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

$$\gamma = \frac{1}{\sqrt{1-(u/c)^2}}[>1] \quad t' = \gamma(t - \frac{ux}{c^2}) \quad x' = \gamma(x - ut) \quad y' = y \quad v'_y = \frac{v_y\sqrt{1-(u/c)^2}}{1 - \frac{v_x u}{c^2}} \qquad \theta' = \tan^{-1}\frac{V'_y}{V'_x}$$

$$t_o = \gamma t_p \quad \text{rate} = \frac{1}{t} \quad L = \frac{L_p}{\gamma} \quad \theta = \tan^{-1}\frac{L_y}{L_x}$$

$$\beta = \frac{v}{c} \quad \lambda_o = \lambda_s\sqrt{\frac{1\pm\beta}{1\mp\beta}} \quad f_o = f_s\sqrt{\frac{1\mp\beta}{1\pm\beta}}$$

$$m = m_0\gamma \qquad E_t = \gamma m_0 c^2 = m_0c^2 + K.E = \sqrt{\rho^2c^2 + E_0^2} \qquad E_0 = m_0c^2 \qquad K.E = (\gamma - 1)E_0$$

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

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

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

$$P = \sigma AT^4 \qquad \sigma = 5.6\times10^{-8} \qquad \lambda_{max}T = 2.898\times10^{-3}mK \qquad {}^\circ K = 273 + {}^\circ C$$

$$\lambda_{min} = \frac{hc}{eV} = \frac{1.26\times10^{-6}}{V}[V\cdot m] \qquad E_{\text{x-ray}} = eV = \frac{hc}{\lambda_{min}} \qquad E_{ph} = 2m_ec^2 + K.E_- + K.E_+$$

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

$$\lambda_c = \frac{h}{mc} = 2.426\times10^{-12} \qquad \lambda' - \lambda = \lambda_c(1-\cos\theta)$$

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

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

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

$$E = \frac{-e^2}{8\pi\epsilon_0 r_n} \quad r_n = a_0n^2 = \frac{n^2h^2\epsilon_0}{\pi me^2} \qquad L = n\hbar = \rho r \qquad f_n = \frac{v}{2\pi r} = \frac{e}{2\pi\sqrt{4\pi\epsilon_0 mr^3}} = \frac{-E_1}{h}(\frac{2}{n^3})$$

$$E_n = \frac{-13.6}{n^2}[eV] \quad E_{ph} = hf = E_i - E_f = -13.6(\frac{1}{n_f^2} - \frac{1}{n_i^2}) \quad \frac{1}{\lambda} = R_\infty(\frac{1}{n_f^2} - \frac{1}{n_i^2}) \quad v_n = \frac{1.28\times10^6}{n}$$

$$N = f\Delta t \quad f = \frac{-E_1}{h}(\frac{1}{n_f^2} - \frac{1}{n_i^2}) \quad f_L = \frac{-E_1}{h}(\frac{2\rho}{n^3}) \quad E = K.E + P.E \quad n\lambda = 2\pi r_n$$

$$K.E = \frac{\rho^2}{2m} \quad \mu = -(\frac{e}{2m})L \quad P.E_m = -\mu B\cos\theta \quad U_m = m_l(\frac{e\hbar}{2m})B$$

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

$$n = 1,2,3,4\ldots \quad l = 0,1,\ldots,n-1 \quad -l \leqslant m_l \leqslant l \quad m_s = \pm0.5 \quad L = \sqrt{l(l+1)}\hbar \quad S = 0.5\sqrt{3}\hbar$$

$$J = L + S \quad N_{max} = 2n^2 \quad L_{max} = 2(2l+1) \qquad \Delta l = \pm1 \quad \Delta m_l = 0, \pm1$$

$$f_1 = f_0 - \mu_B\frac{B}{h} \qquad f_2 = f_0 \qquad f_3 = f_0 + \mu_B\frac{B}{h} \qquad \Delta\lambda = \frac{eB\lambda^2}{4\pi mc} \qquad \Delta f = \frac{eB}{4\pi m}$$

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

$$c = 3\times10^8\ m/s \qquad Mach = 343\ m/s \qquad 1.6\times10^{-19}\ J = 1\ eV \qquad e = 1.6\times10^{-19}\ C \quad h = 6.626\times10^{-34}\ J\cdot s$$

$$m_e = 9.11\times10^{-31}\ kg \quad m_p = 1.67\times10^{-27}\ kg \qquad MeV/c^2 = 1.79\times10^{-30}\ kg \qquad MeV/c = 5.36\times10^{-22}\ kg\cdot m/s$$

$$m_ec^2 = 0.511\ MeV \qquad m_pc^2 = 938\ MeV \qquad m_nc^2 = 939\ MeV \qquad \mu_B = 9.274\times10^{-24}J/T = 5.788\times10^{-5}eV/T$$

$$\frac{h}{m_ec} = 0.024\times10^{-10}\ m \qquad \hbar = 1.054\times10^{-34}\ J\cdot s \qquad a_0 = 0.529\times10^{-10}\ m \qquad R = 1.097\times10^7\ m^{-1}$$

$$1\ L.Y \approx 9.46\times10^{15}\ m \qquad \mu m : 10^{-6} \qquad nm : 10^{-9} \qquad pm : 10^{-12} \qquad fm : 10^{-15} \qquad \text{Å} = 10^{-10}\ m$$