Physics 215 – Elementary Modern Physics

Equations for Test 2

The following equations you should have memorized, and understand how to use them:

Size of atoms and nuclei:

$a \simeq 10^{-10}$ m

$R \simeq 10^{-15}$ m

Bohr model assumption:

$L = n\hbar$

Photoelectric Effect:

$eV_{\max} = hf - \phi$

Math with complex numbers:

$i^2 = -1$

$\mathrm{Re}(x+iy) = x,$

$\mathrm{Im}(x+iy) = y.$

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

$(x+iy)^* = x - iy$

$|z|^2 = zz^*$

Planck's constants:

$\hbar = h/2\pi$

Uncertainty Relations:

$\Delta x \Delta p \ge \frac{1}{2}\hbar$

$\Delta t \Delta E \ge \frac{1}{2}\hbar$

Wave Velocity

$v_p = \frac{\omega}{k} = \lambda f$

$v_g = \frac{d\omega}{dk}$

Light waves:

$v_p = v_g = c \simeq 3.00\times10^8$ m/s

Quantum waves:

$E = hf \qquad p = \frac{h}{\lambda}$

Probability

$P(a<x<b) = \int_a^b |\psi(x)|^2\,dx$

Non-relativistic matter

$E = \frac{p^2}{2m} \qquad v_g = \frac{p}{m}$

Basic Waves

$\cos(kx-\omega t)$

$\sin(kx-\omega t)$

$e^{i(kx-\omega t)}$

Normalization Condition in 1D:

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

The following equations you need not memorize, but you should know how to use them if given to you:

Black Bodies

$U = \frac{\pi^2 (k_B T)^4}{15(\hbar c)^3}$

$\lambda_{\max} T = 2.898\times10^{-3}$ m·K

Constants

$h = 6.626\times10^{-34}$ J·s $= 4.136\times10^{-15}$ eV·s

$\hbar = 1.055\times10^{-34}$ J·s $= 6.582\times10^{-16}$ eV·s

$k_B = 1.3807\times10^{-23}$ J/K $= 8.6173\times10^{-5}$ eV/K

$k = 8.988\times10^{9}$ N·m²/C²

$e = 1.602\times10^{-19}$ C

$\alpha = \frac{ke^2}{\hbar c} = 7.29735\times10^{-3} \simeq \frac{1}{137}$

Wave Relationships

$\lambda = \frac{2\pi}{k}$

$\frac{\omega}{2\pi} = f = \frac{1}{T}$

Rutherford Scattering

$b = \frac{kqQ}{m_\alpha v^2}\cot\left(\frac{\theta}{2}\right)$

$R = \frac{2Ze^2k}{E}$

Reduced Mass:

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

Compton Effect

$\lambda' - \lambda = \frac{h}{mc}(1-\cos\theta)$

$\frac{h}{mc} = 2.426\times10^{-12}$ m

Hydrogen-like atoms

$E_n = \frac{-(13.6\text{ eV})Z^2}{n^2}$

Hydrogen-Like Atoms

$E = -\frac{k^2 e^4 \mu Z^2}{2\hbar^2 n^2} = -\frac{(\mu c^2)\alpha^2 Z^2}{2n^2}$

Layout of the exam: Below is an outline of the exam

This test consists of three parts. Please note that in parts II and III, you can skip one question of those offered.

Part I: Multiple Choice [20 points]
For each question, choose the best answer (2 points each)

[questions 1-10]

Part II: Short answer [20 points]
Choose **two** of the following questions and give a short answer (1-3 sentences) (10 points each).

[questions 11-13]

Part III: Calculation: [60 points]
Choose **three** of the following four questions and perform the indicated calculations (20 points each)
[questions 14-17]