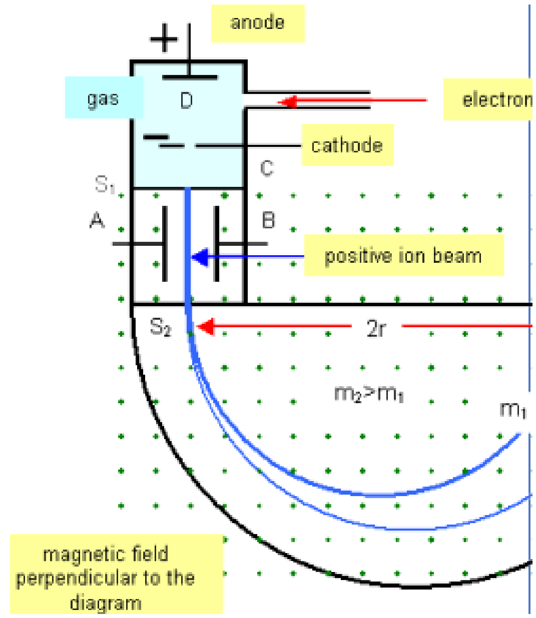
13 Quantum and Nuclear Physics review questions

Nuclear Physics



1. a) Describe how the masses of nuclei may be determined using a Bainbridge mass spectrometer by referring to the diagram on the right.
b) Explain how the existence of isotopes is used as evidence for the existence of neutrons in the nucleus.

2. a) Define decay constant
b) State the equation showing how activity of a radioactive source varies over time.
c) Derive the relationship between decay constant and half-life.
d) Calculate the decay constant for protactinium-234 given that its half-life is approximately 70 seconds.
e) Use this decay constant calculate the time taken for the activity of a protactinium source to reduce to 1% of its original level.

3. Explain Beta+ decay in terms of nucleon transformation.

4. Geiger and Marsden performed an experiment firing alpha particles at a thin gold foil. 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

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. (a) Explain how both absorption and emission spectra in elements provide evidence for the Bohr model of the atom and atomic energy levels.
(b) Describe an experiment to observe emission spectra.
(c) Outline an experiment (Davisson-Germer) that demonstrated de Broglie wavelengths in electrons
(d) If an electron is confined to a box of length L it will form a standing wave
(i) What is wavelength of the standing wave of lowest (zeroeth) energy level?
(ii) What is the general formula for wavelength of the standing wave of energy level n?
(iii) Show that the kinetic energy of such an electron is $n^2h^2/(8m_eL^2)$

(e) Determine the wavelength of the photons emitted by a Hydrogen atom when the electron moves from:

(i) n=2 state with an energy level of -3.4eV to its ground state of n=1 with an energy level of -13.6eV?

(ii) n=4 state with an energy level of -0.8eV to its ground state of n=2 with an energy level of -3.4eV?

4. 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.

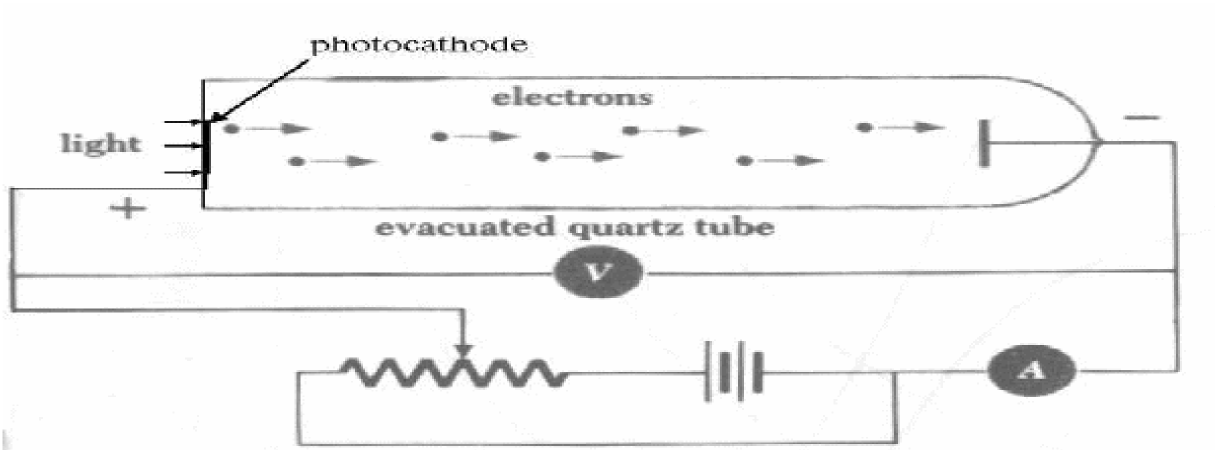
a. Why is the probability of finding an electron at a point as described by the Schrodinger equation always positive even if the Shrodinger equation can give negative values?

b. What property of the electron remains undefined by the Schrodinger equation?

5. 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.

6. (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.