(iii) Deduce an expression for the penetration depth and hence calculate the penetration depth for a 5 eV electron approaching a step barrier of 10 eV. (2,8,5)

5. (a) What is a-decay? Describe the Gamow's theory of a-decay of a radioactive substance.

(b) The nuclei $^{11}_{6}C$ decays to $^{11}_{5}B$ by β^+ emission. What is the maximum energy neutrino can have? (Given mass of $^{11}_{6}C$ = 11.011433 u, mass of $^{11}_{5}B$ = 11.009305 u)

(c) Explain the terms: isotope, isobar, isotone and isomer in context of nuclei. (10,3,2)

6. (a) What are the conditions for the nuclear fusion to take place? Explain the proton-proton cycle and carbon -nitrogen cycle.

(b) Calculate the energy released by the fission of 10g of ^{235}U in kWh given that the energy per fission is 200 MeV. (10, 5)

7. (a) Explain the basic lasing action.

(b) What is population inversion? Why it is necessary for the operation of a laser?

(c) Draw the binding energy per nucleon curve. Explain the characteristics of this curve.

(d) Evaluate the density of a typical nucleus and show that it is same for all nuclei. (3,5,4,3)

(100)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 7368 **H**

Unique Paper Code : 32221402_OC

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. Hons. – (Physics)_Core (Old Course)**

Semester : IV

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **FIVE** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Non programmable calculators allowed.

1 Attempt any **five** of the following :

(a) Verify that uncertainty principle can be expressed in the form $\Delta E.\Delta t \geq \frac{\hbar}{2}$, where ΔE and Δt are uncertainties in the measurement of energy and time respectively.

(b) Derive the relativistic formulae for the de-Broglie wavelength of a charged particle in terms of the potential difference 'V' through which it is accelerated.

(c) What are stationary states? Explain.

(d) The wave function of a particle in a box of length 'L' is

$$\psi(x) = \begin{cases} \sqrt{\frac{2}{L}} \sin\left(\frac{\pi x}{L}\right), & 0 < x < L \\ 0 & , everywhere\ else \end{cases}$$

Calculate the probability of finding the particle in the region $0 < x < \frac{L}{2}$.

(e) Verify the operator equation

$$x^2 p - p x^2 = 2i\hbar x$$

(f) "*Electron cannot exist inside the nucleus.*" Explain.

(g) Under what conditions a nuclei may undergo
(i) β^- decay
(ii) β^+ decay (5×3=15)

2. (a) Derive the Planck's radiation formula. Deduce Rayleigh-Jeans Law and Wien's law from it.

(b) What are the postulates made by Einstein to explain the photoelectric effect? (10,5)

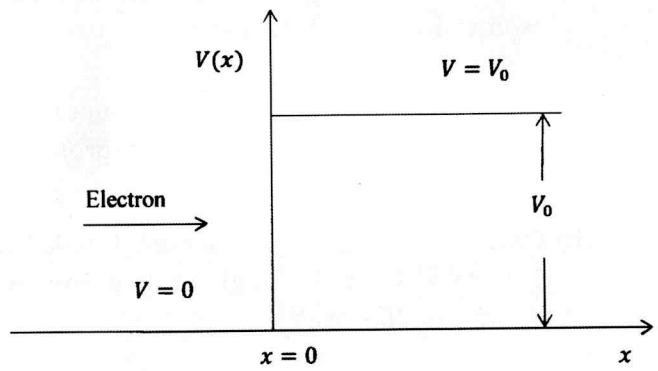
3. (a) Obtain the time-dependent Schrodinger wave equation for a freely moving particle.

(b) Define probability density and obtain an expression for probability current density in one dimension.

(c) State the conditions for a wave function to be physically acceptable. (5,5,5)

4. (a) An electron of energy 'E' approaches a step barrier potential of height 'V_0' from the left as shown. Here

$$V(x) = \begin{cases} 0 & for\ -\infty < x \leq 0 \\ V_0 & for\ 0 \leq x \leq \infty \end{cases}$$



If the energy of the electron is less than the height of the barrier ($E < V_0$)

(i) Describe briefly what will happen if the electron behaves classically.

(ii) Using Schrodinger equation obtain expressions for Transmission and Reflection coefficients.

P.T.O.