Major : PYL100 (*Electromagnetic Waves and Quantum Mechanics*)

(22 November 2016)

Time: 1 hr 15 min (8:45 – 10:00 AM) **Max. Marks:** *25*

> ➤ ***Use of Mobile Phone & Calculator during the exam is STRICTLY prohibited.*** *If found in your possession during the exam, F-grade will be awarded straight away.*

1. The potential seen by an *alpha-particle* formed in a heavy nucleus is approximately given as

$$V(r) = \begin{cases} \left(\dfrac{250}{r}\right) \text{ MeV} - \text{fm} & \text{for } r > 8 \text{ fm} \\ -50 \text{ MeV} & \text{for } r < 8 \text{ fm} \end{cases}$$ (Note: ***r*** is in units of *fm*)

   (a) Sketch the potential as a function of ***r***.

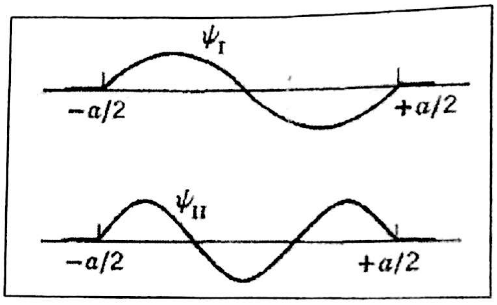
   (b) Find the **maximum** value of the potential.

   (c) Consider an *alpha particle* formed with an energy 4.25 *MeV* inside the nucleus. Find the maximum and minimum values of γ (*i.e., gamma,* usual meaning), in units of *fm*, as the alpha particle crosses the barrier.

   (d) Find the width of the barrier encountered by the alpha particle. ***(2+1+2+1)***

2. A particle is in its **first excited state** in a finite square well potential extended from $x = -L/2$ to $x = L/2$. The maximum value of the wave function ψ, at a particular instant, is A and it occurs at $x = L/3$. Find the value of the wave function at $x = L/2$. ***(3)***

3. Two possible eigen functions for a particle trapped inside an infinite potential well of length ***a*** are shown in figure. When the particle is in the state corresponding to the eigen function Ψ_I, its total energy is **4 *eV***.



   (a) What is its *total energy* in the state corresponding to Ψ_{II}?

   (b) What is the *zero point energy* of the particle in this system? ***(3)***

4. (a) State the *Bloch's* theorem. Also give the equation describing the theorem.

   (b) Sketch the ***E-k*** relation for a **1-dimensional solid** as proposed by the Kronig-Penney model. Show the emergence of forbidden gaps using this graph.

   (c) For comparison, sketch **separately** the ***E-k*** relation for **a free electron**. Also, depict the changes in energy bands using this ***E-k*** graph when compared with **1-dimensional solid.** ***(2+3+2)***

5. (a) A beam of particles of mass *m* and energy *E* is incident on a rectangular potential barrier. The barrier height is $2E$ and its width is $\dfrac{\hbar}{\sqrt{2mE}}$. Find the fraction of the particles reflected from the barrier.

   (b) For a particle inside an infinite potential well, show that the fractional difference in the energy between adjacent eigen-values is given as,

$$\frac{\Delta E_n}{E_n} = \frac{2n+1}{n^2}$$

(3+3)