Exercise-1

✍ **Marked Questions can be used as Revision Questions.**

OBJECTIVE QUESTIONS

☞ **If required, you can use the follwoing data:**

Mass of proton m_p = 1.007276 u, Mass of $_1H^1$ atom = 1.007825 u, Mass of neutron m_n = 1.008665 u, Mass of electron = 0.0005486 u = 511 KeV/c^2, 1 u = 931 MeV/c^2. $N_A = 6.023 \times 10^{23}$
Atomic mass of : H^2 = 2.01410 u, Be^8 = 8.00531u, B^{11} = 11.00930u, Li^7 = 7.01601u, He^4 = 4.002603u.

Section (A) : Properties of Nucleus

A-1. Let E,G and N represents the magnitude of electromagnetic, gravitational and nuclear forces between two protons at a given separation (1 fermi meter) . Then
(1) N < E < G (2) E > N > G (3) G > N > E (4) N > E > G

A-2✍ The mass number of a nucleus is
(1) always less than its atomic number
(2) always more than its atomic number
(3) equal to its atomic number
(4) sometimes more than and sometimes equal to its atomic number

A-3✍ The stable nucleus that has a radius 1/3 that of Os^{189} is -
(1) $_3Li^7$ (2) $_2He^4$ (3) $_5B^{10}$ (4) $_6C^{12}$

Section (B) : Mass Defect and Binding Energy

B-1 Two protons are kept at a separation of 50Å. F_n is the nuclear force and F_e is the electrostatic force between them, then
(1) $F_n >> F_e$ (2) $F_n = F_e$ (3) $F_n << F_e$ (4) F_n F_e

B-2✍ Masses of nucleus, neutron and protons are M, n_m and m_p respectively. If nucleus has been divided in to neutrons and protons, then
(1) $M = (A – Z) m_n + Zm_p$ (2) $M = Zm_n + (A – Z) m_p$
(3) $M < (A – Z) m_n + Zm_p$ (4) $M > (A – Z)m_n + Zm_p$

B-3✍ As the mass number A increases, the binding energy per nucleon in a nucleus
(1) increases (2) decreases (3) remains the same
(4) varies in a way that depends on the actual value of A.

B-4✍ Which of the following is a wrong description of binding energy of a nucleus ?
(1) It is the energy required to break a nucleus into its constituent nucleons.
(2) It is the energy released when free nucleons combine to from a nucleus
(3) It is the sum of the rest mass energies of its nucleons minus the rest mass energy of the nucleus

(4) It is the sum of the kinetic energy of all the nucleons in the nucleus

B-5 The energy of the reaction $Li^7 + p \longrightarrow 2\ He^4$ is (the binding energy per nucleon in Li^7 and He^4 nuclei are 5.60 and 7.06 MeV respectively.)
(1) 17.3 MeV (2) 1.73 MeV (3) 1.46 MeV
(4) Depends on binding energy of proton

Section (C) : Radioactive Decay and Displacement Law

C-1 An α-particle is bombarded on ^{14}N. As a result, a ^{17}O nucleus is formed and a particle is emitted. This particle is a
(1) neutron (2) proton (3) electron (4) positron

C-2 A free neutron decays into a proton, an electron and :
(1) A neutrino (2) An antineutrino (3) An α-particle (4) A β-particle

C-3 The specific activity (per gm) of radium is nearly -
(1) 1 Bq (2) 1 Ci (3) 3.7×10^{10} Ci (4) 1 mCi

Section (D) : Statistical Law of Radioactive Decay

D-1 In one average-life
(1) half the active nuclei decay (2) less than half the active nuclei decay
(3) more than half the active nuclei decay (4) all the nuclei decay

D-2 A freshly prepared radiocative source of half-life 2 h emits radiation of intensity which is 64 times the permissible safe level. The minimum time after which it would be possible to work safely with this source is -
(1) 6 h (2) 12 h (3) 24 h (4) 128 h

D-3 10 grams of ^{57}Co kept in an open container decays β–particle with a half-life of 270 days. The weight of the material inside the container after 540 days will be very nearly -
(1) 10 g (2) 7.5 g (3) 5 g (4) 2.5 g

D-4 After a time equal to four half lives, the amount of radioacitve material remaining undecayed is -
(1) 6.25 % (2) 12.50 % (3) 25.0 % (4) 50.0 %

D-5 The decay constant of the parent nuclide in Uranium series is λ. Then the decay constant of the stable end product of the series will be -
(1) $\lambda/238$ (2) $\lambda/206$ (3) $\lambda/208$ (4) zero

D-6 The half life of thorium (Th^{232}) is 1.4×10^{10} years. Then the fraction of thorium atoms decaying per year is very nearly -
(1) 1×10^{-11} (2) 4.95×10^{-11} (3) 0.69×10^{-11} (4) 7.14×10^{-11}

Section (E) : Nuclear Fission And Fusion

E-1 If mass of the fissionable material is less than the critical mass, then
(1) Fission and chain reactions both are impossible
(2) Fission is possible but chain reaction is impossible

(3) Fission is impossible but chain reaction is possible
(4) Fission and chain reaction both are possible.

E-2 Which of the following materials is used for controlling nuclear fission in nuclear reactor :
(1) heavy water (2) graphite (3) cadmium (4) Berillium oxide

E-3 Atomic reactor is based on
(1) controlled chain reaction (2) uncontrolled chain reaction
(3) nuclear fission (4) nuclear fusion

E-4✍ $_{92}U^{235}$ nucleus absorbs a slow neutron and undergoes fission into $_{54}X^{139}$ and $_{38}Sr^{94}$ nuclei.The other particles porduced in this fission process are
(1) 1 β and 1 α (2) 2 β and 1 neutron (3) 2 neturons (4) 3 neutrons

E-5 Two lithium ^{6}Li nuclei in a lithium vapour at room temperature do not combine to form a carbon ^{12}C nucleus because
(1) a lithium nucleus is more tightly bound than a carbon nucleus
(2) carbon nucleus is an unstable particle
(3) it is not energetically favourable
(4) Coulomb repulsion does not allow the nuclei to come very close

E-6✍ Choose the statement which is true.
(1) The energy released per unit mass is more in fission than in fusion
(2) The energy released per atom is more in fusion than in fission.
(3) The energy released per unit mass is more in fusion and that per atom is more in fission.
(4) Both fission and fusion produce same amount of energy per atom as well as per unit mass.

E-7 Fusion reaction is possible at high temperature because -
(1) atoms are ionised at high temperature
(2) molecules break-up at high temperature
(3) nuclei break-up at high temperature
(4) kinetic energy is high enough to overcome repulsion between nuclei.

Exercise-2

✍ **Marked Questions can be used as Revision Questions.**

PART - I : OBJECTIVE QUESTIONS

1.✍ The graph of $\ell n\,(R/R_0)$ versus $\ell n\,A$ (R = radius of a nucleus and A = its mass number) is
(1) a straight line (2) a parabola (3) an ellipse (4) none of them

2. Let F_{pp}, F_{pn} and F_{nn} denote the magnitudes of the nuclear force by a proton on a proton, by a proton on a neutron and by a neutron on a neutron respectively. When the separation is 1 fm,
(1) $F_{pp} > F_{pn} = F_{nn}$ (2) $F_{pp} = F_{pn} = F_{nn}$ (3) $F_{pp} > F_{pn} > F_{nn}$ (4) $F_{pp} < F_{pn} = F_{nn}$

3. When a β^--particle is emitted from a nucleus, the neutron-proton ratio :
(1) is decreased (2) is increased (3) remains the same (4) first (1) then (2)

4. Free ^{238}U nuclei kept in a train emit alpha particles. When the train is stationery and a uranium nucleus decays, a passenger measures that the separation between the alpha particle and the recoiling nucleus becomes x in time t after the decay. If a decay takes place when the train is moving at a uniform speed υ, the distance between the alpha particle and the recoiling nucleus at a time t after the decay, as measured by the passenger will be -
(1) $x + \upsilon t$ (2) $x - \upsilon t$ (3) x
(4) depends on the direction of the train

5. A sample of radioactive material has mass m, decay constant λ, and molecular weight M. Avogadro constant = N_A. The initial acitvity of the sample is :

(1) λm (2) $\frac{\lambda m}{M}$ (3) $\frac{\lambda m N_A}{M}$ (4) $mN_A e\lambda$

6. Two radioactive sources A and B initially contain equal number of radioactive atoms. Source A has a half-life of 1 hour and source B has a half-life of 2 hours. At the end of 2 hours, the ratio of the rate of disintegration of A to that of B is :

(1) 1 : 2 (2) 2 : 1 (3) 1 : 1 (4) 1 : 4

7. N atoms of a radioactive element emit n alpha particles per second at an instant. Then the half - life of the element is

(1) $\frac{n}{N}$ sec. (2) 1.44 $\frac{n}{N}$ sec. (3) 0.69 $\frac{n}{N}$ sec. (4) 0.69 $\frac{n}{N}$ sec.

8. A free neutron decays to a proton but a free proton does not decay to a neutron. This is beacuse

(1) neutron is a composite particle made of a proton and an electron whereas proton is fundamental particle

(2) neutron is an uncharged particle whereas proton is a charged particle

(3) neutron has larger rest mass than the proton

(4) weak forces can operate in a neutron but not in a proton.

9. Consider a sample of a pure beta-active material

(1) All the beta particles emitted have the same energy

(2) The beta particles originally exist inside the nucleus and are ejected at the time of beta decay

(3) The antineutrino emitted in a beta decay has zero rest mass and hence zero momentum.

(4) The active nucleus changes to one of its isobars after the beta decay

10. The binding energies of two nuclei P^n and Q^{2n} and x and y joules. If 2x > y then the energy released in the reaction

$P^n + P^n \rightarrow Q^{2n}$, will be

(1) 2x + y (2) 2x – y (3) –(2x – y) (4) x + y

11. Two isotopes P and Q of atomic weight 10 and 20, respectively are mixed in equal amount by weight. After 20 days their weight ratio is found to be 1 : 4. Isotope P has a half-life of 10 days. The half-life of isotope Q is

(1) zero (2) 5 days (3) 20 days (4) inifinite

12. In a fission reaction

$${}^{236}_{92}U \longrightarrow {}^{117}X + {}^{117}Y + n + n$$

the average binding energy per nucleon of X and Y is 8.5 MeV whereas that of ${}^{236}U$ is 7.6 MeV. The total energy liberated will be about :

$${}^{236}_{92}U \longrightarrow {}^{117}X + {}^{117}Y + n + n$$

(1) 200 keV (2) 2 MeV (3) 200 MeV (4) 2000 MeV

13. A positron of 1MeV collides with an electron of 1 MeV and gets annihilated and the reaction produces two γ-ray photons. If the effective mass of each photon is 0.0016 amu, then the energy of each γ-ray photon is about-

(1) 1.5 MeV (2) 3 MeV (3) 6 MeV (4) 2 MeV

14. How much uranium is required per day in a nuclear reactor of power capacity of 1 MW

(1) 15 mg (2) 1.05 gm (3) 105 gm (4) 10.5 kg

PART - II : MISCELLANEOUS QUESTIONS

Section (A) : Assertion//Reasoning

A-1. **STATEMENT–1 :** ${}_{Z}X^{A}$ undergoes 2 α decays, 2β decays (negative β) and 2 γ decays. As a result the daughter product is ${}_{Z-2}Y^{A-8}$.
STATEMENT–2 : In α decay the mass number decreases by 4 unit and atomic number decreases by 2 unit. In β decay (negative β) the mass number remains unchanged and atomic number increases by 1 unit. In γ decay, mass number and atomic number remains unchanged.
(1) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

A-2. **STATEMENT–1 :** Q- value of a reaction : A + B $\rightarrow$ C + Q is – 30 MeV. The minimum kinetic energy of bombarding nucleus to initiate the nuclear reaction is 30 MeV.
STATEMENT–2 : Momentum will conserve in the endoergic reaction also.
(1) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

A-3. **STATEMENT–1 :** In spontaneous fission, the energy is always released.
STATEMENT–2 : Spontaneous fission occurs to lower the binding energy of reactant nuclei.
(1) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

Section (B) : Match the column

B-1 In the following question x (an unstable nucleus) decays to another nucleus y. In column I different type of decay processes are mentioned. Atomic mass of element of nucleus x and element of nucleus y are M_x and M_y respectively. The atomic mass of He is M_{He}. The mass of electron is m_e. Now match the entries of column I with II.

Column I (Decay process)	**Column II (Mass defect)**
(1) $x \rightarrow y + \alpha$	(p) $M_x - M_y - m_e$
(2) $x \rightarrow y + {}_{-1}e^0$	(q) $M_x - M_y - M_{He}$
(3) $x \rightarrow y + {}_{+1}e^0$	(r) $M_x - M_y - 2m_e$
(4) $x + {}_{-1}e^0 \rightarrow y + \nu$ +X- rays	(s) $M_x - M_y$

Section (C) : One or More Than One Options Correct

C-1. If a nucleus ${}_{Z}^{A}x$ emits one α particle and one β (negative β) particle in succession, then the daughter nucleus will have which of the following configurations?

(1) A - 4 nucleons (2) 4 nucleons (3) A - Z - 3 neutrons (4) Z - 2 protons

C-2. The heavier stable nuclei tend to have larger N/Z ratio because -

(1) a neutron is heavier than a proton
(2) a neutron is an unstable particle
(3) a neutron does not exert electric repulsion
(4) Coulomb forces have longer range compared to nuclear forces

C-3. A U^{238} sample of mass 1.0 g emits alpha particles at the rate 1.24 x 10^4 particles per second. ($N_A = 6.023 \times 10^{23}$)
(1) The half life of this nuclide is 4.5×10^9 years
(2) The half life of this nuclide is 9×10^9 years
(3) The activity of the prepared sample is 2.48×10^4 particles/sec
(4) The activity of the prepared sample is 1.24×10^4 particles/sec.

C-4.✍ A nitrogen nucleus $_7N^{14}$ absorbs a neutron and can transform into lithium nucleus $_3Li^7$ under suitable conditions, after emitting
(1) 4 protons and 4 neutrons
(2) 5 protons and 1 negative beta particle
(3) 2 alpha particles and 2 gamma particles
(4) 1 alpha particle, 4 protons and 2 negative beta particles.

C-5. The decay constant of a radio active substance is 0.173 $(\text{years})^{-1}$. Therefore:
Use approximation $\ell n2 = 0.692$
(1) Nearly 63% of the radioactive substance will decay in (1/0.173) year.
(2) half life of the radio active substance is (1/0.173) year.
(3) one -forth of the radioactive substance will be left after nearly 8 years.
(4) half of the substance will decay in one average life time.

C-6.✍ Let m_p be the mass of a proton, m_n the mass of a neutron, M_1 the mass of a $^{20}_{10}Ne$ nucleus & M_2 the mass of a $^{40}_{20}Ca$ nucleus. Then :
(1) $M_2 = 2\ M_1$ (2) $M_2 > 2\ M_1$ (3) $M_2 < 2\ M_1$ (4) $M_1 < 10\ (m_n + m_p)$

C-7.✍ Nuclei of radioactive element A are being produced at a constant rate α. The element has a decay constant λ. At time $t = 0$, there are N_0 nuclei of the element.
(1) Number of nuclei of A at time t is $\frac{1}{\lambda}[\alpha - (\alpha - \lambda N_0)\ e^{-\lambda t}]$
(2) Number of nuclei of A at time t is $\frac{1}{\lambda}[(\alpha - \lambda N_0)\ e^{-\lambda t}]$
(3) If $\alpha = 2N_0\lambda$, then the limiting value of number of nuclei of A ($t \to \infty$) will be $2N_0$.
(4) If $\alpha = 2N_0\lambda$, then the number of nuclei of A after one half-life of A will be $N_0/2$.

Exercise-3

✍ **Marked Questions can be used as Revision Questions.**

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. If N_0 is the original mass of the substance of half-life period $t_{l/2}$ = 5 years, then the amount of substance left after 15 years is : **[AIEEE-2002, 4/300]**

(1) $N_0 / 8$ (2) $N_0 / 16$ (3) $N_0 / 2$ (4) $N_0 / 4$

2. Which of the following radiations has the least wavelength? **[AIEEE-2003, 4/300]**
(1) γ-rays (2) β-rays (3) α-rays (4) X-rays

3. When U^{238} nucleus originally at rest, decays by emitting an alpha particle having a speed u, the recoil speed of the residual nucleus is : **[AIEEE-2003, 4/300]**
(1) $\frac{4u}{238}$ (2) $-\frac{4u}{234}$ (3) $\frac{4u}{234}$ (4) $-\frac{4u}{238}$

4. A radioactive sample at any instant has its disintegration rate 5000 disintegrations per minute. After 5 minutes, the rate is 1250 disintegrations per minute. Then, the decay constant (per minute) is : **[AIEEE-2003, 4/300]**
(1) 0.4 ln 2 (2) 0.2 ln 2 (3) 0.1 ln 2 (4) 0.8 ln 2

5. A nucleus with Z = 92 emits the following in a sequence : α, α, β^-, β^-, α, α, α, α; β^-, β^-, α, β^+, β^+, α. The Z of the resulting nucleus is : **[AIEEE-2003, 4/300]**
(1) 76 (2) 78 (3) 82 (4) 74

6. Which of the following cannot be emitted by radioactive substances during their decay? **[AIEEE-2003, 4/300]**
(1) Protons (2) Neutrinos (3) Helium nuclei (4) Electrons

7. In the nuclear fusion reaction, **[AIEEE-2003, 4/300]**

$$^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}He + n$$

given that the repulsive potential energy between the two nuclei is ~ 7.7×10^{-14} J, the temperature at which the gases must be heated to initiate the reaction is nearly (Boltzmann's constant k = 1.38×10^{-23} J/K):
(1) 10^{7} K (2) 10^{5} K (3) 10^{3} K (4) 10^{9} K

8. A nucleus disintegrates into two nuclear parts which have their velocities in the ratio 2 : 1. The ratio of their nuclear sizes will be : **[AIEEE-2004, 4/300]**
(1) $2^{1/3} : 1$ (2) $1 : 3^{1/2}$ (3) $3^{1/2} : 1$ (4) $1 : 2^{1/3}$

9. The binding energy per nucleon of deuteron $\left(^{2}_{1}H\right)$ and helium nucleus $\left(^{4}_{2}He\right)$ is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is : **[AIEEE-2004, 4/300]**
(1) 13.9 MeV (2) 26.9 MeV (3) 23.6 MeV (4) 19.2 MeV

10. An α-particle of energy 5 MeV is scattered through 180º by a fixed uranium nucleus. The distance of the closest approach is of the order of : **[AIEEE-2004, 4/300]**
(1) 1 Å (2) 10^{-10} cm (3) 10^{-12} cm (4) 10^{-15} cm

11. Starting with a sample of pure ^{66}Cu, 7/8 of it decays into Zn in 15 minutes. The corresponding half-life is **[AIEEE-2005, 4/300]**
(1) 10 minute (2) 15 minute (3) 5 minute (4) $7\frac{1}{2}$ minute

12. If radius of the $^{27}_{13}Al$ nucleus is estimated to be 3.6 Fermi, then the radius of $^{125}_{52}Te$ nucleus be nearly:

[AIEEE-2005, 4/300]

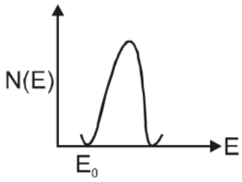
(1) 6 Fermi (2) 8 Fermi (3) 4 Fermi (4) 5 Fermi

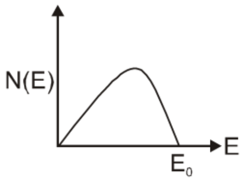
13. A nuclear transformation is denoted by X(n, α) → ${}^{7}_{3}\text{Li}$. Which of the following is the nucleus of element X?

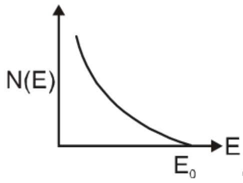
[AIEEE-2005, 4/300]

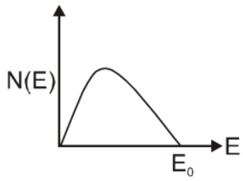
(1) ${}^{12}_{6}\text{C}$ (2) ${}^{10}_{5}\text{B}$ (3) ${}^{9}_{5}\text{B}$ (4) ${}^{11}_{4}\text{Be}$

14. The energy spectrum of β-particles (number N(E) as a function of β-energy E) emitted from a radioactive source is : **[AIEEE-2006, 3/180, –1]**

(1) 

(2) 

(3) 

(4) 

15. When ${}_{3}Li^{7}$ nuclei are bombarded by protons, and the resultant nuclei are ${}_{4}Be^{8}$, the emitted particles will be **[AIEEE-2006, 3/180, –1]**

(1) neutrons (2) alpha particles (3) beta particles (4) gamma photons

16. The 'rad' is the correct unit used to report the measurement of **[AIEEE-2006, 3/180, –1]**

(1) the rate of decay of radioactive source
(2) the ability of a beam of gamma ray photons to produce ions in a target
(3) the energy delivered by radiation to a target.
(4) the biological effect of radiation

17. If the binding energy per nucleon in ${}^{7}_{3}\text{Li}$ and ${}^{4}_{2}\text{He}$ nuclei are 5.60 MeV and 7.06 MeV respectively, then in the reaction

$$p + {}^{7}_{3}\text{Li} \rightarrow 2\,{}^{4}_{2}\text{He}$$

energy of proton must be : **[AIEEE-2006, 3/180, –1]**

(1) 39.2 MeV (2) 28.24 MeV (3) 17.28 MeV (4) 1.46 MeV

18. If M_o is the mass of an oxygen isotope ${}_{8}O^{17}$, M_p and M_N are the masses of a proton and a neutron respectively, the nuclear binding energy of the isotope is : **[AIEEE 2007 ; 3/120, –1]**

(1) $(M_o - 8M_P)C^2$ (2) $(M_o - 8M_P - 9M_N)C^2$ (3) M_oC^2 (4) $(M_o - 17M_N)C^2$

19. In gamma ray emission from a nucleus : **[AIEEE 2007 ; 3/120, –1]**

(1) both the neutron number and the proton number change
(2) there is no change in the proton number and the neutron number
(3) only the neutron number changes
(4) only the proton number changes

20. The half-life period of a radio-active element X is same as the mean life time of another radio-active element Y. Initially they have the same number of atoms. Then : **[AIEEE 2007 ; 3/120, –1]**

(1) X will decay faster than Y (2) Y will decay faster than X
(3) X and Y have same decay rate initially (4) X and Y decay at same rate always

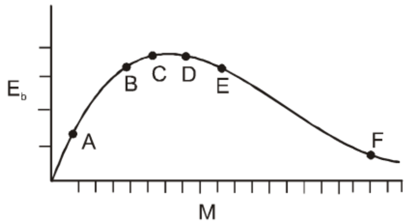
21. This question contains Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements. **[AIEEE-2008 3/105, –1]**

Statement-1 : Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion.

Statement-2 : For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z.

(1) Statement-1 is true, Statement-2 is true; Statement-2 is a correct explanation for Statement-1
(2) Statment-1 is true, Statement-2 is true; Statement-2 is not a correct explanation for Statement-1
(3) Statement-1 is true, Statement-2 is false
(4) Statement-1 is false, Statement-2 is true

22.



The above is a plot of binding energy per nucleon E_b, against the nuclear mass M; A, B, C, D, E, correspond to different nuclei. Consider four reactions : **[AIEEE-2009; 4/144]**

(i) A + B → C + ε (ii) C → A + B + ε (iii) D + E → F + ε and (iv) F → D + E + ε,

where ε is the energy released. In which reactions ε positive?
(1) (i) and (iii) (2) (ii) and (iv) (3) (ii) and (iii) (4) (i) and (iv)

Directions : Question number 23 – 25 are based on the following paragraph.

The nucleus of mass M + Δm is at rest and decays into two daughter nuclei of equal mass $\frac{M}{2}$ each.. Speed of light is c.

23. This binding energy per nucleon for the parent nucleus is E_1 and that for the daughter nuclei is E_2. Then: **[AIEEE 2010; 3/144, –1]**
(1) $E_1 = 2E_2$ (2) $E_1 > E_2$ (3) $E_2 > E_1$ (4) $E_2 = 2E_1$

24. The speed of daughter nuclei is **[AIEEE 2010; 3/144, –1]**
(1) $c\,\frac{\Delta m}{M+\Delta m}$ (2) $c\sqrt{\frac{2\Delta m}{M}}$ (3) $c\sqrt{\frac{\Delta m}{M}}$ (4) $c\sqrt{\frac{\Delta m}{M+\Delta m}}$

25. A radioactive nucleus (initial mass number A and atomic number Z) emits 3 α-particles and 2 positrons. The ratio of number of neutrons to that of protons in the final nucleus will be **[AIEEE 2010; 3/144, –1]**
(1) $\frac{A-Z-8}{Z-4}$ (2) $\frac{A-Z-4}{Z-8}$ (3) $\frac{A-Z-12}{Z-4}$ (4) $\frac{A-Z-4}{Z-2}$

26. The half life of a radioactive substance is 20 minutes. The approximate time interval ($t_2 - t_1$) between the time t_2 when $\frac{2}{3}$ of it has decayed and time t_1 when $\frac{1}{3}$ of it had decayed is **[AIEEE - 2011, 4/120, –1]**
(1) 7 min (2) 14 min (3) 20 min (4) 28 min

27. **Statement - 1 :** A nucleus having energy E_1 decays by β^- emission to daughter nucleus having energy E_2, but the β^- rays are emitted with a continuous energy spectrum having end point energy $E_1 - E_2$.
Statement - 2 : To conserve energy and momentum in β-decay at least three particles must take part in the transformation. **[AIEEE 2011, 11 May; 4/120, –1]**
(1) Statement-1 is correct but statement-2 is not correct.
(2) Statement-1 and statement-2 both are correct and stateemnt-2 is the correct explanation of statement1.
(3) Statement-1 is correct, statement-2 is correct and statement-2 is not the correct explanation of statement-1
(4) Statement-1 is incorrect, statement-2 is correct.

28. Assume that a neutron breaks into a proton and an electron. The energy released during this process is (mass of neutron = 1.6725×10^{-27} kg, Mass of proton = 1.6725×10^{-27} kg, mass of electron = 9×10^{-31} kg)

[AIEEE 2012 ; 4/120, –1]

(1) 0.73 MeV (2) 7.10 MeV (3) 6.30 MeV (4) 5.4 MeV

29. Ina hydrogen like atom electron make transition from an energy level with quantum number n to another with quantum number (n–1). If n>>1, the frequency of radiation emitted is proportional to :

[JEE(Main)-2013, 4/120]

(1) $\frac{1}{n}$ (2) $\frac{1}{n^2}$ (3) $\frac{1}{n^{3/2}}$ (4) $\frac{1}{n^3}$

30. Half-lives of two radioactive elements A and B are 20 minutes and 40 minutes, respectively, Initially, the samples have equal number of nuclei. After 80 minutes, the ratio of decayed numbers of A and B nuclei will be : **[JEE(Main)-2016 ; 4/120, –1]**

(1) 4 : 1 (2) 1 : 4 (3) 5 : 4 (4) 1 : 16

31. A radioactive nucleus A with a half life T, decays into a nucleus B. At t = 0, there is no nucleus B. At sometime t, the ratio of the number of B to that of A is 0.3. Then, t is given by :

[JEE(Main)-2017 ; 4/120, –1]

(1) $t = \frac{T}{\log(1.3)}$ (2) $t = \frac{T}{2}\frac{\log 2}{\log 1.3}$ (3) $t = T\frac{\log 1.3}{\log 2}$ (4) t = T log (1.3)

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. (I) Which of the following processes represents a gamma decay?

(A) ${}^{A}X_{Z} + \gamma \longrightarrow {}^{A}X_{Z-1} + a + b$ (B) ${}^{A}X_{Z} + {}^{1}n_{0} \longrightarrow {}^{A-3}X_{Z-2} + c$

(C) ${}^{A}X_{Z} \longrightarrow {}^{A}X_{Z} + f$ (D) ${}^{A}X_{Z} + e_{-1} \longrightarrow {}^{A}X_{Z-1} + g$

(II) The half life of ^{215}At is 100 μs. The time taken for the radioactivity of a sample of ^{215}At to decay to 1/16th of its initial value is : **[JEE 2002 (Screening) 2 × 3, –1 = 6/90]**

(A) 400 μs (B) 6.3 μs (C) 40 μs (D) 300 μs

2. A nucleus with mass number 220 initially at rest emits an α-particle. If the Q value of the reaction is 5.5 MeV, calculate the kinetic energy of the α-particle **[JEE 2003 (Screening) 3,–1/84]**

(A) 4.4 MeV (B) 5.4 MeV (C) 5.6 MeV (D) 6.5 MeV

3. For uranium nucleus how does its mass vary with volume? **[JEE 2003 (Screening) 3,–1/84]**

(A) $m \propto V$ (B) $m \propto 1/V$ (C) $m \propto \sqrt{V}$ (D) $m \propto V^2$

4. A 280 days old sample of a radioactive substance has activity of 6000 dps. In next 140 days activity falls to 3000 dps. Then initial activity of sample would have been **[JEE 2004 (Screening) 3, –1/84]**

(A) 9000 (B) 24000 (C) 12,000 (D) 18,000

5. Helium nuclei combine to form an oxygen nucleus. The energy released in the reaction is if m_O = 15.9994 amu and m_{He} = 4.0026 amu **[JEE 2005 (Screening) 3/84]**

(A) 10.24 MeV (B) 0 MeV (C) 5.24 MeV (D) 4 MeV

6. Half life of a radio active substance 'A' is 4 days. The probability that a nucleus will decay in two half **[JEE-2006, 3/184]**

(A) $\frac{1}{4}$ (B) $\frac{3}{4}$ (C) $\frac{1}{2}$ (D) 1

7. In the options given below, let E denote the rest mass energy of a nucleus and n a neutron. The correct options is : **[IIT-JEE 2007' 3/81]**

(A) $E\left({}^{236}_{92}U\right) > E\left({}^{137}_{53}I\right) + E\left({}^{97}_{39}Y\right) + 2E(n)$ (B) $E\left({}^{236}_{92}U\right) < E\left({}^{137}_{53}I\right) + E\left({}^{97}_{39}Y\right) + 2E(n)$

(C) $E\left({}^{236}_{92}U\right) < E\left({}^{140}_{56}Ba\right) + \left({}^{94}_{36}Kr\right) + 2E(n)$ (D) $E\left({}^{236}_{92}U\right) = E\left({}^{140}_{56}Ba\right) + E\left({}^{94}_{36}Kr\right) + 2E(n)$

8. A radioactive sample S_1 having an activity of 5μCi has twice the number of nuclei as another sample S_2 which has an activity of 10μCi. The half lives of S_1 and S_2 can be **[JEE 2008, 3/163]**

(A) 20 years and 5 years, respectively (B) 20 years and 10 years, respectively
(C) 10 years each (D) 5 years each

9. A freshly prepared sample of a radioisotope of half-life 1386 s has activity 10^3 disintegrations per second. Given that ln 2 = 0.693, the fraction of the initial number of nuclei (expressed in nearest integer percentage) that will decay in the first 80s after preparation of the sample is :
[JEE(Advanced)-2013; 3/60]

10. Match List I of the nuclear processes with List II containing parent nucleus and one of the end products of each process and then select the correct answer using the codes given below the lists :

List I		List II
P. Alpha decay	1.	${}^{15}_{8}O \rightarrow {}^{15}_{7}N + ...$
Q. β^+ decay	2.	${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + ...$
R. Fission	3.	${}^{185}_{83}Bi \rightarrow {}^{184}_{82}Pb + ...$
S. Proton emission	4.	${}^{239}_{94}Pu \rightarrow {}^{140}_{57}La + ...$

Codes :

	P	Q	R	S
(A)	4	2	1	3
(B)	1	3	2	4
(C)	2	1	4	3
(D)	4	3	2	1

Paragraph for Questions 11 and 12

The mass of a nucleus ${}^{A}_{Z}X$ is less that the sum of the masses of (A – Z) number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of masses m_1 and m_2 only if $(m_1 + m_2) < M$. Also two light nuclei of masses m_3 and m_4 can undergo complete fusion and form a heavy nucleus of mass M' only if $(m_3 + m_4) > M'$. The masses of some neutral atoms are given in the table below : **[JEE (Advanced) 2013 ; 3/60, –1]**

${}^{1}_{1}H$	1.007825u	${}^{2}_{1}H$	2.014102u	${}^{3}_{1}H$	3.016050u	${}^{4}_{2}He$	4.002603u
${}^{6}_{3}Li$	6.015123u	${}^{7}_{3}Li$	7.016004u	${}^{70}_{30}Zn$	69.925325u	${}^{82}_{34}Se$	81.916709u
${}^{152}_{64}Gd$	151.919803u	${}^{206}_{82}Pb$	205.974455u	${}^{209}_{83}Bi$	208.980388u	${}^{210}_{84}Po$	209.982876u

11. The correct statement is :

(A) The nucleus $^{6}_{3}Li$ can emit an alpha particle

(B) The nucleus $^{210}_{84}P_0$ can emit a proton

(C) Deuteron and alpha particle can undergo complete fusion.

(D) The nuclei $^{70}_{30}Zn$ and $^{82}_{34}Se$ can undergo complete fusion.

12. The kinetic energy (in keV) of the alpha particle, when the nucleus $^{210}_{84}P_0$ at rest undergoes alpha decay, is:

(A) 5319 (B) 5422 (C) 5707 (D) 5818

13. A nuclear power planet supplying electrical power to a village uses a radioactive material of half life T years as the fuel. The amount of fuel at the beginning is such that the total power requirement of the village is 12.5% of the electrical power available from the plant at that time. If the plant is able to meet the total power needs of the village for a maximum period of nT years, then the value of n is.

[JEE(Advanced) 2015 ; P-1, 4/88]

14. For a radioactive material, its activity A and rate of change of its activity R are defined as $A = \frac{-dN}{dt}$ and $R = \frac{-dA}{dt}$, where N(t) is the number of nuclei at time t. Two radioactive sources P (mean life τ) and Q (mean life 2τ) have the same activity at t = 0. Their rates of change of activities at $t = 2\tau$ are R_P and R_Q, respectively. If $\frac{R_P}{R_Q} = \frac{n}{e}$, then the value of n is : **[JEE(Advanced) 2015 ; P-2,4/88]**

15. An accident in a nuclear laboratory resulted in deposition of a certain amount of radioactive material of half-life 18 days inside the laboratory. Tests revealed that the radiation was 64 times more than the permissible level required for safe operation of the laboratory. What is the minimum number of days after which the laboratory can be considered safe for use ? **[JEE (Advanced) 2016 ; P-2, 3/62, –1]**

(A) 64 (B) 90 (C) 108 (D) 120

16. The electrostatic energy of Z protons uniformly distributed throughout a spherical nucleus of radius R is given by

$$E = \frac{3}{5}\frac{Z(Z-1)e^2}{4\pi\varepsilon_0 R}$$

The measured masses of the neutron, $^{1}_{1}H$, $^{15}_{7}N$, and $^{15}_{8}O$ are 1.008665 u, 1.007825 u, 15.000109 u and 15.003065 u, respectively. Given that the radii of both the $^{15}_{7}N$ and $^{15}_{8}O$ nuclei are same, 1 u = 931.5 MeV/c^2 (c is the speed of light) and $e^2/(4\pi\varepsilon_0)$=1.44 MeV fm. Assuming that the difference between the binding energies of $^{15}_{7}N$ and $^{15}_{8}O$ is purely due to the electrostatic energy, the radius of either of the nuclei is (1 fm = 10^{-15} m) **[JEE (Advanced) 2016 ; P-2, 3/62, –1]**

(A) 2.85 fm (B) 3.03 fm (C) 3.42 fm (D) 3.80 fm

Answers

EXERCISE # 1

Section (A) :

A-1. (4) **A-2.** (4) **A-3.** (1)

Section (B) :

B-1. (3) **B-2.** (3) **B-3.** (4)

B-4. (4) **B-5.** (1)

Section (C) :

C-1. (2) **C-2.** (2) **C-3.** (2)

Section (D) :

D-1. (3) **D-2.** (2) **D-3.** (1)

D-4. (1) **D-5.** (4) **D-6.** (2)

Section (E) :

E-1. (2) **E-2.** (3) **E-3.** (1)

E-4. (4) **E-5.** (4) **E-6.** (3)

E-7. (4)

EXERCISE # 2

PART- I

1. (1) **2.** (2) **3.** (1)

4. (3) **5.** (3) **6.** (3)

7. (4) **8.** (3) **9.** (4)

10. (3) **11.** (4) **12.** (3)

13. (1) **14.** (2)

PART- II

Section (A) :

A-1. (1) **A-2.** (4) **A-3.** (3)

Section (B) :

B-1. (1 → q); (2 → s); (3 → r); (4 → s)

Section (C) :

C-1. (1,3) **C-2.** (3,4) **C-3.** (1,4)

C-4. (1,3,4) **C-5.** (1,3) **C-6.** (3,4)

C-7. (1,3)

EXERCISE # 3

PART- I

1. (1) **2.** (1) **3.** (3)

4. (1) **5.** (2) **6.** (1)

7. (4) **8.** (4) **9.** (3)

10. (3) **11.** (3) **12.** (1)

13. (2) **14.** (4) **15.** (4)

16. (4) **17.** (3) **18.** (2)

19. (2) **20.** (2) **21.** (3)

22. (4) **23.** (3) **24.** (2)

25. (2) **26.** (3) **27.** (2)

28. (1) **29.** (4) **30.** (3)

31. (3)

PART- II

1. (I) (C) (II) (A)

2. (B) **3.** (A) **4.** (B)

5. (A) **6.** (B) **7.** (A)

8. (A) **9.** 4 **10.** (C)

11. (C) **12.** (A) **13.** 3

14. 2 **15.** (C) **16.** (C)