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Sardar Patel University
Vallabh Vidyanagar
M Sc (Physics)- IV Semester Examination
PS04CPHY01 Nuclear and Particle Physics
Day and Date: Monday, 4th April 2016

Time: 2:30 to 5:30pm **Max marks: 70**

I. **Choose the best possible answer from the choices given below each question** (8x1=8)

1. The fact that the ground state of most of the stable nuclei is of J = 0 is a clear indication of the
   (a) Short range interaction (b) Coulomb interaction among the nucleons
   (c) Pairing force among the nucleons (d) Saturation property of the nuclear force

2. The typical binding energy per nucleon in the case of ${}^{56}_{26}Fe$ nucleus is
   (a) 3.8 MeV/nucleon (b) 8.7 MeV/nucleon
   (c) 10.3 MeV/nucleon (d) 931.6 MeV/nucleon

3. The Bragg-curve of α – particles have a maximum ionization at its end, this maximum ionization appears due to the phenomena known as
   (a) struggling (b) disintegration
   (c) straggling (d) none of the above

4. Nuclear quadrupole moment is measured in units of
   (a) Bohr magneton (b) Nuclear magneton
   (c) Columb/m^2 (d) Barn

5. The relationship between the range and life time of alpha emitter nuclei is known as
   (a) Geiger-Nuttall law (b) Bohr-Mottelson relation
   (c) Gamow-Teller law (d) Katz-Penfold relation

6. Lande g-factor for electron is equal to
   (a) 2π (b) 1.0 (c) 0 (d) 2.0

7. The gauge bosons responsible for the strong interaction are known as
   (a) mesons (b) gravitons
   (c) gluons (d) neutrinos

8. The total energy released per burning of one hydrogen nucleus in the PPI cycle is about
   (a) 931 MeV (b) 6.55 MeV (c) 26 MeV (d) 8.5 MeV

II. Short answer questions (Answer any seven questions given below. 7x2 = 14)

1. Determine the distance of closest approach of a proton of kinetic energy 2MeV to a target of atomic number 40.
   [Given that charge of proton = 1.6 x 10^{-19} Coulomb, $4\pi\varepsilon_0 = 1.11\times10^{-10} C^2 N^{-1} m^{-2}$]
2. Write and explain the Weizsacker's mass formula for a nucleus, (A, Z).
3. Explain inverse β – decay process and for what study it is used?
4. Explain the Nordhiem rule.
5. Explain the selection rules in the case of beta decay transitions.
6. Discuss briefly the idea of neutrino oscillation.

7. Derive disintegration energy of α – particles.
8. What are breeder reactors? How does it work?
9. Draw the quark distribution diagram for the decay, $J/\Psi \rightarrow D^{+} + D^{-}$ according to their quark contents.

III A. Consider a square well potential for the binding energy of the deuteron. Show that it is a very weakly bound system. (6)

B. Discuss the successes and failures of the single particle shell model. Discuss how the collective model explains the shortcomings of the single particle shell model? (6)

OR

B. Using the semiempirical mass formula show that for the families of isobars having odd A nuclei, the neutron excess, (A-2Z) is approximately proportional to $A^{5/3}$. [Given: $a_{C} = 0.71MeV$, $a_{asy} = 22.7MeV$, $M_{p} = 1.0078$ amu and $M_{n} = 1.0086$ amu]. (6)

IV A Describe the different types of the alpha particle spectra. How are these spectra analyzed based on the nuclear energy levels and Explain the Geiger-Nuttel Law (6)

B. Write the beta decay transition of a free neutron. Explain the requirement of anti neutrino emission in this transition. Based on the Fermi theory of β – decay, derive the equation for the transition probability. (6)

OR

B. Derive and discuss the equation of energy loss per unit length by an incoming charged particle in an interaction of heavy charged particles with matter? (6)

V Ai..Define the Q-value of a nuclear reaction. Derive an expression for the same. (3)

ii. How many hydrogen atoms have to be transformed in the reaction ${}_{1}^{1}H + {}_{3}^{7}Li \rightarrow 2\,{}_{2}^{4}He$ to yield 10 Joules of energy?
[Given: masses of $m_{{}_{1}^{1}H} = 1.007825$, $m_{{}_{3}^{7}Li} = 7.016004$ and $m_{{}_{2}^{4}He} = 4.002603$ in amu, 1amu = 931 MeV] (3)

B. Explain the general features of a nuclear reactor. Sketch a schematic diagram of a nuclear power generator. Classify different types of nuclear reactors. (6)

OR

B. Describe the stellar nucleosynthesis for $A \leq 60$ as well as for $A > 60$. (6)

VI A. Discuss Gell-Mann's SU(3) quark model for hadrons. Explain its successes and failures? (6)

B. Discuss the properties of quantum chromo dynamics (QCD) with reference to quantum electro dynamics(QED). (6)

OR

B. What are the different conservation laws abide by the particles of the micro world? Apply these conservation laws to determine whether the following reactions are allowed or forbidden.
i) $P + P \rightarrow K^{+} + \Sigma^{+}$ ii) $\Pi^{+} + n \rightarrow \Lambda^{0} + K^{+}$ (6)

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