PHE-11

BACHELOR OF SCIENCE (B.Sc.)

01177

Term-End Examination

June, 2016

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. You may use non-programmable calculators or log tables. The values of physical constants are given at the end.*

1. Answer any *five* parts :   5×4=20

   (a) Obtain the velocity of a 100 MeV kinetic energy electron of rest mass $\dfrac{0.5}{c^2}$ MeV.

   (b) A ball of mass 92 g moves with a speed 72 ms^{-1}. Calculate the de Broglie wavelength associated with it. Would you be able to observe the ball's wave characteristics ?

   (c) The average lifetime of an excited atom is about 10^{-8} s. Calculate the uncertainty in the energy emitted.

(d) Write the electronic configuration for atoms having (i) Z = 20 and (ii) Z = 31.

(e) The wave function of a particle of mass m inside an infinite square well of width 2 L (– L to L) is

$$\psi(x) = A \cos \frac{3\pi x}{2L} + B \sin \frac{3\pi x}{2L}.$$

Obtain expressions for A and B.

(f) A rod of proper length 2 m measures only 1 m in a reference frame that is moving with respect to the rod. What is the speed of the moving reference frame ?

(g) Obtain an expression for the cyclotron frequency.

2. Answer any *one* part :

(a) Derive an expression for the relativistic force law. Show that in the absence of external forces, relativistic momentum is conserved. *5*

(b) Show that the Lorentz transformation reduces to the Galilean transformation for v << c. *5*

3. Answer any *one* part :

(a) Discuss the statistical interpretation of wave function. Define Hermitian operator and show that its expectation value is real. *4+6*

(b) If two non-commuting operators A and B commute with their commutator [A, B], show that $[A, B^n] = n B^{n-1} [A, B]$, where n is an integer. Hence obtain the value of $[e^x, p_x]$. *10*

4. Answer any *one* part :

(a) Write down the Schrödinger equation for a particle confined in a potential of the form :

$$V(x) = \begin{cases} 0, & x < -a \\ V_0, & -a < x < a \\ 0, & x > a \end{cases}$$

Write down the boundary conditions and obtain the general solution in all three regions. *10*

(b) State Hund's rules. Using Hund's rules obtain the spectral terms and ground state of the He atom. *10*

5. Answer any *one* part :

(a) Define half-life period of a radioactive material. How long does it take for 60% of a sample of radon to decay ? Half-life of radon is 3·8 days. 5

(b) Define multiplication factor. Obtain an expression for the time behaviour of a neutron chain reaction. 5

Physical Constants :

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

$m_e = 9.109 \times 10^{-31}$ kg

$m_p = 1.672 \times 10^{-27}$ kg

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