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Roll No.

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M.Sc. (Fourth Semester)
EXAMINATION, May - June, 2022
PHYSICS
Paper First
(Nuclear and Particle Physics)

Time : Three Hours]

[Maximum Marks:80

Note: Attempt all section as directed.

(Section - A)

(Objective/Multiple Choice Questions)

(1 mark each)

Note: Attempt all questions.

Choose the correct answer:

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1. In semiempirical Binding-energy formula the surface energy term is represented by

(A) $E_s = -aA^{2/3}$

(B) $E_s = aA^{2/3}$

(C) $E_s = aA^{3/2}$

(D) $E_s = -aA^{3/2}$

2. The binding energy per nucleon of helium nucleus is 7 MeV and that of deuteron is 1 MeV then -

(A) Helium nucleus is more stable

(B) Deuteron nucleus is more stable

(C) Both are less stable

(D) Both are equally stable

3. The ratio of the size of ${}_{82}^{208}\text{Pb}$ and ${}_{12}^{26}\text{Mg}$ nuclei is approximately.

(A) 2

(B) 4

(C) 8

(D) 16

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4. The ratio of the mass defect of the nucleus to its mass number is maximum among following nuclei is
- (A) N^{14}
 (B) Si^{28}
 (C) Fe^{56}
 (D) U^{238}
5. The reaction $e^+ + e^- \rightarrow \mu^+ + \pi^-$ is forbidden because of
- (A) Law of Baryon number conservation
 (B) Law of momentum energy conservation
 (C) Lepton number conservation
 (D) None of the above
6. Which one of the following nuclear reaction is possible?
- (A) $^{14}N_7 \rightarrow ^{13}C_6 + \beta^+ + \nu e$
 (B) $^{13}N_7 \rightarrow ^{13}C_6 + \beta^+ + \nu e$
 (C) $^{13}N_7 \rightarrow ^{13}C_6 + \beta^+$
 (D) $^{13}N_7 \rightarrow ^{13}C_7 + \beta^+ + \nu e$
7. The volume of a nucleus in a atom is proportional to the:
- (A) Mass number
 (B) Proton number
 (C) Neutron number
 (D) Electron number

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8. The intensity absorbed in the material or depth d with absorption co-efficient μ when I_0 is the incident intensity or X-ray is
- (A) $(1 - e^{-\mu d})$
 (B) $I_0(1 - e^{-\mu d})$
 (C) $\mu I_0(1 - e^{-\mu d})$
 (D) μd
9. Which one of the following reaction is allowed?
- (A) $p \rightarrow n + e^+$
 (B) $p \rightarrow e^+ + \nu e$
 (C) $p \rightarrow \pi^+ + r$
 (D) $\bar{p} + n \rightarrow \pi^- + \pi^0$
10. The strangeness of the particle Ω^+ is
- (A) + 3
 (B) - 3
 (C) + 2
 (D) - 2

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11. The Quark structure of the particle k^+ is given by -

- (A) $u\bar{s}$
- (B) uud
- (C) ddu
- (D) uus

12. Which one of the following is correspond to an electric

dipole r - transition:

- (A) $\frac{3^+}{2} \rightarrow \frac{1^-}{2}$
- (B) $\frac{3^+}{2} \rightarrow \frac{1^+}{2}$
- (C) $1^+ \rightarrow 1^+$
- (D) $3^+ \rightarrow 0^{-1}$

13. The Q - value equation of β^+ decay is given by:

- (A) $Q_{\beta^+} = [M(X) - M(Y)]C^2$
- (B) $Q_{\beta^+} = [M(X) - M(Y - 2m_e)]C^2$
- (C) $Q_{\beta^+} = [M(Y) - M(X)]C^2$
- (D) None of the above

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14. Spin - parity of the nucleus ${}_8O^{17}$ is given by

- (A) $\frac{5^+}{2}$
- (B) $\frac{5^-}{2}$
- (C) $\frac{3^+}{2}$
- (D) $\frac{3^-}{2}$

15. If $Q \geq 0$ then reaction is

- (A) Exothermic
- (B) Endothermic
- (C) Both
- (D) None of the above

16. Binding energy of deuteron is:

- (A) 2.225 MeV
- (B) 3.335 MeV
- (C) 4.445 MeV
- (D) 5.555 MeV

17. Spin - parity of pseudo scalar meson is

- (A) 0^+
- (B) 0^-
- (C) 1^+
- (D) 1^-

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18. 1 barn is equal to

- (A) 10^{-24} cm^2
- (B) 10^{-24} m^2
- (C) 10^{-28} cm^2
- (D) 10^{-30} m^2

19. A positive parity shell model state can accommodate 14 nucleons, its total angular momentum j and orbital angular momentum l will be-

- (A) $\frac{13}{2}$ and 6
- (B) $\frac{13}{2}$ and 7
- (C) $\frac{11}{2}$ and 6
- (D) $\frac{11}{2}$ and 5

20. Quark structure of the particle Σ^+ is

- (A) uus
- (B) uud
- (C) uds
- (D) None of the above

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Section - B

(Very Short Answer Type Questions)

(2 marks each)

Note: Attempt all questions.

1. What is Tensor forces?
2. What is Reactions cross sections?
3. What is parity violation?
4. What fundamental law of physics is most responsible for the existence of nuclear magic number?
5. What is Hadrons?
6. What is a Q - value of nuclear reaction?
7. What do you mean by β - decay?
8. What is compound nuclear reaction?

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Section - C**(Short Answer Type Questions)****(3 marks each)****Note: Attempt all questions.**

1. Explain Two-nucleon system and properties of nuclear force.
2. Half-life period of U^{234} is 2.5×10^5 years. In how many years it will remain 25% of original amount.
3. What are the predominant modes for the transition-
 $2^+ \rightarrow 0^+, 1^+ \rightarrow 0^+, \frac{1^+}{2} \rightarrow \frac{1^-}{2}, \frac{9^+}{2} \rightarrow \frac{1^-}{2}$
4. The only known nuclei with $A = 7$ are 7Li_3 and 7Be_4 whose atomic masses are $Li = 7.016\mu$, $Be = 7.0169\mu$. Then which of these nuclei is stable to β^- - decay and what process is employed in the β^- -decay of unstable nucleus to the stable nucleus?
5. The total Binding energy of ${}^{15}O$, ${}^{16}O$, ${}^{17}O$ are 111.96, 127.62, and 131.76 MeV respectively. Then calculate the energy gap between ${}^1P_{1/2}$ and ${}^1d_{3/2}$ neutron shell for the nuclei whose mass number is close to 16.
6. A neutral pion π^0 whose kinetic energy is equal to its rest mass energy, decay in flight. Find the angle between two

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γ - photon that are produced in decay process and have same energy $\pi^0 \rightarrow \gamma + \gamma$

7. Explain the fundamental interaction and leptons number.
8. Explain Iso-spin Formation and Exchange force.

Section - D**(Long Answer Type Questions)****(5 marks each)****Note: Attempt any four questions.**

1. Explain the Meson theory of nuclear forces and Yukawa Interaction
2. Explain the Breit-Wigner single-level formula
3. Compute the energies of the pion and proton from the decay, reaction is given that $\Lambda^0 \rightarrow \pi^0 + p$ where
 $M(\Lambda^0) \approx 1116 \text{ MeV}$, $M(\pi^-) \approx 140 \text{ MeV}$,
 $M(p) \approx 938 \text{ MeV}$
4. Explain the Fermi theory of β^- - decay.
5. Explain Liquid drop model and semi-empirical mass formula
6. Explain the Quark model and properties of Quark.

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