Physics 220 Exam 3 review sheet

The exam, primarily over Ch. 8.4-8.10, 9.1-9.6, 9.8, and 10.1-10.8 (but as with any physics course the earlier material may still be relevant), will be held in class Thursday, April 30. Expect 3-4 problems (similar to homework) and 1-2 pages of short answer/qualitative questions. You will be provided with an equation sheet (see below) and information from the inside front cover of the book, as well as atomic data where needed (e.g. periodic table, masses, etc.), other needed conversion factors (e.g. for pressures), and any needed integrals (such as those given in homework problems). Tables of angular and radial functions (Tables 8.1 and 8.2) will also be provided.

Studying hint: a lot of the equations look similar, and the same symbol may be used for different physical quantities. Be sure you know to which situations each of the equations below apply, and what physical quantities the symbols refer to in each case.

DRAFT Equation sheet:

$E = mc^2 + K$ $\quad E^2 = (pc)^2 + (mc^2)^2$ $\quad E = \gamma mc^2$ $\quad \gamma = \frac{1}{\sqrt{1-(v/c)^2}}$

$K = \frac{p^2}{2m}$ $\quad \vec{p} = m\vec{v}$ $\quad \frac{v}{c} = \frac{pc}{E}$

$R = R_0 A^{1/3}$ $\quad pV = nRT = Nk_BT$ $\quad \lambda = \frac{1}{n\sigma}$ $\quad D_{rms} \propto \sqrt{t}$

$\vec{F} = q(\vec{E} + \vec{v} \times \overrightarrow{B})$ $\quad a = \frac{v^2}{r}$ $\quad F = \frac{kqQ}{r^2}$ $\quad E = \frac{kq}{r^2}$

$K_{max} = hf - \phi$

$E = hf$ $\quad E = \frac{hc}{\lambda}$ $\quad f = \frac{c}{\lambda}$

$p = \frac{h}{\lambda}$

$2d\sin\theta = n\lambda$ $\quad \Delta\lambda = \lambda - \lambda_0 = \frac{h}{mc}(1 - \cos\theta)$

$\frac{1}{\lambda} = R\left(\frac{1}{n'^2} - \frac{1}{n^2}\right)$ $\quad R = \frac{E_R}{hc}$ $\quad L = mvr = n\hbar$

$a_B = \frac{\hbar^2}{ke^2m}$ $\quad r = n^2 a_B$ $\quad E_R = \frac{ke^2}{2a_B} = \frac{m(ke^2)^2}{2\hbar^2}$ $\quad E_n = -\frac{E_R}{n^2}$

$E_n = -Z^2\frac{E_R}{n^2}$ $\quad r = \frac{n^2 a_B}{Z}$ $\quad \mu = \frac{m}{1+m/m_{nuc}}$

$E_\gamma = E_{n'} - E_n$

$|\Psi(r,t)|^2 dV = P(r,t)$

$y(x,t) = A\sin(kx \mp \omega t + \phi)$ $\quad k = \frac{2\pi}{\lambda}$ $\quad \omega = 2\pi f = \frac{2\pi}{T}$ $\quad v = \frac{\lambda}{T} = \frac{\omega}{k}$

$\Delta x \Delta p \geq \frac{\hbar}{2}$ $\Delta t \Delta E \geq \frac{\hbar}{2}$

$\frac{d^2\psi}{dx^2} = \frac{2m}{\hbar^2}[U(x) - E]\psi$ $i\hbar \frac{\partial}{\partial t}\Psi(x,t) = \left(-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + U(x)\right)\Psi(x,t)$

$\Psi(x,t) = \psi(x)e^{-i\omega t}$ $e^{i\theta} = \cos\theta + i\sin\theta$

$k = \sqrt{\frac{2mE}{\hbar^2}}$ $\alpha = \sqrt{\frac{2m(U-E)}{\hbar^2}}$

$\psi(x) = \sqrt{\frac{2}{a}}\sin\frac{n\pi x}{a}$ $E_n = n^2\frac{\pi^2\hbar^2}{2ma^2}$

$\int_{-\infty}^{\infty}|\psi(x)|^2dx = 1$ $\langle x\rangle = \int_{-\infty}^{\infty}x|\psi(x)|^2dx$ $P(b \leq x \leq c) = \int_b^c|\psi(x)|^2dx$

$E_n = \left(n + \frac{1}{2}\right)\hbar\omega_c$ $\omega_c = \sqrt{\frac{k}{m}}$ $U = \frac{1}{2}kx^2$ $b = \sqrt{\frac{\hbar}{m\omega_c}}$

$\psi_0 = A_0e^{-x^2/2b^2}$ $\psi_1 = A_1\frac{x}{b}e^{-x^2/2b^2}$

$P \approx e^{-2\alpha L}$

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = \frac{2M}{\hbar^2}[U - E]\psi$$

$\psi(x,y) = A\sin\frac{n_x\pi x}{a}\sin\frac{n_y\pi y}{a}$ $E = \frac{\hbar^2\pi^2}{2Ma^2}({n_x}^2 + {n_y}^2)$

------new stuff------

$L = \sqrt{\ell(\ell+1)}\hbar$ $L_z = m_\ell\hbar$

$\psi(r,\theta,\phi) = R_{n\ell}(r)\Theta_{\ell m_\ell}(\theta)e^{im_\ell\phi}$

$P(r) = 4\pi r^2|R(r)|^2$

$S = \sqrt{s(s+1)}\hbar$ $S_z = m_s\hbar$

$U = -\boldsymbol{\mu}\cdot\boldsymbol{B}$ $\boldsymbol{\mu_{orb}} = -\frac{e}{2m_e}\boldsymbol{L}$ $\mu_B = \frac{e\hbar}{2m_e}$ $\boldsymbol{\mu_{spin}} = -\frac{e}{m_e}\boldsymbol{S}$

$E = -\frac{{Z_{eff}}^2E_R}{n^2}$ $r_{mp} = \frac{n^2a_B}{Z_{eff}}$

Possibly useful mathematical relations:

$\sin^2\theta = \frac{1-\cos 2\theta}{2}$ $\int \sin x\, dx = -\cos x + C$ $\int \cos x\, dx = \sin x + C$

$$\int_0^\infty e^{-\lambda x^2} = \sqrt{\frac{\pi}{4\lambda}}$$

Some other things you should know (won't be on equation sheet)
(this isn't a complete list, of course, just some of the more difficult or important concepts that I wanted to point out)

The possible values for and the rules connecting n, ℓ, and m_ℓ

The vector model for quantized angular momentum

The angular momentum corresponding to the code letters s, p, d, f, and interpreting the notation 1s, 2p, etc.

Be able to interpret radial probability density graphs

How Z_{eff} for a given electron varies with position of that electron relative to the other electrons and the nucleus

How to fill electron shells, given Fig. 10.9

Be able to explain some of the systematic effects of electron shells on ionization energy and atomic radius as a function of Z, as in Fig. 10.11