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PHE-11

BACHELOR OF SCIENCE (B.Sc.)

Term-End Examination

December, 2016

00974

PHYSICS

PHE-11 : MODERN PHYSICS

Time : 2 hours *Maximum Marks : 50*

Note : *Attempt **all** questions. The marks for each question are indicated against it. Symbols have their usual meanings.*

1. Answer any ***five*** parts : *5×3=15*

(a) The proper length of a rod is L. Its length is measured to be L/3 in a reference frame that is moving with respect to the rod. What is the speed of the moving reference frame ?

(b) The momentum of a particle is $2{\cdot}0 \times 10^{-21}$ kg ms^{-1}, at a speed of 0·8 c. Calculate its rest mass.

(c) Write down the properties of a wave function and boundary conditions on it, for it to be physically acceptable.

(d) A ball of mass 5·0 kg is moving with a velocity of 10 ms^{-1}. Calculate its de Broglie wavelength. Will it exhibit observable wave behaviour ? Explain. ($h = 6{\cdot}626 \times 10^{-34}$ Js)

(e) Write down the electronic configuration for atoms with (i) Z = 23 and (ii) Z = 34.

(f) Define the activity of a radioactive sample. A radioactive sample emits, on an average, one β particle every 5 minutes. Determine the activity of the sample.

(g) State the selection rules for X-ray spectra.

(h) Explain whether or not the following reactions are allowed :

(i) $p^+ + n^0 \rightarrow p^+ + p^+$

(ii) $p^+ \rightarrow \pi^+ + \pi^0$

2. Answer any ***two*** parts : *2×5=10*

(a) Explain why we do not observe the effects of time dilation in everyday phenomena. A free neutron at rest has a mean life time of 900 s. If the mean life time of the neutron is observed to be 1800 s, what is its speed ? *2+3*

(b) Write down the relativistic force law. A charged particle moves perpendicular to a uniform magnetic field at relativistic speed. Determine the radius of its orbit. *1+4*

(c) A particle of mass M initially at rest decays into two particles with rest masses m_1 and m_2, respectively. Show that the total energy of m_1 is $\frac{C^2 [M^2 + m_1^2 - m_2^2]}{2M}$. *5*

3. Answer any ***two*** parts : *2×5=10*

(a) Use the uncertainty principle to explain why zero point energy is observed for any particle in a bound state.

(b) A particle is represented at t = 0 by the wave function

$$\Psi(x, 0) = \begin{cases} N(L^2 - x^2), & \text{for } -L \le x \le L \\ 0, & \text{otherwise} \end{cases}$$

Determine the normalization constant N.

(c) Evaluate the commutator : $[L_x, p_y]$.

4. Answer any ***one*** part : *1×10=10*

(a) A particle is confined to a 1-D box located between $x = -L/2$ and $x = L/2$.

(i) Write down the Schrödinger equation for the particle.

(ii) State the boundary conditions on the wave function.

(iii) Solve the Schrödinger equation to obtain the general wave function.

(iv) Obtain the energy eigenvalues. *2+2+4+2*

(b) (i) Calculate the average potential energy for the hydrogen atom in its ground state :

$$\Psi_0(r) = \frac{2}{a_0^{3/2}} e^{-r/a_0}; \quad a_0 = \frac{\hbar^2}{\mu e^2}. \qquad 5$$

(ii) Determine all the spectral terms for a hydrogen-like atom with n = 3. *5*

5. Answer any ***one*** part : *1×5=5*

(a) Describe the shell model of the nucleus.

(b) Define multiplication factor. State the conditions for a nuclear reactor to be subcritical, critical and supercritical.