

Sample Exam Questions - Module 11

- 1) What is the “fine structure” exhibited in the spectra of hydrogen and the He^+ ion? What has it to do with the so-called fine structure constant? Give a brief discussion of the role of hydrogen’s fine structure in the history of quantum physics ca. 1913-1928.
- 2) What are the essential features of the Dirac wave equation, and how does it differ from the ordinary Schrödinger equation and also from its relativistic generalization known as the Klein-Gordon equation? Explain what Dirac’s reasoning was when he suggested his equation of the electron in early 1928. Did he construct the equation with an eye on the electron’s spin?
- 3) From late 1929 to the spring of 1931 Dirac defended the idea that the anti-electron was the same as the proton. What was his motivation behind this hypothesis and what were the main problems with it? Did considerations of a philosophical nature influence Dirac’s proton hypothesis? Dirac reported his idea to Bohr, who was very critical and did not believe in it. What were the main criticism of Bohr and most other quantum physicists?
- 4) In his 1930 paper in *Nature*, Dirac refers to a “difficulty” concerning the atomic nucleus of N-14. What difficulty is he referring to? Unbeknownst to Dirac, at about the same time Pauli considered the anomaly, and also the continuous β -spectrum, in relation to his suggestion of the neutrino (or “neutron,” as he first called it). How did Pauli’s original neutrino differ from the particle we today denote with the same name? What were Pauli’s arguments for introducing a new elementary particle?
- 5) In Dirac’s theory negative-energy electrons turned up formally, as solutions to his equation. But Dirac dismissed the idea of real particles with negative energy. What were his objections? Can you possibly suggest from relativistic mechanics why negative-energy particles behave manifestly absurdly?
- 6) C. D. Anderson received the Nobel Prize for his discovery of the positron. What kind of experiment did he perform and what were his conclusions? Explain the relationship between Dirac’s prediction of the positive anti-electron and Anderson’s discovery of what he called the positron.