

Useful constants and equations

$$\begin{aligned}
 e &= 1.602 \times 10^{-19} \text{ C} & \frac{1}{4\pi\epsilon_0} &= 9.0 \times 10^9 \text{ N m}^2/\text{C}^2 & \frac{e^2}{4\pi\epsilon_0} &= 1.44 \text{ eV nm} \\
 c &= 3.00 \times 10^8 \text{ m/s} & h &= 6.626 \times 10^{-34} \text{ J s} & &= 4.136 \times 10^{-15} \text{ eV s} & \hbar &= \frac{h}{2\pi} \\
 hc &= 1240 \text{ eV nm} & \hbar c &= 197.3 \text{ eV nm} & &= 197.3 \text{ MeV fm} & &1 \text{ eV} &= 1.602 \times 10^{-19} \text{ J} \\
 m_e &= 9.11 \times 10^{-31} \text{ kg} & &= 511 \text{ keV}/c^2 & &= 5.486 \times 10^{-4} \text{ u} & &\text{neutral } {}^{12}_6\text{C atom mass} &= 12.0000 \text{ u} \\
 m_p &= 1.673 \times 10^{-27} \text{ kg} & &= 938.3 \text{ MeV}/c^2 & &= 1.0073 \text{ u} & &1 \text{ u} &= 931.5 \text{ MeV} \\
 m_n &= 1.675 \times 10^{-27} \text{ kg} & &= 939.6 \text{ MeV}/c^2 & &= 1.0087 \text{ u} & & & \\
 a_0 &= 0.0529 \text{ nm} & E_0 &= -13.6 \text{ eV} & \alpha &= 1/137
 \end{aligned}$$

Atomic Physics:

Hydrogen Atom: $E = \frac{-13.6 \text{ eV}}{n^2}$ with $n = 1, 2, 3, \dots$ $l < n$ $-l \leq m \leq +l$

Angular Momentum: $L^2 = l(l+1)\hbar^2$ $l = 0, 1, 2, 3, \dots$ (orbital)
 $L_z = |\vec{L}| \cos \theta = m\hbar$ $-l \leq m_l \leq l$ (integer steps)

Magnetic Moment: orbital: $\vec{\mu} = \frac{q}{2M} \vec{L}$
 for electron: $|\mu_z| = 2 \cdot |m_s| \frac{e\hbar}{2m_e} = \mu_B = 5.8 \times 10^{-5} \text{ eV/T}$
 for proton: $|\mu_z| = g_p \cdot |m_s| \frac{e\hbar}{2m_p} = 5.6 \frac{1}{2} \mu_N = 8.8 \times 10^{-8} \text{ eV/T}$

Energy of magnetic dipole in B field: $E = -\mu \cdot B$

Energy of particle in 3-dim ∞ square well: $E_{n_x n_y n_z} = \frac{(n_x^2 + n_y^2 + n_z^2)\hbar^2}{8mL^2}$

Molecular excitations: vibrational: $E = (n + \frac{1}{2})\hbar\omega$ rotational: $E = \frac{L^2}{2I} = \frac{l(l+1)}{2I} \hbar^2$

Statistical Physics:

Maxwell Boltzmann distribution: $f_{MB} = A e^{-E/kT}$

Bose - Einstein distribution: $f_{BE} = \frac{1}{B e^{E/kT} - 1}$

Fermi - Dirac distribution: $f_{FD} = \frac{1}{e^{(E-E_F)/kT} + 1}$

Boltzmann constant $k = 1.381 \times 10^{-23} \text{ J/K} = 8.617 \times 10^{-5} \text{ eV/K}$

For "gas" of free fermions: $g(E) = \frac{8\sqrt{2}\pi m^{3/2}}{h^3} \sqrt{E}$

$$E_F = \frac{h^2}{2m} \left(\frac{3N}{8\pi V} \right)^{2/3} \quad E_m = \frac{3}{5} E_F$$