Physics IV [2704] Sample Final Exam Questions
(Last Third of Class Only)

Directions: This exam is closed book. You are allowed both sides of an 8.5"x11" sheet with equations etc. Read all questions carefully and answer every part of each question. Please show your work on all problems – partial credit may be granted for correct logic or intermediate steps, even if your final answer is incorrect. Please use a calculator only to check arithmetic – all steps of calculations should be explicitly shown. Unless otherwise instructed, you can express your answers in terms of fundamental constants like *k, h, ħ, c,* ε_0 rather than calculating numerical values. If the question asks for an explanation, please write at least a full sentence explaining your reasoning. Please ask if you have any questions, including clarification on instructions, during the exam.

<u>This test is designed to be gender and race neutral.</u>

Good luck!

A few useful numbers:

v/c = 0.5	γ = 1.15	|	v/c = 0.8	γ = 5/3
v/c = 0.6	γ = 1.25	|	v/c = (√3)/2 = 0.866	γ = 2
v/c = 1/√2	γ = √2	|	v/c = 0.98	γ = 5
v/c = 0.75	γ = 1.51	|	v/c = 0.999	γ = 22

Speed of light $c = 3\text{x}10^8$ m/s

Planck's constant $h = 6.6\text{x}10^{-34}$ J s = $4\text{x}10^{-15}$ eV s $\hbar = h/(2\pi)$

Compton wavelength $h/(m_e c) = 2.4\text{x}10^{-12}$ m

Photon energy = $h\nu = hc/\lambda \sim 1240$ eV-nm /(λ in nm)

Bohr energies $E_n = -m_e e^4/(32\pi^2\varepsilon_0^2\hbar^2) * Z^2/n^2 = -13.6\text{eV} * Z^2/n^2$

Bohr radius $a_0 = 4\pi\varepsilon_0\hbar^2/(m_e e^2) = 0.0529$ nm

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Honor Pledge: I understand that sharing information with anyone during this exam by talking, looking at someone else's test, or any other form of communication, will be interpreted as evidence of cheating. I also understand that if I am caught cheating, the result will be no credit (0 points) for this test, and disciplinary action may result.

Sign Your Name_______________________________________

Print Your Name_______________________________________

Sample Question: Neon (Z = 10) has an electron configuration of 1s2 2s2 2p6. Sodium (Z=11) has an electron configuration of 1s2 2s2 2p6 3s1. Describe three ways in which these two atoms will differ and discuss how those differences are related to the electron configuration.

Sample Question: A K_α X-ray is produced when an electron is knocked out of the *n=1* orbital and replaced by an electron that transitions from the *n=2* orbital to fill the gap in the *n=1* orbital. The approximate energy of the resulting X-ray is $-13.6 * (Z-1)^2 * (1-1/4)$ eV. An L_α X-ray is similar, but is produced when an electron is knocked out of the *n=2* orbital and replaced by an electron that transitions from the *n=3* orbital to fill the gap in the *n=2* orbital. How would you predict that the energy of the resulting X-ray would scale with Z? Justify your answer based on the screening of the nucleus and the electronic energy levels of the atom.

Sample Question: Consider what happens to the rotational and vibrational spacings of potassium hydride (KH, which combines K and H with $m_K = 39$ u and $m_H = 1$ u) when the hydrogen is replaced by deuterium (D, or hydrogen with a neutron, so $m_D = 2$ u). Compared with KH, are the rotational spacings of KD larger or smaller? Are the vibrational spacings of KD larger or smaller than those of KH? Which changes by the larger factor, the rotational or the vibrational spacings? (Assume the equilibrium separations of KH and KD are the same.) EXPLAIN YOUR ANSWERS.

Sample Question: Consider a system of four particles that share two units of energy.

A. How many macro-states does the system have?

B. What is the multiplicity (the number of micro-states) for each macro-state, assuming the particles are distinguishable?

C. What is the overall probability of a given distinguishable particle in this simple system having two units of energy?

D. If the particles were instead indistinguishable, what would be the probability of any given particle having two units of energy?