RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College under University of Calcutta)

B.A./B.SC. SIXTH SEMESTER EXAMINATION, MAY 2015

THIRD YEAR

Date : 15/05/2015 **PHYSICS (Honours)**

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

Group – B

[*Answer **any four** questions*]

1. a) What are the similarities between a nucleus and a liquid drop? Estimate the nuclear charge of the most stable isobar in the family of isobars with A = 91 using semiempirical mass formula. Given, value of Coulomb coefficient = 0·71 MeV, value of asymmetry coefficient = 19·0 MeV and the difference of mass between neutron and proton = 0·8 MeV. [2+3]

   b) In the decay scheme $\mathrm{RaE} \xrightarrow{\beta} \mathrm{RaF} \xrightarrow{\beta} \mathrm{RaG\,(stable)}$, a freshly prepared sample of RaE weighs 2×10^{-3}kg at time t = 0. If the sample is undisturbed, calculate after what time the greatest number of atoms of RaF will be present and what is that number? Deduce the formula you used. Given the half lives of RaE and RaF are 5 days and 138 days respectively and mass number of RaE is 210. [3+2]

2. a) What is neutrino? Explain qualitatively how the neutriono hypothesis solves the apparent breakdown of conservation of angular momentum and energy in β-decay? What is the importance of Kurie plot? [2+3+2]

   b) Write Geiger-Nuttal relation in connection to alpha decay and explain the terms. What is its importance? [2+1]

3. a) What evidences led one to propose the shell model of nucleus? What are the assumptions of the model? Discuss qualitatively the role of spin – orbit coupling in this model. [3+2+2]

   b) Find the total angular momentum for the ground state of $^{33}_{16}\mathrm{S}$ nucleus, using shell model. [3]

4. a) Obtain a formula connecting the Q-value of a nuclear reaction with the scattering angle. [3]

   b) Calculate the Q-value of the following reaction in Mev : [3]

   $^{40}_{20}\mathrm{Ca} + {}^{16}_{8}\mathrm{O} \rightarrow {}^{28}_{14}\mathrm{Si} + {}^{28}_{14}\mathrm{Si}$

   Given the masses of O, Si and Ca respectively 15·994 amu, 27·977 aum and 39·963 amu.

   c) What are the distinctive features of a compound nuclear reaction and a direct nuclear reaction? [4]

5. a) Obtain the minimum value of the quantity Z^2/A required for spontaneous fission of a heavy element in terms of the mass formula constants. [5]

   b) Calculate the energy released in MeV in the following induced fission process : [5]

   $^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{141}_{56}\mathrm{Ba} + {}^{92}_{36}\mathrm{Kr} + 3\,{}^{1}_{0}\mathrm{n}$

   Given the masses of U, Ba, Kr and n are respectively 235·043 amu, 140·912 amu, 91·897 amu and 1·009 amu.

6. a) What are the different methods by which a gamma-ray loses energy when interacting with matter? In which energy regions do each of these processes dominate? [3]

   b) Gamma-rays of energies 0·77 MeV, 0·34 MeV, 0·28 MeV and 0·43 MeV are obtained from a source. Construct a possible level scheme of the excited states of the relevant nucleus. [3]

   c) What are the dominant multipoles in the following gamma-ray transitions : [4]

   i) $(7/2)^+ \rightarrow (3/2)^-$ ii) $0^+ \rightarrow 0^-$ iii) $2^+ \rightarrow 1^+$.

Or,

a) Describe the construction and principle of operation of a fixed frequency cyclotron. Write down its limitations. [5+2]

b) What are dead time, recovery time and resolving time of a GM counter? [3]

7. a) Write down the structure of π^- and Σ^+ particles in terms of the quark model. [2]

b) Show that Baryon number and strangeness number of the following groups satisfy the Gell-Mann-Nishijima relation. [4]

i) K^o, K^+ ii) p, n iii) $K^-, \bar{K}^o$ and iv) $\Sigma^-, \Sigma^o, \Sigma^+$

c) Which of the following interactions are allowed or disallowed? Give reasons. [4]

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

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

iii) $\Lambda^o \rightarrow p + \pi^-$

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

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