$$\mathbf{c = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = 2.988\times10^8\ m/s}$$
$$\mathbf{m_e = 9.11\times10^{-31}\ kg}$$
$$\mathbf{E_0 = m_ec^2 = 0.511\ MeV}$$
$$\mathbf{m_p = 1.67\times10^{-27}\ kg}$$
$$\mathbf{1\ eV = 1.602\times10^{-19}\ J}$$
$$\mathbf{h = 6.626\times10^{-34}\ J.s} \tag{1}$$
$$\mathbf{k = \frac{1}{4\pi\epsilon_0} = 9.0\times10^9 N.m^2/C^2}$$
$$\mathbf{e = 1.602\times10^{-19}C}$$
$$\mathbf{\epsilon_0 = 8.85\times10^{-12}C^2/Nm^2}$$
$$\mathbf{R = 1.097\times10^7\ m^{-1}}$$

$$\mathbf{G(\nu)d\nu = \frac{8\pi\nu^2d\nu}{c^3}} \tag{2}$$
$$\mathbf{u(\nu)d\nu = \bar{\epsilon}G(\nu)d\nu = \frac{8\pi kT}{c^3}\nu^2d\nu} \tag{3}$$
$$\mathbf{u(\nu)d\nu = \frac{8\pi h}{c^3}\frac{\nu^3d\nu}{e^{h\nu/kT}-1}} \tag{4}$$
$$\mathbf{\epsilon_n = nh\nu \quad n = 0,1,2,\ldots} \tag{5}$$
$$\mathbf{\epsilon = \frac{h\nu}{e^{h\nu/kT}-1}} \tag{6}$$
$$\mathbf{\phi = h\nu_0} \tag{7}$$
$$\mathbf{h\nu = KE_{max} + \phi} \tag{8}$$

$$\mathbf{E = \left(\frac{6.626\times10^{-34}\ J.s}{1.602\times10^{-19}\ J/eV}\right)\nu = (4.136\times10^{-15})\nu\ \ eV.s} \tag{9}$$

$$\mathbf{Ve = h\nu_{max} = \frac{hc}{\lambda_{min}}} \tag{10}$$
$$\mathbf{\lambda_{min} = \frac{hc}{Ve} = \frac{1.24\times10^{-6}}{V}\ V.m} \tag{11}$$
$$\mathbf{2d\sin\theta = n\lambda \quad n = 1,2,3,\ldots} \tag{12}$$
$$\mathbf{h\nu - h\nu' = KE} \tag{13}$$
$$\mathbf{p = \frac{E}{c} = \frac{h\nu}{c}} \tag{14}$$

$$\mathbf{\frac{h\nu}{c} + 0 = \frac{h\nu'}{c}\cos\phi + p\cos\theta}$$
$$\mathbf{0 = \frac{h\nu'}{c}\sin\phi - p\sin\theta} \tag{15}$$
$$\mathbf{\lambda' - \lambda = \lambda_C(1-\cos\phi)} \tag{16}$$
$$\mathbf{\lambda_C = \frac{h}{mc}} \tag{17}$$
$$\mathbf{p = \frac{h\nu}{c} = \frac{h}{\lambda} \quad , \quad \lambda = \frac{h}{p}} \tag{18}$$
$$\mathbf{\lambda = \frac{h}{\gamma mv}} \tag{19}$$
$$\mathbf{\gamma = \frac{1}{\sqrt{1-v^2/c^2}}} \tag{20}$$
$$\mathbf{E = \sqrt{E_0^2 + p^2c^2} = KE + E_0} \tag{21}$$
$$\mathbf{v_p = \nu\lambda = \left(\frac{\gamma mc^2}{h}\right)\left(\frac{h}{\gamma mv}\right) = \frac{c^2}{v}} \tag{22}$$
$$\mathbf{y = A\cos(2\pi vt) = A\cos\left(2\pi\nu\left(t - \frac{x}{v_p}\right)\right)} \tag{23}$$
$$\mathbf{\omega = 2\pi\nu} \tag{24}$$
$$\mathbf{k = \frac{2\pi}{\lambda} = \frac{\omega}{v_p}} \tag{25}$$
$$\mathbf{y = A\cos(\omega t - kx)} \tag{26}$$
$$\mathbf{v_g = v \ \ \&\ \ v_p = \frac{\omega}{k} = \frac{c^2}{v}} \tag{27}$$
$$\mathbf{\lambda = \frac{2L}{n} \quad n = 1,2,3,\ldots} \tag{28}$$

$$\mathbf{KE = \frac{1}{2}mv^2 = \frac{p^2}{2m} = \frac{(mv)^2}{2m} = \frac{h^2}{2m\lambda^2}} \tag{29}$$
$$\mathbf{E_n = \frac{n^2h^2}{8mL^2} \quad n = 1,2,3,\ldots} \tag{30}$$
$$\mathbf{k = \frac{2\pi}{\lambda} = \frac{2\pi p}{h} \ \ \&\ \ p = \frac{hk}{2\pi}} \tag{31}$$
$$\mathbf{\Delta x\Delta p \geq \frac{\hbar}{2} \ \ \&\ \ \Delta E\Delta t \geq \frac{\hbar}{2}} \tag{32}$$
$$\mathbf{\sigma = \sqrt{\left(\frac{1}{N}\sum_{i=1}^{N}(x_i - x_0)^2\right)}} \tag{33}$$
$$\mathbf{f(x) = \frac{1}{\sigma\sqrt{2\pi}}e^{-(x-x_0)^2/2\sigma^2}} \tag{34}$$
$$\mathbf{P_{x_1x_2} = \int_{x_1}^{x_2} f(x)dx} \tag{35}$$
$$\mathbf{P_{x_0\pm\sigma} = \int_{x_0-\sigma}^{x_0+\sigma} f(x)dx = 0.683} \tag{36}$$
$$\mathbf{F_e = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2} \ \ \&\ \ F_c = \frac{mv^2}{r}} \tag{37}$$
$$\mathbf{n\lambda = 2\pi r_n \quad n = 1,2,3,\ldots} \tag{38}$$
$$\mathbf{r_n = \frac{n^2h^2\epsilon_0}{\pi me^2} = n^2a_0\ ,\ v_n = \sqrt{\frac{e^2}{4\pi\epsilon_0 mr_n}}\ ,\ n = 1,2,3,\ldots} \tag{39}$$
$$\mathbf{a_0 = r_1 = 5.292\times10^{-11}\ m} \tag{40}$$

$$\mathbf{E_n = -\frac{e^2}{8\pi\epsilon_0 r_n} = -\frac{me^4}{8\epsilon_0^2h^2}\left(\frac{1}{n^2}\right) \quad n = 1,2,3,\ldots}$$
$$\mathbf{E_n = \frac{E_1}{n^2}\ ,\ E_n = \frac{Z^2E_1}{n^2}\ (hydrogen\ like\ atom)} \tag{41}$$
$$\mathbf{E_1 = -2.18\times10^{-18}\ J = -13.6\ eV}$$
$$\mathbf{\nu = \frac{E_i - E_f}{h} = -\frac{E_1}{h}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right),\quad \lambda = \frac{c}{\nu}} \tag{42}$$

$$\mathit{Lyman}\ \mathbf{n_f = 1:\ \frac{1}{\lambda} = -\frac{E_1}{ch}\left(\frac{1}{1^2} - \frac{1}{n^2}\right) \quad n = 2,3,4,\ldots}$$
$$\mathit{Balmer}\ \mathbf{n_f = 2:\ \frac{1}{\lambda} = -\frac{E_1}{ch}\left(\frac{1}{2^2} - \frac{1}{n^2}\right) \quad n = 3,4,5,\ldots}$$
$$\mathit{Paschen}\ \mathbf{n_f = 3:\ \frac{1}{\lambda} = -\frac{E_1}{ch}\left(\frac{1}{3^2} - \frac{1}{n^2}\right) \quad n = 4,5,6,\ldots}$$
$$\mathit{Brackett}\ \mathbf{n_f = 4:\ \frac{1}{\lambda} = -\frac{E_1}{ch}\left(\frac{1}{4^2} - \frac{1}{n^2}\right) \quad n = 5,6,7,\ldots}$$
$$\mathit{Pfund}\ \mathbf{n_f = 5:\ \frac{1}{\lambda} = -\frac{E_1}{ch}\left(\frac{1}{5^2} - \frac{1}{n^2}\right) \quad n = 6,7,8,\ldots} \tag{43}$$

$$\mathbf{\Psi = A + iB \ \ \&\ \ \Psi^* = A - iB} \tag{44}$$
$$\mathbf{|\Psi|^2 = \Psi^*\Psi = A^2 - i^2B^2 = A^2 + B^2} \tag{45}$$
$$\mathbf{\int_{-\infty}^{\infty}|\Psi|^2dV = 0 \ \ \&\ \ \int_{-\infty}^{\infty}|\Psi|^2dV = 1} \tag{46}$$
$$\mathbf{P_{x_1x_2} = \int_{-x_1}^{x_2}|\Psi|^2dV = 1} \tag{47}$$
$$\mathbf{E = h\nu = 2\pi h\lambda \ \ \&\ \ \lambda = \frac{h}{p} = \frac{2\pi h}{p}} \tag{48}$$
$$\mathbf{\Psi = Ae^{-(i/\hbar)(Et-px)} = Ae^{-(iE/\hbar)t}e^{+(ip/\hbar)x} = \psi e^{-(iE/\hbar)t}} \tag{49}$$
$$\mathbf{\frac{\partial^2\Psi}{\partial x^2} = -\frac{p^2}{\hbar^2}\Psi \Rightarrow p^2\Psi = -\hbar^2\frac{\partial^2\Psi}{\partial x^2} \Rightarrow \hat{p} = \frac{\hbar}{i}\frac{\partial}{\partial x}} \tag{50}$$
$$\mathbf{\frac{\partial\Psi}{\partial t} = -\frac{iE}{\hbar}\Psi \Rightarrow E\Psi = -\frac{\hbar}{i}\frac{\partial\Psi}{\partial t} \Rightarrow \hat{E} = i\hbar\frac{\partial}{\partial t}} \tag{51}$$
$$\mathbf{E = \frac{p^2}{2m} + U(x,t) \Rightarrow \hat{E} = \hat{KE} + \hat{U}} \tag{52}$$
$$\mathbf{i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\left(\frac{\partial^2\Psi}{\partial x^2} + \frac{\partial^2\Psi}{\partial y^2} + \frac{\partial^2\Psi}{\partial z^2}\right) + U\Psi} \tag{53}$$
$$\mathbf{\bar{x} = \frac{N_1x_1 + N_2x_2 + N_3x_3 + \ldots}{N_1 + N_2 + N_3 + \ldots} = \frac{\sum N_ix_i}{\sum N_i}} \tag{54}$$

$$\mathbf{<x> = \int_{-\infty}^{\infty} x|\Psi|^2dx} \tag{55}$$
$$\mathbf{<p> = \int_{-\infty}^{\infty}\Psi^*\left(\frac{\hbar}{i}\frac{\partial}{\partial x}\right)\Psi dx} \tag{56}$$
$$\mathbf{<E> = \int_{-\infty}^{\infty}\Psi^*\left(i\hbar\frac{\partial}{\partial t}\right)\Psi dx} \tag{57}$$
$$\mathbf{\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{2m}{\hbar^2}(E-U)\psi = 0} \tag{58}$$
$$\mathbf{E_n = -\frac{me^4}{32\pi^2\epsilon_0^2\hbar^2}\left(\frac{1}{n^2}\right) \quad n = 1,2,3,\ldots} \tag{59}$$
$$\mathbf{L = \sqrt{l(l+1)}\hbar \quad l = 0,1,2,\ldots,(n-1)} \tag{60}$$
$$\mathbf{\hat{H}\psi_n = E_n\psi_n \quad , \quad \hat{H} = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + U} \tag{61}$$
$$\mathbf{E_n = \frac{n^2\pi^2\hbar^2}{2mL^2} \quad n = 1,2,3,\ldots} \tag{62}$$
$$\mathbf{\psi_n = A\sin\frac{\sqrt{2mE_n}}{\hbar}x = A\sin\frac{n\pi x}{L} \quad , \quad A = \sqrt{\frac{2}{L}}} \tag{63}$$
$$\mathbf{\frac{d^2\psi}{dx^2} - a^2\psi = 0 \quad \begin{matrix} x < 0 \\ x > L \end{matrix};\quad a = \frac{\sqrt{2m(U-E)}}{\hbar}} \tag{64}$$

$$\mathbf{\psi_I = Ce^{ax} + De^{-ax} \rightarrow \psi_I = Ce^{ax}}$$
$$\mathbf{\psi_{II} = A\sin\frac{\sqrt{2mE}}{\hbar}x + B\cos\frac{\sqrt{2mE}}{\hbar}x} \tag{65}$$
$$\mathbf{\psi_{III} = Fe^{ax} + Ge^{-ax} \rightarrow \psi_{III} = Ge^{-ax}}$$
$$\mathbf{\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}\left(E - \frac{1}{2}kx^2\right)\psi = 0} \tag{66}$$
$$\mathbf{E_n = \left(n + \frac{1}{2}\right)h\nu \quad , \quad n = 0,1,2,3,\ldots} \tag{67}$$
$$\mathbf{U = -\frac{1}{4\pi\epsilon_0}\frac{e^2}{r} \quad , \quad r = \sqrt{x^2 + y^2 + z^2}} \tag{68}$$
$$\mathbf{\psi(r,\theta,\phi) = R(r)\Theta(\theta)\Phi(\phi) \quad , \quad \psi = R_{nl}\Theta_{lm_l}\Phi_{m_l}} \tag{69}$$
$$\mathbf{\frac{\sin^2\theta}{R}\frac{d}{dr}\left(r^2\frac{dR}{dr}\right) + \frac{\sin\theta}{\Theta}\frac{d}{d\theta}\left(\sin\theta\frac{d\Theta}{d\theta}\right) + \frac{1}{\Phi}\frac{d^2}{d\phi^2} + \frac{2mr^2\sin^2\theta}{\hbar^2}\left(\frac{e^2}{4\pi\epsilon_0 r} + E\right) = 0} \tag{70}$$
$$\mathbf{\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{dR}{dr}\right) + \left[\frac{2m}{\hbar^2}\left(\frac{e^2}{4\pi\epsilon_0 r} + E\right) - \frac{l(l+1)}{r^2}\right]R = 0} \tag{71}$$
$$\mathbf{E_n = -\frac{me^4}{32\pi^2\epsilon_0^2\hbar^2}\left(\frac{1}{n^2}\right) = \frac{E_1}{n^2} \quad n = 1,2,3,\ldots} \tag{72}$$

Principal quantum number $\mathbf{n = 1,2,3,\ldots}$ (73)
Orbital quantum number $\mathbf{l = 0,1,2,\ldots,(n-1)}$
Magnetic quantum number $\mathbf{m_l = 0,\pm1,\pm2,\ldots,\pm l}$

$$\mathbf{L = rmv_{orbital}}$$
$$\mathbf{\Rightarrow L = \sqrt{l(l+1)}\hbar\ ,\ l = 0,1,2,...,(n-1)} \tag{74}$$

Angular-momentum states	l = 0	1	2	3	4	5	6	...
	s	p	d	f	g	h	i	...

(75)

$$\mathbf{L_z = m_l\hbar \quad m_l = 0,\pm1,\pm2,\ldots,\pm l} \tag{76}$$
$$\mathbf{dV = (dr)(rd\theta)(r\sin\theta d\phi) = r^2\sin\theta drd\theta d\phi} \tag{77}$$
$$\mathbf{P(r)dr = r^2|R|^2dr\int_0^{\pi}|\Theta|^2\sin\theta d\theta\int_0^{2\pi}|\Phi|^2d\phi = r^2|R|^2dr} \tag{78}$$
$$\mathbf{\int_{-\infty}^{\infty} u\psi_{n,l,m_l}\psi^*_{n',l',m_l'}dV \neq 0} \tag{79}$$

Selection rules $\mathbf{\Delta l = \pm1}$
$$\mathbf{\Delta m_l = 0,\pm1} \tag{80}$$

Table 6.1 Normalized Wave Functions of the Hydrogen Atom for n = 1, 2, and 3*

n	l	m_l	$\Phi(\phi)$	$\Theta(\theta)$	$R(r)$	$\psi(r, \theta, \phi)$
1	0	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{1}{\sqrt{2}}$	$\frac{2}{a_0^{3/2}} e^{-r/a_0}$	$\frac{1}{\sqrt{\pi}\, a_0^{3/2}} e^{-r/a_0}$
2	0	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2\sqrt{2}\, a_0^{3/2}}\left(2 - \frac{r}{a_0}\right)e^{-r/2a_0}$	$\frac{1}{4\sqrt{2\pi}\, a_0^{3/2}}\left(2 - \frac{r}{a_0}\right)e^{-r/2a_0}$
2	1	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{\sqrt{6}}{2}\cos\theta$	$\frac{1}{2\sqrt{6}\, a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}$	$\frac{1}{4\sqrt{2\pi}\, a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}\cos\theta$
2	1	±1	$\frac{1}{\sqrt{2\pi}} e^{\pm i\phi}$	$\frac{\sqrt{3}}{2}\sin\theta$	$\frac{1}{2\sqrt{6}\, a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}$	$\frac{1}{8\sqrt{\pi}\, a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}\sin\theta\, e^{\pm i\phi}$
3	0	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{1}{\sqrt{2}}$	$\frac{2}{81\sqrt{3}\, a_0^{3/2}}\left(27 - 18\frac{r}{a_0} + 2\frac{r^2}{a_0^2}\right)e^{-r/3a_0}$	$\frac{1}{81\sqrt{3\pi}\, a_0^{3/2}}\left(27 - 18\frac{r}{a_0} + 2\frac{r^2}{a_0^2}\right)e^{-r/3a_0}$
3	1	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{\sqrt{6}}{2}\cos\theta$	$\frac{4}{81\sqrt{6}\, a_0^{3/2}}\left(6 - \frac{r}{a_0}\right)\frac{r}{a_0} e^{-r/3a_0}$	$\frac{\sqrt{2}}{81\sqrt{\pi}\, a_0^{3/2}}\left(6 - \frac{r}{a_0}\right)\frac{r}{a_0} e^{-r/3a_0}\cos\theta$
3	1	±1	$\frac{1}{\sqrt{2\pi}} e^{\pm i\phi}$	$\frac{\sqrt{3}}{2}\sin\theta$	$\frac{4}{81\sqrt{6}\, a_0^{3/2}}\left(6 - \frac{r}{a_0}\right)\frac{r}{a_0} e^{-r/3a_0}$	$\frac{1}{81\sqrt{\pi}\, a_0^{3/2}}\left(6 - \frac{r}{a_0}\right)\frac{r}{a_0} e^{-r/3a_0}\sin\theta\, e^{\pm i\phi}$
3	2	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{\sqrt{10}}{4}(3\cos^2\theta - 1)$	$\frac{4}{81\sqrt{30}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}$	$\frac{1}{81\sqrt{6\pi}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}(3\cos^2\theta - 1)$
3	2	±1	$\frac{1}{\sqrt{2\pi}} e^{\pm i\phi}$	$\frac{\sqrt{15}}{2}\sin\theta\cos\theta$	$\frac{4}{81\sqrt{30}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}$	$\frac{1}{81\sqrt{\pi}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}\sin\theta\cos\theta\, e^{\pm i\phi}$
3	2	±2	$\frac{1}{\sqrt{2\pi}} e^{\pm 2i\phi}$	$\frac{\sqrt{15}}{4}\sin^2\theta$	$\frac{4}{81\sqrt{30}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}$	$\frac{1}{162\sqrt{\pi}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}\sin^2\theta\, e^{\pm 2i\phi}$

*The quantity $a_0 = 4\pi\epsilon_0\hbar^2/me^2 = 5.292 \times 10^{-11}$ m is equal to the radius of the innermost Bohr orbit.

$$\mu = -\mathbf{ef}\pi\mathbf{r^2}\ ,\ \mathbf{L} = \mathbf{mvr} = 2\pi\mathbf{mfr^2}\ ,\ \mu = -\left(\frac{\mathbf{e}}{\mathbf{2m}}\right)\mathbf{L} \tag{81}$$

$$\mathbf{U_m} = -\mu\mathbf{B}\cos\theta \rightarrow \mathbf{U_m} = \mathbf{m_l}\left(\frac{\mathbf{e}\hbar}{\mathbf{2m}}\right)\mathbf{B} = \mathbf{m_l}\mu_\mathbf{B}\mathbf{B} \tag{82}$$

$$\mu_\mathbf{B} = \frac{\mathbf{e}\hbar}{\mathbf{2m}} \tag{83}$$

$$= \mathbf{9.274 \times 10^{-24}\ J/T = 5.788 \times 10^{-5}\ eV/T}$$

Normal Zeeman effect

$$\nu_1 = \nu_0 - \mu_\mathbf{B}\frac{\mathbf{B}}{\mathbf{h}} = \nu_0 - \frac{\mathbf{e}}{4\pi\mathbf{m}}\mathbf{B}$$
$$\nu_2 = \nu_0 \tag{84}$$
$$\nu_3 = \nu_0 + \mu_\mathbf{B}\frac{\mathbf{B}}{\mathbf{h}} = \nu_0 + \frac{\mathbf{e}}{4\pi\mathbf{m}}\mathbf{B}$$

$$\int_0^\infty \mathbf{x^n e^{-cx} dx} = \frac{\mathbf{n!}}{\mathbf{c^{n+1}}}\quad \&\quad \int_0^\pi \sin^3\theta \mathbf{d}\theta = \frac{\mathbf{4}}{\mathbf{3}} \tag{85}$$

$$\int \mathbf{x^n e^{-cx} dx} = \tag{86}$$
$$-\frac{\mathbf{e^{-cx}}}{\mathbf{c}}\left(\mathbf{x^n} + \frac{\mathbf{nx^{n-1}}}{\mathbf{c}} + \frac{\mathbf{n(n-1)x^{n-2}}}{\mathbf{c^2}} + \ldots + \frac{\mathbf{n!}}{\mathbf{c^n}}\right)$$

$$\sin^2\theta = \frac{\mathbf{1}}{\mathbf{2}}(\mathbf{1} - \cos\mathbf{2}\theta) \tag{87}$$

$$\mathbf{S} = \sqrt{\mathbf{s(s+1)}}\hbar = \frac{\sqrt{\mathbf{3}}}{\mathbf{2}}\hbar\ ,\ \mathbf{S_z} = \mathbf{m_s}\hbar = \pm\frac{\mathbf{1}}{\mathbf{2}}\hbar \tag{88}$$

$$\vec{\mu_s} = -\frac{\mathbf{e}}{\mathbf{m}}\vec{\mathbf{S}}\ ,\ \mu_\mathbf{sz} = \pm\frac{\mathbf{e}\hbar}{\mathbf{2m}} = \pm\mu_\mathbf{B} \tag{89}$$

$$n = \mathbf{1\ \ 2\ \ 3\ \ 4\ \ 5}\ \ldots \tag{90}$$
$$\mathbf{K\ L\ M\ N\ O}\ \ldots$$

$$\mathbf{1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2}$$
$$\mathbf{4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6\ 7s^2\ 6d^{10}\ 5f^{14}} \tag{91}$$

$$\nu = \frac{\mathbf{m(Z-1)^2e^4}}{\mathbf{8}\epsilon_0^2\mathbf{h^3}}\left(\frac{\mathbf{1}}{\mathbf{n_f^2}} - \frac{\mathbf{1}}{\mathbf{n_i^2}}\right) \tag{92}$$

$$(\mathbf{2} \mapsto \mathbf{1})\ \nu = \mathbf{cR(Z-1)^2}\left(\frac{\mathbf{1}}{\mathbf{1^2}} - \frac{\mathbf{1}}{\mathbf{2^2}}\right) = \frac{\mathbf{3cR(Z-1)^2}}{\mathbf{4}}$$