University of California at Berkeley

Department of Physics

Physics 8B, Spring 2009, Section 1

Final Examination

May 11, 2011

You will be given 180 minutes to work this exam. No books are allowed, but you may use four pages of handwritten notes on sheets no larger than 8.5 by 11". Do not use a blue book or scratch paper other than that provided. Your description of the physics involved in a problem is worth significantly more than any numerical answer. Show all work and take particular care to explain what you are doing. Please use the symbols described in the problems, tell us why you are writing any new equations, and label any drawings that you make. Write the answers in the space following the question, **after you have decided on your answer**. If there are parts of your solution on other sheets, make a note in the answer space telling us where to look for the additional information, and label that information with the number of the problem. Write clearly; if we can't read it we can't give credit. When asked to "explain", words or formulas or diagrams may be used.

NAME:_____

SID NUMBER:_____

DISCUSSION SECTION NUMBER:_____

DISCUSSION SECTION DATE/TIME:_____

1 (20 pts)	
2 (15 pts)	
3 (10 pts)	
4 (15 pts)	
5 (15 pts)	
6 (10 pts)	
7 (10 pts)	
8 (5 pts)	
9 (10 pts)	
10 (5 pts)	
11 (15 pts)	
12 (15 pts.)	
13 (5 pts)	
Total (150 pts)	

Formulas & approximate constants: $c = 3\times10^{8}$ m/sec, $h = 7\times10^{-34}$ J·s $= 4\times10^{-15}$ eV·s, $hc = 1240$ eV·nm, $e = 2\times10^{-19}$ C, $F_c = mv^2/r = m\omega^2 r$, $k = 1/4\pi\varepsilon_0 = 9\times10^{9}$ N·m^2/C^2, $E_n = 13.6\text{eV}/n^2$, nm $= 10^{-9}$ m, fm $= 10^{-15}$ m, 1eV corresponds to 2×10^{14} Hz

1. (10 pts.) Light of wavelength 200 nm falling on a metal surface causes the emission of electrons. A potential of –1 V is able to stop even the most energetic of these electrons.

a) If an additional Hg lamp, identical to the first, is shined on the surface, explain the effect on

i) the stopping potential

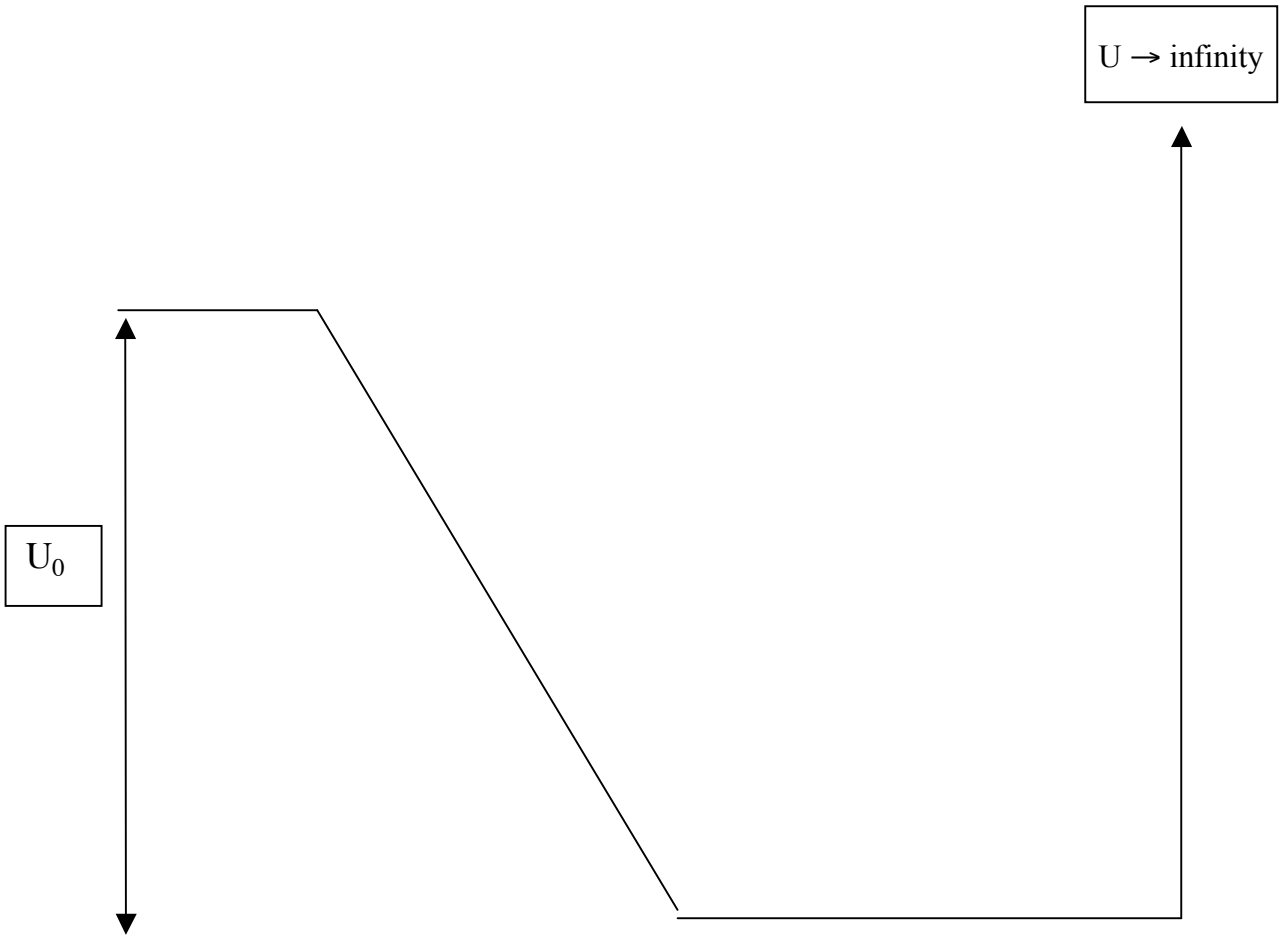
ii) the magnitude of the current

b) If the wavelength of both lamps is halved, and the intensities are kept constant, explain (at least qualitatively) the effect on

i) the stopping potential

ii) the magnitude of the current .

2. (15 pts) Assuming there are at least three bound states in the semi-infinite potential well shown below, sketch qualitatively the wavefunctions of the ground state, and the first two excited energy levels. Explain the number of peaks in the wavefunctions, the spacings of the peaks and their amplitudes.



Explanations:

3. In a nuclear scattering experiment, α particles (Z = 2, A = 4) with energies of 8MeV were available to bombard a foil of zirconium (Z = 40, A = 90).

A) (15 points) What is the closest to the nuclei the α could come? (Set up the formula and substitute appropriate approximate values as provided. The arithmetic is easy.)

B) (5 pts) If the alpha is absorbed by the zirconium nucleus, what are Z and A of the daughter nucleus?

4. Thermal energy can be thought to activate some processes and also to disrupt some processes. For the processes of Black Body Radiation, electrical conduction in metals and phase transitions in materials (melting and vaporization), describe the physical effect of increasing temperature. What happens and why? Where possible, relate the thermal energy to energies characteristic of the material.

Black Body Radiation: As temperature increases…
Electrical conduction in metals: As temperature increases…
Melting and vaporization: As temperature increases…

5. (15) Both electric and magnetic fields can cause charged particles to be held in circular oribits. Examples are the Bohr model of the hydrogen atom and the cyclotron.
Derive formulas for the radii of the circular orbits in these two cases:
a) the Bohr model radius in terms of the charges, the mass of the particle, and the velocity,
b) the cyclotron radius in terms of the magnetic field, mass of the particle and the velocity.
Sketch the directions of the forces, fields and velocities.

a) Electric force: Sketch

b) Magnetic Force: Sketch

6. Check next to the correct answer.

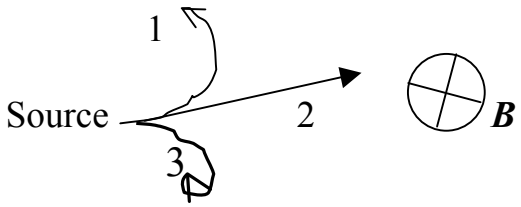
A.(5 pts) The isotopes of an element:

	cannot be separated at all
	occur well separated in nature
	have similar chemical behavior
	cannot be separated by physical methods
	have equal masses

B. (5 pts) The greatest binding energy per nucleon occurs for nuclides with masses near that of:

	helium
	sodium
	iron
	mercury
	uranium

C. (20 pts) The paths taken by emissions from a radioactive source can be visualized as tracks. If the tracks are in a magnetic field that is pointing into the page, and three tracks are found, identify which one may be α, β, γ . Explain.



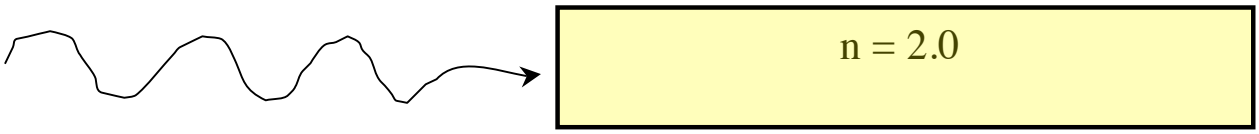
Particle	Track #
α	
β	
γ	

7. (10 pts) The index of refraction of a certain liquid is 1.15. What is the critical angle of total internal reflection for a light ray traveling in this liquid toward a flat layer of air above it? (Answer may be left as an inverse trig function.)

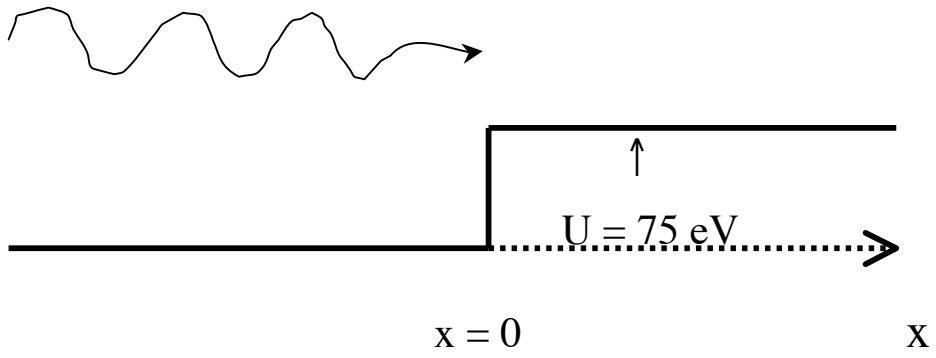
8. (10 pts) A light wave of λ = 500 nm passes from air to glass with a refractive index = 2.0. Inside the glass, what are the wave's
a) speed and

b) wavelength?

c) Sketch the wave in the glass.



9. An electron (matter) wave with kinetic energy 100 eV in region x< 0 passes into a region x > 0 where its potential energy U = 75 eV.

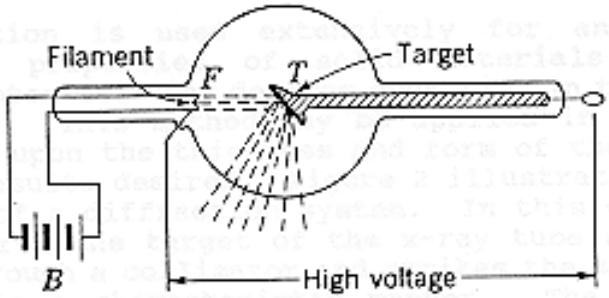


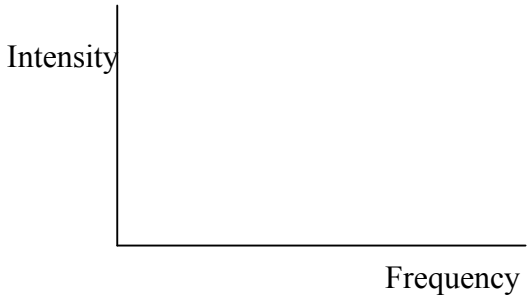
a) (10 pts) What is the ratio of electron velocity in the region x < 0 to the velocity where x > 0,
i.e., v(x < 0) / v(x > 0) = ?

b) (10 pts) What is the ratio of the electron's wavelengths in the two regions, i.e., $\lambda(x < 0) / \lambda(x > 0) = ?$

c) (5 pts) On the Figure above, sketch the wave in the region x > 0.

10. (? pts) This x ray tube (Fig. 8.1 to the left) is used to obtain the graph of photon counts vs x ray energy shown in Fig. 8.2 below. The batteries B provide 100 volts to heat the filament which then emits electrons. The electrons are accelerated by the High Voltage applied between the Filament and the Target. The High Voltage is set here = 10,000 V.





a) Draw a graph of the expected intensity of x rays vs the frequency of the x rays.
b) What is the highest frequency expected?

c) What is the shortest wavelength expected?

d) By analogy with optical diffraction gratings, does the ratio of spacing to wavelength suggest that such a wave could be used to observe diffraction effects in reflection off crystals (spacing of atoms in crystals are of order 10^{-10} m.)

e) Based on the x-ray tube in the Figure, to maintain an electron current of 0.005 A and a potential drop of 10^4 V between target and filament, approximately how much power must the tube consume? Show the calculation.

i) 5×10^1 W
ii) 1×10^2 W
iii) 2×10^4 W
iv) 2×10^6 W.

11. (? pts.)An electron in a hydrogen atom is in its ground state (n=1). The energy level diagram for hydrogen is shown below.

0eV _____ n=∞
-0.85eV _____ n=4
-1.51eV _____ n=3

-3.4eV _____ n=2

-13.6eV _____ n=1

a) (10 pts) If radiation with a frequency of 3.0×10^{15} Hz is incident on the hydrogen atom, what happens? Explain

b) (10 pts) If, instead, a beam of electrons having kinetic energy of 12.4 eV is used, what happens? Explain.

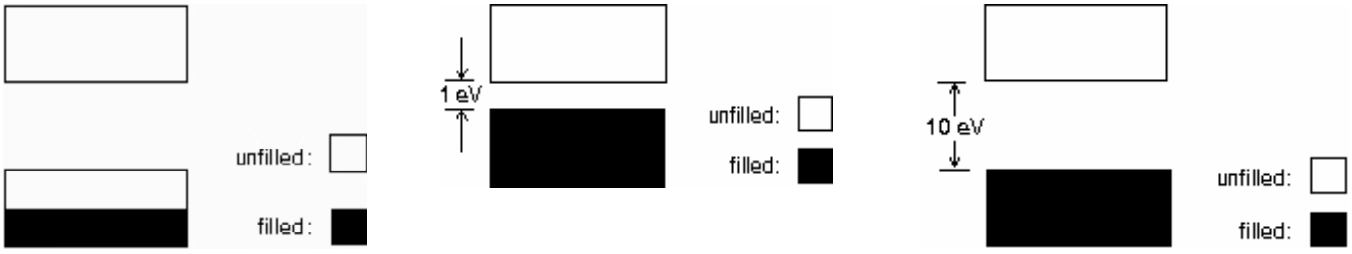
12. a) Estimate the wavelength of the peak intensity of sunlight, λ_{peak}, treating the Sun as a 5800-K blackbody.

b) Use your result to decide whether zinc selenide, with band gap 3.6 eV, would make a good photovoltaic cell. Argue quantitatively.

13. a) In which state of a particle in the an infinitely deep square-potential-well is it most likely to be found in the center?

b) From the three energy level diagrams below, identify the kind of electrical conductor it is and write its number next to its name in the Table.

[1] [2] [3]



	an isolated atom
	an insulator
	a semiconductor
	an isolated molecule
	a conductor

c) Approximately what range of frequencies is required to create a pulse whose width is 10^{-9} sec (= 1 ns)?

14. Two microwave antennas, fed symmetrically with the same 3 cm wavelength waves, are emitting in the x direction. The antennas are 10 m apart in the y direction. At what angle from the line between their centers (the x axis) will there be no signal? (Answer may be stated in radians.)