63/1 (SEM–4) CC9/PHYHC4096

2025

PHYSICS

Paper : PHYHC4096

(Elements of Modern Physics)

Full Marks : 60

Pass Marks : 24

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Choose the correct answer from the following : ***(any five)*** 1×5=5

   (a) An electron and proton have the same de-Broglie wavelength. Then the kinetic energy of the electron is

   (i) Zero

   (ii) Infinite

   (iii) Equal to the KE of the proton

   (iv) Greater than the Ke of the proton

(b) The concept of matter wave was suggested by

(i) Heisenberg

(ii) De Broglie

(iii) Schrödinger

(iv) Einstein

(c) A particle of mass m *kg* and charge q coulomb is accelerated from rest through V volt; then the de Broglie wavelength associated with it is given by

(i) $\lambda = \frac{h}{\sqrt{2mq}}$

(ii) $\lambda = \frac{h}{\sqrt{2mqV}}$

(iii) $\lambda = \frac{2mqV}{\sqrt{h}}$

(iv) $\lambda = \frac{\sqrt{2mqV}}{h}$

(d) The correct relationship between phase and group velocity of material particle moving with non-relativistic velocity ($v < c$) is

(i) $V_p = V_g / 2$

(ii) $V_p = 2V_g$

(iii) $V_p = V_g$

(iv) $V_p = \sqrt{Vg}$

(e) How many neutrons are there in the $^{23}_{11}Na$ atom ?

(i) 11

(ii) 23

(iii) 12

(iv) 18

(f) The energy eigenvalue of a particle in one-dimensional box of infinite depth is proportional to

(i) n^2

(ii) n

(iii) $n^{1/2}$

(iv) n^4

(g) A nucleus emits an α-particle, followed by two β-particles. The final nucleus will be

(i) An isotone of the original one

(ii) An isotope of the original one

(iii) An isobar of the original one

(iv) None of the above

(h) The radius R of a nucleus is given by

(i) $R = r_0 A^{-1/3}$

(ii) $R = r_0 A^{1/3}$

(iii) $R = r_0 A^3$

(iv) None of the above

(i) Gamma radiations are

(i) Deflected by magnetic field only

(ii) Deflected by electric field only

(iii) Deflected by both electric and magnetic field

(iv) Not deflected by either electric or magnetic field

(j) The wavelength of He-Ne laser is

(i) 6328Å

(ii) 6943Å

(iii) 1060Å

(iv) 1600Å

2. Answer ***any five*** of the following questions : 2×5=10

(a) What is eigenfunction and eigenvalues of an operator ?

(b) What is the physical significance of a wave function ?

(c) Write *two* properties of nuclear force.

(d) Calculate the energy released from the fission of 10 *gm* of U^{235}. [Energy per fission is 200 *MeV*]

(e) What is weak function of photoelectric effect ?

(f) 99% of a radioactive element disintegrates in 36 hours. Calculate its half-life. (In2 = 0.693 and In 100 = 4.605)

(g) what is the necessary condition for nuclear fusion reaction.

3. Answer ***any five*** of the following questions : 5×5=25

(a) Define commutator. Show that position and momentum operators do not commute. 2+3=5

(b) Derive *one* dimensional time dependent Schrödinger equation for a moving free particle.

(c) Find the expression for momentum operator.

(d) State the law of radioactive decay. Derive the relation $N = N_0 e^{-\lambda t}$ (symbols have their usual meaning for a radioactive substance. 2+3=5

(e) Write how magic numbers can be explained from nuclear shell model.

(f) What is α decay ? Explain fine structure of α energy spectrum. 1+4=5

(g) What is nuclear reactor ? Describe the main parts of a nuclear reactor.

(h) Write a short note on pair production process.

(i) Explain the following :

(a) Spontaneous emission

(b) Stimulated emission

(c) Metastable state

4. Answer ***any two*** of the following questions : 10×2=20

(a) What is Compton Scattering ? Explain the experimental arrangement of Compton Scattering. Derive the expression of Compton Shift. 1+3+6=10

(b) State Heisenberg's uncertainty principle. Describe gamma ray microscope experiment. Calculate the uncertainty in momentum of an electron if the uncertainty in its position is 0.4 *nm*. ($h = 6.62 \times 10^{-34}\ m^2 kg/sec$) 2+6+2=10

(c) What is meant by isobar? Derive the expression for the atomic number of the most stable isobar of a given A and use it to find the most stable isobar of $A = 25$. 1+6+3=10

(d) Explain briefly about Optical Pumping and Population Inversion. Write a note on *He-Ne* laser. 3+3+4=10