REV-01
MSP/17/22

2024/11

SET A

M.Sc. PHYSICS
THIRD SEMESTER
NUCLEAR & PARTICLE PHYSICS
MSP – 301

[USE OMR 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. The ratio of the sizes of $^{208}_{82}Pb$ and $^{26}_{12}Mg$ nuclei is approximately
   a. 2
   b. 4
   c. 8
   d. 16

2. Consider a nucleus with N neutrons and Z protons. If m_p, m_n and B.E. represents the mass of the proton, mass of the neutron and binding energy of the nucleus respectively. Then mass of the nucleus is given by (c is the speed of light in free space)
   a. $Nm_p + Zm_n$
   b. $Nm_n + Zm_p$
   c. $Nm_n + Zm_p - \frac{B.E.}{c^2}$
   d. $Nm_p + Zm_n + \frac{B.E.}{c^2}$

3. According to liquid drop model, which of the following equation represents the nuclear mass [M (Z, A)] for numbers of an isobaric family (^A_ZX) (Here α, β and γ are some constant with suitable dimensions and δ is pairing energy term)
   a. M (Z, A) = $\alpha A + \beta Z + \gamma Z^3 \pm \delta$
   b. M (Z, A) = $\alpha A + \beta Z^2 + \gamma Z^3 \pm \delta$
   c. M (Z, A) = $\alpha A + \beta Z + \gamma Z^2 \pm \delta$
   d. M (Z, A) = $\alpha AZ + \beta Z^2 + \gamma Z^3 \pm \delta$

4. **According to the nuclear shell model, the ground state spin and parity of $^{11}_{5}$B is**
   a. $(\frac{3}{2})^-$
   b. $(\frac{3}{2})^+$
   c. $(\frac{1}{2})^-$
   d. $(\frac{1}{2})^+$

5. A nuclear decay process is given by $^A_ZX \rightarrow {}_{Z-1}^{A}Y + e^+$, the atomic masses of X and Y are 51.9648u and 51.9571 u. Then the Q- value of the reaction is
   a. 2.7 MeV
   b. 3.7 MeV
   c. 4.7 MeV
   d. 6.2 MeV

6. The isospin and strangeness of Ω^- baryon are
   a. 1, -3
   b. 0, -3
   c. 1, 3
   d. 0, 3

7. The energy evolved in proton-proton cycle is
   a. 20.7 MeV
   b. 24.7 MeV
   c. 10.7 MeV
   d. 30.7 MeV

8. Which of the following option is correct for strong interaction in a nuclear reaction (here S, I and I_3 have their usual meanings)

a. $\Delta S = 0, \Delta I = 0, \Delta I_3 = 0$
b. $\Delta S = 0, \Delta I \neq 0, \Delta I_3 = 0$
c. $\Delta S \neq 0, \Delta I \neq 0, \Delta I_3 = 0$
d. $\Delta S = 0, \Delta I \neq 0, \Delta I_3 \neq 0$

9. Which one of the following is a fermion?

a. α −particle
b. ${}^{7}_{4}Be$ nucleus
c. Hydrogen atom
d. Deuteron

10. The decay $\mu^- \rightarrow e^- + \upsilon_e + \upsilon_\mu$ is forbidden, because it violates

a. Momentum and lepton number conservation
b. Baryon number conservation
c. Angular momentum conservation
d. Lepton number conservation

11. Consider the reaction $k^- + p \rightarrow +k^+ + X$. The particle X is

a. γ
b. Ξ^-
c. n
d. π^o

12. Which of the following particle is exchanged in nuclear reaction via electromagnetic interaction?

a. Photon
b. Meson
c. Graviton
d. Boson

13. Which of the following relation is correct? (here Y, B and S represents the hypercharge, baryon number and strangeness)

a. Y=B+S
b. B=Y+S
c. S=Y+B
d. Y=B-S

14. The electric quadrupole moment of deuteron is

a. Zero
b. Negative
c. Positive but small
d. Infinite

15. Which of the following represents the spin magnetic moment of proton? (μ_N is the nuclear magneton

a. $\mu_s = -1.91\ \mu_N$
b. $\mu_s = -2.79\ \mu_N$
c. $\mu_s = 1.91\ \mu_N$
d. $\mu_s = 2.79\ \mu_N$

16. Match the reactions on the left with the associated interactions on the right

(1) $p + \pi^- \rightarrow n + \pi^o$	(i) Strong
(2) $\Sigma^o \rightarrow \Lambda^o + \gamma$	(ii) Electromagnetic
(3) $\kappa^o \rightarrow \pi^+ + \pi^-$	(iii) Weak

a. (1, iii), (2, ii), (3, i)
b. (1, i), (2, ii), (3, iii)
c. (1, ii), (2, i), (3, iii)
d. (1, iii), (2, i), (3, ii)

17. The isospin (I) and baryon number (B) of the up quark is

a. I=1, B=1
b. I=1, B=1/3
c. I=1/2, B=1
d. I=1/2, B=1/3

18. Which one of the following sets corresponds to fundamental particles?

a. Proton, electron and neutron
b. Proton, electron and photon
c. Electron, photon and neutron
d. Quark, electron and meson

19. Total number of quarks in particle physics are

a. 36
b. 6
c. 3
d. 18

20. The J^P value for even-even nuclei is

a. 0^-
b. 0^+
c. $(\frac{1}{2})^-$
d. $(\frac{1}{2})^+$

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Descriptive

Time : 2 hrs. 30 min. Marks : 50

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

1. What do you mean by Q-value of a nuclear reaction? Deduce theexpression of threshold energy of the nuclear reaction. 2+8=10

2. Determine the energy of released photon when Σ^o hyperon decays at rest into Λ^o hyperon via $\Sigma^o \rightarrow \Lambda^o + \gamma$ (Given $m_{\Sigma^o} = 1192\ MeV, m_{\Lambda^o} = 1116\ MeV$) 10

3. State Nordheim's rule for odd-odd nuclei and hence express the net parity formula. Find the magnetic moment and quadrupole moment of $^{17}_{8}O$. 2+3+2+3 =10

4. Describe the interaction between the quarks. What are the evidences of quarks? 5+5=10

5. What are the assumptions of nuclear liquid drop model? Deduce the equation of binding energy Smi-Empirical mass formula. 2+8=10

6. Describe the working principle of Geiger- Muller (GM) counter. **10**

7. Using the binding energy formula (Liquid drop model) $B = a_v A - a_s A^{\frac{2}{3}} - a_c \frac{Z(Z-1)}{A^{\frac{1}{3}}} - a_a \frac{(A-2Z)^2}{A} \pm \frac{a_p}{A^{\frac{3}{4}}}$, find the Z value for the most stable isobars. If $a_c = 0.58\ MeV$ and $a_a = 19.4\ MeV$, then for A=77, show that the Z value for the most stable isobar is ≈34. **6+4=10**

8. Explain the Fermi's theory of nuclear β decay.

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