Physics Board Questions

Class: 12

Chapter: Nuclei

Delhi 2014

1. (*a*) Deduce the expression, $N = N_0e^{-\lambda t}$, for the law of radioactive decay.
   (*b*) (*i*) Write symbolically the process expressing the β^+ decay of $_{11}Na^{22}$. Also write the basic nuclear process underlying this decay.
   (*ii*) Is the nucleus formed in the decay of the nucleus $_{11}Na^{22}$, an isotope or isobar? [Isobar]

All India 2014

1. Why is it found experimentally difficult to detect neutrinos in nuclear β-decay?
2. For the past some time, Aarti had been observing some erratic body movement, unsteadiness and lack of coordination in the activities of her sister Radha, who also used to complain of severe headache occasionally. Aarti suggested to her parents to get a medical check-up of Radha. The doctor thoroughly examined Radha and diagnosed that she has a brain tumour.
   (*a*) What, according to you, are the values displayed by Aarti?
   (*b*) How can radioisotopes help a doctor to diagnose brain tumour?

Foreign 2014

1. In both β^- decay processes, the mass number of a nucleus remains same whereas the atomic number *Z* increases by one in β^- decay and decreases by one in β^+ decay. Explain, giving reason.
2. (*a*) Define (*i*) half-life ($T_{1/2}$) and (*ii*) average life (τ). Find out their relationships with decay constant (λ).
   (*b*) A radioactive nucleus has a decay constant $\lambda = 0.3465\ (day)^{-1}$. How long would it take the nucleus to decay to 75% of its initial amount? [0.82 days]

Delhi 2013

1. (a) In a typical nuclear reaction, e.g. $H_1^2 + H_1^2 \rightarrow He_2^3 + n + 3.27MeV$,
   although number of nucleons is conserved, yet energy is released. How? Explain.
   (b) Show that nuclear density in a given nucleus is independent of mass number A.
2. (*a*) In a nuclear reaction
   $$He_2^3 + He_2^3 \rightarrow He_2^4 + H_1^1 + H_1^1 + 12.86MeV ,$$
   although number of nucleons is conserved on both sides of the reaction, yet energy is released. How? Explain.
   (*b*) Draw a plot of potential energy between a pair of nucleons as a function of their separation. Mark the regions where potential energy is (i) positive and (ii) negative.

All India 2013

1. Define the activity of a given radioactive substance. Write its S.I. unit.
2. (a) Draw the plot of binding energy per nucleon (BE/A) as a function of mass number A. Write two important conclusions that can be drawn regarding the nature of nuclear force.
   (b) Use this graph to explain the release of energy in both the processes of nuclear fusion and fission.
   (c) Write the basic nuclear process of neutron undergoing β–decay. Why is the detection of neutrinos found very difficult?

Foreign 2013

1. Derive the expression for the law of radioactive decay of a given sample having initially N_0 nuclei decaying to the number N present at any subsequent time t.
   Plot a graph showing the variation of the number of nuclei versus the time t lapsed.
   Mark a point on the plot in terms of $T_{1/2}$ value when the number present $N = N_0/16$.

Delhi 2012

1. (*i*) What characteristic property of nuclear force explains the constancy of binding energy per nucleon (BE/A) in the range of mass number 'A' lying $30 < A < 170$?
   (*ii*) Show that the density of nucleus over a wide range of nuclei is constant independent of mass number A.

All India 2012

1. Draw a plot of potential energy of a pair of nucleons as a function of their separations. Mark the regions where the nuclear force is (*i*) attractive and (*ii*) repulsive. Write any two characteristic features of nuclear forces.

Foreign 2012

1. Write the relationship between the size of a nucleus and its mass number (A).
2. In a given sample, two radioisotopes, A and B, are initially present in the ratio of 1:4. The half lives of A and B are respectively 100 years and 50 years. Find the time after which the amounts of A and B become equal. [200]
3. What are isotopes? Give one example.

Delhi 2011

1. State the law of radioactive decay.
   Plot graph showing the number (N) of undecayed nuclei as a function of time (t) for a given radioactive sample having half life $T_{1/2}$.
   Depict in the plot the number of undecayed nuclei at (*i*) $t = 3T_{1/2}$ & (*ii*) $t = 5T_{1/2}$. [(i)$N_o/8$ (ii) $N_o/32$]
2. State the law of radioactive decay.
   Plot a graph showing the number (N) of undecayed nuclei as a function of time (t) for a given radioactive sample having half life $T_{1/2}$.
   Depict in the plot the number of undecayed nuclei at (*i*) $t = 2T_{1/2}$ and (*ii*) $t = 4T_{1/2}$. [(i)$N_o/4$ (ii) $N_o/16$]

All India 2011

1. Write any two characteristic properties of nuclear force.
2. Using the curve for the binding energy per nucleon as a function of mass number A, state clearly how the release in energy in the processes of nuclear fission and nuclear fusion can be explained.

Foreign 2011

1. How is the mean life of a radioactive sample related to its half life?
2. When four hydrogen nuclei combine to form a helium nucleus, estimate the amount of energy in MeV released in this process of fusion (Neglect the masses of electrons and neutrinos)
   Given: (*i*) mass of $_1H^1 = 1.007825$ u
   (*ii*) mass of helium nucleus = 4.002603 u, 1u = 931 MeV/ c^2 [26.72MeV]

Delhi 2010

1. A heavy nucleus X of mass number 240 and binding energy per nucleon 7.6 MeV is split into two fragments Y and Z of mass numbers 110 and 130. The binding energy of nucleons in Y and Z is 8.5 MeV per nucleon.
   Calculate the energy Q released per fission in MeV. [216MeV]

2. (*i*) Define 'activity' of a radioactive material and write its S.I. unit.
(*ii*) Plot a graph showing variation of activity of a given radioactive sample with time.
(*iii*) The sequence of stepwise decay of a radioactive nucleus is

$$D \xrightarrow{\alpha} D_1 \xrightarrow{\beta^-} D_2$$

If the atomic number & mass number of D_2 are 71 &176 respectively, what are their corresponding values for *D?*

[Z=72,A=180]

All India 2010

1. Define ionisation energy. What is its value for a hydrogen atom?
2. Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions which you can draw regarding the nature of nuclear forces.
3. Draw a graph/plot of the binding energy per nucleon as a function of mass number for a large number of nuclei, $2 \le A \le 240$. How do you explain the constancy of binding energy per nucleon in the range $30 < A < 170$ using the property that nuclear force is short-ranged?
4. (*a*) Write symbolically the β^- decay process of ${}_{15}P^{32}$.
(*b*) Derive an expression for the average life of a radionuclide. Give its relationship with the half-life.

Foreign 2010

1. If both the number of protons and the number of neutrons are conserved in a nuclear reaction like

$$C_6^{12} + C_6^{12} \rightarrow Ne_{10}^{20} + He_2^4$$

in what way is mass converted into energy? Explain.

Delhi 2009

1. Two nuclei have mass numbers in the ratio 1: 2. What is the ratio of their nuclei densities? [1:1]
2. A radioactive nucleus '*A*' undergoes a series of decays according to the following scheme :

$$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$$

The mass number & atomic number of *A* are 180 & 72 respectively. What are these numbers for A_4?

[Z=69, A=172]

3. The nuclei have mass numbers in the ratio 1: 3. What is the ratio of their nuclear densities? [1:1]
4. A radioactive nucleus '*A*' undergoes a series of decays according to the following scheme:

$$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$$

The mass number and atomic number of A 4 are 172 and 69 respectively. What are these numbers for A_4 ?

[Z=72, A=180]

5. Two nuclei have mass numbers in the ratio 2: 5. What is the ratio of their nuclear densities? [1:1]
6. A radioactive nucleus '*A*' undergoes a series of decays according to the following scheme :

$$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$$

The mass number and atomic number of A are 190 and 75 respectively. What are these numbers for A_4 ?

[Z=72, A=182]

All India 2009

1. Two nuclei have mass numbers in the ratio 1: 8. What is the ratio of their nuclear radii? [1:2]
2. (a) The mass of a nucleus in its ground state is always less than the total mass of its constituents – neutrons and protons. Explain.

(b) Plot a graph showing the variation of potential energy of a pair of nucleons as a function of their separation.

3. Draw a plot showing the variation of binding energy per nucleon versus the mass number A.
   Explain with the help of this plot the release of energy in the processes of nuclear fission and fusion.
4. Two nuclei have mass numbers in the ratio 8: 125. What is the ratio of their nuclear radii? [2:5]
5. Two nuclei have mass numbers in the ratio 27: 125. What is the ratio of their nuclear radii? [3:5]
6. Define the activity of a radionuclide. Write its S.I. units.
   Give a plot of the activity of a radioactive species versus time.
   How long will a radioactive isotope, whose half life is T years, take for its activity to reduce to 1/8th of its initial value? [t =3T]

Foreign 2009

1. (a) What is meant by half life of a radioactive element?
   (b) The half life of a radioactive substance is 30 s. Calculate
   (i) the decay constant, and
   (ii) time taken for the sample to decay by 3/4th of the initial value. [(i)0.0231s^{-1} (ii) 60s]
2. (a) What is meant by half life of a radioactive element?
   (b) The half life of a radioactive substance is 20 s. Calculate:
   (i) the decay constant and
   (ii) time taken for the sample to decay by 7/8th of the initial value. [(i)0.0346s^{-1} (ii) 60s]
3. (a) What is meant by half life of a radioactive element?
   (b) The half life of a radioactive substance is 30 s. Calculate:
   (i) the decay constant, and
   (ii) time taken for the sample to decay by 3/4th of the initial value. [(i)0.014s^{-1} (ii) 100s]

Delhi 2008

1. State the reason, why heavy water is generally used as a moderator in a nuclear reactor.
2. A nucleus $_{10}Ne^{23}$ undergoes β-decay and becomes $_{11}Na^{23}$. Calculate the maximum kinetic energy of electrons emitted assuming that the daughter nucleus and anti-neutrino carry negligible kinetic energy.
   [mass of $_{10}Ne^{23}$ =22.994466u, mass of $_{11}Na^{23}$= 22.989770u, 1 u = 931·5 MeV/ c^2] [4.37MeV]
3. Name the absorbing material used to control the reaction rate of neutrons in a nuclear reactor.

All India 2008

1. What is the nuclear radius of ^{125}Fe, if that of ^{27}Al is 3·6 fermi? [6 fermi]
2. State the law of radioactive decay. If N_0 is the number of radioactive nuclei in the sample at some initial time t_0, find out the relation to determine the number N present at a subsequent time.
   Draw a plot of N as a function of time.
3. Draw a plot of the binding energy per nucleon as a function of mass number for a large number of nuclei.
   Explain the energy release in the process of nuclear fission from the above plot. Write a typical nuclear reaction in which a large amount of energy is released in the process of nuclear fission.
4. Distinguish between isotopes and isobars. Give one example for each of the species. A radioactive isotope has a half-life of 5 years. How long will it take the activity to reduce to 3·125%? [25 years]