No. of Printed Pages : 8

PHE-11

BACHELOR OF SCIENCE (B.Sc.)

Term-End Examination

00161

December, 2017

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 velocity of an electron when its mass is equal to twice its rest mass.

(b) Calculate the kinetic energy of an electron whose de Broglie wavelength is 700 nm.

(c) An electron is confined to a box of length 10^{-8} m. Calculate the minimum uncertainty in its velocity.

(d) Calculate the expectation value $< p_x >$ of the momentum of a particle with the wave function

$$\psi_n(x) = \left(\frac{2}{L}\right)^{1/2} \sin\left(\frac{n\pi x}{L}\right).$$

(e) The wavelength corresponding to the first transition of Balmer series of hydrogen is 6563 Å. Calculate the wavelength corresponding to the second transition.

(f) A radioactive element has a half-life of 16 years. Calculate the time in which 70% of the sample will decay.

(g) Calculate the binding energy per nucleon in $_6C^{12}$.

Given : Mass of $_6C^{12}$ = 12·0 u

m_p = 1·007275 u

m_n = 1·008665 u

m_e = 0·00055 u

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

(a) Light of wavelength λ = 4850 Å is emitted by atoms in a galaxy receding from the earth with a speed of 0·3 c. Calculate the wavelength of light observed on the earth. *5*

(b) Calculate the annual loss in the mass of the sun if approximately 8·4 J of radiated energy is received by each square cm of the earth's surface per minute. The distance of the sun from the earth's surface is $1{\cdot}15 \times 10^{11}$ m. *5*

(c) Derive the relation between relativistic energy and momentum of a free particle. 5

3. Attempt any *two* parts : $2\times5=10$

(a) What is the probabilistic interpretation of the wave function ? Write down the time dependent Schrödinger equation. Obtain the time independent Schrödinger equation. *1+1+3*

(b) The unnormalised wave function of a particle is given by

$$\phi = Nx \exp\left(-x^2/a^2\right).$$

Determine the normalization constant N. 5

(c) Show that

$$[L_z, L_x] = i\hbar L_y$$ 5

4. Answer any *two* parts : $2\times5=10$

(a) Consider a particle of mass m confined in a one-dimensional box :

$$V(x) = 0 \quad -a \le x \le a$$
$$= \infty \quad \text{otherwise}$$

Solve the Schrödinger equation for the particle and obtain its energy eigenvalues. 5

(b) State Hund's rule. Use Hund's rule to obtain the spectral terms and ground state of Sc (Z = 21). *3+2*

(c) X-rays from cobalt (Z = 27) tube have a strong K line of wavelength 1·785 Å and a weak line due to copper impurity (Z = 29). Using Moseley's law, calculate the wavelength of the other line. 5

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

(a) Explain the liquid drop model of fission qualitatively with the help of schematic diagrams. 5

(b) Calculate the distance of closest approach of an α-particle of energy 5·3 MeV fired directly towards a nucleus of gold (Z = 79). Given mass of gold nucleus is ($m = 6{\cdot}7 \times 10^{-27}$ kg). 5

(c) List the basic components of a nuclear reactor and explain the functions of moderator and coolant rods. 2+3

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

$c = 3 \times 10^8$ m/s

$e = 1{\cdot}6 \times 10^{-19}$ C

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ Nm^2 C^2