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D–971

M. Sc. (Fourth Semester) (Main/ATKT) EXAMINATION, May-June, 2020

PHYSICS

Paper First

(Nuclear and Particle Physics)

Time : Three Hours] [*Maximum Marks : 80*

Note : Attempt all Sections as directed.

Section—A 1 each

(Objective/Multiple Choice Questions)

Note : Attempt all questions.

Choose the correct answer :

1. Magnetic dipole moment of deuteron is :
   (a) $\mu_n + \mu_p = \mu_d$
   (b) $\mu_n + \mu_p > \mu_d$
   (c) $\mu_n + \mu_p < \mu_d$
   (d) $\mu_d = 0$
2. Parity of the deuteron is :
   (a) even parity
   (b) odd parity
   (c) 96% even parity
   (d) 4% even parity

3. Deuteron has some value of electric quadruple moment. This means :
   (a) Deuteron has one proton and is + ve
   (b) It is the moment of two particles (*n, p*) in deuteron
   (c) Change distribution is not spherical
   (d) Deuteron is always positively charged
4. Size of the deuteron is :
   (a) Double of the range of interaction
   (b) Equal to the range of interaction
   (c) Half of the range of interaction
   (d) Much less than the range of interaction
5. A nuclear reaction would be endothermic, if the Q value is :
   (a) $Q > 0$
   (b) $Q < 0$
   (c) $Q = 0$
   (d) $Q = +1$
6. How much is the fraction of *d*-state in the ground state of deuteron ?
   (a) 40%
   (b) 4%
   (c) 0.4%
   (d) 0.04%
7. 1 barn is equal to :
   (a) 10^{-28} m
   (b) 10^{28} m
   (c) 10^{-28} m^2
   (d) 10^{28} m^2

8. How the total scattering cross-section would be obtained from triplet and singlet states ?

(a) $\sigma = \frac{3}{4}\sigma_t + \frac{1}{4}\sigma_s$

(b) $\sigma = \frac{1}{4}\sigma_t + \frac{3}{4}\sigma_s$

(c) $\sigma = \frac{4}{3}\sigma_t - \frac{1}{3}\sigma_s$

(d) $\sigma = \sigma_t + \sigma_s$

9. Which one is correct in partial wave analysis of nuclear reaction ?

(a) Maximum of $(\sigma_{l,\mathrm{Re}})$ = Maximum of $\left(\sigma_{l,\mathrm{Sc}}\right)$

(b) Maximum of $(\sigma_{l,\mathrm{Re}})$ = 4 × Maximum of $\left(\sigma_{l,\mathrm{Sc}}\right)$

(c) 4 × Maximum of $\left(\sigma_{l,\mathrm{Sc}}\right)$ = Maximum of $\left(\sigma_{l,\mathrm{Sc}}\right)$

(d) Maximum of $\left(\sigma_{l,\mathrm{Sc}}\right)$ = Maximum of $(\sigma_{l,\mathrm{Re}})/2$

10. At what value of shift (η_l), reaction cross-section $(\sigma_{l,\mathrm{Re}})$ will be maximum ?

(a) $\eta_l = -1$

(b) $\eta_l = 0$

(c) $\eta_l = 1$

(d) $|\eta_l| = 1$

11. Which one is the correct beta decay process ?

(a) $n \rightarrow p + \beta^- + \overline{v}$

(b) $n \rightarrow p + \beta^+ + v$

(c) $p \rightarrow n + \beta^- + v$

(d) $p \rightarrow n + \beta^+ + \overline{v}$

12. After doing the Coulomb correction in Fermi's theory of beta decay :

(a) probability of negatron emission increases

(b) probability of positron emission increases

(c) probability of negatron emission decreases

(d) There is no effect of Coulomb correction

13. Cowans and Reins detected the following particle :

(a) υ_e

(b) υ_μ

(c) υ_τ

(d) $\overline{\upsilon}_e$

14. Which one is true ?

(a) Probability of decay is high for higher value of comparative half life.

(b) Probability of decay is low for higher value of comparative half life.

(c) Nucleus is less stable for higher value of comparative half life.

(d) Nucleus is more stable for lower value of comparative half life.

15. In the internal conversion of gamma decay :

(a) first gamma photon is emitted and then ejects the electron

(b) first gamma photon is emitted and then creates positron

(c) first gamma photon is emitted and then electron-positron pair is created

(d) electron is emitted directly without emission of gamma photon

16. Hardrons are :
    (a) very heavy particles
    (b) strongly interacting particles
    (c) hydrogen like particles
    (d) particle hardly interacting

17. Which particle will be called a baryon ?
    (a) electron
    (b) μ -meson
    (c) π -meson
    (d) proton

18. A nucleus with magic number :
    (a) gets excited easily
    (b) does not excite easily
    (c) can be excited without any energy
    (d) has very low binding energy

19. Spin-parity of $_8O^{16}$ will be :
    (a) $\frac{1^-}{2}$
    (b) 8^+
    (c) 8^-
    (d) 0^+

20. In the process of $p \rightarrow n + e^+ + v$, a quark will transform as below :
    (a) $u \rightarrow d$
    (b) $d \rightarrow s$
    (c) $s \rightarrow u$
    (d) $d \rightarrow u$

Section—B 2 each

(Very Short Answer Type Questions)

Note : Attempt all questions.

1. Ground state of the deuteron is $^3S_1$, what does this mean ? What are the numbers 3 and 1 and what does the symbol 'S' stand for ?
2. Give examples of different types of nuclear reactions in brief.
3. $E = Q = \Delta m.c^2$ is constant for a given nuclear reaction, then why the beta particles have different values of kinetic energy ?
4. What is a Curie plot ? Write an expression for this (final expression only). Draw this plot and tell about its significance.
5. How would you obtain the spin and parity of $_8O^{17}$ using shell model. What about $_{33}As^{75}$?
6. Write some properties of neutrino and compare it with a photon.
7. State why $\Delta l = 0$ is not observed in gamma decay, but sometimes nucleus de-excites through gamma decay even with $\Delta l = 0$. Yes/No, give reason for your choice of answer.
8. Write the name of particles exchanged in the fundamental interactions. Why should these exchange particles be Boson particles ?

Section—C 3 each

(Short Answer Type Questions)

Note : Attempt all questions.

1. From the observed properties of ground state of the deuteron, how would you show that only $^3D_1$ state can be the admixture with $^3S_1$ state ?
2. Write an expression (don't derive partial wave analysis) for $\sigma_{l,\text{total}} = \sigma_{l,\text{Re}} + \sigma_{l,\text{Sc}} = ?$ in term of shift parameter (η_l). Could you obtain values of reaction cross-section $(\sigma_{l,\text{Re}})$ and scattering cross-section $(\sigma_{l,\text{Sc}})$ for differing values of η_l. Show your results in a plot.
3. How and why the probability of $\beta^{\pm}$ gets affected by Coulomb correction ? Make a diagram showing the effect of Coulomb correction.
4. Explain the result of Wu's experiment, in what way the parity was found to be violating (don't describe the details of experiment).
5. Explain selection rules in gramma decay.
6. What is magic number ? In what they are linked to the structure of the nucleus ? Hence, explain how does this number affect the properties of nucleus ? Give suitable example wherever required.
7. Why the concept of colour was introduced in Quark theory ? What is the role of colour in Quantum Chromodynamics ?
8. How are the various quantum numbers conserved in particle interactions ? Explain briefly with some examples.

Section—D 5 each

(Long Answer Type Questions)

Note : Attempt all questions.

1. Explain *n-p* scattering at low energy.

   Or

   Explain ground state of deuteron.

2. Obtain the expression for probability using Fermi's theory of beta decay.

   Or

   Discuss the fission of nucleus using Bohr-Wheeler's theory.

3. Discuss Q-value and reaction kinematics.

   Or

   Obtain the magic number using shell model.

4. Discuss the Fundamental Interactions.

   Or

   Explain Quark model of hadrons. Show that combination of quarks in eight fold way diagram of Baryon/Meson.