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PHE-11

BACHELOR OF SCIENCE (B.Sc.)

Term-End Examination

June, 2018

02575

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 a calculator or log tables. The values of physical constants are given at the end. Symbols have their usual meanings.*

1. Attempt any ***five*** parts : *5×2=10*

(a) Calculate the kinetic energy of an electron moving with a velocity of 0·98 c.

(b) Show that the de Broglie wavelength associated with an electron of energy V electron volts is approximately $1{\cdot}227/\sqrt{V}$ nm.

(c) Are the following wave functions physically acceptable ? Justify your answer.

(i) $\psi(x) = Ax\ e^{-x^2}$, $-\infty < x < \infty$

(ii) $\psi(x) = \dfrac{A}{x^2 - a^2}$, $-\infty < x < \infty$

(d) The average lifetime of an excited atom is about 10^{-8} s. Obtain the uncertainty in its energy.

(e) Determine the spectral terms of a hydrogen atom in n = 2 state.

(f) The mean half-life of a radioactive element is 10 days. Calculate the time required for 70% of the element to decay.

(g) Give the charge, baryon number and spin of a photon and a proton.

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

(a) A pion at rest decays into a muon and a neutrino (zero rest mass). Using the law of conservation of energy and momentum, obtain the momentum of muons in terms of m_π and m_μ.

(b) The mean lifetime of a particle measured when it moves with a speed 0·9 c is 10^{-10} s. What is its proper mean lifetime ?

(c) Derive the relativistic velocity addition law.

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

(a) Using Heisenberg's uncertainty principle, explain why an electron cannot exist inside the atomic nucleus.

(b) Determine the normalisation constant N for the wave function

$$\psi(x) = N \sin \frac{n\pi x}{L}, \quad 0 < x < L.$$

(c) Show that

$$\frac{d < x >}{dt} = \frac{< px >}{m}.$$

4. Attempt any ***two*** parts : *2×5=10*

(a) Write the selection rules for X-ray spectra. What is the maximum frequency of the X-rays produced in a tube operating at 10 kV ? *2+3*

(b) Obtain the expectation value of r for the ground state of hydrogen atom, given by *5*

$$\psi_0(r) = \frac{2}{a_0^{3/2}} e^{-r/a_0}$$

(c) State Hund's rules and using them find the ground state of helium atom. *3+2*

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

(a) With the help of binding energy curve for nuclei, explain the phenomena of nuclear fusion and nuclear fission.

(b) Describe the working of the Wilson Cloud Chamber.

(c) Define multiplication factor for a nuclear reactor. Derive the equation for the number of neutrons as a function of time.

Physical Constants :

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

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