1. Nuclear Force-Solutions

Practice Set 1 Solutions

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

[NET JUNE 2017]

A. 1.40fm **B.** 7.70fm

C. 0.25fm **D.** 0.18fm

Solution: Range for nuclear force between nucleon will be $R = c\Delta t = \frac{\hbar c}{mc^2}$ and $\hbar c = 199\text{MeVfm}$
$\Rightarrow R = \frac{199\text{MeVfm}}{770\frac{\text{MeV}}{c^2}\times c^2} \approx 0.25\text{fm}$

2. The reaction ${}^2_1D + {}^2_1D \rightarrow {}^4_2He + \pi^0$ cannot proceed via strong interactions because it violates the conservation of

[NET/JRF (JUNE-2015)]

a. Angular momentum **b.** Electric charge

c. Baryon number **d.** Isospin

Solution:

$${}_1D^2 + {}_1D^2 \rightarrow {}_2\text{He}^4 + \pi^0 \quad \text{(Not conserved)}$$
$$I: 0 \quad 0 \rightarrow \quad 0 \quad 1$$
This isopin is not conserved in above reaction.

3. 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

[NET/JRF (JUNE-2018)]

a. Linear combination of a singlet and a triplet **b.** Singlet

c. Triplet **d.** Doublet

Solution:

Parity must conserve intersections

$\pi + d \rightarrow n + n$

The parity of the initial state is

$(-1)^l P_\pi P_d = (-1)^1(-1)(+1) = +1$

The parity of the final state is

$(-1)^l P_n P_n = (-1)^l(+1)(+1) = (-1)^l = 1 \qquad \because l = 0, 2, \ldots.$

word or phrase

So the correct answer is **Option (b)**

4. 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 $0.2\text{fm} < r < 2\text{fm}$?

a. F_{np} is attractive for triplet spin state, and F_{nn}, F_{pp} are always repulsive

b. F_{nn} and F_{np} are always attractive and F_{pp} is repulsive in the triplet spin state

c. F_{pp} and F_{np} are always attractive and F_{nn} is always repulsive

d. All three forces are always attractive

Solution: Inside the nucleus the interaction between neutron neutron and newtran-proton is always attractive due to nuclear force whereas between proton-proton it is repulsive due to coulombic interaction: Thus F_{nn} and F_{np} are always attractive and F_{pp} is repulsive
So the correct answer is **Option (b)**

Answer key

Q.No.	Answer	Q.No.	Answer
1	**0.25**	2	
3	**b**	4	**b**
5		6	

Practice Set-2 Solutions

1. The ground state wavefunction of deuteron is in a superposition of *s* and *d* states. Which of the following is NOT true as a consequence?

[GATE 2010]

A. It has a non-zero quadruple moment

B. The neutron-proton potential is non-central

C. The orbital wavefunction is not spherically symmetric

D. The Hamiltonian does not conserve the total angular momentum

Solution: So the correct answer is **Option (d)**

2. Deuteron has only one bound state with spin parity 1^+, isospin 0 and electric quadrupole moment 0.286efm^2. These data suggest that the nuclear forces are having

[GATE 2012]

A. Only spin and isospin dependence

B. No spin dependence and no tensor components

C. Spin dependence but no tensor components

D. Spin dependence along with tensor components

Solution: So the correct answer is **Option (d)**

3. Which of the following statements is NOT correct?

[GATE 2016]

A. A deuteron can be disintegrated by irradiating it with gamma rays of energy 4MeV.

B. A deuteron has no excited states.

C. A deuteron has no electric quadrupole moment.

D. The $^1S_0$ state of deuteron cannot be formed.

Solution: So the correct answer is **Option (c)**

Answer key			
Q.No.	Answer	Q.No.	Answer
1	**d**	2	**d**
3	**c**	4	
5		6	

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