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PHE-11

BACHELOR OF SCIENCE (B.Sc.)

Term-End Examination

00141

June, 2014

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 calculator and log tables. The values of physical constants are given at the end. Symbol have their usual meanings.*

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

(a) Half-life of a particle at rest is $1{\cdot}8 \times 10^{-9}$ s. What will its half-life be when its speed is $0{\cdot}8$ c ?

(b) A negatively charged particle has linear momentum of magnitude $1{\cdot}8 \times 10^{-21}$ kg ms^{-1} at a speed of $0{\cdot}9$ c. Calculate its rest mass.

(c) The radius of an atom is $5{\cdot}0 \times 10^{-11}$ m. Determine the minimum kinetic energy of an electron in this atom using the uncertainty principle.

(d) Explain the use of radioisotopes in sterilization and food preservation.

(e) Calculate the de Broglie wavelength of a particle of mass 1 g moving with velocity $1\ ms^{-1}$ and that of a 200 eV electron.

(f) Write down the electronic configurations for Gallium (Z = 31) and Rubidium (Z = 37).

(g) How can nuclear fission be explained on the basis of the binding energy curve ?

(h) Explain giving reasons whether the following decay reactions are allowed :

(i) $\mu \rightarrow e^- + \nu_\mu + \bar{\nu}_e$

(ii) $\bar{\Lambda}^\circ \rightarrow p + \pi^-$

2. Attempt any ***two*** parts :

(a) Using Lorentz transformation equations, show that

$$x'^2 - c^2 t'^2 = x^2 - c^2 t^2$$ 5

(b) Given that the acceleration of a particle is parallel to its velocity, express the relativistic force law in the form 5

$$F = \frac{m_0 a}{\left[1 - \frac{v^2}{c^2}\right]^{3/2}}.$$

(c) A rod is projected in the space at such a high speed that its length appears contracted to $\frac{1}{3}^{rd}$ of its initial value. How fast is it moving ? 5

3. Attempt any ***one*** part :

(a) A particle is described by a one-dimensional wave function

$$\psi(x, t) = N\, e^{i(kx - \omega t)} \text{ for } -a < x < a$$

Determine the normalisation constant N. Obtain the expectation values of momentum and position of the particle. *3+4+3=10*

(b) Prove the Ehrenfest theorems : *5+5=10*

$$\frac{d<x>}{dt} = \frac{1}{m} < p_x > \text{ and}$$

$$\frac{d<p_x>}{dt} = < -\frac{\partial V}{\partial x} >$$

4. Attempt any ***one*** part :

(a) Write down the Schrödinger equation for a particle of energy E in a one-dimensional rectangular potential barrier of height V_0 and width 2a. Obtain its general solutions for the case when $E < V_0$. *10*

(b) State Hund's rules. Apply them and obtain the ground state term for Z = 14. *3+7=10*

5. Attempt any ***one*** part :

(a) The half-life of a radioactive substance is 30 days. What is the time taken for $\left(\frac{3}{4}\right)^{th}$ of its original mass to disintegrate ? *5*

(b) Describe the liquid drop model of nuclear fission. 5

Physical Constants :

$h = 6{\cdot}626 \times 10^{-34}$ Js

$m_e = 9{\cdot}1 \times 10^{-31}$ kg

$m_p = 1{\cdot}6725 \times 10^{-27}$ kg

$m_n = 1{\cdot}6747 \times 10^{-27}$ kg

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