RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SIXTH SEMESTER EXAMINATION, MAY 2017

THIRD YEAR [BATCH 2014-17]

Date : 04/05/2017 **PHYSICS (Honours)**

Time : 11 am – 1 pm **Paper :** VII (Gr. A) Full Marks : 50

Answer **any five** questions : [5×10]

1. a) Justify that electron cannot be a constituent particle of the nucleus. 5
   b) Explain why the neutron is associated with a negative magnetic moment. 2
   c) The isotopes of ^{238}U and ^{235}U occur in nature in the ratio 140 : 1. Assuming that at the time of the earth formation they were present in equal ratio, make an estimate of the age of the Earth. Half-lives of ^{238}U and ^{235}U are 4.5×10^{9} years and 7.13×10^{8} years respectively. 3

2. a) State Geiger-Nuttall law. Discuss its importance. 3
   b) Explain the mechanism of α-decay according to Gamow's theory to establish Geiger and Nuttall law. Assume the nuclear potential as rectangular potential barrier. 5
   c) $^{212}_{83}Bi$ decays with a half-life of 60.5 min by emitting 5 groups of α-particles with energy 6.08 MeV, 6.04 MeV, 5.76 MeV, 5.62 MeV and 5.60 MeV. Calculate the α-disintegration energies. Sketch the energy scheme. 2

3. a) What do you mean by continuous β-spectrum? What is discrete β-spectrum and end-point energy? 3
   b) Show that the electron capture is possible, if and only if the mass of the parent atom is greater than that of the daughter atom by at least the binding energy of the electron. 2
   c) Explain the basic principle of CCD detector. 3
   d) Find the ground state spins and parities of $^{27}_{13}Al$ and $^{33}_{16}S$. 2

4. a) Explain the origin of the surface term and the asymmetry term in the semi-empirical mass formula. 2+2
   b) How does the shell Model account for the magic numbers? What is the role of the spin-orbit coupling in this connection? 3+3

5. a) Obtain the general expression for Q number for the following nuclear reaction $^{A}_{Z}X + {}^{a}_{z}x \rightarrow {}^{A'}_{Z'}Y + {}^{a'}_{z'}y$. Show that the threshold energy can be written as: 3+2

   $E_{th} = -a\left(1+ {}^{M_x}\!/_{M_X}\right)$ where M_x and M_X are respectively the masses of the nuclei x and X.

   b) Calculate the Q-value for the reaction in MeV

   $$p + {}^{9}_{4}Be \rightarrow {}^{6}_{3}Li + {}^{4}_{2}He$$

   Masses of proton = $1.0078u$, $^{4}_{2}He = 4.002u$, $^{6}_{3}Li = 6.0151u$, $^{9}_{4}Be = 9.0122u$ 5

6. a) Explain the nuclear fission from the Liquid Drop Model.
   Calculate the energy released in the process.
   Comment which of the two Uranium Isotopes is more fissionable than the other. 3+1+2
   b) Explain the energetics of nuclear fusion from the Liquid drop Model. Write down the reaction of He formation from protons. 3+1

7. a) State which of the following processes are allowed and which are forbidden giving reasons in terms of conservation laws and stating the dominant interaction in the case of allowed processes. 6

i) $\mu^- \rightarrow e^- + \nu_e + \bar{\nu}_\mu$

ii) $\wedge^o \rightarrow \pi^o + n$

iii) $\pi^- + p \rightarrow K^- + \pi^+ + \wedge^o$

iv) $\pi^- + p \rightarrow \Sigma^+ + K^-$

v) $K^- + p \rightarrow \Omega^- + K^+ + K^o$

vi) $\pi^- + p \rightarrow K^+ + \pi^- + \wedge^o$

b) Name and compare the four basic interactions in nature. Why is β-decay called a weak process? 2+2

8. a) Give the quark structure of the following hadrons: 2
(i) n (ii) K^+ (iii) Σ^+ (iv) π^+

b) What is the Gell-Mann-Nishijima scheme for strongly interacting particles? Omega (Ω^-) particle is an isosinglet strange baryon. What should be its strangeness according to the scheme? 2

c) What do you mean by the charge conjugation operation? How does the electric field transform under charge conjugation? Show that the charge parities of a charge conjugate eigenstate can only be ±1. If electrodynamics is invariant under charge conjugation, find the charge parity of π^o. Show that $\pi^o \rightarrow n\gamma$ where *n* is an odd integer is not possible. 6

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