Chapter 20. Atoms and Nuclei

1. Radioactive material 'A' has decay constant '8λ' and material 'B' has decay constant 'λ'. Initially they have same number of nuclei. After what time, the ratio of number of nuclei of material 'B' to that 'A' will be $\frac{1}{e}$?

(a) $\frac{1}{7\lambda}$ (b) $\frac{1}{8\lambda}$ (c) $\frac{1}{9\lambda}$ (d) $\frac{1}{\lambda}$

(NEET 2017)

2. The ratio of wavelengths of the last line of Balmer series and the last line of Lyman series is

(a) 1 (b) 4
(c) 0.5 (d) 2 *(NEET 2017)*

3. If an electron in a hydrogen atom jumps from the 3^{rd} orbit to the 2^{nd} orbit, it emits a photon of wavelength λ. When it jumps from the 4^{th} orbit to the 3^{rd} orbit, the corresponding wavelength of the photon will be

(a) $\frac{16}{25}\lambda$ (b) $\frac{9}{16}\lambda$ (c) $\frac{20}{7}\lambda$ (d) $\frac{20}{13}\lambda$

(NEET-II 2016)

4. The half-life of a radioactive substance is 30 minutes. The time (in minutes) taken between 40% decay and 85% decay of the same radioactive substance is

(a) 15 (b) 30 (c) 45 (d) 60

(NEET-II 2016)

5. Given the value of Rydberg constant is 10^7 m^{-1}, the wave number of the last line of the Balmer series in hydrogen spectrum will be

(a) 0.25×10^7 m^{-1} (b) 2.5×10^7 m^{-1}
(c) 0.025×10^4 m^{-1} (d) 0.5×10^7 m^{-1}

(NEET-I 2016)

6. When an α-particle of mass m moving with velocity v bombards on a heavy nucleus of charge Ze, its distance of closest approach from the nucleus depends on m as

(a) $\frac{1}{m^2}$ (b) m (c) $\frac{1}{m}$ (d) $\frac{1}{\sqrt{m}}$

(NEET-I 2016)

7. A nucleus of uranium decays at rest into nuclei of thorium and helium. Then

(a) The helium nucleus has more momentum than the thorium nucleus.
(b) The helium nucleus has less kinetic energy than the thorium nucleus.
(c) The helium nucleus has more kinetic energy than the thorium nucleus.
(d) The helium nucleus has less momentum than the thorium nucleus.

(2015)

8. In the spectrum of hydrogen, the ratio of the longest wavelength in the Lyman series to the longest wavelength in the Balmer series is

(a) $\frac{27}{5}$ (b) $\frac{5}{27}$ (c) $\frac{4}{9}$ (d) $\frac{9}{4}$

(2015)

9. If radius of the $^{27}_{13}$Al nucleus is taken to be R_{Al}, then the radius of $^{125}_{53}$Te nucleus is nearly

(a) $\frac{3}{5}R_{Al}$ (b) $\left(\frac{13}{53}\right)^{1/3} R_{Al}$

(c) $\left(\frac{53}{13}\right)^{1/3} R_{Al}$ (d) $\frac{5}{3}R_{Al}$

(2015 Cancelled)

10. Consider 3^{rd} orbit of He^+ (Helium), using non-relativistic approach, the speed of electron in this orbit will be [given $K = 9 \times 10^9$ constant, $Z = 2$ and h (Planck's Constant) $= 6.6 \times 10^{-34}$ J s]

(a) 0.73×10^6 m/s (b) 3.0×10^8 m/s
(c) 2.92×10^6 m/s (d) 1.46×10^6 m/s

(2015 Cancelled)

11. Hydrogen atom in ground state is excited by a monochromatic radiation of $\lambda = 975$ Å. Number of spectral lines in the resulting spectrum emitted will be

(a) 3 (b) 2 (c) 6 (d)0 10

(2014)

12. The binding energy per nucleon of and nuclei are 5.60 MeV and 7.06 MeV respectively. In the nuclear reaction

$$^{7}_{3}Li + ^{1}_{1}H \rightarrow ^{4}_{2}He + ^{4}_{2}He + Q$$

the value of energy Q released is

(a) 19.6 MeV (b) –2.4 MeV
(c) 8.4 MeV (d) 17.3 MeV

(2014)

13. A radioisotope X with a half life 1.4×10^9 years decays to Y which is stable. A sample of the rock from a cave was found to contain X and Y in the ratio 1 : 7. The age of the rock is

(a) 1.96×10^9 years (b) 3.92×10^9 years
(c) 4.20×10^9 years (d) 8.40×10^9 years

(2014)

14. Ratio of longest wave lengths corresponding to Lyman and Balmer series in hydrogen spectrum is

(a) $\frac{7}{29}$ (b) $\frac{9}{31}$ (c) $\frac{5}{27}$ (d) $\frac{3}{23}$

(NEET 2013)

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

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

(NEET 2013)

16. 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 1 : 7 in a sample of a given rock. The age of the rock is estimated to be

(a) 80 years (b) 100 years
(c) 40 years (d) 60 years

(NEET 2013)

17. How does the Binding Energy per nucleon vary with the increase in the number of nucleons?

(a) Decrease continuously with mass number.
(b) First decreases and then increases with increase in mass number.
(c) First increases and then decreases with increase in mass number.
(d) Increases continuously with mass number. *(Karnataka NEET 2013)*

18. An electron in hydrogen atom makes a transition $n_1 \rightarrow n_2$ where n_1 and n_2 are principal quantum numbers of the two states. Assuming Bohr's model to be valid, the time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are

(a) $n_1 = 6$ and $n_2 = 2$ (b) $n_1 = 8$ and $n_2 = 1$
(c) $n_1 = 8$ and $n_2 = 2$ (d) $n_1 = 4$ and $n_2 = 2$

(Karnataka NEET 2013)

19. α-particles, β-particles and γ-rays are all having same energy. Their penetrating power in a given medium in increasing order will be

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

(Karnataka NEET 2013)

20. Electron in hydrogen atom first jumps from third excited state to second excited state and then from second excited to the first excited state. The ratio of the wavelengths $\lambda_1 : \lambda_2$ emitted in the two cases is

(a) $\frac{7}{5}$ (b) $\frac{27}{20}$ (c) $\frac{27}{5}$ (d) $\frac{20}{7}$

(2012)

21. If the nuclear radius of ^{27}Al is 3.6 fermi, the approximate nuclear radius of ^{64}Cu in fermi is

(a) 2.4 (b) 1.2 (c) 4.8 (d) 3.6

(2012)

22. 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

(2012)

23. An electron of a stationary hydrogen atom passes from the fifth energy level to the ground level. The velocity that the atom acquired as a result of photon emission will be

(a) $\frac{24hR}{25m}$ (b) $\frac{25hR}{24m}$
(c) $\frac{25m}{24hR}$ (d) $\frac{24m}{25hR}$ *(2012)*

(m is the mass of the electron, R, Rydberg constant and h Planck's constant)

24. The transition from the state $n = 3$ to $n = 1$ in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from

(a) $2 \to 1$ (b) $3 \to 2$
(c) $4 \to 2$ (d) $4 \to 3$
(Mains 2012)

25. 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
(Mains 2012)

26. The wavelength of the first line of Lyman series for hydrogen atom is equal to that of the second line of Balmer series for a hydrogen like ion. The atomic number Z of hydrogen like ion is
(a) 3 (b) 4
(c) 1 (d) 2 *(2011)*

27. The half life of a radioactive isotope X is 50 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 : 15 in a sample of a given rock. The age of the rock was estimated to be
(a) 150 years (b) 200 years
(c) 250 years (d) 100 years *(2011)*

28. The power obtained in a reactor using U^{235} disintegration is 1000 kW. The mass decay of U^{235} per hour is
(a) 10 microgram (b) 20 microgram
(c) 40 microgram (d) 1 microgram
(2011)

29. A radioactive nucleus of mass M emits a photon of frequency υ and the nucleus recoils. The recoil energy will be
(a) $Mc^2 - h\upsilon$ (b) $h^2\upsilon^2/2Mc^2$
(c) zero (d) $h\upsilon$ *(2011)*

30. A nucleus ${}^{m}_{n}X$ 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) ${}^{m-4}_{n-2}Y$ *(2011)*

31. Fusion reaction takes place at high temperature because
(a) nuclei break up at high temperature
(b) atoms get ionised at high temperature
(c) kinetic energy is high enough to overcome the coulomb repulsion between nuclei
(d) molecules break up at high temperature
(2011)

32. An electron in the hydrogen atom jumps from excited state n to the ground state. The wavelength so emitted illuminates a photosensitive material having work function 2.75 eV. If the stopping potential of the photoelectron is 10 V, then the value of n is
(a) 2 (b) 3
(c) 4 (d) 5 *(Mains 2011)*

33. 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) $2\,N_0$ (b) $3\,N_0$ (c) $\frac{9N_0}{2}$ (d) $\frac{5N_0}{2}$
(Mains 2011)

34. Out of the following which one is not a possible energy for a photon to be emitted by hydrogen atom according to Bohr's atomic model?
(a) 0.65 eV (b) 1.9 eV
(c) 11.1 eV (d) 13.6 eV
(Mains 2011)

35. The mass of a ${}^{7}_{3}Li$ nucleus is 0.042 u less than the sum of the masses of all its nucleons. The binding energy per nucleon of ${}^{7}_{3}Li$ nucleus is nearly
(a) 46 MeV (b) 5.6 MeV
(c) 3.9 MeV (d) 23 MeV *(2010)*

36. 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) $\log_e \frac{2}{5}$ (b) $\frac{5}{\log_e 2}$
(c) $5\log_{10} 2$ (d) $5\log_e 2$ *(2010)*

37. The energy of a hydrogen atom in the ground state is −13.6 eV. The energy of a He^+ ion in the first excited state will be
(a) −13.6 eV (b) −27.2 eV
(c) −54.4 eV (d) −6.8 eV *(2010)*

38. An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nuclear target of charge Ze. Then the distance of closest approach for the alpha nucleus will be proportional to

(a) $\frac{1}{Ze}$ (b) v^2 (c) $\frac{1}{m}$ (d) $\frac{1}{v^4}$

(2010)

39. The decay constant of a radio isotope is λ. If A_1 and A_2 are its activities at times t_1 and t_2 respectively, the number of nuclei which have decayed during the time $(t_1 - t_2)$

(a) $A_1t_1 - A_2t_2$ (b) $A_1 - A_2$
(c) $(A_1 - A_2)/\lambda$ (d) $\lambda(A_1 - A_2)$

(Mains 2010)

40. The binding energy per nucleon in deuterium and helium nuclei are 1.1 MeV and 7.0 MeV, respectively. When two deuterium nuclei fuse to form a helium nucleus the energy released in the fusion is

(a) 23.6 MeV (b) 2.2 MeV
(c) 28.0 MeV (d) 30.2 MeV

(Mains 2010)

41. In the nuclear decay given below

$${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}Y \rightarrow {}^{A-4}_{Z-1}B^* \rightarrow {}^{A-4}_{Z-1}B,$$

the particles emitted in the sequence are

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

(2009, 1993)

42. The number of beta particles emitted by a radioactive substance is twice the number of alpha particles emitted by it. The resulting daughter is an

(a) isomer of parent (b) isotone of parent
(c) isotope of parent (d) isobar of parent

(2009)

43. In a Rutherford scattering experiment when a projectile of charge z_1 and mass M_1 approaches a target nucleus of charge z_2 and mass M_2, the distance of closest approach is r_0. The energy of the projectile is

(a) directly proportional to z_1z_2
(b) inversely proportional to z_1
(c) directly proportional to mass M_1
(d) directly proportional to $M_1 \times M_2$ *(2009)*

44. The ionization energy of the electron in the hydrogen atom in its ground state is 13.6 eV. The atoms are excited to higher energy levels to emit radiations of 6 wavelengths. Maximum wavelength of emitted radiation corresponds to the transition between

(a) $n = 3$ to $n = 1$ states
(b) $n = 2$ to $n = 1$ states
(c) $n = 4$ to $n = 3$ states
(d) $n = 3$ to $n = 2$ states *(2009)*

45. If $M(A; Z)$, M_p and M_n denote the masses of the nucleus ${}^{A}_{Z}X$, proton and neutron respectively in units of u (1 u = 931.5 MeV/c^2) and BE represents its bonding energy in MeV, then

(a) $M(A, Z) = ZM_p + (A - Z)M_n - BE$
(b) $M(A, Z) = ZM_p + (A - Z)M_n + BE/c^2$
(c) $M(A, Z) = ZM_p + (A - Z)M_n - BE/c^2$
(d) $M(A, Z) = ZM_p + (A - Z)M_n + BE$

(2008, 2004)

46. Two nuclei have their mass numbers in the ratio of 1 : 3. The ratio of their nuclear densities would be

(a) $(3)^{1/3} : 1$ (b) 1 : 1
(c) 1 : 3 (d) 3 : 1 *(2008)*

47. The ground state energy of hydrogen atom is –13.6 eV. When its electron is in the first excited state, its excitation energy is

(a) 10.2 eV (b) 0
(c) 3.4 eV (d) 6.8 eV *(2008)*

48. Two radioactive materials X_1 and X_2 have decay constants 5λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that X_2 will be $1/e$ after a time

(a) $1/4\lambda$ (b) e/λ
(c) λ (d) $\frac{1}{2}\lambda$ *(2008)*

49. Two radioactive substances A and B have decay constants 5λ and λ respectively. At $t = 0$ they have the same number of nuclei. The ratio of number of nuclei of A to those of B will be $(1/e)^2$ after a time interval

(a) 4λ (b) 2λ
(c) $1/2\lambda$ (d) $1/4\lambda$. *(2007)*

50. In a radioactive decay process, the negatively charged emitted β-particles are

(a) the electrons produced as a result of the decay of neutrons inside the nucleus
(b) the electrons produced as a result of collisions between atoms
(c) the electrons orbiting around the nucleus
(d) the electrons present inside the nucleus.

(2007)

51. In a mass spectrometer used for measuring the masses of ions, the ions are initially accelerated by an electric potential V and then made to describe semicircular paths of radius R using a magnetic field B. If V and B are kept constant, the ratio $\left(\frac{\text{charge on the ion}}{\text{mass of the ion}}\right)$ will be proportional to

(a) $1/R^2$ (b) R^2
(c) R (d) $1/R$. *(2007)*

52. A nucleus ${}^A_Z X$ has mass represented by $M(A, Z)$. If M_p and M_n denote the mass of proton and neutron respectively and B.E. the binding energy in MeV, then

(a) $\text{B.E.} = [ZM_p + (A - Z)M_n - M(A, Z)]c^2$
(b) $\text{B.E.} = [ZM_p + AM_n - M(A, Z)]c^2$
(c) $\text{B.E.} = M(A, Z) - ZM_p - (A - Z)M_n$
(d) $\text{B.E.} = [M(A, Z) - ZM_p - (A - Z)M_n]c^2$. *(2007)*

53. If the nucleus ${}^{27}_{13}\text{Al}$ has a nuclear radius of about 3.6 fm, then ${}^{125}_{32}\text{Te}$ would have its radius approximately as

(a) 9.6 fm (b) 12.0 fm
(c) 4.8 fm (d) 6.0 fm. *(2007)*

54. The total energy of electron in the ground state of hydrogen atom is –13.6 eV. The kinetic energy of an electron in the first excited state is

(a) 6.8 eV (b) 13.6 eV
(c) 1.7 eV (d) 3.4 eV. *(2007)*

55. Ionization potential of hydrogen atom is 13.6 eV. Hydrogen atoms in the ground state are excited by monochromatic radiation of photon energy 12.1 eV. According to Bohr's theory, the spectral lines emitted by hydrogen will be

(a) one (b) two
(c) three (d) four. *(2006)*

56. In a radioactive material the activity at time t_1 is R_1 and at a later time t_2, it is R_2. If the decay constant of the material is λ, then

(a) $R_1 = R_2$ (b) $R_1 = R_2 e^{-\lambda(t_1 - t_2)}$
(c) $R_1 = R_2 e^{\lambda(t_1 - t_2)}$ (d) $R_1 = R_2(t_2/t_1)$. *(2006)*

57. The binding energy of deuteron is 2.2 MeV and that of ${}^4_2\text{He}$ is 28 MeV. If two deuterons are fused to form one ${}^4_2\text{He}$ then the energy released is

(a) 30.2 MeV (b) 25.8 MeV
(c) 23.6 MeV (d) 19.2 MeV. *(2006)*

58. The radius of germanium (Ge) nuclide is measured to be twice the radius of ${}^9_4\text{Be}$. The number of nucleons in Ge are

(a) 72 (b) 73
(c) 74 (d) 75. *(2006)*

59. In the reaction ${}^2_1\text{H} + {}^3_1\text{H} \rightarrow {}^4_2\text{He} + {}^1_0 n$, if the binding energies of ${}^2_1\text{H}$, ${}^3_1\text{H}$ and ${}^4_2\text{He}$ are respectively a, b and c (in MeV), then the energy (in MeV) released in this reaction is

(a) $a + b + c$ (b) $a + b - c$
(c) $c - a - b$ (d) $c + a - b$. *(2005)*

60. The total energy of an electron in the first excited state of hydrogen atom is about – 3.4 eV. Its kinetic energy in this state is

(a) 3.4 eV (b) 6.8 eV
(c) – 3.4 eV (d) – 6.8 eV. *(2005)*

61. Which one of the following pairs of nuclei are isotones?

(a) ${}_{34}\text{Se}^{74}$, ${}_{31}\text{Ga}^{71}$ (b) ${}_{38}\text{Sr}^{84}$, ${}_{38}\text{Sr}^{86}$
(c) ${}_{42}\text{Mo}^{92}$, ${}_{40}\text{Zr}^{92}$ (d) ${}_{20}\text{Ca}^{40}$, ${}_{16}\text{S}^{32}$. *(2005)*

62. In any fission process the ratio $\frac{\text{mass of fission products}}{\text{mass of parent nucleus}}$ is

(a) equal to 1
(b) greater than 1
(c) less than 1
(d) depends on the mass of the parent nucleus. *(2005)*

63. Energy levels A, B and C of a certain atom corresponding to increasing values of energy *i.e.* $E_A < E_B < E_C$. If λ_1, λ_2 and λ_3 are wavelengths of radiations corresponding to transitions C to B, B to A and C to A respectively, which of the following relations is correct?

(a) $\lambda_3 = \lambda_1 + \lambda_2$ (b) $\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$
(c) $\lambda_1 + \lambda_2 + \lambda_3 = 0$ (d) $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$. *(2005, 1990)*

64. Fission of nuclei is possible because the binding energy per nucleon in them

(a) increases with mass number at low mass numbers

(b) decreases with mass number at low mass numbers
(c) increases with mass number at high mass numbers
(d) decreases with mass number at high mass numbers. (2005)

65. A nucleus represented by the symbol ^A_ZX has
(a) Z neutrons and $A - Z$ protons
(b) Z protons and $A - Z$ neutrons
(c) Z protons and A neutrons
(d) A protons and $Z - A$ neutrons (2004)

66. If in a nuclear fusion process the masses of the fusing nuclei be m_1 and m_2 and the mass of the resultant nucleus be m_3, then
(a) $m_3 = m_1 + m_2$ (b) $m_3 = |m_1 - m_2|$
(c) $m_3 < (m_1 + m_2)$ (d) $m_3 > (m_1 + m_2)$ (2004)

67. The Bohr model of atoms
(a) Assumes that the angular momentum of electrons is quantized.
(b) Uses Einstein's photoelectric equation.
(c) Predicts continuous emission spectra for atoms.
(d) Predicts the same emission spectra for all types of atoms. (2004)

68. The half life of radium is about 1600 years. Of 100 g of radium existing now, 25 g will remain unchanged after
(a) 4800 years (b) 6400 years
(c) 2400 years (d) 3200 years (2004)

69. An electron is moving round the nucleus of a hydrogen atom in a circular orbit of radius r. The Coulomb force $\vec{F}$ between the two is
(a) $K\frac{e^2}{r^2}\hat{r}$ (b) $-K\frac{e^2}{r^3}\hat{r}$
(c) $K\frac{e^2}{r^3}\vec{r}$ (d) $-K\frac{e^2}{r^3}\vec{r}$
$\left(\text{where } K = \frac{1}{4\pi\varepsilon_0}\right)$ (2003)

70. Solar energy is mainly caused due to
(a) burning of hydrogen in the oxygen
(b) fission of uranium present in the Sun
(c) fusion of protons during synthesis of heavier elements
(d) gravitational contraction (2003)

71. The volume occupied by an atom is greater than the volume of the nucleus by a factor of about
(a) 10^1 (b) 10^5
(c) 10^{10} (d) 10^{15} (2003)

72. A sample of radioactive element has a mass of 10 g at an instant $t = 0$. The approximate mass of this element in the sample after two mean lives is
(a) 1.35 g (b) 2.50 g
(c) 3.70 g (d) 6.30 g (2003)

73. In which of the following systems will the radius of the first orbit ($n = 1$) be minimum ?
(a) doubly ionized lithium
(b) singly ionized helium
(c) deuterium atom
(d) hydrogen atom (2003)

74. The mass of proton is 1.0073 u and that of neutron is 1.0087 u (u = atomic mass unit). The binding energy of $^4_2$He is
(Given helium nucleus mass ≈ 4.0015 u.)
(a) 0.0305 J (b) 0.0305 erg
(c) 28.4 MeV (d) 0.061 u (2003)

75. The mass number of a nucleus is
(a) always less than its atomic number
(b) always more than its atomic number
(c) sometimes equal to its atomic number
(d) sometimes less than and sometimes more than its atomic number (2003)

76. A nuclear reaction given by
$_ZX^A \rightarrow {}_{Z+1}Y^A + {}_{-1}e^0 + \bar{\nu}$ represents
(a) β-decay (b) γ-decay
(c) fusion (d) fission (2003)

77. Which of the following are suitable for the fusion process?
(a) light nuclei
(b) heavy nuclei
(c) element lying in the middle of the periodic table
(d) middle elements, which are lying on binding energy curve. (2002)

78. A sample of radioactive element containing 4×10^{16} active nuclei. Half life of element is 10 days, then number of decayed nuclei after 30 days
(a) 0.5×10^{16} (b) 2×10^{16}
(c) 3.5×10^{16} (d) 1×10^{16}. (2002)

79. A deutron is bombarded on $_8O^{16}$ nucleus then α-particle is emitted. The product nucleus is
(a) $_7N^{13}$ (b) $_5B^{10}$
(c) $_4Be^9$ (d) $_7N^{14}$. *(2002)*

80. Which rays contain (positive) charged particles?
(a) α-rays (b) β-rays
(c) γ-rays (d) X-rays. *(2001)*

81. $X(n, \alpha)\ ^7_3Li$, then X will be
(a) $^{10}_5B$ (b) ^9_5B
(c) $^{11}_4Be$ (d) ^4_2He. *(2001)*

82. Half life of a radioactive element is 12.5 hour and its quantity is 256 g. After how much time its quantity will remain 1 g?
(a) 50 hrs (b) 100 hrs
(c) 150 hrs (d) 200 hrs. *(2001)*

83. The interplanar distance in a crystal is 2.8×10^{-8} m. The value of maximum wavelength which can be diffracted
(a) 2.8×10^{-8} m (b) 5.6×10^{-8} m
(c) 1.4×10^{-8} m (d) 7.6×10^{-8} m
(2001)

84. The energy of hydrogen atom in n^{th} orbit is E_n then the energy in n^{th} orbit of singly ionised helium atom will be
(a) $4E_n$ (b) $E_n/4$
(c) $2E_n$ (d) $E_n/2$. *(2001)*

85. M_n and M_p represent the mass of neutron and proton respectively. An element having mass M has N neutrons and Z protons, then the correct relation will be
(a) $M < \{N \cdot M_n + Z \cdot M_p\}$
(b) $M > \{N \cdot M_n + Z \cdot M_p\}$
(c) $M = \{N \cdot M_n + Z \cdot M_p\}$
(d) $M = N\{M_n + M_p\}$ *(2001)*

86. Energy released in nuclear fission is due to
(a) some mass is converted into energy
(b) total binding energy of fragments is more than the binding energy of parental element
(c) total binding energy of fragments is less than the binding energy of parental element
(d) total binding energy of fragments is equal to the binding energy of parental element. *(2001)*

87. For the given reaction, the particle X is

$$_6C^{11} \rightarrow {}_5B^{11} + \beta^+ + X$$

(a) neutron (b) anti neutrino
(c) neutrino (d) proton. *(2000)*

88. Maximum frequency of emission is obtained for the transition
(a) $n = 2$ to $n = 1$ (b) $n = 6$ to $n = 2$
(c) $n = 1$ to $n = 2$ (d) $n = 2$ to $n = 6$.
(2000)

89. The relation between λ and $T_{1/2}$ as ($T_{1/2} \rightarrow$ half life)
(a) $T_{1/2} = \frac{\ln 2}{\lambda}$ (b) $T_{1/2}\ \ln 2 = \lambda$
(c) $T_{1/2} = \frac{1}{\lambda}$ (d) $(\lambda + T_{1/2}) = \ln 2$.
(2000)

90. Nuclear fission is best explained by
(a) liquid droplet theory
(b) Yukawa π-meson theory
(c) independent particle model of the nucleus
(d) proton-proton cycle. *(2000)*

91. The life span of atomic hydrogen is
(a) fraction of one second
(b) one year
(c) one hour
(d) one day. *(2000)*

92. When an electron does transition from $n = 4$ to $n = 2$, then emitted line spectrum will be
(a) first line of Lyman series
(b) second line of Balmer series
(c) first line of Paschen series
(d) second line of Paschen series. *(2000)*

93. Alpha particles are
(a) neutrally charged
(b) positron
(c) protons
(d) ionized helium atoms *(1999)*

94. After 1α and 2β-emissions
(a) mass number reduces by 6
(b) mass number reduces by 4
(c) mass number reduces by 2
(d) atomic number remains unchanged *(1999)*

95. Complete the equation for the following fission process

$${}_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{38}Sr^{90} + ...$$

(a) ${}_{57}X^{142} + 3{}_{0}n^{1}$ (b) ${}_{54}X^{145} + 3{}_{0}n^{1}$

(c) ${}_{54}X^{143} + 3{}_{0}n^{1}$ (d) ${}_{54}X^{142} + {}_{0}n^{1}$

(1998)

96. A nucleus ${}_{n}X^{m}$ emits one α and two β particles. The resulting nucleus is

(a) ${}_{n-4}Z^{m-4}$ (b) ${}_{n-2}Y^{m-4}$

(c) ${}_{n}X^{m-4}$ (d) ${}_{n}Z^{m-4}$ *(1998)*

97. Atomic weight of Boron is 10.81 and it has two isotopes ${}_{5}B^{10}$ and ${}_{5}B^{11}$. Then the ratio of ${}_{5}B^{10}$: ${}_{5}B^{11}$ in nature would be

(a) 15 : 16 (b) 10 : 11

(c) 19 : 81 (d) 81 : 19 *(1998)*

98. In the Bohr model of a hydrogen atom, the centripetal force is furnished by the coulomb attraction between the proton and the electron. If a_0 is the radius of the ground state orbit, m is the mass and e is the charge on the electron and ε_0 is the vacuum permittivity, the speed of the electron is

(a) $\frac{e}{\sqrt{4\pi\varepsilon_0 a_0 m}}$ (b) $\frac{e}{\sqrt{\varepsilon_0 a_0 m}}$

(c) 0 (d) $\frac{\sqrt{4\pi\varepsilon_0 a_0 m}}{e}$

(1998)

99. The 21 cm radiowave emitted by hydrogen in interstellar space is due to the interaction called the hyperfine interaction in atomic hydrogen. The energy of the emitted wave is nearly

(a) 7×10^{-8} joule (b) 1 joule

(c) 10^{-17} joule (d) 10^{-24} joule

(1998)

100. Half-lives of two radioactive substances A and B are respectively 20 minutes and 40 minutes. Initially the samples of A and B have equal number of nuclei. After 80 minutes the ratio of remaining numbers of A and B nuclei is

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

(c) 1 : 16 (d) 1 : 1 *(1998)*

101. Due to earth's magnetic field, the charged cosmic rays particles

(a) can never reach the pole

(b) can never reach the equator

(c) require greater kinetic energy to reach the equator than pole

(d) require less kinetic energy to reach the equator than pole. *(1997)*

102. Which of the following is used as a moderator in nuclear reaction?

(a) cadmium (b) plutonium

(c) uranium (d) heavy water.

(1997)

103. The energy of the ground electronic state of hydrogen atom is – 13.6 eV. The energy of the first excited state will be

(a) – 27.2 eV (b) – 52.4 eV

(c) – 3.4 eV (d) – 6.8 eV. *(1997)*

104. When hydrogen atom is in its first excited level, its radius is .... of the Bohr radius.

(a) twice (b) 4 times

(c) same (d) half. *(1997)*

105. The most penetrating radiation out of the following are

(a) β-rays (b) γ-rays

(c) X-rays (d) α-rays. *(1997)*

106. The minimum wavelength of the X-rays produced by electrons accelerated through a potential difference of V volts is directly proportional to

(a) $\frac{1}{\sqrt{V}}$ (b) $\frac{1}{V}$ (c) $\sqrt{V}$ (d) V^2.

(1996)

107. The energy of a hydrogen atom in its ground state is – 13.6 eV. The energy of the level corresponding to the quantum number $n = 2$ in the hydrogen atom is

(a) – 0.54 eV (b) – 3.4 eV

(c) – 2.72 eV (d) – 0.85 eV. *(1996)*

108. According to Bohr's principle, the relation between principal quantum number (n) and radius of orbit (r) is

(a) $r \propto \frac{1}{n}$ (b) $r \propto \frac{1}{n^2}$

(c) $r \propto n$ (d) $r \propto n^2$. *(1996)*

109. A nucleus ruptures into two nuclear parts, which have their velocity ratio equal to 2 : 1. What will be the ratio of their nuclear size (nuclear radius)?

(a) $3^{1/2} : 1$ (b) $1 : 3^{1/2}$
(c) $2^{1/3} : 1$ (d) $1 : 2^{1/3}$. *(1996)*

110. What is the respective number of α and β particles emitted in the following radioactive decay?

$$^{200}X_{90} \rightarrow {}^{168}Y_{80}$$

(a) 8 and 8 (b) 8 and 6
(c) 6 and 8 (d) 6 and 6. *(1995)*

111. The binding energies per nucleon for a deuteron and an α-particle are x_1 and x_2 respectively. The energy Q released in the reaction

$$^2H_1 + {}^2H_1 \rightarrow {}^4He_2 + Q, \text{ is}$$

(a) $4(x_1 + x_2)$ (b) $4(x_2 - x_1)$
(c) $2(x_2 - x_1)$ (d) $2(x_1 + x_2)$. *(1995)*

112. The count rate of a Geiger Muller counter for the radiation of a radioactive material of half-life of 30 minutes decreases to 5 $second^{-1}$ after 2 hours. The initial count rate was

(a) 80 $second^{-1}$ (b) 625 $second^{-1}$
(c) 20 $second^{-1}$ (d) 25 $second^{-1}$. *(1995)*

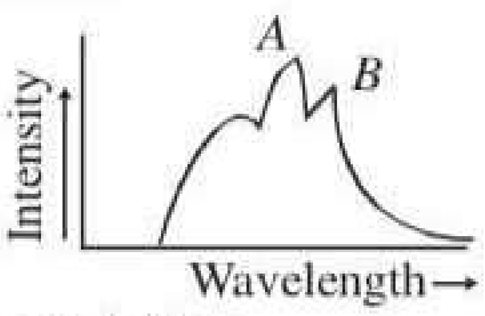
113. An electron makes a transition from orbit $n = 4$ to the orbit $n = 2$ of a hydrogen atom. What is the wavelength of the emitted radiations? (R = Rydberg's constant)

(a) $\frac{16}{4R}$ (b) $\frac{16}{5R}$ (c) $\frac{16}{2R}$ (d) $\frac{16}{3R}$. *(1995)*

114. When a hydrogen atom is raised from the ground state to an excited state,

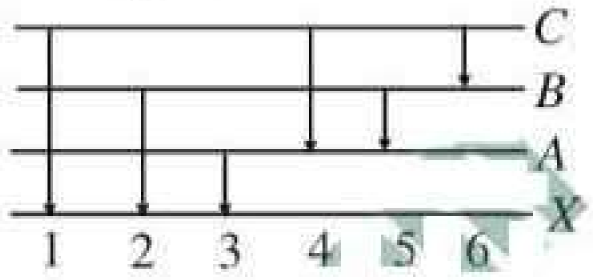
(a) both K.E. and P.E. increase
(b) both K.E. and P.E. decrease
(c) the P.E. decreases and K.E. increases
(d) the P.E. increases and K.E. decreases. *(1995)*

115. The figure represents the observed intensity of X-rays emitted by an X-ray tube, as a function of wavelength. The sharp peaks A and B denote



(a) white radiations
(b) characteristic radiations
(c) band spectrum
(d) continuous spectrum *(1995)*

116. The figure indicates the energy level diagram of an atom and the origin of six spectral lines in emission (*e.g.* line no. 5 arises from the transition from level B to A). Which of the following spectral lines will occur in the absorption spectrum?



(a) 4, 5, 6 (b) 1, 2, 3, 4, 5, 6
(c) 1, 2, 3 (d) 1, 4, 6. *(1995)*

117. The mass number of He is 4 and that of sulphur is 32. The radius of sulphur nucleus is larger than that of helium by the factor of

(a) 4 (b) 2
(c) 8 (d) $\sqrt{8}$. *(1995)*

118. The binding energy per nucleon is maximum in case of

(a) ^4_2He (b) $^{56}_{26}Fe$
(c) $^{141}_{56}Ba$ (d) $^{235}_{92}U$ *(1993)*

119. Which source is associated with a line emission spectrum?

(a) Electric fire (b) Neon street sign
(c) Red traffic light (d) Sun *(1993)*

120. Energy released in the fission of a single $^{235}_{92}U$ nucleus is 200 MeV. The fission rate of $^{235}_{92}U$ filled reactor operating at a power level of 5 W is

(a) $1.56 \times 10^{-10}\ s^{-1}$ (b) $1.56 \times 10^{11}\ s^{-1}$
(c) $1.56 \times 10^{-16}\ s^{-1}$ (d) $1.56 \times 10^{-17}\ s^{-1}$ *(1993)*

121. Hydrogen atoms are excited from ground state of the principle quantum number 4. Then the number of spectral lines observed will be

(a) 3 (b) 6
(c) 5 (d) 2 *(1993)*

122. In terms of Bohr radius a_0, the radius of the second Bohr orbit of a hydrogen atom is given by

(a) $4a_0$ (b) $8a_0$
(c) $\sqrt{2}a_0$ (d) $2a_0$ *(1992)*

123. Solar energy is due to
(a) fusion reaction (b) fission reaction
(c) combustion reaction
(d) chemical reaction *(1992)*

124. The ionization energy of hydrogen atom is 13.6 eV. Following Bohr's theory, the energy corresponding to a transition between 3^{rd} and 4^{th} orbit is
(a) 3.40 eV (b) 1.51 eV
(c) 0.85 eV (d) 0.66 eV *(1992)*

125. The energy equivalent of one atomic mass unit is
(a) 1.6×10^{-19} J (b) 6.02×10^{23} J
(c) 931 MeV (d) 9.31 MeV *(1992)*

126. The mass of α-particle is
(a) less than the sum of masses of two protons and two neutrons
(b) equal to mass of four protons
(c) equal to mass of four neutrons
(d) equal to sum of masses of two protons and two neutrons *(1992)*

127. Of the following pairs of species which one will have the same electronic configuration for both members?
(a) Li^+ and Na^+ (b) He and Ne^+
(c) H and Li (d) C and N^+ *(1992)*

128. The mass density of a nucleus varies with mass number A as
(a) A^2 (b) A
(c) constant (d) $1/A$ *(1992)*

129. The constituents of atomic nuclei are believed to be
(a) neutrons and protons
(b) protons only
(c) electron and protons
(d) electrons, protons and neutrons *(1991)*

130. The half life of radium is 1600 years. The fraction of a sample of radium that would remain after 6400 years
(a) 1/4 (b) 1/2
(c) 1/8 (d) 1/16 *(1991)*

131. In the nucleus of $_{11}Na^{23}$, the number of protons, neutrons and electrons are
(a) 11, 12, 0 (b) 23, 12, 11
(c) 12, 11, 0 (d) 23, 11, 12 *(1991)*

132. The ground state energy of H-atom 13.6 eV. The energy needed to ionize H-atom from its second excited state
(a) 1.51 eV (b) 3.4 eV
(c) 13.6 eV (d) none of these *(1991)*

133. If the nuclear force between two protons, two neutrons and between proton and neutron is denoted by F_{pp}, F_{nn} and F_{pn} respectively, then
(a) $F_{pp} \approx F_{nn} \approx F_{pn}$
(b) $F_{pp} \neq F_{nn}$ and $F_{pp} = F_{nn}$
(c) $F_{pp} = F_{nn} = F_{pn}$
(d) $F_{pp} \neq F_{nn} \neq F_{pn}$ *(1991)*

134. The valence electron in alkali metal is a
(a) f-electron (b) p-electron
(c) s-electron (d) d-electron *(1990)*

135. Consider an electron in the n^{th} orbit of a hydrogen atom in the Bohr model. The circumference of the orbit can be expressed in terms of de Broglie wavelength λ of that electron as
(a) $(0.529)n\lambda$ (b) $\sqrt{n}\lambda$
(c) $(13.6)\lambda$ (d) $n\lambda$ *(1990)*

136. The nuclei $_6C^{13}$ and $_7N^{14}$ can be described as
(a) isotones
(b) isobars
(c) isotopes of carbon
(d) isotopes of nitrogen *(1990)*

137. Which of the folowing statements is true for nuclear forces?
(a) They obey the inverse square law of distance.
(b) They obey the inverse third power law of distance.
(c) They are short range forces.
(d) they are equal in strength to electromagnetic forces. *(1990)*

138. The ratio of the radii of the nuclei $_{13}Al^{27}$ and $_{52}Te^{125}$ approximately
(a) 6 : 10 (b) 13 : 52
(c) 40 : 177 (d) 14 : 73 *(1990)*

139. The nucleus $_6C^{12}$ absorbs an energetic neutron and emits a beta particle (β). The resulting nucleus is
(a) $_7N^{14}$ (b) $_7N^{13}$
(c) $_5B^{13}$ (d) $_6C^{13}$ *(1990)*

140. A radioactive element has half life period 800 years. After 6400 years what amount will remain?

(a) 1/2 (b) 1/16
(c) 1/8 (d) 1/256 *(1989)*

141. An element A decays into element C by a two step process

$A \rightarrow B + {}_2He^4;\ B \rightarrow C + 2e^-$

Then

(a) A and C are isotopes
(b) A and C are isobars
(c) A and B are isotopes
(d) A and B are isobars *(1989)*

142. Curie is a unit of

(a) energy of gamma rays
(b) half-life
(c) radioactivity
(d) intensity of gamma rays *(1989)*

143. The average binding energy of a nucleon inside an atomic nucleus is about

(a) 8 MeV (b) 8 eV
(c) 8 J (d) 8 erg *(1989)*

144. To explain his theory, Bohr used

(a) conservation of linear momentum
(b) quantisation of angular momentum
(c) conservation of quantum frequency
(d) none of these *(1989)*

145. The atomic number of silicon is 14. Its ground state electron configuration is

(a) $1s^2\ 2s^2\ 2p^2\ 2s^4$ (b) $1s^2\ 2s^2\ 2p^6\ 3s^1\ 3p^3$
(c) $1s^2\ 2s^2\ 2p^8\ 3s^2$ (d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ *(1989)*

146. A radioactive sample with a half life of 1 month has the label : 'Activity = 2 micro curies on 1 - 8 - 1991'. What would be its activity two months earlier?

(a) 1.0 micro curie (b) 0.5 micro curie
(c) 4 micro curie (d) 8 micro curie *(1988)*

147. The nucleus ${}^{115}_{48}Cd$, after two successive β-decay will give

(a) ${}^{115}_{46}Pa$ (b) ${}^{114}_{49}In$
(c) ${}^{113}_{50}Sn$ (d) ${}^{115}_{50}Sn$ *(1988)*

148. The ionisation energy of hydrogen atom is 13.6 eV, the ionisation energy of a singly ionised helium atom would be

(a) 13.6 eV (b) 27.2 eV
(c) 6.8 eV (d) 54.4 eV *(1988)*

Answer Key

1. (*)	**2.** (b)	**3.** (c)	**4.** (d)	**5.** (a)	**6.** (c)	**7.** (c)	**8.** (b)	**9.** (d)	**10.** (d)
11. (c)	**12.** (d)	**13.** (c)	**14.** (c)	**15.** (a)	**16.** (d)	**17.** (c)	**18.** (d)	**19.** (b)	**20.** (d)
21. (c)	**22.** (d)	**23.** (a)	**24.** (d)	**25.** (b)	**26.** (d)	**27.** (b)	**28.** (c)	**29.** (b)	**30.** (c)
31. (c)	**32.** (c)	**33.** (c)	**34.** (c)	**35.** (b)	**36.** (d)	**37.** (a)	**38.** (c)	**39.** (c)	**40.** (a)
41. (d)	**42.** (c)	**43.** (a)	**44.** (c)	**45.** (c)	**46.** (b)	**47.** (a)	**48.** (a)	**49.** (c)	**50.** (a)
51. (a)	**52.** (a)	**53.** (d)	**54.** (d)	**55.** (c)	**56.** (b)	**57.** (c)	**58.** (a)	**59.** (c)	**60.** (a)
61. (a)	**62.** (c)	**63.** (b)	**64.** (d)	**65.** (b)	**66.** (c)	**67.** (a)	**68.** (d)	**69.** (d)	**70.** (c)
71. (d)	**72.** (a)	**73.** (a)	**74.** (c)	**75.** (c)	**76.** (a)	**77.** (a)	**78.** (c)	**79.** (d)	**80.** (a)
81. (a)	**82.** (b)	**83.** (b)	**84.** (a)	**85.** (a)	**86.** (a)	**87.** (c)	**88.** (a)	**89.** (a)	**90.** (a)
91. (a)	**92.** (b)	**93.** (d)	**94.** (b,d)	**95.** (c)	**96.** (c)	**97.** (c)	**98.** (a)	**99.** (d)	**100.** (a)
101. (c)	**102.** (d)	**103.** (c)	**104.** (b)	**105.** (b)	**106.** (b)	**107.** (b)	**108.** (d)	**109.** (d)	**110.** (b)
111. (b)	**112.** (a)	**113.** (d)	**114.** (b)	**115.** (b)	**116.** (c)	**117.** (b)	**118.** (b)	**119.** (b)	**120.** (b)
121. (b)	**122.** (a)	**123.** (a)	**124.** (d)	**125.** (c)	**126.** (a)	**127.** (d)	**128.** (c)	**129.** (a)	**130.** (d)
131. (a)	**132.** (a)	**133.** (c)	**134.** (c)	**135.** (d)	**136.** (a)	**137.** (c)	**138.** (a)	**139.** (b)	**140.** (d)
141. (a)	**142.** (c)	**143.** (a)	**144.** (b)	**145.** (d)	**146.** (d)	**147.** (d)	**148.** (d)		

* None is correct.

EXPLANATIONS

1. **(*)** : The number of radioactive nuclei 'N' at any time t is given as

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

where N_0 is number of radioactive nuclei in the sample at some aribitrary time $t = 0$ and λ is the radioactive decay constant.

Given: $\lambda_A = 8\lambda, \lambda_B = \lambda, N_{0A} = N_{0B} = N_0$

$$\therefore \quad \frac{N_B}{N_A} = \frac{e^{-\lambda t}}{e^{-8\lambda t}}$$

$$\frac{1}{e} = e^{-\lambda t} e^{8\lambda t} = e^{7\lambda t}$$

$$\Rightarrow \; -1 = 7\lambda t \text{ or } t = \frac{-1}{7\lambda}$$

*Negative value of time is not possible.

So given ratio in question should be $\frac{N_B}{N_A} = e$.

2. **(b)** : The wavelength of last line of Balmer series

$$\frac{1}{\lambda_B} = Rc\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = \frac{Rc}{4}$$

The wavelength of last line of Lyman series

$$\frac{1}{\lambda_L} = Rc\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) = Rc$$

$$\therefore \quad \frac{l_B}{\lambda_L} = \frac{4}{1} = 4$$

3. **(c)** : When electron jumps from higher orbit to lower orbit then, wavelength of emitted photon is given by,

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\text{so, } \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$$

$$\text{and } \frac{1}{\lambda'} = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = \frac{7R}{144}$$

$$\therefore \lambda' = \frac{144}{7} \times \frac{5\lambda}{36} = \frac{20\lambda}{7}$$

4. **(d)** : N_0 = Nuclei at time $t = 0$

N_1 = Remaining nuclei after 40% decay
$= (1 - 0.4) N_0 = 0.6 N_0$

N_2 = Remaining nuclei after 85% decay
$= (1 - 0.85) N_0 = 0.15 N_0$

$$\therefore \quad \frac{N_2}{N_1} = \frac{0.15N_0}{0.6N_0} = \frac{1}{4} = \left(\frac{1}{2}\right)^2$$

Hence, two half life is required between 40% decay and 85% decay of a radioactive substance.

$\therefore$ Time taken $= 2\tau_{1/2} = 2 \times 30 \text{ min} = 60 \text{ min}$

5. **(a)** : Here, $R = 10^7 \text{ m}^{-1}$

The wave number of the last line of the Balmer series in hydrogen spectrum is given by

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = \frac{R}{4} = \frac{10^7}{4} = 0.25 \times 10^7 \text{ m}^{-1}$$

6. **(c)** : Distance of closest approach when an α-particle of mass m moving with velocity v is bombarded on a heavy nucleus of charge Ze, is given by

$$r_0 = \frac{Ze^2}{\pi\varepsilon_0 m v^2} \quad \therefore \quad r_0 \propto \frac{1}{m}$$

7. **(c)** : If $\vec{p}_{Th}$ and $\vec{p}_{He}$ are the momenta of thorium and helium nuclei respectively, then according to law of conservation of linear momentum

$$0 = \vec{p}_{Th} + \vec{p}_{He} \quad \text{or} \quad \vec{p}_{Th} = -\vec{p}_{He}$$

–ve sign shows that both are moving in opposite directions.

But in magnitude

$p_{Th} = p_{He}$

If m_{Th} and m_{He} are the masses of thorium and helium nuclei respectively, then

Kinetic energy of thorium nucleus is $K_{Th} = \frac{p_{Th}^2}{2m_{Th}}$

and that of helium nucleus is

$$K_{He} = \frac{p_{He}^2}{2m_{He}}$$

$$\therefore \quad \frac{K_{Th}}{K_{He}} = \left(\frac{p_{Th}}{p_{He}}\right)^2 \left(\frac{m_{He}}{m_{Th}}\right)$$

But $p_{Th} = p_{He}$ and $m_{He} < m_{Th}$

$\therefore \; K_{Th} < K_{He}$ or $K_{He} > K_{Th}$

Thus the helium nucleus has more kinetic energy than the thorium nucleus.

8. **(b)** : The wavelength of a spectral line in the Lyman series is

$$\frac{1}{\lambda_L} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right), n = 2, 3, 4, \; ....$$

and that in the Balmer series is

$$\frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right), n = 3, 4, 5, \; ....$$

For the longest wavelength in the Lyman series, $n = 2$

$$\therefore \quad \frac{1}{\lambda_L} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = R\left(\frac{1}{1} - \frac{1}{4}\right) = R\left(\frac{4-1}{4}\right) = \frac{3R}{4}$$

or $\lambda_L = \dfrac{4}{3R}$

For the longest wavelength in the Balmer series, $n = 3$

$$\therefore \quad \frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R\left(\frac{1}{4} - \frac{1}{9}\right) = R\left(\frac{9-4}{36}\right) = \frac{5R}{36}$$

or $\lambda_B = \dfrac{36}{5R}$

$$\text{Thus, } \frac{\lambda_L}{\lambda_B} = \frac{\frac{4}{3R}}{\frac{36}{5R}} = \frac{4}{3R} \times \frac{5R}{36} = \frac{5}{27}$$

9. (d) : Radius of the nucleus $R = R_0 A^{1/3}$

$$\therefore \quad \frac{R_{Al}}{R_{Te}} = \left(\frac{A_{Al}}{A_{Te}}\right)^{1/3}$$

Here, $A_{Al} = 27, A_{Te} = 125, R_{Te} = ?$

$$\frac{R_{Al}}{R_{Te}} = \left(\frac{27}{125}\right)^{1/3} = \frac{3}{5} \Rightarrow R_{Te} = \frac{5}{3} R_{Al}$$

10. (d) : Energy of electron in He^+ 3rd orbit

$$E_3 = -13.6 \times \frac{Z^2}{n^2} \text{ eV} = -13.6 \times \frac{4}{9} \text{ eV}$$

$$= -13.6 \times \frac{4}{9} \times 1.6 \times 10^{-19} \text{ J} = -9.7 \times 10^{-19} \text{ J}$$

As per Bohr's model,

Kinetic energy of electron in the 3rd orbit $= -E_3$

$$\therefore \quad 9.7 \times 10^{-19} = \frac{1}{2} m_e v^2$$

$$v = \sqrt{\frac{2 \times 9.7 \times 10^{-19}}{9.1 \times 10^{-31}}} = 1.46 \times 10^6 \text{ m s}^{-1}$$

11. (c) : Energy of the photon, $E = \dfrac{hc}{\lambda}$

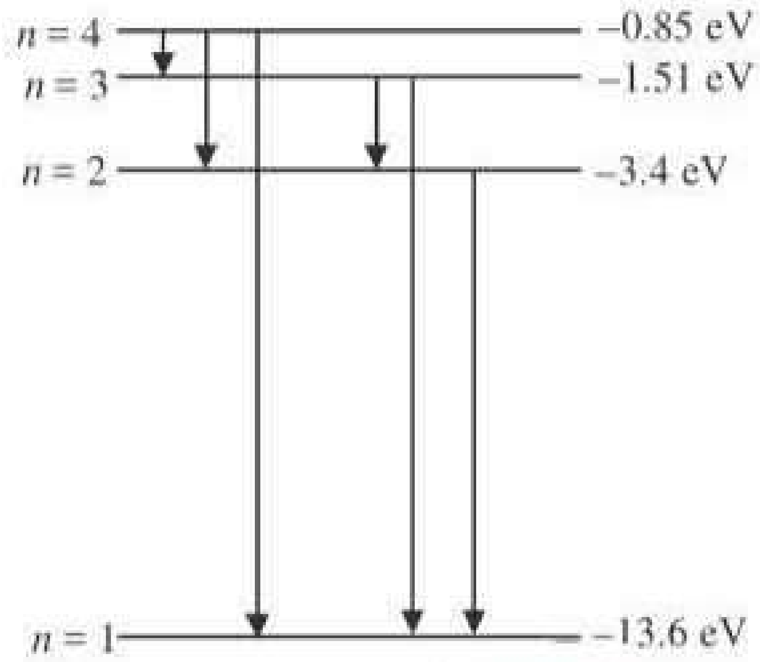
$$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{975 \times 10^{-10}} \text{ J}$$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{975 \times 10^{-10} \times 1.6 \times 10^{-19}} \text{ eV} = 12.75 \text{ eV}$$

After absorbing a photon of energy 12.75 eV, the electron will reach to third excited state of energy –0.85 eV, since energy difference corresponding to $n = 1$ and $n = 4$ is 12.75 eV.

$\therefore$ Number of spectral lines emitted

$$= \frac{(n)(n-1)}{2} = \frac{(4)(4-1)}{2} = 6$$



12. (d) : Binding energy of ${}^7_3Li$ nucleus

$= 7 \times 5.60$ MeV $= 39.2$ MeV

Binding energy of ${}_2^4He$ nucleus

$= 4 \times 7.06$ MeV $= 28.24$ MeV

The reaction is

$${}^7_3Li + {}^1_1H \rightarrow 2({}^4_2He) + Q$$

$\therefore$ $Q = 2(\text{BE of } {}^4_2He) - (\text{BE of } {}^7_3Li)$

$= 2 \times 28.24$ MeV $- 39.2$ MeV

$= 56.48$ MeV $- 39.2$ MeV $= 17.28$ MeV

13. (c) :

	X	$\rightarrow$ Y
Number of nuclei at $t = 0$	N_0	0
Number of nuclei after time t	$N_0 - x$	x

(As per question)

$$\frac{N_0 - x}{x} = \frac{1}{7}$$

$$7N_0 - 7x = x \text{ or } x = \frac{7}{8} N_0$$

$\therefore$ Remaining nuclei of isotope X

$$= N_0 - x = N_0 - \frac{7}{8} N_0 = \frac{1}{8} N_0 = \left(\frac{1}{2}\right)^3 N_0$$

So three half lives would have been passed.

$\therefore$ $t = nT_{1/2} = 3 \times 1.4 \times 10^9$ years $= 4.2 \times 10^9$ years

Hence, the age of the rock is 4.2×10^9 years.

14. (c) : The wavelength of different spectral lines of Lyman series is given by

$$\frac{1}{\lambda_L} = R\left[\frac{1}{1^2} - \frac{1}{n^2}\right] \text{ where } n = 2, 3, 4, \ldots$$

where subscript L refers to Lyman.

For longest wavelength, $n = 2$

$$\therefore \quad \frac{1}{\lambda_{L_{longest}}} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3}{4} R \quad \text{...(i)}$$

The wavelength of different spectral series of Balmer series is given by

$$\frac{1}{\lambda_B} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right] \text{ where } n = 3, 4, 5, \ldots$$

where subscript B refers to Balmer.

For longest wavelength, $n = 3$

$$\therefore \quad \frac{1}{\lambda_{B_{\text{longest}}}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = R\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5R}{36} \quad \text{...(ii)}$$

Divide (ii) by (i), we get

$$\frac{\lambda_{L_{\text{longest}}}}{\lambda_{B_{\text{longest}}}} = \frac{5R}{36} \times \frac{4}{3R} = \frac{5}{27}$$

15. (a) : As ${}_1^2H + {}_1^2H \rightarrow {}_2^4He$

Here, $\Delta M = 0.02866$ u

$\therefore$ The energy liberated per u is $= \frac{\Delta M \times 931}{4}$ MeV

$$= \frac{0.02866 \times 931}{4} \text{ MeV} = \frac{26.7}{4} \text{ MeV} = 6.675 \text{ MeV}$$

16. (d) :

	X	$\rightarrow$ Y
Initial number of atoms,	N_0	0
Number of atoms after time t	N	$N_0 - N$

As per question

$$\frac{N}{N_0 - N} = \frac{1}{7} \Rightarrow 7N = N_0 - N \quad \text{or} \quad 8N = N_0$$

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

As $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$ where n is the no. of half lives

$$\therefore \quad \frac{1}{8} = \left(\frac{1}{2}\right)^n \quad \text{or} \quad \left(\frac{1}{2}\right)^3 = \left(\frac{1}{2}\right)^n$$

$\therefore \quad n = 3$

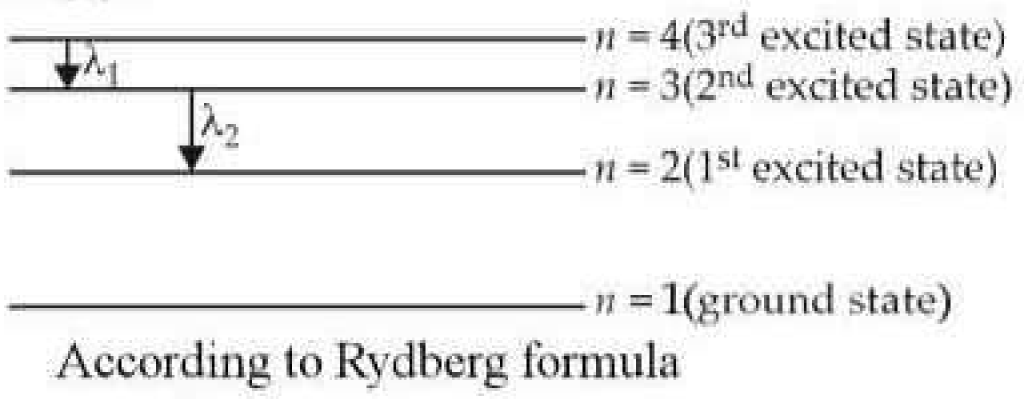
$$n = \frac{t}{T_{1/2}} \text{ or } t = nT_{1/2} = 3 \times 20 \text{ years} = 60 \text{ years}$$

Hence, the age of rock is 60 years.

17. (c) **18. (d)**

19. (b) : For a given energy, γ-rays has highest penetrating power and α-particles has least penetrating power.

20. (d) :



According to Rydberg formula

$$\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

In first case, $n_f = 3$, $n_i = 4$

$$\therefore \quad \frac{1}{\lambda_1} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right] = R\left[\frac{1}{9} - \frac{1}{16}\right] = \frac{7}{144}R \quad \text{...(i)}$$

In second case, $n_f = 2$, $n_i = 3$

$$\therefore \quad \frac{1}{\lambda_2} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = R\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5}{36}R \quad \text{...(ii)}$$

Divide (ii) by (i), we get

$$\frac{\lambda_1}{\lambda_2} = \frac{5}{36} \times \frac{144}{7} = \frac{20}{7}$$

21. (c) : Nuclear radius, $R = R_0 A^{1/3}$

where R_0 is a constant and A is the mass number

$$\therefore \quad \frac{R_{Al}}{R_{Cu}} = \frac{(27)^{1/3}}{(64)^{1/3}} = \frac{3}{4}$$

$$\text{or} \quad R_{Cu} = \frac{4}{3} \times R_{Al} = \frac{4}{3} \times 3.6 \text{ fermi} = 4.8 \text{ fermi}$$

22. (d) : Let after t s amount of the A_1 and A_2 will become equal in the mixture.

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

where n is the number of half-lives

For A_1, $N_1 = N_{01}\left(\frac{1}{2}\right)^{t/20}$

For A_2, $N_2 = N_{02}\left(\frac{1}{2}\right)^{t/10}$

According to question, $N_1 = N_2$

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

$$2^{t/10} = 4(2^{t/20}) \text{ or } 2^{t/10} = 2^2 2^{t/20} \Rightarrow 2^{t/10} = 2^{\left(\frac{t}{20}+2\right)}$$

$$\frac{t}{10} = \frac{t}{20} + 2 \quad \text{or} \quad \frac{t}{10} - \frac{t}{20} = 2$$

$$\text{or} \quad \frac{t}{20} = 2 \quad \text{or} \quad t = 40 \text{ s}$$

23. (a) : According to Rydberg formula

$$\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

Here, $n_f = 1$, $n_i = 5$

$$\therefore \quad \frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{5^2}\right] = R\left[\frac{1}{1} - \frac{1}{25}\right] = \frac{24}{25}R$$

According to conservation of linear momentum, we get

Momentum of photon = Momentum of atom

$$\frac{h}{\lambda} = mv \quad \text{or} \quad v = \frac{h}{m\lambda} = \frac{h}{m}\left(\frac{24R}{25}\right) = \frac{24hR}{25m}$$

24. (d)

25. (b) : According to radioactive decay law
$N = N_0 e^{-\lambda t}$
where N_0 = Number of radioactive nuclei at time $t = 0$
N = Number of radioactive nuclei left undecayed at any time t
λ = decay constant

At time t_2, $\frac{2}{3}$ of the sample had decayed

$\therefore\ N = \frac{1}{3}N_0$

$\therefore\ \frac{1}{3}N_0 = N_0 e^{-\lambda t_2}$ ...(i)

At time t_1, $\frac{1}{3}$ of the sample had decayed,

$\therefore\ N = \frac{2}{3}N_0$

$\therefore\ \frac{2}{3}N_0 = N_0 e^{-\lambda t_1}$ ...(ii)

Divide (i) by (ii), we get

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

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

$$t_2 - t_1 = \frac{\ln 2}{\lambda} = \frac{\ln 2}{\left(\frac{\ln 2}{T_{1/2}}\right)} \quad \left(\because \lambda = \frac{\ln 2}{T_{1/2}}\right)$$

$$= T_{1/2} = 50 \text{ days}$$

26. (d) : The wavelength of the first line of lyman series for hydrogen atom is

$$\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$$

The wavelength of the second line of Balmer series for hydrogen like ion is

$$\frac{1}{\lambda'} = Z^2 R\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$$

According to question $\lambda = \lambda'$

$$\Rightarrow\ R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = Z^2 R\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$$

or $\frac{3}{4} = \frac{3Z^2}{16}$ or $Z^2 = 4$ or $Z = 2$

27. (b) : $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

where n is number of half lives

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

Let the age of rock be t years.

$\because\ n = \frac{t}{T_{1/2}}$

or $t = nT_{1/2} = 4 \times 50$ years $= 200$ years

28. (c) : According to Einstein's mass energy relation

$E = mc^2$ or $m = \frac{E}{c^2}$

Mass decay per second

$$= \frac{\Delta m}{\Delta t} = \frac{1}{c^2}\frac{\Delta E}{\Delta t} = \frac{P}{c^2} = \frac{1000 \times 10^3\ \text{W}}{(3 \times 10^8\ \text{m/s})^2}$$

$$= \frac{10^6}{9 \times 10^{16}}\ \text{kg/s}$$

Mass decay per hour

$$= \frac{\Delta m}{\Delta t} \times 60 \times 60 = \left(\frac{10^6}{9 \times 10^{16}}\ \text{kg/s}\right)(3600\ \text{s})$$

$$= 4 \times 10^{-8}\ \text{kg} = 40 \times 10^{-6}\ \text{g} = 40\ \mu\text{g}$$

29. (b) : Momentum of emitted photon

$$= p_{\text{photon}} = \frac{h\upsilon}{c}$$

From the law of conservation of linear momentum,
Momentum of recoil nucleus

$$= p_{\text{nucleus}} = p_{\text{photon}}$$

$\therefore\ Mv = \frac{h\upsilon}{c}$

where v is the recoil speed of the nucleus

or $v = \frac{h\upsilon}{Mc}$ ...(i)

The recoil energy of the nucleus

$$= \frac{1}{2}Mv^2 = \frac{1}{2}M\left(\frac{h\upsilon}{Mc}\right)^2 = \frac{h^2\upsilon^2}{2Mc^2} \quad \text{(Using (i))}$$

30. (c) : When an alpha particle $\left({}_2^4\text{He}\right)$ is emitted, the mass number and the atomic number of the daughter nucleus decreases by four and two respectively. When a beta particle (β^-) is emitted, the atomic number of the daughter nucleus increases by one but the mass number remains the same.

$$\therefore\ {}_n^mX \xrightarrow{\alpha} {}_{n-2}^{m-4}Y \xrightarrow{2\beta^-} {}_n^{m-4}X$$

31. (c) : Extremely high temperature needed for fusion make kinetic energy large enough to overcome coulomb repulsion between nuclei.

32. (c) : Here, Stopping potential, $V_0 = 10\text{V}$

Work function, $W = 2.75$ eV

According to Einstein's photoelectric equation

$$eV_0 = h\upsilon - W \quad \text{or} \quad h\upsilon = eV_0 + W$$
$$= 10\text{ eV} + 2.75\text{ eV} = 12.75\text{ eV} \quad ...(i)$$

When an electron in the hydrogen atom makes a transition from excited state n to the gound state (n=1), then the frequency (υ) of the emitted photon is given by

$$h\upsilon = E_n - E_1 \Rightarrow h\upsilon = -\frac{13.6}{n^2} - \left(-\frac{13.6}{1^2}\right)$$

$$\left[\because \text{ For hydrogen atom,} E_n = -\frac{13.6}{n^2}\text{eV}\right]$$

According to given problem

$$-\frac{13.6}{n^2} + 13.6 = 12.75 \qquad \text{(Using (i))}$$

$$\frac{13.6}{n^2} = 0.85 \Rightarrow n^2 = \frac{13.6}{0.85} = 16$$

or $n = 4$

33. (c) :

	P	Q
No. of nuclei, at $t = 0$	$4N_0$	N_0
Half- life	1 min	2 min
No. of nuclei after time t	N_P	N_Q

Let after t min the number of nuclei of P and Q are equal.

$$\therefore \quad N_P = 4N_0\left(\frac{1}{2}\right)^{t/1} \text{ and } N_Q = N_0\left(\frac{1}{2}\right)^{t/2}$$

As $N_P = N_Q$

$$\therefore \quad 4N_0\left(\frac{1}{2}\right)^{t/1} = N_0\left(\frac{1}{2}\right)^{t/2}$$

$$\frac{4}{2^{t/1}} = \frac{1}{2^{t/2}} \text{ or } 4 = \frac{2^t}{2^{t/2}}$$

or $4 = 2^{t/2}$ or $2^2 = 2^{t/2}$

or $\frac{t}{2} = 2$ or $t = 4$ min

After 4 minutes, both P and Q have equal number of nuclei.

$\therefore$ Number of nuclei of R

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

$$= \frac{15N_0}{4} + \frac{3N_0}{4} = \frac{9N_0}{2}$$

34. (c) : The energy of n^{th} orbit of hydrogen atom is given as

$$E_n = -\frac{13.6}{n^2}\text{ eV}$$

$$\therefore \quad E_1 = -13.6\text{ eV}\,;\; E_2 = -\frac{13.6}{2^2} = -3.4\text{ eV}$$

$$E_3 = -\frac{13.6}{3^2} = -1.5\text{ eV}\,;\; E_4 = -\frac{13.6}{4^2} = -0.85\text{ eV}$$

$$\therefore \quad E_3 - E_2 = -1.5 - (-3.4) = 1.9\text{ eV}$$
$$E_4 - E_3 = -0.85 - (-1.5) = 0.65\text{ eV}$$

35. (b) : For ${}^7_3$Li nucleus,

Mass defect, $\Delta M = 0.042$ u

$\because \quad 1\text{ u} = 931.5\text{ MeV}/c^2$

$\therefore \quad \Delta M = 0.042 \times 931.5\text{ MeV}/c^2 = 39.1\text{ MeV}/c^2$

Binding energy, $E_b = \Delta Mc^2$

$$= \left(39.1\frac{\text{MeV}}{c^2}\right)c^2 = 39.1\text{ MeV}$$

Binding energy per nucleon, $E_{bn} = \frac{E_b}{A} = \frac{39.1\text{ MeV}}{7}$
$= 5.6$ MeV

36. (d) : According to activity law

$$R = R_0 e^{-\lambda t} \quad ...(i)$$

According to given problem,

$R_0 = N_0$ counts per minute

$R = \frac{N_0}{e}$ counts per minute

$t = 5$ minutes

Substituting these values in equation (i), we get

$$\frac{N_0}{e} = N_0 e^{-5\lambda}$$
$$e^{-1} = e^{-5\lambda}$$
$$5\lambda = 1 \text{ or } \lambda = \frac{1}{5} \text{ per minute 1}$$

At $t = T_{1/2}$, the activity R reduces to $\frac{R_0}{2}$.

where $T_{1/2}$ = half life of a radioactive sample

From equation (i), we get

$$\frac{R_0}{2} = R_0 e^{-\lambda T_{1/2}}$$
$$e^{\lambda T_{1/2}} = 2$$

Taking natural logarithms of both sides of above equation, we get

$$\lambda T_{1/2} = \log_e 2$$

or $T_{1/2} = \frac{\log_e 2}{\lambda} = \frac{\log_e 2}{\left(\frac{1}{5}\right)} = 5\log_e 2$ minutes

37. (a) **38. (c)**

39. (c) : $A_1 = \lambda N_1$ at time t_1

$A_2 = \lambda N_2$ at time t_2

Therefore, number of nuclei decayed during time interval $(t_1 - t_2)$ is

$$N_1 - N_2 = \frac{[A_1 - A_2]}{\lambda}$$

40. (a) : ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + \Delta E$

The binding energy per nucleon of a deuteron = 1.1 MeV

$\therefore$ Total binding energy = 2 × 1.1 = 2.2 MeV

The binding energy per nucleon of a helium nuclei = 7 MeV

$\therefore$ Total binding energy = 4 × 7 = 28 MeV

Hence, energy released

$$\Delta E = (28 - 2 \times 2.2) = 23.6 \text{ MeV}$$

41. (d) :

$${}^A_Z X \xrightarrow{\beta^-} {}^{A}_{Z+1}Y \xrightarrow{\alpha} {}^{A-4}_{Z-1}B^* \xrightarrow{\gamma} {}^{A-4}_{Z-1}B$$

First X decays by β^- emission emitting $\bar{\upsilon}$, antineutrino simultaneously. Y emits α resulting in the excited level of B which in turn emits a γ ray.

$\therefore$ β^-, α, γ is the answer.

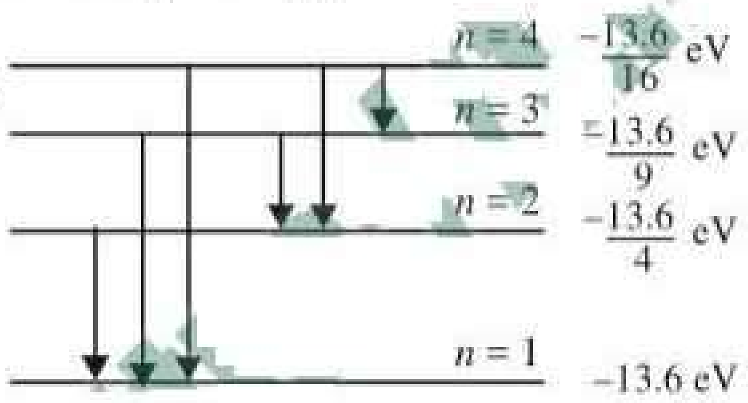
42. (c) : ${}^A_Z X \xrightarrow{2\beta^-} {}^{A}_{Z+2}Y_1 \xrightarrow{\alpha} {}^{A-4}_{Z}Y_2$

The resultant daughter is an isotope of the original parent nucleus.

43. (a) : Energy of the projectile is the potential energy at closest approach, $\frac{1}{4\pi\varepsilon_0}\frac{z_1 z_2}{r}$

Therefore energy $\propto z_1 z_2$.

44. (c) :



The maximum wavelength emitted here corresponds to the transition $n = 4 \rightarrow n = 3$ (Paschen series 1st line)

45. (c) : $ZM_p + (A - Z)M_n - M(A, Z)$

$$= \text{mass effect} = \frac{B.E}{c^2}$$

$$\Rightarrow M(A, Z) = ZM_p + (A - Z)M_n - \frac{B.E}{c^2}$$

46. (b) : $A_1 : A_2 = 1 : 3$

Their radii will be in the ratio

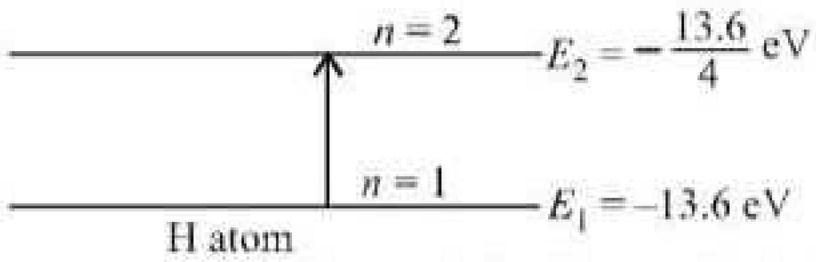
$$R_0 A_1^{1/3} : R_0 A_2^{1/3} = 1 : 3^{1/3}$$

$$\text{Density} = \frac{A}{\frac{4}{3}\pi R^3}$$

$$\therefore \rho_{A_1} : \rho_{A_2} = \frac{1}{\frac{4}{3}\pi R_0^3 \cdot 1^3} = \frac{3}{\frac{4}{3}\pi R_0^3 (3^{1/3})^3}$$

Their nuclear densities will be the same.

47. (a) :



1st excitation energy $E_{n2} - E_{n1} = (-3.4 + 13.6) = 10.2$ eV

48. (a) : $X_1 = N_0 e^{-\lambda_1 t}$; $X_2 = N_0 e^{-\lambda_2 t}$

$$\frac{X_1}{X_2} = e^{-1} = e^{(-\lambda_1 + \lambda_2)t} ; e^{-1} = e^{-(\lambda_1 - \lambda_2)t}$$

$$\therefore t = \left|\frac{1}{\lambda_1 - \lambda_2}\right| = \frac{1}{(5\lambda - \lambda)} = \frac{1}{4\lambda}$$

49. (c) : Given : $\lambda_A = 5\lambda, \lambda_B = \lambda$

At $t = 0$, $(N_0)_A = (N_0)_B$

$$\frac{N_A}{N_B} = \left(\frac{1}{e}\right)^2$$

According to radioactive decay, $\frac{N}{N_0} = e^{-\lambda t}$

$$\therefore \frac{N_A}{(N_0)_A} = e^{-\lambda_A t} \quad \text{... (i)}$$

$$\frac{N_B}{(N_0)_B} = e^{-\lambda_B t} \quad \text{... (ii)}$$

Divide (i) by (ii), we get

$$\frac{N_A}{N_B} = e^{-(\lambda_A - \lambda_B)t} \quad \text{or,} \quad \frac{N_A}{N_B} = e^{-(5\lambda - \lambda)t}$$

$$\text{or,} \left(\frac{1}{e}\right)^2 = e^{-4\lambda t} \quad \text{or,} \left(\frac{1}{e}\right)^2 = \left(\frac{1}{e}\right)^{4\lambda t}$$

$$\text{or, } 4\lambda t = 2 \Rightarrow t = \frac{2}{4\lambda} = \frac{1}{2\lambda}.$$

50. (a) : In beta minus decay (β^-), a neutron is transformed into a proton and an electron is emitted with the nucleus along with an antineutrino.

$$n \rightarrow p + e^- + \bar{\nu}$$

where $\bar{\nu}$ is the antineutrino.

51. (a) : In mass spectrometer when ions are accelerated through potential V,

$$\frac{1}{2}mv^2 = qV \quad \text{... (i)}$$

where m is the mass of ion, q is the charge of the ion.

As the magnetic field curves the path of the ions in a semicircular orbit

$$\therefore Bqv = \frac{mv^2}{R} \Rightarrow v = \frac{BqR}{m} \quad \text{... (ii)}$$

Substituting (ii) in (i), we get

$$\frac{1}{2}m\left[\frac{BqR}{m}\right]^2 = qV \qquad \text{or,} \qquad \frac{q}{m} = \frac{2V}{B^2R^2}$$

Since V, B are constants,

$$\frac{q}{m} \propto \frac{1}{R^2} \quad \text{or,} \quad \frac{\text{charge on the ion}}{\text{mass of the ion}} \propto \frac{1}{R^2}.$$

52. (a)

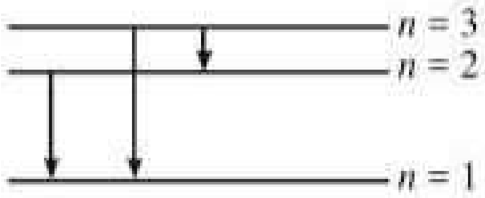
53. (d) : Nuclear radii $R = (R_0)A^{1/3}$
where A is the mass number.

$$\therefore \quad \frac{R_{Te}}{R_{Al}} = \left(\frac{A_{Te}}{A_{Al}}\right)^{1/3} = \left(\frac{125}{27}\right)^{1/3} = \left(\frac{5}{3}\right)$$

or, $R_{Te} = \frac{5}{3} \times R_{Al} = \frac{5}{3} \times 3.6 = 6$ fm.

(Given R_{Al} =3.6 fm)

54. (d) : Energy of n^{th} orbit of hydrogen atom is given by



$$E_n = \frac{-13.6}{n^2}\text{ eV}$$

For ground state, $n = 1$

$$\therefore \quad E_1 = \frac{-13.6}{1^2} = -13.6 \text{ eV}$$

For first excited state, $n = 2$

$$\therefore \quad E_2 = \frac{-13.6}{2^2} = -3.4 \text{ eV}$$

Kinetic energy of an electron in the first excited state is

$K = -E_2 = 3.4$ eV.

55. (c) : Ionisation potential of hydrogen atom is 13.6 eV.

Energy required for exciting the hydrogen atom in the ground state to orbit n is given by

$E = E_n - E_1$

i.e. $$12.1 = -\frac{13.6}{n^2} - \left(\frac{-13.6}{1^2}\right) = -\frac{13.6}{n^2} + 13.6$$

or, $-1.5 = \frac{-13.6}{n^2}$ or, $n^2 = \frac{13.6}{1.5} = 9$ or, $n = 3$

Number of spectral lines emitted

$$= \frac{n(n-1)}{2} = \frac{3 \times 2}{2} = 3.$$

56. (b) : According to activity law, $R = R_0 e^{-\lambda t}$

$\therefore$ $R_1 = R_0 e^{-\lambda t_1}$ and $R_2 = R_0 e^{-\lambda t_2}$

$$\therefore \quad \frac{R_1}{R_2} = \frac{R_0 e^{-\lambda t_1}}{R_0 e^{-\lambda t_2}} = e^{-\lambda t_1} e^{\lambda t_2} = e^{-\lambda(t_1 - t_2)}$$

or, $R_1 = R_2 e^{-\lambda(t_1 - t_2)}$.

57. (c) : ${}_1^2H + {}_1^2H \rightarrow {}_2^4He + \text{energy}$

$\therefore$ Energy released = B.E. of ${}_2^4$He − 2(B.E. of ${}_1^2$H)
= 28 − 2(2.2) = 28 − 4.4 = 23.6 MeV.

58. (a) : Nuclear radii $R = R_0(A)^{1/3}$,
where $R_0 \approx 1.2$ Fm
or $R \propto (A)^{1/3}$

$$\therefore \quad \frac{R_{Be}}{R_{Ge}} = \frac{(9)^{1/3}}{(A)^{1/3}} \quad \text{or,} \quad \frac{R_{Be}}{2R_{Be}} = \frac{(9)^{1/3}}{(A)^{1/3}}$$

($\because$ given $R_{Ge} = 2R_{Be}$)

or, $(A)^{1/3} = 2 \times (9)^{1/3}$ or, $A = 2^3 \times 9 = 8 \times 9 = 72$.

$\therefore$ The number of nucleons in Ge is 72.

59. (c) : Energy released, $E = (\Delta m) \times 931$ MeV
Δm = mass of product − mass of reactant
$\Delta m = c - a - b$
$E = (\Delta m) \times 931$ or, $E = (c - a - b)$.

60. (a) : K.E. $= \left|\frac{1}{2}\text{P.E.}\right|$

But P.E. is negative.

$\therefore$ Total energy

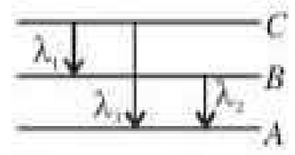
$$= \left|\frac{1}{2}\text{P.E.}\right| - \text{P.E.} = \frac{-P.E.}{2} = -3.4 \text{ eV}.$$

$\therefore$ K.E. = + 3.4 eV.

61. (a) : Isotones means number of neutron remains same.

62. (c)

63. (b) :



$$(E_C - E_A) = (E_C - E_B) + (E_B - E_A)$$

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \quad \text{or} \quad \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

$$\therefore \quad \frac{1}{\lambda_3} = \frac{\lambda_1 + \lambda_2}{\lambda_1\lambda_2} \quad \text{or} \quad \lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$$

64. (d) : For nuclei having $A > 56$ binding energy per nucleon gradually decreases.

65. (b) : Z is number of protons and A is the total number of protons and neutrons.

66. (c) : In nuclear fusion the mass of end product or resultant is always less than the sum of initial product, the rest is liberated in the form of energy, like in Sun energy is liberated due to fusion of two hydrogen atoms.

67. (a)

68. (d) : Using $N = N_0\left(\frac{1}{2}\right)^n \Rightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

$$\Rightarrow \frac{25}{100} = \left(\frac{1}{2}\right)^n \Rightarrow n = 2.$$

The total time in which radium change to 25 g is
$= 2 \times 1600 = 3200$ yr.

69. (d) : The charge on hydrogen nucleus $q_1 = +e$ charge on electron, $q_2 = -e$

Coulomb force, $F = K\frac{q_1 q_2}{r^2} = K\frac{(+e)(-e)}{r^2}$

$= -\frac{Ke^2}{r^3}\vec{r} = -\frac{Ke^2}{r^2}\hat{r}.$

70. (c)

71. (d): $\frac{\text{Volume of atom}}{\text{Volume of nucleus}} = \frac{\frac{4}{3}\pi(10^{-10})^3}{\frac{4}{3}\pi(10^{-15})^3} = 10^{15}.$

72. (a) : Let, $t = 0, M_0 = 10$ g

$t = 2\tau = 2\left(\frac{1}{\lambda}\right)$ (given)

Then from, $M = M_0 e^{-\lambda t} = 10e^{-\lambda\left(\frac{2}{\lambda}\right)}$

$= 10\left(\frac{1}{e}\right)^2 = 1.35$ g.

73. (a) : Radius of first orbit, $r \propto \frac{1}{Z}$,
for doubly ionized lithium $Z (= 3)$ will be maximum, hence for doubly ionized lithium, r will be minimum.

74. (c) : Mass defect $= 2M_P + 2M_N - M_{He}$
$= 2\times1.0073 + 2\times1.0087 - 4.0015 = 0.0305.$
$\Rightarrow$ Binding energy = (931 × mass defect) MeV
$= 931 \times 0.0305$ MeV $= 28.4$ MeV
(1 amu = 931 Mev).

75. (c) : Mass number = atomic number + no. of neutrons
For hydrogen, number of neutrons = 0
So, mass number = Atomic number.
Hence mass number is sometimes equal to atomic number.

76. (a) : β-decay.

77. (a) : The nuclei of light elements have a lower binding energy than that for the elements of intermediate mass. They are therefore less stable; consequently the fusion of the light elements results in more stable nucleus.

78. (c) : Number of initial active nuclei $= 4 \times 10^{16}$
Number of decayed nuclei after 10 days (half life)

$= \frac{4\times10^{16}}{2} = 2\times10^{16}.$

Remaining number of nuclei after 10 days

$= 4 \times 10^{16} - 2 \times 10^{16} = 2 \times 10^{16}.$

$\therefore$ Number of decayed nuclei in next 10 days

$= \frac{2\times10^{16}}{2} = 1\times10^{16}.$

Similarly, number of decayed nuclei in next 10 days $= 0.5 \times 10^{16}$

$\therefore$ Total number of nuclei decayed after 30 days
$= 2 \times 10^{16} + 1 \times 10^{16} + 0.5 \times 10^{16} = 3.5 \times 10^{16}.$

79. (d) : The nuclear reaction is
$${}_8O^{16} + {}_1H^2 \rightarrow {}_7N^{14} + {}_2He^4$$
So when a deuteron is bombarded on ${}_8O^{16}$ nucleus then an α-particle (${}_2He^4$) is emitted and the product nucleus is ${}_7N^{14}$.

80. (a) : α-rays are positively charged particles.

81. (a) : ${}^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{4}_{2}He + {}^{7}_{3}Li$

82. (b) : $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$ $n \rightarrow$ no. of decays.

$\frac{1}{256} = \left(\frac{1}{2}\right)^8 = \left(\frac{1}{2}\right)^n \quad \therefore n = 8$

Time for 8 half life = 100 hours.

83. (b) : $2d\sin\phi = n\lambda$; $(\sin\phi)_{max} = 1$
i.e. $\lambda_{max} = 2d \Rightarrow \lambda_{max}$
$= 2 \times 2.8 \times 10^{-8} = 5.6 \times 10^{-8}$ m.

84. (a) : $E \propto \frac{Z^2}{n^2}$

85. (a) **86. (a)** **87. (c)**

88. (a) : $\upsilon \propto \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

89. (a) **90. (a)** **91. (a)**

92. (b) : Jump to second orbit leads to Balmer series. The jump from 4th orbit shall give rise to second line of Balmer series.

93. (d)

94. (b,d) : 1α reduce the mass number by 4 units and atomic number by 2 units, while 1β only increase the atomic number by 1 unit.

95. (c)

96. (c) : ${}_nX^m \xrightarrow{-1\alpha} {}_{n-2}Z^{m-4} \xrightarrow{-2\beta} {}_nX^{m-4}.$

97. (c) : Let ${}_5B^{10}$ be present as x%
and percentage of ${}_5B^{11} = (100 - x)$

$\therefore$ Average atomic coefficient $= \frac{10x + 11(100-x)}{100}$
$= 10.81$

$\Rightarrow x = 19$
$\therefore$ % of ${}_5B^{11}$ is $100 - 19 = 81$. Ratio is 19 : 81.

98. (a) : Centripetal force = force of attraction of nucleus on electron

$\frac{mv^2}{a_0} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{a_0^2}; \quad v = \frac{e}{\sqrt{4\pi\varepsilon_0 a_0 m}}.$

99. (d) : Energy = $h\upsilon$

$$= \frac{hc}{\lambda} = \frac{6.625\times10^{-34}\times3\times10^{8}}{21\times10^{-2}}$$

$= 0.9464 \times 10^{-24}$ J $\cong 1 \times 10^{-24}$ J.

100. (a) : For A, 80 min. = 4 half lives

No. of atoms left $= \frac{N_0}{16}$

For B, 80 min. $\cong$ 2 half lives

No. of atoms left $= \frac{N_0}{4}$. Ratio = 1 : 4.

101. (c)

102. (d) : In nuclear fission, the chain reaction is controlled in such way that only one neutron, produced in each fission, causes further fission. Therefore some moderator is used to slow down the neutrons. Heavy water is used for this purpose.

103. (c) : Energy of the ground electronic state of hydrogen atom $E = -13.6$ eV.

We know that energy of the first excited state for second orbit (where $n = 2$)

$$E_n = -\frac{13.6}{(n)^2} = -\frac{13.6}{(2)^2} = -3.4 \text{ eV}.$$

104. (b) : When a hydrogen atom is in its excited level, then $n = 2$. Therefore radius of hydrogen atom in its first excited level $(r) \propto n^2 r_0 \propto (2)^2 = 4r_0$.

105. (b) : γ-ray are most penetrating radiations.

106. (b) : By the law of photo-electric effect

$$\frac{hc}{\lambda} = eV \text{ or } \lambda = \frac{hc}{eV} \propto \frac{1}{V}.$$

107. (b) : Energy of hydrogen atom in ground state $= -13.6$ eV and quantum number $(n) = 2$.

We know that energy of hydrogen atom

$$(E_n) = -\frac{13.6}{n^2} = -\frac{13.6}{(2)^2} = -3.4 \text{ eV}.$$

108. (d) : According to Bohr's principle, radius of orbit $(r) = 4\pi\varepsilon_0 \times \frac{n^2h^2}{4\pi^2me^2} \propto n^2$. where n = principal quantum number.

109. (d) : Velocity ratio $(v_1 : v_2) = 2 : 1$.

Mass $(m) \propto$ Volume $\propto r^3$.

According to law of conservation of momentum,

$$m_1v_1 = m_2v_2$$

Therefore $\frac{v_1}{v_2} = \frac{m_2}{m_1} = \frac{r_2^3}{r_1^3}$

or $\frac{r_1}{r_2} = \left(\frac{v_2}{v_1}\right)^{1/3} = \left(\frac{1}{2}\right)^{1/3} = \frac{1}{2^{1/3}}$

or $r_1 : r_2 = 1 : 2^{1/3}$.

110. (b) : On emission of one α-particle, atomic number decreases by 2 units and atomic mass number decrease by 4 units.

Here, decrease in mass number = 200 – 168 = 32.

$\therefore$ Number of α-particles = 32/4 = 8.

While the emission of β-particle does not effect the mass number and atomic number increases by 1 unit.

$\therefore$ Number of β-particles = 16 – 10 = 6.

111. (b) : Number of nucleon on reactant side = 4

Binding energy for one nucleon = x_1

Binding energy for 4 nucleons = $4x_1$

Similarly on product side binding energy = $4x_2$

Now, Q = change in binding energy = $4(x_2 - x_1)$.

112. (a) : Half-life time = 30 minutes; Rate of decrease (N) = 5 per second and total time = 2 hours = 120 minutes. Relation for initial and final count rate $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\text{time/half-life}} = \left(\frac{1}{2}\right)^{120/30} = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$.

Therefore $N_0 = 16 \times N = 16 \times 5 = 80$ s^{-1}.

113. (d) : Transition of hydrogen atom from orbit $n_1 = 4$ to $n_2 = 2$.

$$\text{Wave number} = \frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = R\left[\frac{1}{(2)^2} - \frac{1}{(4)^2}\right]$$

$$= R\left[\frac{1}{4} - \frac{1}{16}\right] = R\left[\frac{4-1}{16}\right] = \frac{3R}{16}$$

$\Rightarrow \lambda = 16/3R$.

114. (b) : P.E. $= -\frac{k\,Ze^2}{R}$ and K.E. $= \frac{1}{2}mv^2 = \frac{k\,Ze^2}{2R}$.

Therefore when a hydrogen atom is raised from the ground, it increases the value of the radius R. As a result of this, both K.E. and P.E. decrease.

115. (b)

116. (c) : Absorption spectrum involves only excitation of ground level to higher level. Therefore spectral lines 1, 2, 3 will occur in the absorption spectrum.

117. (b) : Mass number of helium $(A_{He}) = 4$ and mass number of sulphur $(A_S) = 32$.

Radius of nucleus, $r = r_0(A)^{1/3} \propto (A)^{1/3}$. Therefore

$$\frac{r_s}{r_{He}} = \left(\frac{A_s}{A_{He}}\right)^{1/3} = \left(\frac{32}{4}\right)^{1/3} = (8)^{1/3} = 2.$$

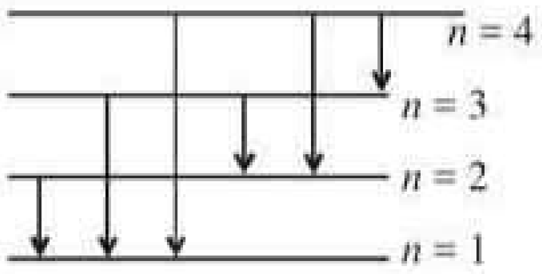
118. (b) : From binding energy curve, the curve reaches peak for ${}_{26}Fe^{56}$.

119. (b) : Neon street sign is a source of line emission spectrum.

120. (b) : Fission rate

$$= \frac{\text{total power}}{\frac{\text{energy}}{\text{fission}}} = \frac{5}{200 \times 1.6 \times 10^{-13}} = 1.56 \times 10^{11}\ s^{-1}$$

121. (b) :



No. of spectral lines $= \frac{n(n-1)}{2} = \frac{4(4-1)}{2} = 6$

122. (a) : As $r \propto n^2$, therefore, radius of 2nd Bohr's orbit = $4a_0$

123. (a) : Fusion reaction.

124. (d) : $E = E_4 - E_3$

$$= -\frac{13.6}{4^2} - \left(-\frac{13.6}{3^2}\right) = -0.85 + 1.51 = 0.66\text{ eV}$$

125. (c) : 1 a.m.u = 931 MeV

126. (a) : α-particle = ${}_2He^4$. It contains 2 p and 2 n. As some mass is converted into binding energy, therefore, mass of α particle is slightly less than sum of the masses of $2p$ and $2n$.

127. (d) : Clearly C and N^+ have same electronic configuration as they are isoelectronic.

128. (c) : The nuclear radius r varies with mass number A according to the relation

$r = r_0 A^{1/3} \Rightarrow r \propto A^{1/3}$ or $A \propto r^3$

Now density $= \frac{\text{mass}}{\text{volume}}$

Further mass $\propto A$ and volume $\propto r^3$

$\therefore \frac{\text{mass}}{\text{volume}} = \text{constant}$

129. (a) : Nucleus contains only neutrons and protons

130. (d) : $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{6400/1600} = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$

131. (a) : $Z = 11$ *i.e.*, number of protons = 11, $A = 23$

$\therefore$ Number of neutrons = $A - Z = 12$

Number of electron = 0 (No electron in nucleus)

Therefore 11, 12, 0.

132. (a) : Second excited state corresponds to $n = 3$

$$\therefore\ E = \frac{13.6}{3^2}\text{ eV} = 1.51\text{ eV}$$

but one has to ionise only from ground state. Even if one has to excite an atom from $n = 3$, one has to excite from $n = 1$.

133. (c) : Nuclear force is the same between any two nucleons

134. (c) : For all first group elements, Na, K, Rb, Cs, Fr. They have one electron in the s subsell.

135. (d) : The circumference of an orbit in an atom in terms of wavelength of wave associated with electron is given by the relation,

Circumference = $n\lambda$

where n = 1, 2, 3, ...

136. (a) : As ${}_6C^{13}$ and ${}_7N^{14}$ have same no. of neutrons (13 – 6 = 7 for C and 14 – 7 = 7 for N), they are isotones.

137. (c) : Nuclear forces are short range forces

138. (a) : $R \propto (A)^{1/3}$ from $R = R_0 A^{1/3}$.

$\therefore\ R_{Al} \propto (27)^{1/3}$ and $R_{Te} \propto (125)^{1/3}$

$\therefore \frac{R_{Al}}{R_{Te}} = \frac{3}{5} = \frac{6}{10}$

139. (b) : ${}_6C^{12} + {}_0n^1 \rightarrow {}_6C^{13} \rightarrow {}_7N^{13} + {}_{-1}\beta^0 + \text{Energy}$

140. (d) : Number of half lives, $n = \frac{t}{T} = \frac{6400}{800} = 8$

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^8 = \frac{1}{256}$$

141. (a) : From equation (ii), B has 2 units of charge more than C.

From equation (i), A loses 2 units of charge by emission of alpha particle. Hence, A and C are isotopes as their charge number is same.

142. (c) : Curie is a unit of radioactivity

143. (a) : Average binding energy/nucleon in nuclei is of the order of 8 MeV.

144. (b) : Bohr used quantisation of angular momentum. For stationary orbits, Angular momentum

$I\omega = \frac{nh}{2\pi}$ where n = 1, 2, 3,...etc.

145. (d)

146. (d) : In two half lives, the activity becomes one fourth.

Activity on 1 - 8 - 91 was 2 micro curie

$\therefore$ Activity before two months,

4×2 micro-Curie = 8 micro curie

147. (d) : Two successive β decays increase the charge no. by 2.

148. (d) : $E \propto Z^2$ and Z for singly ionised helium is 2 (*i.e.*, 2 protons in the nucleus)

$\therefore\ (E)_{He} = 4 \times 13.6 = 54.4$ eV.