12 Quantum and Nuclear Physics review questions

Nuclear Physics

1. a) Define decay constant
b) State the equation showing how activity of a radioactive source varies over time.
c) Protactinium-234 half-life can be measured in the classroom because the protactinium salt dissolves in an organic layer above the stock solution. The decay constant for protactinium-234 = 0.010 s^{-1}. Calculate the time taken for the number of atoms of Protactinium-234 to halve.
d) State the half-life of protactinium.
e) If the activity of a source is 44,800 Bq calculate the number of Protactinium-234 present.
f) Calculate the time taken for the activity of a protactinium source to reduce to 1% of its original level.

2. Geiger and Marsden performed an experiment firing alpha particles at a thin gold foil.
(a) Explain the conclusions that were drawn from this experiment and how they fit in with the Rutherford model of the atom that these results gave rise to.
(b) If an alpha particle has an initial velocity of 2×10^{7} m/s and it rebounds from a gold nucleus (without touching it) what is the maximum radius of that gold nucleus?
$\mathbf{q}_{gold} = 79\times(1.6\times10^{-19})$ C

3. A more accurate way to measure nuclear diameters is to think of the particles as matter waves and realize that the nucleus that is interacting with the matter wave is causing diffraction. A beam of 80.0 MeV neutrons has de Broglie wavelength of 3.2×10^{-15} m and are diffracted upon passing through a thin lead foil. The first minimum in the diffraction pattern is measured at 12.6°. Estimate the diameter of the lead nucleus.

Quantum Physics

1. Which forms of nuclear radiation have discrete energy levels?

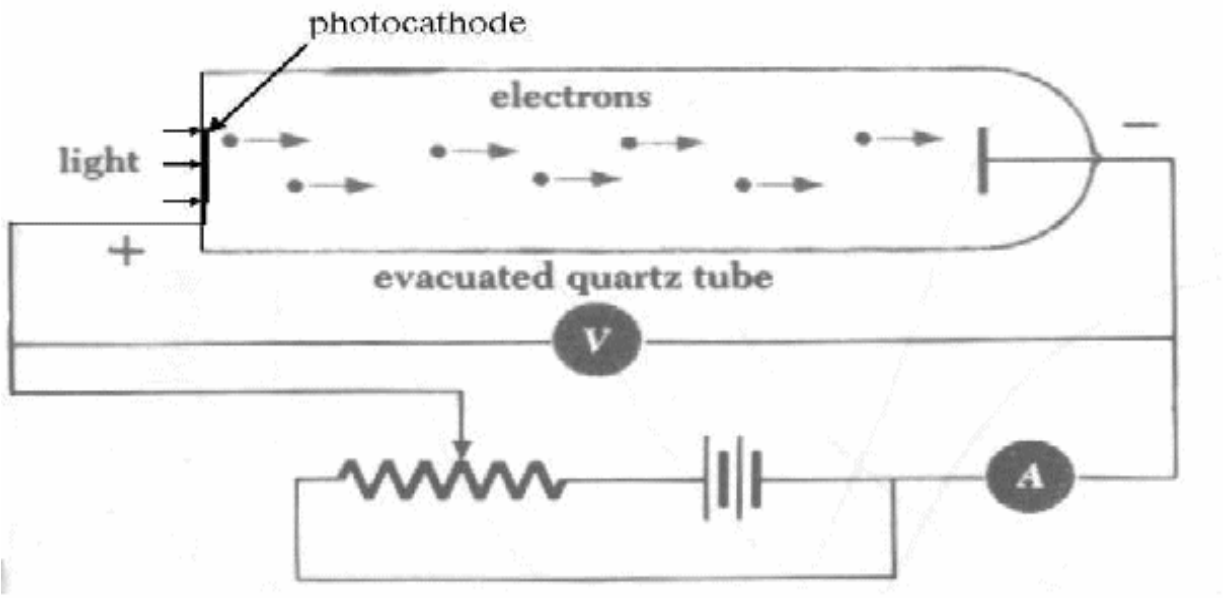
2. Explain why the fact that both B+ and B- spectra are continuous gives rise to the postulate of the existence of the neutrino.

3. In Schrodinger's wave equation fits the boundary conditions of the three dimensions of the atom giving rise to both radial and angular allowed modes with discrete energy states. All you need to know is that the probability of finding an electron at a point is given by the square of the amplitude of the wave function gives the probability.

a. Why is the probability of finding an electron at a point as described by the Schrodinger equation always positive even if the Shrodinger equation can give negative values?
b. What property of the electron remains undefined by the Schrodinger equation?

4. Outline the Hesienberg uncertainty principle and use it to explain why knowing precisely the de Broglie wavelength of a particle means that its position is very uncertain.

5. (a) Explain why the wave model of light does not account for the observation of the photoelectric effect (light causes electron leave a surface if the light is of a high enough frequency, the intensity does not change the ability of light to remove electrons from a surface)
(b) How does the Einstein model of light explain the photo-electric effect?



(c) Using the apparatus above scientists can measure the stopping voltage needed to stop the photoelectrons causing a current. Draw a graph of stopping voltage against frequency and show what measurement can be used to determine the energy needed to ionize the photocathode.

6. In the Bohr model of the atom electrons orbit the nuclei in an approximately circular orbit.
a) Calculate the angular momentum with which the electron must orbit the proton for the ground state (n = 1) in the Bohr model of the hydrogen atom.
b) Calculate the velocity of the electron.
b) What is the radius of this ground state orbit?