

PHYSICS 101B

MIDTERM II

PUT YOUR NAME ON THE EXAM RIGHT AWAY!

PLEASE SHOW ALL OF YOUR WORK. You may use the back of the page if necessary. Please clearly mark all problems for which you have information on the back of the page that you would like to be considered during the grading of the exam.

EQUATIONS AND FORMULAE

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

$$\beta = v/c$$

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

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

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

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

$$E = \gamma mc^2$$

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

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

$$\nu = c/\lambda$$

$$R = \sigma T^4; \quad \sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{-K}^4$$

$$n(\lambda) = 8\pi\lambda^{-4}$$

$$u(\lambda) = \frac{8\pi hc\lambda^{-5}}{\exp(hc/\lambda kT) - 1}$$

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

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

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

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

$$U_E = \frac{kq_1 q_2}{r}$$

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

$$L = n\hbar$$

$$\lambda = h/p$$

$$n\lambda = D \sin \theta$$

$$p = \hbar k$$

$$v = \omega/k$$

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

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

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

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

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

$$L = L_P/\gamma$$

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

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

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

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

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

$$pc = \beta E$$

$$E = h\nu$$

$$\lambda_{max} T = 2.898 \times 10^{-3} \text{ m-K}$$

$$\bar{E} = kT$$

$$\bar{E} = \frac{h\nu}{\exp(hc/\lambda kT) - 1}$$

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

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

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

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

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

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

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

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

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

$$KE = p^2/2m$$

$$v_g = d\omega/dk$$

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

$$\int P(x) dx = 1$$

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

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

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

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

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

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

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

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

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

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

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

$$Y_{lm}(\theta, \phi) = C_{lm} f_{lm}(\theta) g_m(\phi) \text{ and } g_m(\phi) = e^{im\phi}$$

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

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

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

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

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

$$PV = nRT$$

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

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

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

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

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

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

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

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

$$hc = 1240 \text{ eV-nm}$$

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

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

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

$$G(x; \sigma) = 1/(\sqrt{2\pi}\sigma) * \exp[-1/2(x^2/\sigma^2)]$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\hbar = h/2\pi$$

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

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

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

$$a_0 = \hbar^2/mke^2 = 0.0529 \text{ nm}$$

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

$$e^{i\phi} = \cos \phi + i \sin \phi$$