



**Q.1. Answer the following short questions: (10x3=30)**

- (i) Give at least two examples of strange particles. Also discuss why are they called strange?
- (ii) Are the processes  $p \rightarrow n + e^+ + \bar{\nu}_e$  and  $\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$  allowed or forbidden in nature. If forbidden then why?
- (iii) What is C-parity? What are its possible values? How does it differ from G-parity?
- (iv) How is it possible that two hadrons carrying different masses and spins (e.g  $\Delta^0$  and  $n$ ) can have same combination of quarks?
- (v) What is color hypothesis? Why is it necessary to assign color charge to quarks?
- (vi) What are gauge transformations? Also explain the difference in Lorentz gauge and Coulomb gauge.
- (vii) How many quarks does  $\Delta^+$  contains? Write down its quark content. Also write down its isospin state vector.
- (viii) Draw the primitive vertices for elementary processes in QED and QCD. Also discuss conservation of electric charge and color charge at these vertices.
- (ix) What is quark model? Is there any experimental evidence which supports this model?
- (x) What is Fine Structure constant. Give its significance.

**Answer the following questions. (3x10=30)**

**Question 2: (10)**

Describe the phenomena of vacuum polarization in QED and QCD. How the vacuum polarization implies the variation of coupling of electromagnetic ( $\alpha_e$ ) and strong interaction ( $\alpha_s$ ) with distance or energy of the interacting particles?

**Question 3: (5 + 5 = 10)**

(a): Write down the spin states,  $|s, m_s\rangle$  of a system of two spin-1/2 particles in terms of the constituent spins. Also comment on the symmetry of these states.

(b): Show that

$$J_{\pm}|j, m\rangle = [j(j+1) - m(m\pm 1)]^{1/2}|j, m\pm 1\rangle$$

where  $|j, m\rangle$  are eigen-states of  $J^2$  and  $J_z$  with eigen values  $j(j+1)$  and  $m$ , respectively.

**Question 4: (10)**

What is parity? Explain in detail how parity is violated in the weak interaction of cobalt decay. What kind of special characteristics of neutrino make weak processes to violate the conservation of parity?