Register Number:

DATE:

ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27
M.Sc. PHYSICS – IV SEMESTER
SEMESTER EXAMINATION : APRIL 2018
PH 0216 : NUCLEAR AND PARTICLE PHYSICS

Time: 2 1/2 hours **Maximum Marks:70**

This question paper contains 2 printed pages and 2 parts
Use of Clark's tables and scientific calculators permitted.

Instructions : *Draw appropriate figures wherever necessary.*

PART – A

Answer any 5 questions. Each carries 10 marks. (5 x 10 = 50)

1. a) What is the meaning of the terms scattering cross section and differential scattering cross section? If it is desired to obtain a particular product after the reaction, would you prefer a high/low value for the scattering cross section? Why?

   b) Obtain the upper limit for the projectile kinetic energy for $l=0$ scattering to happen.

   c) What is the effect of scattering potential on the incident and the scattered wave functions?

   (5+3+2)

2. a) Write a note on angular momentum and parity selection rules in alpha decay.

   b) Obtain an expression for Q-value of an alpha decay process.

   (7+3)

3. a) What is mass parabola? How is it relevant for beta decay of a nucleus?

   b) What is the meaning of intrinsic spin of a nucleus? How is it calculated based on extreme single particle model (shell model)?

   (5+5)

4. a) Describe the process of Coulomb scattering. Compare it with nuclear scattering. Identify the ideal projectile particles to perform Coulomb and nuclear scattering.

   b) It is required to excite a nucleus from its ground state to one of the higher energy states. Which is the best method to achieve this? How can one determine energy, spin and parity of the state to which the nucleus is excited?

   (6+4)

5. Explain the design, principle and working of a proton sychrotron.

6. a) What are (i) mesons and (ii) meson resonances? What are their properties? How can a resonance particle be produced?

   b) Explain the features of the four fundamental forces in nature. How are the forces mediated? What are the time scales in which these interactions happen?

   (5+5)

7. Which are the three generations of quarks? Mention the quantum numbers governing interactions of quarks. What is color hypothesis? Write a note on quark confinement.

   (2+2+3+3)

PART – B

Answer any 4 questions. Each carries 5 marks. (4 x 5 = 20)

8. A nucleus has the following sequence of states beginning with the ground state: $\frac{3}{2}^+, \frac{7}{2}^+, \frac{5}{2}^+, \frac{1}{2}^-$ and $\frac{3}{2}^-$. Draw a level scheme showing the intense γ transitions likely to be emitted and indicate their multipole assignment.

9. Analyze the following reactions according to their quark content

   (i) $K^- + p \rightarrow \Omega^- + K^+ + K^0$ (ii) $p + p \rightarrow p + \pi^+ + \Lambda^0 + K^0$

   (iii) $K^- + p \rightarrow \Xi^- + K^+$ (iv) $\pi^- + n \rightarrow \Delta^- + \pi^0$

10. Given that $\mu = \mu_N (g_l l_z + g_s s_z)/\hbar$, derive the equation for magnetic moment of the nucleus for the case $j = l + \frac{1}{2}$

11. The recently-discovered Higgs boson at the LHC experiment has a decay mode into a photon and a Z boson. If the rest masses of the Higgs and Z boson are 125 GeV/c^2 and 90 GeV/c^2 respectively, and the decaying Higgs particle is at rest, calculate the energy of the photon.

12. If the binding energy B of a nucleus (mass number A and charge Z) is given by

    $B = a_V A - a_S A^{2/3} - a_{sym} \frac{(2Z - A)^2}{A} - a_C \frac{Z^2}{A^{1/3}}$ where

    $a_V = 16\,MeV, a_S = 16\,MeV, a_{sym} = 24\,MeV, a_C = 0.75\,MeV$

    Find the Z for most stable isobar with $A = 216$.

13. Calculate the electric field at the surface of the wire of a GM counter. The radius of the wire is 0.1 mm, the inner radius of the outer cylinder is 2 cm and the potential applied between the two electrodes is 500 V.