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# Nuclei — CBSE Class 12 Physics Chapter Test

FREE CHAPTER TEST · CLASS XII · PHYSICS (042) · PATTERN OF THE CBSE SAMPLE QUESTION PAPER 2026-27

| TIME ALLOWED | MAXIMUM MARKS | QUESTIONS | NAME / ROLL NO. |
|---|---|---|---|
| 1½ hours | 37 | 17 (A 8 · B 3 · C 3 · D 1 · E 2) | |

## GENERAL INSTRUCTIONS

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 17 questions. All questions are compulsory.
2. This question paper is divided into five sections: A, B, C, D and E.
3. Section A (Q1–8) contains 6 multiple choice questions and 2 assertion-reason based questions of 1 mark each.
4. Section B (Q9–11) contains short answer questions of 2 marks each.
5. Section C (Q12–14) contains short answer questions of 3 marks each.
6. Section D (Q15) contains case study based questions of 4 marks each, with four sub-parts of 1 mark.
7. Section E (Q16–17) contains long answer questions of 5 marks each.
8. There is no overall choice. However, an internal choice has been provided in 1 question in Section B, 1 question in Section C, 2 questions in Section E. Attempt only one of the alternatives in such questions.
9. Use of calculators is not allowed. You may use: 1 u = 931.5 MeV/$c^2$, 1 MeV = $1.6 \times 10^{-13}$ J, c = $3 \times 10^8$ m $s^{-1}$, $1/4\pi\varepsilon_0 = 9 \times 10^9$ N $m^2$ $C^{-2}$.
10. This chapter test follows the section structure, question types and marks per question of the CBSE Class XII Physics (042) Sample Question Paper 2026-27, at about half the length of the 70-mark board paper: 37 marks in 1½ hours.
11. The answer key and the marking scheme are at the end of this booklet. Attempt the paper in 1½ hours before you look at them.

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**Chapter:** Nuclei · **Topics:** Composition and size of the nucleus · Mass-energy and mass defect · Binding energy per nucleon · Nuclear force · Nuclear fission and fusion

## SECTION A

*This section comprises 8 questions of 1 mark each: 6 multiple choice questions (MCQs) and 2 assertion-reason based questions.*

**1.** Taking $R_0$ = 1.2 fm, the radius of a nucleus of mass number 64 is 1

(A) 4.8 fm (B) 1.2 fm

(C) 76.8 fm (D) 9.6 fm

**2.** The density of nuclear matter 1

(A) is proportional to the mass number A (B) is proportional to $A^{1/3}$

(C) is inversely proportional to A (D) is about the same for all nuclei

**3.** The energy equivalent of 1 atomic mass unit is about 1

(A) 9.31 MeV (B) 931.5 MeV

(C) 0.511 MeV (D) $1.6 \times 10^{-13}$ MeV

**4.** The mass defect of a helium-4 nucleus is 0.0304 u. Its binding energy is about 1

(A) 7.1 MeV (B) 3.8 MeV

(C) 28.3 MeV (D) 931 MeV

**5.** Isotopes of an element have the same 1

(A) mass number (B) atomic number

(C) number of neutrons (D) nuclear mass

**6.** The nuclear force between nucleons is 1

(A) long-range and attractive (B) dependent on the charges of the nucleons

(C) weaker than the electrostatic force (D) short-range and nearly independent of charge

**7.** **Assertion (A) :** Energy is released when two very light nuclei fuse to form a heavier nucleus. 1
**Reason (R) :** The binding energy per nucleon of the product nucleus is greater than that of the light nuclei.

(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) Assertion (A) is false and Reason (R) is also false.

**8.** **Assertion (A) :** Heavy nuclei such as uranium contain more neutrons than protons. 1

**Reason (R) :** The nuclear force between two neutrons is much stronger than that between two protons.

(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) Assertion (A) is false and Reason (R) is also false.

## SECTION B

*This section comprises 3 short answer questions of 2 marks each.*

**9.** Each fission of a uranium-235 nucleus releases about 200 MeV. Find the energy released by the complete fission of 1.0 g of uranium-235. ($N_A = 6.02 \times 10^{23}$ mol$^{-1}$) 2

**10.** (a) State two features of the curve of binding energy per nucleon against mass number. 2

**OR**

(b) Show that the density of nuclear matter does not depend on the mass number, and estimate it, taking the mass of a nucleon as $1.66 \times 10^{-27}$ kg and $R_0 = 1.2$ fm.

**11.** Find the binding energy per nucleon of $^{16}_{8}O$. (Atomic masses: $^{16}O$ = 15.994915 u, $^{1}H$ = 1.007825 u; $m_n$ = 1.008665 u; 1 u = 931.5 MeV/$c^2$) 2

## SECTION C

*This section comprises 3 short answer questions of 3 marks each.*

**12.** (a) What is meant by the mass defect and the binding energy of a nucleus? Using the binding-energy curve, explain why energy is released both in the fission of a heavy nucleus and in the fusion of light nuclei. 3

**OR**

(b) Find the energy released in the fusion reaction $^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He + {}^{1}_{0}n$. (Atomic masses: $^{2}H$ = 2.014102 u, $^{3}He$ = 3.016029 u; $m_n$ = 1.008665 u; 1 u = 931.5 MeV/$c^2$)

**13.** Find (i) the ratio of the radii of the nuclei $^{27}_{13}Al$ and $^{216}_{84}Po$, (ii) the radius of the polonium nucleus ($R_0$ = 1.2 fm) and (iii) the ratio of their densities. 3

**14.** In one fission of uranium-235: $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$. Find the energy released. Why are the neutrons released in fission important? (Atomic masses: $^{235}U$ = 235.043930 u, $^{141}Ba$ = 140.914411 u, $^{92}Kr$ = 91.926156 u; $m_n$ = 1.008665 u; 1 u = 931.5 MeV/$c^2$) 3

## SECTION D

*This section comprises 1 case study based question of 4 marks, with four sub-parts of 1 mark each.*

**15.** The Sun gives out about $3.8 \times 10^{26}$ W. This energy comes from reactions in its core, at about $1.5 \times 10^{7}$ K, in which four hydrogen nuclei finally become one helium nucleus, releasing about 26.7 MeV each time. ($1\ u = 931.5\ MeV/c^2$, $c = 3 \times 10^{8}\ m\ s^{-1}$)

**(I)** The process that produces the Sun's energy is
(A) nuclear fission (B) nuclear fusion (C) chemical burning of hydrogen (D) radioactive decay [1]

**(II)** The reaction needs a very high temperature because the nuclei must
(A) be split into nucleons first (B) lose their electrons to become heavier (C) be made to move slowly (D) overcome the electrostatic repulsion between them [1]

**(III)** The mass converted into energy in one such conversion (26.7 MeV) is about
(A) 0.0287 u (B) 0.287 u (C) 2.87 u (D) 0.00287 u [1]

**(IV)** The mass the Sun loses every second because of the energy it radiates is about
(A) $1.3 \times 10^{18}$ kg (B) $3.8 \times 10^{26}$ kg (C) $4.2 \times 10^{9}$ kg (D) $1.3 \times 10^{9}$ kg [1]

## SECTION E

*This section comprises 2 long answer questions of 5 marks each.*

**16.** (a) (i) Describe (draw) the curve of binding energy per nucleon against mass number and state its main features. Explain from it why nuclei near A = 56 are the most stable. 5

(ii) Find the binding energy per nucleon of $^{56}_{26}Fe$. (Atomic masses: $^{56}Fe = 55.934939$ u, $^{1}H = 1.007825$ u; $m_n = 1.008665$ u; $1\ u = 931.5\ MeV/c^2$)

**OR**

(b) (i) Write the main properties of the nuclear force. Describe how the potential energy of a pair of nucleons varies with their separation.
(ii) Find the electrostatic potential energy of two protons 2.0 fm apart, in MeV, and compare it with the binding energy per nucleon of a typical nucleus (about 8 MeV).

**17.** (a) (i) Distinguish between nuclear fission and nuclear fusion, giving one example of each. Why is it difficult to produce fusion on Earth? 5
(ii) A power station produces 100 MW from the fission of uranium-235, each fission releasing 200 MeV. Find the number of fissions per second and the mass of uranium-235 used up in a day. ($N_A = 6.02 \times 10^{23}\ mol^{-1}$)

**OR**

(b) (i) What is a nucleus made of? Define isotopes, isobars and isotones, with one example of each.
(ii) Classify the pairs ($^{12}C$, $^{14}C$), ($^{14}C$, $^{14}N$) and ($^{13}C$, $^{14}N$) as isotopes, isobars or isotones.

**END OF THE QUESTION PAPER**

## ANSWER KEY — SECTION A

| Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 |
|---|---|---|---|---|---|---|---|
| (A) | (D) | (B) | (C) | (B) | (D) | (A) | (C) |

## MARKING SCHEME AND WORKED SOLUTIONS

*Marks for each step are shown in brackets, as in the CBSE marking scheme. Any correct alternative method earns full marks.*

**Q1. Answer (A).** $R = R_0 A^{1/3} = 1.2 \times 64^{1/3} = 1.2 \times 4 = 4.8$ fm.

**Q2. Answer (D).** Mass $\propto$ A and volume $\propto R^3 \propto$ A, so the density is independent of A (about $2.3 \times 10^{17}$ kg m$^{-3}$).

**Q3. Answer (B).** $E = mc^2 = 1.66 \times 10^{-27} \times (3 \times 10^8)^2$ J $\approx 931.5$ MeV.

**Q4. Answer (C).** BE = $0.0304 \times 931.5 \approx 28.3$ MeV (about 7.1 MeV per nucleon).

**Q5. Answer (B).** Isotopes have the same Z (number of protons) but different numbers of neutrons.

**Q6. Answer (D).** It acts only over a few femtometres, is much stronger than the Coulomb force there, and is about the same for n–n, p–p and n–p.

**Q7. Answer (A).** The nucleons end up more tightly bound; the extra binding energy is released. R explains A. Answer (A).

**Q8. Answer (C).** A is true (the extra neutrons add attraction without adding Coulomb repulsion). R is false: the nuclear force is nearly charge-independent. Answer (C).

**Q9. (2 marks)** Answer: $\approx 8.2 \times 10^{10}$ J.
Nuclei in 1.0 g: $N = 6.02 \times 10^{23}/235 \approx 2.56 \times 10^{21}$. [1]
$E = 2.56 \times 10^{21} \times 200 \times 1.6 \times 10^{-13}$ J $\approx 8.2 \times 10^{10}$ J. [1]

**Q10. (2 marks)** Answer: (a) any two features; (b) $\approx 2.3 \times 10^{17}$ kg m$^{-3}$.
**(a)** Any two [2]: it is nearly constant (about 8 MeV) for the middle range of A (about 30 to 170); it has its maximum (about 8.75 MeV) near A = 56 (iron); it falls slowly for heavy nuclei (about 7.6 MeV for A = 238); it is low for light nuclei (A < 30), with peaks for $^4$He, $^{12}$C, $^{16}$O.
**OR (b)** $\rho$ = mass/volume = $Am/(4/3\ \pi R_0^3 A) = m/(4/3\ \pi R_0^3)$, independent of A. [1]
$\rho = 1.66 \times 10^{-27}/(4/3 \times \pi \times (1.2 \times 10^{-15})^3) \approx 2.3 \times 10^{17}$ kg m$^{-3}$. [1]

**Q11. (2 marks)** Answer: $\approx 7.98$ MeV.
$\Delta m = 8 \times 1.007825 + 8 \times 1.008665 - 15.994915 = 0.137005$ u. [1]
BE = $0.137005 \times 931.5 \approx 127.6$ MeV; per nucleon $\approx 127.6/16 \approx 7.98$ MeV. [1]

**Q12. (3 marks)** Answer: (a) fission and fusion both raise the BE per nucleon; (b) $\approx 3.27$ MeV.
**(a)** Mass defect $\Delta m = [Zm_p + (A - Z)m_n] - M$: the nucleus weighs less than its separate nucleons. Binding energy = $\Delta m\ c^2$, the energy needed to separate the nucleus into free nucleons. [1]
Fission: a heavy nucleus (about 7.6 MeV per nucleon) splits into two middle-mass nuclei (about 8.5 MeV per nucleon); the nucleons become more tightly bound and the difference (about 1 MeV per nucleon) is released. [1]
Fusion: light nuclei have a low binding energy per nucleon; the heavier product has a higher value, so energy is released. [1]
**OR (b)** $\Delta m = 2 \times 2.014102 - (3.016029 + 1.008665) = 4.028204 - 4.024694 = 0.003510$ u. [1½]
Q = $0.003510 \times 931.5 \approx 3.27$ MeV, released. [1½]

**Q13. (3 marks)** Answer: (i) 1 : 2; (ii) 7.2 fm; (iii) 1 : 1.
(i) $R \propto A^{1/3}$: $R_{Al}/R_{Po} = (27/216)^{1/3} = 3/6 = 1/2$. [1]
(ii) $R_{Po} = 1.2 \times 216^{1/3} = 1.2 \times 6 = 7.2$ fm. [1]
(iii) Nuclear density is independent of A: 1 : 1. [1]

**Q14. (3 marks)** Answer: ≈ 173 MeV; they can sustain a chain reaction.
$\Delta m = (235.043930 + 1.008665) - (140.914411 + 91.926156 + 3 \times 1.008665) = 236.052595 - 235.866562 = 0.186033$ u. [1]
$Q = 0.186033 \times 931.5 \approx 173$ MeV. [1]
The released neutrons can cause further fissions, so a self-sustaining chain reaction is possible. [1]

**Q15. (4 marks)** Answer: (I) B; (II) D; (III) A; (IV) C.
(I) (B) Light nuclei combine: fusion (thermonuclear). [1]
(II) (D) Only very fast nuclei can come close enough, against the Coulomb repulsion, for the nuclear force to act. [1]
(III) (A) $\Delta m = 26.7/931.5 \approx 0.0287$ u. [1]
(IV) (C) $\Delta m = P/c^2 = 3.8 \times 10^{26}/(9 \times 10^{16}) \approx 4.2 \times 10^9$ kg per second. [1]

**Q16. (5 marks)** Answer: (a) peak ≈ 8.75 MeV near A = 56; ≈ 8.79 MeV; (b) ≈ 0.72 MeV.
**(a)** (i) The curve rises steeply for light nuclei (with peaks at $^4$He, $^{12}$C, $^{16}$O), is nearly flat at about 8 MeV for A ≈ 30 to 170, reaches its maximum of about 8.75 MeV near A = 56, and falls slowly to about 7.6 MeV for A = 238. [2] Nuclei near A = 56 have the largest binding energy per nucleon: the most energy is needed to pull out each nucleon, so they are the most stable. [1]
(ii) $\Delta m = 26 \times 1.007825 + 30 \times 1.008665 - 55.934939 = 0.528461$ u; BE = $0.528461 \times 931.5 \approx 492.3$ MeV. [1] Per nucleon: 492.3/56 ≈ 8.79 MeV. [1]
**OR (b)** (i) Any four [2]: much stronger than the Coulomb force at nuclear distances; short-range (negligible beyond a few fm); nearly independent of charge (n–n, p–p, n–p alike); attractive for separations above about 0.8 fm and strongly repulsive below it; saturates (a nucleon interacts only with its near neighbours). The potential energy of two nucleons has a minimum near 0.8 fm, rises steeply at smaller separations and goes to zero beyond a few fm. [1]
(ii) $U = (1/4\pi\varepsilon_0)e^2/r = 9 \times 10^9 \times (1.6 \times 10^{-19})^2/(2.0 \times 10^{-15}) \approx 1.15 \times 10^{-13}$ J ≈ 0.72 MeV. [1] This is small compared with the binding energy per nucleon (about 8 MeV), showing that the nuclear force must be much stronger than the Coulomb force at this distance. [1]

**Q17. (5 marks)** Answer: (a) ≈ $3.1 \times 10^{18}$ s$^{-1}$; ≈ 105 g per day; (b) isotopes, isobars, isotones.
**(a)** (i) Fission: a heavy nucleus splits into two middle-mass nuclei, e.g. $^{235}$U + n → $^{141}$Ba + $^{92}$Kr + 3n. [1] Fusion: light nuclei combine to form a heavier one, e.g. $^2$H + $^2$H → $^3$He + n. [1] Fusion needs temperatures of about $10^7$ K so that the nuclei move fast enough to overcome their Coulomb repulsion; such hot matter is very hard to confine. [1]
(ii) Fissions per second = $10^8/(200 \times 1.6 \times 10^{-13}) \approx 3.1 \times 10^{18}$. [1] In a day: $3.125 \times 10^{18} \times 86\,400 \approx 2.7 \times 10^{23}$ nuclei, mass = $2.7 \times 10^{23} \times 235/6.02 \times 10^{23} \approx 105$ g. [1]
**OR (b)** (i) A nucleus has Z protons and N = A − Z neutrons (A nucleons). [1] Isotopes: same Z, different A ($^{12}$C, $^{14}$C). Isobars: same A, different Z ($^{14}$C, $^{14}$N). Isotones: same N, different Z ($^{13}$C, $^{14}$N, both N = 7). [2]
(ii) $^{12}$C and $^{14}$C: isotopes; $^{14}$C and $^{14}$N: isobars; $^{13}$C and $^{14}$N: isotones (7 neutrons each). [2]

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