Useful Combinations of Constants

$\hbar = h/2\pi = 1.0546 \times 10^{-34}\ \text{J} \cdot \text{s} = 6.5821 \times 10^{-16}\ \text{eV} \cdot \text{s}$

$hc = 1.9864 \times 10^{-25}\ \text{J} \cdot \text{m} = 1239.8\ \text{eV} \cdot \text{nm}$

$\hbar c = 3.1615 \times 10^{-26}\ \text{J} \cdot \text{m} = 197.33\ \text{eV} \cdot \text{nm}$

$\dfrac{1}{4\pi\epsilon_0} = 8.9876 \times 10^{9}\ \text{N} \cdot \text{m}^2 \cdot \text{C}^{-2}$

Compton wavelength $\lambda_c = \dfrac{h}{m_e c} = 2.4263 \times 10^{-12}\ \text{m}$

$\dfrac{e^2}{4\pi\epsilon_0} = 2.3071 \times 10^{-28}\ \text{J} \cdot \text{m} = 1.4400 \times 10^{-9}\ \text{eV} \cdot \text{m}$

Fine structure constant $\alpha = \dfrac{e^2}{4\pi\epsilon_0 \hbar c} = 0.0072974 \approx \dfrac{1}{137}$

Bohr magneton $\mu_B = \dfrac{e\hbar}{2m_e} = 9.2740 \times 10^{-24}\ \text{J/T} = 5.7884 \times 10^{-5}\ \text{eV/T}$

Nuclear magneton $\mu_N = \dfrac{e\hbar}{2m_p} = 5.0508 \times 10^{-27}\ \text{J/T}$
$= 3.1525 \times 10^{-8}\ \text{eV/T}$

Bohr radius $a_0 = \dfrac{4\pi\epsilon_0 \hbar^2}{m_e e^2} = 5.2918 \times 10^{-11}\ \text{m}$

Hydrogen ground state $E_0 = \dfrac{e^2}{8\pi\epsilon_0 a_0} = 13.606\ \text{eV} = 2.1799 \times 10^{-18}\ \text{J}$

Rydberg constant $R_\infty = \dfrac{\alpha^2 m_e c}{2h} = 1.09737 \times 10^{7}\ \text{m}^{-1}$

Hydrogen Rydberg $R_H = \dfrac{\mu}{m_e} R_\infty = 1.09678 \times 10^{7}\ \text{m}^{-1}$

Gas constant $R = N_A k = 8.3145\ \text{J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$

Magnetic flux quantum $\Phi_0 = \dfrac{h}{2e} = 2.0678 \times 10^{-15}\ \text{T} \cdot \text{m}^2$

Classical electron radius $r_e = \alpha^2 a_0 = 2.8179 \times 10^{-15}\ \text{m}$

$kT = 2.5249 \times 10^{-2}\ \text{eV} \approx \dfrac{1}{40}\ \text{eV}$ at $T = 293\ \text{K}$

Note: The latest values of the fundamental constants can be found at the National Institute of Standards and Technology website at http://physics.nist.gov/cuu/Constants

Table 3.3 Work Functions

Element	ϕ (eV)	Element	ϕ (eV)	Element	ϕ (eV)
Ag	4.64	K	2.29	Pd	5.22
Al	4.20	Li	2.93	Pt	5.64
C	5.0	Na	2.36	W	4.63
Cs	1.95	Nd	3.2	Zr	4.05
Cu	4.48	Ni	5.22		
Fe	4.67	Pb	4.25		

From *Handbook of Chemistry and Physics*, 90th ed. Boca Raton, Fla.: CRC Press (2009–10), pp. 12-114.

Fundamental Constants

Quantity	Symbol	Value(s)
Elementary charge	e	1.6022×10^{-19} C
Speed of light in vacuum	c	2.9979×10^{8} m/s
Permeability of vacuum (magnetic constant)	μ_0	$4\pi \times 10^{-7}$ N · A^{-2}
Permittivity of vacuum (electric constant)	ϵ_0	8.8542×10^{-12} F · m^{-1}
Gravitation constant	G	6.6738×10^{-11} N · m^2 · kg^{-2}
Planck constant	h	6.6261×10^{-34} J · s
		4.1357×10^{-15} eV · s
Avogadro constant	N_A	6.0221×10^{23} mol^{-1}
Boltzmann constant	k	1.3807×10^{-23} J · K^{-1}
Stefan-Boltzmann constant	σ	5.6704×10^{-8} W · m^{-2} · K^{-4}
Atomic mass unit	u	$1.66053886 \times 10^{-27}$ kg
		931.494061 MeV/c^2

Conversion Factors

1 y = 3.156×10^{7} s
1 lightyear = 9.461×10^{15} m
1 cal = 4.186 J
1 MeV/c = 5.344×10^{-22} kg · m/s
1 eV = 1.6022×10^{-19} J
1 T = 10^{4} G
1 Ci = 3.7×10^{10} Bq
1 barn = 10^{-28} m^2
1 u = 1.66054×10^{-27} kg

Particle Masses

	Mass in units of		
Particle	kg	MeV/c^2	u
Electron	9.1094×10^{-31}	0.51100	5.4858×10^{-4}
Muon	1.8835×10^{-28}	105.66	0.11343
Proton	1.6726×10^{-27}	938.27	1.00728
Neutron	1.6749×10^{-27}	939.57	1.00866
Deuteron	3.3436×10^{-27}	1875.61	2.01355
α particle	6.6447×10^{-27}	3727.38	4.00151

Table 3.4 Results of Compton Scattering

Energy or Momentum	Initial System	Final System
Photon energy	hf	hf'
Photon momentum in x direction (p_x)	$\frac{h}{\lambda}$	$\frac{h}{\lambda'}\cos\theta$
Photon momentum in y direction (p_y)	0	$\frac{h}{\lambda'}\sin\theta$
Electron energy	mc^2	$E_e = mc^2 + \text{K.E.}$
Electron momentum in x direction (p_x)	0	$p_e \cos\phi$
Electron momentum in y direction (p_y)	0	$-p_e \sin\phi$

Table 3.2 Hydrogen Series of Spectral Lines

Discoverer (year)	Wavelength	n	k
Lyman (1916)	Ultraviolet	1	>1
Balmer (1885)	Visible, ultraviolet	2	>2
Paschen (1908)	Infrared	3	>3
Brackett (1922)	Infrared	4	>4
Pfund (1924)	Infrared	5	>5