THE UNIVERSITY OF HULL

Final Examination: Part II

For the Special Degree of Bachelor of Science
PHYSICS IV
1971

Tuesday, Ist June, 2 p.m. to 5 p.m.

Answer FOUR *questions. Answers to questions from the two Sections must be written in separate answer books.*

SECTION A

1. Give an account of the weak interaction between subnuclear particles.

2. Give a short account of the physical principles involved in the design and operation of a proton synchrotron. A high energy proton beam interacts with a liquid hydrogen target to produce Ω^- particles (strangeness -3, intrinsic spin $\frac{3}{2}$). Obtain an expression for the minimum kinetic energy of the incident protons, in terms of the rest masses of the particles involved, required to produce the Ω^- particles. Limit consideration of the other particles produced to K mesons and Σ hyperons.

3. Discuss briefly how the spin and the magnetic and quadrupole moments of nuclei have been determined. To what extent do these results agree with predictions made assuming various nuclear models?

4. Assuming that the neutron-proton interaction in the deuteron can be represented by a square well potential derive an expression for the binding energy of this nucleus in terms of the range and depth of the potential. Hence find an expression for the total cross-section for the scattering of slow neutrons by protons in terms of the binding energy of the deuteron. Discuss the significance of this result when compared to that obtained experimentally. Assume that the scattering amplitude can be expressed in the usual notation as,

$$f(\theta) = (1/2ik)\sum_{l=0}^{\infty}(e^{2i\delta_l} - 1)(2l+1)P_l(\cos\theta).$$

SECTION B

5. Classical physics could be said to be determinate and quantum physics indeterminate. Give three examples of actual observed phenomena which illustrate indeterminancy. Discuss briefly three ways in which indeterminacy is treated mathematically in quantum mechanics. Explain why the maximum z-component of angular momentum is usually less than the magnitude of the total angular momentum.

6. Derive the commutation relation between the x and z components, L_x and L_z, of angular momentum and between L_z and L^2 where $L^2 = {L_x}^2 + {L_y}^2 + {L_z}^2$. What do these relations mean physically? Show that the quantum numbers corresponding to angular momentum must be either integer or half integer. Explain the importance of the half integer values in atomic physics and derive the Pauli Spin Matrices.

7. Derive the first order Rayleigh-Schrodinger Perturbation Theory for the degenerate case. The ground state of a particle in a certain potential has an eigenfunction of the form $Ae^{-\alpha r}$. What is the change in the ground state energy if a small additional potential, v, is applied such that

$$v = \begin{cases} b, & \text{for } 0 \leq r < c, \\ 0 & \text{for } c \leq r < \infty. \end{cases}$$