DAY THIRTY FIVE

Unit Test 7

(Dual Nature of Matter, Atoms and Nuclei)

1 The de-Broglie wavelength associated with a proton moving with a velocity, equal to $\frac{1}{20}$ th of the velocity of light

(a) 2.75×10^{-14} m (b) 1.5×10^{-7} m
(c) 1.5×10^{7} m (d) 2.634×10^{14} m

2 An electron has been accelerated from rest through a potential difference of 100 V, its de-Broglie wavelength is

(a) 225 Å (b) 1.225 Å (c) 225 m (d) 1.225 cm

3 The experiments of Frank and Hertz showed that

(a) an atom has energy states having a continuous distribution
(b) nothing can be send a bond energy states of atom
(c) at atom has energy states, having discrete values
(d) atom is an indivisible particle

4 A photon and an electron have same energy, the ratio of their wavelengths is

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

5 If the wavelength of incident light changes from 400 nm to 300 nm, the stopping potential for photoelectrons emitted from a surface becomes approximately

(a) 1.0 V greater (b) 1.0 V smaller
(c) 0.5 V greater (d) 0.5 V smaller

6 The photosensitive surface is receiving light of wavelength 5000 Å at the rate of 10^{-8} Js^{-1}. The number of photons received per second, is

(a) 2.5×10^{10} (b) 2.5×10^{11}
(c) 2.5×10^{12} (d) 2.5×10^{9}

7 The wavelength of quantum of radiant energy emitted, if an electron transmitted into radiation and converted into one quantum, is

(a) 0.0242 Å (b) 2.42 Å (c) 532 Å (d) 0.532 Å

8 The electric potential at the surface of an atomic nucleus ($Z = 50$) of radius 9.0×10^{-13} cm, is

(a) 9×10^{5} V (b) 8×10^{6} V (c) 80 V (d) 9 V

9 K_α wavelength emitted by an atom of atomic number $Z = 11$ is λ. Find the atomic number for an atom that emits K_α radiation with wavelength 4λ, is

(a) $Z = 6$ (b) $Z = 4$ (c) $Z = 11$ (d) $Z = 44$

10 The ratio of minimum wavelengths of Lyman and Balmer series will be

(a) 1.25 (b) 0.25 (c) 5 (d) 10

11 What will be the amount of energy absorbed when an electron jumps from first orbit to second orbits, if the value of energy in nth orbit of H-atom is expressed as $\left(E_n = -\frac{13.6}{n^2} \text{eV}\right)$?

(a) -3.4 eV (b) -6.6 eV
(c) -8.1 eV (d) -10.2 eV

12 An electron changes its position from orbit $n = 2$ to the orbit $n = 4$ of an atom. The wavelength of the emitted radiations is (R = Rydberg's constant)

(a) $\frac{16}{R}$ (b) $\frac{16}{3R}$
(c) $\frac{16}{5R}$ (d) $\frac{16}{7R}$

13 Imagine an atom made of a proton and a hypothetical particle of double the mass of the electron but having same charge as the electron. Apply Bohr atom model and consider all possible transitions of the hypothetical particle to the first excited level. The longest wavelength photon that will be emitted has wavelength λ equal to

(a) $\frac{9}{5R}$ (b) $\frac{36}{5R}$
(c) $\frac{18}{5R}$ (d) $\frac{4}{R}$

14 Ionisation potential of hydrogen atom is 13.6 eV. Hydrogen atoms in 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) 2 (b) 3 (c) 4 (d) 1

15 In Bohr's model the atomic radius of the first orbit is r_0, the radius of the third orbit will be

(a) $9r_0$ (b) $3r_0$ (c) r_0 (d) $\frac{r_0}{3}$

16 Taking Rydberg's constant $R_H = 1.097 \times 10^7$ m first and second wavelength of Balmer series in hydrogen spectrum, are

(a) 2000 Å, 3000 Å (b) 1575 Å, 2960 Å
(c) 6529 Å, 4280 Å (d) 6562 Å, 4863 Å

17 Which of the following lines of the H-atom spectrum belongs to Balmer series?

(a) 1025 Å (b) 12184 Å (c) 4861 Å (d) 18751 Å

18 The density of uranium is of the order of

(a) 10^{20} kgm^{-3} (b) 10^{17} kgm^{-3} (c) 10^{14} kgm^{-3} (d) 10^{11} kgm^{-3}

19 Two radioactive materials A and B have decay constants 10λ and λ, respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of A to that of B will be $1/e$ after a time.

(a) $\frac{1}{10\lambda}$ (b) $\frac{1}{11\lambda}$ (c) $\frac{11}{10\lambda}$ (d) $\frac{1}{9\lambda}$

20 In an experiment, a radioactive isotope is being produced at a constant rate $\frac{dN}{dt} = R$. Its half life is $t_{1/2}$.

After $t >> t_{1/2}$, the number of active nuclei will become constant. The value of this constant is

(a) $\frac{Rt_{1/2}}{0.693}$ (b) $\frac{t_{1/2}}{R}$ (c) $\frac{R}{t_{1/2}}$ (d) $\frac{0.693}{Rt_{1/2}}$

21 If R is the radius and A is the mass number, then log R *versus* log A graph will be

(a) a straight line (b) a parabola
(c) an ellipse (d) a hyperbola

22 Two radioactive materials X and Y have 3000 and 6000 number of nuclei respectively at initial. If decay constant of material X and Y are 12 minute^{-1} and 10 minute^{-1}, then the time, in which both elements have same number of nuceli:

(a) $\log_e\left[\frac{1}{2}\right]$ (b) $\frac{1}{2}\log_e^2$
(c) $\frac{1}{2}\log_e\frac{1}{2}$ (d) $\log_e[2]$

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

(a) 3 months (b) 4 months
(c) 8 months (d) 12 months

24 C^{14} has half-life 5700 yr. At the end of 11400 yr, actual amount left is

(a) 0.5 of original amount (b) 0.25 of original amount
(c) 0.125 of original amount (d) 0.0625 of original amount

25 ^{208}Ra has half-life 120 days. The amount of ^{208}Ra, if the activity level is one mCi

(a) 0.184 μg (b) 0.184 mg (c) 0.134 μg (d) 0.314 mg

26 The counting rate observed from a radioactive source at $t = 0$ s was 1600 count per second, and at $t = 8$ s, it was 100 count per second. The counting rate observed at $t = 6$ s was

(a) 400 (b) 300 (c) 200 (d) 150

27 Mean life of a radioactive sample is 100 s. Then, its half-life (in minute) is

(a) 0.693 (b) 1 (c) 10^{-4} (d) 1.155

28 If parent decays to daughter nucleus with a rate r and daughter nucleus has average life τ and number of nuclei of daughter nucleus at any instant is N, then for radioactive equilibrium to be achieved, we have

(a) $r = N\tau$ (b) $r = \tau N$ (c) $r\tau = N$ (d) $\tau = r$

29 In a specific case, angular momentum is an even integral multiple of $\frac{h}{2\pi}$. The longest possible wavelength emitted by hydrogen in visible region in such a world, according to Bohr's model is

(a) 273 nm (b) 470 nm (c) 523 nm (d) zero

30 If the binding energies of a deuteron and an α-particle are 1.125 MeV and 7.2 MeV, respectively. Then, the more stable of the two is

(a) deuteron
(b) α-particle
(c) Both (a) and (b)
(d) sometimes deuteron and sometimes alpha particle

31 The nuclei of which one of the following pairs of nuclei are isotones?

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

32 In the nuclear reaction,

$$_{72}X^{180} \xrightarrow{-\alpha} Y \xrightarrow{-\beta} Z \xrightarrow{-\alpha} A \xrightarrow{-\gamma} P$$

the atomic mass and atomic number of P are, respectively

(a) 170, 69 (b) 172, 69 (c) 172, 70 (d) 170, 70

33 A nuclei X with mass number A and charge number Z, disintegrates into one α-particle and one β-particle. The resulting nuclide R has atomic mass and atomic number, equal to

(a) $(A - Z)$ and $(Z - 1)$ (b) $(A - Z)$ and $(Z - 2)$
(c) $(A - 4)$ and $(A - 2)$ (d) $(A - 4)$ and $(Z - 1)$

34 In a nuclear reaction, $C_6^{11} \longrightarrow B_5^{11} + \beta^+ + X$
What does X stand for?
(a) An electron (b) A proton
(c) A neutron (d) A neutrino

35 The particle A is converted into C *via* following reaction,

$$A \longrightarrow B + {}_2He^4, B \longrightarrow C + 2e^-$$

Then,
(a) A and C are isobars (b) A and C are isotopes
(c) A and B are isobars (d) A and B are isotopes

36 A nucleus with mass number 220 initially emits α-particle. If the Q value of the reaction is 5.5 MeV. Then, the kinetic energy of the α-particle is
(a) 4.4 MeV (b) 5.4 MeV
(c) 5.6 eV (d) 6.5 eV

Direction (Q. Nos. 37-42) *These questions consist of two statements, each linked as Assertion and Reason. While answering of these questions, you are required to choose any one of the following.*

(a) If both Assertion and Reason are true and Reason is the correct explanation of the Assertion
(b) If both Assertion and Reason are true but Reason is not correct explanation of the Assertion
(c) If Assertion is true but Reason is false
(d) If Assertion is false but Reason is true

37 **Assertion** (A) If wavelength of incident photons is halved, then maximum kinetic energy of photoelectron will become two times.
Reason (R) Energy of photon $\propto \frac{1}{\lambda}$.

38 **Assertion** (A) Second orbit circumference of hydrogen atom is two times the de-Broglie wavelength of electrons in that orbit.
Reason (R) de-Broglie wavelength of electron in ground state is minimum.

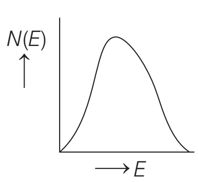
39 **Assertion** (A) Energy E_1 is required to remove first electron from helium atom and energy E_2 is to required to remove the second electron. Then, $E_1 < E_2$.
Reason (R) Ionisation energy of single electron of He^+ is 54.4 eV.

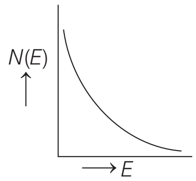
40 **Assertion** (A) If high pressure is applied on a radioactive substance, rate of radioactivity will increase.
Reason (R) Radioactivity is a nuclear process.

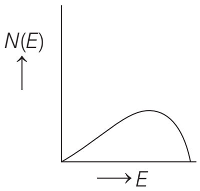
41 **Assertion** (A) At time $t = 0$, activity of a radioactive substance is 10 units. At $t = 1$ s, it remains 90 units. Then, at $t = 2$ s it should remain 80 units.
Reason (R) In equal interval of time, percentage change is same in a radioactive substance.

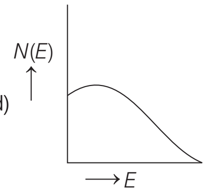
42 **Assertion** (A) If light continuously falls on a metal surface, then emission of electrons will stop after some time.
Reason (R) We cannot extract all the electrons of a metal.

43 The energy spectrum of β-particles number $N(E)$ as a function of β energy E emitted from a radioactive source, is

(a)


(b)


(c)


(d)


44 If a star can convert all the He nuclei completely into oxygen nuclei, the energy released per oxygen nucleus 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

45 A nuclear transformation is denoted by $X(n, \alpha)\,{}_3^7Li$. Which of the following is the nucleus of element X ?
(a) ${}_4^{11}Be$ (b) ${}_5^9B$ (c) ${}_5^{10}B$ (d) ${}_6^{12}C$

ANSWERS

1 (a)	**2** (b)	**3** (c)	**4** (c)	**5** (a)	**6** (a)	**7** (a)	**8** (b)	**9** (a)	**10** (b)
11 (d)	**12** (b)	**13** (b)	**14** (b)	**15** (a)	**16** (d)	**17** (c)	**18** (a)	**19** (d)	**20** (a)
21 (a)	**22** (c)	**23** (c)	**24** (b)	**25** (a)	**26** (c)	**27** (d)	**28** (c)	**29** (b)	**30** (b)
31 (a)	**32** (b)	**33** (d)	**34** (d)	**35** (b)	**36** (b)	**37** (d)	**38** (b)	**39** (b)	**40** (d)
41 (d)	**42** (c)	**43** (d)	**44** (c)	**45** (c)					

Hints and Explanations

1 Velocity of proton,

$$v = \frac{3 \times 10^8}{20} = 1.5 \times 10^7 \text{ m/s}$$

$$m = 1.67 \times 10^{-27} \text{ kg}$$

$$\lambda = \frac{h}{mv} = \frac{6.6 \times 10^{-34}}{1.6 \times 10^{-27} \times 1.5 \times 10^7} = 2.75 \times 10^{-14} \text{ m}$$

2 $$\lambda = \frac{12.25}{\sqrt{V}} \text{ Å}$$

$$V = 100 \text{ V}$$

$$\lambda = \frac{12.25}{\sqrt{100}} = 1.225 \text{ Å}$$

3 The series of experiments by Frank and Hertz in 1914 produced direct evidence for energy levels in atoms. In studying the motion of electron through mercury vapour under the action of an electric field, they observed that the spectrum line at 254 nm was emitted by the vapour when the electrokinetic energy was greater than 4.9 eV. But there was no spectrum line when kinetic energy was found less than 4.9 eV.

4 The de-Broglie wavelength of electron is given by

$$\lambda_e = \frac{h}{mv}$$

and $\frac{1}{2}mv^2 = E$

or $mv = \sqrt{2mE}$

$\therefore$ $\lambda_e = \frac{h}{\sqrt{2mE}}$

The de-Broglie wavelength of photon

$$\lambda_{ph} = \frac{hc}{E}$$

$$\frac{\lambda_{ph}}{\lambda_e} = \frac{hc}{E}\frac{\sqrt{2mE}}{h} = c\sqrt{\frac{2m}{E}} = \sqrt{\frac{2mc^2}{E}}$$

5 $E = \frac{hc}{\lambda} \Rightarrow E \propto \frac{1}{\lambda} \Rightarrow \frac{E'}{E} \propto \frac{400}{300} = 1.33$

But $E = eV_s$, where V_s is stopping potential.

Thus, stopping potential for photoelectrons from a surface becomes approximately 1.0 V greater.

6 $E = \frac{hc}{\lambda}, \lambda = 5000 \text{ Å} = 5 \times 10^{-7} \text{ m}$

$$E = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{5 \times 10^{-7}}$$

$$E = 3.96 \times 10^{-19} \text{ J}$$

Energy received per second $= 10^{-8} \text{ Js}^{-1}$

$\therefore$ Number of photons received per second

$$= \frac{\text{Energy received per second}}{\text{Energy of one photon}} = \frac{10^{-8}}{3.98 \times 10^{-19}} = 2.5 \times 10^{10}$$

7 When an energy of an electron is transmitted into radiation, we have

$$E = mc^2, E = h\nu = \frac{hc}{\lambda}$$

$$\lambda = \frac{h}{mc} = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 3 \times 10^8} = 0.0242 \text{ Å}$$

8 Electric potential at the surface of an atomic nucleus is

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Ze}{r} = \frac{9 \times 10^9 \times 50 \times 1.6 \times 10^{-19}}{9 \times 10^{-15}} = 8 \times 10^6 \text{ V}$$

9 $\frac{1}{\lambda} \propto (Z-1)^2$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \left(\frac{Z_2 - 1}{Z_1 - 1}\right)^2 \Rightarrow \frac{1}{4} = \left(\frac{Z_2 - 1}{11 - 1}\right)^2$$

Taking square root on both sides, we get

$$\frac{1}{2} = \frac{Z_2 - 1}{11 - 1} \Rightarrow Z_2 = 6$$

10 The series end of Lyman series corresponds to transitions from $n_i = \infty$ to $n_f = 1$, corresponding to wavelength

$$\frac{1}{(\lambda_{\min})_L} = R\left(\frac{1}{1} - \frac{1}{\infty}\right) = R$$

$$\Rightarrow (\lambda_{\min})_L = \frac{1}{R} = 912 \text{ Å}$$

Two rows line of Balmer series,

$$\frac{1}{(\lambda_{\min})_B} = R\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = \frac{R}{4}$$

$$\Rightarrow (\lambda_{\min})_B = \frac{4}{R} = 3636 \text{ Å}$$

Ratio is given by $\frac{(\lambda_{\min})_L}{(\lambda_{\min})_B} = 0.25$

11 Energy of nth orbit of hydrogen atom,

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

The energy absorbed, when an electron jumps from the first energy level $(n = 1)$ to second level $(n = 2)$

$$= -13.6 \times \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = -13.6\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right] = -13.6 \times \frac{3}{4} = -10.2 \text{eV}$$

12 Wavelength of lines emitted is given by

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

where, R = Rydberg's constant

Given, $n_1 = 2, n_2 = 4$

$$\therefore \quad \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16} \Rightarrow \lambda = \frac{16}{3R}$$

13 $$E_n = \frac{-Rhc}{n^2} \Rightarrow \frac{hc}{\lambda} = E_3 - E_2$$

$$\Rightarrow \frac{hc}{\lambda} = Rhc\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \Rightarrow \lambda_m = \frac{36}{5R}$$

14 Ionisation energy corresponding to ionisation potential $= -13.6$ eV

Photon energy incident $= 12.1$ eV

So, the energy of electron in excited state $= -13.6 + 12.1 = -1.5$ eV

$$E_n = -\frac{13.6}{n^2} \text{ eV} \Rightarrow -1.5 = \frac{-13.6}{n^2}$$

$$\Rightarrow n^2 = \frac{-13.6}{-1.5} \approx 9 \Rightarrow n = 3$$

$\therefore$ Energy of electron in excited state corresponds to third orbit.

The possible spectral lines are when electron jumps from orbit 3rd to 2nd, 3rd to 1st and 2nd to 1st. Thus, 3 spectral lines are emitted.

15 Here, radius of first orbit $= r_0$

The radius of nth orbit is given by,

$$r_n = \frac{\varepsilon_0 h^2}{\pi m Ze^2} \times n^2 \propto n^2$$

Hence, $\frac{r_1}{r_3} = \left(\frac{n_1}{n_3}\right)^2 = \frac{1}{9}$

or $r_3 = 9r_1 = 9r_0$

[where, r_3 is the radius of 3rd orbit]

16 The wavelength of the lines in Balmer series is represented by,

$$\frac{1}{\lambda} = R_H\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$$

For first wavelength,

$$\frac{1}{\lambda_1} = 1.097 \times 10^7\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = 1.524 \times 10^6 \text{ m}$$

or $\lambda_1 = \frac{1}{1.524 \times 10^6} = 6.562 \times 10^{-7}$

$\lambda_1 = 6562$ Å

For second wavelength,

$$\frac{1}{\lambda_1} = 1.097 \times 10^7\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = 2.056 \times 10^6$$

or $\lambda_2 = \frac{1}{2.056 \times 10^6}$

or $\lambda_2 = 4.863$ or $\lambda_2 = 4863$ Å

17 The wavelength of different members of Balmer series are

$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{n_1^2}\right)$ where, $n = 3, 4, 5, \ldots$

The first member of Balmer series (H_α) corresponds to $n_i = 3$. It has maximum energy and hence the longest wavelength.

$$\therefore \quad \frac{1}{\lambda_1} = R_H\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$= 1.097 \times 10^7 \left(\frac{5}{36}\right)$$

$$\Rightarrow \quad \lambda_1 = \frac{36}{5 \times 1.097 \times 10^7}$$

$$= 6.563 \times 10^{-7} \text{ m}$$

$$\Rightarrow \quad n = 6563 \text{ Å}$$

The wavelength of the Balmer series limit corresponds to $n_i = \infty$ and has shortest wavelength.

$\therefore$ Wavelength of Balmer series limit is given by

$$\frac{1}{\lambda_\infty} = R_H\left[\frac{1}{2^2} - \frac{1}{\infty}\right] = 1.097 \times 10^7 \times \frac{1}{4}$$

$$\lambda_\infty = \frac{4}{1.097 \times 10^7} = 3.646 \times 10^{-7} \text{m}$$

$$= 3646 \text{ Å}$$

Only 4861Å is between the first and last line of the Balmer series.

18 Mass of uranium nucleus = Mass of proton + Mass of neutron

$$= 92 \times 1.6725 \times 10^{-27} + 143 \times 1.6747 \times 10^{-27}$$

$$= (153.87 \times 10^{-27} + 239.48 \times 10^{-27})$$

$$= 393.35 \times 10^{-27} \text{ kg}$$

Radius of nucleus is of the order of 10^{-15}m, hence volume is

$V \propto (10^{-15})^3 \text{ m}^3 \propto 10^{-45} \text{ m}^3$.

$$\therefore \text{ Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$= \frac{393.35 \times 10^{-27}}{10^{-45}} = 10^{20} \text{ kgm}^{-3}$$

19 Number of nuclei remain undecayed

$$N_A = N_0 e^{-10\lambda t}$$

and $\quad N_B = N_0 e^{-\lambda t}$

$$\Rightarrow \quad \frac{N_A}{N_B} = \frac{1}{e} = e^{(-10\lambda t + \lambda t)}$$

or $\quad 9\lambda t = 1$

$$\therefore \quad t = \frac{1}{9\lambda}$$

20 After $t >> t_{1/2}$, the equilibrium will be achieved, so that

$$\frac{dN}{dt} = \lambda N$$

$$\Rightarrow \quad R = \lambda N \Rightarrow N = \frac{R}{\lambda} = \frac{Rt_{1/2}}{0.693}$$

21 $R = R_0 A^{1/3}$

$\log R = \log R_0 + \frac{1}{3}\log A$,

which is a straight line.

22 $$\frac{N_X}{N_Y} = \frac{N_{0X} e^{-\lambda_X t}}{N_{0Y} e^{-\lambda_Y t}} = \frac{3000e^{-12t}}{6000e^{-10t}}$$

$$\frac{N_X}{N_Y} = \frac{1}{2}e^{-2t} \Rightarrow 1 = \frac{1}{2}e^{-2t} \qquad (N_X = N_Y)$$

$$e^{2t} = \frac{1}{2} \Rightarrow \log_e e^{2t} = \log_e \frac{1}{2}$$

$$2t = \log_e\left(\frac{1}{2}\right) \Rightarrow t = \frac{1}{2}\log_e\left[\frac{1}{2}\right]$$

23 From Rutherford-Soddy's law,

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

Given, $\quad N = 1 - \frac{3}{4} = \frac{1}{4}N_0, n = \frac{t}{T} = \frac{t}{4}$

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

$$\Rightarrow \quad 2 = \frac{t}{4} \Rightarrow t = 8 \text{ months}$$

24 From Rutherford law, $N = N_0\left(\frac{1}{2}\right)^n$

where, n is number of half-lives.

$$n = \frac{11400}{5700} = 2$$

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

$$\Rightarrow \quad \frac{N}{N_0} = \frac{1}{4} = 0.25 \Rightarrow N = 0.25N_0$$

$N = 0.25$ of original amount

25 $\lambda N = 3.7 \times 10^7$

$$\lambda = \frac{0.693}{t_{1/2}}$$

$$\therefore N = \frac{3.7 \times 10^7 \times t_{1/2}}{0.693} = 5.33 \times 10^{14}$$

6.023×10^{23} nuclides = 208 g

$\therefore$ 5.3×10^{14} nuclides

$$= \frac{208 \times 5.3 \times 10^{14}}{6.023 \times 10^{23}}$$

$$= 1.837 \times 10^{-7} \text{ g} = 0.184 \,\mu\text{g}$$

26 Number of half-lives, $n = 100 = \frac{1600}{2^n}$

or $\quad n = 4$ or $4t_{1/2} = 8$s

$$\therefore \quad t_{1/2} = 4 \text{ s}$$

$$N = \frac{N_0}{2^3} = \frac{1600}{8} = 200$$

27 Mean life $\tau = 1.44\, T_{1/2}$

$$\therefore \quad T_{1/2} = \frac{100}{1.44} = 69.44 \text{ s}$$

$$= \frac{69.44}{60} \approx 1.155 \text{ min}$$

28 $r = n_1\lambda_1, \tau = \frac{1}{\lambda}$

For radioactive equilibrium,

$$n_1\lambda_1 = n_2\lambda_2$$

$$r = N\lambda$$

$$r = N \cdot \frac{1}{\tau}$$

i.e. $\quad r\tau = N$

29 Since, $mvr = \frac{2nh}{2\pi}$

$\therefore$ In 2nd state KE becomes $\frac{1}{4}$ th of the initial KE i.e. 3.4 eV in $n = 1$.

Binding energy BE = − 27.2 + 3.4

= 23.8 eV

$$E_1 = 23.8 \text{ eV}, E_2 = \frac{23.8}{2^2} = 5.95 \text{eV},$$

$$E_3 = 2.64 \text{ eV} = \left(\frac{23.8}{3^2}\right)$$

$\therefore$ Minimum visible light energy is 2.64 eV.

$$\lambda = \frac{1242}{2.64} = 470 \text{ nm} \qquad \left[\because \lambda \propto \frac{1}{E}\right]$$

30 In order to compare the stability of the nuclei of different atoms, binding energy per nucleon is determined. Higher the binding energy per nucleon more stable is the nucleus.

$\therefore$ BE per nucleon of deuteron

$$= \frac{1.125}{2} = 0.5625 \text{ MeV}$$

BE per nucleon of α-particle = $\frac{7.2}{4}$

= 1.8 MeV

Since, binding energy per nucleon of α-particle is more. Hence, it is more stable.

31 The nuclei which have same number of neutrons but different atomic number and mass number are known as isotones. In choice (a) nuclei of ${}_{34}Se^{74}$ and ${}_{31}Ga^{71}$ are isotones, as

$$A - Z = 74 - 34$$

$$= 71 - 31$$

$$= 40$$

32 When an atom emits an α-particle, its mass number decreases by 4 and atomic number by 2, when it emits a β-particle its atomic number increases by 1, while there is no change in mass number and atomic number in γ-ray emission remains same.

$${}_{72}X^{180} \xrightarrow{-\alpha} {}_{70}Y^{176} \xrightarrow{-\beta}$$

$${}_{71}Z^{176} \xrightarrow{-\alpha} {}_{69}A^{172} \xrightarrow{-\gamma} {}_{69}P^{172}$$

33 When an α-particle is emitted, mass number of nuclide X is reduced by 4 and its charge number reduced by 2.

But when a β-particle is emitted, mass number of nuclide remains the same and its charge number is increased by 1. Hence, the resulting nuclide has atomic mass $(A-4)$ and atomic number $(Z-1)$.

34 X is neutrino because mass number and atomic number of neutrino is zero.

35 Let x be the mass number of A and y be the atomic number. Then, since atomic number and mass number remain conserved, we have

$$_yA^x \longrightarrow {}_{y-2}B^{x-4} + {}_2\text{He}^4$$

$$_{y-2}B^{x-4} \longrightarrow {}_yC^{x-4} + 2{}_{-1}e^0$$

Hence, we observe that A and C are isotopes as their atomic numbers are same but mass numbers are different.

36 $^{220}X \longrightarrow {}^{216}_{z-2}y + {}^4_2\text{He}$

$$0 = 216v_1 + 4v_2$$

$$\Rightarrow \quad v_1 = \frac{-4v_2}{216} = -\frac{v_2}{54}$$

$$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = Q$$

$$108v_1^2 + 2v_2^2 = 5.5\,\text{MeV}$$

$$108\left(-\frac{v_2}{54}\right)^2 + 2v_2^2 = 5.5\,\text{MeV}$$

$$\frac{v_2^2}{27} + 2v_2^2 = 5.5\,\text{MeV}$$

$$\Rightarrow \quad 2v_2^2 = 5.4\text{ MeV}$$

37 From Einstein's photoelectric equation

$$K = \frac{hc}{\lambda} - W$$

$$K' = \frac{hc}{\lambda/2} - W = 2\left(\frac{hc}{\lambda} - W\right) + W$$

$$= 2K + W$$

Energy $\propto \frac{1}{\lambda}$

38 From Bohr's orbit concept,

$$mv_2r_2 = 2\left(\frac{h}{2\pi}\right)$$

$$2\pi r_2 = 2\left(\frac{h}{mv_2}\right) = 2\lambda_2$$

Further $\lambda = \frac{h}{p}$ (de-Broglie concept)

$\therefore$ Speed of momentum is maximum in ground state.
Hence, λ is minimum.

39 $E_\text{H} = 13.6\text{ eV}$ [ionisation energy]

$$E_{\text{He}^+} = 13.6\,(z)^2$$

$$= 13.6\,(2)^2 = 54.4\text{ eV}$$

$$\Rightarrow \quad E_1 < E_2$$

Also, ionisation energy of single electron of He^+ is 54.4 eV.

40 Rate of nuclear process cannot be altered by altering pressure or temperature. Because any nuclear process involves huge amount of energy, also radioactivity is a nuclear phenomena.

41 In 1s only 90% remains.

At $t = 2$ s, activity will remain 90% of 90, i.e. 81 units.

42 Already emitted electrons will repel the new electrons, hence assertion is true but reason is false.

43 In the process of β-decay, either electron or positron is emitted because either a neutrino or an antineutrino is emitted. Thus, β-rays have a continuous energy spectrum. The maximum kinetic energy or end point energy (E) must be equal to disintegration energy. When electron (or positron) has maximum energy, the energy carried by the daughter nucleus and neutrino is nearly zero.

44 When four helium nuclei are fused together, one oxygen nucleus is formed. The reaction is

$$4 \times {}_2\text{He}^4 \rightarrow {}_8\text{O}^{16} + Q$$

Mass defect, $\Delta m = 4 \times m_\text{He} - m_{\text{O}_2}$

$$= 4 \times 4.0026 - 15.9994 = 0.011\text{ amu}$$

Energy produced,

$$E = 0.011 \times 931 = 10.24\text{ MeV}$$

45 $_ZX^A + {}_0n^1 \rightarrow {}_3\text{Li}^7 + {}_2\text{He}^4$

$A + 1 = 7 + 4$; $A = 11 - 1 = 10$

$Z + 0 = 3 + 2$; $Z = 5$

The element X is $_5\text{B}^{10}$.