DMM-1617
M. Sc. (Sem. IV) Examination
April/May - 2016
Physics : PH-541
(Sub-atomic Physics)

Time : 3 Hours] [Total Marks : 70

Instructions :

(1) Fill up strictly the details of signs on your answer book.

(2) Attempt all questions.
(3) Symbols used have their usual meaning.
(4) Figures to the right indicate marks.
(5) Assume data whenever necessary.
(6) Scientific calculator may be used.

1 Attempt any two questions :

(1) (a) Define electric quadrupole moment for a nucleus and show that its value is zero for spherical nuclei. 

(b) Discuss Yukawa’s theory of nuclear force. 

(2) (a) Calculate the range of a nuclear force caused by the exchange of a pion of mass 140 MeV/c². Compare it with that of the weak interaction.

(b) Discuss in brief developments in particle physics.

(3) (a) Draw the experimental binding energy per nucleon Vs. mass number and using it explain why fission of heavy nuclei and fusion of light nuclei can release energy.

(b) Discuss Heisenberg, Majorana, Basrtlett and Wigner exchange forces.
2 Attempt any two questions:

(1) (a) Define binding energy of a nucleus and calculate it in MeV for \(_{8}O^{16}\) given:
\[ M(\text{O}^{16}) = 15.994915 \text{ amu} \]
\[ M(H^1) = 1.0078252 \text{ amu} \]
\[ M(n^1) = 1.0086654 \text{ amu} \]
(Hint : 1 amu = 931 MeV)

(b) Derive the Wieszacker semi-empirical mass formula.

(2) (a) What are the evidences for collective model?

(b) Find \(J^\pi\) of the ground state of the following nuclei on the basis of shell model:
\(^{11}\text{Na}^{23}, \quad ^{12}\text{Mg}^{24}, \quad ^{13}\text{Al}^{27}, \quad ^{30}\text{Zn}^{67}\).

(3) (a) What is need for deformed potential well in shell model of nuclei?

(b) Discuss various phonon vibrational states of a spherical nucleus.

3 Attempt any two questions:

(1) (a) Discuss how alpha-decay of a nucleus corresponds to a barrier penetration problem.

(b) Write the expressions for electric and magnetic multi-pole moments. How the quantum mechanical calculation differs from the classical one for such moments? How can one experimentally determine the multipole character of a \(\gamma\)-transition?

(2) (a) Obtain the wavelength for gamma-rays of energy 1.17 MeV and 1.33 MeV.

(b) Explain the Fermi-Kurie plot and what does the end point energy suggest?

(3) (a) Explain the selection rules for the E2 and M1 transitions in nuclei.

(b) Derive the formula for momentum distribution of electrons in the beta-decay of a nucleus using the Fermi theory.
4 Attempt any two questions:
(1) (a) Describe the partial wave analysis for nuclear reaction cross-section.
(b) Give the Breit and Wigner single level relation for scattering and absorption cross-section in the vicinity of a resonance observed in neutron reaction.

(2) (a) Discuss the validity of classical calculation in heavy-ion collision calculations.
(b) Calculate the compound nucleus formation cross section when \( l = 0 \), 4.0 MeV neutrons are incident on a nucleus with \( V_0 = 50 \) MeV.

(3) (a) Explain how the liquid drop model of the nuclei helps to understand the nuclear fission.
(b) Discuss the partial wave analysis of scattering and absorption in a nuclear reaction and obtain expressions for \( \sigma_{SC,l} \) and \( \sigma_{r,l} \).

5 Attempt any two questions:
(1) (a) Classify the elementary particles. What do you know about leptons and mesons?
(b) Given the wave function for \( \pi^- \)
\[ |\pi^-> = |\bar{ud}> \]
Find the wave function for \( \pi^0 \) using the isospin raising operator.

(2) (a) What are mesons? What is meant by pseudoscalar mesons and vector mesons?
(b) Explain G-Parity, Isospin and Baryon number in brief.

(3) (a) What are mesons? What is meant by pseudoscalar mesons and vector mesons?
(b) Write the quark structure of the following particles: Proton, neutron, \( \pi^- \)-meson and K-meson; also comment on their charge (Q).