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

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

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

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

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

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

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

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

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

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

$\lambda_{min} = \frac{hc}{eV} = \frac{1.26\times10^{-6}}{V}[V\cdot m] \quad E = \rho c \quad \lambda' = \lambda + \frac{h}{mc}(1-\cos\theta) \quad \lambda_c = \frac{h}{mc} = 2.426\times10^{-12}$

$K.E_e = E_{ph} - E'_{ph} \quad \frac{1}{E'_{ph}} = \frac{1}{E_{ph}} + \frac{1-\cos\theta}{m_eC^2} \quad E_{x\text{-ray}} = eV = \frac{hc}{\lambda_{min}}$

$x : \rho_i = \rho_s\cos\theta + \rho_e\cos\phi \quad \tan\phi = \frac{\sin\theta}{\lambda_f/\lambda_i - \cos\theta} = \frac{\rho'\sin\theta}{\rho - \rho'\cos\theta} \quad E = 2mc^2 + K_- + K_+$

$y : \rho_s\sin\theta = \rho_e\sin\phi \quad E_{ph} + m_ec^2 = E'_{ph} + E_e \quad \lambda' - \lambda = \frac{h}{mc}(1-\cos\theta)$

$\lambda_{brog} = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mKE}} \quad hf = 2\gamma mc^2 \quad \Delta x\Delta P \geqslant \frac{\hbar}{2} \quad \Delta E\Delta t \geqslant \frac{\hbar}{2} \quad \Delta P = m\Delta v \quad \Delta E = h\Delta f$

$F_c = \frac{mv^2}{r} = F_e = \frac{1}{4\pi\epsilon_0}\frac{e}{r^2} \quad v = \frac{e}{\sqrt{4\pi\epsilon_0 mr}} \quad KE = \frac{1}{2}mv^2 \quad KE_n = \frac{e^2}{8\pi\epsilon_0 r_n} \quad PE = \frac{-e^2}{4\pi\epsilon_0 r_n} \quad E = \frac{-e^2}{8\pi\epsilon_0 r_n}$

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

$E_n = \frac{-13.6}{n^2}eV \quad E = KE + PE \quad \frac{1}{\lambda} = R_\infty(\frac{1}{n_f^2} - \frac{1}{n_i^2})E_ph = hf = E_i - E_f$

$N = f\Delta t \quad v = \frac{-E_1}{h}(\frac{1}{n_f^2} - \frac{1}{n_i^2}) \quad v_L = \frac{-E_1}{h}(\frac{2P}{n^3})$

$KE = \frac{p^2}{2m} \quad L = \sqrt{l(l+1)}\hbar \quad \hbar = \frac{h}{2\pi} \quad L_z = m_l\hbar = L\cos\theta \quad \mu = -(\frac{e}{2m})L \quad PE_m = (\frac{e}{2m})LB\cos\theta$

$\cos\theta = \frac{m_l}{\sqrt{l(l+1)}} \quad S = \frac{\sqrt{3}}{2}\hbar S_z = \pm\frac{1}{2}\hbar \quad \frac{-e}{m}S \quad \mu_{sz} = \pm\frac{e\hbar}{2m} = \pm\mu_B l = n-1 \quad -l \leqslant m_l \leqslant l$

$m_s = \pm\frac{1}{2} \quad N_{max} = 2n^2 \quad L_{max} = 2(2l+1) \quad \Delta l = \pm1 \quad \Delta m_l = 0, \pm1 \quad n = 1,2,3,4\ldots \quad \Delta v = \frac{eB}{4\pi m}$

$\Delta\lambda = \frac{eB\lambda^2}{4\pi mc}$

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

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

$m_ec^2 = 0.511$ MeV $\quad m_pc^2 = 938$ MeV $\quad m_nc^2 = 939$ MeV $\quad a_0 = 0.529\times10^{-10}$ m

$\mu_B = 9.274\times10^{-24}$J/T $= 5.788\times10^{-5}$eV/T $\quad R = 1.097\times10^7$ m^{-1} $\quad \frac{h}{m_ec} = 0.024\times10^{-10}$ m

1 L.Y $\approx 9.4610^{15}$ m $\quad$ µm : 10^{-6} $\quad$ nm : 10^{-9} $\quad$ pm : 10^{-12} $\quad$ fm : 10^{-15} $\quad$ 1 Å $= 10^{-10}$ m $\quad$ 1 Ma $= 343$ m/s

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p 7s