REV-01
MSP/11/16

2022/12

SET A

M.Sc. PHYSICS
THIRD SEMESTER
HIGH ENERGY PHYSICS
MSP – 304C

[USE OMR SHEET FOR OBJECTIVE PART]

Duration : 3 hrs. **Full Marks : 70**

(Objective)

Time: 30 min. **Marks: 20**

Choose the correct answer from the following: ***1X20=20***

1. In natural unit, time is expressed in GeV^{-1}. The actual dimension of time is
   a. $\frac{GeV}{c^2}$ b. $\frac{\hbar c}{GeV}$
   c. $\frac{\hbar}{GeV}$ d. $\frac{\hbar c^2}{GeV}$

2. The $e^+ + e^- \rightarrow \mu^+ + \mu^-$ interaction is a
   a. Strong interaction b. Weak interaction
   c. Electromagnetic interaction d. Both a and c

3. Ω^- hyperon can be classified as a
   a. nucleon and hadron b. baryon and pentaquark
   c. nucleon and meson d. baryon and hadron

4. One of the following reactions does not conserve strangeness. Which one?
   a. $\pi^- + p \rightarrow \pi^0 + K^0$ b. $n + \bar{n} \rightarrow \pi^+ + \pi^- + \pi^0$
   c. $\Sigma^- \rightarrow \Lambda + \pi^-$ d. $\pi^- + p \rightarrow \Lambda + K^0$

5. The quark content of K^- baryon is
   a. $u\bar{s}$ b. $s\bar{u}$
   c. $s\bar{d}$ d. $d\bar{s}$

6. The color factor between two interacting B and G quarks is _____ for symmetric state and _____ for antisymmetric state respectively.
   a. +4/3, -2/3 b. +1/3, -8/3
   c. +2/3 , -4/3 d. +1, -1

7. The $|I, I_3\rangle$ for Δ^+ is
   a. $|\frac{1}{2}, \frac{1}{2}\rangle$ b. $|\frac{1}{2}, -\frac{1}{2}\rangle$
   c. $|\frac{3}{2}, -\frac{1}{2}\rangle$ d. $|\frac{3}{2}, \frac{1}{2}\rangle$

8. The charge of the particle dds is
   a. -1 b. 0
   c. +1 d. -1/3

9. The group SU(2) is a lie group of rank
   a. 0 b. 1
   c. 2 d. 3

10. The reaction $\mu^- \longrightarrow e^- + \overline{\nu_e} + \nu_\mu$ conserves
   a. muon lepton number but not electron lepton number
   b. electron lepton number but not muon lepton number
   c. both muon and electron lepton numbers
   d. neither muon lepton nor electron lepton number.

11. The fundamental representations of group SU(3) are 4x4 matrices which are known as
   a. Pauli's matrices b. Dirac matrices
   c. Gell-Mann matrices d. None of these

12. If one attempts to include the relativistic rest energy into the Schrodinger equation the result is either the Klein-Gordon equation or the ---
   a. uncertainty equation b. wave equation
   c. Drake equation d. Dirac equation

13. The Dirac Lagrangian is expressed as
   a. $\mathcal{L} = \bar{\psi}(\gamma^\mu \partial_\mu - m^2)\psi = 0$ b. $\mathcal{L} = \bar{\psi}(i\gamma^\mu \partial_\mu + m)\psi$
   c. $\mathcal{L} = \bar{\psi}(i\gamma^\mu \partial_\mu)\psi$ d. $\mathcal{L} = \bar{\psi}(i\gamma^\mu \partial_\mu - m)\psi$

14. The commutation relation satisfied by the field $\phi(x)$ and its canonical momentum $\pi(x)$ is
   a. $[\phi_a(\vec{x}), \pi_b(\vec{y})] = i\delta^{(3)}(\vec{x} - \vec{y})\delta_{ab}$ b. $[\phi_a(\vec{x}), \pi^b(\vec{y})] = 0$
   c. $[\phi_a(\vec{x}), \phi_b(\vec{y})] = i\delta_a^b$ d. $[\pi^a(\vec{x}), \pi^b(\vec{y})] = \delta^{(3)}(\vec{x} - \vec{y})$

15. Particles that participate in the strong interaction are called
   a. neutrinos b. hadrons
   c. leptons d. photons

16. Which of the following theorem states that "Every symmetry of nature yields a conservation law"?
   a. Factorization theorem b. CPT theorem
   c. Noether's theorem d. Big bang theorem

17. Which of the following reactions is a strong interaction?
   a. $p + \gamma \rightarrow \pi^o + \Delta$ b. $K^- + n \rightarrow \Xi^- + K^0$
   c. $K^- + n \rightarrow \Xi^- + K^0$ d. $p + p \rightarrow \Sigma^+ + n + K^0 + \pi^+ + \pi^0$

18. A simple diagram, first used by Richard Feynman, that consists of different shapes and lines that represent the interactions of subatomic particles over space and time is called a _____.
   a. Quantum diagram b. Feynman diagram
   c. Electrodynamic diagram d. Mechanical diagram

19. There are two motivations for studying the many-particle problem. The first is a straightforward need in condensed matter physics, The second is in ----

a. meson field theory
b. black body radiation
c. gluon theory
d. particle physics*

20. The Klein-Gordon (KG) equation and Dirac equation, both are relativistic versions of the Schrodinger equation. However, the KG equation describes spin-0 particles and the Dirac equation describes

a. spin-0 particles
b. spin-1/2 particles
c. only spin-1 particles,
d. Both (a) and (b)

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Descriptive

Time : 2 hrs. 30mins. Marks : 50

[Answer question no.1 & any four (4) from the rest]

1. a. State the assumptions of quark model of particle physics. 2+8=10

   b. Draw the figures of the eightfold ways of baryon decuplet and meson nonet putting the symbols of the baryons and mesons in appropriate places.

2. a. Write down the quark contents of the baryon octet in tabular form. 2+8=10

   b. Justify whether the following processes are allowed or forbidden according to standard model. Also mention the type of interaction if allowed:

   (i) $p + p \rightarrow \Sigma^+ + n + K^0 + \pi^+ + \pi^0$ (iii) $K^0 + p \rightarrow \Sigma^+ + \pi^0$

   (iii) $K^+ \rightarrow \mu^+ + \upsilon_e + \gamma$ (iv) $\Sigma^0 \rightarrow \Lambda + \gamma$

3. a. What is the charge and spin of a gluon? 2+2+6 =10

   b. Write down the eight different color combinations of gluons in quantum chromodynamics.

   c. Determine the color factors for the following interactions:
   (i) $R - G$ quark interaction (ii) $B - \overline{B}$ quark interaction

4. a. Write the characteristics of a lie group. 2+4+4 =10

   b. Write a short note on group SU(2).

   c. What are the quark multiplets of group SU(3). Describe briefly.

5. a. What do mean by natural unit system? 2+3+2+3 =10

   b. The SI unit of mass is kg. Express it in natural unit.

   c. State Noether's theorem in quantum field theory.

   d. State the basic difference between quantization of a Dirac field and quantization of a classical field.

6. a. Derive the Euler-Lagrange equations for a classical field. **5+5=10**

   b. For a real scalar field ϕ if the Lagrangian is defined as

$$\mathcal{L} = \frac{1}{2}(\partial_\mu \phi)(\partial^\mu \phi) - \frac{1}{2}m^2\phi^2 - V(\phi),$$

   find the Hamiltonian.

7. Treating the Klein-Gordon field as harmonic oscillator, find the spectrum of the Klein-Gordon Hamiltonian. **10**

8. Describe in detail the quantization of the non relativistic Schrodinger equation for bosons of mass m moving in a potential field ψ. **10**

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