NUCLEI

FACT/DEFINITION TYPE QUESTIONS

1. Chadwick was awarded the 1935 nobel prize in physics for his discovery of the
(a) electron (b) proton
(c) neutron (d) positron

2. The element gold has
(a) 16 isotopes (b) 32 isotopes
(c) 96 isotopes (d) 173 isotopes

3. The nuclear radius is of the order of
(a) 10^{-10} m (b) 10^{-6} m
(c) 10^{-15} m (d) 10^{-14} m

4. Particles which can be added to the nucleus of an atom without changing its chemical properties are called
(a) neutrons (b) electrons
(c) protons (d) alpha particles

5. The radius of a nucleus is
(a) directly proportional to its mass number
(b) inversely proportional to its atomic weight
(c) directly proportional to the cube root of its mass number
(d) None of these

6. Nucleus of an atom whose atomic mass is 24 consists of
(a) 11 electrons, 11 protons and 13 neutrons
(b) 11 electrons, 13 protons and 11 neutrons
(c) 11 protons and 13 neutrons
(d) 11 protons and 13 electrons

7. The electrons cannot exist inside the nucleus because
(a) de-Broglie wavelength associated with electron in β-decay is much less than the size of nucleus
(b) de-Broglie wavelength associated with electron in β-decay is much greater than the size of nucleus
(c) de-Broglie wavelength associated with electron in β-decay is equal to the size of nucleus
(d) negative charge cannot exist in the nucleus

8. In ...*X*... water is circulated though the reactor vessel and transfers energy to steam generator in the ...*Y*... Here, *X* and *Y* refer to
(a) primary loop, secondary loop
(b) reactor core, turbine
(c) secondary loop, primary loop
(d) turbine, reactor core

9. A nuclei having same number of neutron but different number of protons / atomic number are called
(a) isobars (b) isomers
(c) isotones (d) isotopes

10. Which one of the following has the identical property for isotopes?
(a) Physical property (b) Chemical property
(c) Nuclear property (d) Thermal property

11. The number of protons in an atom of atomic number Z and mass number A is
(a) zero (b) Z
(c) A – Z (d) A

12. When the number of nucleons in nuclei increases, the binding energy per nucleon
(a) increases continuously with mass number
(b) decreases continuously with mass number
(c) remains constant with mass number
(d) first increases and then decreases with increase of mass number

13. M_p denotes the mass of a proton and M_n that of a neutron. A given nucleus, of binding energy B, contains Z protons and N neutrons. The mass M(N, Z) of the nucleus is given by (c is the velocity of light)
(a) $M(N, Z) = NM_n + ZM_p + B/c^2$
(b) $M(N, Z) = NM_n + ZM_p - Bc^2$
(c) $M(N, Z) = NM_n + ZM_p + Bc^2$
(d) $M(N, Z) = NM_n + ZM_p - B/c^2$

14. Mass energy equation was propounded by
(a) Newton (b) Madam Curie
(c) C. V. Raman (d) Einstein

15. The mass of an atomic nucleus is less than the sum of the masses of its constituents. This mass defect is converted into
(a) heat energy
(b) light energy
(c) electrical energy
(d) energy which binds nucleons together

16. Which of the following statement is not true regarding Einsteins mass energy relation?
(a) Mass disappears to reappear as energy.
(b) Energy disappears to reappear as mass.
(c) Mass and energy are two different forms of the same entity.
(d) Mass and energy can never be related to each other.

17. 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
(a) can easily be broken up
(b) is very stable
(c) can be used as fissionable meterial
(d) is radioactive

18. Nuclear forces are
(a) spin dependent and have no non-central part
(b) spin dependent and have a non-central part
(c) spin independent and have no non-central part
(d) spin independent and have a non-central part

19. Nuclear forces exists between
(a) neutron - neutron (b) proton - proton
(c) neutron - proton (d) all of these

20. The antiparticle of electron is
(a) positron (b) α-particle
(c) proton (d) β-particle

21. Neutron decay in free space is given as follows

$${}_0n^1 \rightarrow {}_1H^1 + {}_{-1}e^0 + [\ ]$$

Then the parenthesis [ ] represents a
(a) neutrino (b) photon
(c) antineutrino (d) graviton

22. Radioactivity is
(a) irreversible process
(b) self disintegration process
(c) spontaneous
(d) all of the above

23. γ-rays are deflected by
(a) an electric field but not by a magnetic field
(b) a magnetic field but not by an electric field
(c) both electric and magnetic field
(d) neither by electric field nor by magnetic field

24. Beta rays emitted by a radioactive material are
(a) electromagnetic radiations
(b) the electrons orbiting around the nucleus
(c) charged particles emitted by nucleus
(d) neutral particles

25. Which of the following is not a mode of radioactive decay ?
(a) Positron emission (b) Electron capture
(c) Fusion (d) Alpha decay

26. The half-life period and the mean life period of a radioactive element are denoted respectively by T_h and T_m. Then
(a) $T_h = T_m$ (b) $T_h > T_m$
(c) $T_h < T_m$ (d) $T_h \geq T_m$

27. In γ ray emission from a nucleus
(a) only the proton number changes
(b) both the neutron number and the proton number change
(c) there is no change in the proton number and the neutron number
(d) only the neutron number changes

28. Artificial radioactivity was discovered by
(a) Klaproth (b) Rontgen
(c) Irene Curie and Joliot (d) P. Curie and M. Curie

29. Radioactive samples are stored in lead boxes because it is
(a) heavy (b) strong
(c) good absorber (d) bad conductor

30. The process of radioactive radiations remains unaffected due to
(a) physical changes
(b) chemical changes
(c) electric or magnetic fields
(d) all of the above

31. A radioactive material undergoes decay by ejecting electrons. The electron ejected in this process is
(a) the electron from the decay of a neutron
(b) the electron present in the nucleus
(c) the resulting from the conversion of γ photon
(d) an orbital electron

32. The same radioactive nucleus may emit
(a) all the three α, β and γ one after another
(b) all the three α, β and γ radiations simultaneously
(c) only α and β simultaneously
(d) only one α, β and γ at a time

33. Which of the following of a radioactive material is a measure of its instability?
(a) Full life (b) Mean life
(c) Half life (d) None of these

34. The rate of disintegration at a given instant, is directly proportional to the number of atoms present at that instant. This is the statement of
(a) law of radioactive decay
(b) half life
(c) law of radioactive transformation
(d) group displacement law

35. N atoms of a radioactive substance emit na-particles per second. The half life of the radioactive substance is
(a) $\frac{n}{N}$ sec (b) $\frac{N}{n}$ sec
(c) $\frac{0.693N}{n}$ sec (d) $\frac{0.693n}{N}$ sec

36. Three specimens A, B, C of same radioactive element has activities 1 microcurie, 1 rutherford and 1 becquerel respectively. Which specimen has maximum mass?
(a) A (b) B
(c) C (d) all have equal masses

37. Charge on an α-particle is
(a) 1.6×10^{-19} C (b) 3.2×10^{-19} C
(c) 1.6×10^{-20} C (d) 4.8×10^{-19} C

38. If a radioactive element is placed in an evacuated chamber, then the rate of radioactive decay will
(a) decrease (b) remains unchanged
(c) increase (d) none of these

39. The γ radiations are
(a) electromagnetic radiation with high energy
(b) electromagnetic radiation with low energy
(c) charged particles emitted by the nucleus
(d) electrons orbiting the nucleus

40. Radioactive substance emits
(a) α-rays (b) β-rays
(c) γ-rays (d) All of the above

41. The 'rad' is the correct unit used to report the measurement of
(a) the ability of a beam of gamma ray photons to produce ions in a target
(b) the energy delivered by radiation to a target
(c) the biological effect of radiation
(d) the rate of decay of a radioactive source

42. One curie is equal to
(a) 3.7×10^{10} disintegration/sec
(b) 3.2×10^{8} disintegration/sec
(c) 2.8×10^{10} disintegration/sec
(d) None of these

43. Half life of radioactive element depends upon
(a) amount of element present
(b) temperature
(c) pressure
(d) nature of element

44. A nuclear reaction is given by

$_{Z}X^{A} \rightarrow _{Z+1}Y^{A} + _{-1}e^{0} + \overline{\nu}$, represents

(a) fission (b) β-decay
(c) σ-decay (d) fusion

45. Fusion reaction occurs at temperatures of the order of
(a) 10^{3} K (b) 10^{7} K (c) 10 K (d) 10^{4} K

46. Control rods used in nuclear reactors are made of
(a) stainless steel (b) graphite
(c) cadmium (d) plutonium

47. Boron rods in a nuclear reactor are used to
(a) absorb excess neutrons
(b) absorb alpha particle
(c) slow down the reaction
(d) speed up the reaction

48. A moderator is used in nuclear reactors in order to
(a) slow down the speed of the nuetrons
(b) acceleerate the neutrons
(c) increase the number of neutrons
(d) decrease the number of neutrons

49. Fusion reactions take place at high temperature because
(a) atoms are ionised at high temperature
(b) molecules break up at high temperature
(c) nuclei break up at high temperature
(d) kinetic enrgy is high enough to overcome repulsion between nuclei

50. For a nuclear fusion process, suitable nuclei are
(a) any nuclei
(b) heavy nuclei
(c) lighter nuclei
(d) nuclei lying in the middle of periodic table

STATEMENT TYPE QUESTIONS

51. Consider the following statements and select the correct statement(s).
I. The relative abundance of different isotopes differs from element to element.
II. Atomic species of the same element differing in mass are called isotopes.
III. Hydrogen has two isotopes.
(a) I only (b) II only
(c) I and II (d) I, II and III

52. Which of the following statements are correct?
I. Atoms of isotopes have same electronic structure.
II. Atoms of isotopes occupies same place in periodic table.
III. Atoms of isotopes have same number of protons.
IV. Atoms of isotopes have same number of neutrons.
(a) I and II (b) I, II and III
(c) I, II III and IV (d) II and IV

53. Which of the following statements are correct ?
I. Nuclear density is a constant for all matter.
II. Nuclear density is around 2.3×10^{17} kg/m^{3}.
II. Nuclear density is very large compared to ordinary matter.
IV. Mass of ordinary matter is mainly due to nucleus.
(a) I, II and III (b) II and III
(c) I and II (d) I, II, III and IV

54. For binding energy per nucleon *versus* mass number curve, which of the following are correct ?
I. Binding energy per nucleon E_{bn} is independent of mass number range $30 < A < 170$.
II. Binding energy is lower for both light nucei ($A < 30$) and heavy nuclei ($A < 170$).
III. Binding energy is maximum of about 8.75 MeV for A = 56.
IV. In region $0 < A < 80$, binding energy increases with mass number.
(a) I, II, III and IV (b) I, II and IV
(c) II, III and IV (d) I, II and III

55. In one half-life time duration
I. activity of a sample reduced to half of its initial value.
II. total number of nuclei present are reduced to half of its initial value.
III. number of radio active nuclei present is reduced to half of its initial value.
IV. mass of sample is reduced to half of its initial value.
Out of these, correct statements are
(a) I and II (b) I and II
(c) II and IV (d) II and III

56. At a specific instant emission of radioactive compound is deflected in a magnetic field. The compound can emit

I electrons II protons
III He^{2+} IV neutrons

The emission at instant can be
(a) I, II and III (b) I, II, III and IV
(c) IV only (d) II and III

MATCHING TYPE QUESTIONS

57. Match the Column I and Column II.

Column – I	Column – II
(A) Isotopes	(1) Mass number same but different atomic number
(B) Isobars	(2) Atomic number same but different mass number.
(C) Isotones	(3) Number of nentrons plus number of protons
(D) Nucleons	(4) Number of nentrons same but different atomic number

(a) (A)→(3); (B)→(1); (C)→(2); (D)→(4)
(b) (A)→(2); (B)→(1); (C)→(4); (D)→(3)
(c) (A)→(1); (B)→(2); (C)→(3); (D)→(4)
(d) (A)→(1); (B)→(3); (C)→(2); (D)→(4)

58. Match Column I of the nuclear processes with Column II containing parent nucleus and one of the end products of each process.

Column I	Column II
(A) Alpha decay	(1) ${}^{15}_{8}O \to {}^{15}_{7}N + ...$
(B) β^+ decay	(2) ${}^{238}_{92}U \to {}^{234}_{90}Th + ...$
(C) Fission	(3) ${}^{185}_{83}Bi \to {}^{184}_{82}Pb + ...$
(D) Proton emission	(4) ${}^{239}_{94}Pu \to {}^{140}_{57}La + ...$

(a) (A)→(1); (B)→(3); (C)→(2); (D)→(4)
(b) (A)→(4); (B)→(3); (C)→(2); (D)→(1)
(c) (A)→(2); (B)→(1); (C)→(4); (D)→(3)
(d) (A)→(3); (B)→(1); (C)→(2); (D)→(4)

59.

Column – I	Column – II
(A) Nuclear fusion	(1) $E = mc^2$
(B) Nuclear fission	(2) Generally possible for nuclei with low atomic number
(C) β-decay	(3) Generally possible for nuclei with higher atomic number
(D) Mass-energy equivalence	(4) Essentially proceeds by weak reaction nuclear forces

(a) (A)→(2); (B)→(3); (C)→(4); (D)→(1)
(b) (A)→(4); (B)→(1); (C)→(2); (D)→(4)
(c) (A)→(1); (B)→(3); (C)→(2); (D)→(4)
(d) (A)→(3); (B)→(4); (C)→(2); (D)→(1)

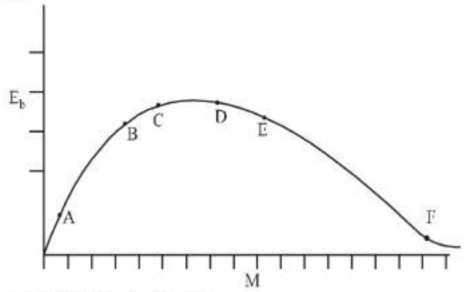
60.

Column – I	Column – II
(A) Hydrogen bomb	(1) Fission
(B) Atom bomb	(2) Fusion
(C) Binding energy	(3) Critical mass
(D) Nuclear reactor	(4) Mass defect

(a) (A)→(3); (B)→(2); (C)→(1); (D)→(4)
(b) (A)→(2); (B)→(1); (C)→(4); (D)→(3)
(c) (A)→(3); (B)→(1); (C)→(2); (D)→(4)
(d) (A)→(4); (B)→(2); (C)→(3); (D)→(1)

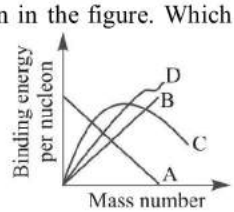
DIAGRAM TYPE QUESTIONS

61. There is a plot of binding energy per nucleon E_b, against the nuclear mass M; A, B, C, D, E, F correspond to different nuclei.

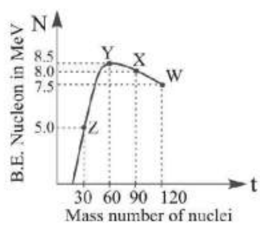


Consider four reactions
(i) $A + B \to C + \varepsilon$ (ii) $C \to A + B + \varepsilon$
(iii) $D + E \to F + \varepsilon$ and (iv) $F \to D + E + \varepsilon$,
where ε is the energy released? In which reactions is ε positive?
(a) (i) and (iii) (b) (ii) and (iv)
(c) (ii) and (iii) (d) (i) and (iv)

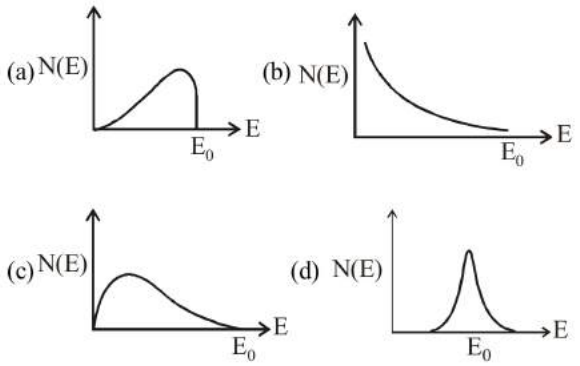
62. Binding energy per nucleon plot against the mass number for stable nuclei is shown in the figure. Which curve is correct?
(a) A
(b) B
(c) C
(d) D



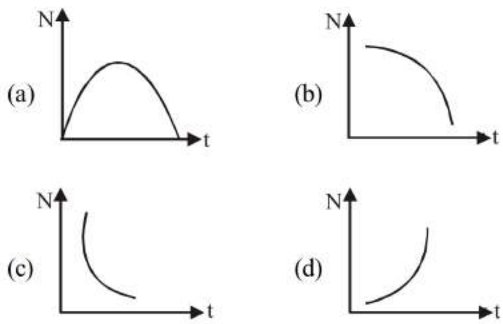
63. Binding energy per nucleon versus mass number curve for nuclei is shown in the figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is
(a) Y → 2Z
(b) W → X + Z
(c) W → 2Y
(d) X → Y + Z



64. The energy spectrum of β-particles [number N(E) as a function of β-energy E] emitted from a radioactive source is



65. Radioactive element decays to form a stable nuclide, then the rate of decay of reactant is



ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

66. **Assertion :** Density of all the nuclei is same.
Reason : Radius of nucleus is directly proportional to the cube root of mass number.

67. **Assertion :** Neutrons penetrate matter more readily as compared to protons.
Reason : Neutrons are slightly more massive than protons.

68. **Assertion :** The mass number of a nucleus is always less than its atomic number.
Reason : Mass number of a nucleus may be equal to its atomic number.

69. **Assertion :** The binding energy per nucleon, for nuclei with atomic mass number A > 100, decrease with A.
Reason : The forces are weak for heavier nuclei.

70. **Assertion :** Radioactivity of 10^8 undecayed radioactive nuclei of half life of 50 days is equal to that of 1.2×10^8 number of undecayed nuclei of some other material with half life of 60 days.
Reason : Radioactivity is proportional to half-life.

71. **Assertion :** The ionising power of β-particle is less compared to α-particles but their penetrating power is more.
Reason : The mass of β-particle is less than the mass of α-particle.

72. **Assertion :** Radioactive nuclei emit β^{-1} particles.
Reason : Electrons exist inside the nucleus.

73. **Assertion :** ${}_ZX^A$ undergoes 2α, 2β- particles and 2γ-rays, the daughter product is ${}_{Z-2}Y^{A-8}$.
Reason : In α- decay the mass number decreases by 4 and atomic number decreases by 2. In β-decay the mass number remains unchanged, but atomic number increases by 1.

74. **Assertion :** The heavier nuclei tend to have larger N/Z ratio because neutron does not exert electric force.
Reason : Coulomb forces have longer range compared to the nuclear force.

75. **Assertion :** A free neutron decays to a proton but a free proton does not decay to a neutron. This is because neutron is an uncharged particle and proton is a charged particle.
Reason : Neutron has larger rest mass than the proton.

76. **Assertion :** Cobalt-60 is useful in cancer therapy.
Reason : Cobalt -60 is source of γ- radiations capable of killing cancerous cells.

77. **Assertion :** It is not possible to use ^{35}Cl as the fuel for fusion energy.
Reason : The binding energy of ^{35}Cl is to small.

78. **Assertion :** Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion and
Reason : For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z.

CRITICAL THINKING TYPE QUESTIONS

79. The mass number of He is 4 and that for sulphur is 32. The radius of sulphur nuclei is larger than that of helium by
(a) $\sqrt{8}$ (b) 4
(c) 2 (d) 8

80. A nucleus splits into two nuclear parts which have their velocity ratio equal to 2 : 1. What will be the ratio of their nuclear radius?
(a) $2^{1/3}:1$ (b) $1:2^{1/3}$
(c) $3^{1/2}:1$ (d) $1:3^{1/2}$

81. 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
(a) 8 fermi (b) 6 fermi
(c) 5 fermi (d) 4 fermi

82. If M_O is the mass of an oxygen isotope $_8O^{17}$, M_P and M_N are the masses of a proton and a neutron respectively, the nuclear binding energy of the isotope is

(a) $(M_O - 17M_N)c^2$ (b) $(M_O - 8M_P)c^2$
(c) $(M_O - 8M_P - 9M_N)c^2$ (d) M_Oc^2

83. In the options given below, let E denote the rest mass energy of a nucleus and n neutron. Then the correct option is

(a) E[$^{236}_{92}$U] ţ E[$^{137}_{53}$I] Ġ E[$^{97}_{39}$Y] Ġ 2E(n)

(b) E[$^{236}_{92}$U] ť E[$^{137}_{53}$I] Ġ E[$^{97}_{39}$Y] Ġ 2E(n)

(c) E[$^{236}_{92}$U] ť E[$^{140}_{56}$Ba] Ġ E[$^{94}_{36}$Kr] Ġ 2E(n)

(d) E[$^{236}_{92}$U] † E[$^{140}_{56}$Ba] Ġ E[$^{94}_{36}$Kr] Ġ 2E(n)

84. If the total binding energies of ^2_1H, ^4_2He, $^{56}_{26}Fe$ & $^{235}_{92}U$ nuclei are 2.22, 28.3, 492 and 1786 MeV respectively, identify the most stable nucleus of the following.

(a) $^{56}_{26}Fe$ (b) ^2_1H (c) $^{235}_{92}U$ (d) ^4_2He

85. The mass of a ^7_3Li nucleus is 0.042 u less than the sum of the masses of all its nucleons. The binding energy per nucleon of ^7_3Li nucleus is nearly

(a) 46 MeV (b) 5.6 MeV
(c) 3.9 MeV (d) 23 MeV

86. The mass defect in a particular nuclear reaction is 0.3 grams. The amount of energy liberated in kilowatt hour is (Velocity of light = 3×10^8 m/s)

(a) 1.5×10^6 (b) 2.5×10^6
(c) 3×10^6 (d) 7.5×10^6

87. The binding energies per nucleon for a deuteron and an α-particle are x_1 and x_2 respectively. What will be the energy Q released in the reaction $_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + Q$

(a) $4(x_1 + x_2)$ (b) $4(x_2 - x_1)$
(c) $2(x_1 + x_2)$ (d) $2(x_2 - x_1)$

88. A heavy nucleus having mass number 200 gets disintegrated into two small fragments of mass number 80 and 120. If binding energy per nucleon for parent atom is 6.5 MeV and for daughter nuclei is 7 MeV and 8 MeV respectively, then the energy released in the decay is $X \times 110$ MeV. Find the value of X

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

89. The masses of neutron and proton are 1.0087 a.m.u. and 1.0073 a.m.u. respectively. If the neutrons and protons combine to form a helium nucleus (alpha particles) of mass 4.0015 a.m.u the binding energy of the helium nucleus will be (1 a.m.u. = 931 MeV)

(a) 28.4 MeV (b) 20.8 MeV
(c) 27.3 MeV (d) 14.2 MeV

90. If 1 mg of U^{235} is completely annihilated, the energy liberated is

(a) 9×10^{10} J (b) 9×10^{19} J
(c) 9×10^{18} J (d) 9×10^{17} J

91. A radioactive substance has a half life of four months. Three fourth of the substance will decay in

(a) three months (b) four months
(c) eight months (d) twelve months

92. In the uranium radioactive series, the initial nucleus is $_{92}U^{238}$ and that the final nucleus is $_{82}Pb^{206}$. When uranium nucleus decays to lead, the number of α particles and β particles emitted are

(a) 8α, 6β (b) 6α, 7β
(c) 6α, 8β (d) 4α, 3β

93. A radioactive nucleus undergoes α-emission to form a stable element. What will be the recoil velocity of the daughter nucleus if v is the velocity of α emission?

(a) $\frac{4v}{A-4}$ (b) $\frac{2v}{A-4}$

(c) $\frac{4v}{A+4}$ (d) $\frac{2v}{A+4}$

94. A radioactive element forms its own isotope after three consecutive disintegrations. The particles emitted are

(a) 3 β–particles
(b) 2 β–particles and 1 α–particle
(c) 3 β–particles and 1 α–particle
(d) 2 α–particles and 1 β–particle.

95. The ratio of half-life times of two elements A and B is $\frac{T_A}{T_B}$.

The ratio of respective decay constant $\frac{\lambda_A}{\lambda_B}$, is

(a) T_B/T_A (b) T_A/T_B

(c) $\frac{T_A + T_B}{T_A}$ (d) $\frac{T_A - T_B}{T_A}$

96. A radioactive nucleus undergoes a series of decay according to the scheme

$$A \xrightarrow{a} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$$

If the mass number and atomic number of 'A' are 180 and 72 respectively, then what are these numbers for A_4

(a) 172 and 69 (b) 174 and 70
(c) 176 and 69 (d) 176 and 70

97. The radioactivity of a sample is R_1 at a time T_1 and R_2 at a time T_2. If the half-life of the specimen is T, the number of atoms that have disintegrated in the time $(T_1 - T_2)$ is proportional to

(a) $(R_1T_1 - R_2T_2)$ (b) $(R_1 - R_2)$
(c) $(R_1 - R_2)/T$ (d) $(R_1 - R_2)T$

98. Actinium 231, $^{231}AC_{89}$, emit in succession two β particles, four α-particles, one β and one α plus several γ rays. What is the resultant isotope?

(a) $^{221}Au_{79}$ (b) $^{211}Au_{79}$

(c) $^{221}Pb_{82}$ (d) $^{211}Pb_{82}$

99. The activity of a radioactive sample is measured as 9750 counts per minute at t = 0 & 975 counts per minute at T = 5 minutes. The decay constant is approximately.

(a) 0.922 per minutes (b) 0.691 per minutes

(c) 0.461 per minutes (d) 0.230 per minutes

100. Half lives of two radio active substance A & B are respectively 20 minutes & 40 minutes. Initially the samples of A & B have equal numbers of nulcei. After 80 minutes the ratio of remaining numbers of A & B nuclei is

(a) 1 : 16 (b) 4 : 1

(c) 1 : 4 (d) 1 : 1

101. The activity of a radioactive sample is measured as N_0 counts per minute at $t = 0$ and N_0/e counts per minute at $t = 5$ minutes. The time (in minutes) at which the activity reduces to half its value is

(a) $\log_e 2/5$ (b) $\frac{5}{\log_e 2}$

(c) $5 \log_{10} 2$ (d) $5 \log_e 2$

102. A radioactive nucleus of mass M emits a photon of frequency ν and the nucleus recoils. The recoil energy will be

(a) $Mc^2 - h\nu$ (b) $h^2\nu^2 / 2Mc^2$

(c) zero (d) hν

103. Two radioactive nuclei P and Q, in a given sample decay into a stable nucleus R. At time t = 0, number of P species are 4 N_0 and that of Q are N_0. Half-life of P (for conversion to R) is 1 minute where as that of Q is 2 minutes. Initially there are no nuclei of R present in the sample. When number of nuclei of P and Q are equal, the number of nuclei of R present in the sample would be

(a) $3N_0$ (b) $\frac{9N_0}{2}$

(c) $\frac{5N_0}{2}$ (d) $2N_0$

104. The half life of a radioactive nucleus is 50 days. The time interval $(t_2 - t_1)$ between the time t_2 when $\frac{2}{3}$ of it has decayed and the time t_1 when $\frac{1}{3}$ of it had decayed is

(a) 30 days (b) 50 days

(c) 60 days (d) 15 days

105. A mixture consists of two radioactive materials A_1 and A_2 with half lives of 20 s and 10 s respectively. Initially the mixture has 40 g of A_1 and 160 g of A_2. The amount of the two in the mixture will become equal after

(a) 60 s (b) 80 s

(c) 20 s (d) 40 s

106. The half life of a radioactive isotope 'X' is 20 years. It decays to another element 'Y' which is stable. The two elements 'X' and 'Y' were found to be in the ratio of 1 : 7 in a sample of a the given rock. The age of the rock is estimated to be

(a) 60 years (b) 80 years

(c) 100 years (d) 40 years

107. If N_0 is the original mass of the substance of half-life period $t_{1/2}$ = 5 years, then the amount of substance left after 15 years is

(a) $N_0/8$ (b) $N_0/16$

(c) $N_0/2$ (d) $N_0/4$

108. When a U^{238} nucleus originally at rest, decays by emitting an alpha particle having a speed 'u', the recoil speed of the residual nucleus is

(a) $\frac{4u}{238}$ (b) $-\frac{4u}{234}$

(c) $\frac{4u}{234}$ (d) $-\frac{4u}{238}$

109. 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

(a) 0.4 ln 2 (b) 0.2 ln 2

(c) 0.1 ln 2 (d) 0.8 ln 2

110. $^{221}_{87}Ra$ is a radioactive substance having half life of 4 days. Find the probability that a nucleus undergoes decay after two half lives

(a) 1 (b) $\frac{1}{2}$

(c) $\frac{3}{4}$ (d) $\frac{1}{4}$

111. The activity of a freshly prepared radioactive sample is 10^{10} disintegrations per second, whose mean life is 10^9 s. The mass of an atom of this radioisotope is 10^{-25} kg. The mass (in mg) of the radioactive sample is

(a) 1 (b) 3

(c) 5 (d) 6

112. The half life of the radioactive substance is 40 days. The substance will disintegrate completely in

(a) 40 days (b) 400 days

(c) 4000 days (d) infinite time

113. A radioactive substance contains 10000 nuclei and its half-life period is 20 days. The number of nuclei present at the end of 10 days is

(a) 7070 (b) 9000

(c) 8000 (d) 7500

114. The half-life of radioactive Radon is 3.8 days. The time at the end of which (1/20)th of the Radon sample will remain undecayed is (given $\log_{10}e = 0.4343$)
(a) 13.8 days (b) 16.5 days
(c) 33 days (d) 76 days

115. A freshly prepared radioactive source of half life 2 hr 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
(a) 6 hr (b) 12 hr
(c) 24 hr (d) 128 hr

116. At time t = 0, N_1 nuclei of decay constant λ_1 and N_2 nuclei of decay constant λ_2 are mixed. The decay rate of mixture is
(a) $-N_1N_2e^{-(\lambda_1+\lambda_2)t}$
(b) $-\left(\frac{N_1}{N_2}\right)e^{-(\lambda_1+\lambda_2)t}$
(c) $-(N_1\lambda_1e^{-\lambda_1 t} + N_1\lambda_2e^{-\lambda_2 t})$
(d) $-N_1\lambda_1N_2\lambda_2e^{(-\lambda_1+\lambda_2)t}$

117. Radium ^{226}Ra, spontaneously decays to radon with the emission of an α-particle and a γ ray. If the speed of the α particle upon emission from an initially stationary radium nucleus is 1.5×10^7 m/s, what is the recoil speed of the resultant radon nucleus? Assume the momentum of γ ray is negligible compared to that of α particle.
(a) $2..0 \times 10^5$ m/s (b) 2.7×10^5 m/s
(c) 3.5×10^5 m/s (d) 1.5×10^7 m/s

118. The fossil bone has a $^{14}C : ^{12}C$ ratio, which is $\left[\frac{1}{16}\right]$ of that in a living animal bone. If the half-life of ^{14}C is 5730 years, then the age of the fossil bone is
(a) 11460 years (b) 17190 years
(c) 22920 years (d) 45840 years

119. An archaeologist analyses the wood in a prehistoric structure and finds that C^{14} (Half life = 5700 years) to C^{12} is only one-fourth of that found in the cells of buried plants. The age of the wood is about
(a) 5700 years (b) 2850 years
(c) 11,400 years (d) 22,800 years

120. Atomic weight of boron is 10.81 and it has two isotopes $_5B^{10}$ and $_5B^{11}$. Then ratio of $_5B^{10} : {}_5B^{11}$ in nature would be
(a) 19 : 81 (b) 10 : 11
(c) 15 : 16 (d) 81 : 19

121. A radioactive element X converts into another stable element Y. Half life of X is 2 hrs. Initially only X is present. After time t, the ratio of atoms of X and Y is found to be 1 : 4, then t in hours is
(a) 2 (b) 4
(c) between 4 and 6 (d) 6

122. After 150 days, the activity of a radioactive sample is 5000 dps. The activity becomes 2500 dps after another 75 days. The initial activity of the sample is
(a) 20000 dps (b) 40000 dps
(c) 7500 dps (d) 10000 dps

123. At any instant, the ratio of the amount of radioactive substances is 2 : 1. If their half lives be respectively 12 and 16 hours, then after two days, what will be the ratio of the substances ?
(a) 1 : 1 (b) 2 : 1 (c) 1 : 2 (d) 1 : 4

124. Half lives for α and β emission of a radioactive material are 16 years and 48 years respectively. When material decays giving α and β emission simultaneously, time in which 3/4th material decays is
(a) 29 years (b) 24 years
(c) 64 years (d) 12 years

125. In a given reaction

$$_zA^A \rightarrow {}_{z+1}Y^A \rightarrow {}_{z-1}K^{A-4} \rightarrow {}_{z-1}K^{A-4}$$

Radioactive radiations are emitted in the sequence of
(a) α, β, γ (b) γ, α, β
(c) β, α, γ (d) γ, β, α

126. An element A decays into an element C by a two step process $A \rightarrow B + 2He^4$ and $B \rightarrow C + 2e^-$. Then,
(a) A and C are isotopes (b) A and C are isobars
(c) B and C are isotopes (d) A and B are isobars

127. In which sequence the radioactive radiations are emitted in the following nuclear reaction?

$$_ZX^A \longrightarrow {}_{Z+1}Y^A \longrightarrow {}_{Z-1}K^{A-4}$$

(a) γ and β (b) α and γ
(c) β and α (d) β and γ

128. Half life of a radioactive substance is 20 minute. Difference between points of time when it is 33% disintegrated and 67% disintegrated is approximately
(a) 40 minute (b) 10 minute
(c) 15 minute (d) 20 minute

129. A nucleus ^m_nX emits one α-particle and two β-particles. The resulting nucleus is
(a) $^{m-6}_{n-4}Z$ (b) $^{m-6}_{n}Z$
(c) $^{m-4}_{n}X$ (d) $^{m-4}_{n-2}Y$

130. A nucleus with Z = 92 emits the following in a sequence:

$$\alpha, \beta^-, \beta^- \alpha, \alpha, \alpha, \alpha, \alpha, \beta^-, \beta^-, \alpha, \beta^+, \beta^+, \alpha$$

Then Z of the resulting nucleus is
(a) 76 (b) 78
(c) 82 (d) 74

131. 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

(a) X and Y decay at same rate always
(b) X will decay faster than Y
(c) Y will decay faster than X
(d) X and Y have same decay rate initially

132. 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

(a) $\frac{A-Z-8}{Z-4}$ (b) $\frac{A-Z-4}{Z-8}$

(c) $\frac{A-Z-12}{Z-4}$ (d) $\frac{A-Z-4}{Z-2}$

133. A nuclear transformation is denoted by $X(n, \alpha)\,^7_3Li$. Which of the following is the nucleus of element X ?

(a) $^{10}_{5}Be$ (b) $^{12}C_6$

(c) $^{11}_{4}Be$ (d) $^{9}_{5}B$

134. In a fission reaction

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

the binding energy per nucleon of X & Y is 8.5 MeV. Whereas of ^{236}U is 7.6 MeV. The total energy liberated will be about

(a) 2000 MeV (b) 200 MeV
(c) 2 MwV (d) 200 KeV

135. If a star can convert all the He nuclei completely into oxygen nuclei. The energy released per oxygen nuclei is [Mass of He nucleus is 4.0026 amu and mass of Oxygen nucleus is 15.9994 amu]

(a) 7.6 MeV (b) 56.12 MeV
(c) 10.24 MeV (d) 23.9 MeV

136. The energy released per fission of a $_{92}U^{235}$ nucleus is nearly

(a) 200 eV (b) 20 eV
(c) 200 MeV (d) 2000 eV

137. If 200 MeV energy is released in the fission of a single U^{235} nucleus, the number of fissions required per second to produce 1 kilowatt power shall be (Given 1eV = 1.6×10^{-19} J)

(a) 3.125×10^{13} (b) 3.125×10^{14}
(c) 3.125×10^{15} (d) 3.125×10^{16}

138. A certain mass of Hydrogen is changed to Helium by the process of fusion. The mass defect in fusion reaction is 0.02866 a.m.u. The energy liberated per a.m.u. is
(Given : 1 a.m.u = 931 MeV)

(a) 26.7 MeV (b) 6.675 MeV
(c) 13.35 MeV (d) 2.67 MeV

139. The binding energy per nucleon of deuteron $\left(^2_1H\right)$ and helium nucleus $\left(^4_2He\right)$ is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is

(a) 23.6 MeV (b) 26.9 MeV
(c) 13.9 MeV (d) 19.2 MeV

140. If the binding energy per nucleon in ^7_3Li and ^4_2He nuclei are 5.60 MeV and 7.06 MeV respectively, then in the reaction

$$p + ^7_3Li \longrightarrow 2\,^4_2He$$

energy of proton must be

(a) 28.24 MeV (b) 17.28 MeV
(c) 1.46 MeV (d) 39.2 MeV

141. 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).

(a) 0.511 MeV (b) 7.10 MeV
(c) 6.30 MeV (d) 5.4 MeV

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. (c)
2. (b) Gold has 32 isotopes ranging from A = 173 to A = 204
3. (d) Nuclear radius = 10^{-14} m.
4. (a) Chemical properties are unaffected with addition of neutrons to the nucleus.
5. (c) Radius of nucleus $R = R_0 A^{1/3}$ where A is the mass number of nucleus.

   $\therefore$ Volume of nucleus $= \frac{4}{3}\pi R^3 = \left(\frac{4}{3}\pi R_0^3\right)A$

   $\therefore$ Volume is proportional to A.
6. (c) Nucleus does not contain electron.
7. (b)
8. (a) In pressurised-water, nuclear reactor, in primary loop water is circulated through the reactor vessel and transfers energy to steam generator in secondary loop.
9. (c) 10. (b) 11. (b)
12. (d) Average BE/nucleon increases first, and then decreases, as is clear from BE curve.
13. (d) Mass defect $= \frac{B.E}{c^2}$

    Mass of nucleus = Mass of proton + mass of neutron − mass defect
14. (d) 15. (d) 16. (d) 17. (b)
18. (b) 19. (d)
20. (a) Antiparticle of electron $({}_{-1}e^0)$ is positron $({}_{+1}e^0)$
21. (c) An electron is accompanied by an antineutrino.
22. (d) All the characteristics given are true for radioactivity.
23. (d) γ-rays carry no charge. They are neither deflected by an electric field nor by a magnetic field.
24. (c) β-rays are charged particles emitted by nucleus.
25. (c) Fusion is not a mode of decay.
26. (c) Half life $T_h = \frac{0.693}{\lambda}$, $T_m = \frac{1}{\lambda}$ Clearly, $T_h < T_m$.
27. (c) 28. (c) 29. (c) 30. (d) 31. (a)
32. (d) 33. (c) 34. (a)
35. (c) Number of a-particles emitting

    per second $= \frac{dN}{dt}$

    $= \lambda N = n$

    $\therefore \quad \lambda = \frac{n}{N}$

    $\therefore \quad T = \frac{0.693}{\lambda}$

    $= \frac{0.693N}{n}$
36. (b) Activity is proportional to mass. Activity of specimen B is maximum. Thus, mass of specimen B is also maximum.
37. (b) 38. (b) 39. (a) 40. (d)
41. (c) The risk posed to a human being by any radiation exposure depends partly upon the absorbed dose, the amount of energy absorbed per gram of tissue. Absorbed dose is expressed in rad. A rad is equal to 100 ergs of energy absorbed by 1 gram of tissue. The more modern, internationally adopted unit is the gray (named after the English medical physicist L. H. Gray); one gray equals 100 rad.
42. (a)
43. (d) Half life of a substance doesn't depends upon amount, temperature and pressure. It depends upon the nature of the substance.
44. (b) ${}_{-1}e^0$ is known as β^- particle & $\bar{\nu}$ is known as antineutrino. Since in this reaction $\bar{\nu}$ is emitted with ${}_{-1}e^0$ (β^- particle or electron), so it is known as β-decay.
45. (b)
46. (c) Control rods are made of cadmium.
47. (a) Boron rods absorb excess neutrons.
48. (c) Moderator slows down neutrons.
49. (d) Extremely high temps needed for fusion make K.E. large enough to overcome repulsion between nuclei.
50. (c)

STATEMENT TYPE QUESTIONS

51. (c) Hydrogen has three isotopes Hydrogen $\left({}_1^1H\right)$, Denterium $\left({}_1^2H\right)$, and Tritium $\left({}_1^3H\right)$.
52. (b) The chemical properties of elements depend on their electronic structure. As the atoms of isotopes have identical electronic structure they have identical chemical behaviour and are placed in the same location in the periodic table.
53. (d) As $R \propto A^{1/3}$ and volume of nucleus is proportional to R^3 is proportional to A. Thus, the density of nucleus is a constant, independent of A, for all nuclei. Different nuclei are likes drop of liquid of

constant density. The density of nuclear matter is approximately 2.3×10^{17} kg m^{-3}.

This density is very large compared to ordinary matter, say water which is 10^{23} kg m^{-3}. This is understandable, as we have already seen that most of the atom is empty. Ordinary matter consisting of atoms has a large amount of empty space.

54. **(d)** For $0 < A < 80$, E_{bn} first increases then decreases.

55. **(b)** The common time measure of how long any given type of radionuclide lasts is the half-life $T_{1/2}$ of a radionuclide, Which is the time at which both N and R have been reduced to one-half their initial values. A sample may have nuclei which are not radioactive.

56. **(a)** Neutrons can't be deflected by a magnetic field.

MATCHING TYPE QUESTIONS

57. **(b)** (A)→(2); (B)→(1); (C)→(4); (D)→(3)

58. **(c)** (A)→(2); (B)→(1); (C)→(4); (D)→(3)

$$^{15}_{8}O \longrightarrow ^{15}_{7}N + \underset{\beta^+ \text{ particle}}{^{0}_{1}\beta}$$

$$^{238}_{92}U \longrightarrow ^{234}_{90}Th + \underset{\alpha-\text{particle}}{^{4}_{2}He}$$

$$^{185}_{83}Bi \longrightarrow ^{184}_{82}Pb + \underset{\text{proton}}{^{1}_{1}H}$$

$$^{239}_{94}Pu \longrightarrow ^{140}_{57}La + ^{99}_{37}X$$

(c) is the correct option.

59. **(a)** (A)→(2); (B)→(3); (C)→(4); (D)→(1)

60. **(b)** (A)→(2); (B)→(1); (C)→(4); (D)→(3)

DIAGRAM TYPE QUESTIONS

61. **(d)** For $A + B \to C + \varepsilon$, ε is the positive. This is because E_b for D and E is greater then E_b for F.

62. **(c)**

63. **(c)** Energy is released in a process when total binding energy (BE) of products is more than the reactants. By calculations we can see that this happens in option (c).

Given $W = 2Y$

BE of reactants = 120 × 7.5 = 900 MeV

BE of products = 2 × (60 × 8.5) = 1020 MeV.

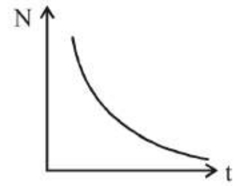
64. **(c)** The range of energy of β-particles is from zero to some maximum value.

65. **(c)** No. of nuclide at time t is given by $N = N_o e^{-\lambda t}$

Where N_o = initial nuclide

thus this equation is equivalent to $y = ae^{-kx}$

thus correct graph is



ASSERTION- REASON TYPE QUESTIONS

66. **(a)** $$\rho = \frac{M}{V} = \frac{A}{\frac{4}{3}\pi r^3}$$

$$= \frac{A}{\frac{4}{3}\pi(r_0 A^{1/3})^3} = \frac{1}{\left(\frac{4}{3}\pi r_0^3\right)} = \text{constant}$$

67. **(b)** Both statements are separately correct.

68. **(d)** In case of hydrogen atom mass number and atomic number are equal.

69. **(c)** Nuclear force is nearly same for all nucleus.

70. **(c)** Radioactivity $= -\frac{dN}{dt} = \lambda N = \frac{0.693N}{T_{1/2}}$

$$= \frac{0.693 \times 10^8}{50} = \frac{0.693 \times 1.2 \times 10^8}{60} = 0.693 \times 2 \times 10^6.$$

Radioactivity is proportional to $1/T_{1/2}$, and not to $T_{1/2}$.

71. **(b)** β-particles, being emitted with very high speed compared to α-particles, pass for very little time near the atoms of the medium. So the probability of the atoms being ionised is comparatively less. But due to this reason, their loss of energy is very slow and they can penetrate the medium through a sufficient depth.

72. **(c)** Electrons are not inside nucleus.

73. **(a)** **74.** **(a)** **75.** **(d)** **76.** **(d)** **77.** **(c)**

78. **(d)** We know that energy is released when heavy nuclei undergo fission or light nuclei undergo fusion. Therefore statement (1) is correct.

The second statement is false because for heavy nuclei the binding energy per nucleon decreases with increasing Z and for light nuclei, B.E/nucleon increases with increasing Z.

CRITICAL THINKING TYPE QUESTIONS

79. **(c)** $$\frac{R_s}{R_{He}} = \left(\frac{A_s}{A_{He}}\right)^{1/3} = \left(\frac{32}{4}\right)^{1/3} = 2$$

80. **(b)** As momentum is conserved, therefore,

$$\frac{m_1}{m_2} = \frac{A_1}{A_2} = \frac{v_2}{v_1} = \frac{1}{2}$$

$\therefore \quad \frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} = \left(\frac{1}{2}\right)^{1/3} = 1 : 2^{1/3}$

81. **(b)** $R = R_0(A)^{1/3}$

$\therefore \frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} = \left(\frac{27}{125}\right)^{1/3} = \frac{3}{5}$

$R_2 = \frac{5}{3} \times 3.6 = 6$ fermi

82. **(c)** Binding energy

$= [ZM_P + (A - Z)M_N - M]c^2$

$= [8M_P + (17 - 8)M_N - M]c^2$

$= [8M_P + 9M_N - M]c^2$

$= [8M_P + 9M_N - M_o]c^2$

83. **(a)** Iodine and Yttrium are medium sized nuclei and therefore have more binding energy per nucleon as compared to Uranium which has a big nucleus and less B.E. / nucleon. In other words, Iodine and Yttrium are more stable and therefore, possess less energy and less rest mass. Also, when Uranium nuclei explodes, it will convert into I and Y nuclei having kinetic energies.

84. **(a)** $B.E_H = \frac{2.22}{2} = 1.11$

$B.E_{He} = \frac{28.3}{4} = 7.08$

$B.E_{Fe} = \frac{492}{56} = 8.78 = \text{maximum}$

$B.E_U = \frac{1786}{235} = 7.6$

${}^{56}_{26}Fe$ is most stable as it has maximum binding energy per nucleon.

85. **(b)** $B.E. = 0.042 \times 931 \simeq 42$ MeV

Number of nucleons in ${}^{7}_{3}Li$ is 7.

$\therefore$ B.E./ nucleon $= \frac{42}{7} = 6$ MeV $\simeq$ 5.6 MeV

86. **(d)** $E = \Delta m.c^2 \Rightarrow E = \frac{0.3}{1000} \times (3 \times 10^8)^2 = 2.7 \times 10^{13}$ J

$= \frac{2.7 \times 10^{13}}{3.6 \times 10^6} = 7.5 \times 10^6$ kWh.

87. **(b)** $Q = 4(x_2 - x_1)$

88. **(c)** Energy released $= (80 \times 7 + 120 \times 8 - 200 \times 6.5)$

89. **(a)** $B.E. = \Delta mc^2 = \Delta \times 931$ MeV

$= [2(1.0087 + 1.0073) - 4.0015] \times 931 = 28.4$ MeV

90. **(a)** $E = mc^2 = 10^{-6} \times (3 \times 10^8)^2 = 10^{-6} \times 9 \times 10^{16} = 9 \times 10^{10}$ J

91. **(c)** Substance left undecayed, $N_0 - \frac{3}{4}N_0 = \frac{1}{4}N_0$

$\frac{N}{N_0} = \frac{1}{4} = \left(\frac{1}{2}\right)^n$

$\therefore$ Number of atoms left undecayed,

$n = 2$ i.e. in two half lives

$\therefore \quad t = nT = 2 \times 4 = 8$ months

92. **(a)** Let no. of α-particles emitted be x and no. of β particles emitted be y.

Diff. in mass no. $4x = 238 - 206 = 32 \Rightarrow x = 8$

Diff. in charge no. $2x - 1y = 92 - 82 = 10$

$16 - y = 10, y = 6$

93. **(a)** We assume that mass number of nucleus when it was at rest = A

$\because$ mass number of α -particle = 4

$\therefore$ mass number of remaining nucleus = A - 4

As there is no external force, so momentum of the system will remain conserved

$\Rightarrow 0 = (A-4)v' + 4v \;\; \Rightarrow v' = -\frac{4v}{(A-4)}$)

negative sign represents that direction is opposite to the direction of motion of α -particle.

94. **(b)** A nucleus is denoted by ${}_ZX^A$

An isotope should have same Z.

α–particle $= {}_2He^4$; β–particle $= {}_{-1}\beta^0$

The emission of one α particle and the emission of two β particles maintain the Z same.

Hence, for isotope formation 2β particles and one α particle are emitted.

95. **(a)** $T_{1/2} = \frac{\ln 2}{\lambda} \therefore \lambda = \frac{\ln 2}{T_{1/2}}$

$\Rightarrow \lambda_A = \frac{\ln 2}{T_A}, \lambda_B = \frac{\ln 2}{T_B} \Rightarrow \frac{\lambda_A}{\lambda_B} = \frac{T_B}{T_A}.$

96. **(a)** ${}_{72}A^{180} \xrightarrow{\alpha} {}_{70}A_1^{176} \xrightarrow{\beta} {}_{71}A_2^{176}$

$\xrightarrow{\alpha} {}_{69}A_3^{172} \xrightarrow{\gamma} {}_{69}A_4^{172}$

97. **(d)** Radioactivity at T_1, $R_1 = \lambda N_1$

Radioactivity at T_2, $R_2 = \lambda N_2$

$\therefore$ Number of atoms decayed in time

$(T_1 - T_2) = (N_1 - N_2)$

$$= \frac{(R_1 - R_2)}{\lambda} = \frac{(R_1 - R_2)T}{0.693} \propto (R_1 - R_2)T$$

98. (d)

99. (c) $\frac{dN}{dt} = \lambda N = \text{activity } R$

$R_0 = \lambda N_0$ at $t = 0$, $R_1 = \lambda N_1$ at $t = 5$ minutes

where $\lambda = \frac{2.303}{t} \log \frac{N_0}{N_1}$

100. (c) $\frac{N_A}{N_B} = \frac{(1/2)^{n_A}}{(1/2)^{n_B}} = \frac{(1/2)^4}{(1/2)^2} = \frac{1}{4}$, where n_A & n_B are number of half lives of samples A & B respectively. N_A & N_B are the remaining numbers of A & B after 80 minutes in this case.

101. (d) $N = N_0 e^{-\lambda t}$

Here, $t = 5$ minutes

$$\frac{N_0}{e} = N_0 \cdot e^{-5\lambda}$$

$$\Rightarrow \quad 5\lambda = 1, \text{ or } \quad \lambda = \frac{1}{5},$$

Now, $T_{1/2} = \frac{\ell n 2}{\lambda} = 5 \ \ell n 2$

102. (b) Momentum

$$Mu = \frac{E}{c} = \frac{h\nu}{c}$$

Recoil energy

$$\frac{1}{2} Mu^2 = \frac{1}{2} \frac{M^2 u^2}{M} = \frac{1}{2M} \left(\frac{h\nu}{c}\right)^2 = \frac{h^2 \nu^2}{2Mc^2}$$

103. (b) Initially $P \to 4N_0$

$Q \to N_0$

Half life $T_P = 1$ min.

$T_Q = 2$ min.

Let after time t number of nuclei of P and Q are equal, that is

$$\frac{4N_0}{2^{t/1}} = \frac{N_0}{2^{t/2}} \Rightarrow \frac{4N}{2^{t/1}} = \frac{1}{2^{t/2}} \Rightarrow 2^{t/1} = 4.2^{t/2}$$

$$2^2.2^{t/2} = 2^{(2 + t/2)}$$

$$\Rightarrow \frac{t}{1} = 2 + \frac{t}{2} \Rightarrow \frac{t}{2} = 2 \Rightarrow t = 4 \text{ min}$$

$$N_P = \frac{(4N_0)}{2^{4/1}} = \frac{N_0}{4}$$

at $t = 4$ min.

$$N_0 = \frac{N_0}{4} = \frac{N_0}{4}$$

or population of R

$$\left(4N_0 - \frac{N_0}{4}\right) + \left(N_0 - \frac{N_0}{4}\right) = \frac{9N_0}{2}$$

104. (b) $N_1 = N_0 e^{-\lambda t} \qquad N_1 = \frac{1}{3} N_0$

$$\frac{N_0}{3} = N_0 e^{-\lambda t_2}$$

$$\Rightarrow \quad \frac{1}{3} = e^{-\lambda t^2} \qquad \text{...(i)}$$

$$N_2 = \frac{2}{3} N_0$$

$$\frac{2}{3} N_0 = N_0 e^{-\lambda t_1}$$

$$\Rightarrow \quad \frac{2}{3} = e^{-\lambda t_1} \qquad \text{...(ii)}$$

Dividing equation (i) by equation (ii)

$$\frac{1}{2} = e^{-\lambda(t_2 - t_1)}$$

$$\lambda(t_2 - t_1) = \ln 2$$

$$t_2 - t_1 = \frac{\ln 2}{\lambda} = T_{1/2} = 50 \text{ days}$$

105. (d) Let, the amount of the two in the mixture will become equal after t years.

The amount of A_1, which remains after t years

$$N_1 = \frac{N_{01}}{(2)^{t/20}}$$

The amount of A_2, which remains, after t years

$$N_2 = \frac{N_{02}}{(2)^{t/10}}$$

According to the problem

$N_1 = N_2$

$$\frac{40}{(2)^{t/20}} = \frac{160}{(2)^{t/10}}$$

$$2^{t/20} = 2^{\left(\frac{t}{10}-2\right)}$$

$$\frac{t}{20} = \frac{t}{10} - 2$$

$$\frac{t}{20} - \frac{t}{10} = 2$$

$$\frac{t}{20} = 2$$

$t = 40$ s

106. (a) The value of x is $\frac{1}{8}$

$$= \frac{x_0}{8} = \frac{x_0}{2^3} \Rightarrow t = 3T = 3 \times 20 = 60 \text{ years}$$

Hence the estimated age of the rock is 60 years

ALTERNATE : X $\rightarrow$ Y_0

at t = 0 N_0 0

at t = t N $N_0 - N$

$$\frac{N}{N_0 - N} = \frac{1}{7} = \frac{N}{N_0} = \frac{1}{8}$$

t = 3T

= 3 × 20 = 60 years

107. (a) Amount left = $N_0/2^n = N_0/8$ (Here n=15/5=3)

108. (a) Applying the principle of conservation of linear momentum

$$(4)(u) = (v)(238) \Rightarrow v = \frac{4u}{238}$$

109. (a) $K = \frac{1}{t}\ell n\left(\frac{N_0}{N}\right) \Rightarrow K = \frac{1}{5}\ell n\left(\frac{5000}{1250}\right)$

$$\frac{1}{5}\ell n(4) = \frac{2}{5}\ell n2 = 0.4\ell n2$$

110. (b) Radioactive decay is a random process. Each decay is a completely independent event. Therefore, which particular nucleus will decay at a given instant of time cannot be predicted. In other words when a particular nucleus will decay cannot be predicted. Each nucleus has same probability of disintegration.

111. (a) We know that , $\left|\frac{dN}{dt}\right| = \lambda N = \frac{1}{T_{mean}} N$

$$\therefore \quad 10^{10} = \frac{1}{10^9} \times N$$

$$\therefore \quad N = 10^{19}$$

i.e. 10^{19} radioactive atoms are present in the freshly prepared sample.

The mass of the sample

$= 10^{19} \times 10^{-25}$ kg $= 10^{-6}$kg = 1 mg

112. (d) Time taken to disintegrate completely by a substance is infinity as $\log\frac{N_0}{N} = \lambda t$

$$\Rightarrow \log\frac{N_0}{0} = \lambda t$$

$$\log\infty = \lambda t$$

hence when $N \rightarrow 0, t \rightarrow \infty$.

113. (a) $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{t}{T}}$ or $\frac{N}{10000} = \left(\frac{1}{2}\right)^{\frac{10}{20}}$

or $N = \frac{10000 \times 1}{\sqrt{2}} = \frac{10000}{1.414} = 7070.$

114. (b) $\left(\frac{1}{2}\right)^n = \frac{N}{N_0} = \frac{1}{20}$ gives n = 4.32

t = nT = 4.3 × 3.8 = 16.5 days

115. (b) To work safely, intensity must reduce by 1/64

$$\therefore \frac{N}{N_0} = \frac{1}{64} = \left(\frac{1}{2}\right)^{t/T} \text{ i.e. } \left(\frac{1}{2}\right)^6 = \left(\frac{1}{2}\right)^{t/T}$$

or $\frac{t}{T} = 6$ or t = 6 T = 12 hrs

116. (d)

117. (b) Conservation of linear momentum requires:

$m_{radon}v_{radon} = m_{helium}v_{helium}$ with helium identified as the alpha particle. The nuclear masses can be approximated by their mass numbers (222 and 4). Thus, the recoil speed of the radon is $(4/222) \times 1.5 \times 10^7$ m/s = 2.7×10^5 m/s.

118. (c) $\frac{^{14}C}{^{12}C} = \frac{1}{16} = \frac{N}{N_0}$

$$\because \quad \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$$

$$\Rightarrow \frac{1}{16} = \left(\frac{1}{2}\right)^n \Rightarrow \left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^n$$

or, n = 4

or $\frac{t}{T} = 4$

or t = 4 × T = 4 × 5730 = 22920 years

119. (c)

$$\frac{C_{14}}{C_{12}}=\frac{1}{4}=\left(\frac{1}{2}\right)^{t/5700} \Rightarrow \frac{t}{5700}=2 \Rightarrow t=11400 \text{ years}$$

120. (a) Let the percentage of B^{10} atoms be x, then average atomic weight

$$=\frac{10x+11(100-x)}{100}=10.81 \Rightarrow x=19$$

$$\therefore \frac{N_{B^{10}}}{N_{B^{11}}}=\frac{19}{81}$$

121. (c) Let N_0 be the number of atoms of X at time t = 0.
Then at t = 4 hrs (two half lives)

$$N_x=\frac{N_0}{4} \text{ and } N_y=\frac{3N_0}{4}$$

$\therefore\ N_x/N_y = 1/3$
and at t = 6 hrs (three half lives)

$$N_x=\frac{N_0}{8} \text{ and } N_y=\frac{7N_0}{8}$$

or $\frac{N_x}{N_y}=\frac{1}{7}$

The given ratio $\frac{1}{4}$ lies between $\frac{1}{3}$ and $\frac{1}{7}$.

Therefore, t lies between 4 hrs and 6 hrs.

122. (a) Activity of sample becomes 2500 from 5000 in 75 days therefore its half life is 75 days, so

$$R=\frac{R_0}{2^{\frac{150}{75}}}=5000 \Rightarrow R_0=5000\times 4=20,000$$

123. (a) For substance A :

$$2N_0 \rightarrow N_A=2N_0\left(\frac{1}{2}\right)^{48/12}=\frac{N_0}{2^3}=\frac{N_0}{8}$$

For substance B :

$$N_0 \rightarrow N_B=N_0\left(\frac{1}{2}\right)^{48/16}=\frac{N_0}{2^3}=\frac{N_0}{8}$$

$N_A : N_B = 1 : 1$

124. (b) Effective half life is calculated as

$$\frac{1}{T}=\frac{1}{T_1}+\frac{1}{T_2}$$

$$\frac{1}{T}=\frac{1}{16}+\frac{1}{48} \Rightarrow T=12 \text{ years}$$

Time in which $\frac{3}{4}$ will decay is 2 half lives = 24 years

125. (c) **126. (a)** **127. (c)** **128. (d)**

129. (c) When ${}^{m}_{n}X$ emits one α-particle then its atomic mass decreases by 4 units and atomic number by 2. Therefore, the new nucleus becomes ${}^{m-4}_{n-2}Y$. But as it emits two β^- particles, its atomic number increases by 2. Thus the resulting nucleus is ${}^{m-4}_{n}X$.

130. (b) No. of α particles emitted = 8
No. of β^- particles emitted = 4
No. of β^+ particles emitted = 2
$Z = 92 - 2\times 8 + 4 - 2 = 78$

131. (c) According to question,
Half life of X, $T_{1/2}=\tau_{av}$, mean life of Y

$$\Rightarrow \frac{0.693}{\lambda_X}=\frac{1}{\lambda_Y}$$

$$\Rightarrow \lambda_X=(0.693).\lambda_Y$$

$$\therefore \lambda_X > \lambda_Y.$$

Now, the rate of decay is given by

$$-\left(\frac{dN}{dt}\right)=\lambda_X N_0$$

$$-\left(\frac{dN}{dt}\right)_4=\lambda_4 N_0$$

Y will decay faster than X.

132. (b) As a result of emission of 1 α-particle, the mass number decreases by 4 units and atomic number decreases by 2 units. And by the emission of 1 positron the atomic number decreases by 1 unit but mass number remains constant.

$\therefore$ Mass number of final nucleus = $A - 12$

Atomic number of final nucleus = $Z - 8$

$\therefore$ Number of neutrons $=(A-12)-(Z-8)$

$= A - Z - 4$

Number of protons = $Z - 8$

$$\therefore \text{Required ratio}=\frac{A-Z-4}{Z-8}$$

133. (a) ${}_ZX^A + {}_0n^1 \longrightarrow {}_3Li^7 + {}_2He^4$

On comparison,
$A = 7 + 4 - 1 = 10$, $z = 3 + 2 - 0 = 5$
It is boron ${}_5B^{10}$

134. (b) Liberated energy $Q = 117\times 8.5 + 117\times 8.5 - 236\times 7.6 =$ 200 MeV. Thus, in fission of one Uranium nuclei nearly 200 MeV energy is liberated.

135. (c) $4\ {}^4_2He \longrightarrow {}^{16}_{8}O$

B.E = ΔM × 931.5 MeV
$= (4\times 4.0026 - 15.9994)\times 931.5 = 10.24$ MeV

136. (c) Energy released per fission is ≈ 200 MeV

137. (a) $P = n\left(\frac{E}{t}\right) \Rightarrow 1000 = \frac{n \times 200 \times 10^6 \times 1.6 \times 10^{-19}}{t}$

$\Rightarrow \frac{n}{t} = 3.125 \times 10^{13}$.

138. (b) Mass defect $\Delta m = 0.02866$ a.m.u.

Energy $= 0.02866 \times 931 = 26.7$ MeV

As ${}_1H^2 + {}_1H^2 \longrightarrow {}_2He^4$

Energy liberated per a.m.u $= 13.35/2$ MeV

$= 6.675$ MeV

139. (a) The chemical reaction of process is $2{}_1^2H \rightarrow {}_2^4He$

Energy released $= 4 \times (7) - 4(1.1) = 23.6$ eV

140. (b) Let E be the energy of proton, then

$E + 7 \times 5.6 = 2 \times [4 \times 7.06]$

$\Rightarrow E = 56.48 - 39.2 = 17.28 MeV$

141. (a) ${}_0^1n \longrightarrow {}_1^1H + {}_{-1}e^0 + \overline{v} + Q$

The mass defect during the process

$\Delta m = m_n - m_H - m_e$

$= 1.6725 \times 10^{-27} - (1.6725 \times 10^{-27} + 9 \times 10^{-31} kg)$

$= -9 \times 10^{-31}$ kg

The energy released during the process

$E = \Delta mc^2$

$E = 9 \times 10^{-31} \times 9 \times 10^{16} = 81 \times 10^{-15}$ Joules

$E = \frac{81 \times 10^{-15}}{1.6 \times 10^{-19}} = 0.511 MeV$