Name_____

PH2400 Exam III Spring 2001

Some Constants:

$\pi = 3.14159$
$h = 6.626 \times 10^{-34}$ J·s
$hc = 1240$ eV·nm
$c = 3.00 \times 10^{8}$ m/s
$R_H = 1.0974 \times 10^{7}$ m^{-1} = 13.606 eV/hc
1 eV = 1.6022×10^{-19} J
1 amu = 931.48432 MeV/c^2 = 1.66054×10^{-27} kg

Write your solutions on these pages, and turn in the entire exam along with your equation sheet. If you need extra paper, just ask.

For problems 11 to 15: to receive full credit for correct answers, you must show your work!

Report numerical answers to three (3) significant figures.

Score Summary (to be filled in by instructor)

Mult Choice	Short Answer	Problems
1._____	6._____	11._____
2._____	7._____	12._____
3._____	8._____	13._____
4._____	9._____	14._____
5._____	10._____	15._____

Totals _____ + _____ + _____ = _____

Multiple Choice:

(Circle your choice(s))

1. A transition between vibrational states for a typical diatomic molecule corresponds to a vibrational energy change closest to

a. 13.6 eV b. 0.511×10^6 eV c. 0.3 eV d. 0.005 eV e. 0

2. The ground state electronic configuration of a certain neutral atom is given as $1s^2 2s^2 2p^6 3s^2 3p^3$. The atomic number, Z, for this atom is

a. 0 b. 1 c. 3 d. 11 e. 15 f. 32

3. At t = 0, a scientist measures the activity of 1.00 g of a radioactive isotope to be 4.00 Ci. After 1 hour, the scientist measures the activity from the same sample to be 1.00 Ci. What is the half-life of this isotope?

a. 1.50 Ci b. 2.00 hours c. 30.0 min d. 1.39 hours e. 0.719 hours

4. A typical fermi energy for a solid would be about

a. 938 MeV b. 13.6 eV c. 3 eV d. 0.1 eV f. 1/40 eV

5. Some properties of the neutron are that it has a spin = ½ (same as proton), mass ≈mass of proton, size ≈size of proton, no net charge, and a magnetic moment roughly the same magnitude (within a factor of 2) of that of the proton (though of opposite sign). Which of the following is a logical conclusion about the neutron based on this information?

a. the neutron can be accelerated by a uniform electric field.
b. the neutron has some internal structure - it is not a uniform distribution of matter.
c. the number of neutrons in a nucleus should be roughly the same as the number of protons.
d. the neutron can be accelerated by a non-uniform electric field.
e. the neutron can be accelerated by a uniform magnetic field.

Short Answer

Provide a short answer (1 or 2 sentences, equations, and/or appropriately labeled diagram) for each.

6. Consider the electronic states of an atom. How many states are there with n = 3?

7. Consider the nuclear reaction ${}^{215}_{84}Po \rightarrow X + \alpha$. What are Z and A for the nucleus *X*?

8. ^{115}In (Z = 49) decays via beta decay to ^{115}Sn (Z = 50) with a half-life of 6×10^{14} yr. Does the beta particle emitted have a positive or negative charge? Explain.

9. Why does the electrical resistance of a semiconductor decrease with an increase in temperature?

10. The electron of a hydrogen atom makes a transition from the n=4, l = 2 subshell to the n = 2 shell. What is the value of l for the final state?

Problems

(SHOW YOUR WORK, you will not get credit unless I can see how you got your answer.)

11. A magnesium (Mg) atom with one electron removed is a Mg^+ ion. It has 11 electrons. In the ground state of this ion, how many of these electrons are in a state with orbital quantum number, $l = 0$?

12. A blue LED emits light with an typical wavelength of 470 nm. Based on this data, what is the band gap for the semiconductor used?

13. ^{22}Na undergoes beta decay with a ½ life of 2.62 years. What is the maximum energy the beta particle can have? You may find the data below to be of use.

Masses (in amu)

$^{20}_{9}F$	19.999 982
$^{20}_{10}Ne$	19.992 435
$^{22}_{10}Ne$	21.991383
$^{22}_{11}Na$	21.994 434
$^{23}_{12}Mg$	22.994124

14. Radioactive carbon-14 (^{14}C) is used for "carbon dating." The ^{14}C is naturally created in the atmosphere by cosmic rays and is incorporated into living plants and animals just like other isotopes of carbon. Once the plant or animal dies, no further ^{14}C is supplied. If the fraction of the carbon which is ^{14}C in a living plant is F, and the fraction of the carbon which is ^{14}C in a sample of a plant from an archeological dig is $F/10$, how long ago did the plant die? The half-life for ^{14}C decay is 5730 years.

15. Consider an electron in a magnetic field of B = 8.50 Teslas = 8.50 T. The energy levels are given by $E = \mu_z B$. The possible values for z-component of the electron's spin magnetic moment are determined by $\mu_z = \frac{e\hbar}{m_e} S_z = (11.58 \times 10^{-5} eV/T)\, S_z$. What is(are) the wavelength(s) of photons which will be absorbed?

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