$v \ll 0.1c$ $\quad$ $t' = t$ $\quad$ $u = v_{S'} - v_S$ $\quad$ $x' = x - ut$ $\quad$ $v'_x = v_x - u$ $\quad$ $a'_x = a_x$

$y' = y$ $\quad$ $v'_y = v_y$ $\quad$ $a'_y = a_y$ $\quad$ $K.E = \dfrac{1}{2}mv^2$ $\quad$ $\rho = mv$ $\quad$ $E = Fd$

$v \geqslant 0.1c$ $\quad$ $\gamma = \dfrac{1}{\sqrt{1-(u/c)^2}} > 1$ $\quad$ $t' = \gamma(t - \dfrac{ux}{c^2})$ $\quad$ $x' = \gamma(x - ut)$

$v'_x = \dfrac{v_x - u}{1 - \dfrac{v_x u}{c^2}}$ $\quad$ $y' = y$ $\quad$ $v'_y = \dfrac{v_y\sqrt{1-(u/c)^2}}{1 - \dfrac{v_x u}{c^2}}$ $\quad$ $\theta' = \tan^{-1}\dfrac{V'_y}{V'_x}$

$t_o = \gamma t_p$ $\quad$ $\text{rate} = \dfrac{1}{t}$ $\quad$ $L = \dfrac{L_p}{\gamma}$ $\quad$ $\theta = \tan^{-1}\dfrac{L_y}{L_x}$ $\quad\bigg|$ $\quad \beta = \dfrac{v}{c}$ $\quad$ $\lambda_o = \lambda_s\sqrt{\dfrac{1\pm\beta}{1\mp\beta}}$ $\quad$ $f_o = f_s\sqrt{\dfrac{1\mp\beta}{1\pm\beta}}$

$m = m_0\gamma$ $\quad$ $E_t = \gamma m_0 c^2 = m_0 c^2 + K.E = \sqrt{\rho^2 c^2 + E_0^2}$ $\quad$ $E_0 = m_0 c^2$ $\quad$ $K.E = (\gamma - 1)E_0$

$\rho = \gamma m_0 v = \dfrac{1}{c}\sqrt{E_t^2 - E_0^2}$ $\quad$ $\rho^2 c^2 = E_t^2 - E_0^2$ $\quad$ $F = \gamma^3 m_0 a$ $\quad$ $v = \dfrac{pc^2}{E_t} = c\sqrt{1-(1/\gamma^2)}$

$c = \lambda f$ $\quad$ $E = hf = \dfrac{hc}{\lambda} = W + K.E = W + eV$ $\quad$ $W = hf_c = \dfrac{hc}{\lambda_c}$ $\quad$ $K.E_{max} = \dfrac{1}{2}mv_{max}^2 = eV_S$

$\dfrac{n}{t} = \dfrac{IA}{hf} = \dfrac{P}{E}$ $\quad$ $i = \dfrac{n}{t}\cdot e = \dfrac{Q}{t}$ $\quad$ $I = \dfrac{P}{A}$ $\quad$ $E_n = nhf$ $\quad$ $E_i > W$ $\quad$ $f_i > f_c$ $\quad$ $\lambda_i < \lambda_c$

$P = \sigma A T^4$ $\quad$ $\sigma = 5.6\times 10^{-8}$ $\quad$ $\lambda_{max}T = 2.898\times 10^{-3}mK$ $\quad$ $^{\circ}K = 273 + {}^{\circ}C$

$\lambda_{min} = \dfrac{hc}{eV} = \dfrac{1.26\times 10^{-6}}{V}[V\cdot m]$ $\quad$ $E_{x\text{-ray}} = eV = \dfrac{hc}{\lambda_{min}}$ $\quad\bigg|$ $\quad E_{ph} = 2m_e c^2 + K.E_- + K.E_+$

$E = \rho c = eV$ $\quad$ $\rho_{ph} = \dfrac{E_{ph}}{c} = \dfrac{h}{\lambda}$ $\quad$ $\rho_e = mv$ $\quad$ $K.E_e = \dfrac{1}{2}mv^2 = E_{ph} - E'_{ph}$ $\quad$ $E_{ph} + m_e c^2 = E'_{ph} + E_e$

$\lambda_c = \dfrac{h}{mc} = 2.426\times 10^{-12}$ $\quad$ $\lambda' - \lambda = \lambda_c(1 - \cos\theta)$

$x : \rho_i = \rho_s\cos\theta + \rho_e\cos\phi$ $\quad$ $y : \rho_s\sin\theta = \rho_e\sin\phi$ $\quad$ $\tan\phi = \dfrac{\sin\theta}{\lambda_f/\lambda_i - \cos\theta} = \dfrac{\rho'\sin\theta}{\rho - \rho'\cos\theta}$

$\lambda_{brog} = \dfrac{h}{\rho_{ph}} = \dfrac{h}{mv} = \dfrac{h}{\sqrt{2mK.E}}$ $\quad$ $hf = 2\gamma mc^2$ $\quad$ $\Delta x\Delta P \geqslant \dfrac{\hbar}{2}$ $\quad$ $\Delta E\Delta t \geqslant \dfrac{\hbar}{2}$ $\quad$ $\Delta\rho = m\Delta v$ $\quad$ $\Delta E = h\Delta f$

$F_c = \dfrac{mv^2}{r} = F_e = \dfrac{1}{4\pi\epsilon_0}\dfrac{e}{r^2}$ $\quad$ $v = \dfrac{e}{\sqrt{4\pi\epsilon_0 mr}}$ $\quad$ $K.E = \dfrac{1}{2}mv^2$ $\quad$ $K.E_n = \dfrac{e^2}{8\pi\epsilon_0 r_n}$ $\quad$ $P.E = \dfrac{-e^2}{4\pi\epsilon_0 r_n}$

$E = \dfrac{-e^2}{8\pi\epsilon_0 r_n}$ $\quad$ $r_n = a_0 n^2 = \dfrac{n^2 h^2\epsilon_0}{\pi m e^2}$ $\quad$ $L = n\hbar = \rho r$ $\quad$ $f_n = \dfrac{v}{2\pi r} = \dfrac{e}{2\pi\sqrt{4\pi\epsilon_0 mr^3}} = \dfrac{-E_1}{h}(\dfrac{2}{n^3})$

$E_n = \dfrac{-13.6}{n^2}[eV]$ $\quad$ $\dfrac{1}{\lambda} = R_\infty(\dfrac{1}{n_f^2} - \dfrac{1}{n_i^2})$ $\quad$ $E_{ph} = hf = E_i - E_f$ $\quad$ $N = f\Delta t$ $\quad$ $f = \dfrac{-E_1}{h}(\dfrac{1}{n_f^2} - \dfrac{1}{n_i^2})$ $\quad$ $f_L = \dfrac{-E_1}{h}(\dfrac{2\rho}{n^3})$

$K.E = \dfrac{\rho^2}{2m}$ $\quad$ $\hbar = \dfrac{h}{2\pi}$ $\quad$ $\mu = -(\dfrac{e}{2m})L$ $\quad$ $P.E_m = -\mu B\cos\theta$ $\quad$ $\Delta\lambda = \dfrac{eB\lambda^2}{4\pi mc}$ $\quad$ $\Delta v = \dfrac{eB}{4\pi m}$

$L_z = m_l\hbar = L\cos\theta$ $\quad$ $\cos\theta = \dfrac{m_l}{\sqrt{l(l+1)}}$ $\quad$ $S_z = \pm\dfrac{1}{2}\hbar$ $\quad$ $\mu_s = \dfrac{-e}{m}S$ $\quad$ $\mu_{sz} = \pm\dfrac{e\hbar}{2m} = \pm\mu_B l = n - 1$

$n = 1, 2, 3, 4\ldots$ $\quad$ $l = 0, 1, \ldots, n-1$ $\quad$ $-l \leqslant m_l \leqslant l$ $\quad$ $m_s = \pm\dfrac{1}{2}$ $\quad$ $L = \sqrt{l(l+1)}\hbar$ $\quad$ $S = \dfrac{\sqrt{3}}{2}\hbar$ $\quad$ $J = L + S$

$N_{max} = 2n^2$ $\quad$ $L_{max} = 2(2l+1)$ $\quad$ $\Delta l = \pm 1$ $\quad$ $\Delta m_l = 0, \pm 1$

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

$c = 3\times 10^8$ m/s $\quad$ Mach $= 343$ m/s $\quad$ 1.6×10^{-19} J $= 1$ eV $\quad$ $e = 1.6\times 10^{-19}$ C

$m_e = 9.11\times 10^{-31}$ kg $\quad$ $m_p = 1.67\times 10^{-27}$ kg $\quad$ MeV/c^2 $= 1.79\times 10^{-30}$ kg $\quad$ MeV/c $= 5.36\times 10^{-22}$ kg·m/s

$m_e c^2 = 0.511$ MeV $\quad$ $m_p c^2 = 938$ MeV $\quad$ $m_n c^2 = 939$ MeV

$\mu_B = 9.274\times 10^{-24}$ J/T $= 5.788\times 10^{-5}$ eV/T $\quad$ $\dfrac{h}{m_e c} = 0.024\times 10^{-10}$ m

$h = 6.626\times 10^{-34}$ J·s $\quad$ $\hbar = 1.054\times 10^{-34}$ J·s $\quad$ $a_0 = 0.529\times 10^{-10}$ m $\quad$ $R = 1.097\times 10^7$ m^{-1}

1 L.Y $\approx 9.46\times 10^{15}$ m $\quad$ μm : 10^{-6} $\quad$ nm : 10^{-9} $\quad$ pm : 10^{-12} $\quad$ fm : 10^{-15} $\quad$ Å $= 10^{-10}$ m