# PHYSICS 101B SPRING 2000

# FINAL EXAM

## PUT YOUR NAME ON THE EXAM RIGHT AWAY!

## EQUATIONS AND FORMULAE

$x' = x - vt$; $y' = y$; $z' = z$

$\beta = v/c$

$\Delta t = \gamma \Delta t'$

$(\Delta s)^2 = (c\Delta t)^2 - (\Delta x)^2$

$u'_x = (u_x - v)/[1 - (vu_x/c^2)]$

$u'_z = u_z/\gamma[1 - (vu_x/c^2)]$

$E = \gamma mc^2$

$p = (E/c, p_x, p_y, p_z)$

$E^2 = (mc^2)^2 + (pc)^2$

$\nu = c/\lambda$

$eV_{stop} = h\nu - \phi$

$\lambda_c = 2.43 \times 10^{-12}$ m

$\Delta N = \frac{I_0 A_{sc} n t}{r^2} \frac{kzZe^2}{4E_k}^2 \frac{1}{\sin^4(\theta/2)}$

$\frac{d\sigma}{d\Omega} = \frac{kzZe^2}{4E_k}^2 \frac{1}{\sin^4(\theta/2)}$

$U_E = \frac{kq_1q_2}{r^2}$

$\frac{1}{\lambda_{Nn}} = Z^2 R \left(\frac{1}{N^2} - \frac{1}{n^2}\right)$

$L = n\hbar$

$\lambda = h/p$

$n\lambda = D \sin\theta$

$p = \hbar k$

$v = \omega/k$

$\Delta x \Delta p_x \geq \hbar/2$

$P(x) = |\psi(x,t)|^2$

$\Delta x^2 = \sum (x - \bar{x})^2/N$

$-\frac{\hbar^2}{2m}\frac{\partial^2\psi(x,t)}{\partial x^2} + V(x,t)\psi(x,t) = i\hbar\frac{\partial\psi(x,t)}{\partial t}$

$k = \frac{\sqrt{2m(E-V)}}{\hbar}$

$E_n = (h^2n^2)/(8mL^2)$

$ct' = \gamma(ct - \beta x)$; $x' = \gamma(x - \beta ct)$

$\gamma = 1/\sqrt{1-\beta^2}$

$L = L_P/\gamma$

$\Delta\tau = \Delta s/c$

$u'_y = u_y/\gamma[1 - (vu_x/c^2)]$

$\vec{p} = \gamma m\vec{v}$

$E'/c = \gamma(E/c - \beta p_x)$; $p'_x = \gamma(p_x - \beta E/c)$

$M = |p|/c$; $|p|^2 = (E/c)^2 - p_x^2 - p_y^2 - p_z^2$

$pc = \beta E$

$E = h\nu$

$\lambda_2 - \lambda_1 = \lambda_c(1 - \cos\theta)$

$b = \frac{kzZe^2}{2E_k} \cot\frac{\theta}{2}$

$d\Omega = \sin\theta d\theta d\phi$

$r_d = \frac{kzZe^2}{E_k}$

$E_n = -hcR\frac{Z^2}{n^2}$

$\mu = \frac{mM}{m+M}$

$\sqrt{\nu} = A_n(Z - b)$

$\omega = 2\pi\nu = E/\hbar$

$\lambda = h/\sqrt{2mE_k}$

$E = p^2/2m$

$v_g = d\omega/dk$

$\Delta t \Delta E \geq \hbar/2$

$\int P(x)dx = 1$

$\phi(t) = \exp(-i\omega t)$

$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + V(x)\psi(x) = E\psi(x)$

$K = \frac{\sqrt{2m(V-E)}}{\hbar}$

$\psi_n(x) = \sqrt{2/L}\sin(n\pi x/L)$

$\langle O \rangle = \int \psi(x)^* O \psi(x) dx$

$p_x^{op} = \frac{\hbar}{i} \frac{\partial}{\partial x}$

$V(x) = (1/2) m\omega^2 x^2$

$\psi_{nm}(x_1, x_2) = \psi_n(x_1)\psi_m(x_2)$

$E_{n_1 n_2 n_3} = \frac{h^2}{8mL^2}(n_1^2 + n_2^2 + n_3^2)$

$-\frac{\hbar^2}{2\mu}\nabla^2\psi + V\psi = E\psi$

$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$

$\nabla^2 = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 \frac{\partial}{\partial r}) - L_{op}^2/\hbar^2$

$L_{op}^2 = -\hbar^2[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial}{\partial\theta}) + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\phi^2}]$

$L_z^{op} = -i\hbar\frac{\partial}{\partial\phi}$

$f_{lm}(\theta) = \sin\theta^{|m|}\frac{d^{|m|}P_l(\theta)}{d\cos\theta^{|m|}}$

$P_l(\theta) = (\frac{d}{d\cos\theta})^l(\cos^2\theta - 1)^l$

$g(\phi) = e^{im\phi}$

$R(r) = r^l L_{nl}(\frac{2r}{na_0})e^{-r/(na_0)}$

$L_{nl}(\rho) = (\frac{d}{d\rho})^{2l+1}[e^\rho(\frac{d}{d\rho})^{n+l}(\rho^{n+l}e^{-\rho})]$

$E_n = -\frac{Z^2 E_1}{n^2}$

$E_1 = \frac{k^2 e^4 \mu}{2\hbar^2} \simeq 13.6$ eV

$\int_0^\infty x^n e^{-x} dx = n!$

Let $I_n = \int_0^{+\infty} x^n e^{-\lambda x^2} dx$

$I_0 = \frac{1}{2}\sqrt{\frac{\pi}{\lambda}} \quad I_1 = \frac{1}{2\lambda}$

$I_2 = \frac{1}{4}\sqrt{\frac{\pi}{\lambda^3}} \quad I_3 = \frac{1}{2\lambda^2}$

$I_4 = \frac{3}{8}\sqrt{\frac{\pi}{\lambda^5}} \quad I_5 = \frac{1}{\lambda^3}$

$j_1 + j_2 \geq j_{tot} \geq |j_1 - j_2|$

$|\vec{J}| = \sqrt{(j)(j+1)}\hbar$

$PV = nRT$

$C_V = \frac{1}{n}(\frac{\partial Q}{\partial T})_V$

$\langle E \rangle = \frac{1}{2}N_{dof}kT; \;\; C_V = \frac{1}{2}N_{dof}R$

$f_D(E) = Ae^{-E/kT}$

$f_{BE}(E) = \frac{1}{e^\alpha e^{E/kT} - 1}$

$f_{FD}(E) = \frac{1}{e^{(E-E_F)/kT} + 1}$

$n(E) = g(E)f(E)$

$n(v)dv = 4\pi N(\frac{m}{2\pi kT})^{3/2} e^{-mv^2/2kT} v^2 dv$

$g(E) = \frac{4\pi(2m)^{3/2}}{h^3} V E^{1/2}$

$E_F = \frac{h^2}{2m}(\frac{3N}{8\pi V})^{2/3}$

$\varrho = \frac{m<v>}{ne^2\tau}$

$< v >= \sqrt{(8kT)/(m\pi)}$

$n(E)dE = 2\pi N(\frac{1}{\pi kT})^{3/2} E^{1/2} e^{-E/kT} dE$

$N(x) = N_0 e^{-x/\lambda}$

$\lambda = \frac{1}{\rho\pi r^2}$

$V_d = \frac{F}{m}\frac{\lambda}{\langle v \rangle}$

$I = \frac{ne^2}{\rho\pi r_a^2 m<v>}\frac{A}{L}V$

$\varrho = \frac{A}{L}R$

$I_{net} = I_0(e^{eV/kT} - 1)$

$I_c = \beta I_b$

$R_n = R_0 A^{1/3}; \;\; R_0 = 1.2$fm

$N(t) = N_0 e^{-t/\tau}$

$M(N,Z)c^2 = Zm_p c^2 + Nm_n c^2 - A\Gamma(N,Z)$

$\Gamma(A,Z) = a_1 - \frac{a_2}{A^{1/3}} - a_3\frac{Z^2}{A^{4/3}} - a_4\frac{(Z^{5/3} + N^{5/3})}{A^{5/3}}$

c $= 2.998 \times 10^8$ m/s

$\hbar = h/2\pi$

$\hbar = 1.054 \times 10^{-34}$ J-s $= 6.582 \times 10^{-16}$ eV-s

$h = 6.626 \times 10^{-34}$ J-s

$hc = 1240$ eV-nm

$k = 1.381 \times 10^{-23}$ J/K $= 8.617 \times 10^{-5}$ eV/K

$e = 1.602 \times 10^{-19}$ C

There are $1.602 \times 10^{-19}$ J per eV

$m_e = 5.110 \times 10^5$ eV/c$^2$ $= 9.109 \times 10^{-31}$ kg

$a_0 = \hbar^2/mke^2 = 0.0529$ nm

$R_\infty = 1.097 \times 10^7$ m$^{-1}$

$k = 8.99 \times 10^9$ N-m$^2$/C$^2$ (electrostatic constant)

$N_0 = 6.02 \times 10^{23}$

$R = N_0 k = 8.31 J/^0K - mol$

$m_p = 938.3$MeV/c$^2$

$m_n = 939.6$MeV/c$^2$

$G(x;\sigma) = A * \exp[1/2(x^2/\sigma^2)]$

$A = 1/(\sqrt{2\pi}\sigma)$