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PHE-11

BACHELOR OF SCIENCE (B.Sc.)

Term-End Examination

December, 2013

PHYSICS

PHE-11 : MODERN PHYSICS

Time : 2 hours *Maximum Marks : 50*

Note : *Attempt* ***all*** *questions. The marks for each question are indicated against it. You* ***may use calculators and log tables.*** *The values of physical constants are given at the end Symbols have their usual meanings.*

1. Attempt **any five** parts : **3x5=15**

(a) Show that the lorentz transformation reduces to the Galilean transformation for $v << c$.

(b) A particle at rest has a mean life time of 600s. If we measure its mean life time as 1800s, what is its speed relative to us ?

(c) An electron and a proton have equal De Broglie wavelengths. Calculate the ratio of their energies.

(d) Explain why an electron cannot be accelerated in a cyclotron.

(e) State giving reasons whether the following transitions for a multi electron atom are allowed or not.

(i) $3S_1 \rightarrow 1S_0$

(ii) $1S_{1/2} \rightarrow 1P_{3/2}$

(f) Explain the function of control rods in a nuclear reactor. What materials are used in control rods and why ?

(g) State three applications of X-rays.

(h) A radioactive substance decays to $\left(\frac{1}{32}\right)$ of its initial activity in 25 days. Calculate its half life.

2. Attempt **any one** part :

(a) Write the expression for relativistic linear momentum. Obtain the relativistic energy relation $E = \sqrt{p^2c^2 + m_0^2c^4}$. A proton has kinetic energy 100 MeV. Calculate the total energy (in MeV) of the proton and its relativistic mass, given that its rest mass is 938 MeV/c^2. **1+5+4=10**

(b) Prove the relativistic velocity addition formula. Two galaxies are observed to recede in opposite directions at speed 0.4C. What speed of recession would an observer in one of these galaxies observe for the other galaxy ? **6+4=10**

3. Answer **any two** parts :

(a) An electron cannot exist inside the nucleous but a proton can. Justify the statement using uncertainty principle. **5**

(b) The steady state wave function of a system is given by $\psi(x) = Nxe^{-x^2}$. Determine the value of the normalisation constant N. **5**

(c) Show that $[L_z, L_x] = i\hbar L_y$. **5**

4. Attempt **any one** part :

(a) Write down the Schrodinger equation for the one-dimensional simple harmonic oscillator. What is its ground state energy ? Calculate the mean kinetic energy and potential energy of the simple harmonic oscillator for its ground state given by

$$\psi_0 = \left(\frac{a}{\sqrt{\pi}}\right)^{1/2} \exp\left(\frac{-a^2x^2}{2}\right), a^2 = m\omega/\hbar$$

1+1+6+2=10

(b) Obtain the most probable value and expectation value of r for ground state of H-atom. **5+5=10**

5. Answer **any one** part :

(a) Define binding energy of nucleus. Draw a curve between mass number and binding energy per nucleon. Explain why the binding energy per nucleon of heavy nuclei decreases with mass number. **1+3+1=5**

(b) Discuss the discovery of positron. How is a positron different from an electron ? **4+1=5**

Physical Constants :

$h = 6.626 \times 10^{-34}$ Js.

$m_e = 9.1 \times 10^{-31}$ kg.

$m_p = 1.6725 \times 10^{-27}$ kg.

$m_n = 1.6747 \times 10^{-27}$ kg.

$c = 3 \times 10^8 ms^{-1}$