CLASS XII – PHYSICS (042)
PRACTICE PAPER – CHAPTER 13: NUCLEI

Academic Session 2026–27

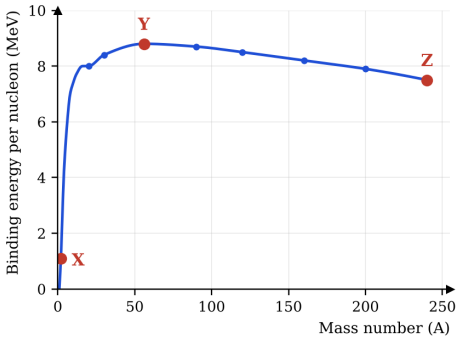
Maximum Marks : 35 **Time Allowed : 1 hour 15 minutes**

General Instructions

(1) There are 18 questions in all. All questions are compulsory.
(2) The question paper has five sections: Section A, B, C, D and E.
(3) Section A (Q.1–9) has seven MCQs and two Assertion–Reasoning questions of 1 mark each. Section B (Q.10–13) has four questions of 2 marks each. Section C (Q.14–16) has three questions of 3 marks each. Section D (Q.17) is one case study based question of 4 marks. Section E (Q.18) is one long answer question of 5 marks.
(4) There is no overall choice. An internal choice is provided in Q.12 (Section B), Q.15 (Section C), Q.17 part (iv) (Section D) and Q.18 (Section E). Attempt only one of the choices in such questions.
(5) Use of calculators is not allowed.
(6) You may use the following values wherever necessary: $c = 3 \times 10^8$ m s^{-1}, 1 u = 931 MeV/c^2 = 1.66×10^{-27} kg, 1 MeV = 1.6×10^{-13} J, R_0 = 1.2 fm, 1 fm = 10^{-15} m, $e^2/4\pi\varepsilon_0$ = 1.44 MeV fm, $N_A = 6 \times 10^{23}$ mol^{-1}, π = 3.14.

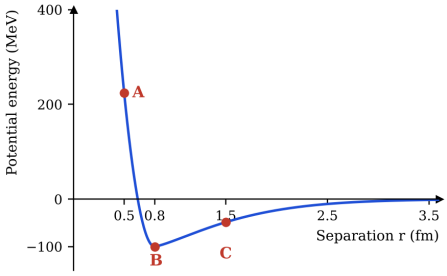
SECTION A (9 × 1 = 9)

1. The graph shows the variation of binding energy per nucleon with mass number. X, Y and Z are three nuclei. Which of the following statements is correct? **1**



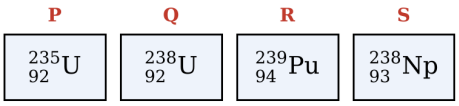
(a) Nucleus Y is the most stable, and energy is released when X fuses with another nucleus and when Z splits into two medium-mass nuclei.
(b) Nucleus X is the most stable because it has the fewest nucleons.
(c) Energy is absorbed when Z splits into two medium-mass nuclei.
(d) Energy is released only when Y is broken into smaller nuclei.

2. The graph shows the potential energy of a pair of nucleons as a function of their separation. At the separations marked A, B and C, the force between the nucleons is respectively **1**



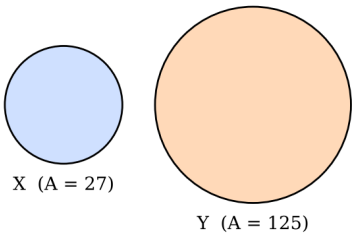
(a) attractive, zero, repulsive
(b) repulsive, attractive, zero
(c) repulsive, zero, attractive
(d) attractive, attractive, attractive

3. Four nuclides P, Q, R and S are shown. A pair of isobars is **1**



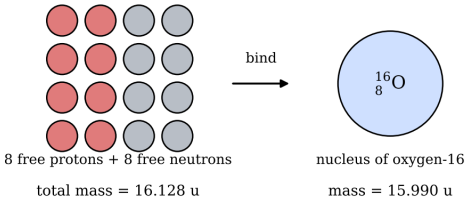
(a) P and Q
(b) Q and S
(c) R and S
(d) P and R

4. The nuclei X (A = 27) and Y (A = 125) are shown. The ratio of the radius of Y to the radius of X, and the ratio of their nuclear densities $\rho_Y : \rho_X$, are respectively **1**



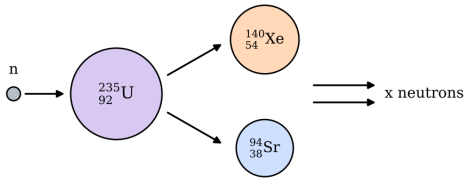
(a) 5/3 and 125/27
(b) 125/27 and 1
(c) 5/3 and 5/3
(d) 5/3 and 1

5. The masses of the free constituents and of the oxygen-16 nucleus are shown. Given the mass of a proton = 1.007 u and of a neutron = 1.009 u, the binding energy of the nucleus is about **1**



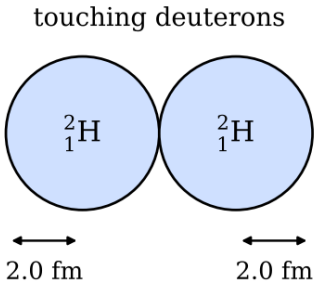
(a) 12.85 MeV
(b) 64.2 MeV
(c) 128.5 MeV
(d) 257 MeV

6. A uranium nucleus absorbs a neutron and breaks up as shown. The number x of neutrons released is **1**



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

7. Two deuterons, each treated as a hard sphere of radius 2.0 fm, are brought together until they just touch, as shown. The height of the Coulomb barrier for this head-on collision is **1**



(a) 360 keV
(b) 720 keV
(c) 180 keV
(d) 1.44 MeV

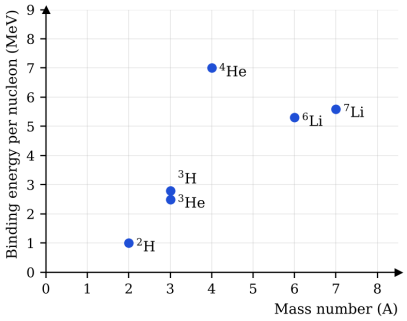
For Questions 8 and 9, a statement of Assertion (A) is followed by a statement of Reason (R). Select the correct answer from the options below.
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

8. **Assertion (A):** Energy is released when a heavy nucleus undergoes fission. **1**
Reason (R): A free neutron is unstable and decays into a proton, an electron and an antineutrino.

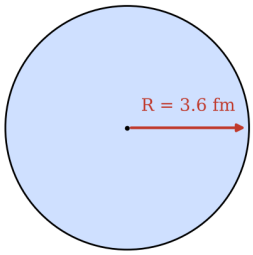
9. **Assertion (A):** Mass–energy interconversion takes place only in nuclear reactions and never in chemical reactions. **1**
Reason (R): The mass defect in a chemical reaction is about a million times smaller than that in a nuclear reaction.

SECTION B (4 × 2 = 8)

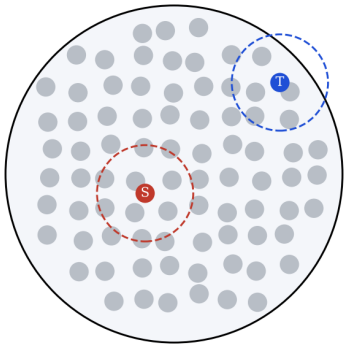
10. The graph shows the binding energy per nucleon of some light nuclei. (a) Read from the graph the total binding energy of ^{2}H and of ^{4}He. (b) Find the energy released when two ^{2}H nuclei fuse to form one ^{4}He nucleus. **2**



11. A nucleus of radius 3.6 fm is shown. (a) Find its mass number. (b) If the nucleus is that of aluminium (Z = 13), write its symbol in the form ${}^{A}_{Z}X$ and find the number of neutrons in it. **2**



12. **(A)** In the large nucleus shown, the dashed circles show the range of the nuclear force around the nucleons S and T. Using the figure, explain the saturation property of the nuclear force, and hence why the binding energy per nucleon is nearly constant for medium and heavy nuclei. **2**



dashed circles: range of the nuclear force

OR

(B) Define mass defect and binding energy of a nucleus. Write the relation between them.

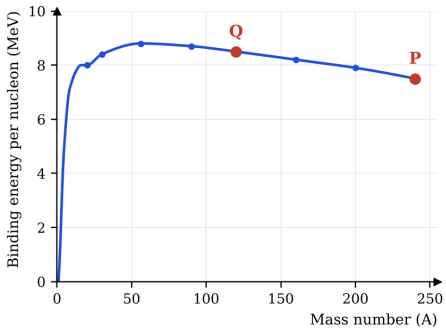
13. The fusion reaction shown takes place with the masses given in the table. Find the Q-value of the reaction, and state whether the reaction is exothermic or endothermic. **2**

${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He + n$

Particle	${}^{2}_{1}H$	${}^{3}_{2}He$	n
Mass	2.0141 u	3.0160 u	1.0087 u

SECTION C (3 × 3 = 9)

14. The graph shows the binding energy per nucleon against mass number. (a) Which nucleus has the greatest binding energy per nucleon, and roughly what is its value? (b) Why is energy released when two light nuclei fuse? (c) Using the values of P (A = 240) and Q (A = 120) read from the graph, find the energy released when a nucleus of mass number 240 splits into two nuclei of mass number 120. **3**



15. **(A)** The figure shows the proton–proton cycle, which is the source of energy in the Sun. (a) Why must reactions (i), (ii) and (iii) take place twice before reaction (iv)? (b) Add the reactions suitably to find the net energy released when four hydrogen nuclei form one helium nucleus. (c) Why does this fusion need a very high temperature? **3**

(i) ${}_1^1\mathrm{H} + {}_1^1\mathrm{H} \rightarrow {}_1^2\mathrm{H} + e^+ + \nu + 0.42$ MeV

(ii) $e^+ + e^- \rightarrow \gamma + \gamma + 1.02$ MeV

(iii) ${}_1^2\mathrm{H} + {}_1^1\mathrm{H} \rightarrow {}_2^3\mathrm{He} + \gamma + 5.49$ MeV

(iv) ${}_2^3\mathrm{He} + {}_2^3\mathrm{He} \rightarrow {}_2^4\mathrm{He} + {}_1^1\mathrm{H} + {}_1^1\mathrm{H} + 12.86$ MeV

OR

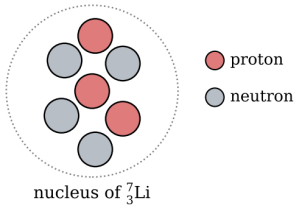
(B) Using the graph of binding energy per nucleon against mass number, explain why energy is released in the fission of a heavy nucleus and in the fusion of light nuclei. Write one example of a fission reaction.

16. A fissile nuclide of mass number 240 releases 200 MeV in each fission, as shown. Take the molar mass as 240 g. For 1 kg of the nuclide, find (a) the number of nuclei, (b) the total energy that can be released, in joule, and (c) the ratio of this energy to the energy obtained by burning 1 kg of coal. **3**

1 kg of fissile nuclide	**1 kg of coal**
mass number A = 240	burning gives 1×10^7 J
energy per fission = 200 MeV	

SECTION D (1 × 4 = 4)

17. **Case Study.** A student wants to find how tightly the nucleons are bound in the lithium-7 nucleus (Z = 3, A = 7), shown in the figure. The mass of a proton is 1.007 u, the mass of a neutron is 1.009 u and the mass of the $^{7}_{3}$Li nucleus is 7.014 u. Answer the following: **4**



(i) The total mass of the separate protons and neutrons of this nucleus is

(a) 7.000 u (b) 7.014 u (c) 7.057 u (d) 7.100 u

(ii) The mass defect of the nucleus is

(a) 0.043 u (b) 0.057 u (c) 0.014 u (d) 0.100 u

(iii) The binding energy of the nucleus is about

(a) 4.0 MeV (b) 20 MeV (c) 80 MeV (d) 40 MeV

(iv) The binding energy per nucleon is about

(a) 40 MeV (b) 5.7 MeV (c) 0.043 MeV (d) 11.4 MeV

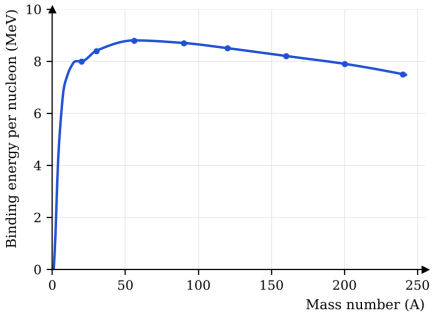
OR

(iv) Compared with ^{4}He (binding energy per nucleon about 7.0 MeV), the ^{7}Li nucleus is

(a) more tightly bound (b) less tightly bound (c) equally tightly bound (d) not bound at all

SECTION E (1 × 5 = 5)

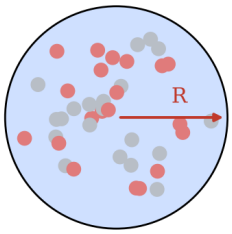
18. **(A)** (a) The graph shows the binding energy per nucleon against the mass number. Describe the two main features of the curve and state what each tells us about the nuclear force or about nuclear energy. (3) **5**



(b) The mass of the $^{4}_{2}He$ nucleus is 4.002 u. Find its binding energy and binding energy per nucleon. (2)

OR

(B) (a) A nucleus of mass number A has the radius $R = R_0 A^{1/3}$, as shown. Show that the density of nuclear matter is independent of A. (3)



$R = R_0\ A^{1/3}$

A nucleons

(b) Using 1 u = 1.66×10^{-27} kg and $R_0^{\,3} = 1.73 \times 10^{-45}\ m^3$, estimate the density of nuclear matter, and the mass of 1 cm^3 of it. (2)

— End of Question Paper —