Square root:** $\sqrt{x} = x^{1/2}$
- Reciprocal:** $1/x = x^{-1}$

Pitfall: Your calculator has separate keys for \ln (base e), \log (base 10), 10^x and e^x .
Sample chemical applications: pH of acid and base.

HOW TO CALCULATE ROOTS OF A POLYNOMIAL

An equation of the form, $ax^2 + bx + c = 0$ has 2 solutions or roots, given by the quadratic formula:

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

- Sample:** Determine the roots for the equation, $3x^2 - 4x + 1 = 0$
- Given: $a = 3$, $b = -4$, $c = 1$
- Calculate: Root 1 = $\frac{-(-4) + \sqrt{(-4)^2 - 4 \times 3 \times 1}}{2 \times 3} = \frac{4 + \sqrt{16 - 12}}{6} = \frac{4 + 2}{6} = 1$
- Calculate: Root 2 = $\frac{-(-4) - \sqrt{(-4)^2 - 4 \times 3 \times 1}}{2 \times 3} = \frac{4 - 2}{6} = \frac{2}{6} = \frac{1}{3}$

Pitfall: Reround round off error. Substitute the roots into the equation to verify results.
Sample chemical applications: Weak acids, weak bases, buffers, chemical equilibria.

HOW TO DETERMINE THE EQUATION OF A LINE

LINEAR EQUATION: $y = mx + b$
 m = slope of the line; $m = \Delta y/\Delta x$
 b = y-intercept; the line crosses the y-axis at $(0, b) = y_0$ mm.
Sample: Determine the equation of a line using (x, y) data.
Given: $(1, 2)$, $(2, 4)$, $(3, 6)$
 $y - 2 = (4 - 2)/(2 - 1) \times (x - 1)$
Calculate: Slope = $m = \Delta y/\Delta x = (4 - 2)/(2 - 1) = 2$
Calculate: y-intercept = $b = y_0 - mx_0 = (2) - (2 \times 1) = 0$
The equation of the line is $y = 2x + 0$
Sample chemical applications: Gas calculations, Beer's Law; studying reaction rate data.



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