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NUCLEAR & PARTICLE PHYSICS

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NUCLEAR & PARTICLE PHYSICS

PREVIOUS YEARS' QUESTION

LEVEL-1 (Solve Yourself)

LEVEL-2

LEVEL-1

GATE Previous Years' Questions

1. The mean momentum of a nucleon in a nucleus with mass number A varies as [GATE 2000]
(a) A (b) A^2 (c) $A^{-2/3}$ (d) $A^{-1/3}$

2. The masses of hydrogen atom, neutron and ${}_{92}U^{238}$ are given by 1.0078, 1.0087 and 238.0508 a.m.u., respectively. The binding energy of ${}_{92}U^{238}$ is therefore approximately equal to [GATE 2000 & 03]
(Taking 1 a.m.u. = 931.64 MeV)
(a) 120 MeV (b) 1500 MeV (c) 1600 MeV (d) 1800 MeV

3. The volume of a nucleus in an atom is proportional to the [GATE 2004]
(a) mass number (b) proton number
(c) neutron number (d) electron number

4. The order of magnitude of the binding energy per nucleon in a nucleus is: [GATE 2006]
(a) 10^{-5} MeV (b) 10^{-3} MeV (c) 0.1 MeV (d) 10 MeV

5. An ${}_8O^{16}$ nucleus is spherical and has a charge radius R and a volume $V = \frac{4}{3}\pi R^3$. According to empirical observations of the charge radii, the volume of the ${}_{54}Xe^{128}$ nucleus assumed to be spherical is
(a) 8 V (b) 2 V (c) 6.75 V (d) 1.89 V [GATE 2008]

6. The Compton wavelength of a proton is _____ fm. (up to two decimal places). [GATE 2017]
$(m_p = 1.67\times10^{-27}\,\text{kg}, h = 6.626\times10^{-34}\,\text{Js}, e = 1.602\times10^{-19}\,\text{C}, c = 3\times10^8\,\text{ms}^{-1})$

ANSWER KEY

1. (d) 2. (d) 3. (a) 4. (d) 5. (a) 6. (1.32)

CSIR-UGC-NET Previous Years' Questions

1. The range of the nuclear force between two nucleons due to the exchange of pions is 1.40 fm. If the mass of the pion is 140 MeV/c^2 and the mass of the rho-meson is 770 MeV/c^2, then the range of the force due to exchange of rho mesons is **[NET June 2017]**

(a) 1.40 fm (b) 7.70 fm (c) 0.25 fm (d) 0.18 fm

ANSWER KEY

1. (c)

JEST Previous Years' Questions

1. The stable nucleus that has $\frac{1}{3}$ the radius of ^{189}Os nucleus is, [JEST 2016]

(a) ^{7}Li (b) ^{16}O (c) ^{4}He (d) ^{14}N

ANSWER KEY

1. (a)

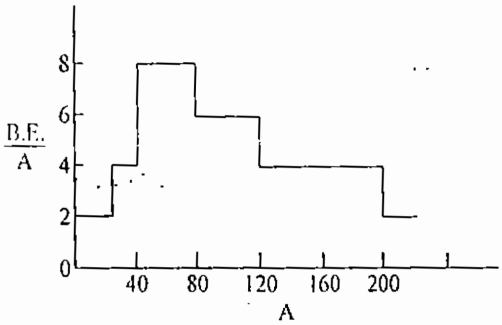
Other Examinations Previous Years' Questions

1. If M_e, M_p and M_H are the rest masses of electron, proton and hydrogen atom in the ground state (with energy -13.6 eV), respectively, which of the following is exactly true? (c is the speed of light in free space)

(a) $M_H = M_p + M_e$ (b) $M_H = M_p + M_e - \frac{13.6\text{ eV}}{c^2}$ (c) $M_H = M_p + M_e + \frac{13.6\text{ eV}}{c^2}$

(d) $M_H = M_p + M_e + K$, where $K \neq \pm\frac{13.6\text{ eV}}{c^2}$ or zero.

2. The following histogram represents the binding energy per particle (B.E./A) in MeV as a function of the mass number A of a nucleus.



A nucleus with mass number $A = 180$ fissions into two nuclei of equal masses. In the process

(a) 180 MeV of energy is released. (b) 180 MeV of energy is absorbed.
(c) 360 MeV of energy is released. (d) 360 MeV of energy is absorbed.

3. A nucleus has a size of 10^{-15} m. Consider an electron bound within a nucleus. The estimated energy of this electron is of the order of.

(a) 1 MeV (b) 10^2 MeV (c) 10^4 MeV (d) 10^6 MeV

4. Two spherical nuclei have mass numbers 216 and 64 with their radii R_1 and R_2 respectively. The ratio $\frac{R_1}{R_2}$ is:

(a) 1.0 (b) 1.5 (c) 2.0 (d) 2.5

ANSWER KEY

1. (b) 2. (c) 3. (b) 4. (b)

GATE Previous Years' Questions

1. The angular momentum and parity of $^{17}_{8}O$ nucleus, according to the nuclear shell model (including spin-orbit coupling), is: **[GATE 1998]**

(a) 0^+ (b) $\frac{1}{2}^-$ (c) $\frac{3}{2}^+$ (d) $\frac{5}{2}^+$

2. The asymmetry terms in the Weizsacker semi-empirical mass formula is because of **[GATE 2002]**

(a) non-spherical shape of the nucleus.
(b) non-zero spin of nucleus.
(c) unequal number of protons and neutrons inside the nucleus.
(d) odd number of protons inside the nucleus.

3. The spin and parity of $_4Be^9$ nucleus, as predicted by the shell model, are respectively. **[GATE 2002]**

(a) 3/2 and odd (b) 1/2 and odd (c) 3/2 and even (d) 1/2 and even

Common Data for Q.4 and Q.5:

The nucleus ^{41}Ca can be described by the single particle shell model.

4. The single particle states occupied by the last proton and the last neutron, respectively, are given by **[GATE 2004]**

(a) $d_{5/2}$ and $f_{7/2}$ (b) $d_{3/2}$ and $f_{5/2}$ (c) $d_{5/2}$ and $f_{5/2}$ (d) $d_{3/2}$ and $f_{7/2}$

5. The ground state angular momentum and parity of ^{41}Ca are: **[GATE 2004]**

(a) $\left(\frac{7}{2}\right)^-$ (b) $\frac{3}{2}^+$ (c) $\frac{5}{2}^+$ (d) $\frac{5}{2}^-$

6. Which of the following expressions for total binding energy B of a nucleus is correct $(a_1, a_2, a_3, a_4 > 0)$? **[GATE 2005]**

(a) $B = a_1 A - a_2 A^{2/3} - a_3 \frac{Z(Z-1)}{A^{1/3}} - a_4 \frac{(A-2Z)^2}{A} + \delta$

(b) $B = a_1 A + a_2 A^{2/3} - a_3 \frac{Z(Z-1)}{A^{1/3}} - a_4 \frac{(A-2Z)^2}{A} + \delta$

(c) $B = a_1 A + a_2 A^{1/3} - a_3 \frac{Z(Z-1)}{A^{1/3}} - a_4 \frac{(A-2Z)^2}{A} + \delta$

(d) $B = a_1 A - a_2 A^{1/3} - a_3 \frac{Z(Z-1)}{A^{1/3}} - a_4 \frac{(A-2Z)^2}{A} + \delta$

7. According to shell model, the ground state of $^{15}_{8}O$ nucleus is **[GATE 2005]**

(a) $\frac{3}{2}^+$ (b) $\frac{1}{2}^+$ (c) $\frac{3}{2}^-$ (d) $\frac{1}{2}^-$

8. According to the shell model the ground state spin of the ^{17}O nucleus is [GATE 2007]

(a) $\frac{3}{2}^{+}$ (b) $\frac{5}{2}^{+}$ (c) $\frac{3}{2}^{-}$ (d) $\frac{5}{2}^{-}$

9. The four possible configurations of neutrons in the ground state of $_4Be^9$ nucleus according to the shell model, and the associated nuclear spin are listed below. Choose the correct one. [GATE 2008]

(a) $\left({}^1s_{1/2}\right)^2\left({}^1p_{3/2}\right)^3;\ J=\frac{3}{2}$ (b) $\left({}^1s_{1/2}\right)^2\left({}^1p_{1/2}\right)^2\left({}^1p_{3/2}\right)^1;\ J=\frac{3}{2}$

(c) $\left({}^1s_{1/2}\right)^2\left({}^1p_{3/2}\right)^4;\ J=\frac{1}{2}$ (d) $\left({}^1s_{1/2}\right)^2\left({}^1p_{3/2}\right)^2\left({}^1p_{1/2}\right)^1;\ J=\frac{1}{2}$

10. Consider a nucleus with N neutrons and Z protons. If m_p, m_n and $B.E.$ represents the mass of the proton, the mass of the neutron and the binding energy of the nucleus respectively and c is the velocity of light in free space, the mass of the nucleus is given by [GATE 2009]

(a) $Nm_n + Zm_p$ (b) $Nm_p + Zm_n$ (c) $Nm_n + Zm_p - \frac{B.E.}{c^2}$ (d) $Nm_p + Zm_n + \frac{B.E.}{c^2}$

11. In the nuclear shell model the spin parity of $^{15}_{7}N$ is given by [GATE 2010]

(a) $\frac{1}{2}^{-}$ (b) $\frac{1}{2}^{+}$ (c) $\frac{3}{2}^{-}$ (d) $\frac{3}{2}^{+}$

12. The semi-empirical mass formula for the binding energy of nucleus contains a surface correction term. This term depends on the mass number A of the nucleus as [GATE 2011]

(a) $A^{-1/3}$ (b) $A^{1/3}$ (c) $A^{2/3}$ (d) A

13. According to the single particle nuclear shell model, the spin parity of the ground state of $^{17}_{8}O$ is

(a) $\frac{1}{2}^{-}$ (b) $\frac{3}{2}^{-}$ (c) $\frac{3}{2}^{+}$ (d) $\frac{5}{2}^{+}$ [GATE 2011]

14. A proton is confined to a cubic box, whose sides have length $10^{-12}\,m$. What is the minimum kinetic energy of the proton? The mass of proton is $1.67 \times 10^{-27}\,kg$ and Planck's constant is $6.63 \times 10^{-34}\,Js$. [GATE 2013]

(a) $1.1 \times 10^{-17}\,J$ (b) $3.3 \times 10^{-17}\,J$ (c) $9.9 \times 10^{-17}\,J$ (d) $6.6 \times 10^{-17}\,J$

15. In the nuclear shell model, the potential is modeled as $V(r)=\frac{1}{2}m\omega^2r^2-\lambda\vec{L}\cdot\vec{S},\ \lambda>0$. The correct spin-parity and isospin assignments for the ground state of ^{13}C is [GATE 2015]

(a) $\frac{1}{2}^{-};\frac{-1}{2}$ (b) $\frac{1}{2}^{+};\frac{-1}{2}$ (c) $\frac{3}{2}^{+};\frac{1}{2}$ (d) $\frac{3}{2}^{-};\frac{-1}{2}$

16. According to the nuclear shell model, the respective ground state spin-parity values of $^{15}_{8}O$ and $^{17}_{8}O$ nuclei are

(a) $\frac{1}{2}^{+},\frac{1}{2}^{-}$ (b) $\frac{1}{2}^{-},\frac{5}{2}^{+}$ (c) $\frac{3}{2}^{-},\frac{5}{2}^{+}$ (d) $\frac{3}{2}^{-},\frac{1}{2}^{-}$ [GATE 2016]

17. For nucleus ^{164}Er, a $J^{\pi}=2^{+}$ state is at 90 keV. Assuming ^{164}Er to be a rigid rotor, the energy of its 4^{+} state is ________ keV. (up to one decimal place). [GATE 2018]

18. 4 MeV γ-rays emitted by the de-excitation of ^{19}F are attributed, assuming spherical symmetry, to the transition of protons from 1 $d_{3/2}$ state. If the contribution of spin-orbit term to the total energy is written as $C(\vec{l}\cdot\vec{s})$, the magnitude of C is ________ MeV (up to one decimal place). [GATE 2018]

ANSWER KEY

1. (d)	2. (c)	3. (a)	4. (d)	5. (a)	6. (a)	7. (d)
8. (b)	9. (a)	10. (c)	11. (a)	12. (c)	13. (d)	14. (c)
15. (a)	16. (b)	17. (300)	18. (1.6)			

CSIR-UGC-NET Previous Years' Questions

1. According to the shell model, the total angular momentum (in units of $\hbar$) and the parity of the ground state of the ^7_3Li nucleus is [NET Dec. 2013]

(a) $\frac{3}{2}$ with negative parity (b) $\frac{3}{2}$ with positive parity

(c) $\frac{1}{2}$ with positive parity (d) $\frac{7}{2}$ with negative parity

2. A permanently deformed even-even nucleus with $J^P = 2^+$ has rotational energy 93 keV. The energy of the next excited state is [NET June 2014]

(a) 372 keV (b) 310 keV (c) 273 keV (d) 186 keV

3. Let us approximate the nuclear potential in the shell model by a 3-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 ? [NET June 2015]

(a) $^4_2$He and $^{16}_8$O (b) $^2_1$D and $^8_4$Be (c) $^4_2$He and $^8_4$Be (d) $^4_2$He and $^{12}_6$Be

4. 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 $a_C = 0.7$MeV and $a_{sym} = 22.5$ MeV respectively) is a maximum for [NET Dec. 2015]

(a) $^{125}_{54}$Xe (b) $^{125}_{53}$I (c) $^{125}_{52}$Te (d) $^{125}_{51}$Sb

ANSWER KEY

1. (a) 2. (b) 3. (a) 4. (c)

TIFR Previous Years' Questions

1. In the semi-empirical mass formula, the volume (V), surface (S), coulomb (C), and pairing (P) contributions to the binding energy of a nucleus ${}^A_Z X$ vary with mass number A as [TIFR 2015]

(a) $V \propto A$, $S \propto A^{2/3}$, $C \propto A^{-1/3}$, $P \propto A^{-3/4}$

(b) $V \propto A$, $S \propto A^{1/3}$, $C \propto A^{-1/3}$, $P \propto A^{-3/4}$

(c) $V \propto A$, $S \propto A^{-2/3}$, $C \propto A^{1/3}$, $P \propto A^{-3/4}$

(d) $V \propto A^2$, $S \propto A^{2/3}$, $C \propto A^{-1/3}$, $P \propto A^{-3/4}$

ANSWER KEY

1. (a)

Other Examinations Previous Years' Questions

1. A nucleus may be modelled as a drop of liquid consisting of the nucleons (protons and neutrons). In this model, the dominant contribution to the nuclear binding energy is from the volume, which is proportional to A, the total number of nucleons. Then the two important subdominant contributions from the surface tension and the coulomb repulsion of the protons are, proportional to
(a) $A^{2/3}$ and $Z/A^{1/3}$ respectively (b) $A^{2/3}$ and $Z^2/A^{1/3}$ respectively
(c) $A^{1/3}$ and $Z^2/A^{2/3}$ respectively (d) $A^{1/2}$ and $Z^2/A^{1/3}$ respectively

ANSWER KEY

1. (b)

GATE Previous Years' Questions

1. The plot of $\log A_t$ is versus time t, where, A_t is activity, as shown in the figure, corresponds to decay

[GATE 2005]

(a) from only one kind of radioactive nuclei having same half-life.
(b) from only neutron activated nuclei
(c) from a mixture of radioactive nuclei having different half-lives.
(d) which is unphysical.

2. The evidence for the non-conservation of parity in β-decay has been obtained from the observation that the β-intensity [GATE 2005]
(a) anti-parallel to the nuclear spin directions is same as that along the nuclear spin direction
(b) anti-parallel to the nuclear spin direction is not the same as that along the nuclear spin direction
(c) shows a continuous distribution as a function of momentum
(d) is independent of the nuclear spin direction

3. Which one of the following disintegration series of the heavy elements will give ^{209}Bi as a stable nucleus?
(a) Thorium series (b) Neptunium series [GATE 2006]
(c) Uranium series (d) Actinium series

4. Consider Fermi theory of β-decay [GATE 2006]
(I) The number of final states of electrons corresponding to momenta between p and $(p + dp)$ is
(a) independent of p (b) proportion to pdp
(c) proportional to p^2dp (d) proportional to p^3dp
(II) The number of emitted electrons with momentum (p) and energy (E) in the allowed approximation is proportional to (E_0 is the total energy given up by the nucleus)
(a) $(E_0 - E)$ (b) $p(E_0 - E)$ (c) $p^2(E_0 - E)^2$ (d) $p(E_0 - E)^2$

5. Half-life of a radioisotope is 4×10^8 years. If these are 10^3 radioactive nuclei in a sample today, the number of such nuclei in the sample 4×10^9 years ago were [GATE 2007]
(a) 128×10^3 (b) 256×10^3 (c) 512×10^3 (d) 1024×10^3

6. The disintegration energy is defined to be the difference in the rest energy between the initial and final states. Consider the following process: [GATE 2009]
$$^{240}_{94}Pu \rightarrow ^{236}_{92}U + ^4_2He$$
The emitted α particle has a kinetic energy 5.17 MeV. The value of the disintegration energy is
(a) 5.26 MeV (b) 5.17 MeV (c) 5.08 MeV (d) 2.59 MeV

7. In the β-decay of neutron, $n \rightarrow p + e^- + \bar{\nu}_e$, the anti-neutrino $\bar{\nu}_e$ escapes detection. Its existence is inferred from the measurement of [GATE 2011]
(a) energy distribution of electrons (b) angular distribution of electrons
(c) helicity distribution of electrons (d) forward-backward asymmetry of electrons

ANSWER KEY

1. (c)	2. (c)	3. (b)	4. (c)	5. (d)	6. (a)	7. (a)

JEST Previous Years' Questions

1. The half-life of a radioactive nuclear source is 9 days. The fraction of nuclei which are left undecayed after 3 days is: [JEST 2016]

(a) $\frac{7}{8}$ (b) $\frac{1}{3}$ (c) $\frac{5}{6}$ (d) $\frac{1}{2^{1/3}}$

ANSWER KEY

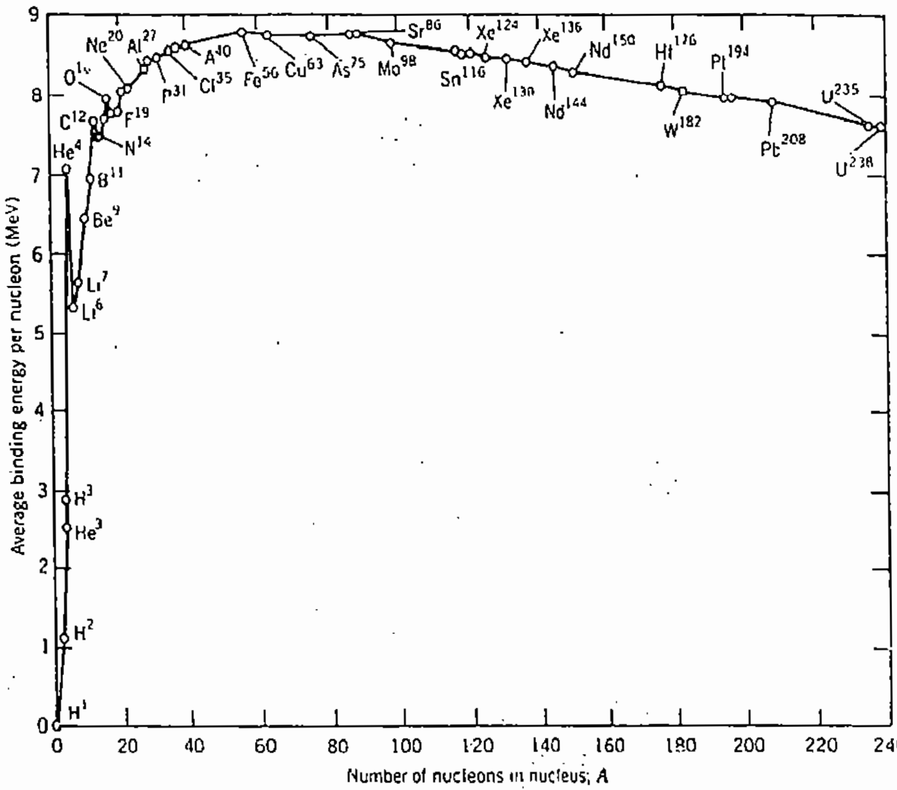
1. (d)

Other Examinations Previous Years' Questions

1. $^{60}_{27}Co$ is a radioactive nucleus of half-life $2\ell n\ 2\times10^{8}$ s. The activity of 10 g of $^{60}_{27}Co$ in disintegration per second is:

(a) $\frac{1}{5}\times10^{10}$ (b) 5×10^{10} (c) $\frac{1}{5}\times10^{14}$ (d) 5×10^{14}

2. The variation of binding energy per nucleus with respect to the mass of nuclei is shown in the figure



Consider the following reactions:

(1) $^{238}_{92}U \rightarrow\ ^{206}_{82}Pb+10p+22n$ (2) $^{238}_{92}U \rightarrow\ ^{206}_{82}Pb+8\,^{4}_{2}He+6e^{-}$

Which one of the following statements is true for the given decay modes of $^{238}_{92}U$?

(a) both 1 and 2 are allowed (b) both 1 and 2 are forbidden
(c) 1 is forbidden and 2 is allowed (d) 1 is allowed and 2 is forbidden

3. A particular radioisotope has a half-life of 5 days. In 15 days the probability of decay in percentage will be ________

4. Radon has a half-life of 3.8 days. If we start with 10.24 gm of radon, the amount of it which will be left after 38 days is

(a) 10^{-4} gm (b) 10^{-2} gm (c) 10^{-6} gm (d) 10^{-3} gm

ANSWER KEY

1. (d) 2. (c) 3. (87 to 88) 4. (b)

GATE Previous Years' Questions

1. Typical energies released in a nuclear fission and a nuclear fusion reactions are respectively:
(a) 50 MeV and 1000 MeV (b) 200 MeV and 1000 MeV
(c) 1000 MeV and 50 MeV (d) 200 MeV and 10 MeV [GATE 2002]

2. A thermal neutron having speed v impinges on a U^{235} nucleus. The reaction cross-section is proportional to [GATE 2004]
(a) v^{-1} (b) v (c) $v^{1/2}$ (d) $v^{-1/2}$

3. By capturing an electron $_{25}Mn_{29}^{54}$ transforms into $_{24}Cr_{30}^{54}$ releasing [GATE 2006]
(a) a neutrino (b) an anti neutrino (c) an α-particle (d) a positron

4. Fission fragments are generally radioactive as [GATE 2007]
(a) they have excess of neutrons (b) they have excess of protons
(c) they are products of radioactive nuclide (d) their total kinetic energy is of the order of 200 MeV.

5. A neutron scatters elastically from a heavy nucleus, the initial and final states of the neutron have the [GATE 2007]
(a) same energy (b) same energy and linear momentum
(c) same energy and angular momentum (d) same linear and angular momenta

6. The energy released in the fission of 1 kg Uranium (approximately [in Joule]): [GATE 2008]
(a) 10^{14} (b) 10^{17} (c) 10^{16} (d) 10^{10}

7. The atomic masses of $^{152}_{63}Eu$, $^{152}_{62}Sm$, $^{1}_{1}H$ and neutron are 151.921749, 151.919756, 1.007825 and 1.008665 in atomic mass units (a.m.u.), respectively. Using the above information, the Q-value of the reaction $^{152}_{63}Eu + n \rightarrow ^{152}_{62}Sm + p$ is______ $\times 10^{-3}$ a.m.u. (upto three decimal places) [GATE 2015]

ANSWER KEY

1. (d) 2. (a) 3. (a) 4. (a) 5. (a) 6. (a)
7. (2.833)

TIFR Previous Years' Questions

1. The binding energy per nucleon for ^{235}U is 7.6 MeV. The ^{235}U nucleus undergoes fission to produce two fragments, both having binding energy per nucleon 8.5 MeV. The energy released, in Joules, from the complete fission of 1 kg of ^{235}U is therefore, [TIFR 2010]

(a) 8000 (b) 10^{35} (c) 450 (d) 20000

(e) 8.7×10^{13} (f) 5.0×10^{8}

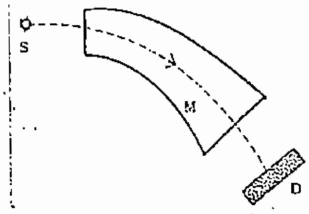
2. A fast-moving ^{14}N nucleus collides with an α particle at rest in the laboratory frame, giving rise to the reaction

$$^{14}N + \alpha \to {}^{17}O + p$$ [TIFR 2011]

Given the masses 14.00307 a.m.u. and 16.99913 a.m.u. for ^{14}N and ^{17}O nuclei respectively, and 4.00260 a.m.u. and 1.00783 a.m.u. for α and p respectively, the minimum kinetic energy in the laboratory frame of the ^{14}N nucleus must be

(a) 4.20 MeV (b) 1.20 MeV (c) 5.41 MeV (d) 1.55 MeV

3. In a beta decay experiment, an electromagnet M and a detector D are used to measure the energy of electrons (β^-), as shown in the figure. [TIFR 2014]



The detector D is capable of detecting either electons (β^-) or positrons (β^+). Now the β^- source is replaced with a β^+ source, and we would like to measure the energy of the positrons (β^+) using the same setup. Which of the following is correct?

(a) This can be done quite easily, if the polarity of current in the coils of the electromagnet is reversed.

(b) This is can done trivially, without changing anything, since the detector D can detect either β^- or β^+.

(c) There is no way to do this with the given set up, since β^+ will have to be converted into β^-, which is obviously not possible.

(d) This cannot be done since the magnet does not have a symmetric shape.

4. It is well-known that the energy of the Sun arises from the fusion of hydrogen nuclei (protons) inside the core of the Sun. This takes place through several mechanisms, each resulting in emission of energy.

Which of the following reactions is NOT possible during the proton fusion inside the Sun? [TIFR 2014]

(a) ${}^1_1H + {}^1_1H \longrightarrow {}^2_2He$ (b) ${}^2_1H + {}^1_1H \longrightarrow {}^3_2He$

(c) ${}^1_1H + {}^1_1H \longrightarrow {}^2_1H + e^+ + \nu_e$ (d) ${}^1_1H + {}^1_1H + {}^1_1H + {}^1_1H \longrightarrow {}^4_2He + 2e^+$

ANSWER KEY

1. (e) 2. (d) 3. (a) 4. (d)

JEST Previous Years' Questions

1. If hydrogen atom is bombarded by energetic electrons, it will emit [JEST 2014]

(a) K_α X-rays (b) β-rays (c) Neutrons (d) None of the above

ANSWER KEY

1. (d)

GATE Previous Years' Questions

1. Which of the following functions describes the nature of interaction potential $V(r)$ between two quarks inside a nucleon? (r is the distance between the quarks and a and b are positive constants of suitable dimensions). **[GATE 2001]**

(a) $V(r)=\frac{a}{r}+br$ (b) $V(r)=-\frac{a}{r}+br$ (c) $V(r)=\frac{a}{r}-br$ (d) $V(r)=-\frac{a}{r}-br$

2. Which of the following reactions violates lepton number conservation? **[GATE 2001]**

(a) $e^{+}+e^{-}\rightarrow \nu_e+\overline{\nu}_e$ (b) $e^{-}+p\rightarrow \nu_e+n$ (c) $e^{+}+n\rightarrow p+\nu_e$ (d) $\mu^{-}\rightarrow e^{-}+\nu_\mu+\overline{\nu}_e$

3. The cross-sections of the reactions **[GATE 2001]**

$p+\pi^{-}\rightarrow \Sigma^{-}+K^{+}$ and $p^{-}+\pi^{+}\rightarrow \overline{\Sigma}^{-}+K^{-}$

at a given energy are the same due to

(a) baryon number conservation (b) time reversal invariance
(c) charge conjugation (d) parity conservation

4. The Baryon number of proton, the lepton number of proton, the baryon number of electron and the lepton number of the electron are respectively **[GATE 2002]**

(a) zero, zero, one and zero (b) one, one, zero and one
(c) one, zero, zero and one (d) zero, one, one and zero

5. The nucleus of the atom $^{9}Be_4$ consists of **[GATE 2003]**

(a) 13 up quarks and 13 down quarks (b) 13 up quarks and 14 down quarks
(c) 14 up quarks and 13 down quarks (d) 14 up quarks and 14 down quarks

6. Which one of the following nuclear reactions is possible? **[GATE 2003]**

(a) $^{14}N_7 \longrightarrow {}^{13}C_6+\beta^{+}+\nu_e$ (b) $^{13}N_7 \longrightarrow {}^{13}C_6+\beta^{+}+\nu_e$

(c) $^{13}N_7 \longrightarrow {}^{13}C_6+\beta^{+}$ (d) $^{13}N_7 \longrightarrow {}^{13}C_7+\beta^{+}+\nu_e$

7. Suppose that a neutron at rest in free space decays into a proton and an electron. This process would violate **[GATE 2003]**

(a) conservation of charge (b) conservation of energy
(c) conservation of linear momentum (d) conservation of angular momentum

8. Choose the particle with zero Baryon number from the list given below **[GATE 2004]**

(a) pion (b) neutron (c) proton (d) Δ^{+}

9. Which one of the following reactions is allowed? **[GATE 2004]**

(a) $p\rightarrow n+e^{+}$ (b) $p\rightarrow e^{+}+\nu_e$ (c) $p\rightarrow \pi^{+}+\gamma$ (d) $\overline{p}+n\rightarrow \pi^{-}+\pi^{0}$

10. Which of the following decay is forbidden? **[GATE 2005]**

(a) $\mu^{-}\longrightarrow e^{-}+\nu_\mu+\overline{\nu}_e$ (b) $\pi^{+}\longrightarrow \mu^{+}+\nu_\mu$

(c) $\pi^{+}\longrightarrow e^{+}+\nu_e$ (d) $\mu^{-}\longrightarrow e^{+}+e^{-}+e^{-}$

11. The interaction potential between two quarks, separated by a distance r inside a nucleon, can be described y (a, b and β are positive cosntants) **[GATE 2006]**

(a) $ae^{-\beta r}$ (b) $\frac{a}{r}+br$ (c) $-\frac{a}{r}+br$ (d) $\frac{a}{r}$

12. Which one of the following nuclear processes is forbidden? **[GATE 2006]**

(a) $\overline{\nu}+p\rightarrow n+e^{+}$ (b) $\pi^{-}\rightarrow e^{-}+\nu_e+\pi^{0}$

(c) $\pi^{-}+p\rightarrow n+K^{+}+K^{-}$ (d) $\mu^{-}\rightarrow e^{-}+\overline{\nu}_e+\nu_\mu$

13. Weak nuclear forces act on [GATE 2006]
(a) both hadrons and leptons (b) hadrons only
(c) all particles (d) all charged particles

14. The strangeness quantum number is conserved in [GATE 2007]
(a) strong, weak and electromagnetic interactions
(b) weak and electromagnetic interactions
(c) strong and weak interactions
(d) strong and electromagnetic interactions.

15. The strange baryon Σ^+ has the quark structure [GATE 2007]
(a) uds (b) uud (c) uus (d) $u\bar{s}$

16. According to the quark model, the K^+ meson is composed which of the following quarks
(a) uud (b) $u\bar{c}$ (c) $u\bar{s}$ (d) $s\bar{u}$ [GATE 2008]

17. In the quark model which one of the following represents a proton? [GATE 2009]
(a) udd (b) uud (c) $u\bar{b}$ (d) $c\bar{c}$

18. The quark content of Σ^+, K^-, π^- and p is indicated. [GATE 2010]

$|\Sigma^+\rangle = |\mathrm{uus}\rangle$; $|K^-\rangle = |\mathrm{s\bar{u}}\rangle$; $|\pi^-\rangle = |\mathrm{d\bar{u}}\rangle$; $|p\rangle = |\mathrm{uud}\rangle$

In the process $\pi^- + p \to K^- + \Sigma^+$;

Considering strong interactions only, which of the following is true?
(a) the process is allowed because, $\Delta S = 0$
(b) the process is allowed because, $\Delta I_3 = 0$
(c) the process is not allowed because, $\Delta S \neq 0$ and $\Delta I_3 \neq 0$
(d) the process is not allowed because the baryon number is violated.

19. The isospin and the strangeness of Ω^- baryon are [GATE 2011]
(a) 1, –3 (b) 0, –3 (c) 1, 3 (d) 0, 3

20. Which one of the following sets corresponds to fundamental particles? [GATE 2012]
(a) proton, electron and neutron (b) proton, electron and photon
(c) electron, photon and neutrino (d) quark, electron and meson

21. The decay process $n \to p^+ + e^- + \bar{\nu}_e$ violates [GATE 2013]
(a) baryon number (b) lepton number (c) isospin (d) strangeness

22. The isospin (I) and baryon number (B) of the upquark is [GATE 2013]
(a) $I = 1, B = 1$ (b) $I = 1, B = 1/3$ (c) $I = 1/2, B = 1$ (d) $I = 1/2, B = 1/3$

23. Consider the decay of a pion into a muon and an anti-neutrino $\pi^- \to \mu^- + \bar{\nu}_\mu$ in the pion rest frame.

$m_\pi = 139.6\,\mathrm{MeV/c^2}$, $m_\mu = 105.7\,\mathrm{MeV/c^2}$, $m_\nu \approx 0$. The energy (in MeV) of the emitted neutrino, to the nearest integer is ______. [GATE 2013]

24. The decay $\mu^+ \to e^+ + \gamma$ is forbidden, because it violates [GATE 2015]
(a) momentum and lepton number conservations
(b) baryon and lepton number conservations
(c) angular momentum conservation
(d) lepton number conservation

25. In the $SU(3)$ quark model, the triplet of mesons (π^+, π^0, π^-) has [GATE 2016]

(a) Isospin = 0, Strangeness = 0
(b) Isospin = 1, Strangeness = 0
(c) Isospin = ½, Strangeness = +1
(d) Isospin = ½, Strangeness = –1

26. Electromagnetic interactions are : [GATE 2017]

(a) C conserving
(b) C non-conserving but CP conserving
(c) CP non-conserving but CPT conserving
(d) CPT non-conserving

27. Which one of the following conservation laws is violated in the decay $\tau^+ \to \mu^+\mu^+\mu^-$ [GATE 2017]

(a) Angular momentum
(b) Total Lepton number
(c) Electric charge
(d) Tau number

28. Consider the reaction ${}^{54}_{25}Mn + e^- \to {}^{54}_{24}Cr + X$. The particle X is [GATE 2016]

(a) γ (b) ν_e (c) n (d) π^0

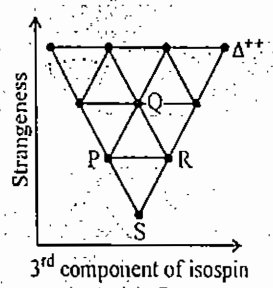
29. In the nuclear reaction ${}^{13}C_6 + \nu_e \to {}^{13}N_7 + X$, the particle X is [GATE 2017]

(a) an electron (b) an anti-electron (c) a muon (d) a pion

30. Among electric field $(\vec{E})$, magnetic field $(\vec{B})$, angular momentum $(\vec{L})$, and vector potential $(\vec{A})$, which is/are odd under parity (space inversion) operation? [GATE 2018]

(a) $\vec{E}$ only (b) $\vec{E}$ and $\vec{A}$ only (c) $\vec{E}$ and $\vec{B}$ only (d) $\vec{B}$ and $\vec{L}$ only

31. The elementary particle Ξ^0 is placed in the baryon decuplet, shown below, at [GATE 2018]



(a) P (b) Q (c) R (d) S

32. In the decay, $\mu^+ \to e^+ + \nu_e + X$, what is X? [GATE 2018]

(a) γ (b) $\bar{\nu}_e$ (c) ν_μ (d) $\bar{\nu}_\mu$

ANSWER KEY

1. (b)	2. (c)	3. (c)	4. (c)	5. (b)	6. (b)	7. (d)
8. (a)	9. (d)	10. (d)	11. (c)	12. (b)	13. (c)	14. (d)
15. (c)	16. (c)	17. (b)	18. (c)	19. (b)	20. (c)	21. (c)
22. (d)	23. (30)	24. (d)	25. (b)	26. (c)	27. (b)	28. (b)
29. (a)	30. (b)	31. (c)	32. (d)			

CSIR-UGC-NET Previous Years' Questions

1. Consider the following particles: the proton p, the neutron n, the neutral pion π^0 and the delta resonance Δ^+. When ordered in terms of decreasing lifetime, the correct arrangement is as follows: **[NET Dec. 2012]**

(a) π^0, n, p, Δ^+ (b) p, n, Δ^+, π^0 (c) p, n, π^0, Δ^+ (d) Δ^+, n, π^0, p

2. The recently-discovered Higgs boson at the LHC experiment has a decay mode into a photon and a Z boson. If the rest masses of the Higgs and Z boson are 125 GeV/c^2 and 90 GeV/c^2 respectively, and the decaying Higgs particle is at rest, the energy of the photon will approximately be **[NET June 2014]**

(a) $35\sqrt{3}$ GeV (b) 35 GeV (c) 30 GeV (d) 15 GeV

3. 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? **[NET June 2015]**

(a) $I_3 + \frac{1}{2}(B - S - C)$ (b) $I_3 + \frac{1}{2}(B - S + C)$

(c) $I_3 + \frac{1}{2}(B + S - C)$ (d) $I_3 + \frac{1}{2}(B + S + C)$

4. A particle, which is a composite state of three quarks u, d and s, has electric charge, spin and strangeness respectively, equal to **[NET Dec. 2016]**

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

5. A baryon X decays by strong interaction as $X \to \Sigma^+ + \pi^- + \pi^0$, where Σ^+ is a member of the isotriplet $(\Sigma^+, \Sigma^0, \Sigma^-)$. The third component I_3 of the isospin of X is **[NET June 2017]**

(a) 0 (b) 1/2 (c) 1 (d) 3/2

6. Which of the following elementary particle processes does not conserve strangeness? **[NET June 2018]**

(a) $\pi^0 + p \to K^+ + \Lambda^0$ (b) $\pi^- + p \to K^0 + \Lambda^0$

(c) $\Delta^0 \to \pi^0 + n$ (d) $K^0 \to \pi^+ + \pi^-$

ANSWER KEY

1. (c) 2. (c) 3. (d) 4. (c) 5. (a) 6. (d)

TIFR Previous Years' Questions

1. Consider the hyperon decay (1) $\Lambda \to n + \pi^0$ followed by (2) $\pi^0 \to \gamma\gamma$. If the isospin component, baryon number and strangeness quantum numbers are denoted by I_z, B and S respectively, then which of the following statements is completely correct? [TIFR 2016]

(a) In (1) I_z is not conserved, B is conserved, S is not conserved;
In (2) I_z is conserved, B is conserved, S is conserved.

(b) In (1) I_z is conserved, B is not conserved, S is not conserved;
In (2) I_z is conserved, B is conserved, S is conserved.

(c) In (1) I_z is not conserved, B is conserved, S is not conserved;
In (2) I_z is not conserved, B is conserved, S is conserved.

(d) In (1) I_z is not conserved, B is conserved, S is conserved;
In (2) I_z is conserved, B is conserved, S is conserved.

ANSWER KEY

1. (a)

JEST Previous Years' Questions

1. A K-meson (with a rest mass of 494 MeV) at rest decays into a muon (with a rest mass of 106 MeV) and a neutrino. The energy of the neutrino, which can be taken as massless, approximately
(a) 120 MeV (b) 236 MeV (c) 300 MeV (d) 388 MeV **[JEST 2013]**

2. The reaction $e^{+} + e^{-} \rightarrow \gamma$ is forbidden because, **[JEST 2015]**
(a) lepton number is not conserved (b) linear memementum is not conserved
(c) angular momentum is not conserved (d) charge is not conserved

ANSWER KEY

1. (b) **2. (b)**

GATE Previous Years' Questions

1. An admissible potential between the proton and the neutron in a deutron is [GATE 2000]
(a) Coulomb (b) Harmonic oscillator
(c) Finite square potential (d) Infinite square well.

2. Nuclear forces are [GATE 2002]
(a) spin dependent and have no non-central part
(b) spin dependent and have a non-central part
(c) spin independent and have no non-central part
(d) spin independent and have a non-central part

3. With reference to nuclear forces which of the following statements is NOT true? [GATE 2005]
The nuclear forces are
(a) short range (b) charge independent (c) velocity dependent (d) spin independent

4. To explain the observed magnetic moment of deutron (0.8574 μ_N), its ground state wavefunction is taken to be an admixture of S and D states, the expectation values of the z-component of the magnetic momenta in pure S and pure D-states are 0.8797 μ_N and 0.3101 μ_N respectively. The contribution of the D-state to the mixed ground state is approximately [GATE 2006]
(a) 40% (b) 4% (c) 0.4% (d) 0.04%

5. In the deuterium + tritium ($d+t$) fusion more energy is released as compared to deuterium + deuterium ($d+d$) fusion because [GATE 2007]
(a) tritium is radioactive
(b) more nucleus participate in fusion
(c) the coulomb parrier is lower for the $d+t$ system then ($d+d$) system
(d) the reaction product ^{4}He is more tightly bound

6. A heavy nucleus is found to contain more neutrons than protons. This fact is related to which one of the following statement [GATE 2008]
(a) the nuclear force between neutrons is stronger than that between protons.
(b) the nuclear force between protons is of a shorter range than those between neutrons, so that a smaller number of protons are held together by the nuclear force.
(c) protons are unstable, to their number in a nucleus diminishes.
(d) it costs more energy to add a proton to a (heavy) nucleus than a neutron because of the Coulomb repulsion between protons.

7. 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

8. A neutron passing through a detector is detected because of [GATE 2011]
(a) the ionization it produces
(b) the scintillation light it produces
(c) the electron-hole pair it produces
(d) the secondary particles produced in a nuclear reaction in the detector medium.

9. In case of a Geiger-Muller (GM) counter, which one of the following statements is **CORRECT**? [GATE 2012]

(a) Multiplication factor of the detector is of the order of 10^{10}.

(b) Type of the particles detected can be identified.

(c) Energy of the particles detected can be distinguished.

(d) Operating voltage of the detector is few tens of Volts.

10. Deuteron has only one bound state with spin parity 1^+, isospin 0 and electric quadrupole moment 0.286 efm^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

11. The value of the magnetic field required to maintain non-relativistic protons of energy 1 MeV in a circular orbit of radius 100 mm is ________ Tesla. [GATE 2014]

(Given: $m_p = 1.67\times10^{-27}$ kg, $e = 1.6\times10^{-19}$ C

12. Which of the following statements is **NOT** correct? [GATE 2016]

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

(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

ANSWER KEY

1. (d)	2. (b)	3. (d)	4. (b)	5. (a)	6. (d)	7. (d)
8. (d)	9. (a)	10. (d)	11. (1.44)	12. (c)		

TIFR Previous Years' Questions

1. An atom is capable of existing in two states: a ground state of mass M and an excited state of mass $M + \Delta$. If the transtion from the ground state to the excited state proceeds by the absorption of a photon, the photon frequency in the laboratory frame (where the atom is initially at rest) is **[TIFR 2010]**

(a) $\frac{\Delta c^2}{h}$ (b) $\frac{\Delta c^2}{h}\left(1+\frac{\Delta}{2M}\right)$ (c) $\frac{Mc^2}{h}$ (d) $\frac{\Delta c^2}{h}\left(1-\frac{\Delta}{2M}\right)$

(e) $\frac{Mc^2}{h}\left(1+\frac{\Delta}{2M}\right)$ (f) $\frac{Mc^2}{h}\left(1-\frac{\Delta}{2M}\right)$

ANSWER KEY

1. (b)

JEST Previous Years' Questions

1. The binding energy of the k-shell electron in a Uranium atom (Z = 92, A = 238) will be modified due to (i) screening caused by other electrons and (ii) the finite extent of the nucleus as follows: [JEST 2013]
 (a) increases due to (i), remains unchanged due to (ii).
 (b) decreases due to (i), decreases due to (ii).
 (c) increases due to (i), increases due to (ii).
 (d) decreases due to (i), remains unchanged due to (ii).

ANSWER KEY

1. (b)

LEVEL-2

Solve Yourself

GATE Previous Years' Questions

1. As one moves along the line of stability from ^{56}Fe to ^{235}U nucleus, the nuclear binding energy per particle decreases from about 8.8 MeV to 7.6 MeV. This trend is mainly due to the:
(a) short range nature of the nuclear forces. [GATE 2004]
(b) long range nature of the coulomb forces.
(c) tensor nature of the nuclear forces.
(d) spin dependence of the nuclear forces.

2. The experimentally measured spin g-factors of proton and neutron indicate that [GATE 2006]
(a) both proton and neutron are elementary point particles.
(b) both proton and neutron are not elementary point particles.
(c) while proton is an elementary point particle, neutron is not
(d) while neutron is an elementary point particle, proton is not.

3. A particle is confined within a spherical region of radius one femtometer (10^{-15} m). Its momentum can be expressed to be about [GATE 2010]

(a) $20\frac{keV}{c}$ (b) $200\frac{keV}{c}$ (c) $200\frac{MeV}{c}$ (d) $2\frac{GeV}{c}$

4. The mean kinetic energy of a nucleon in a nucleus of atomic weight A varies as A^n, where n is______ (upto two decimal places) [GATE 2015]

ANSWER KEY

1. (b) 2. (b) 3. (c) 4. (−0.66 to −0.67)

CSIR-UGC-NET Previous Years' Questions

1. The radius of a $^{64}_{29}Cu$ nucleus is measured to be 4.8×10^{-13} cm. [NET June 2011]

(A) The radius of a $^{27}_{12}Mg$ nucleus can be estimated to be

(a) 2.86×10^{-13} cm (b) 5.2×10^{-13} cm (c) 3.6×10^{-13} cm (d) 8.6×10^{-13} cm

(B) The root-mean-square (rms) energy of a nucleon in a nucleus of atomic number A in its ground state varies as:

(a) $A^{4/3}$ (b) $A^{1/3}$ (c) $A^{-1/3}$ (d) $A^{-2/3}$

2. The intrinsic electric dipole moment of a nucleus $^{A}_{Z}X$ [NET Dec. 2013]

(a) increases with Z, but independent of A
(b) decreases with Z, but independent of A
(c) is always zero
(d) increases with Z and A

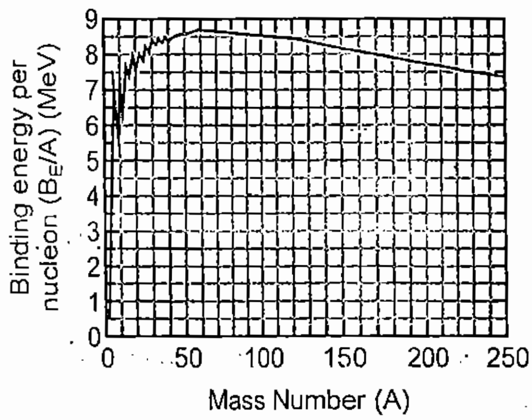
ANSWER KEY

1_A(c) 1_B(d) 2. (c)

TIFR Previous Years' Questions

1. A proton is accelerated to a high energy E and shot at a nucleus of Oxygen $\left({}^{16}_{8}O\right)$. In order to penetrate the Coulomb barrier and reach the surface of the Oxygen nucleus, E must be at least [TIFR 2012]
(a) 3.6 MeV (b) 1.8 MeV (c) 45 keV (d) 180 eV

2. In a theoretical model of the nucleus, the binding energy per nucleon was predicted as shown in the figure below.



If a nucleus of mass number A = 240 undergoes a symmetric fission to two daughter nuclei each of mass number A = 120, write down the amount of energy released in this process, in units of MeV, using this theoretical model. [TIFR 2017]

ANSWER KEY

1. (a) 2. (240)

Other Examinations Previous Years' Questions

1. A neutron of mass $m_n = 10^{-27}$ kg is moving inside a nucleus. Assume the nucleus to be a cubical box of size 10^{-14} m with impenetrable walls. Take $\hbar \approx 10^{-34}$ Js and $1\ \text{MeV} \approx 10^{-13}\ \text{J}$. An estimate of the energy in MeV of the neutron is:

   (a) 80 MeV (b) $\frac{1}{8}$ MeV (c) 8 MeV (d) $\frac{1}{80}$ MeV

2. According to the uncertainty principle, the kinetic energy of an electron confined to a spherical region of volume 10^{-33} m^3 is of the order of

   (a) 10^{-10} J (b) 10^{-12} J (c) 10^{-14} J (d) 10^{-16} J

3. The radius of the nucleus of the Ra atom, which carries an electric charge +88e, is 7.0×10^{-15} m. What should roughly be the speed of a proton, if it has to reach as close as 1.0×10^{-14} m from the centre of the nucleus?[The radius of the cloud of orbital electrons of the Ra atom is approximately 5.0×10^{-11}m.]

   (a) 6.7×10^{9} m/s (b) 3.1×10^{8} m/s (c) 1.4×10^{5} m/s (d) 4.9×10^{7} m/s

ANSWER KEY

1. (c) 2. (b) 3. (d)

GATE Previous Years' Questions

1. The nuclear spins of ${}_6C^{14}$ and ${}_{12}Mg^{25}$ nuclei are respectively, [GATE 2002]

(a) zero and half integer (b) half integer and zero

(c) an integer and half integer (d) both half integer

2. The following gives a list of pairs containing [GATE 2008]

(i) a nucleus (ii) one of its properties

Find the pair which is in appropriate.

(a) (i) ${}_{10}Ne^{20}$ nucleus, (ii) stable nucleus;

(b) (i) a spheroidal nucleus, (ii) an electric quadrupole moment;

(c) (i) ${}_8O^{16}$ nucleus, (ii) nucleus spin $J = \frac{1}{2}$;

(d) (i) U^{238} nucleus, (ii) binding energy = 1785 MeV (approx);

3. The mass difference between the pair of mirror nuclei ${}_6C^{11}$ and ${}_5B^{11}$ is given to be $\Delta MeV/c^2$. According to the semi empirical mass formula, the mass difference between the pair of mirror nuclei ${}_9^{17}F$ and ${}_8^{17}O$ will approximately be (rest mass of proton m_p = 938.27 MeV/c^2 and rest mass of neutron m_n = 939.57 MeV/c^2). [GATE 2008]

(a) $1.39\,\Delta MeV/c^2$ (b) $(1.39\Delta + 0.5)MeV/c^2$

(c) $1.86\,\Delta MeV/c^2$ (d) $(1.6\Delta + 0.78)MeV/c^2$

4. Consider the following expression for the mass of a nucleus with Z protons and A nucleons.

$$M(A,Z) = \frac{1}{c^2}\left[f(A) + yZ + zZ^2\right]$$

Here, $f(A)$ is a function of A. [GATE 2009]

$$y = -4a_A$$

$$z = a_c A^{-1/3} + 4a_A A^{-1}$$

a_A and a_c are constants of suitable dimensions. For a fixed A, the expression of Z for the most stable nucleus is

(a) $Z = \frac{A/2}{\left[1 + \left(\frac{a_c}{a_A}\right)A^{2/3}\right]}$ (b) $Z = \frac{A/2}{\left[1 - \left(\frac{a_c}{4a_A}\right)A^{2/3}\right]}$

(c) $Z = \frac{A/2}{\left[1 + \left(\frac{a_c}{4a_A}\right)A^{2/3}\right]}$ (d) $Z = \frac{A}{\left(1 + A^{2/3}\right)}$

5. The first three energy level of $^{228}Th_{90}$ are shown below [GATE 2010]

4^+ ———————— 187 keV

2^+ ———————— 57.5 keV

0^+ ———————— 0 keV

The expected spin-parity and energy of the next level are given by

(a) (6^+; 400 keV) (b) (6^+; 300 keV) (c) (2^+; 400 keV) (d) (4^+; 300 keV)

6. Total binding energies of O^{15}, O^{16} and O^{17} are 111.96 MeV, 127.62 MeV and 131.76 MeV, respectively. The energy gap between $^1p_{1/2}$ and $^1d_{5/2}$ neutron shells for the nuclei whose mass number is close to 16, is: [GATE 2012]

(a) 4.1 MeV (b) 11.5 MeV (c) 15.7 MeV (d) 19.8 MeV

7. The electromagnetic form factor $F(q^2)$ of a nucleus is given by, $F(q^2) = \exp\left[-\dfrac{q^2}{2Q^2}\right]$ [GATE 2013]

where Q is a constant. Given that $F(q^2) = \dfrac{4\pi}{q}\int_0^\infty r\,dr\,\rho(r)\sin qr$

$$\int d^3r\,\rho(r) = 1$$

where $\rho(r)$ is the charge density, the root mean square radius of the nucleus is given by

(a) $1/Q$ (b) $\sqrt{2}/Q$ (c) $\sqrt{3}/Q$ (d) $\sqrt{6}/Q$

Statement for Linked Answer Q. 8 and Q.9:

In the Schmidt model of nuclear magnetic moments, we have,

$$\vec{\mu} = \frac{e\hbar}{2Mc}(g_l\vec{l} + g_s\vec{S})$$

where the symbols have their usual meaning

8. For the case $J = l + 1/2$, where J is the total angular momentum, the expectation value of $\vec{S}.\vec{J}$ in the nuclear ground state is equal to, [GATE 2013]

(a) $(J-1)/2$ (b) $(J+1)/2$ (c) $J/2$ (d) $-J/2$

9. For the O^{17} nucleus (A = 17, Z = 8), the effective magnetic moment is given by,

$$\vec{\mu}_{eff} = \frac{e\hbar}{2Mc}g\vec{J}$$

where g is equal to, (g_s = 5.59 for proton and −3.83 for neutron) [GATE 2013]

(a) 1.12 (b) −0.77 (c) −1.28 (d) 1.28

ANSWER KEY

1. (a) 2. (c) 3. (b) 4. (c) 5. (a) 6. (b) 7. (c)
8. (b) 9. (b)

CSIR-UGC-NET Previous Years' Questions

1. The difference in the Coulomb energy between the mirror nuclei ${}^{49}_{24}Cr$ and ${}^{49}_{25}Mn$ is 6.0 MeV. Assuming that the nuclei have a spherically symmetric charge distribution and that e^2 is approximately 1.0 MeV-fm, the radius of the ${}^{49}_{25}Mn$ nucleus is [NET Dec. 2011]

(a) 4.9×10^{-13} m (b) 4.9×10^{-15} m (c) 5.1×10^{-13} m (d) 5.1×10^{-15} m

2. According to the shell model the spin and parity of the two nuclei ${}^{125}_{51}Sb$ and ${}^{89}_{38}Sr$ are, respectively.

[NET Dec. 2011]

(a) $\left(\frac{5}{2}\right)^+$ and $\left(\frac{5}{2}\right)^+$ (b) $\left(\frac{5}{2}\right)^+$ and $\left(\frac{7}{2}\right)^+$ (c) $\left(\frac{7}{2}\right)^+$ and $\left(\frac{5}{2}\right)^+$ (d) $\left(\frac{7}{2}\right)^+$ and $\left(\frac{7}{2}\right)^+$

3. The single particle energy difference between the p-orbitals (i.e. $p_{3/2}$ and $p_{1/2}$) of the nucleus ${}^{114}_{50}Sn$ is 3 MeV. The energy difference between the states in its $1f$ orbital is [NET Dec. 2012]

(a) –7 MeV (b) 7 MeV (c) 5 MeV (d) – 5 MeV

4. The binding energy of a light nucleus (Z, A) in MeV is given by the approximate formula

$$B(A,Z)\approx16A-20A^{2/3}-\frac{3}{4}Z^2A^{-1/3}+30\frac{(N-Z)^2}{A}$$ [NET June 2013]

where N = A – Z is the neutron number. The value of Z of the most stable isobar for a given A is

(a) $\frac{A}{2}\left(1-\frac{A^{2/3}}{160}\right)^{-1}$ (b) $\frac{A}{2}$ (c) $\frac{A}{2}\left(1-\frac{A^{2/3}}{120}\right)^{-1}$ (d) $\frac{A}{2}\left(1+\frac{A^{4/3}}{64}\right)$

5. If the binding energy B of a nucleus (mass number A and charge Z) is given by [NET Dec. 2014]

$B=a_VA-a_SA^{2/3}-a_{sym}\frac{(2Z-A)^2}{A}-\frac{a_cZ^2}{A^{1/3}}$ where $a_V=16$ MeV, $a_S=16$ MeV, $a_{sym}=24$ MeV and $a_c=0.75$ MeV, then the Z for the most stable isobar for a nucleus with $A=216$ is

(a) 68 (b) 72 (c) 84 (d) 92

6. 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 $R_0=1.2$ fm, what is the value, in barn, of the quadrupole moment of the ${}^{27}Al$ nucleus in the shell model? [NET Dec. 2015]

(a) 0.043 (b) 0.023 (c) 0.915 (d) 0

7. Let E_S denote the contribution of the surface energy per nucleon in the liquid drop model. The ratio $E_S\left({}^{27}_{13}Al\right):E_S\left({}^{64}_{30}Zn\right)$ is [NET June 2016]

(a) 2:3 (b) 4:3 (c) 5:3 (d) 3:2

8. According to the shell model, the nuclear magnetic moment of the $^{27}_{13}Al$ nucleus is (Given that for a proton $g_l = 1$, $g_s = 5.586$, and for a neutron $g_l = 0$, $g_s = -3.826$). [NET June 2016]

(a) $-1.913\,\mu_N$ (b) $14.414\,\mu_N$ (c) $4.793\,\mu_N$ (d) 0

9. The spin-parity assignments for the ground and first excited states of the isotrope $^{57}_{28}Ni$, in the single particle shell model, are [NET Dec. 2017]

(a) $\left(\frac{1}{2}\right)^-$ and $\left(\frac{3}{2}\right)^-$ (b) $\left(\frac{5}{2}\right)^+$ and $\left(\frac{7}{2}\right)^+$ (c) $\left(\frac{3}{2}\right)^+$ and $\left(\frac{5}{2}\right)^+$ (d) $\left(\frac{3}{2}\right)^-$ and $\left(\frac{5}{2}\right)^-$

10. 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 [NET Dec. 2017]

(a) 150 (b) 120 (c) 90 (d) 60

ANSWER KEY

1. (b)	2. (c)	3. (b)	4. (a)	5. (c)	6. (a)	7. (b)
8. (c)	9. (d)	10. (a)				

TIFR Previous Years' Questions

1. The Weizäcker semi-empirical mass formula for an odd nucleus with Z protons and A nucleons may be written as $M(Z, A) = \alpha_1 A + \alpha_2 A^{2/3} + \alpha_3 Z + \alpha_4 Z^2$ where the α_i are constants independent of Z, A. For a given A, if Z_A is the number of photons of the most stable isobar, the total energy released when an unstable nuclide undergoes a single β^- decay to (Z_A, A) is [TIFR 2016]

(a) α_3 (b) α_4 (c) $\alpha_4 - \alpha_3$ (d) $\alpha_1 + \alpha_2$

ANSWER KEY

1. (b)

GATE Previous Years' Questions

1. A nucleus having mass number 240 decays by a emission to the grond state of its daughter nucleus. The Q value of the process is 5.26 MeV. The energy (in MeV) of the a particle is: [GATE 2005]
(a) 5.26 (b) 5.17 (c) 5.13 (d) 5.09

Statement for Linked Answer Q.2 and Q.3

Consider the β-decay of a free neutron at rest in the laboratory.

2. Which of the following configurations of the decay products correspond to the largest energy of the anti-neutrino $\bar{\nu}$? (rest mass of electron, $m_e = 0.51\ MeV/c^2$, rest mass of proton $m_p = 938.27\ MeV/c^2$ and rest mass of neutron $m_n = 939.57\ MeV/c^2$) [GATE 2008]
(a) In the laboratory, proton is produced at rest
(b) In the laboratory, momenta of proton, electron and the anti-neutrino all have the same magnitude.
(c) In the laboratory, proton and electron fly-off with (nearly) equal and opposite momenta.
(d) In the laboratory, electron is produced at rest.

3. Using the result of above problem, answer the following. Which of the following represents approximately the maximum allowed energy of the anti-neutrino $\bar{\nu}$? [GATE 2008]
(a) 1.3 MeV (b) 0.8 MeV (c) 0.5 MeV (d) 2.0 MeV

4. In the β-decay process, the transition $2^+ \to 3^+$, is [GATE 2013]
(a) allowed both by Fermi and Gamow-Teller selection rule
(b) allowed by Fermi and but not by Gamow-Teller selection rule
(c) not allowed by Fermi but allowed by Gamow-Teller selection rule
(d) not allowed both by Fermi and Gamow-Teller selection rule

5. A nucleus X undergoes a first forbidden β-decay to a nucleus Y. If the angular momentum (I) and parity (P), denoted by I^P as $\frac{7^-}{2}$ for X, which of the following is a possible I^P value for Y?
(a) $\frac{1^+}{2}$ (b) $\frac{1^-}{2}$ (c) $\frac{3^+}{2}$ (d) $\frac{3^-}{2}$ [GATE 2014]

6. A beam of X-ray of intensity I_0 is incident normally on a metal sheet of thickness 2 mm. The intensity of the transmitted beam is $0.025I_0$. The linear absorption coefficient of the metal sheet (in m^{-1}) is ________ (upto one decimal place) [GATE 2015]

7. An α particle is emitted by a $^{230}_{90}Th$ nucleus. Assuming the potential to be purely Coulombic beyond the point of separation, the height of the Coulomb barrier is _______ MeV (up to two decimal places).
$\left(\frac{e^2}{4\pi\varepsilon_0} = 1.44\ \text{MeV-fm},\ r_0 = 1.30\ \text{fm}\right)$ [GATE 2018]

ANSWER KEY

1. (b) 2. (d) 3. (b) 4. (c) 5. (c) 6. (1844.4)
7. (25.38)

CSIR-UGC-NET Previous Years' Questions

1. The ground state of $^{207}_{82}Pb$ nucleus has spin-parity $J^P = \frac{1^-}{2}$, while the first excited state has $J^P = \frac{5^-}{2}$. The electromagnetic radiation emitted when the nucleus makes a transition from the first excited state to the ground state are **[NET June 2012]**
(a) E2 and E3 (b) M2 and E3 (c) E2 and M3 (d) M2 and M3

2. 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 **[NET June 2016]**
(a) $\frac{1}{2}\lambda_1\lambda_2 N_0 t^2$ (b) $\frac{\lambda_1\lambda_2}{2(\lambda_1+\lambda_2)}N_0 t$ (c) $(\lambda_1+\lambda_2)^2 N_0 t^2$ (d) $(\lambda_1+\lambda_2)N_0 t$

ANSWER KEY

1. (c) **2. (a)**

TIFR Previous Years' Questions

1. A detector is used to count the numbr of γ-rays emitted by a radioactive source. If the number of counts recorded in exactly 20 seconds is 10000, the error in the counting rate per second is [TIFR 2010]

(a) ± 5.0 (b) ± 22.4 (c) ± 44.7 (d) ± 220.0

2. A lead container contains 1 gm of a $^{60}_{27}Co$ radioactive source. It is known that a $^{60}_{27}Co$ nucleus emits a β-particle of energy 316 KeV followed by two γ-emissions of energy 1173 and 1333 KeV respectively. Which of the following experimental methods would be the best way to determine the lifetime of the $^{60}_{27}Co$ source?

(a) Measure the change in temperature of the source [TIFR 2010]

(b) Measure the weight of the source now and again after one year

(c) Measure the recoil momentum of the nucleus during β-emission

(d) Measure the number of γ-photons emitted by this source

3. An excited atomic electron undergoes a spontaneous transition, $3d_{3/2} \to 2p_{1/2}$ [TIFR 2011]
The interaction responsible for this transition must be of the type

(a) electric dipole (E1) OR magnetic quadrupole (M2)

(b) electric dipole (E1) OR magnetic dipole (M1)

(c) electric quadrupole (E2) OR magnetic quadrupole (M2)

(d) electric quadrupole (E2) OR magnetic dipole (M1)

4. A cloud Chamber of width 0.01 m is filled with pure nitrogen gas (N_2) at normal temperature and pressure. A beam of α–particles, when incident normally on the chamber, make tracks which are visible under strong illumination. Whenever an α–particle $\left(^4_2He\right)$ has a nuclear collision with a $^{14}_{7}N$ nucleus, the track shows a distinct bend. The radius of a nucleus is given by $r = r_0 A^{1/3}$ where $r_0 = 1.217 \times 10^{-15}$ m and A is the atomic mass number. If the α particles move at non-relativistic speeds, and the total number of incident α particles is 10^7, the number of such distinct bends is approximately. [TIFR 2011]

(a) 100 (b) 200 (c) 300 (d) 400
(e) 500 (f) 600

5. Let E_N be the energy released when one mole of pure ^{235}U undergoes controlled fission, and E_C be the energy released when one mole of pure carbon undergoes complete combustion. The ratio E_N/E_C will have the order of magnitude [TIFR 2013]

(a) 10^4 (b) 10^8 (c) 10^9 (d) 10^6

6. A standard radioactive source is known to decay by emission of γ-rays. The source is provided to a student in a thick sealed capsule of unbreakable plastic and she is asked to find out the half-life. Which of the following would be the most useful advice to the student? [TIFR 2014]

(a) The half-life cannot be measured because the initial concentration of the source is not given.

(b) Mount the source in front of a gamma ray detector and count the number of photons detected in one hour.

(c) Measure the mass of the source at different times with an accurate balance having a least count of 1 mg. Plot these values on a curve and fit it with an exponential decay law.

(d) Mount the source in front of a gamma ray detector and count the number of photons detected in a specific time interval. Repeat this experiment at different times and note how the count changes.

7. Which of the following radioactive decay chains is it possible to observe ? **[TIFR 2015]**

(a) ${}^{206}_{82}Pb \to {}^{202}_{80}Hg \to {}^{202}_{79}Au$ (b) ${}^{210}_{83}Bi \to {}^{210}_{84}Po \to {}^{206}_{82}Pb$

(c) ${}^{214}_{88}Ra \to {}^{210}_{86}Rn \to {}^{207}_{82}Pb$ (d) ${}^{206}_{82}Pb \to {}^{202}_{80}Hg \to {}^{202}_{79}Au$

8. In an experiment, ${}^{197}_{79}Au$ nuclei were bombarded with neutrons leading to formation of ${}^{198}_{79}Au$, which is unstable. The half-life of ${}^{198}_{79}Au$ was measured to be 2.25 days and it was found later that this measured half-life was an underestimate by 10%. The corresponding percentage error in the estimated population of ${}^{198}_{79}Au$ after 9 days is **[TIFR 2015]**

(a) 10% (b) 25% (c) 2.5% (d) 15%

9. Cosmic ray muons, which decay spontaneously with proper lifetime 2.2 μs, are produced in the atmosphere, at a height of 5 km above sea level. These move straight downwards at 98% of the speed of light. Find the percent ratio $100 \times (N_A/N_B)$ of the number of muons measured at the top of two mountains A and B, which are at heights 4,848 m and 2,682 m respectively above mean sea level. **[TIFR 2017]**

ANSWER KEY

1. (b)	2. (d)	3. (a)	4. ( )	5. (d)	6. (d)	7. (b)
8. (b)	9. (181)					

JEST Previous Years' Questions

1. ^{238}U decays with a half life of 4.51×10^9 years, the decay series eventually ending at ^{206}Pb, which is stable. A rock smaple analysis shows that the ratio of the numbers of atoms of ^{206}Pb to ^{238}U is 0.0058. Assuming that all the ^{206}Pb has been produced by the decay of ^{238}U and that all other half lives in the chain are negligible, the age of rock sample is **[JEST 2013]**
(a) 38×10^6 years (b) 48×10^6 years (c) 38×10^7 years (d) 48×10^7 years

2. In the mixture of isotopes normally found on the earth at the present time, $^{238}_{92}U$ has on aboundance of 99.3% and $^{235}_{92}U$ has an aboundance of 0.7%. The measured lifetimes of these isotopes are 6.52×10^9 years and 1.02×10^9 years respectively. Assuming that they were equally aboundant when the earth was formed, the estimated age of the earth, in years is **[JEST 2014]**
(a) 6.0×10^9 (b) 1.0×10^9 (c) 6.0×10^8 (d) 1.0×10^8

ANSWER KEY

1. (a) **2. (a)**

Other Examinations Previous Years' Questions

1. The activity of a radioactive sample is decreased to 75% of the initial value after 30 days. The half-life (in days) of the sample is approximately [You may use $\ln 3 \approx 1.1$, $\ln 4 \approx 1.4$]
(a) 38 (b) 45 (c) 59 (d) 69

2. The radioactivity of a sample of Co^{55} decreases by 4% every hour. (The decay product is not radioactive). The half-life of Co^{55} is approximately
(a) 1 hour (b) 1 day (c) 1 month (d) 1 year.

3. A radioactive nucleus X decays to Y with a mean lifetime $\tau_2 = (= \tau_1 / 2)$. If N_0 nuclei of X (but no nuclei of Y) are present at t=0, how many nuclei of Y will be there when the number of X nuclei becomes $N_0 / 2$?
(a) $N_0 / 2e$ (b) $N_0 / 4$ (c) $N_0 / 2$ (d) N_0 / e

ANSWER KEY

1. (d) 2. (b) 3. (b)

GATE Previous Years' Questions -

1. An atomic bomb consisting of ^{235}U explodes and releases an energy of 10^{14} J. It is known that each ^{235}U which undergoes fission releases 3 neutrons and about 200 MeV of energy. Further, only 20% of the ^{235}U atoms in the bomb undergoes fission: [GATE 2003]

(i) the total number of neutrons released is about

(a) 4.7×10^{24} (b) 9.7×10^{24} (c) 1.9×10^{25} (d) 3.7×10^{25}

(ii) The mass of ^{235}U in the bomb is about

(a) 1.5 kg (b) 3.0 kg (c) 6.1 kg (d) 12 kg.

2. The threshold temperature above which the thermonuclear reaction: [GATE 2005]

$$^3_2He + ^3_2He \rightarrow ^4_2He + 2^1_1H + 12.86\text{ MeV}$$

can occur is (use $e^2/4\pi\varepsilon_0 = 1.44\times10^{-15}$ MeV-m)

(a) 1.28×10^{10} K (b) 1.28×10^{9} K (c) 1.28×10^{8} K (d) 1.28×10^{7} K

Linked Answer Q.3 and Q.4

A 16 μA beam of alpha particles, having cross-sectional area 10^{-4} m^2, is incident on a Rhodium target of thickness 1 μm. This produces neutrons through the reaction,

$\alpha + ^{100}Rh \longrightarrow ^{101}Pd + 3n$

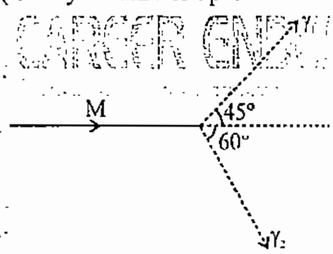
3. The number of α particles hitting the target per second is [GATE 2007]

(a) 0.5×10^{14} (b) 1.0×10^{14} (c) 2.0×10^{20} (d) 4.0×10^{20}

4. The neutrons are observed at the rate of 1.806×10^8 s^{-1}. If the density of rhodium is approximated as 10^4 kg m^{-3} the cross-section for the reaction (in barns) is [GATE 2007]

(a) 0.1 (b) 0.2 (c) 0.4 (d) 0.8

5. A particle of rest mass M is moving along the positive x-direction. It decays into two photons γ_1 and γ_2 as shown in the figure. The energy of γ_1 is 1GeV and the energy of γ_2 is 0.82 GeV. The value of M (in units of GeV/c^2) is ____________ (Give your answer upto two decimal places) [GATE 2016]



6. The π^+ decays at rest to μ^+ and ν_μ. Assuming the neutrino to be massless, the momentum of the neutrino is ________ MeV/c. (up to two decimal places) [GATE 2017]

$\left(m_\pi = 139\text{ MeV}/c^2, m_\mu = 105\text{ MeV}/c^2\right)$.

ANSWER KEY

1_(i)(b) 1_(ii)(c) 2. (a) 3. (b) 4. (a) 5. (1.44)
6. (29.50 to 30.10)

CSIR-UGC-NET Previous Years' Questions

1. 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 ${}_2^4He$, ${}_1^3H$ and ${}_1^1H$ are 4.0026 amu, 3.0161 amu and 1.0073 amu, respectively, and 1 amu $\approx$ 938 MeV). [NET Dec. 2016]
(a) 32.2 MeV (b) 3 MeV (c) 19.3 MeV (d) 931.5 MeV

2. If in a spontaneous α-decay of ${}_{92}^{232}U$ at rest, the total energy released in the reaction is Q, then the energy carried by the α-particle is [NET June 2017]
(a) $\frac{57Q}{58}$ (b) $\frac{Q}{57}$ (c) $\frac{Q}{58}$ (d) $\frac{23Q}{58}$

3. The reaction ${}^{63}Cu_{29} + p \to {}^{63}Zn_{30} + n$ is followed by a prompt β-decay of zinc ${}^{63}Zn_{30} \to {}^{63}Cu_{29} + e^+ + \nu_e$. 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 electrons, proton and neutron to be 0.5 MeV/c^2, 938 MeV/c^2 and 939.5 MeV/c^2, respectively]. [NET June 2018]
(a) −4.4 (b) −2.4 (c) −4.8 (d) −3.4

ANSWER KEY

1. (c) 2. (a) 3. (a)

TIFR Previous Years' Questions

1. In a nuclear reactor, Plutonium ($^{239}_{94}Pu$) is used as fuel, releasing energy by its fission into isotopes of Barium ($^{146}_{54}Ba$) and Strontium ($^{91}_{38}Sr$) through the reaction **[TIFR 2012]**

$$^{239}_{94}Pu + ^{1}_{0}n \longrightarrow ^{146}_{56}Ba + ^{91}_{38}Sr + 3 \times ^{1}_{0}n$$

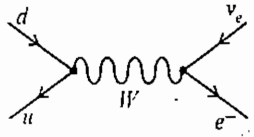
The binding energy ($B.E.$) per nucleon of each of these nuclides is given in the table below:

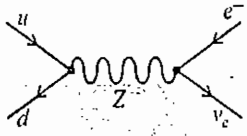
Nuclide	$^{239}_{94}Pu$	$^{146}_{56}Ba$	$^{91}_{38}Sr$
B.E. per nucleon (MeV)	7.6	8.2	8.6

Using this information, one can estimate the number of such fission reactions per second in a 100 MW reactor as

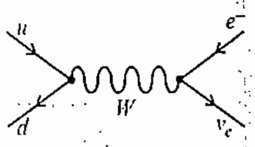
(a) 3.9×10^{18} (b) 7.8×10^{18} (c) 5.2×10^{19} (d) 5.2×10^{18}
(e) 8.9×10^{17}

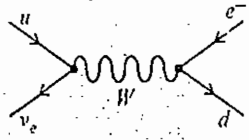
2. The process of electron capture $p + e^- \rightarrow n + \nu_e$ **[TIFR 2013]**
takes place at the quark level through the Feynman diagram

(a) 

(b) 

time

(c) 

(d) 

3. A gold foil, having $N(0)$ number of ^{197}Au nuclides per cm^2, is irradiated by a beam of thermal neutrons with a flux of F neutrons-cm^{-2}-s^{-1}. As a result, the nuclide ^{198}Au, with a half-life τ of several years, is produced by the reaction **[TIFR 2013]**

$$^{197}\text{Au} + n \rightarrow ^{198}\text{Au} + \gamma$$

which has a cross section of σ cm^2. Assuming that the gold foil has 100% abundancy of ^{197}Au nuclides, the maximum number of ^{198}Au nuclides that can accumulate at any time in the foil is proportional to

(a) $\sigma\tau F\, N(0)$ (b) $\frac{\tau}{\sigma F} N(0)$ (c) $\frac{1}{\sigma\tau F} N(0)$ (d) $\frac{\sigma F}{\tau} N(0)$

4. Consider a process in which atoms of Actinium-226 ($^{226}_{89}Ac$) get converted to atoms of Radium-226 ($^{226}_{88}Ra$) and the yield of energy is 0.64 MeV per atom. This occurs through **[TIFR 2016]**

(a) Both $p \rightarrow n + e^+ + \nu_e$ and $p + e^- \rightarrow n + \nu_e$ (b) Both $p \rightarrow n + e^+ + \nu_e$ and $n \rightarrow p + e^- + \bar{\nu}_e$
(c) Only $p \rightarrow n + e^+ + \nu_e$ (d) Only $p + e^- \rightarrow n + \nu_e$

5. A deuteron of mass M and binding energy B is struck by a gamma ray photon of energy E_γ, and is observed to disintegrate into a neutron and a proton. If $B \ll Mc^2$, the minimum value of E_γ must be **[TIFR 2017]**

(a) $2B + \frac{B^2}{2Mc^2}$ (b) $B + \frac{B^2}{Mc^2}$ (c) $\frac{1}{2}\left(3B + \frac{B^2}{Mc^2}\right)$ (d) $\frac{1}{2}\left(2B + \frac{B^2}{Mc^2}\right)$

ANSWER KEY

1. (a) 2. (c) 3. (a) 4. (d) 5. (d)

GATE Previous Years' Questions

1. Identify the reaction which has the same transition probability as $\pi^+ + p \to \pi^+ + p$ [GATE 2000]

(a) $\pi^+ + n \to \pi^+ + n$ (b) $\pi^- + p \to \pi^0 + n$ (c) $\pi + n \to \pi + n$ (d) $\pi^0 + p \to \pi^+ + n$

2. A stationary particle in free space is oberved to spontaneously decay into two photons. This imples that

(a) the particle carries electric charge [GATE 2003]

(b) the spin of the particle must be greater than or equal to 2

(c) the particle is a boson

(d) the mass of the particle must be greater than or equal to the mass of the hydrogen atom

3. A relativistic particle travels a length of 3×10^{-3} m in air before decaying. The decay process of the particle is dominated by: [GATE 2007]

(a) strong interactions (b) electromagnetic interactions.

(c) weak interactions. (d) gravitational interactions

4. Choose the correct statement from the following: [GATE 2008]

(a) The reaction $K^+K^- \longrightarrow p\,\bar{p}$ can proceed irrespective of the kinetic energies of K^+ and K^-.

(b) The reaction $K^+K^- \longrightarrow p\bar{p}$ is forbidden by the Baryon number conservation.

(c) The reaction $K^+K^- \longrightarrow 2\gamma$ is forbidden by strangeness conservation.

(d) The decay $K^0 \longrightarrow \pi^+\pi^-$ proceeds via weak interaction.

5. A neutral pi meson (π^0) has a rest-mass of approximately 140 MeV/c^2 and a lifetime of τ sec. A π^0 produced in the laboratory is found to decay after 1.25 τ sec into two photons. Which of the following sets represents a possible set of energies of the two photons as seen in the laboratory?

(a) 70 MeV and 70 MeV (b) 35 MeV and 100 MeV [GATE 2008]

(c) 75 MeV and 100 MeV (d) 25 MeV and 150 MeV

6. Let $|n\rangle$ and $|p\rangle$ denote the isospin state with $I = \frac{1}{2}, I_3 = \frac{1}{2}$ and $I = \frac{1}{2}, I_3 = -\frac{1}{2}$ of a nuclear respectively.

Which one of the following two nuclear state has $I = 0, I_3 = 0$? [GATE 2009]

(a) $\frac{1}{\sqrt{2}}(|nn\rangle - |pp\rangle)$ (b) $\frac{1}{\sqrt{2}}(|nn\rangle + |pp\rangle)$ (c) $\frac{1}{\sqrt{2}}(|np\rangle - |pn\rangle)$ (d) $\frac{1}{\sqrt{2}}(|np\rangle + |pn\rangle)$

7. The basic process underlying the neutron β-decay is [GATE 2010]

(a) $d \to u + e^- + \bar{\nu}_e$ (b) $d \to u + e^-$ (c) $s \to u + e^- + \bar{\nu}_e$ (d) $u \to d + e^- + \bar{\nu}_e$

8. Match the reactions on the left with the associated interactions on the right [GATE 2010]

(1) $\pi^+ \to \mu^+ + \nu_\mu$ (i) strong

(2) $\pi^0 \to \gamma + \gamma$ (ii) electromagnetic

(3) $\pi^0 + n \to \pi^- + p$ (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

9. Match the typical spectra of stable molecules with the corresponding wave-number range [GATE 2010]

1. Electronic spectra	i. 10^6 cm^{-1} and above
2. Rotational spectra	ii. $10^5 - 10^6$ cm^{-1}
3. Molecular dissociation	iii. $10^0 - 10^2$ cm^{-1}

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

10. Consider the operations $P: \vec{r} \to -\vec{r}$ (parity) and $T: t \to -t$ (time-reversal). For the electric and magnetic fields $\vec{E}$ and $\vec{B}$, which of the following set of transformations is correct? [GATE 2010]

(a) $P: \vec{E} \to -\vec{E}, \vec{B} \to \vec{B}$; $T: \vec{E} \to \vec{E}, \vec{B} \to -\vec{B}$

(b) $P: \vec{E} \to \vec{E}, \vec{B} \to \vec{B}$; $T: \vec{E} \to \vec{E}, \vec{B} \to \vec{B}$

(c) $P: \vec{E} \to -\vec{E}, \vec{B} \to \vec{B}$; $T: \vec{E} \to -\vec{E}, \vec{B} \to -\vec{B}$

(d) $P: \vec{E} \to \vec{E}, \vec{B} \to -\vec{B}$; $T: \vec{E} \to -\vec{E}, \vec{B} \to \vec{B}$

11. Choose the CORRECT statement from the following [GATE 2012]
(a) Neutron interacts through electromagnetic interaction
(b) Electron does not interact through weak interaction
(c) Neutrino interacts through weak and electromagnetic interaction
(d) Quark interacts through strong interaction but not through weak interaction

12. Consider the process $\mu^+ + \mu^- \to \pi^+ + \pi^-$. The minimum kinetic energy of the muons (μ) in the centre of mass frame required to produce the pion (π) pairs at rest is ________ MeV. [GATE 2014]

(Given: $m_\mu = 105$ MeV/c^2, $m_\pi = 140$ MeV/c^2)

13. Which one of the following three-quark states (qqq), denoted by X, CANNOT be a possible baryon? The corresponding electric charge is indicated in the superscript [GATE 2014]

(a) X^{++} (b) X^{+} (c) X^{-} (d) X^{--}

14. Which one of the following high energy processes is allowed by conservation laws? [GATE 2014]

(a) $p + \bar{p} \to \Lambda^0 + \Lambda^0$ (b) $\pi^- + p \to \pi^0 + n$

(c) $n \to p + e^- + \nu_e$ (d) $\mu^+ \to e^- + \gamma$

15. Which one of the following is a fermion? [GATE 2014]

(a) α particle (b) ${}_4Be^7$ nucleus (c) hydrogen atom (d) deuteron

ANSWER KEY

1. (b)	2. (c)	3. (c)	4. (d)	5. (c)	6. (c)	7. (a)
8. (a)	9. (b)	10. (a)	11. (a)	12. (35)	13. (d)	14. (b)
15. (b)						

CSIR-UGC-NET Previous Years' Questions

1. A beam of pions (π^+) is incident on a proton target, giving rise to the process $\pi^+ p \to n + \pi^+ + \pi^+$

(A) Assuming that the decay proceeds through strong interactions, the total isospin I and its third component I_3 for the decay products, are [NET June 2011]

(a) $I=\frac{3}{2}, I_3=\frac{3}{2}$ (b) $I=\frac{5}{2}, I_3=\frac{5}{2}$ (c) $I=\frac{5}{2}, I_3=\frac{3}{2}$ (d) $I=\frac{1}{2}, I_3=-\frac{1}{2}$

(B) Using isospin symmetry, the cross-section for the above process can be related to that of the process

(a) $\pi^- n \to p\pi^-\pi^-$ (b) $\pi^-\bar{p} \to \bar{n}\pi^-\pi^-$ (c) $\pi^+ n \to p\pi^+\pi^-$ (d) $\pi^+\bar{p} \to n\pi^+\pi^-$

2. Consider the decay process $\tau^- \to \pi^- + \nu_\tau$ in the rest frame of the τ^-. The masses of τ^-, π^- and ν_τ are M_τ, M_π and zero repectively. [NET June 2011]

(A) The energy of π^- is:

(a) $\frac{\left(M_\tau^2-M_\pi^2\right)c^2}{2M_\tau}$ (b) $\frac{\left(M_\tau^2+M_\pi^2\right)c^2}{2M_\tau}$ (c) $\left(M_\tau-M_\pi\right)c^2$ (d) $\sqrt{M_\tau M_\pi}\,c^2$

(B) The velocity is π^- is:

(a) $\frac{\left(M_\tau^2-M_\pi^2\right)c}{M_\tau^2+M_\pi^2}$ (b) $\frac{\left(M_\tau^2-M_\pi^2\right)c}{M_\tau^2-M_\pi^2}$ (c) $\frac{M_\pi c}{M_\tau}$ (d) $\frac{M_\tau c}{M_\pi}$

3. An electron of energy 27 GeV collides with a proton of energy 820 GeV. The heaviest particle which can be produced in this collision has mass close to [NET Dec. 2011]

(a) 300 GeV (b) 821 GeV (c) 850 GeV (d) 1127 GeV

4. The dominant interactions underlying the following processes [NET June 2012]

A. $K^- + p \to \Sigma^- + \pi^+$ B. $\mu^- + \mu^+ \to K^- + K^+$ C. $\Sigma^+ \to p + \pi^0$ are

(a) A: strong, B: electromagnetic and C: weak (b) A: strong, B: weak and C: weak

(c) A: weak, B: electromagnetic and C: strong (d) A: weak, B: electromagnetic and C: weak

5. A spin-1/2 particle A undergoes the decay $A \to B + C + D$ where it is known that B and C are also spin-1/2 particles. The complete set of allowed values of the spin of the particle D is [NET June 2013]

(a) $\frac{1}{2}, 1, \frac{3}{2}, 2, \frac{5}{2}, 3, ...$ (b) 0, 1 (c) $\frac{1}{2}$ only (d) $\frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \frac{7}{2}, ...$

6. Muons are produced through the annihilation of particle a and its antiparticle, namely the process $a + \bar{a} \to \mu^+ + \mu^-$. A muon has a rest mass of 105 MeV/c² and its proper life time is 2 μs. If the center of mass energy of the collision is 2.1 GeV in the laboratory frame that coincides with the center-of-mass frame, then the fraction of muons that will decay before they reach a detector placed 6km away from the interaction point is [NET June 2013]

(a) e^{-1} (b) $1 - e^{-1}$ (c) $1 - e^{-2}$ (d) e^{-10}

7. Consider the following ratios of the partial decay widths $R_1 = \frac{\Gamma(\rho^+ \to \pi^+ + \pi^0)}{\Gamma(\rho^- \to \pi^- + \pi^0)}$ and $R_2 = \frac{\Gamma(\Delta^{++} \to \pi^+ + p)}{\Gamma(\Delta^- \to \pi^- + n)}$. If the effects of electromagnetic and weak interactions are neglected, then R_1 and R_2 are, respectively, **[NET Dec. 2013]**

(a) 1 and $\sqrt{2}$ (b) 1 and 2 (c) 2 and 1 (d) 1 and 1

8. In a classical model, a scalar (spin-0) meson consists of a quark and an antiquark bound by a potential $V(r) = ar + \frac{b}{r}$, where $a = 200$ MeV fm^{-1} and $b = 100$ MeV fm. If the masses of the quark and antiquark are negligible, the mass of the meson can be estimated as approximately **[NET June 2014]**

(a) 141 MeV/c^2 (b) 283 MeV/c^2 (c) 353 MeV/c^2 (d) 425 MeV/c^2

9. In deep inelastic scattering electrons are scattered off protons to determine if a proton has any internal structure. The energy of the electron for this must be at least **[NET Dec. 2014]**

(a) 1.25×10^9 eV (b) 1.25×10^{12} eV (c) 1.25×10^6 eV (d) 1.25×10^8 eV

10. Consider the four processes **[NET Dec. 2014]**

(i) $p^+ \to n + e^+ + \nu_e$ (ii) $\Lambda^0 \to p^+ + e^+ + \nu_e$

(iii) $\pi^+ \to e^+ + \nu_e$ (iv) $\pi^0 \to \gamma + \gamma$

Which of the above is/are forbidden for free particles?

(a) only (ii) (b) (ii) and (iv) (c) (i) and (iv) (d) (i) and (ii)

11. The reaction ${}^2_1D + {}^2_1D \to {}^4_2He + \pi^0$ cannot proceed via strong interactions because it violates the conservations of **[NET June 2015]**

(a) angular momentum (b) electric charge (c) baryon number (d) isospin

12. Consider the following processes involving free particles **[NET Dec. 2015]**

(i) $\bar{n} \to \bar{p} + e^+ + \bar{\nu}_e$ (ii) $\bar{p} + n \to \pi^-$ (iii) $p + n \to \pi^+ + \pi^0 + \pi^0$ (iv) $p + \bar{\nu}_e \to n + e^+$

Which of the following statements is true?

(a) Process (i) obeys all conservation laws

(b) Process (ii) conserves baryon number, but violates energy-momentum conservation

(c) Process (iii) is not allowed by strong interactions, but is allowed by weak interactions

(d) Process (iv) conserves baryon number, but violates lepton number conservation

13. 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 center of mass energy of a proton-proton pair is 14 TeV, which of the following is the best approximation for the proper time taken by a proton to traverse the entire path? **[NET June 2016]**

(a) 12 ns (b) 1.2 μs (c) 1.2 ns (d) 0.12 μs

14. Which of the following reaction(s) is/are allowed by the conservation laws? **[NET Dec. 2016]**

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

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

(a) Both (i) and (ii) (b) Only (i) (c) Only (ii) (d) Neither (i) nor (ii)

15. Which of the following processes is not allowed by the strong interaction but is allowed by the weak interaction? **[NET Dec. 2017]**

(a) $K^0 + \pi^0 \to \bar{K}^0 + \pi^+ + \pi^-$ (b) $p + n \to d + p + \bar{p}$

(c) $\Delta^+ + K^0 \to p + n$ (d) $p + \Delta^+ \to \bar{n} + \Delta^{++}$

16. A deutron 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 a **[NET June 2018]**

(a) linear combination of a singlet and a triplet (b) singlet

(c) triplet (d) doublet

ANSWER KEY

1_A(c)	1_B(b)	2_A(b)	2_B(a)	3. (a)	4. (a)	5. (d)
6. (b)	7. (d)	8. (b)	9. (a)	10. (d)	11. (d)	12. (b)
13. (a)	14. (a)	15. (a)	16. (b)			

TIFR Previous Years' Questions

1. A spin-$\frac{1}{2}$ particle A decays to two other particles B and C. If B and C are of spin-$\frac{1}{2}$ and spin-1 respectively, then a complete list of the possible values of the orbital angular momentum of the final state (i.e. B + C) is **[TIFR 2013]**

(a) 0, 1 (b) $\frac{1}{2},\frac{3}{2}$ (c) 0, 1, 2 (d) 0, ±1

2. Cosmic ray muons generated at the top of the Earth's atmosphere decay according to the radioactive decay law **[TIFR 2014]**

$$N(t)=N(0)\exp\left(-\frac{0.693t}{T_{1/2}}\right)$$

where $N(t)$ is the number of muons at time t, and $T_{1/2}$ = 1.52 μs is the proper half-life of the muon. Immediately after generation, most of these muons shoot down towards the Eearth's surface. Some of these muons decay on the way, but their interaction with the atmosphere is negligible.

An observer on the top of a mountain of height 2.0 km above mean sea level detects muons with the speed 0.98c over a period of time and counts 1000 muons. The number of muons of the same speed detected by an observer at mean sea level in the same period of time would be

(a) 232 (b) 539 (c) 839 (d) 983

3. A spin-2 nucleus absorbs a spin-½ electron and is then observed to decay to a stable nucleus in two stages, recoiling against an emitted invisible particle in the first stage and against an emitted spin-1 photons in the second stage. If the stable nucleus is spinless, then the set of all possible spin values of the invisible particle is **[TIFR 2014]**

(a) {1/2, 5/2} (b) {3/2, 7/2} (c) {1/2, 3/2, 5/2} (d) {1/2, 3/2, 5/2, 7/2}

4. The interaction strength of the recently-discovered Higgs boson (mass approximately 125 GeV/c^2) with any other elementary particle is proportional to the mass of that particle. Which of the following decay processes will have the greatest probability? **[TIFR 2014]**

(a) Higgs boson decaying to a top quark + a top anti-quark

(b) Higgs boson decaying to a bottom quark + a bottom anti-quark

(c) Higgs boson decaying to an electron and a positron

(d) Higgs boson decaying to a neutrino-antineutrino pair.

5. Consider the following reaction involving elementary particles: **[TIFR 2015]**

(A) $\pi^- + p \to K^- + \Sigma^+$

(B) $K^- + p \to K^- + \rho^+$

Which of the following statements is true for strong interactions?

(a) (A) and (B) are both forbidden (b) (B) is allowed but (A) is forbidden

(c) (A) is allowed but (B) is forbidden (d) (A) and (B) are both allowed

6. In a fixed target experiment, a proton of total energy 200 GeV is bombarded on a proton at rest and produces a nucleus ${}^Z_A N$ and its anti-nucleus ${}^Z_A \bar{N}$

$$p + p \to {}^Z_A N + {}^Z_A \bar{N} + p + p$$

The heaviest nucleus ${}^Z_A N$ that can be created has atomic mass number A =

(a) 15 (b) 9 (c) 5 (d) 4

7. A subatomic particle ψ and its excited state ψ^* have rest masses 3.1 GeV/c^2 and 3.7 GeV/c^2 respectively. A table of its assigned quantum numbers is given below.

Angular Momentum	Parity	C - Parity	Isospin	Electric charge
$J=1$	$P=-1$	$C=-1$	$I=0$	$Q=0$

If π^{0*} is an excited state of π^0 with a mass about 1.3 GeV/c^2, which of the following reaction is possible when the above quantum numbers are conserved ? **[TIFR 2017]**

(a) $\psi^* \to \gamma\gamma$ (b) $\psi^* \to \psi\pi^+\pi^-$ (c) $\psi^* \to \pi^0\pi^0$ (d) $\psi^* \to \psi\pi^{0*}$

ANSWER KEY

1. (c) **2. (b)** **3. (d)** **4. (b)** **5. (a)** **6. (b)** **7. (b)**

GATE Previous Years' Questions

1. Pick the wrong statement [GATE 2009]

(a) the nuclear force is independent of electric charge

(b) the Yukawa potential is proportinoal to $r^{-1}\exp\left(\frac{m}{h}r\right)$. Where, r is the seperation between two nucleons.

(c) The range of nuclear force is of the order of $10^{-15}-10^{-14}\,\text{m}$

(d) the nucleons interact among each other by the exchange of mesons.

2. An alpha particle is accelerated in a cyclotron. It leaves the cyclotron with a kinetic energy of 16 MeV. The potential difference between the D electrodes is 50 kilovolts. The number of revolutions the alpha particle makes in its spiral path before it leaves the cyclotron is _______ [GATE 2016]

ANSWER KEY

1. (b) 2. (80)

CSIR-UGC-NET Previous Years' Questions

1. An atom of mass M can be excited to a state of mass $M+\Delta$ by photon capture. The frequency of a photon which can cause this transition is: **[NET Dec. 2011]**

   (a) $\Delta c^2/2h$ (b) $\Delta c^2/h$ (c) $\Delta^2 c^2/2Mh$ (d) $\Delta(\Delta+2M)c^2/2Mh$

ANSWER KEY

1. (d)

TIFR Previous Years' Questions

1. An electron enters a linear accelerator with a speed $v = 10$ m s^{-1}. A vertical section of the accelerator tube is shown in the figure, where the lengths of the successive sections are designed such that the electron takes the same time $\tau = 20$ ms to traverse each section. **[TIFR 2018]**

If the momentum of the electron increases by 2 % every time it crosses the narrow gap between two sections, what is the length (in km) of the collider which will be required to accelerate it to 100 km-s^{-1}?

ANSWER KEY

1. ()

Other Examinations Previous Years' Questions

1. A proton moves in a circular orbit in a plane which is perpendicular to a uniform magnetic field of strength B. When the kinetic energy of the proton changes from $0.25\, m_p c^2$ to $m_p c^2$ (where m_p is the rest mass of the proton) the freqency of rotation changes from ω_1 to ω_2. The ratio ω_1 / ω_2 is

(a) 1 (b) 8 (c) 8/5 (d) $1/\sqrt{8}$ (e) $\sqrt{8}$

ANSWER KEY

1. (c)