Quantity	Symbol	Value	Units
Speed of light	c	2.99792458×10^{8}	$m\ s^{-1}$
Elementry charge	e	$1.60217653 \times 10^{-19}$	C
Boltzmann constant	k	$1.3806505 \times 10^{-23}$	$J\ K^{-1}$
Gas Constant	R	8.314472	$J\ K^{-1}\ mol^{-1}$
Planck Constant	h	$6.6260693 \times 10^{-34}$	J s
h / 2π	ħ	$1.05457168 \times 10^{-34}$	J s
Avagadro's Number	NA	6.0221415×10^{23}	mol^{-1}
Atomic mass constant (unit)	m_u	$1.66053886 \times 10^{-27}$	kg
mass of electron	m_e	$9.1093826 \times 10^{-31}$	kg
mass of proton	m_p	$1.67262171 \times 10^{-27}$	kg
mass of neutron	m_n	$1.67492728 \times 10^{-27}$	kg
Bohr radius	a_o	$5.291772108 \times 10^{-11}$	m
second radiation constant	c_2	1.4387752×10^{-2}	m K
Stefan-Boltzmann constant	σ	5.670400×10^{-8}	$W\ m^{-2}\ K^{-4}$
Standard acceleration of gravity	g	9.80665	$m\ s^{-2}$
Permittivity of free space	ε_o	$8.85418782 \times 10^{-12}$	$m^{-3}\ kg^{-1}\ s^{4}\ A^{2}$

$$1J = \frac{kg\ \ m^2}{s^2} \qquad 1N = \frac{kg\ \ m}{s^2}$$

$$1eV = 1C * 1V = 1.6022x10^{-19}\,J$$

1 hartree = 1.4.36 E-18 J

Some useful formulas and unit definitions

$$E = h\nu \qquad c = \lambda\nu \qquad \lambda = \frac{h}{p} \qquad \hbar = \frac{h}{2\pi}$$

$$P^* = \frac{Power}{Area} = \varepsilon\sigma T^4 \qquad \lambda_{max} = \frac{C_2}{5T} \qquad h\nu = \Phi + E_K$$

$$\hat{x} = x \qquad \hat{p}_x = \frac{\hbar}{i}\frac{\partial}{\partial x} \qquad \hat{l}_z = \frac{\hbar}{i}\frac{\partial}{\partial \phi} \qquad \hat{\mu} = er \qquad \Delta x \Delta p \geq \frac{\hbar}{2}$$

$$\hat{H} = \hat{E}_k + \hat{V} \qquad \hat{H}\psi = E\psi \qquad \left[-\frac{\hbar}{2m}\frac{\partial^2}{\partial x^2} + V(x)\right]\psi(x) = E\psi(x)$$

$$\left[-\frac{\hbar}{2m}\nabla^2 + V(x,y,z)\right]\psi(x,y,z) = E\psi(x,y,z) \qquad \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right) = \nabla^2 = Laplacian$$

$$\left[\frac{-h^2}{8\pi\mu}\nabla^2 - \frac{Ze^2}{4\pi\varepsilon_0 r}\right]\psi(r,\theta,\phi) = E\psi(r,\theta,\phi) \qquad \nabla^2 = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial}{\partial\theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2}{\partial\phi^2}$$

$$\langle O \rangle = \int_{all\ space} \psi\hat{O}\psi d\tau \qquad \text{for normalized wavefunctions} \qquad d\tau = dx\ \ dy\ \ dz = r^2\sin\theta\ \ dr\ \ d\theta\ \ d\phi$$

Particle in 1D box $\qquad \psi_n(x) = \sqrt{\frac{2}{L}}\sin(\frac{n\pi}{L}x) \qquad E_n = \frac{\hbar^2\pi^2}{2m}\frac{n^2}{L^2}$

Particle in 2D box $\qquad \psi_{n_x,n_y}(x,y) = \sqrt{\frac{2}{L_x}}\sqrt{\frac{2}{L_y}}\sin(\frac{n_x\pi}{L_x}x)\sin(\frac{n_y\pi}{L_y}y) \qquad E_n = \frac{\hbar^2\pi^2}{2m}\left(\frac{n_x^2}{L_x^2} + \frac{n_y^2}{L_y^2}\right)$

Harmonic oscillator $\qquad V(x) = \frac{1}{2}kx^2 \qquad \nu_{os} = \frac{1}{t'} = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad E_n = \left(n + \frac{1}{2}\right)h\nu_{os}$

Particle on a ring $\qquad \psi_n(\phi) = \sqrt{\frac{1}{\pi}}\sin(n\phi) \qquad \psi_n(\phi) = \sqrt{\frac{1}{\pi}}\cos(n\phi) \qquad E = \frac{n^2\hbar^2}{2I}$

$$\hat{L}_z Y_{l,m}(\theta,\varphi) = m\hbar Y_{l,m}(\theta,\varphi) \qquad \hat{L}^2 Y_{l,m}(\theta,\varphi) = l(l+1)\hbar^2 Y_{l,m}(\theta,\varphi)$$

$$H_{average} = \int \phi^* \hat{H} \phi d\tau \geq E_0$$

$$E_{rot} = \frac{J(J+1)\hbar^2}{2I} \qquad B = \frac{\hbar^2}{2I} = \frac{h^2}{8\pi^2 I} \qquad \mu = \frac{m_1 m_2}{(m_1 + m_2)} \qquad I = \frac{h^2}{8\pi^2 B} = \mu r^2$$

$$I = \sum_i m_i r_i^2$$

$$rate_{2\leftarrow 1}(stimulated) = B_{21} N_1 \rho(\tilde{\nu}) \qquad rate_{2\rightarrow 1}(stimulated) = B_{12} N_2 \rho(\tilde{\nu}) \qquad rate_{2\rightarrow 1} = A_{12} N_2$$

$$A_{12} = 8\pi hc\, \tilde{\nu}_{21}^3 B_{12} \qquad A_{12} = \frac{16\pi^3 \tilde{\nu}_{21}^3 |\mu_{21}|^2}{3h\varepsilon_o g_2} \qquad B_{12} = \frac{2\pi^2 |\mu_{21}|^2}{3ch^2 \varepsilon_o g_2}$$

The Solutions to the Hydrogen atom (wavefunctions are in atomic units)

1s	$\frac{1}{\sqrt{\pi}} Z^{\frac{3}{2}} e^{-Zr}$	3s	$\frac{1}{81\sqrt{3\pi}} Z^{\frac{3}{2}} \left(27 - 18Zr + 2Z^2 r^2\right) e^{-\frac{Zr}{3}}$
2s	$\frac{1}{4\sqrt{2\pi}} Z^{\frac{3}{2}} (2 - Zr) e^{-\frac{Zr}{2}}$	$3p_x$	$\frac{\sqrt{2}}{81\sqrt{\pi}} Z^{\frac{5}{2}} r (6 - Zr) e^{-\frac{Zr}{3}} \sin\theta\cos\phi$
$2p_x$	$\frac{1}{4\sqrt{2\pi}} Z^{\frac{5}{2}} r e^{-\frac{Zr}{2}} \sin\theta\cos\phi$	$3p_y$	$\frac{\sqrt{2}}{81\sqrt{\pi}} Z^{\frac{5}{2}} r (6 - Zr) e^{-\frac{Zr}{3}} \sin\theta\sin\phi$
$2p_y$	$\frac{1}{4\sqrt{2\pi}} Z^{\frac{5}{2}} r e^{-\frac{Zr}{2}} \sin\theta\sin\phi$	$3p_z$	$\frac{\sqrt{2}}{81\sqrt{\pi}} Z^{\frac{5}{2}} r (6 - Zr) e^{-\frac{Zr}{3}} \cos\theta$
$2p_z$	$\frac{1}{4\sqrt{2\pi}} Z^{\frac{5}{2}} r e^{-\frac{Zr}{2}} \cos\theta$		

$$E_n = \left(-\frac{\mu_e e^4}{8\varepsilon_0^2 h^2} \frac{Z^2}{n^2} \right)_{\text{SI units}} = \left(\frac{Z^2}{n^2} \right)_{\text{atomic units}}$$

The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.9897670	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)