RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College under University of Calcutta)

B.A./B.Sc. SIXTH SEMESTER EXAMINATION, MAY 2014

THIRD YEAR

Date : 22/05/2014 **PHYSICS (Honours)**

Time : 11 am – 1 pm **Paper :** VII Full Marks : 40

Group – C

(*Answer **any four** questions*)

1. a) Define binding energy B(A,Z) of a nucleus ${}_ZX^A$, and explain its physical significance. [2]

   b) From the shape of the E–A curve, where $E = \frac{B(A,Z)}{A}$ is the binding energy per nucleon, show that :

      i) Nuclear forces are attractive, short-ranged and have saturation properties;

      ii) Nuclear fission is energetically favourable for heavy nucleus;

      iii) Nuclear fusion is energetically favourable for light nuclei. [6]

   c) Show that the separation energy of a proton from a nucleus ${}_ZX^A$ is given by :
   $S_p = B(A,Z) - B(A-1,Z-1)$. [2]

2. a) How is nuclear size related with the mass number? Hence derive an expression for the density of nuclear matter. [3]

   b) What are surface, volume and Coulomb energies of a nucleus under liquid drop model? Explain. Write down the Bethe-Weizsâcker formula for the binding energy of a nucleus. [4]

   c) Derive a formula for the atomic number of a most stable isobar with mass number A. [3]

3. a) Explain how a charged particle is detected in Geiger-Mueller (GM) counter. [2]

   b) Describe a fixed frequency cyclotron and explain its basic principle of operation. Show that the radius of curvature(R) of the path of the particle in a cyclotron is proportional to $\sqrt{n}$, where n is the number of times the particle has been accelerated across the space between the Dee. [5+3]

4. a) Explain why $\beta-$ray spectrum is continuous. [5]

   b) Give examples of β^-, β^+ emissions and electrons capture. [3]

   c) Show that the decay of ${}^7Be_4$ to ${}^7Li_3$ can take place only by electrons capture and not by positron emission. [Given : $\mu\left({}^7Be_4\right) = 7{\cdot}1963\,u$ and $\mu\left({}^7Li_3\right) = 7{\cdot}0160\,u$] [2]

5. a) Define Q-value of a nuclear reaction. [2]

   b) Find an expression for the Q-value of the reaction $a + b \rightarrow c + d$ in terms of the incident energy, ejectile energy and the scattering angle. [5]

   c) Find the Q-value of beta decay of a free neutron. [3]

6. a) What is a nuclear reaction? How are they classified? State and explain the conservation laws associated with nuclear reaction. [3]

   b) What is reaction cross section and how is it derived? Express the decay law interms of reaction cross section. [4]

   c) The cross section of ${}^{113}Cd$ for capturing thermal neutrons is 2×10^4barns, the mean atomic mass of neutral Cadmium is 112u and its density is $8{\cdot}64\ kg/m^3$.

      i) What fraction of an incident beam of thermal neutrons is absorbed by a Cadmium sheet of thickness 1mm?

      ii) What thickness of Cadmium sheet is necessary to absorb 99% of the incident beam of thermal neutrons?

      [${}^{113}Cd$ constitutes 12% of natural Cadmium and $1u = 1{\cdot}66\times10^{-27}\,kg$] [3]

7. a) Which of the following interactions are allowed or disallowed? Give reasons for your answer. [4]

   i) $\pi^- + p \rightarrow \Sigma^+ + k^-$

   ii) $\nu_\mu + n \rightarrow \mu^- + \Sigma^+$

   iii) $k^- + p \rightarrow \Omega^- + k^- + k^0$

   iv) $e^+ + e^- \rightarrow \mu^+ + \mu^-$

   b) Write down the minimal interaction in which an antiproton can be created in a proton proton collision. If one proton is at rest in the laboratory, find the minimum kinetic energy of the incident proton so that the reaction is possible. $\left(m_p = 938\,{}^{MeV}/_{c^2}\right)$ [4]

   c) What are the decay products of a muon? Assume lepton number conservation. What is the order of magnitude of the life time of muon? [2]