Physics 314 – Final exam, formula sheet

$$c = 3 \times 10^8 \text{ m/s} \qquad h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s} = 4.136 \times 10^{-15} \text{ eV} \cdot \text{s}$$

$$\hbar \equiv \frac{h}{2\pi} = 1.0546 \times 10^{-34} \text{ J} \cdot \text{s} = 6.582 \times 10^{-16} \text{ eV} \cdot \text{s}$$

$$1 \text{ eV} = 1.60218 \times 10^{-19} \text{ J} \qquad \mathrm{m_e} = 9.1094 \times 10^{-31} \text{ kg} = 0.511 \text{ MeV/c}^2$$

$$m_{\text{proton}} = 1.007276470u \qquad m_{\text{neutron}} = 1.008664924u \qquad 1\ u = 931.4943 \text{ MeV}/c^2$$

$$\text{Hydrogen atom mass}: \quad m_{\text{H}} = 1.007976u \qquad e^2/4\pi\epsilon_0 = 1.439965 \text{ eV} \cdot \text{nm}$$

$$\Delta t = \frac{\Delta t_0}{\sqrt{1 - u^2/c^2}} \qquad L = L_0\sqrt{1 - u^2/c^2} \qquad v = \frac{v' + u}{1 + v'u/c^2}$$

$$\mathbf{p} = \frac{m\mathbf{v}}{\sqrt{1 - v^2/c^2}}$$

$$K = \frac{mc^2}{\sqrt{1 - v^2/c^2}} - mc^2 \qquad K = E - E_0 \qquad E = \frac{mc^2}{\sqrt{1 - v^2/c^2}} \qquad E_0 = mc^2$$

$$E = \sqrt{(pc)^2 + (mc^2)^2} \qquad \nu' = \nu\sqrt{\frac{1 - u/c}{1 + u/c}}$$

$$2d\sin\theta = n\lambda \qquad n = 1, 2, 3\ldots$$

$$E = h\nu \qquad \nu = \frac{c}{\lambda} \qquad p = \frac{h}{\lambda}$$

$$K_{\text{max}} = h\nu - \phi \qquad K_{\text{max}} = eV_{\text{s}}$$

$$I = \sigma T^4 \qquad \sigma = 5.6704 \times 10^{-8} \text{ W/m}^2 \cdot \text{K}^4 \qquad \lambda_{\text{max}}T = 2.898 \times 10^{-3} \text{ m} \cdot \text{K}$$

$$R(\lambda) = \left(\frac{c}{4}\right)\left(\frac{8\pi}{\lambda^4}\right)\left[\left(\frac{hc}{\lambda}\right)\frac{1}{e^{hc/\lambda kT} - 1}\right]$$

$$E + m_{\text{e}}c^2 = E' + E_{\text{e}} \qquad \frac{1}{E'} - \frac{1}{E} = \frac{1}{m_{\text{e}}c^2}(1 - \cos\theta) \qquad \lambda' - \lambda = \frac{h}{m_{\text{e}}c}(1 - \cos\theta)$$

$$\lambda = \frac{h}{p} \qquad \Delta x \Delta p_x \le \hbar \qquad \hbar \equiv \frac{h}{2\pi}$$

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2} = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2} = \frac{mv^2}{r}; \quad K = \frac{1}{2}mv^2 = \frac{1}{8\pi\epsilon_0}\frac{e^2}{r}; \quad U = -\frac{1}{4\pi\epsilon_0}\frac{e^2}{r}; \quad E = -\frac{1}{8\pi\epsilon_0}\frac{e^2}{r}$$

$$mvr = n\hbar \ \ (n = 1, 2, 3, \ldots); \quad \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{n\hbar}{mr}\right)^2 = \frac{1}{8\pi\epsilon_0}\frac{e^2}{r}; \quad r_n = \frac{4\pi\epsilon_0\hbar^2}{me^2}n^2 = a_0 n^2$$

$$a_0 = \frac{4\pi\epsilon_0\hbar^2}{me^2} = 0.0529 \text{ nm}; \quad E_n = -\frac{me^4}{32\pi^2\epsilon_0^2\hbar^2}\frac{1}{n^2} = \frac{-13.6 \text{ eV}}{n^2}$$

$$h\nu = E_{n_1} - E_{n_2}; \quad \nu = \frac{me^4}{64\pi^3\epsilon_0^2\hbar^3}\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right); \quad \lambda = \frac{c}{\nu} = \frac{64\pi^2\epsilon_0^2\hbar^3 c}{me^4}\left(\frac{n_1^2 n_2^2}{n_1^2 - n_2^2}\right)$$

$$E_n = -\frac{m(Ze^2)^2}{32\pi^2\epsilon_0^2\hbar^2}\frac{1}{n^2} = -(13.6\text{eV})\frac{Z^2}{n^2}; \ \text{ or } \ E_n = -\frac{\mu(Ze^2)^2}{32\pi^2\epsilon_0^2\hbar^2}\frac{1}{n^2} \ \text{ where } \ \mu = \frac{mM}{m+M}$$

$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + U\psi = E\psi$$

$$P(x)dx = |\psi(x)|^2 dx \qquad \int_{-\infty}^{\infty} |\psi(x)|^2 dx = 1$$

$$\psi_n(x) = \sqrt{\frac{2}{L}}\sin\left(\frac{n\pi x}{L}\right) \qquad (n = 1, 2, 3, \ldots) \qquad E_n = \frac{\hbar^2\pi^2 n^2}{2mL^2} = E_1 n^2$$

$$\psi(x, y) = \frac{2}{L}\sin\left(\frac{n_x\pi x}{L}\right)\sin\left(\frac{n_y\pi y}{L}\right) \qquad (n_x, n_y = 1, 2, 3, \ldots) \qquad E = \frac{\hbar^2\pi^2}{2mL^2}(n_x^2 + n_y^2)$$

$$\omega_0 = \sqrt{k/m} \qquad E_n = (n + \frac{1}{2})\hbar\omega_0 \qquad (n = 0, 1, 2, 3, \ldots)$$

$$\psi_{n,l,m_l}(r, \theta, \phi) = R_{n,l}(r)\Theta_{l,m_l}(\theta)\Phi_{m_l}(\phi); \qquad P(r, \theta, \phi)dV = |\psi_{n,l,m_l}(r, \theta, \phi)|^2 dV$$

$$dV = r^2 \sin\theta dr d\theta d\phi$$

$$|\psi_{n,l,m_l}(r, \theta, \phi)|^2 dV = |R_{n,l}(r)|^2|\Theta_{l,m_l}(\theta)|^2|\Phi_{m_l}(\phi)|^2 r^2 \sin\theta dr d\theta d\phi$$

$$P(r)dr = |R_{n,l}(r)|^2 r^2 dr \int_0^\pi |\Theta_{l,m_l}(\theta)|^2 \sin\theta d\theta \int_0^{2\pi} |\Phi_{m_l}(\phi)|^2 d\phi = |R_{n,l}(r)|^2 r^2 dr$$

$$P(r)dr = r^2|R_{n,l}(r)|^2 dr$$