

Class 12 Physics Chapterwise PYQs

2026 – 2003 | All CBSE Board Papers

Chapter-wise previous year questions, sorted by marks and year

Chapter 13: Nuclei

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1-Mark Questions (38 questions · Section A · MCQ)

Q1. Two statements are given - one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer from the options below: (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A). (B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). (C) Assertion (A) is true, but Reason (R) is false. (D) Both Assertion (A) and Reason (R) are false. Assertion (A): The mass of a nucleus is less than the sum of the masses of the constituent nucleons. Reason (R): Energy is absorbed when the nucleons are bound together to form a nucleus.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are false.

[2026 • Set 55-1-1]

Q2. If r_1 and r_2 are the radii of atomic nuclei of mass numbers 64 and 27 respectively, then the value of $\left(\frac{r_1}{r_2}\right)$ is:

- (A) 1
- (B) $\frac{4}{3}$
- (C) $\frac{3}{4}$
- (D) $\frac{27}{64}$

[2026 • Set 55-3-1]

Q3. Assertion (A): Nuclear forces are always attractive. Reason (R): The nuclear force between protons and neutrons in a nucleus is a weak force. Select the correct answer from the codes (A), (B), (C) and (D) given below:

- (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
- (B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
- (C) Assertion (A) is true, but Reason (R) is false.
- (D) Both Assertion (A) and Reason (R) are false.

[2026 • Set 55-3-1]

Q4. Assertion (A): Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion. Reason (R): For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei, it decreases with increasing Z . Select the correct answer from the codes given below:

- (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
- (B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
- (C) Assertion (A) is true, but Reason (R) is false.
- (D) Both Assertion (A) and Reason (R) are false.

[2026 • Set 55-5-1]

Q5. Nuclides with the same number of neutrons are called:

- (A) Isobars
- (B) Isotones
- (C) Isotopes
- (D) Isomers

[2026 • Set 55-5-1]

Q6. The radius of a nucleus of mass number 125 is:

- (A) 6.0 fm
- (B) 3.0 fm
- (C) 7.2 fm

(D) 150 fm

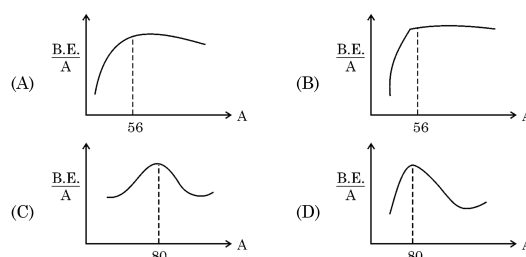
[2026 • Set 55-5-1]

Q7. Consider the nuclear reaction $X \rightarrow Y + Z$. Let M_x , M_y and M_z be the masses of the three nuclei X , Y and Z respectively. Then which of the following relations hold true?

- (A) $(M_x - M_y) < M_z$
 (B) $(M_x - M_z) < M_y$
 (C) $M_x > (M_y + M_z)$
 (D) $M_x < (M_y + M_z)$

[2026 • Set 55-5-3]

Q8. Which of the following figures correctly represent the shape of curve of binding energy per nucleon as a function of mass number?



- (A) Peak rises to a maximum near $A = 56$ and then falls (curve A)
 (B) Curve B
 (C) Peak near $A = 56$ inverted (curve C)
 (D) Peak near $A = 80$ (curve D)

[2025 • Set 55-1-1]

Q9. Assertion (A): During formation of a nucleus, the mass defect produced is the source of the binding energy of the nucleus. Reason (R): For all nuclei, the value of binding energy per nucleon increases with mass number.

- (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
 (B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
 (C) Assertion (A) is true, but Reason (R) is false.
 (D) Both Assertion (A) and Reason (R) are false.

[2025 • Set 55-5-1]

Q10. Inside a nucleus, the nuclear forces between proton and proton, proton and neutron, neutron and neutron are F_{pp} , F_{pn} and F_{nn} respectively. Then:

- (A) $F_{pp} > F_{pn} > F_{nn}$
 (B) $F_{pn} > F_{nn} > F_{pp}$

(C) $F_{nn} > F_{pp} > F_{pn}$

(D) $F_{pp} = F_{pn} = F_{nn}$

[2025 • Set 55-6-1]

Q11. Assertion (A): The binding energy per nucleon is practically constant for mass number in the range ($30 < A < 170$). Reason (R): Nuclear forces between the nucleons for mass numbers in the range ($30 < A < 170$) are not short-range. Select the correct answer from the codes given below:

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are false.

[2025 • Set 55-6-1]

Q12. Isotones are the nuclides having:

(A) same mass numbers

(B) same atomic numbers

(C) same neutron number, but different atomic number

(D) different neutron number, and different mass number

[2025 • Set 55-7-1]

Q13. The mass numbers of two nuclei A and B are 27 and 64 respectively. The ratio of their radii $\left(\frac{r_A}{r_B}\right)$ will be:

(A) $\frac{27}{64}$

(B) $\frac{9}{16}$

(C) $\frac{3\sqrt{3}}{2}$

(D) $\frac{3}{4}$

[2025 • Set 55-7-2]

Q14. The potential energy between two nucleons inside a nucleus is minimum at a distance of about:

(A) 0.8 fm

(B) 1.6 fm

(C) 2.0 fm

(D) 2.8 fm

[2024 • Set 55-5-1]

Q15. The mass density of a nucleus of mass number A is:

- (A) proportional to $A^{1/3}$
- (B) proportional to $A^{2/3}$
- (C) proportional to A
- (D) independent of A

[2023 • Set 55-1-1]

Q16. The curve of binding energy per nucleon as a function of atomic mass number has a sharp peak for helium nucleus. This implies that helium nucleus is

- (A) radioactive
- (B) unstable
- (C) easily fissionable
- (D) more stable nucleus than its neighbours

[2023 • Set 55-2-1]

Q17. The radius of ${}^{27}\text{X}$ nucleus is R . The radius of ${}^{64}\text{Y}$ nucleus will be

- (A) $3R$
- (B) $\left(\frac{3}{4}\right)^{1/3} R$
- (C) $\left(\frac{4}{3}\right) R$
- (D) $\left(\frac{64}{27}\right)^{1/3} R$

[2023 • Set 55-2-3]

Q18. Assertion (A): The nucleus ${}^{15}_7\text{X}$ is more stable than the nucleus ${}^{17}_7\text{Y}$. Reason (R): ${}^{17}_7\text{X}$ contains more number of protons.

- (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
- (B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
- (C) Assertion (A) is true, but Reason (R) is false.
- (D) Assertion (A) is false and Reason (R) is also false.

[2023 • Set 55-3-1]

Q19. The difference in mass of ${}^7\text{X}$ nucleus and total mass of its constituent nucleons is 21.00 u. The binding energy per nucleon for this nucleus is equal to the energy equivalent of:

- (A) $3 u$
- (B) $3.5 u$
- (C) $7 u$
- (D) $21 u$

[2023 • Set 55-4-1]

Q20. Which of the following statements is not true for nuclear forces?

- (A) They are stronger than Coulomb forces.
- (B) They have about the same magnitude for different pairs of nucleons.
- (C) They are always attractive.
- (D) They saturate as the separation between two nucleons increases.

[2023 • Set 55-4-1]

Q21. The ratio of the nuclear densities of two nuclei having mass numbers 64 and 125 is

- (A) $\frac{64}{125}$
- (B) $\frac{4}{5}$
- (C) $\frac{5}{4}$
- (D) 1

[2023 • Set 55-5-1]

Q22. The saturation property of the nuclear forces is due to the fact that they are (A) charge independent forces. (B) non-central forces. (C) spin-dependent forces. (D) short-range forces.

[2021]

Q23. Why are neutrons preferred as better projectiles in causing nuclear reaction?

[2021]

Q24. In β -decay, the parent and daughter nuclei have the same number of _____.

[2020 • Set 55-1-1]

Q25. The nuclear radius of ${}_{13}^{27}\text{Al}$ is 3.6 fermi. Find the nuclear radius of ${}_{29}^{64}\text{Cu}$.

[2020 • Set 55-1-1]

Q26. Fill in the blank with appropriate answer. In β -decay, a neutron is converted into a proton, e^- and _____.

[2020 • Set 55-4-2]

Q27. Four nuclei of an element undergo fusion to form a heavier nucleus, with release of energy. Which of the two — the parent or the daughter nucleus — would have higher binding energy per nucleon ?

[2018]

- Q28. Why is it found experimentally difficult to detect neutrinos in nuclear β -decay ?
[2014]
- Q29. Write the relationship between the size of a nucleus and its mass number (A).
[2012]
- Q30. Write any two characteristic properties of nuclear force.
[2011]
- Q31. How is the mean life of a radioactive sample related to its half life?
[2011 • Set 55-2-1]
- Q32. Two nuclei have mass numbers in the ratio 1 : 2. What is the ratio of their nuclear densities?
[2009]
- Q33. State the reason, why heavy water is generally used as a moderator in a nuclear reactor.
[2008]
- Q34. What is the nuclear radius of ^{125}Fe , if that of ^{27}Al is 3.6 fermi?
[2008]
- Q35. The radioactive isotope D decays according to the sequence $D \xrightarrow{\alpha\text{-particle}} D_1 \xrightarrow{\beta\text{-particle}} D_2$. If the mass number and atomic number of D_2 are 176 and 71 respectively, what is (i) the mass number (ii) atomic number of D ?
[2007]
- Q36. Define the term 'activity' of a radionuclide. Write its SI unit.
[2007]
- Q37. Write the nuclear decay process for β^- -decay of $^{32}_{15}\text{P}$.
[2004]
- Q38. 'Heavy water is often used as a moderator in thermal nuclear reactors.' Give reason.
[2004]

2-Mark Questions (43 questions · Section B · VSA)

- Q1. Draw the plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions that can be drawn from this plot.
[2026 • Set 55-1-1]

- Q2.** Draw a graph showing variation of binding energy per nucleon as a function of mass number A . The binding energy per nucleon for heavy nuclei ($A > 170$) decreases with increase in mass number. Explain its significance.
[2026 • Set 55-1-2]
- Q3.** Suppose a nucleus with mass number $A = 240$ and B.E. per nucleon = 7.6 MeV, breaks into two nuclei, each of mass number $A = 120$ with B.E. per nucleon = 8.5 MeV. Calculate the energy released in the process.
[2026 • Set 55-1-3]
- Q4.** Explain the terms mass defect and binding energy. How are they related?
[2026 • Set 55-3-1]
- Q5.** Prove that the density of nuclear matter is same for all nuclei.
[2026 • Set 55-4-2]
- Q6.** Calculate the mass of an α -particle in atomic mass unit (u). Given, Mass of a normal helium atom = 4.002603 u Mass of carbon atom = 1.9926×10^{-26} kg
[2025 • Set 55-4-1]
- Q7.** When a neutron collides with ${}_{92}^{235}\text{U}$, the nucleus gives ${}_{54}^{140}\text{Xe}$ and ${}_{38}^{94}\text{Sr}$ as fission products and two neutrons are ejected. Calculate the mass defect and the energy released (in MeV) in the process. Given: $m({}_{92}^{235}\text{U}) = 235.04393$ u, $m({}_{54}^{140}\text{Xe}) = 139.92164$ u $m({}_{38}^{94}\text{Sr}) = 93.91536$ u, $m_n = 1.00866$ u 1 u = 931 MeV/ c^2
[2025 • Set 55-5-1]
- Q8. (a)** Why is the mass of a nucleus always less than the sum of the masses of its constituents, i.e. free neutrons and free protons?
(b) How is Coulomb repulsion between protons in a nucleus overcome? Explain.
[2025 • Set 55-5-2]
- Q9.** Calculate the binding energy per nucleon (in MeV) of a helium nucleus (${}^4_2\text{He}$). Given: $m({}^4_2\text{He}) = 4.002603$ u, $m_n = 1.008665$ u, $m_p = 1.007825$ u, 1 u = 931.5 MeV/ c^2 .
[2025 • Set 55-7-2]
- Q10.** The carbon isotope ${}^{12}_6\text{C}$ has a nuclear mass of 12.000000 u. Calculate the binding energy of its nucleus. Given $m_p = 1.007825$ u; $m_n = 1.008665$ u.
[2024 • Set 55-2-1]
- Q11.** Calculate the energy released/absorbed in the following nuclear reaction: ${}^{12}_6\text{C} + {}^{12}_6\text{C} \longrightarrow {}^{20}_{10}\text{Ne} + {}^4_2\text{He}$ Given: $m({}^{12}_6\text{C}) = 12.000000$ u $m({}^{20}_{10}\text{Ne}) = 19.992439$ u $m({}^4_2\text{He}) = 4.002603$ u

$$1 u = 931 \text{ MeV}/c^2$$

[2024 • Set 55-2-2]

Q12. Deuterium undergoes the following fusion reaction: ${}^2_1\text{H} + {}^2_1\text{H} \longrightarrow {}^3_2\text{He} + {}^1_0n + 3.27 \text{ MeV}$
How long an electric bulb of 200 W will glow by using the energy released in 2 g of deuterium?

[2024 • Set 55-5-3]

Q13. Define the term, mass defect. How is it related to stability of the nucleus?

[2023 • Set 55-2-1]

Q14. (a) Draw a graph showing the variation of binding energy per nucleon as a function of mass number A . The binding energy per nucleon for heavy nuclei ($A > 170$) decreases with the increase in mass number. Explain.

————— OR —————

(b) Using Bohr's postulates, obtain the expression for radius of n^{th} stable orbit in a hydrogen atom.

[2023 • Set 55-3-1]

Q15. Draw the graph showing the variation of binding energy per nucleon with mass number A of nuclei ($2 \leq A \leq 170$). Use this graph to explain the release of energy in nuclear fission.

[2023 • Set 55-4-1]

Q16. Briefly describe the multi-step process involved in the generation of energy in the Sun.

[2023 • Set 55-4-3]

Q17. (i) Distinguish between isotopes and isobars.

(ii) Two nuclei have different mass numbers A_1 and A_2 . Are these nuclei necessarily the isotopes of the same element? Explain.

[2022 • Set 55-3-1]

Q18. Define the term 'Half-life' of a radioactive substance. Two different radioactive substances have half-lives T_1 and T_2 and number of undecayed atoms at an instant, N_1 and N_2 , respectively. Find the ratio of their activities at that instant.

[2020 • Set 55-1-1]

Q19. Define activity of a sample of a radioactive substance. The value of the disintegration constant of a radioactive substance is 0.0693 h^{-1} . Find the time after which the activity of

a sample of this substance reduces to one-half that of its present value.

[2020 • Set 55-1-2]

Q20. (a) For a radioactive substance, show the variation of the total mass disintegrated as a function of time t graphically.

(b) Initial mass of a radioactive substance is 3.2 mg. It has a half-life of 4 h. Find the mass of the substance left undecayed after 8 h.

[2020 • Set 55-2-2]

Q21. (a) Write the SI unit of activity of a radioactive substance.

(b) Find the half-life of a radioactive substance if the activity of the substance drops to $\frac{1}{16}$ of its initial value in 15 years.

[2020 • Set 55-2-3]

Q22. A heavy nucleus P of mass number 240 and binding energy 7.6 MeV per nucleon splits in to two nuclei Q and R of mass numbers 110, 130 and binding energy per nucleon 8.5 MeV and 8.4 MeV, respectively. Calculate the energy released in the fission.

[2020 • Set 55-5-1]

Q23. (a) Define one Becquerel.

(b) A radioactive substance disintegrates into two types of daughter nuclei, one type with disintegration constant λ_1 and the other type with disintegration constant λ_2 . Determine the half-life of the radioactive substance.

[2020 • Set 55-5-2]

Q24. Calculate for how many years will the fusion of 2.0 kg deuterium keep 800 W electric lamp glowing. Take the fusion reaction as ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He} + {}^1_0\text{n} + 3.27\text{ MeV}$

[2020 • Set 55-5-3]

Q25. Plot a graph showing the variation of undecayed nuclei N versus time t . From the graph, find out how one can determine the half-life and average life of the radioactive nuclei.

[2019 • Set 55-3-1]

Q26. (a) Write two distinguishing features of nuclear forces.

(b) Complete the following nuclear reactions for α and β decay: (i) ${}^{238}_{92}\text{U} \rightarrow ? + {}^4_2\text{He} + Q$
(ii) ${}^{22}_{11}\text{Na} \rightarrow {}^{22}_{10}\text{Ne} + ? + \nu$

[2019 • Set 55-3-1]

Q27. Distinguish between nuclear fusion and nuclear fission. Give one example for each.

[2019 • Set 55-3-2]

Q28. (a) Which property of nuclear force explains the constancy of binding energy per nucleon $\left(\frac{B}{A}\right)$ for nuclei in the range $20 < A < 170$?

(b) Complete the following nuclear reactions: (i) ${}^{32}_{15}\text{P} \longrightarrow {}^A_Z\text{X} + e^- + \bar{\nu}$ (ii) ${}^{12}_6\text{C} + {}^{12}_6\text{C} \longrightarrow {}^A_Z\text{Y} + {}^4_2\text{He}$

[2019 • Set 55-3-3]

Q29. 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.

————— OR —————

Draw a plot of the binding energy per nucleon as a function of mass number for a large number of nuclei, $2 \leq A \leq 240$. 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?

[2012]

Q30. 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.

[2012]

Q31. 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.

[2011]

Q32. 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 ${}^1_1\text{H} = 1.007825 \text{ u}$

(ii) mass of helium nucleus = 4.002603 u, $1 \text{ u} = 931 \text{ MeV}/c^2$

[2011 • Set 55-2-1]

Q33. 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.

[2010]

Q34. A radioactive nucleus A undergoes a series of decays according to the following scheme:

$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\gamma} A_3 \xrightarrow{\gamma} A_4$ The mass number and atomic number of A are 180 and 72 respectively. What are these numbers for A_4 ?

[2009]

Q35. (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.

[2009]

Q36. A nucleus ${}_{10}^{23}\text{Ne}$ undergoes β -decay and becomes ${}_{11}^{23}\text{Na}$. Calculate the maximum kinetic energy of electrons emitted assuming that the daughter nucleus and anti-neutrino carry negligible kinetic energy. Mass of ${}_{10}^{23}\text{Ne} = 22.994455 u$ Mass of ${}_{11}^{23}\text{Na} = 22.989770 u$
 $1 u = 931.5 \text{ MeV}/c^2$

[2008]

Q37. 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.

[2008]

Q38. 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.

[2008]

Q39. Draw a plot of potential energy of a pair of nucleons as a function of their separation. What is the significance of negative potential energy in the graph drawn?

[2007]

Q40. Draw a graph showing the variation of potential energy between a pair of nucleons as a function of their separation. Indicate the regions in which the nuclear force is (i) attractive, (ii) repulsive.

[2007]

Q41. Draw the graph showing the variation of binding energy per nucleon with mass number. Give the reason for the decrease of binding energy per nucleon for nuclei with high mass numbers.

[2004]

Q42. Name the reaction which takes place when a slow neutron beam strikes ${}_{92}^{235}\text{U}$ nuclei. Write

the nuclear reaction involved.

[2003]

- Q43.** In the series of radioactive disintegration of ${}_{92}^{238}\text{U}$, first an alpha-particle and then a beta-particle is emitted. What is the atomic number and mass number of the new nucleus formed by these successive disintegrations?

[2003]

3-Mark Questions (72 questions · Section C · SA)

- Q1. (a)** Consider the following nuclides: ${}_{6}^{12}\text{C}$, ${}_{80}^{198}\text{Hg}$, ${}_{6}^{14}\text{C}$, ${}_{79}^{197}\text{Au}$. Group them into isotopes and isotones.

- (b)** How does the size of a nucleus depend on its mass number A ? Hence prove that the density of nucleus is a constant, independent of A , for all nuclei.

[2026 • Set 55-2-1]

- Q2.** Differentiate between nuclear fission and nuclear fusion. Give one example for each with nuclear reaction.

[2026 • Set 55-3-1]

- Q3.** Draw a plot showing the variation of potential energy of a pair of nucleons as a function of their separation (r). Using this plot, show that the nuclear force is (i) attractive for $r > r_0$, and (ii) repulsive for $r < r_0$.

[2026 • Set 55-3-2]

- Q4.** In the nuclear reaction: ${}_{1}^{2}\text{H} + {}_{1}^{2}\text{H} \rightarrow {}_{2}^{A}\text{X} + {}_{0}^{1}\text{n}$

- (a)** Find the value of A .

- (b)** Calculate the amount of energy released in the reaction. Given: $m({}_{1}^{2}\text{H}) = 2 \cdot 014102 \text{ u}$, $m({}_{2}^{A}\text{X}) = 3 \cdot 016049 \text{ u}$, $m({}_{0}^{1}\text{n}) = 1 \cdot 008665 \text{ u}$, $1 \text{ u} = 931.5 \text{ MeV}/c^2$

[2026 • Set 55-4-1]

- Q5. (a)** Distinguish between isotopes and isobars, giving one example for each.

- (b)** Derive the relation between atomic mass unit (u) and electron volt (eV).

[2026 • Set 55-4-3]

- Q6. (a)** (i) Write any two features of nuclear forces. (ii) If both the number of protons and the neutrons are conserved in each nuclear reaction, in what way is mass converted into energy (or vice versa) in a nuclear reaction? Explain.

[2026 • Set 55-5-1]

Q7. (a) Define 'Mass defect' and 'Binding energy' of a nucleus. Describe 'Fission process' on the basis of binding energy per nucleon.

(b) A deuteron contains a proton and a neutron and has a mass of 2.013553 u. Calculate the mass defect for it in u and its energy equivalence in MeV. ($m_p = 1.007277$ u, $m_n = 1.008665$ u, $1 \text{ u} = 931.5 \text{ MeV}/c^2$)

[2025 • Set 55-1-1]

Q8. (a) Show the variation of binding energy per nucleon with mass number. Write the significance of the binding energy curve.

(b) Two nuclei with lower binding energy per nucleon form a nuclei with more binding energy per nucleon. (i) What type of nuclear reaction is it? (ii) Whether the total mass of nuclei increases, decreases or remains unchanged? (iii) Does the process require energy or produce energy?

[2025 • Set 55-2-1]

Q9. (a) Consider the so-called 'D-T reaction' (Deuterium-Tritium reaction). In a thermonuclear fusion reactor, the following nuclear reaction occurs: ${}^2_1\text{H} + {}^3_1\text{H} \longrightarrow {}^4_2\text{He} + {}^1_0\text{n} + Q$ Find the amount of energy released in the reaction. Given: $m({}^2_1\text{H}) = 2.014102$ u $m({}^3_1\text{H}) = 3.016049$ u $m({}^4_2\text{He}) = 4.002603$ u $m({}^1_0\text{n}) = 1.008665$ u $1 \text{ u} = 931 \text{ MeV}/c^2$

————— OR —————

(b) Show that the nuclear density is independent of mass number.

[2025 • Set 55-6-1]

Q10. Find the Q value of the following nuclear reaction: ${}^{12}_6\text{C} + {}^{12}_6\text{C} \longrightarrow {}^{20}_{10}\text{Ne} + {}^4_2\text{He}$ Is this reaction exothermic or endothermic? Given: $m({}^{12}_6\text{C}) = 12.000000$ u $m({}^{20}_{10}\text{Ne}) = 19.992439$ u $m({}^4_2\text{He}) = 4.002603$ u $1 \text{ u} = 931 \text{ MeV}/c^2$

[2025 • Set 55-6-2]

Q11. (a) Differentiate between 'nuclear fission' and 'nuclear fusion'. Briefly discuss one example of each.

(b) Draw a graph of potential energy between a pair of nucleons as a function of their separation.

[2025 • Set 55-6-3]

Q12. Briefly explain how energy is produced in stars, giving two examples of the nuclear reactions involved.

[2025 • Set 55-7-1]

Q13. (a) State any two properties of a nucleus.

- (b) Why is the density of a nucleus much more than that of an atom?
(c) Show that the density of the nuclear matter is the same for all nuclei.

[2024 • Set 55-1-1]

Q14. (a) Write two characteristic properties of nuclear force.

- (b) Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions that can be drawn from the plot.

[2024 • Set 55-1-2]

Q15. (a) Plot a graph depicting potential energy of a pair of nucleons in a nucleus as a function of their separation.

- (b) Identify the regions where the nuclear force is (i) attractive, and (ii) repulsive. Justify your answer.

[2024 • Set 55-2-2]

Q16. (a) Briefly discuss three characteristics of the forces between nucleons.

- (b) Which out of ${}^1_8\text{O}$ and ${}^1_7\text{N}$ nuclei is more stable and why?

[2024 • Set 55-2-3]

Q17. (a) Define atomic mass unit (u).

- (b) Calculate the energy required to separate a deuteron into its constituent parts (a proton and a neutron). Given: $m(D) = 2.014102 \text{ u}$; $m_p = 1.007825 \text{ u}$; $m_n = 1.008665 \text{ u}$.

[2024 • Set 55-3-1]

Q18. (a) Differentiate between nuclear fission and fusion.

- (b) The fission properties of ${}^{239}_{94}\text{Pu}$ are very similar to those of ${}^{235}_{92}\text{U}$. How much energy (in MeV), is released if all the atoms in 1 g of pure ${}^{239}_{94}\text{Pu}$ undergo fission? The average energy released per fission is 180 MeV.

[2024 • Set 55-4-1]

Q19. Draw a diagram to show the variation of binding energy per nucleon with mass number for different nuclei and mention its two features. Why do lighter nuclei usually undergo nuclear fusion?

[2023 • Set 55-1-1]

Q20. (i) Distinguish between nuclear fission and fusion giving an example of each.

- (ii) Explain the release of energy in nuclear fission and fusion on the basis of binding

energy per nucleon curve.

[2023 • Set 55-2-1]

Q21. (i) How is the size of a nucleus found experimentally? Write the relation between the radius and mass number of a nucleus.

(ii) Prove that the density of a nucleus is independent of its mass number.

[2023 • Set 55-2-1]

Q22. (a) (i) Prove that the nuclear density is same for all nuclei. **(ii)** Draw a plot of potential energy of a pair of nucleons as a function of their separation. Draw two inferences from this plot.

————— **OR** —————

(b) (i) Draw a graph to show the variation of the number of scattered particles detected (N) in Geiger-Marsden experiment as a function of scattering angle (θ). **(ii)** Discuss briefly two conclusions that can be drawn from this graph and how they lead to the discovery of nucleus in an atom.

[2023 • Set 55-3-1]

Q23. Draw a plot showing the variation of potential energy of two nucleons as a function of distance between them. Identify the regions in which the force between the nucleons is **(i)** attractive, and **(ii)** repulsive. Justify your answers.

[2023 • Set 55-4-3]

Q24. (a) Calculate the binding energy of an alpha particle in MeV. Given mass of a proton = $1.007825 u$ mass of a neutron = $1.008665 u$ mass of He nucleus = $4.002800 u$ $1 u = 931 \text{ MeV}/c^2$

————— **OR** —————

(b) A heavy nucleus P of mass number 240 and binding energy 7.6 MeV per nucleon splits into two nuclei Q and R of mass number 110 and 130 and binding energy per nucleon 8.5 MeV and 8.4 MeV respectively. Calculate the energy released in the fission.

[2023 • Set 55-5-3]

Q25. Calculate the energy released in MeV in the following reaction: ${}^2_1\text{H} + {}^3_1\text{H} \rightarrow {}^4_2\text{He} + n$ Given: $m({}^2_1\text{H}) = 2.014102 u$ $m({}^3_1\text{H}) = 3.016049 u$ $m({}^4_2\text{He}) = 4.002603 u$ $m_n = 1.008665 u$

[2022 • Set 55-1-1]

Q26. (i) Depict the variation of the potential energy of a pair of nucleons with the separation between them.

- (ii) Imagine the fission of a ${}^{56}_{26}\text{Fe}$ into two equal fragments of ${}^{28}_{13}\text{Al}$ nucleus. Is the fission energetically possible? Justify your answer by working out Q value of the process. Given: $m({}^{56}_{26}\text{Fe}) = 55.93494 \text{ u}$, $m({}^{28}_{13}\text{Al}) = 27.98191 \text{ u}$.

[2022 • Set 55-2-1]

Q27. (a) James Chadwick, in 1932, studied the emission of neutral radiations when Beryllium nuclei were bombarded with alpha particles. He concluded that emitted radiations were neutrons and not photons. Explain.

- (b) Two nuclei may have the same radius, even though they contain different number of protons and neutrons. Explain.

[2022 • Set 55-3-3]

Q28. (a) Differentiate between nuclear fission and nuclear fusion.

- (b) Deuterium undergoes fusion as per the reaction: ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He} + {}^1_0\text{n} + 3.27 \text{ MeV}$. Find the duration for which an electric bulb of 500 W can be kept glowing by the fusion of 100 g of deuterium.

[2022 • Set 55-4-1]

Q29. In a fission event of ${}^{238}_{92}\text{U}$ by fast moving neutrons, no neutrons are emitted and final products, after the beta decay of the primary fragments, are ${}^{140}_{58}\text{Ce}$ and ${}^{99}_{44}\text{Ru}$. Calculate Q for this process. Neglect the masses of electrons/positrons emitted during the intermediate steps. Given: $m({}^{238}_{92}\text{U}) = 238.05079 \text{ u}$; $m({}^{140}_{58}\text{Ce}) = 139.90543 \text{ u}$; $m({}^{99}_{44}\text{Ru}) = 98.90594 \text{ u}$; $m({}^1_0\text{n}) = 1.008665 \text{ u}$.

[2022 • Set 55-5-1]

Q30. The nucleus ${}^{235}_{92}\text{U}$ initially at rest, decays into ${}^{231}_{90}\text{X}$ by emitting an α -particle ${}^{235}_{92}\text{U} \rightarrow {}^{231}_{90}\text{X} + {}^4_2\text{He} + \text{energy}$. The binding energies per nucleon of the parent nucleus, the daughter nucleus and α -particle are 7.8 MeV, 7.835 MeV and 7.07 MeV, respectively. Assuming the daughter nucleus to be formed in the unexcited state and neglecting its share in the energy of the reaction, find the speed of the emitted α -particle. (Mass of α -particle = $6.68 \times 10^{-27} \text{ kg}$)

[2020 • Set 55-1-1]

Q31. (a) Differentiate between half-life and average life of a radioactive substance.

- (b) A radioactive substance decays for an interval of time equal to its mean life. Find the fraction of the amount of the substance which is left undecayed after this time interval.

[2020 • Set 55-2-1]

Q32. (a) The density of the nuclear matter is tremendously larger than the physical density of the material. Explain.

- (b) The nuclear forces are not coulomb forces between nucleons. Explain.
- (c) Draw a plot of the potential energy between a pair of nucleons as a function of distance between them inside a nucleus.

[2020 • Set 55-3-1]

Q33. (a) Define the term decay constant of a radioactive substance.

- (b) The half life of ${}_{92}^{238}\text{U}$ undergoing α decay is 4.5×10^9 years. Calculate the activity of 10 g sample of ${}_{92}^{238}\text{U}$.

[2020 • Set 55-5-1]

Q34. Draw the curve showing the variation of binding energy per nucleon with the mass number of nuclei. Using it explain the fusion of nuclei lying on ascending part and fission of nuclei lying on descending part of this curve.

[2020 • Set 55-5-2]

Q35. Define the term 'decay constant' of a radioactive sample. The rate of disintegration of a given radioactive nucleus is 10000 disintegrations/s and 5000 disintegrations/s after 20 hr and 30 hr respectively from start. Calculate the half life and initial number of nuclei at $t = 0$.

[2019 • Set 55-1-1]

Q36. Write the relation between half life and average life of a radioactive nucleus.

[2019 • Set 55-1-2]

Q37. In a given sample two isotopes A and B are initially present in the ratio of 1 : 2. Their half lives are 60 years and 30 years respectively. How long will it take so that the sample has these isotopes in the ratio of 2 : 1?

[2019 • Set 55-1-2]

Q38. Show that density of nucleus is independent of its mass number A .

[2019 • Set 55-1-3]

Q39. Why is it difficult to detect the presence of an anti-neutrino during β -decay? Define the term decay constant of a radioactive nucleus and derive the expression for its mean life in terms of the decay constant.

————— OR —————

- (a) State two distinguishing features of nuclear force.
- (b) Draw a plot showing the variation of potential energy of a pair of nucleons as a function of their separation. Mark the regions on the graph where the force is (i) attractive, and (ii) repulsive.

[2019 • Set 55-2-1]

Q40. Draw a graph showing the variation of binding energy per nucleon with mass number of different nuclei. Write any two salient features of the curve. How does this curve explain the release of energy both in the processes of nuclear fission and fusion?

[2019 • Set 55-4-1]

Q41. (a) Plot a graph showing the variation of potential energy of a pair of nucleons as a function of their separation. Also indicate the regions where the force is (i) attractive and (ii) repulsive.

(b) Write two characteristic properties of nuclear force.

[2019 • Set 55-4-2]

Q42. Plot a graph showing the variation of number of undecayed nuclei in a radioisotope as a function of time. Hence define half life of a nucleus and obtain its relation with average life.

[2019 • Set 55-4-3]

Q43. (a) Distinguish between isotopes and isobars, giving one example for each.

(b) Why is the mass of a nucleus always less than the sum of the masses of its constituents? Write one example to justify your answer.

————— OR —————

(a) Classify the following six nuclides into (i) isotones, (ii) isotopes, and (iii) isobars: ${}^{12}_6\text{C}$, ${}^3_2\text{He}$, ${}^{198}_{80}\text{Hg}$, ${}^3_1\text{H}$, ${}^{197}_{79}\text{Au}$, ${}^{14}_6\text{C}$.

(b) How does the size of a nucleus depend on its mass number? Hence explain why the density of nuclear matter should be independent of the size of the nucleus.

[2019 • Set 55-5-1]

Q44. (a) Explain the processes of nuclear fission and nuclear fusion by using the plot of binding energy per nucleon (BE/A) versus the mass number A .

(b) A radioactive isotope has a half-life of 10 years. How long will it take for the activity to reduce to 3.125% ?

[2018]

Q45. (i) A radioactive nucleus 'A' undergoes a series of decays as given below: $A \xrightarrow{\alpha} A_1 \xrightarrow{\beta^-} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$ The mass number and atomic number of A_2 are 176 and 71 respectively. Determine the mass and atomic numbers of A_4 and A.

(ii) Write the basic nuclear processes underlying β^+ and β^- decays.

[2017]

Q46. (a) State the law of radioactive decay. Write the SI unit of 'activity'.

(b) There are $4\sqrt{2} \times 10^6$ radioactive nuclei in a given radioactive sample. If the half life of the sample is 20 s, how many nuclei will decay in 10 s?

[2017]

Q47. (a) Write the process of β -decay. How can radioactive nuclei emit β -particles even though they do not contain them? Why do all electrons emitted during β -decay not have the same energy?

(b) A heavy nucleus splits into two lighter nuclei. Which one of the two – parent nucleus or the daughter nuclei has more binding energy per nucleon?

[2017]

Q48. (a) Derive the relation between the decay constant and half life of a radioactive substance.

(b) A radioactive element reduces to 25% of its initial mass in 1000 years. Find its half life.

[2017]

Q49. (a) Write the basic nuclear process involved in the emission of β^+ in a symbolic form, by a radioactive nucleus.

(b) In the reactions given below: (i) ${}^6_{11}\text{C} \rightarrow {}^z_{y}\text{B} + x + \nu$ (ii) ${}^6_{12}\text{C} + {}^6_{12}\text{C} \rightarrow {}^a_{20}\text{Ne} + {}^b_c\text{He}$ Find the values of $x, y,$ and z and a, b and c .

[2016]

Q50. Half life of ${}^{238}_{92}\text{U}$ against α -decay is 4.5×10^9 years. Calculate the activity of 1 g sample of ${}^{238}_{92}\text{U}$. Given Avogadro's number = 6×10^{26} atoms/kmol.

[2016]

Q51. (a) Derive the mathematical expression for law of radioactive decay for a sample of a radioactive nucleus.

(b) How is the mean life of a given radioactive nucleus related to the decay constant?

[2016]

Q52. Plot a graph showing the variation of binding energy per nucleon as a function of mass number. Which property of nuclear force explains the approximate constancy of binding energy in the range $30 < A < 170$? How does one explain the release of energy in both the processes of nuclear fission and fusion from the graph?

[2016]

Q53. Obtain the relation between the decay constant and half life of a radioactive sample. The half life of a certain radioactive material against α -decay is 100 days. After how much time, will the undecayed fraction of the material be 6.25%?

[2015]

Q54. Distinguish between nuclear fission and fusion. Show how in both these processes energy is released. Calculate the energy release in MeV in the deuterium-tritium fusion reaction: ${}^2_1H + {}^3_1H \rightarrow {}^4_2He + n$ Using the data: $m({}^2_1H) = 2.014102 \text{ u}$, $m({}^3_1H) = 3.016049 \text{ u}$, $m({}^4_2He) = 4.002603 \text{ u}$, $m_n = 1.008665 \text{ u}$, $1 \text{ u} = 931.5 \text{ MeV}/c^2$

[2015]

Q55. (a) Deduce the expression, $N = N_0 e^{-\lambda t}$, for the law of radioactive decay.

(b) (i) Write symbolically the process expressing the β^+ decay of ${}^{22}_{11}\text{Na}$. Also write the basic nuclear process underlying this decay. **(ii)** Is the nucleus formed in the decay of the nucleus ${}^{22}_{11}\text{Na}$, an isotope or isobar ?

[2014]

Q56. 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 ?

[2014]

Q57. (a) In a typical nuclear reaction, e.g.



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 .

[2013]

Q58. (a) Write symbolically the β^- decay process of ${}^{32}_{15}\text{P}$.

(b) Derive an expression for the average life of a radionuclide. Give its relationship with the half-life.

[2012]

Q59. 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.

[2012]

Q60. (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 .

[2012]

Q61. 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) $t = 3T_{1/2}$ and (ii) $t = 5T_{1/2}$.

[2011 • Set 55-1-1]

Q62. (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 and mass number of D_2 are 71 and 176 respectively, what are their corresponding values for D?

[2010]

Q63. 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.

[2009]

Q64. Distinguish between isotopes and isobars. Give one example for each species. A radioactive isotope has a half-life of 5 years. How long will it take the activity to reduce to 3.125%?

[2008]

Q65. Calculate the energy released during the α -decay of ${}_{92}^{238}\text{U} \rightarrow {}_{90}^{234}\text{Th} + {}_2^4\text{He}$. Given: 1. atomic mass of ${}_{92}^{238}\text{U} = 238.05079$ u 2. atomic mass of ${}_{90}^{234}\text{Th} = 234.04363$ u 3. atomic mass of ${}_2^4\text{He} = 4.00260$ u $1 \text{ u} = 931.5 \text{ MeV}/c^2$. Is this decay spontaneous? Give reason.

[2007]

Q66. Draw the graph to show variation of binding energy per nucleon with mass number of different atomic nuclei. Calculate binding energy/nucleon of ${}_{20}^{40}\text{Ca}$ nucleus. Given: mass of ${}_{20}^{40}\text{Ca} = 39.962589$ u mass of proton = 1.007825 u mass of neutron = 1.008665 u and

$$1 \text{ u} = 931 \text{ MeV}/c^2$$

[2007]

Q67. Explain, with the help of a nuclear reaction in each of the following cases, how the neutron to proton ratio changes during (i) alpha-decay (ii) beta-decay.

[2006]

Q68. Why is the mass of a nucleus always less than the sum of the masses of its constituents, neutrons and protons? If the total number of neutrons and protons in a nuclear reaction is conserved, how then is the energy absorbed or evolved in the reaction? Explain.

[2006]

Q69. Draw a graph showing the variation of binding energy per nucleon with mass number for different nuclei. Explain, with the help of this graph, the release of energy by the process of nuclear fusion.

[2006]

Q70. (a) Draw a graph showing the variation of potential energy of a pair of nucleons as a function of their separation. Indicate the regions in which nuclear force is (i) attractive, and (ii) repulsive.

(b) Write two characteristic features of nuclear force which distinguish it from the coulomb force.

[2005]

Q71. (a) Show that the decay rate ' R ' of a sample of a radionuclide is related to the number of radioactive nuclei ' N ' at the same instant by the expression $R = \lambda N$.

(b) The half-life of ^{238}U against α -decay is 1.5×10^{17} s. What is the activity of a sample of ^{238}U having 25×10^{20} atoms?

[2005]

Q72. Give the mass number and atomic number of elements on the right-hand side of the decay process. The graph shows how the activity of a sample of radon-220 changes with time. Use the graph to determine its half-life. Calculate the value of decay constant of radon-220.



[2004]

4-Mark Questions (1 questions · Section D · Case Study)

Q1. Asha's mother read an article in the newspaper about a disaster that took place at Chernobyl. She could not understand much from the article and asked a few questions from Asha regarding the article. Asha tried to answer her mother's questions based on what she learnt in Class XII Physics.

- What was the installation at Chernobyl where the disaster took place? What, according to you, was the cause of this disaster?
- Explain the process of release of energy in the installation at Chernobyl.
- What, according to you, were the values displayed by Asha and her mother?

[2017]

5-Mark Questions (4 questions · Section E · Long Answer)

- Q1. (a)** Derive the law of radioactive decay $N = N_0 e^{-\lambda t}$.
- (b)** The half life of ^{238}U undergoing α -decay is 4.5×10^9 years. Find its mean life.
- (c)** What fraction of the initial mass of a radioactive substance will decay in five half-life periods?

————— OR —————

- State the postulates of Bohr's model of hydrogen atom and derive the expression for Bohr radius.
- Find the ratio of the longest and the shortest wavelengths amongst the spectral lines of Balmer series in the spectrum of hydrogen atom.

[2020 • Set 55-4-1]

Q2. Distinguish between 'nuclear fission' and 'nuclear fusion'. Which one of them is used for

release of energy in a nuclear reactor? Name one fuel used in a nuclear reactor.

[2010]

Q3. What are radiation hazards? Mention four safety measures which should be taken against radioactive radiation.

[2010]

Q4. What are radio isotopes? Write their any four uses.

[2010]