

Nuclei — CBSE Pattern Test 1

Class 12 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 1 — CBSE Pattern (90 minutes, 40 marks)

Class 12 Physics · Nuclei · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.
 (2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.
 (3) For MCQ questions choose the single correct option; for VSA answers write a single line.
 (4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

1. The radius of a nucleus is proportional to
 - (A) $A^{1/3}$
 - (B) A
 - (C) A^2
 - (D) $A^{1/2}$
2. 1 u of mass corresponds to an energy of
 - (A) 931.5 MeV
 - (B) 1 MeV
 - (C) 13.6 eV
 - (D) $1.6 \times 10^{-13} \text{ J}$
3. In alpha decay, the atomic number of the nucleus
 - (A) decreases by 2
 - (B) increases by 2
 - (C) decreases by 4
 - (D) is unchanged
4. In beta-minus decay, the atomic number
 - (A) increases by 1
 - (B) decreases by 1
 - (C) decreases by 2
 - (D) is unchanged
5. The half-life of a radioactive substance is related to the decay constant by
 - (A) $T_{1/2} = 0.693/\lambda$
 - (B) $T_{1/2} = \lambda/0.693$
 - (C) $T_{1/2} = 0.693\lambda$
 - (D) $T_{1/2} = 1/\lambda$
6. The mean life of a radioactive substance is
 - (A) $1/\lambda$
 - (B) $0.693/\lambda$
 - (C) λ
 - (D) 0.693λ
7. Nuclear fission involves the
 - (A) splitting of a heavy nucleus

- (B) combining of light nuclei
 - (C) emission of an electron
 - (D) absorption of a photon
8. Nuclear fusion is the source of energy in
- (A) the Sun and stars
 - (B) a nuclear reactor
 - (C) a betatron
 - (D) a cyclotron
9. State the radioactive decay law.
10. What is meant by the binding energy of a nucleus?

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. The mass defect of a nucleus is 0.2 u. Find its binding energy.
12. A radioactive sample has a half-life of 20 minutes. Find the time in which $\frac{3}{4}$ of the sample decays.
13. The decay constant of a radioactive substance is 0.0693 per year. Find its half-life.
14. Find the binding energy per nucleon of a nucleus of mass number 56 with a mass defect of 0.1 u.

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. Derive the relation between the radius of a nucleus and its mass number and show that nuclear density is nearly constant.
16. State the laws of radioactive disintegration and derive the relation $N = N_0 e^{(-\lambda t)}$.
17. Define half-life and mean life and derive the relation between them.
18. Explain nuclear fission and describe how a chain reaction is maintained in a nuclear reactor.

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Derive the expression for the binding energy of a nucleus. Explain, with the help of the binding energy per nucleon curve, why heavy nuclei undergo fission and light nuclei undergo fusion.
20. State the laws of radioactive decay and derive $N = N_0 e^{(-\lambda t)}$. Define half-life and mean life, and obtain the relation between them.

Answer Key (Marking Scheme)

- Q1 — (A) $A^{(1/3)}$. Q2 — (A) 931.5 MeV. Q3 — (A) decreases by 2. Q4 — (A) increases by 1.
- Q5 — (A) $T_{(1/2)} = 0.693/\lambda$. Q6 — (A) $1/\lambda$. Q7 — (A) splitting of a heavy nucleus. Q8 — (A) the Sun and stars.
- Q9 — The rate of decay is proportional to the number of undecayed nuclei: $dN/dt = -\lambda N$.
- Q10 — The minimum energy required to separate the nucleons of a nucleus completely.
- Q11 — B.E. = $0.2 \times 931.5 = 186.3$ MeV.
- Q12 — $\frac{3}{4}$ decayed after 2 half-lives = 40 minutes.
- Q13 — $T_{(1/2)} = 0.693/0.0693 = 10$ years.
- Q14 — B.E. = $0.1 \times 931.5 = 93.15$ MeV; per nucleon = $93.15/56 \approx 1.66$ MeV.
- Q15 — $r = r_0 A^{(1/3)}$; volume A and mass A , so density is constant.
- Q16 — $dN/dt = -\lambda N$ integrates to $N = N_0 e^{(-\lambda t)}$.

Q17 — $T_{1/2} = 0.693/\lambda$, $\tau = 1/\lambda$, so $\tau = T_{1/2}/0.693 = 1.44 T_{1/2}$.

Q18 — A heavy nucleus splits on absorbing a neutron, releasing energy and more neutrons, sustaining the chain.

Q19 — $\Delta m c^2$ gives B.E.; the curve peaks near $A = 56$, so heavy nuclei split and light nuclei fuse to move towards higher B.E. per nucleon.

Q20 — See Q16 and Q17.