End Semester Examination, 2022

Semester - IV

Modern Physics

PAPER - CC9T

Full Marks : 40

Time : 2 Hours

Group - A

1. *Attempt any <u>five</u> questions :* ***5x2=10***

a) Find $\left[xyz, P_x^2\right]$ 2

b) Find the probabilities of finding a particle trapped in a box of length L in the region from 0.45L to 0.55L from the ground state. 2

c) Calculate the packing fraction and average binding energy per nuclear for ${}_8O^{16}$ of neclear mass 15.994916u. Given $m_p = 1.007825u$ and $m_n = 1.008665u$. 2

d) The half life of a radioactive substance is 15 years. Calculate the period in which 2.5% of the initial quantity will be left over. 2

e) Differentiate between spontaneous and stimulated emissions. 2

f) An election is confined to a box of length 1 nm. Calculate the minimum uncertainty in its velocity.

g) What is the coherence length of laser beam in vacuum, if the band width is 30 MH_z.

(Turn Over)

h) An x-ray photon is found to have doubled its wavelength on being scattered by 90^0. Find the wavelength of the incident photon.

Group - B

Attempt any <u>four</u> questions : ***4x5=20***

2. What is the probabilistic interpretation of the wavefunction ?

   The unnormalised wavefunction of a particle is given by,

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

   Determine the normalisation constant N. 2+3

3. Consider a particle of mass m confined in a one dimensional box :

   $V(x) = 0, \quad -a \le x \le a$

   $= \alpha, \quad otherwise$

   Solve the schrodinger equation for the particle and obtain its energy eigen values. 3+2

4.a) How does the uncertainty principle rule out the possibility of electron being inside the nucleus ?

b) Using the single particle shell model, calculate the spin and parity of $_{19}K^{39}$ nucleus in its ground state. 3+2

5. Show that the relation between Einstein's A and B co-efficient for transition between two states 1 and 2 is given by

   $$\frac{A_{21}}{B_{21}} = \frac{8\Pi h\gamma^3}{C^3}$$

6. What is pair production ? Show that electron-positron pair cannot be created by an isolated photon. 1+4

7. In the fission of a nucleus of mass number A_0 into the two nuclei A_1 and A_2, the energy release is $Q = M_0C^2 - M_1C^2 - M_2C^2$. Estimate Q for symmetric fission of a nucleus with A_0=240.

Group - C

Attempt any <u>one</u> question : ***1x10=10***

8.i) Why does a monochromatic wave cannot represent a particle ?

ii) What is the significance of Davisson and Germer experimental result ?

iii) An electron having kinetic energy 10ev at $x = -\infty$ is moving from left to right along x-axis. The potential energy is V = 0 for $x < 0$ and V = 20ev for $x > 0$. Treating to electron as a one dimensional plane wave :-

a) Write down schrödinger equation for $x < 0$ and $x > 0$.

b) Sketch the solution of schrödinger equation in the two regions $x < 0$ and $x > 0$.

c) What is the probability of finding the electron at some positive value of x. 2+2+(2+2+2)

9. The Weizacker semi-empirical mass formula is given by—

$$M(A,Z) = ZM_H + (A-Z)M_N - a_v A + a_s A^{2/3} + a_c \frac{z(z-1)}{A^{1/3}}$$

$$+ a_a \frac{(A-2z)^2}{A}(\pm,0)a_p A^{-3/4}$$

[Where, $a_v = 14\,MeV$, $a_s = 13\,MeV$, $a_c = 0.60\,MeV$

$a_a = 19\,MeV$, $a_p = 34\,MeV$]

a) Using this formula, show that $M(A,Z)$ follows a parabolic variation with Z for a group of isobars.

b) Find out an expression for the atomic number for the most stable isobar and hence identify the most stable isobar corresponding to mass mumber. A = 109.

c) Show the plotting of binding energy per nuclon as the sum of volume, surface, coulamb and asymmetry energies.

d) Write down the limitations of the above formula.

2+(2+1)+3+2