PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

CSIR NET Physics - Nuclear and Particle Physics

All PYQs (2015-2025) with answer key

59 questions . Answer key included

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Q1. [Dec 2015] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2015 Dec	5 M

Consider the following processes involving free particles

(i) $\bar{n} \rightarrow \bar{p} + e^{+} + \bar{\nu}_e$

(ii) $\bar{p} + n \rightarrow \pi^{-}$

(iii) $p + n \rightarrow \pi^{+} + \pi^{0} + \pi^{0}$

(iv) $p + \bar{\nu}_e \rightarrow n + e^{+}$

Which of the following statements is true?

1. Process (i) obeys all conservation laws
2. Process (ii) conserves baryon number, but violates energy-momentum conservation
3. process (iii) is not allowed by strong interaction but is allowed by weak interactions
4. Process (iv) conserves baryon number, but violates lepton number conservation

Q2. [Dec 2015] . 5.0 marks

Nuclear and Particle Physics > Shell model

CSIR NET	2015 Dec	5 M

The electric quadrupole moment of an odd proton nucleus is $\frac{(2j-1)}{2(j+1)}\langle r^2\rangle$, where j is the total angular momentum. Given that $R_0 = 1.2\text{fm}$, what is the value in barn, of the quadrupole moment of the ^{27}Al nucleus in the shell model?

1. 0.043
2. 0.023
3. 0.915
4. 0

Q3. [Dec 2015] . 5.0 marks

Nuclear and Particle Physics > Liquid drop Model

CSIR NET	2015 Dec	5 M

Of the nuclei of mass number $A = 125$, the binding energy calculated from the liquid drop model (given that the coefficients for the Coulomb and the asymmetry energy are $a_c = 0.7\text{MeV}$ and $a_{sym} = 22.5\text{MeV}$ respectively) is a maximum for

1. $^{125}_{54}\text{Xe}$
2. $^{124}_{53}\text{I}$
3. $^{125}_{52}\text{Te}$
4. $^{125}_{51}\text{Sb}$

Q4. [June 2015] . 5.0 marks

Nuclear and Particle Physics > Shell model

CSIR NET	2015 June	5 M

Let us approximate the nuclear potential in the shell model by a three dimensional isotropic harmonic oscillator. Since the lowest two energy levels have angular momenta $l = 0$ and $l = 1$ respectively. which of the following two nuclei have magic numbers of protons and neutrons?

1. ${}^{4}_{2}\mathrm{He}$ and ${}^{16}_{8}\mathrm{O}$
2. ${}^{2}_{1}\mathrm{D}$ and ${}^{8}_{4}\mathrm{Be}$
3. ${}^{4}_{2}\mathrm{He}$ and ${}^{8}_{4}\mathrm{Be}$
4. ${}^{4}_{2}\mathrm{He}$ and ${}^{12}_{6}\mathrm{C}$

Q5. [June 2015] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2015 June	5 M

The charm quark is assigned a charm quantum number $C = 1$. How should the Gellmann-Nishijima formula for electric charge be modified for four flavours of quarks?

1. $I_3 + \frac{1}{2}(B - S - C)$
2. $I_3 + \frac{1}{2}(B - S + C)$
3. $I_3 + \frac{1}{2}(B + S - C)$
4. $I_3 + \frac{1}{2}(B + S + C)$

Q6. [June 2015] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2015 June	5 M

The reaction ${}^{2}_{1}\mathrm{D} + {}^{2}_{1}\mathrm{D} \rightarrow {}^{4}_{2}\mathrm{He} + \pi^{0}$ cannot proceed via strong interactions because it violates the conservation of

1. angular momentum
2. electric charge
3. baryon number
4. isospin

Q7. [Dec 2016] . 5.0 marks

Nuclear and Particle Physics > Nuclear properties

CSIR NET	2016 Dec	5M

What should be the minimum energy of a photon for it to split an α-particle at rest into a tritium and a proton?

(The masses of $^4_2\mathrm{He}$, $^3_1\mathrm{H}$ and $^1_1\mathrm{H}$ are 4.0026 amu, 3.0161 amu and 1.0073 amu, respectively, and $1\mathrm{amu} \approx 938\mathrm{MeV}$.)

1. 32.2 MeV
2. 3 MeV
3. 19.3 MeV
4. $931.5\mathrm{MeV}$

Q8. [Dec 2016] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2016 Dec	5M

Which of the following reaction(s) is/are allowed by the conservation laws?

(i) $\pi^+ + n \rightarrow \Lambda^0 + K^+$

(ii) $\pi^- + p \rightarrow \Lambda^0 + K^0$

1. both (i) and (ii)
2. only (i)
3. only (ii)
4. neither (i) nor (ii)

Q9. [Dec 2016] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2016 Dec	5M

A particle, which is a composite state of three quarks u, d and s, has electric charge, spin and strangeness respectively, equal to

1. $1, \frac{1}{2}, -1$
2. $0, 0, -1$
3. $0, \frac{1}{2}, -1$
4. $-1, -\frac{1}{2}, +1$

Q10. [June 2016] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2016 June	5M

A radioactive element X decays to Y, which in turn decays to a stable element Z. The decay constant from X to Y is λ_1, and that from Y to Z is λ_2. If, to begin with, there are only N_0 atoms of X, at short times $(t \ll 1/\lambda_1$ as well as $1/\lambda_2$) the number of atoms of Z will be

1. $\frac{1}{2}\lambda_1\lambda_2 N_0 t^2$
2. $\frac{\lambda_1\lambda_2}{2(\lambda_1+\lambda_2)} N_0 t$
3. $(\lambda_1+\lambda_2)^2 N_0 t^2$
4. $(\lambda_1+\lambda_2) N_0 t$

Q11. [June 2016] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2016 June	5M

In the large hadron collider (LHC), two equal energy proton beams traverse in opposite directions along a circular path of length 27 km . If the total centre of mass energy of a proton-proton pair is 14 TeV , which of the following is the best approximation for the proton time taken by a proton to traverse the entire path?

1. $12\ \text{ns}$
2. $1.2\mu s$
3. $1.2\ \text{ns}$
4. $0.12\mu s$

Q12. [June 2016] . 5.0 marks

Nuclear and Particle Physics > Liquid drop Model

CSIR NET	2016 June	5M

Let E_S denote the contribution of the surface energy per nucleon in the liquid drop model. The ratio $E_S\left(^{27}_{13}\mathrm{Al}\right): E_S\left(^{64}_{30}\mathrm{Zn}\right)$ is

1. $2:3$
2. $4:3$
3. $5:3$
4. $3:2$

Q13. [June 2016] . 5.0 marks

Nuclear and Particle Physics > Shell model

CSIR NET	2016 June	5M

According to the shell model, the nuclear magnetic moment of the $^{27}_{13}\mathrm{Al}$ nucleus is (Given that for a proton $g_l = 1, g_s = 5.586$, and for a neutron $g_l = 0, g_s = -3.826$.)

1. $-1.913\mu_N$
2. $14.414\mu_N$
3. $4.793\mu_N$
4. 0

Q14. [Dec 2017] . 5.0 marks

Nuclear and Particle Physics > Shell model

CSIR NET	2017 Dec	5M

The spin-parity assignments for the ground and first excited states of the isotope $^{57}_{28}\mathrm{Ni}$, in the single particle shell model, are

1. $\left(\frac{1}{2}\right)^{-}$ and $\left(\frac{3}{2}\right)^{-}$
2. $\left(\frac{5}{2}\right)^{+}$ and $\left(\frac{7}{2}\right)^{+}$
3. $\left(\frac{3}{2}\right)^{+}$ and $\left(\frac{5}{2}\right)^{+}$
4. $\left(\frac{3}{2}\right)^{-}$ and $\left(\frac{5}{2}\right)^{-}$

Q15. [Dec 2017] . 5.0 marks

Nuclear and Particle Physics > Collective model

CSIR NET	2017 Dec	5M

The first excited state of the rotational spectrum of the nucleus $^{238}_{92}U$ has an energy 45 keV above the ground state. The energy of the second excited state (in keV) is

1. 150
2. 120
3. 90
4. 60

Q16. [Dec 2017] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2017 Dec	5M

Which of the following process is not allowed by the strong interaction but is allowed by the weak interaction?

1. $K^0 + \pi^0 \rightarrow \bar{K}^0 + \pi^+ + \pi^-$
2. $p + n \rightarrow d + p + \bar{p}$
3. $\Delta^+ + K^0 \rightarrow p + n$
4. $p + \Delta^+ \rightarrow \bar{n} + \Delta^{++}$

Q17. [June 2017] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2017 June	5M

If in a spontaneous α - decay of $^{232}_{92}U$ at rest, the total energy released in the reaction is Q, then the energy carried by the α-particle is

1. $57Q/58$
2. $Q/57$
3. $Q/58$
4. $23Q/58$

Q18. [June 2017] . 5.0 marks

Nuclear and Particle Physics > Nuclear forces and Scattering

CSIR NET	2017 June	5M

The range of the nuclear force between two nucleons due to the exchange of pions is 1.40 fm . If the mass of pion is $140\text{MeV}/c^2$ and the mass of the rho-meson is $770\text{MeV}/c^2$, then the range of the force due to exchange of rho-mesons is

1. 1.40 fm
2. 7.70 fm
3. 0.25 fm
4. 0.18 fm

Q19. [June 2017] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2017 June	5M

A baryon X decays by strong interaction as $X \rightarrow \Sigma^+ + \pi^- + \pi^0$, where Σ^+ is a member of the isotriplet $(\Sigma^+, \Sigma^0, \Sigma^-)$. The third component I_3 of the isospin of X is

1. 0
2. ½
3. 1
4. $^3/_2$

Q20. [Dec 2018] . 5.0 marks

Nuclear and Particle Physics > Nuclear forces and Scattering

CSIR NET	2018 Dec	5M

Assume that pion-nucleon scattering at low energies, in which isospin is conserved is described by the effective interaction potential $V_{\text{eff}} = F(r)\vec{I}_\pi.\vec{I}_N$, where $F(r)$ is a function of the radial separation r and $\vec{I}_\pi$ and $\vec{I}_N$ denote, respectively, the isospin vectors of a pion and the nucleon. The ratio $\frac{\sigma_{I=3/2}}{\sigma_{I=1/2}}$ of the scattering cross-sections corresponding to total isospins $I = \frac{3}{2}$ and $\frac{1}{2}$ is

1. $\frac{3}{2}$
2. $\frac{1}{4}$
3. $\frac{5}{4}$
4. $\frac{1}{2}$

Q21. [Dec 2018] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2018 Dec	5M

A nucleus decays by the emission of a gamma ray from an excited state of spin parity 2^+ to the ground state with spin-parity 0^+ what is the type of the corresponding radiation?

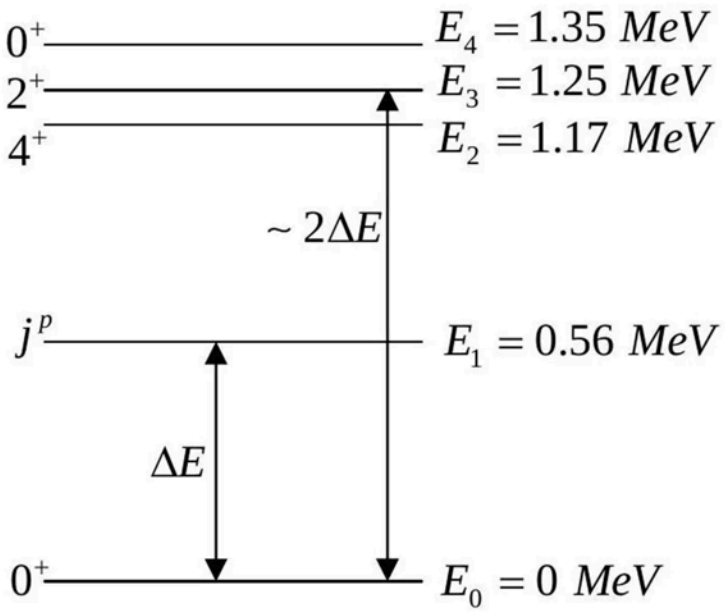
1. magnetic dipole
2. electric quadrupole
3. electric dipole
4. magnetic quadrupole

Q22. [Dec 2018] . 5.0 marks

Nuclear and Particle Physics > Collective model

CSIR NET	2018 Dec	5M

The low-lying energy levels due to the vibrational excitations of an even-even nucleus are shown in the figure below. The spin-parity j^p of the level E_1 is



1. 1^+
2. 1^-
3. 2^-
4. 2^+

Q23. [June 2018] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2018 June	5M

Which of the following elementary particle processes does not conserve strangeness?

1. $\pi^0 + p \rightarrow k^+ + \Lambda^0$
2. $\pi^- + p \rightarrow k^0 + \Lambda^0$
3. $\Delta^0 \rightarrow \pi^0 + n$
4. $\mathrm{K}^0 \rightarrow \pi^+ + \pi^-$

Q24. [June 2018] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2018 June	5M

A deuteron d captures a charged pion π^- in the $l = 1$ state, and subsequently decays into a pair of neutrons (n) via strong interaction. Given that the intrinsic parities of π^-, d and n are $-1, +1$ and +1 respectively, the spin wavefunction of the final state neutrons is.

1. linear combination of a singlet and a triplet
2. Singlet
3. Triplet
4. doublet

Q25. [June 2018] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2018 June	5M

The reaction $^{63}\mathrm{Cu}_{29} + p \rightarrow {}^{63}\mathrm{Zn}_{30} + n$ is followed by a prompt β-decay of zinc $^{63}\mathrm{Zn}_{30} \rightarrow {}^{63}\mathrm{Cu}_{29} + e^{+} + \nu_e$. If the maximum energy of the position is 2.4 MeV , the Q value of the original reaction in MeV is nearest to [Take the masses of electron, proton and neutron to be $0.5MeV/c^2, 938MeV/c^2$ and $939.5\mathrm{MeV}/c^2$, respectively.]

1. -4.4
2. -2.4
3. -4.8
4. -3.4

Q26. [Dec 2019] . 5.0 marks

Nuclear and Particle Physics > Nuclear forces and Scattering

CSIR NET	2019 Dec	5M

The strong nuclear force between a neutron and a proton in a zero orbital angular momentum state is denoted by $F_{np}(r)$, where r is the separation between them. Similarly, $F_{nn}(r)$ and $F_{pp}(r)$ denote the forces between a pair of neutrons and protons, respectively, in zero orbital momentum state. Which of the following is true on average if the inter-nucleon distance is $0.2fm < r < 2fm$?

1. F_{np} is attractive for triplet spin state, and F_{nn}, F_{pp} are always repulsive
2. F_{nn} and F_{np} are always attractive and F_{pp} is repulsive in the triplet spin state
3. F_{pp} and F_{np} are always attractive and F_{nn} is always repulsive
4. All three forces are always attractive

Q27. [Dec 2019] . 5.0 marks

Nuclear and Particle Physics > Liquid drop Model

CSIR NET	2019 Dec	5M

The Bethe-Weizsacker formula for the binding energy (in MeV) of a nucleus of atomic number Z and mass number A is

$$15.8A - 18.3A^{2/3} - 0.714\frac{Z(Z-1)}{A^{1/3}} - 23.2\frac{(A-2Z)^2}{A}$$

The ratio Z/A for the most stable isobar of a $A = 64$ nucleus, is nearest to

1. 0.30
2. 0.35
3. 0.45
4. 0.50

Q28. [Dec 2019] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2019 Dec	5M

Which of the following decay processes is allowed?

1. $\mathrm{K}^0 \rightarrow \mu^+ + \mu^-$
2. $\mu^- \rightarrow e^- + \gamma$
3. $n \rightarrow p + \pi^-$
4. $n \rightarrow \pi^+ + \pi^-$

Q29. [June 2019] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2019 June	5M

An excited state of a $^{8}_{4}\mathrm{Be}$ nucleus decays into two α-particles which are in a spin-parity 0^{+} state. If the mean life-time of this decay is $10^{-22}s$, the spin-parity of the excited state of the nucleus is

1. 2^{+}
2. 3^{+}
3. 0^{-}
4. 4^{-}

Q30. [June 2019] . 5.0 marks

Nuclear and Particle Physics > Nuclear forces and Scattering

CSIR NET	2019 June	5M

The elastic scattering of a neutrino v_e by an electron e^{-}, i.e. the reaction $v_e + e^{-} \rightarrow v_e + e^{-}$ can be described by the interaction Hamiltonian

$$H_{\text{int}} = \frac{1}{\sqrt{2}} G_F \int d^3x (\bar{\psi}_e(x)\gamma^{\mu}\psi_{ve}(x))\left(\bar{\psi}_{ve}(x)\gamma_{\mu}\psi_e(x)\right)$$

The cross-section of the above process depends on the centre of mass energy E, as

1. $\frac{1}{E^2}$
2. E^2
3. E
4. $\sqrt{E}$

Q31. [June 2019] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2019 June	5M

The mean life-time of the following decays:

$\rho_0 \to \pi^+ + \pi^-, \pi^0 \to \gamma + \gamma, \mu^- \to e^- + \bar{\nu}_e + \nu_\mu$, are τ_ρ, τ_π and τ_μ respectively.

They satisfy

1. $\tau_\pi < \tau_\rho < \tau_\mu$
2. $\tau_\mu < \tau_\rho < \tau_\pi$
3. $\tau_\rho < \tau_\pi < \tau_\mu$
4. $\tau_\rho < \tau_\mu < \tau_\pi$

Q32. [June 2020] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2020 June	5M

Charged pions π^- decay to muons μ^- and anti-muon neutrinos $\vec{\nu}_\mu$; $\pi^- \to \mu^- + \vec{\nu}_\mu$. Take the rest masses of a muon and a pion to be 105 MeV and 140 MeV, respectively. The probability that the measurement of the muon spin along the direction of its momentum is positive, is closest to

1. 0.5
2. 0.75
3. 1
4. 0

Q33. [June 2020] . 5.0 marks

Nuclear and Particle Physics > Liquid drop Model

CSIR NET	2020 June	5M

The binding energy B of a nucleus is approximated by the formula $B = a_1A - a_2A^{2/3} - a_3Z^2A^{-1/3} - a_4(A-2Z)^2A^{-1}$, where Z is the atomic number and A is the mass number of the nucleus. If $\frac{a_4}{a_2} \simeq 30$. The atomic number Z for naturally stable isobars (constant value of A) is

1. $\frac{30A}{60+A^{2/3}}$
2. $\frac{30A}{30+A^{2/3}}$
3. $\frac{60A}{120+A^{2/3}}$
4. $\frac{120A}{60+A^{2/3}}$

Q34. [June 2020] . 5.0 marks

Nuclear and Particle Physics > Shell model

CSIR NET	2020 June	5M

The magnetic moments of a proton and a neutron are $2.792\ \mu_N$ and $-1.913\ \mu_N$, where μ_N is the nucleon magnetic moment. The values of the magnetic moments of the mirror nuclei ${}^{19}_{9}F_{10}$ and ${}^{19}_{10}Ne_{9}$, respectively, in the Shell model, are closest to

1. $23.652\ \mu_N$ and $-18.873\ \mu_N$
2. $26.283\ \mu_N$ and $-16.983\ \mu_N$
3. $-2.628\ \mu_N$ and $1.887\ \mu_N$
4. $2.628\ \mu_N$ and $-1.887\ \mu_N$

Q35. [June 2021] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2021 June	5M

The nuclei of ^{137}Cs decay by the emission of β-particles with a half-life of 30.08 years. The activity (in units of disintegrations per second or Bq) of a 1mg source of ^{137}Cs, prepared on January 1, 1980, as measured on January 1, 2021 is closest to

1. 1.79×10^{16}
2. 1.79×10^{9}
3. 1.24×10^{16}
4. 1.24×10^{9}

Q36. [June 2021] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2021 June	5M

In the reaction $p + n \rightarrow p + K^+ + X$ mediated by strong interaction, the baryon number B, strangeness S and the third component of isospin I_3 of the particle X are, respectively

1. $-1, -1$ and -1
2. $+1, -1$ and -1
3. $+1, -2$ and $-\frac{1}{2}$
4. $-1, -1$ and 0

Q37. [June 2021] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2021 June	5M

A ^{60}Co nucleus β-decays from its ground state with $J^P = 5^+$ to a state of ^{60}Ni with $J^P = 4^+$. From the angular momentum selection rules, the allowed values of the orbital angular momentum L and the total spin S of the electron-antineutrino pair are

1. $L = 0$ and $S = 1$
2. $L = 1$ and $S = 0$
3. $L = 0$ and $S = 0$
4. $L = 1$ and $S = 1$

Q38. [June 2021] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2021 June	5M

The Q-value of the α-decay of $^{232}\mathrm{Th}$ to the ground state of $^{228}\mathrm{Ra}$ in $4082\ \mathrm{keV}$. The maximum possible kinetic energy of the α-particle is closest to

1. 4082 keV
2. 4050 keV
3. 4035 keV
4. 4012 keV

Q39. [June 2022] . 5.0 marks

Nuclear and Particle Physics > Nuclear forces and Scattering

CSIR NET	2022 June	5M

The tensor component of the nuclear force may be inferred from the fact that deuteron nucleus ${}_1^2H$

1. has only one bound state with total spin $S = 1$
2. has a non-zero electric quadrupole moment in its ground state
3. is stable while triton ${}_1^3\mathrm{H}$ is unstable
4. is the only two nucleon bound state

Q40. [June 2022] . 5.0 marks

Nuclear and Particle Physics > Nuclear forces and Scattering

CSIR NET	2022 June	5M

The elastic scattering process $\pi^- p \to \pi^- p$ may be treated as a hard-sphere scattering. The mass of π^-, $m_\pi \cong \frac{1}{6} m_p$, where $m_p \cong 938\text{MeV}/c^2$ is the mass of the proton. The total scattering cross-section is closet to

1. 0.01 milli-barn
2. 1 milli-barn
3. 0.1 barn
4. 10 barn

Q41. [June 2022] . 5.0 marks

Nuclear and Particle Physics > Particle Detectors and accelerators

CSIR NET	2022 June	5M

Thermal neutrons may be detected most efficiently by a

1. ^6Li loaded plastic scintillator
2. Geiger-Muller counter
3. inorganic scintillator CaF_2
4. silicon detector

Q42. [Dec 2023] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2023 Dec	5 M

Atmospheric neutrinos are produced from the cascading decays of cosmic pions ($\pi^{\pm}$) to stable particles. Ignoring all other neutrino sources, the ratio of muon neutrino $(\nu_\mu + \bar{\nu}_\mu)$ flux to electron neutrino $(\nu_e + \bar{\nu}_e)$ flux in atmosphere is expected to be closest to

1. 2:3
2. 1: 1
3. 1: 2
4. 2: 1

Q43. [Dec 2023] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2023 Dec	5 M

The ground state of $^{207}_{82}\text{Pb}$ nucleus has spin-parity $J^{\pi} = \left(\frac{1}{2}\right)^{-}$, while first excited state has $J^{\pi} = \left(\frac{5}{2}\right)^{-}$. For the transition from the first excited state to the ground state, possible multipolarities of emitted electromagnetic radiation are

1. E2, E3
2. M2, M3
3. M2, E3
4. E2, M3

Q44. [Dec 2023] . 5.0 marks

Nuclear and Particle Physics > Shell model

CSIR NET	2023 Dec	5 M

In a shell model description, neglecting Coulomb effects, which of the following statements for the energy and spin-parity is correct for the first excited state of $A = 12$ isobars $^{12}_{5}B$, $^{12}_{6}C$, $^{12}_{7}N$?

1. same for $^{12}_{5}B$, $^{12}_{6}C$ and $^{12}_{7}N$
2. different for each $^{12}_{5}\text{B}$, $^{12}_{6}\text{C}$ and $^{12}_{7}\text{N}$
3. same for $^{12}_{6}C$ and $^{12}_{7}N$, but different for $^{12}_{5}B$
4. same for $^{12}_{5}B$ and $^{12}_{7}N$ but different for $^{12}_{6}C$

Q45. [June 2023] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2023 June	5M

The nucleus of $^{40}\mathrm{K}$ (of spin-parity 4^+ in the ground state) is unstable and decays to $^{40}\mathrm{Ar}$. The mass difference between these two nuclei is $\Delta \mathrm{Mc}^2 = 1504.4\,\mathrm{keV}$. The nucleus $^{40}\mathrm{Ar}$ has an excited state at 1460.8 keV with spinparity 2^+. The most probable decay mode of $^{40}\mathrm{K}$ is by

1. a β^+-decay to the 2^+ state of $^{40}\mathrm{Ar}$
2. an electron capture to the 2^+ state of $^{40}\mathrm{Ar}$
3. an electron capture to the ground state of $^{40}\mathrm{Ar}$
4. a β^+-decay to the ground state of $^{40}\mathrm{Ar}$

Q46. [June 2023] . 5.0 marks

Nuclear and Particle Physics > Nuclear forces and Scattering

CSIR NET	2023 June	5M

A neutral particle X^0 is produced in $\pi^- + p \rightarrow X^0 + n$ by s-wave scattering. The branching ratios of the decay of X^0 to $2\gamma, 3\pi$ and 2π are 0.38,0.30 and less than 10^{-3}, respectively. The quantum numbers J^{CP} of X^0 are

1. 0^{-+}
2. 0^{+-}
3. 1^{-+}
4. 1^{+-}

Q47. [June 2023] . 5.0 marks

Nuclear and Particle Physics > Collective model

CSIR NET	2023 June	5M

The energy (in keV) and spin-parity values $E(J^p)$ of the low lying excited states of a nucleus of mass number $A = 152$, are $122(2^+), 366(4^+), 707(6^+)$, and $1125(8^+)$. It may be inferred that these energy levels correspond to a

1. rotational spectrum of a deformed nucleus
2. rotational spectrum of a spherically symmetric nucleus
3. vibrational spectrum of a deformed nucleus
4. vibrational spectrum of a spherically symmetric nucleus

Q48. [Dec 2024] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2024 Dec	5M

The masses of proton, neutron, Polonium and Lead nuclei are as follows:

$$m_p = 1.007825 \text{ a.u}, m_n = 1.008665 \text{ a.u}$$
$$m\left(^{210}_{84}\text{Po}\right) = 209.982876 \text{ a.u},$$
$$m\left(^{206}_{82}\text{Pb}\right) = 205.974455 \text{ a.u.}$$

Binding energy of $^{4}_{2}\text{He}$ is 28.80 MeV and

$$1\text{a.u} = 931.99 \frac{\text{MeV}}{c^2}$$

The binding energies of $^{210}_{84}\text{Po}$, $^{206}_{82}\text{Pb}$ and the Q value of the α-decay of $^{210}_{84}\text{Po}$ are closest to

1. $1645.21\text{MeV}, 1622.33\text{MeV}, 5.92\text{MeV}$
2. $1645.21\text{MeV}, 1622.33\text{MeV}, -5.92\text{MeV}$
3. $1545.21\text{MeV}, 1522.33\text{MeV}, -5.92\text{MeV}$
4. $1645.21\text{MeV}, 1522.33\text{MeV}, 5.92\text{MeV}$

Q49. [Dec 2024] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2024 Dec	5M

Naturally occurring uranium is a mixture of the $^{238}U(99.28\%)$ and $^{235}U(0.72\%)$ isotopes. The life times are $\tau(^{235}U) = 1 \times 10^9$ years and $\tau(^{238}U) = 6.6 \times 10^9$ years. What is the closest value of the age of the solar system if one assumes that at its creation both isotopes were present in equal quantities?

1. 6.2×10^9 years
2. 5.8×10^9 years
3. 4.7×10^9 years
4. 7.2×10^9 years

Q50. [Dec 2024] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2024 Dec	5M

For the decay of the Δ-baryons, the ratio of the decay rates $\frac{\Gamma(\Delta^- \to n\pi^-)}{\Gamma(\Delta^0 \to p\pi^-)}$ is best approximated by

1. $\frac{3}{2}$
2. 3
3. 1
4. $\frac{2}{3}$

Q51. [June 2024] . 5.0 marks

Nuclear and Particle Physics > Nuclear forces and Scattering

CSIR NET	2024 June	5M

In a scattering experiment, a beam of e^- with an energy of 420 MeV scatters off an atomic nucleus. If this first minimum of the differential cross section is observed at a scattering angle of $45°$, the radius of the nucleus (in fermi) is closest to

1. 0.4
2. 8.0
3. 2.5
4. 0.8

Q52. [June 2024] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2024 June	5M

π^-has spin 0 and negative intrinsic parity. In a reaction a deuteron in its ground state ($J = 1$, parity +1) captures a π^-in p-wave to produce a pair of neutrons (intrinsic parity is +1). The neutrons will be produced in a state with

1. $l = 1, S = 0$
2. $l = 0, S = 1$
3. $l = 1, S = 1$
4. $l = 0, S = 0$

Q53. [June 2024] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2024 June	5M

The Δ^{++}can be produced by colliding a pion beam onto a H_2 target, in a reaction $\pi^+ + p \rightarrow \Delta^{++} \rightarrow \pi^+ + p$. In the rest frame of Δ^{++}, the energy and momentum of the pion in the final state (in MeV) are closest to (assume $c = 1$, and $m_\pi \approx 140\text{MeV}, m_p \approx 1\text{GeV}, m_{\Delta^{++}} \approx 1.2\text{GeV}$)

1. 210,156
2. 230,182
3. 175,105
4. 190, 130

Q54. [Dec 2025] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2025 Dec	5M	NPP

Consider the cross-sections

$$\sigma_1 = \sigma(p + n \rightarrow \Delta^+ + n) \text{ and } \sigma_2 = \sigma\left(p + n \rightarrow \Delta^0 + p\right)$$

where the (Δ^+, Δ^0) are part of the baryon decuplet.

Then

1. one of the $\sigma_{1,2}$ vanishes identically.
2. $\sigma_1 \gg \sigma_2$, with both being non-zero.
3. $\sigma_1 \ll \sigma_2$, with both being non-zero.
4. $\sigma_1 \approx \sigma_2$.

Q55. [Dec 2025] . 5.0 marks

Nuclear and Particle Physics > Nuclear properties

CSIR NET	2025 Dec	5M	NPP

For a spherical nucleus, consider the interior charge distribution to be

$$\rho(r) = \frac{\rho_0}{1 + \exp[(r - R)/a]}$$

where ρ_0, R and a are constants of appropriate dimensions. In the limit $a \to 0^+$, the number of protons (charge e) inside a sphere of radius $2R$ is given by

1. $\frac{2\rho_0}{e}\left(\frac{4}{3}\pi R^3\right)$
2. $\frac{\rho_0}{e}\left(\frac{4}{3}\pi R^3\right)$
3. $\frac{8\rho_0}{e}\left(\frac{4}{3}\pi R^3\right)$
4. $\frac{4\rho_0}{e}\left(\frac{4}{3}\pi R^3\right)$

Q56. [Dec 2025] . 5.0 marks

Nuclear and Particle Physics > Liquid drop Model

CSIR NET	2025 Dec	5M	NPP

Suppose that the volume and the surface terms are the most dominant ones in the semi-empirical formula for the binding energy of a nucleus. Let C_s and C_v be the coefficients of the surface and volume terms. Which of the following is a criterion for stability of the nucleus?

1. $A > \left(\frac{C_s}{C_v}\right)^3$
2. $A < \left(\frac{C_s}{C_v}\right)^3$
3. $A > \left(\frac{2C_s}{3C_v}\right)^3$
4. $A < \left(\frac{2C_s}{3C_v}\right)^3$

Q57. [June 2025] . 5.0 marks

Nuclear and Particle Physics > Nuclear properties

CSIR NET	2025 June	5M	NPP

If the binding energies per nucleon of the nuclei $X(A = 240)$ and $Y(A = 120)$ are 7.6 MeV and 8.5 MeV respectively, the energy released in the symmetric fission, $X \rightarrow Y + Y$ is

1. 94 MeV
2. 9.4MeV
3. 108 MeV
4. 216 MeV

Q58. [June 2025] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2025 June	5M	NPP

When a neutron of 1 keV kinetic energy impinges on a ^{12}C target, the total scattering cross section is 1000 barns. The approximate value of the phase shift δ_0 is

1. 18°
2. 108°
3. 90°
4. 36°

Q59. [June 2025] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2025 June	5M	NPP

The ρ-mesons are $J^P = 1^-$ particles that decay strongly into pions. The ratio of the particle decay widths $\frac{\Gamma(\rho^0 \to \pi^0\pi^0)}{\Gamma(\rho^+ \to \pi^+\pi^0)}$ is closest to

1. 1
2. $\frac{1}{2}$
3. 0
4. 2

Answer Key

59 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Nuclear and Particle Physics	Particle physics	**2**
Q2	Nuclear and Particle Physics	Shell model	**1**
Q3	Nuclear and Particle Physics	Liquid drop Model	**3**
Q4	Nuclear and Particle Physics	Shell model	**1**
Q5	Nuclear and Particle Physics	Particle physics	**4**
Q6	Nuclear and Particle Physics	Particle physics	**4**
Q7	Nuclear and Particle Physics	Nuclear properties	**1**
Q8	Nuclear and Particle Physics	Particle physics	**1**
Q9	Nuclear and Particle Physics	Particle physics	**3**
Q10	Nuclear and Particle Physics	Radioactivity	**1**
Q11	Nuclear and Particle Physics	Radioactivity	**1**
Q12	Nuclear and Particle Physics	Liquid drop Model	**2**
Q13	Nuclear and Particle Physics	Shell model	**3**
Q14	Nuclear and Particle Physics	Shell model	**4**
Q15	Nuclear and Particle Physics	Collective model	**1**
Q16	Nuclear and Particle Physics	Particle physics	**1**
Q17	Nuclear and Particle Physics	Radioactivity	**1**
Q18	Nuclear and Particle Physics	Nuclear forces and Scattering	**3**
Q19	Nuclear and Particle Physics	Particle physics	**1**
Q20	Nuclear and Particle Physics	Nuclear forces and Scattering	**2**
Q21	Nuclear and Particle Physics	Radioactivity	**2**
Q22	Nuclear and Particle Physics	Collective model	**4**
Q23	Nuclear and Particle Physics	Particle physics	**4**
Q24	Nuclear and Particle Physics	Particle physics	**2**
Q25	Nuclear and Particle Physics	Radioactivity	**1**
Q26	Nuclear and Particle Physics	Nuclear forces and Scattering	**2**
Q27	Nuclear and Particle Physics	Liquid drop Model	**3**
Q28	Nuclear and Particle Physics	Particle physics	**1**
Q29	Nuclear and Particle Physics	Radioactivity	**1**
Q30	Nuclear and Particle Physics	Nuclear forces and Scattering	**2**
Q31	Nuclear and Particle Physics	Particle physics	**3**
Q32	Nuclear and Particle Physics	Particle physics	**3**
Q33	Nuclear and Particle Physics	Liquid drop Model	**3**
Q34	Nuclear and Particle Physics	Shell model	**4**
Q35	Nuclear and Particle Physics	Radioactivity	**4**
Q36	Nuclear and Particle Physics	Particle physics	**2**
Q37	Nuclear and Particle Physics	Radioactivity	**1**
Q38	Nuclear and Particle Physics	Radioactivity	**4**
Q39	Nuclear and Particle Physics	Nuclear forces and Scattering	**2**
Q40	Nuclear and Particle Physics	Nuclear forces and Scattering	**3**

Answer Key (cont.)

Q. No	Subject	Topic	Answer
Q41	Nuclear and Particle Physics	Particle Detectors and accelerators	**1**
Q42	Nuclear and Particle Physics	Particle physics	**4**
Q43	Nuclear and Particle Physics	Radioactivity	**4**
Q44	Nuclear and Particle Physics	Shell model	**4**
Q45	Nuclear and Particle Physics	Radioactivity	**2**
Q46	Nuclear and Particle Physics	Nuclear forces and Scattering	**2**
Q47	Nuclear and Particle Physics	Collective model	**1**
Q48	Nuclear and Particle Physics	Radioactivity	**1**
Q49	Nuclear and Particle Physics	Radioactivity	**2**
Q50	Nuclear and Particle Physics	Particle physics	**2**
Q51	Nuclear and Particle Physics	Nuclear forces and Scattering	**3**
Q52	Nuclear and Particle Physics	Radioactivity	**4**
Q53	Nuclear and Particle Physics	Particle physics	**4**
Q54	Nuclear and Particle Physics	Particle physics	**4**
Q55	Nuclear and Particle Physics	Nuclear properties	**2**
Q56	Nuclear and Particle Physics	Liquid drop Model	**1**
Q57	Nuclear and Particle Physics	Nuclear properties	**4**
Q58	Nuclear and Particle Physics	Particle physics	**4**
Q59	Nuclear and Particle Physics	Particle physics	**3**

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