

Physics 215 – Elementary Modern Physics
Equations for Test 2

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

<u>Size of atoms and nuclei:</u> $a \approx 10^{-10}$ m $R \approx 10^{-15}$ m	<u>Bohr model assumption:</u> $L = n\hbar$	<u>Photoelectric Effect:</u> $eV_{\max} = hf - \phi$	<u>Math with complex numbers:</u> $i^2 = -1$ $\text{Re}(x + iy) = x,$ $\text{Im}(x + iy) = y.$ $e^{i\theta} = \cos \theta + i \sin \theta$ $(x + iy)^* = x - iy$ $ z ^2 = zz^*$
<u>Planck's constants:</u> $\hbar = h/2\pi$	<u>Uncertainty Relations:</u> $\Delta x \Delta p \geq \frac{1}{2} \hbar$ $\Delta t \Delta E \geq \frac{1}{2} \hbar$	<u>Wave Velocity</u> $v_p = \frac{\omega}{k} = \lambda f$ $v_g = \frac{d\omega}{dk}$	
<u>Light waves:</u> $v_p = v_g = c \approx 3.00 \times 10^8$ m/s	<u>Quantum waves:</u> $E = hf$ $p = \frac{h}{\lambda}$	<u>Probability</u> $P(a < x < b) = \int_a^b \psi(x) ^2 dx$	
<u>Non-relativistic matter</u> $E = \frac{p^2}{2m}$ $v_g = \frac{p}{m}$	<u>Basic Waves</u> $\cos(kx - \omega t)$ $\sin(kx - \omega t)$ $e^{i(kx - \omega t)}$	<u>Normalization Condition in 1D:</u> $\int_{-\infty}^{\infty} \psi(x) ^2 dx = 1$	

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

<u>Black Bodies</u> $U = \frac{\pi^2 (k_B T)^4}{15(\hbar c)^3}$ $\lambda_{\max} T = 2.898 \times 10^{-3}$ m · K	<u>Constants</u> $h = 6.626 \times 10^{-34}$ J · s = 4.136×10^{-15} eV · s $\hbar = 1.055 \times 10^{-34}$ J · s = 6.582×10^{-16} eV · s $k_B = 1.3807 \times 10^{-23}$ J/K = 8.6173×10^{-5} eV/K $k = 8.988 \times 10^9$ N · m ² / C ² $e = 1.602 \times 10^{-19}$ C $\alpha = \frac{ke^2}{\hbar c} = 7.29735 \times 10^{-3} \approx \frac{1}{137}$	<u>Wave Relationships</u> $\lambda = \frac{2\pi}{k}$ $\frac{\omega}{2\pi} = f = \frac{1}{T}$
<u>Rutherford Scattering</u> $b = \frac{kqQ}{m_\alpha v^2} \cot\left(\frac{\theta}{2}\right)$ $R = \frac{2Ze^2 k}{E}$	<u>Compton Effect</u> $\lambda' - \lambda = \frac{h}{mc} (1 - \cos \theta)$ $\frac{h}{mc} = 2.426 \times 10^{-12}$ m	<u>Reduced Mass:</u> $\mu = \frac{mM}{m + M}$
<u>Hydrogen-like atoms</u> $E_n = \frac{-(13.6 \text{ eV}) Z^2}{n^2}$	<u>Hydrogen-Like Atoms</u> $E = -\frac{k^2 e^4 \mu Z^2}{2\hbar^2 n^2} = -\frac{(\mu c^2) \alpha^2 Z^2}{2n^2}$	

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]