# 18 Atom and Nucleus

**$\alpha$ – Scattering experiment and Rutherford's atomic model :**

– Radioactive source ${}_{83}Bi^{214}$ emitts, $\alpha$ – particles of energy 5.5 MeV, incident on a thin gold foil of thickness $2.1 \times 10^{-7}$ m. Scattered $\alpha$ – particles observed on circular scintillation screen of ZnS. [zinc sulphide]

– $10^5$ $\alpha$ – particles scattered at $< 15°$, 0.1% Scattered at ~150°, about only 1 out of $10^4$ $\alpha$ – particle was scattered at 180°.

– Path of scattered $\alpha$ – particle can be determined with the help of Coloumb's law and Newton's second law. Repulsive force acting between $\alpha$ – particle and gold nucleus is $F = \frac{1}{4\pi \in_0} \frac{(2e)(79e)}{r^2}$.

The magnitude and direction of the force on $\alpha$ – particle continuously changes as it approaches the nucleus.

– The perpendicular distance of the initial velocity vector of the $\alpha$ – particle from the centre of the nucleus is known as the **impact parameter (*b*)**.

– For head on collision $b = 0$.

– The minimum distance of the $\alpha$ – particle from the centre of the nucleus (for $b = 0$) is known as the **distance of closest approach.**

– Radius of nucleus is about $10^{-15}$ m.

● If '*t*' is thickness of foil and '*N*' are No. of scattered $\alpha$ – particles then, $\frac{N}{t}$ = constant,

$$\frac{N_1}{t_1} = \frac{N_2}{t_2}.$$

According to Rutherford, orbit of an electron is not circular but spiral and motion of an electron ends inside the nucleus. In this case the atom cannot remain stable. Thus Rutherford's atomic model failed to explain the stability of atom.

---

(1) An $\alpha$ – Particle of 10 MeV is moving for a head on collision. What will be the distance of closest approach from the nucleus of atomic number Z = 60 ?

(A) $1.44 \times 10^{-14}$ m (B) $2.88 \times 10^{-14}$ m (C) $0.53 \times 10^{-14}$ m (D) $1.728 \times 10^{-14}$ m

(2) An $\alpha$ – particle with some energy is moving for head on collision with nucleus of Z = 85, if the distance of closest approach is $1.85 \times 10^{-14}$ m, find the energy of $\alpha$ – particle.

(A) 23.13 MeV (B) 13.2 MeV (C) 10 MeV (D) 20 MeV

(3) Distance of closest approach of an $\alpha$ – particle with energy 27 MeV is $1.10 \times 10^{-14}$ m. Find atomic no of an atom ?

(A) 100 (B) 103 (C) 105 (D) 90

(4) If thickness of foil in $\alpha$ – scattering experiment increases from $2 \times 10^{-7}$ m to $2.5 \times 10^{-6}$ m, Find the increased number of scattered $\alpha$ – particles ?

(A) about 12 times (B) 100 times (C) remains constant (D) 10 times

(5) If number of scattered $\alpha$ – particles increased by 40%, what is the percentage change in thickness of foil ?

(A) 40 % (B) 80 % (C) 10 % (D) 20 %

(6) If thickness of foil is $t_1$, number of scattered $\alpha$ – particles are 8500 and thickness of foil is $t_2$, No. of scattered $\alpha$ – particles are 27,500 then,

(A) $t_1 = 3.2\, t_2$ (B) $t_2 = 3.2\, t_1$ (C) $t_2 = 1.6\, t_1$ (D) $t_2 = t_1$

| **Ans. : 1 (D), 2 (B), 3 (B), 4 (A), 5 (A), 6 (B)** |
|---|

**Bohr's atomic model and energy levels of *H*-atom**

**Hypothesis-1 :** Electron can revolve only in those orbits in which its orbital angular momentum is an integral multiple of $\frac{h}{2\pi}$. These orbits are known as **stationary** or **stable** orbits. In such orbit electron does not radiate energy. $\frac{h}{2\pi} = \hbar$ and $h =$ Plank's constant $= 6.625 \times 10^{-34}$ Js.

**Hypothesis-2 :** When electron transit from higher energy $(E_i)$ orbit to lower energy $(E_k)$ orbit. It radiates photon of frequency *f*. Similarly when electron absorbs a photon of frequency *f*, it makes transition from lower energy state $(E_k)$ to higher energy state $(E_i)$. $E_i - E_k = hf$.

$$l = mvr = \frac{nh}{2\pi} = n\hbar$$

$$E_i - E_k = hf = \frac{hc}{\lambda}$$

- Radius of an orbit is,

$$r = \frac{n^2 h^2 \epsilon_0}{\pi m Z e^2}$$ where, $n =$ principle quantum no.

$$r \propto \frac{n^2}{Z}$$ $\epsilon_0 =$ permittivity of vaccum

m = mass of an electron, Z = atomic number

For H – atom $r \propto n^2$.

- Kinetic energy for electron,

$$K = \frac{1}{2} mv^2 = \frac{1}{8\pi \epsilon_0} \frac{Ze^2}{r}$$

Potential energy, $U = \frac{-1}{4\pi \epsilon_0} \frac{(Ze)(e)}{r}$

$$= \frac{-1}{4\pi \epsilon_0} \frac{Ze^2}{r}$$

Total energy (E) = K + U

$$E = \frac{-1}{8\pi \epsilon_0} \frac{Ze^2}{r}$$

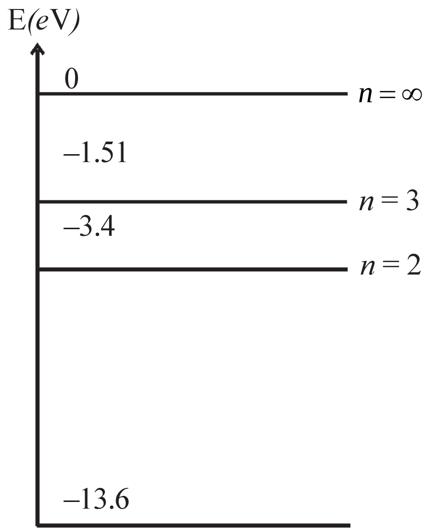
$$\boxed{E = -K = \frac{U}{2}}$$

- by substituting value of $r$, $E = E_n = \frac{-me^4Z^2}{8\epsilon_0^2 h^2 n^2}$, by substituting value of m, $e$, $\epsilon_0$, $h$

$$E_n = \frac{-13.6\ Z^2}{n^2}\ eV,\quad E_n \ \alpha\ \frac{-Z^2}{n^2}$$

For H – atom $Z = 1 \Rightarrow E_n = \frac{-13.6}{n^2}\ eV \qquad E_n \propto -\frac{1}{n^2}$.

**Energy levels of *H* – atom :**




$n = 3$ (Second excited state)

$n = 2$ (First excited state)

$n = 1$ (Ground State)

- Transition of an electron from orbit with quantum number $n_i$ and energy $E_i$ to orbit with quantum number $n_k$ and energy $E_k$, $E_i - E_k = hf$

$$\therefore \quad f = \frac{me^4}{8 \in_0^2 h^3}\left(\frac{1}{n_k^2} - \frac{1}{n_i^2}\right)$$

$$\therefore \quad \frac{1}{\lambda} = \frac{me^4}{8 \in_0^2 C\, h^3}\left(\frac{1}{n_k^2} - \frac{1}{n_i^2}\right)$$

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

જ્યાં $\frac{me^4}{8 \in_0^2 c h^3} = R$ = Rydberg constant = $10973700\ m^{-1}$.

- Rydberg constant for an atom,

$$R_{atom} = \frac{R_\infty}{1+\frac{m}{M_{atom}}}$$

$R_\infty = 10973700\ m^{-1}$, m = mass of an electron, M = mass of nucleus of atom.

- Frequency of electron in a orbit with principle quantum number '*n*' for hydrogen atom,

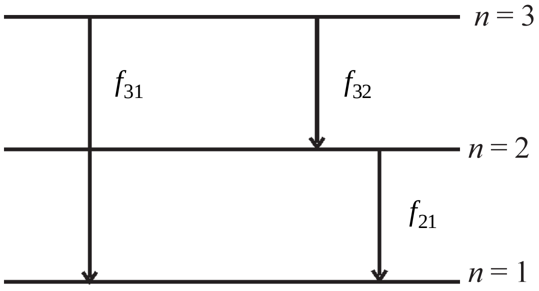
$$f = \frac{me^4}{4 \in_0^2 h^3 n^3}, \qquad \text{angular frequency} \qquad \omega = \frac{\pi me^4}{2 \in_0^2 h^3 n^3}$$

$$f = \frac{2Rc}{n^3} \qquad\qquad \omega \propto \frac{1}{n^3}$$

$$\frac{1}{\lambda} = \frac{2R}{n^3} \qquad\qquad \text{(Periodic time)}\ T \propto n^3$$

$$f \ \alpha\ n^{-3}, \quad \lambda \propto n^3$$

- If electron transit form $n = 3$ to $n = 2$ and $n = 2$ to $n = 1$




$$hf_{31} = hf_{32} + hf_{21}$$

$$\therefore \quad f_{31} = f_{32} + f_{21}$$

$$\therefore \quad \frac{1}{\lambda_{31}} = \frac{1}{\lambda_{32}} + \frac{1}{\lambda_{21}}$$

**Success of the Bohr model :**

- Stability and energy of Hydrogen-like atoms can be calculated.
- Atomic spectra of Hydrogenic atoms $\left(\text{e.g. } He^{+},\ Li^{+2},\ Be^{+3}\right)$ can be explain.
- It is useful for the confirmation of some principles, for the invention of "heavy hydrogen" or "deuterium".

**Limitations :**

- The orbits of an electron need not to be circular.
- There is an odd combination of classical and quantum mechanics.
- Unable to explain the relative intensities of the spectral lines.
- Fine structure of spectral lines can not be explained.
- Unable to explain the arrangement of electrons in atoms.

---

(7) The ratio of energies in Fourth and third excited state for Hydrogen atom is ________.

(A) 4 : 5 (B) 16 : 25 (C) 25 : 16 (D) 1 : 1

(8) Momentum of photon of red light with frequency $400 \times 10^{12}$ Hz is ________ .

($c = 3 \times 10^{8}\ ms^{-1}$)

(A) Zero (B) $8.8 \times 10^{-28}\ kgms^{-1}$

(C) $11.65 \times 10^{-6}\ MeV\ C^{-1}$ (D) insufficient information

(9) Calculate the radius of an electron in most external orbit, when Phosphorus atom is added in Silicon (whose Di-electric constant = 12).

(A) 380.9 pm (B) 390.8 pm (C) 930.8 pm (D) 830.9 pm

(10) Linear speed of an electron in Hydrogen atom for ground state (first orbit) is ________.

(A) $\frac{c}{2}$ (B) $\frac{c}{11}$ (C) $\frac{c}{137}$ (D) $\frac{c}{274}$

(11) When electron transit from $n = 5$ to $n = 1$ in Hydrogen atom. Find the speed of emitted photon.

(A) $10^{-4}\ ms^{-1}$ (B) $2 \times 10^{-2}\ ms^{-1}$ (C) $4\ ms^{-1}$ (D) $8 \times 10^{2}\ ms^{-1}$

(12) If R, $v$, T and E are radius of orbit, speed of electron, periodic time of revolution and total energy of an electron respectively. Which option is not directly proportional to quantum number '$n$'.

(A) $v$R (B) RE (C) $\frac{v}{E}$ (D) $\frac{T}{R}$

(13) Total energy of an electron in first excited state for Hydrogen atom is –3.4 *e*V. What is kinetic energy of this electron ?

(A) 0 (B) 3.4 eV (C) –3.4 eV (D) 6.8 eV

(14) Angular momentum of an electron in Hydrogen atom for ground state is $L_1$ and for fourth excited state is $L_4$ then $L_4 - L_1 =$ ________.

(A) $5L_1$ (B) $3L_1$ (C) $2L_1$ (D) $4L_1$

(15) Energy of photon in Hydrogen atom is 12.1 eV, its angular momentum is ________.

(A) $1.05 \times 10^{-34}$ Js (B) $2.11 \times 10^{-34}$ Js (C) $3.16 \times 10^{-34}$ Js (D) $4.22 \times 10^{-34}$ Js

(16) Kinetic energy of an electron in $n$ = 1 for H-atom is 13.6 eV, Total energy of an electron for $n$ = 2 for $He^{+2}$ is ________.

(A) 13.6 eV (B) 3.4 eV (C) −13.6 eV (D) −3.4 eV

(17) Find the ratio of orbital periodic time for an electron in $n$ = 1 and $n$ = 2.

(A) 1 : 2 (B) 2 : 1 (C) 1 : 4 (D) 1 : 8

(18) Ratio of orbital area for an electron in first excited state and ground state in Hydrogen atom is ________.

(A) 2 : 1 (B) 4 : 1 (C) 8 : 1 (D) 16 : 1

(19) Energy of an electron in ground state for H – atom is (R = Rydberg's constant) ________.

(A) $-\frac{Rh}{c}$ (B) $\frac{-1}{Rhc}$ (C) $-Rhc$ (D) $\frac{hc}{R}$

(20) Radius of first orbit in Hydrogen atom is $0.528\ \mathring{A}$, radius of second orbit is ________.

(A) $4.752\ \mathring{A}$ (B) $2.112\ \mathring{A}$ (C) $0.071\ \mathring{A}$ (D) $0.142\ \mathring{A}$

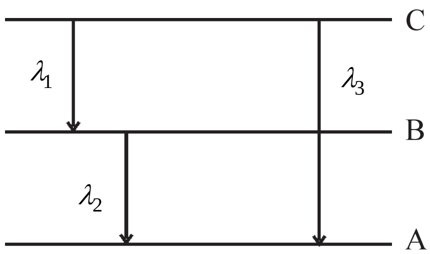
(21) Find the speed of photon during transition $n$ = 5 to $n$ = 1 in Hydrogen atom.

(A) $4.718\ ms^{-1}$ (B) $7.418\ ms^{-1}$ (C) $4.178\ ms^{-1}$ (D) $7.148\ ms^{-1}$

(22) If principle quantum number $n > 4$ is not possible, then number of possible elements are ________.

(A) 4 (B) 32 (C) 60 (D) 64

(23) For energy levels A, B and C, $E_A < E_B < E_C$. $\lambda_1, \lambda_2$ and $\lambda_3$ are wave lengths for A, B, and C. Which option is true for a transistion in Figure.




(A) $\lambda_3 = \lambda_1 + \lambda_2$ (B) $\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$

(C) $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$ (D) $\lambda_1 + \lambda_2 + \lambda_3 = 0$

(24) Electron transit from fourth orbit to first excited state in Hydrogen atom, Find the frequency of radiation. $\left(R = 10^7\ m^{-1}\right)$

(A) $\frac{3}{16} \times 10^5$ Hz (B) $\frac{3}{16} \times 10^{15}$ Hz (C) $\frac{9}{16} \times 10^{15}$ Hz (D) $\frac{3}{4} \times 10^{15}$ Hz

(25) Total energy of an electron in excited state of H – atom is –3.4 *e*V. calculate the De-broglie wavelength.

(A) $6.6 \times 10^{-10}$ m (B) $6.6 \times 10^{-11}$ m (C) $6.6 \times 10^{-9}$ m (D) $6.6 \times 10^{-12}$ m

(26) Orbital angular momentum quantum number $l = 7$, What is orbital angular momentum ?

(A) $\frac{7h}{2\pi}$ (B) $\frac{42h}{2\pi}$ (C) $\sqrt{7}\frac{h}{2\pi}$ (D) $\sqrt{56}\frac{h}{2\pi}$

**Ans. : 7 (C), 8 (B), 9 (A), 10 (C), 11 (C), 12 (B), 13 (B), 14 (D), 15 (B), 16 (C), 17 (D), 18 (D), 19 (C), 20 (B), 21 (C), 22 (C), 23 (B), 24 (C), 25 (A), 26 (D)**

**Hydrogen spectrum :**

When Hydrogen electrically discharged at low pressure, atom excited and emits radiation of certain wavelengths. The group of these radiations is called Hydrogen spectrum.

- **Different series**

**Lyman series :** $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$

where $n = 2, 3, 4 ...$

$n = 2 \rightarrow H_\alpha$ or $L_\alpha$ line

$n = 3 \rightarrow H_\beta$ or $L_\beta$ line

$n = 4 \rightarrow H_\gamma$ or $L_\gamma$ line

- In Lyman series for maximum wavelength $n = 2$ and minimum wavelength $n = \infty$.
- It is seen in ultraviolet region.
- **Balmar series :** $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$

where $n = 3, 4, 5, 6 ...$

$n = 3 \rightarrow H_\alpha$ | for maximum wavelength $\rightarrow n = 3$

$n = 4 \rightarrow H_\beta$ | for minimum wavelength $\rightarrow n = \infty$

- It is seen in visible region.

- **Paschen series** $\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right)$

  Where $n = 4, 5, 6, 7 \ldots$

- $n = 4 \rightarrow H_\alpha,\ n = 5 \rightarrow H_\beta, \ldots.$
- for maximum $\lambda \rightarrow n = 4$, for minimum $\lambda \rightarrow n = \infty$
- In near infrared region.
- **Brackett series** $\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n^2}\right)$

  where $n = 5, 6, 7, 8 \ldots$

- $n = 5 \rightarrow H_\alpha,\ n = 6 \rightarrow H_\beta, \ldots.$
- for $\lambda_{max} \rightarrow n = 5$, for $\lambda_{min} \rightarrow n = \infty$
- In infrared region.
- **Pfund series :** $\frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{n^2}\right)$

  where $n = 6, 7, 8 \ldots$

- $n = 6 \rightarrow H_\alpha,\ n = 7 \rightarrow H_\beta, \ldots.$
- for $\lambda_{max} \rightarrow n = 6$, for $\lambda_{min} \rightarrow n = \infty$ In far infrared region

- When electron transits in lower orbit from $n^{th}$ orbit no. of emitted spectrat lines = $\frac{n(n-1)}{2}$.
- Emitted wavelength for any atonic spectra, $\frac{1}{\lambda} = R\,Z^2\left(\frac{1}{n_{k^2}} - \frac{1}{n_{i^2}}\right)$.

---

(27) Hydrogen $\left({}_1H^1\right)$, deuterium $\left({}_1H^2\right)$, ionized helium $\left({}_2He^4\right)^+$ and ionized lithium $\left({}_3Li^6\right)^{++}$ are given. Their wavelengths are $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ respectively compare their wavelengths for a transistion of an electron from $n = 2$ to $n = 1$.

(A) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$ (B) $4\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

(C) $\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$ (D) $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

(28) Calculate the number of emitted spectral lines, when hydrogen atom having principle quantum number = 4 moves from ground state to specific excited state.

(A) 3 (B) 5 (C) 6 (D) 2

(29) Find the ratio of minimum and maximum wavelength for H-spectra.

(A) 81.86 (B) 86.81 (C) 0.012 (D) 0.12

(30) Find the ratio of maximum and minimum wavelength for Brackett series.

(A) 3.6 (B) 0.36 (C) 78.2 (D) 2.78

(31) Maximum wave number in infrared series is ________ $m^{-1}$.

(A) $12.18 \times 10^5$ (B) $12.18 \times 10^{10}$ (C) $18.12 \times 10^5$ (D) 8204

(32) Find the ratio of $\lambda$ of $\alpha -$ line, for Balmer and Lyman series.

(A) 27 : 5 (B) 5 : 27 (C) 1 : 4 (D) 20 : 27

(33) Wavelength of first line for Balmar series ________.

(A) 6563 $\overset{\circ}{A}$ (B) 6365 $\overset{\circ}{A}$ (C) 6563 m (D) 6563 cm

(34) $f_1$ and $f_2$ are frequency of last and first line of Lyman series. $f_3$ is frequency of last line of Balmar series then,

(A) $f_1 - f_2 = f_3$ (B) $f_2 - f_1 = f_3$ (C) $f_3 = \frac{1}{2}(f_1 + f_2)$ (D) $f_1 + f_2 = f_3$

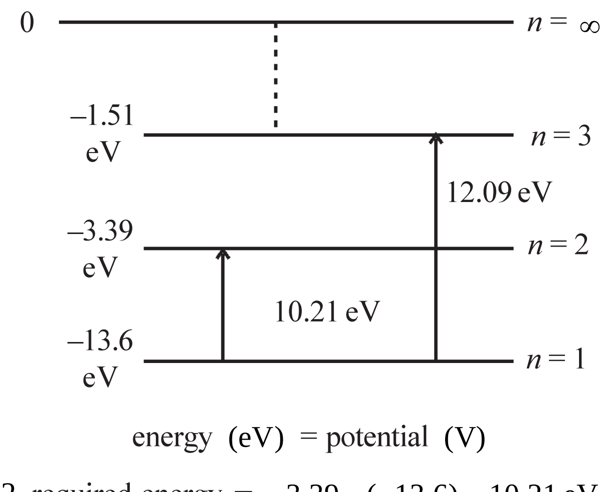
(35) Minimum wavelength of Lyman series is $912\ \overset{\circ}{A}$, then maximum wavelength is ________ $\overset{\circ}{A}$.

(A) 1216 $\overset{\circ}{A}$ (B) 1824 $\overset{\circ}{A}$ (C) 2434 $\overset{\circ}{A}$ (D) 3648 $\overset{\circ}{A}$

| **Ans. : 27 (D), 28 (C), 29 (C), 30 (D), 31 (A), 32 (A), 33 (A), 34 (A), 35 (A)** |
|---|

**Excitation and Ionization energy and potential**

- Electron revolving in a stationary orbit absorbs specific energy and jumps to an orbit of higher energy, absorbed energy is called excitation energy and corresponding potential is called excitatoion potential.

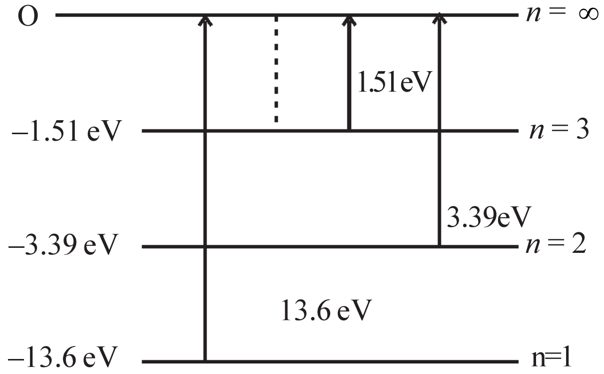



energy (eV) = potential (V)

$n = 1 \rightarrow n = 2$ required energy $= -3.39 - (-13.6) = 10.21$ eV

$n = 1 \rightarrow n = 3$ required energy $= -1.51 - (-13.6) = 12.09$ eV

- The minimum energy required to remove an electron from an atom (to send is it $n = \infty$) is called ionization energy and corresponding potantial is called ionization potential. Ionization energy $(e\text{V}) = \text{Ionization patential (V)}$.

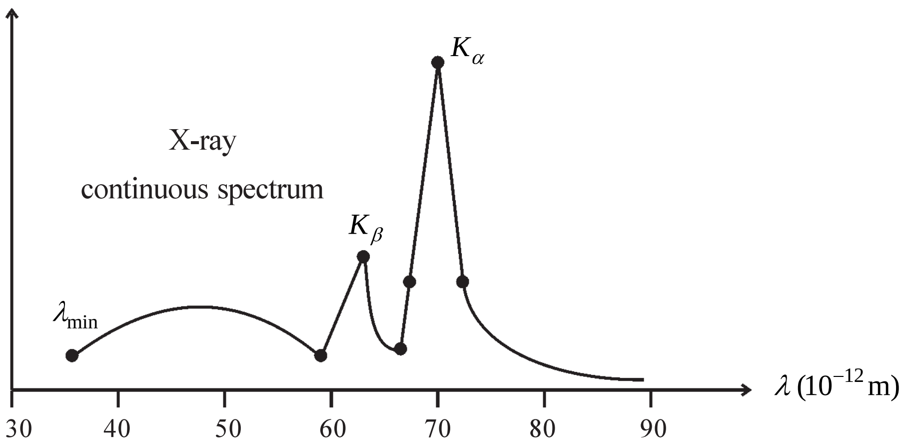



- $n = 1 \rightarrow n = \infty$ required energy $= 0 - (-13.6) = 13.6$ eV
- $n = 2 \rightarrow n = \infty$ $0 - (-3.39) = 3.39$ eV

**Emission and absorption spectra**

- During the transition of an electron from higher energy $(E_i)$ orbit to lower energy $(E_k)$ orbit, the emitted radiation is called emission spectrum $E_i - E_k = hf$ .
- Intensity of such a spectral lines increases as atomic density increases and it decreases as temperature increases.
- Wavelength of spectraline depends on atomic number.
- Radiation of continuous wavelength is incident on atomic gas to send electron from lower energy orbit to higher energy orbit. In incident radiation certain wavelength absorbs, these appear as dark lines in the spectrum, such a spectrum is known as "absorption spectrum".
- For example, radiation emitted by the lower layer of photosphere in the Sun, certain wavelength are absorbed hence dark lines are observed. These lines are called fraun hoffer lines.

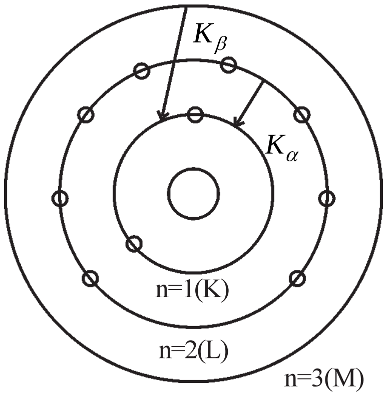
- **X-ray :** Discovered by Rontgen. wavelength between 0.001 to 1 nm.
  - X-ray emitted when there is a collision between electron and anode of Cu, Tungston and $M_o$ . Electrons accelerated with $20 - 40$ kV .
  - **Relative intensity**



- All the wavelengths (frequencies) emitted in X – ray radiation causes continuous spectrum.
- During the head on collision of electron with anode, radiation of minimum wavelength and maximum frequency emitted.

$\lambda_{min} = \dfrac{hc}{eV}$ where V = potential required to accelerate the electron.

- **Characteristic *X* – ray spectrum :**




- Incident electrons penetrate deep into the atoms of the anode and knock out the electron from the atom, from the inner shells, which creates vacancies. The electron from outer shells experience transition to these vacancies and fill them. The radiation of definite frequencies are emitted during such transition.
- The radiation is called $K_\alpha$, if it is emitted when electron of K – shell ($n=1$) is thrown out and the vacancy is filled by the electron from L – shell ($n=2$). Similarly $K_\beta$ during the transition from $n=3$ to $n=1$, $L_\alpha$ during the transition from $n=3$ to $n=2$. The $X$ – ray spectrum formed by such lines is called the **chracteristic spectrum.**
- Due to screening of the charge of the nucleus $Z \to Z-1$.

Energy $\quad E_n = -\dfrac{me^4 (Z-1)^2}{8\epsilon_0^2 n^2 h^2}$

$$= -\frac{13.6 (Z-1)^2}{n^2} eV$$

- For $K_\alpha$ radiation : $E_L - E_K = hf_{K_\alpha}$

$\therefore \quad hf_{k_\alpha} = 13.6 (Z-1)^2 \left(\dfrac{1}{1^2} - \dfrac{1}{2^2}\right) \times 1.6 \times 10^{-19}$ J

$\therefore \quad f_{k_\alpha} = \dfrac{13.6 \times 1.6 \times 10^{-19}}{6.62 \times 10^{-34}} \left(\dfrac{3}{4}\right) (Z-1)^2$

$$\therefore \quad \sqrt{f} = \sqrt{\frac{13.6 \times 1.6 \times 10^{-19} \times 3}{6.62 \times 10^{-34} \times 4}} \; (Z-1)$$

$$\therefore \quad \sqrt{f} = C \; (Z-1)$$

$$\therefore \quad \sqrt{f} = CZ - C$$ equation of straigth line.

where $C = 4.965 \times 10^{7} \; Hz^{\frac{1}{2}}$

$\sqrt{f} \rightarrow Z$ graph is straight lines and its slope is C.

**Moseley's expt. work :**

- Moseley suggested that the elements should be arranged with respect to their atomic numbers, which establish the relation between chemical properties and position of elements in the periodic table.
- Missing positions in periodic table filled up with appropriate elements.
- Rare earth (Lanthanide) elements, elements coming after Uranium, are arranged properly.
- Information regarding to charge of nucleus can be obtained with the help of $K_\alpha$ radiation.

**Other useful information :**

- $\lambda \le 4\overset{\circ}{A}$ radiation, whose penetration is high, called hard X – ray.
- $\lambda > 4\overset{\circ}{A}$ radiction, whose penetration is low, called soft X – ray.
- Only 1 % energy of incident electron converts in energy of X – ray 99 % energy, waste in form of Heat. So, arrangement of cooling is required in coolidge tube.
- If $f$ is a fraction of kinetic energy of an electron, converts in X – ray then wavelength of emitted X – ray is, $\lambda = \dfrac{hc}{f\,eV_0}$.
- $\underset{(L \rightarrow K)}{K_\alpha}$ radiation : $E_L - E_K = hf_{K_\alpha}$
- $\underset{(M \rightarrow K)}{K_\beta}$ radiation : $E_M - E_K = hf_{K_\beta}$
- $\underset{(M \rightarrow L)}{L_\alpha}$ radiation : $E_M - E_L = hf_{L_\alpha}$

(36) Excitation energy in third orbit for Hydrogen atom is ________eV.

(A) 1.51 eV (B) 3.4 eV (C) 0.66 eV (D) 0.85 eV

(37) Energy required to send an electron from second orbit to third orbit is 47.22 *e*V for a given atom, then its atomic number is ________.

(A) 1 (B) 3 (C) 4 (D) 5

(38) Excitation potential of Helium atom in second orbit is ________.

(A) 7.55 V (B) 21.7 V (C) 13.2 V (D) 10.21 V

(39) For an atom excitation potential in first is 'V' volt, its ionization potential is ________ volt.

(A) $\frac{1}{4}$ (B) $\frac{3}{4}$ (C) $\frac{4}{3}$ (D) $\frac{5}{4}$

(40) Energy required to remove an electron from first excited state in $Li^{++}$ is ________ eV.

(A) 122.4 (B) 30.6 (C) 13.6 (D) 3.4

(41) If accelerating potential in X – ray tube increases, ________.

(A) Intensity of X – ray increases. (B) minimum wavelength of X – ray increases.

(C) minimum wavelength of X – ray decreases. (D) Intensity of X – ray decreases.

(42) Wavelength of X – ray photon is $3.3\ \mathring{A}$, its corresponding energy is ________.

(A) 7.5 keV (B) 3.8 keV (C) 5.5 MeV (D) 3.7 MeV

(43) Minimum wavelength in X – ray tube of potential 4 MV is ________$\mathring{A}$.

(A) 1 (B) 0.0062 (C) 0.0031 (D) $10^{-5}$

(44) Changing of position of molecules and proper place of molecules can be explained with the help of ________.

(A) Moseley's law (B) Mendeleev's law (C) Crompton effect (D) Hund's law

(45) Wavelength $K_\alpha$ X-Ray is $0.76\ \mathring{A}$, then find the atomic number of element of anode.

(A) 20 (B) 60 (C) 41 (D) 80

(46) In two different emission of $K_\alpha$ radiation atomic number of target nucleus are 65 and 81. Find the ratio of their wavelengths.

(A) $\frac{1}{4}$ (B) $\frac{1}{16}$ (C) $\frac{2}{\sqrt{5}}$ (D) $\frac{25}{16}$

(47) If accelerating potential in X – ray tube increases, speed of X – ray ________.

(A) Increases (B) Decreases (C) Does not change (D) nothing can be said

(48) Operating voltage in X – ray tube is 66 kV, in continuous spectrum of X – ray ________.

(A) 0.01 nm and 0.02 nm wavelengths remains present.

(B) Both the above wavelengths are absent.

(C) 0.01 nm wavelength would be present and 0.02 nm wavelength would be absent.

(D) 0.01 nm wavelength would be absent and 0.02 nm wavelength would be present.

(49) Maximum radiated frequency in X-ray tube is '$f$' and operating voltage is 'V' volt. If operating voltage becomes $\frac{V}{2}$, find maximum radiated frequency.

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

(50) Wavelength of $K_\alpha$ radiation from $Z = 41$ is $\lambda$, wavelength of $K_\alpha$ radiation from $Z = 21$ is ________.

(A) $4\lambda$ (B) $\frac{\lambda}{4}$ (C) $3.08\,\lambda$ (D) $0.26\,\lambda$

(51) Electron beam of 80 keV energy is incident on Tungston in $X$ – ray tube. If energy of an electron in K – shell of Tungston is –72.5 keV then ________.

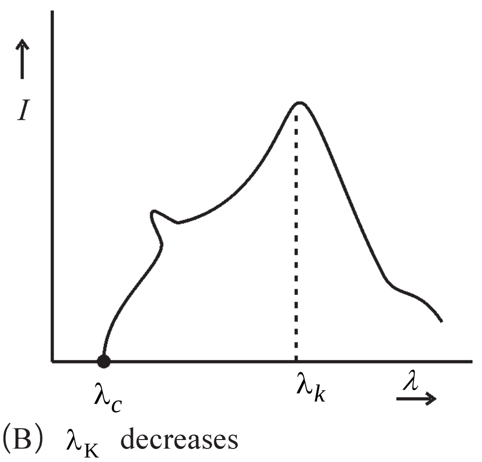
(A) Presence of continuous spectrum with minimum wavelength $0.155\ \mathring{A}$ is observed.

(B) Continuous spectrum of all the wavelengths is observed.

(C) Characteristic spectrum of $X$ – ray of tungston is observed.

(D) Continuous spectrum of minimum wavelength $0.155\ \mathring{A}$ and characteristic spectrum of $X$ – ray is observed.

(52) Gragh of Intensity of X – ray $\rightarrow$ wavelength in Coolidge tube is as shown in Figure. $\lambda_c$ = minimum wavelength and $\lambda_K$ = wavelength of $K_\alpha$. If Accelerating potential increases then ________.




(A) $\lambda_c$ Increases (B) $\lambda_K$ decreases

(C) $\lambda_K - \lambda_c$ Increases (D) $\lambda_c$, $\lambda_K$ decreases but $\lambda_K - \lambda_c$ remain constant.

(53) Ionization energy of H–atom is 13.6 eV. H–atom in the ground state is excited with the help of radiation of 12.1 eV energy. Number of radiated spectral lines are ________ .

(A) One (B) Two (C) Three (D) Four

(54) Wavelength of $K_\alpha$ radiation in H-atom during the emission of X-ray is 0.32 $\overset{\circ}{A}$, then wavelength of $K_\beta$ radiation is ________.

(A) 0.21 $\overset{\circ}{A}$ (B) 0.27 $\overset{\circ}{A}$ (C) 0.34 $\overset{\circ}{A}$ (D) 0.40 $\overset{\circ}{A}$

(55) If $Z$ is atomic number of element, Frequency of characteristic spectrum of $X-$ ray is directly proportional to ________.

(A) $Z^2$ (B) $(Z-1)^2$ (C) $Z$ (D) $\frac{1}{Z}$

| | |
|---|---|
| **Ans. :** | **36 (C), 37 (D), 38 (A), 39 (C), 40 (B), 41 (C), 42 (B), 43 (C), 44 (A), 45 (C), 46 (D), 47 (C), 48 (D), 49 (A), 50 (A), 51 (D), 52 (C), 53 (C), 54 (B), 55 (B)** |

**Atomic mass and the constitution of Nucleus :**

- The entire mass and entire positive charge are concentrated at the central region, known as nucleus, includes protons and neutrons.
- Proton and neutron are is also called nucleon.
- Atomic number (Z) = number of protons (P)
- Atomic mass number (A) = [P + *n*]
- neutron number (N) = A – Z
- Symbol for element $_ZX^A$ or $^A_ZX$
- The 12th (twelfth) part of the mass of unexcited $_6C^{12}$ atom is called 1 *amu*.

  $1u = 1\ amu = 1.66 \times 10^{-27}$ kg
- mass spectrometer is used to measured mass of an atoms accurately.
- **Isotops** having same chemical propertics but different mass. same number of protons but different number of neutrons.
- For example in case of C*l*, the proportion of 34.98 *u* is 75.4 % and 36.98 *u* is 24.6 %. Hence the mass of C*l* atom is obtained from its weighted average.

  mass of C*l* Atom = $\frac{75.4 \times 34.98 + 24.6 \times 36.98}{100}$

  $= 35.47\ u$
- The nuclei for which the neutron number (N = A – Z) is same are called **isotones.**
- For nuclei Z, A, N are same but radio active properties are different called **isomers.**
- For nuclei atomic mass number (A) are same, called **isobars.**

- e.g. of isotops : ${}_{92}U^{235}$, ${}_{92}U^{238}$
- e.g. of isotops : ${}_{36}Kr^{86}$, ${}_{37}Rb^{87}$
- e.g. of isobars : ${}_{82}Pb^{214}$, ${}_{83}Bi^{214}$
- ${}_{35}Br^{80}$ having a pair of isomers.

**Naclear forces, nuclear radius and stability of nucleus**

- P–P, P–n, n–n strong nuclear force.
- It is also called quark-quark force because P and n are made up of quarks.
- Types of quarks : up, down, charm, strange, top, bottom.
- Nuclear forces depends on orientation of spin.
- Average radius of nucleus is given by $R = R_0\ A^{\frac{1}{3}}$ where $R_0 = 1.1\ fm$
- Density of nucleus is about $2.3 \times 10^{17}$ kgm$^{-3}$, $10^{14}$ times than density of water.
- As atomic number increases, coloumbian force increases multiplyingly, to balance it number of neutron increases so that strong nuclear force icreased.

  For e.g. ${}_{6}C^{12}$ P = 6, n = 6 but in ${}_{92}U^{235}$ P = 92, n = 143

  It is essential condition for the stability of nucleus.
- **Mass - energy :** $1\,u = 1.66 \times 10^{-27}$ kg ; $1\text{ eV} = 1.6 \times 10^{-19}$ J

  $1\,u = 931.48$ MeV $\rightarrow$ mass-energy equivalency

  $$E = mc^2$$

  $$= (1\,u)\ (3 \times 10^8\ \text{ms}^{-1})^2$$

  $$= \frac{(1.66 \times 10^{-27})\ (9 \times 10^{16})}{1.6 \times 10^{-19}} = 931.48 \times 10^6 = 931.48\ \text{MeV}$$

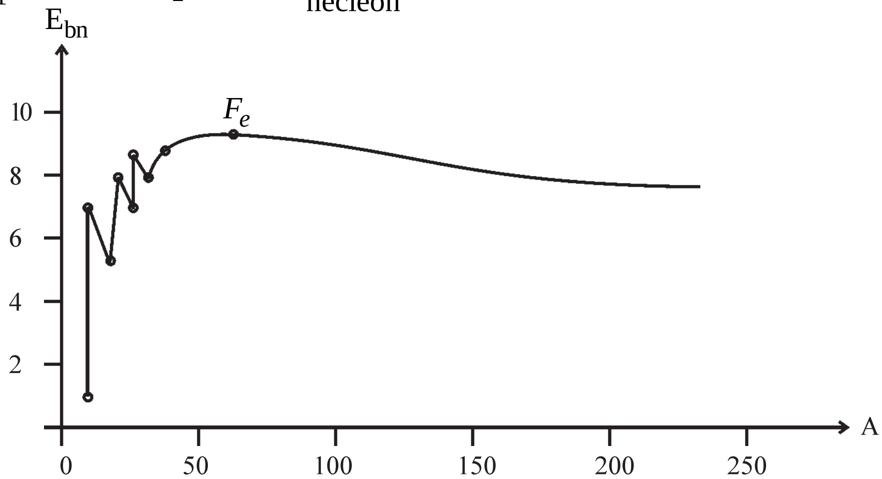
**Binding energy of nucleus**

Mass of the nucleus is always less than the total mass of its constituents in the free state. This decrease in the mass is called **mass defect,**

$$M < Zm_p + Nm_n$$

$$\Delta m = Zm_p + Nm_n - M$$

- The energy equivalent to mass defect is called **binding energy** of nucleus. $E_b = (\Delta m)\, c^2$.
- When it is divided with number of nucleons, we get average **binding energy per nucleon-** $E_{bn} = \left(\frac{E_b}{A}\right)$, this energy is actually measurement of stability of the nucleus.
- $E_{bn}$ is an average energy per nucleon to release all the constituent particles from the nucleus.
- Average binding energy per nucleon $(E_{bn})$ is measurement of stability of the nucleus.
- In case of deutron, ${}_1H^2$ its mass is 2.0141 *u* and sum of the mass of proton and neutron in free state is 2.0165 *u*. $\Delta m = 2.0165 - 2.0141 = 0.0024\, u$, the energy equivalent to this mass defect is $= 0.0024 \times 931.48 = 2.24$ MeV. Which is called binding energy.
- Hence, binding energy of ${}_1H^2$ is 2.24 MeV.
- Thus to liberate proton and neutron from ${}_1H^2$, 2.24 MeV energy has to be supplied to it from outside. Conversely if one proton and one neutron coalease 2.24 MeV energy is emitted out.
- For ${}_1H^2$ $E_{bn} = \frac{2.24}{2} = 1.12 \frac{\text{MeV}}{\text{necleon}}$.




- $E_{bn}$ is maximum $\left(\approx 8.8 \frac{\text{MeV}}{\textit{nucleon}}\right)$ for the nucleus of (Fe) $[A = 56]$.
- $E_{bn}$ is small for $A < 30$ and $A > 170$.
- For $30 < A < 170$ $E_{bn}$ is almost constant. These nuclei are the most stable. It is due to the saturation property of the nuclear forces.
- When heavy nucleus $(A > 170)$ gets divided in two lighter nuclei, energy released, this process is called **nuclear fission.**
- Two lighter nuclei $(A < 10)$ are fused to form a heavier nucleus and energy is produced, this process is called **nuclear fusion.**

- The energy to be supplied to separate a nucleon from a nucleus is called **separation energy.**
- Mass defect per nucleon is called **packing fraction** ($f$).

$$f = \frac{\Delta m}{A} \Rightarrow E_{bn} = f\,c^2 \text{ or } f \times 931.48 \frac{MeV}{necleon}.$$

---

(56) For the same separation of 1 *fm* in the nucleus, the force acting between two proton is $F_1$, between two neutron is $F_2$ and between proton and neutron is $F_3$ then, ________

(A) $F_1 < F_2 < F_3$ (B) $F_2 < F_1 < F_3$ (C) $F_1 < F_2 = F_3$ (D) $F_1 = F_2 < F_3$

(57) $10^{40}$ deuterons are present in a star initially. Energy released according to reaction given below :

$${}_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + p \text{ and } {}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + n$$

If emitted power is $10^{16}$ W. The time to destroy quantity of deuteron is ________.

(A) $10^6$ s (B) $10^8$ s (C) $10^{12}$ s (D) $10^{16}$ s

$m\left({}_1H^2\right) = 2.014\,u$, $m(P) = 1.007\,u$, $m(n) = 1.008\,u$, $m({}_2He^4) = 4.001\,u$.

(58) Reaction of nuclear fission, ${}_{92}U^{236} \rightarrow X^{117} + Y^{117} + n + n.$ For X and Y $E_{bn} = 8.5$ MeV and $E_{bn} = 7.6$ MeV for $U^{236}$ then produced energy ________ MeV.

(A) 2000 MeV (B) 200 MeV (C) 20 MeV (D) 2 MeV

(59) Packing fraction ($f$) = ________.

(A) $\frac{A}{M-A}$ (B) $\frac{A-M}{A}$ (C) $\frac{M}{M-A}$ (D) $\frac{M-A}{A}$

(60) If $u = 1$ *amu* and A = atomic mass number If mass of an atom is Au then A = ________.

(A) 1 (B) 12 (C) 16 (D) between 1 to 110

(61) Mass in the proton is completely converted in energy, then energy is ________ MeV.

(A) 9310 (B) 931 (C) 10078 (D) 100

(62) $A$ and $B$ are Isotops, $B$ and $C$ are Isobars. $d_A$, $d_B$ and $d_C$ are the densities of their nuclei then ________.

(A) $d_A > d_B > d_C$ (B) $d_A < d_B < d_C$ (C) $d_A = d_B = d_C$ (D) $d_A = d_B < d_C$

(63) The energy required to separate a nucleon from a nucleus is called ________.

(A) Binding energy per nucleon (B) Binding energy

(C) Reaction energy (D) Separation energy

(64) Calculate the released energy $Q$ in nuclear fusion. ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + Q$

$$m\left({}_1H^2\right) = 2.0141\,u,\ m\left({}_2He^4\right) = 4.0024\,u.$$

(A) 12 MeV (B) 6 MeV (C) 24 MeV (D) 48 MeV

(65) If velocity of light becomes $\frac{2}{3}$, the energy releases in nuclear fission decreases in multiple of ________.

(A) $\frac{2}{3}$ (B) $\frac{4}{9}$ (C) $\frac{5}{9}$ (D) $\sqrt{\frac{5}{9}}$

(66) Mass of two isotops of Boron ${}_5B^{10}$ and ${}_5B^{11}$ are 10.01294 $u$ and 11.00931 $u$ respectively. Mass of an atom of Boron is 10.811 $u$. Find the proportion of these two isotops.

(A) 30 %, 70 % (B) 40.12 %, 59.88 % (C) 72.05 %, 27.95 % (D) 19.90 %, 80.10 %

(67) Mass defect in nuclear fission is 0.03 %. Energy released in fission of 1 kg mass is ________.

(A) $2.7 \times 10^{13}$ J (B) $27 \times 10^{14}$ J (C) $0.27 \times 10^{-13}$ J (D) none of these

(68) In a nuclear reaction given below, ${}_ZX^A$ = ________.

$${}_7N^{14} + {}_2He^4 \rightarrow {}_ZX^A + {}_1H^1$$

(A) ${}_7N^{16}$ (B) ${}_7N^{17}$ (C) ${}_8O^{16}$ (D) ${}_8O^{17}$

(69) For ${}_8O^{16}$, $E_{bn}$ = ________ MeV. $m_p = 1.007825\,amu$, $m_N = 1.008665\,amu$. $M\left({}_8O^{16}\right)$ $= 15.9949\,amu$.

(A) 7.973 (B) 79.73 (C) 0.79 (D) none of these

(70) Find the number of electron, proton and neutron in 12 g, ${}_6C^{12}$.

(A) $6 \times 10^{23}$ (each) (B) $12 \times 10^{23}$ (each)

(C) $18 \times 10^{23}$ (each) (D) $36 \times 10^{23}$ (each)

(71) Mass-defect for the nucleus with $Z = 2$ and $A = 4$ is $0.04\,u$. Calculate the binding per nucleon.

(A) 931 MeV (B) 93.1 MeV (C) 9.31 MeV (D) 0.04 MeV

(72) Energy produced due to destruction of proton is 3724 MeV in a nuclear reaction, then these number of protons = ________.

(A) One (B) Two (C) Three (D) Four

(73) Atomic mass number of Helium and sulpher are 4 and 32 respectively. The radius of Sulphur nucleus is ________ times the radius of Helium nucleus.

(A) 2 (B) 4 (C) 8 (D) 12

(74) $_1H^2 + {_1H^3} \rightarrow {_2He^4} + {_0n^1}$. Binding energies of $_1H^2$, $_1H^3$ and $_2He^4$ are *a, b* and *c* (M*e*V) respectively. Energy releases in the reaction = ________ M*e*V.

(A) $a+b-c$ (B) $c+a-b$ (C) $c-a-b$ (D) $a+b+c$

(75) $E_{bn}$ for the nucleus of $_3Li^7$ and $_2He^4$ is 5.60 M*e*V and 7.06 M*e*V respectively. Energy released = ________ M*e*V.

$_3Li^7 + p \rightarrow 2\ {_2He^4}$

(A) 19.6 (B) 17.3 (C) 8.6 (D) 2.4

(76) Energy releases in a given fusion = ________.

$$_1H^2 + {_1H^2} \rightarrow {_1H^3} + {_1H^1}$$

(A) 1 erg (B) 1 *e*V (C) 4 M*e*V (D) 4 *ke*V

(77) Energy released in each fission of $U^{235}$ is 200 M*e*V. Output power in nuclear reactor is 1.6 MW. Find the rate of fission. (number of fission per second).

(A) $5 \times 10^{16}$ (B) $10^{17}$ (C) $1.6 \times 10^{13}$ (D) $10^{19}$

**Ans. : 56 (C), 57 (C), 58 (B), 59 (D), 60 (B), 61 (B), 62 (C), 63 (D), 64 (C), 65 (C), 66 (D), 67 (A), 68 (D), 69 (A), 70 (D), 71 (C), 72 (D), 73 (A), 74 (C), 75 (B), 76 (C), 77 (A)**

**Natural Radio activity**

- Becquerel found that radiations of certain specific properties are emitted naturally from Uranium, this phenomenon is called narural radio activity. Those radiations were initially known as Becquerel rays.
- Madam curie separated two new elements from the ore of Uranium called pitch blende. They were named Polonium and Radium, their activities are several times that of Uranium.
- The emission of radioactive radiations is spontaneous, instantaneous and continuous. It is not affected by temperature, pressure, electric field and magnetic field.
- One can not stop the emission of radioactive radiations or can not change the rate of emission.
- Heavy element emits radioactive radiation to become stable from unstability.
- $\alpha$ – **particles :** $\alpha$ – particle is a nucleus of - $_2He^4$ with 2-proton and 2 neutron. Charge is +2 *e*.

- Almost the nucleus for which $Z > 83$ emits $\alpha-$particles.

$$_{Z}X^{A} \rightarrow {}_{Z-2}Y^{A-4} + {}_{2}He^{4} \ (\alpha)$$

e.g., $$_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4} \ (\alpha)$$

- The disintegrating nucleus is called the **parent nucleus** and newly formed nucleus is called the **daughter nucleus.**
- In the emission of $\alpha-$particle, atomic number decreases by 2 and atomic mass number decreases by 4.
- $\beta-$**particle :** $\beta-$particles are electrons emitted from nucleus. Their velocity depends on the nuclide emitting them. In other reaction of $\beta-$decay positrons are also emitted.
- $\overline{e} = \overline{\beta}$ and $e^{+} = \beta^{+}$.
- When a neutron converts into proton and electron is produced in the nucleus which can not live in a nucleus so emits as $\beta^{-}$

$$n \rightarrow p + \overline{e} + \overline{\upsilon} \text{ (anti neutrino)}$$

$$_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} + \overline{e}\left(\overline{\beta}\right) + \overline{\upsilon}$$

Atomic number increases by one and Atomic mass number does not change.

- When a proton converts in to a neutron positron, is emitted as $\beta^{+}$. Atomic number decreases by one and atomic mass number does not change.

$$p \rightarrow n + e^{+} + \upsilon \text{ (neutrino)}$$

$$_{Z}X^{A} \rightarrow {}_{Z-1}Y^{A} + e^{+}\left(\beta^{+}\right) + \upsilon$$

- $\gamma-$ **rays :** They are electromagnetic waves.
- Photon of $\gamma-$rays emitted during the transition of nucleus from higher energy state to lower energy state, wavelength $\lambda = \dfrac{hc}{E}$.
- When nucleus emits $\alpha$ and $\beta$ particles it is in a excited state, according to need, by emitting photon of $\gamma-$ray comes to a stable state.
- e.g., Due to emission of $\beta^{-}$ $_{27}Co^{60}$ converts into $_{28}Ni^{60}$, during this emits $\gamma-$rays of 1.17 MeV and 1.33 MeV step by step.

- All these raido active radiations affect the photographic plate, produce fluorescence.

| | $\alpha$ | $\beta$ | $\gamma$ |
|---|---|---|---|
| Relative ionizing power : | 10000 | 100 | 1 |
| Relative penetration power : | 1 | 100 | 10000 |

- Energy value in $\alpha-$emission

$Q = K_{\alpha}\left(\frac{A}{A-4}\right)$ Where, $k_{\alpha}$ = kinetic energy of $\alpha$, A = atomic mass number

**Nuclear Reactions**

- By bombarding suitable particles of suitable energy on a stable element, transformed into another element is called **artificial nuclear reaction.** Energy gain or loss is denoted as $Q-$ value.

$$A + a \to B + b + Q$$

$$_7N^{14} + \alpha\left(_2He^4\right) \to {}_8O^{17} + {}_1H^1 + Q$$

A $\to$ Target nucleus $\to$ $_7N^{14}$

$a$ $\to$ projectile particle $\to$ $\alpha\left(_2He^4\right)$

B $\to$ product nucleus $\to$ $_8O^{17}$

$b$ $\to$ product (emitted) particle $\to$ $_1H^1$

$$Q = \left[m_A + m_a - m_B - m_b\right] c^2$$

$Q > 0$ exoergic reaction, $Q < 0$ endoergic reaction

- In nuclear reaction momentum, electric charge and energy each one is conserved.
- $Q-$ value of reaction = energy equivalent to decrease in mass in the reaction = increase in the kinetic energy.

**Nuclear Fission :**

Neutron is good projectile because it is charge less and does not have to face the coloumb repulsive forces.

- Disintegration of nucleus in which enormous energy is produced. This process was named nuclear fission.

e.g.,

$$_{92}U^{235} + {}_0n^1 \to {}_{92}U^{236} \to {}_{51}Sb^{133} + {}_{41}Nb^{99} + 4\,{}_0n^1 + Q$$

$$_{92}U^{235} + {}_0n^1 \to {}_{92}U^{236} \to {}_{56}Ba^{144} + {}_{36}Kr^{89} + 3\,{}_0n^1 + Q$$

$$_{92}U^{235} + {}_0n^1 \to {}_{92}U^{236} \to {}_{54}Xe^{140} + {}_{38}Sr^{94} + 2\,{}_0n^1 + Q$$

- Fission fragments having $Z$ values between 36 to 56 and $A$ values between 90 to 95. They converts into stable nuclei with emission of $\beta^-$ and $\gamma$.
- Energy of incident neutron is about 2 M$e$V.
- Energy produced is about 200 M$e$V.

**Nuclear chain reaction and Nuclear reactor**

- With the help of neutrons produced nuclear fission, more nuclei is accomplished. So, we get more energy and more neutrons. A series of such processes is called **nuclear chain reaction.** If such a process is properly controlled, then energy can be obtained continuously at steady rate. **Nuclear reactor** is the illustration of this.

**Difficulties encountered in nuclear reactor and their removal :**

- To stop neutrons from escaping reflecting surfaces, moderators like water, heavy water, Graphite and Beryllium are used.
- In a chain reaction enormous heat energy is produced and the temperature is likely to become $10^6$ K. Hence coolants like water, liquid sodium are used.
- The ratio of number of neutrons produced at any stage to the number of neutrons incident is called **multiplication factor (K).** It is a measure of the growth of number of neutrons. If K = 1 the reactor is said to be critical. If K > 1 is said to be super critical in such a condition explosion can take place, if K < 1 said to be subcritical, the process slows down and eventually stops.
- In order to control the value of K, rods of Boron and Cadmium are kept, called control rods.

  **Reactor :** As a fuel 3 % ${}_{92}\mathrm{U}^{235}$ and remaining ${}_{92}\mathrm{U}^{238}$.

- ${}_{92}\mathrm{U}^{235} + {}_{0}n^{1} \rightarrow {}_{93}\mathrm{Np}^{239} + {}_{-1}e^{0} + \bar{\upsilon}$

  ${}_{93}\mathrm{Np}^{239} \rightarrow {}_{94}\mathrm{Pu}^{239} + {}_{-1}e^{0} + \bar{\upsilon}$

  Plutonium is intense radio active and fissionable by slow neutron.

- In **Pressurised Water Reactor** normal water is used as moderator and also as coolent.
- Water is pushed into the core of the reactor at temperacure 600 K and 150 atm pressure, generated steam operates the turbine, which produces electric power.

**Thermonuclear Fusion in Sun and other Stars :**

- The sun emitting energy at the rate of $3.8 \times 10^{26}\ \mathrm{Js}^{-1}$.
- When two proper light nuclei are fused at a very high temperature to form a heavy nucleus, enormous energy is produced, such process is called **thermonuclear fusion.**

- Proton - Proton cycle :

$${}_{1}H^{1} + {}_{1}H^{1} \rightarrow {}_{1}H^{2} + {}_{-1}e^{0} + \upsilon + 0.42\ MeV$$

$${}_{+1}e^{0} + {}_{-1}e^{0} \rightarrow 2\gamma + 1.02\ MeV$$

$${}_{1}H^{2} + {}_{1}H^{1} \rightarrow {}_{2}He^{3} + \gamma + 5.49\ MeV$$

$${}_{2}He^{3} + {}_{2}He^{3} \rightarrow {}_{2}He^{4} + {}_{1}H^{1} + {}_{1}H^{1} + 12.86\ MeV$$

- First three reaction ocur twice.
- Total produced energy = $2 \times 0.42 + 2 \times 1.02 + 2 \times 5.49 + 12.86 = 26.7\ MeV$.

---

(78) What is produced in a consecutive step in a given reaction ?

$${}_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} \rightarrow {}_{Z-1}T^{A-4} \rightarrow {}_{Z-1}T^{A-4}$$

(A) $\alpha, \beta, \gamma$ (B) $\beta, \alpha, \gamma$ (C) $\gamma, \alpha, \beta$ (D) $\alpha, \gamma, \beta$

(79) Find the number of $\alpha$ and $\beta-$ particles in the conversion ${}_{92}X^{235} \rightarrow {}_{88}Y^{219}$.

(A) 4, 4 (B) 5, 5 (C) 6, 6 (D) 4, 8

(80) If $P_\alpha, P_\beta, P_\gamma$ are penetrating power of $\alpha, \beta, \gamma$ then ________.

(A) $P_\alpha = P_\beta = P_\gamma$ (B) $P_\alpha > P_\beta > P_\gamma$ (C) $P_\alpha < P_\beta < P_\gamma$ (D) $P_\alpha = P_\beta < P_\gamma$

(81) $\alpha$ and $\beta$ particles are emitted from the ends A and B respectively in a wire, then ________.

(A) Electric current flows from $A$ to $B$

(B) Electric current flows from $B$ to $A$

(C) Electric current is not produced.

(D) Electric current flows toward the mid-pt. from every side.

(82) During the radio active emission of element having atomic number 90 and atomic mass number 232, final product is ${}_{82}Pb^{208}$. Find the emitted number of $\alpha$ and $\beta-$ particles.

(A) $\alpha = 3,\ \beta = 3$ (B) $\alpha = 6,\ \beta = 4$ (C) $\alpha = 6,\ \beta = 0$ (D) $\alpha = 1,\ \beta = 6$

(83) Nuclear reaction : ${}_{5}B^{10} + {}_{2}He^{4} \rightarrow {}_{7}N^{13} +$ ________

(A) Proton (B) neutron (C) electron (D) $\alpha$

(84) ${}_{6}C^{12}$ absorps neutron and emits $\beta-$particle. Find the final product.

(A) ${}_{7}N^{14}$ (B) ${}_{5}B^{13}$ (C) ${}_{7}N^{13}$ (D) ${}_{6}C^{13}$

(85) Arrange the ionizing power of $\alpha, \beta$ and $\gamma$ in descending order.

(A) $\gamma, \alpha, \beta$ (B) $\gamma, \beta, \alpha$ (C) $\alpha, \beta, \gamma$ (D) $\beta, \gamma, \alpha$

(86) Energy produced in nuclear fission is 200 MeV. If output power of reactor is 5W then find the rate of fission.

(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) $1.56 \times 10^{-17}\ s^{-1}$

(87) $\alpha-$particle is emitted by nucleus $_ZX^A$. Final nucleus emits $\beta^+$. Then find the atomic number and atomic mass number of final nucleus.

(A) $Z-3, A-4$ (B) $Z-1, A-4$ (C) $Z-2, A-4$ (D) $Z, A-2$

(88) Three $\alpha-$ particles and one $\beta-$particle are emitted by $_{86}R_n{}^{236}$, then for product nucleus $X$ ________.

(A) $Z = 83, A = 224$ (B) $Z = 84, A = 218$

(C) $Z = 84, A = 220$ (D) $Z = 82, A = 223$

(89) Calculate the release energy in reaction, $_{88}Ra^{226} \rightarrow {}_{86}Ra^{222} + {}_2He^4$. Kinetic energy of $\alpha-$particle is $4.78$ MeV. Parent element is stable.

(A) 8 MeV (B) 4.78 MeV (C) 4.87 MeV (D) none of these

(90) Energy emitted from a star is $2.7 \times 10^{36}\ Js^{-1}$. Find the decrement in its mass.

(A) $3 \times 10^{18}\ kg\ s^{-1}$ (B) $3 \times 10^{19}\ kg\ s^{-1}$ (C) $3 \times 10^{20}\ kg\ s^{-1}$ (D) $3 \times 10^{21}\ kg\ s^{-1}$

(91) Series of emitted particles from the nucleus $(Z = 92)$ is $\alpha, \alpha, \beta^-, \beta^-, \alpha, \alpha, \alpha, \alpha, \beta^-, \beta^-, \alpha, \beta^+, \beta^+, \alpha$. Then $Z$ of final nucleus = ________.

(A) 78 (B) 82 (C) 74 (D) 76

(92) $_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + n,$ potential energy due to repulsive force between two nucleus in nuclear fusion is $7.7 \times 10^{-14}$ J. How much temperature should be given to the gas so this reaction be possible ?

(A) $10^5$ K (B) $10^3$ K (C) $10^9$ K (D) $10^7$ K

(93) What this reaction suggest ?

$$4\,{}_1H^1 \rightarrow {}_2He^4 + 2\,{}_{+1}e^0 + 26\ MeV.$$

(A) $\beta-$decay (B) $\gamma-$decay (C) Fusion (D) Fission

(94) $\alpha -$ particles are emitted from stable radio active element having atomic mass mumber 208. Energy of emitted $\alpha -$ particles is E. Find the energy of disintegration.

(A) $\frac{52}{51}$ E (B) $\frac{51}{52}$ E (C) 52 E (D) E

| | |
|---|---|
| **Ans. :** | **78 (B), 79 (A), 80 (C), 81 (A), 82 (B), 83 (B), 84 (C), 85 (C), 86 (B), 87 (A), 88 (A), 89 (C), 90 (B), 91 (A), 92 (C), 93 (C), 94 (A)** |

**Radio active constant and Activity**

- In a specimen of radio active material, if the number of undisintegrated nuclei of an element at time $t$ is $N$ and there after if $\Delta N$ nuclei disintegrate in time interval $\Delta t$, then $\lim_{\Delta t \to 0} \frac{\Delta N}{\Delta t} = \frac{dN}{dt}$ is called the **rate of disintegration** or **the decay rate** or **activity (*I*)** of that element at time t. Activity means the number of nuclei decaying per unit time.

- The decay rate is proportional to the number of undisintegrated nuclei at that time. $\frac{dN}{dt} \propto -N$

  $\therefore \boxed{I = \frac{dN}{dt} = -\lambda N}$ (negative sign indicates that as time passes N decreases.)

  $\lambda =$ Radioactive constant = decay constant, unit = $s^{-1}$) its value depends on the type of disintegrating element. For different unstable isotops of the same element, the values of $\lambda$ are different.

- $\lambda \to$ large $\to I \to$ more $\to$ shortlived elements.

  $\lambda \to$ small $\to I \to$ less $\to$ longlived elements.

- $\lambda$ is independent of temperature pressure, electric field and magnetic field.

- For the nucleus of a given element $\lambda$ $\left(\lambda = \frac{-dN}{Ndt}\right)$ shows the probability of disintegration per unit time.

**Units of Activity**

- 1 disintegration oceur in one second, then activity of body is called **1 Becquerel.**

  1 Bq = 1 disintegration / sec.

- If $3.7 \times 10^{10}$ disintegration per second take place, the activity of a substance called 1 curie (Ci).

  1 Ci = $3.7 \times 10^{10}$ disintegration / sec.

  1 Ci = $3.7 \times 10^{10}$ Bq.

**Exponential law of Radio active Disintegration**

$$\frac{dN}{dt} = -\lambda N \Rightarrow \frac{dN}{N} = -\lambda\, dt$$

$$\int_{N_0}^{N} \frac{dN}{N} = -\lambda \int_{0}^{t} dt \qquad \left[\begin{array}{l} t=0 \rightarrow N = N_0 \\ t=t \rightarrow N = N \end{array}\right]$$

$$\therefore \quad [\ln N]_{N_0}^{N} = -\lambda\,[t]_0^t$$

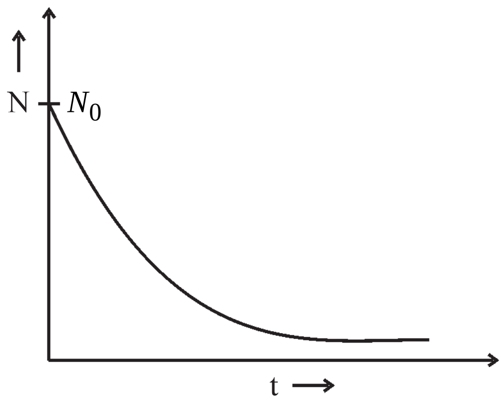
$$\therefore \quad \ln N - \ln N_0 = -\lambda t$$

$$\therefore \quad \ln\left(\frac{N}{N_0}\right) = -\lambda t$$

$$\therefore \quad \frac{N}{N_0} = e^{-\lambda t} \quad \Rightarrow \quad N = N_0\, e^{-\lambda t}$$

Similarly, $I = I_0\, e^{-\lambda t}$ and $\mathrm{M} = \mathrm{M}_0\, e^{-\lambda t}$ $\mathrm{M}_0 =$ Initial mass, M = mass after disintegration.

- As time passes, the number of nuclei and activity decreases exponentially. This curve is called **decay curve.** For $I \rightarrow t$ and $\mathrm{M} \rightarrow t$ similar graph is obtained.




**Half life :**

- The time interval in which the number of nuclei of radioactive element becomes half of its value at the beginning, is called **half life** of that element $\left(\tau_{\frac{1}{2}}\right)$.

$$N = N_0\, e^{-\lambda t}, \quad t = \tau_{\frac{1}{2}} \text{ and } N = \frac{N_0}{2}$$

$$\frac{N_0}{2} = N_0\, e^{-\lambda \tau_{\frac{1}{2}}} \quad \Rightarrow \quad 2^{-1} = e^{-\lambda \tau_{\frac{1}{2}}} \quad \Rightarrow \quad 2 = e^{\lambda \tau_{\frac{1}{2}}}$$

$$\therefore \quad \ln 2 = \lambda \tau_{\frac{1}{2}} \quad \Rightarrow \quad \tau_{\frac{1}{2}} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$$

- Half life of different radio active elements are from $10^{-7}$ s to $10^{10}$ Yr.

- $t = 0$ time $N = N_0 \Rightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^0$

$t = \tau_{\frac{1}{2}}$ time $N = \frac{N_0}{2} \Rightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^1$

$t = 2\tau_{\frac{1}{2}}$ time $N = \frac{N_0}{4} \Rightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^2$

$t = 3\tau_{\frac{1}{2}}$ time $N = \frac{N_0}{8} \Rightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^3$

| | |

$t = n\tau_{\frac{1}{2}}$ time $\longrightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$.

Where $n = \frac{t}{\tau_{\frac{1}{2}}} = \frac{\text{given time}}{\text{Half life}}$

| Time | undecayed part | Decayed part |
|---|---|---|
| $t = 0$ | 100 % | 0 % |
| $t = \tau_{\frac{1}{2}}$ | 50 % | 50 % |
| $t = 2\tau_{\frac{1}{2}}$ | 25 % | 75 % |
| $t = 3\tau_{\frac{1}{2}}$ | 12.5 % | 87.5 % |
| $t = 4\tau_{\frac{1}{2}}$ | 6.25 % | 93.75 % |

**Mean life $(\tau)$**

The time interval during which the number of nuclei of a radioactive element becomes $e^{\text{th}}$ part of its original, is called **Mean** or **average life** $(\tau)$ of that element. ($e = 2.718$)

- $N = N_0\, e^{-\lambda t}$, $t = \tau$ and $N = \frac{N_0}{e}$, $\frac{N_0}{e} = N_0\, e^{-\lambda\tau} \Rightarrow e^{-1} = e^{-\lambda\tau}$

$\Rightarrow \lambda\tau = 1 \Rightarrow \tau = \frac{1}{\lambda}$

**other informations :**

– $\tau_{\frac{1}{2}} = 0.693\,\tau$

– $\tau = \tau_{\frac{1}{2}} \times 1.44$

- For the emission of $\alpha$ and $\beta$, total $\lambda_t = \lambda_\alpha + \lambda_\beta$

$\therefore \frac{1}{\tau_{(t)}} = \frac{1}{\tau_\alpha} + \frac{1}{\tau_\beta}$ Similarly, $\frac{1}{\tau_{\frac{1}{2}(t)}} = \frac{1}{\tau_{\frac{1}{2}(\alpha)}} + \frac{1}{\tau_{\frac{1}{2}(\beta)}}$

---

(95) Half life of $At^{215}$ is $100\ \mu s$, The time in which activity of its specimen becomes $\frac{1}{16}^{th}$ of its original is ________.

(A) $400\ \mu s$ (B) $6.3\ \mu s$ (C) $40\ \mu s$ (D) $300\ \mu s$

(96) Activity of Radio active element at time $t_1$ is $R_1$ and at time $t_2$ is $R_2$. $(t_2 > t_1)$. If the mean life $(\tau)$ then ________.

(A) $R_1 t_1 = R_2 t_2$ (B) $\frac{R_1 - R_2}{t_2 - t_1} =$ constant

(C) $R_2 = R_1 \exp\left(\frac{t_1 - t_2}{\tau}\right)$ (D) $R_2 = R_1 \exp\left(\frac{t_1}{\tau t_2}\right)$

(97) Quantity of Radon is 16 g and its half life is 3.8 days. Find the disintegration of Radon in 19 days ?

(A) 5 g (B) 0.5 g (C) 15.5 g (D) none of these

(98) Half-life of radio active element is 30 days. Find the time to disintetrate its $\frac{3}{4}^{th}$ mass.

(A) 15 days (B) 45 days (C) 30 days (D) 60 days

(99) Find the half life of radio active element whose activity becomes $\frac{1}{16}^{th}$ of original in 30 years.

(A) 90 years (B) 120 years (C) 15 years (D) 7.5 years

(100) Find the decay constant of an element in Que : 99.

(A) $0.0924\ Yr^{-1}$ (B) $9.24\ Yr^{-1}$ (C) $924\ Yr^{-1}$ (D) $0.0688\ Yr^{-1}$

(101) Initially number of atoms in radio active element $A$ and $B$ are equal. Their half lives are 1 *hr* and 2 *hr* respectively. Find the ratio of rate of disintegration after 2 hr.

(A) 4 : 2 (B) 1 : 1 (C) 1 : 2 (D) 8 : 1

(102) Find the number of disintegration per second in 2.3 g, ${}_{90}Th^{230}$ whose half life = $2.4 \times 10^{11}$ s.

(A) $6 \times 10^{21}$ (B) $0.73 \times 10^{10}$ (C) $1.73 \times 10^{10}$ (D) $10^9$

(103) Half life of radio active isotop is 10 min. At a given moment number of radio active nucleus are $10^8$. Number of nucleus after 5 min = ________.

(A) $\frac{10^8}{2}$ (B) $10^4$ (C) $\sqrt{2} \times 10^7$ (D) $\frac{10^8}{\sqrt{2}}$

(104) Half life of $Pa^{218}$ is 3 min and mass of specimen is 16 *g*. How much mass is remaining after 15 min.

(A) 3.2 g (B) 2.0 g (C) 1.6 g (D) 0.5 g

(105) Half life of radio active element is 5 min. ________ % of element remains undecayed after 25 min.

(A) 25 % (B) 75 % (C) 6.25 % (D) 3.125 %

(106) Activity of recenty bought bottle of radio active Tritium is 3 %, "seven years old" labelled on the bottle, then is was made before how many years ? (Half life = 12.5 Yr)

(A) before 220 years (B) before 420 years (C) before 63 years (D) before 70 years

(107) Half life of radio active element is 10 years, then its average life is ________ .

(A) 14.4 yr (B) 20 yr (C) 15 yr (D) 28.8 yr

(108) Activity of radio active sample at time $t_1$ is $I_1$ and at time $t_2$ is $I_2$. If the half life of sample is $\tau_{\frac{1}{2}}$, the number of undecayed nucleus in $t_2 - t_1$ time is directly proportional to ________.

(A) $I_1 t_2 - I_2 t_1$ (B) $I_1 - I_2$ (C) $\frac{I_1 - I_2}{\tau_{\frac{1}{2}}}$ (D) $(I_2 - I_1)\,\tau_{\frac{1}{2}}$

(109) Half life of radio active element is 20 min. Time to decay from 20% to 80 % is ________ .

(A) 20 min (B) 40 min (C) 25 min (D) 30 min

(110) Half lives of radio active element for $\alpha$ and $\beta$ decay are 8 year and 24 year respectively. After 12 year, its activity is how much percentage of its original activity ?

(A) 50 (B) 12.5 (C) 25 (D) 6.25

(111) There are $4 \times 10^{16}$ nucleus in a radio active sample. Half life of element is 10 days. Find the number of decayed nucleus in 30 days.

(A) $0.5 \times 10^{16}$ (B) $2 \times 10^{16}$ (C) $3.5 \times 10^{16}$ (D) $1 \times 10^{16}$

(112) Mass of radio active sample at $t = 0$ is 10 g. After two mean life mass of sample is ________

(A) 1.36 g (B) 2.50 g (C) 3.70 g (D) 6.30 g

(113) Half life of Radium is 1600 year. Mass of sample is 100 g. The time for which its mass becomes 25 g is ________ years.

(A) 6400 (B) 2400 (C) 3200 (D) 4800

(114) After decayed two radio active nucleus $P$ and $Q$ becomes stable element $R$. At $t = 0$, the number of nucleus in $P$ and $Q$ are $4\ N_0$ and $N_0$ respectively. Half lives of $P$ and $Q$ are 1 min and 2 min respectively. When stable element $R$ formed, number of nucleus in $P$ and $Q$ are equal. Then number of nucleus in stable element $R$ is ________.

(A) $2\ N_0$ (B) $3\ N_0$ (C) $\frac{3N_0}{2}$ (D) $\frac{9N_0}{2}$

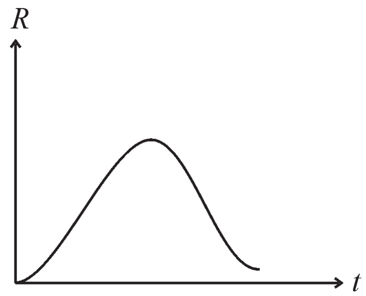
(115) Half life of radio active isotop $X$ is 50 year, after decayed it converts into stable element $Y$. If the proportion of $X$ and $Y$ is 1 : 15, approximate life of rock is ________.

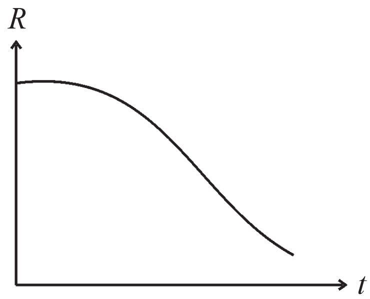
(A) 100 year (B) 150 year (C) 200 year (D) 250 year

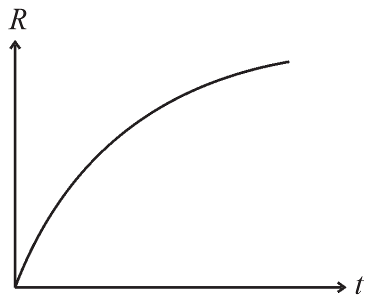
(116) Sample of Cu decayed upto $\frac{7}{8}$ in 15 min and converts in Zn, its Half life is ________.

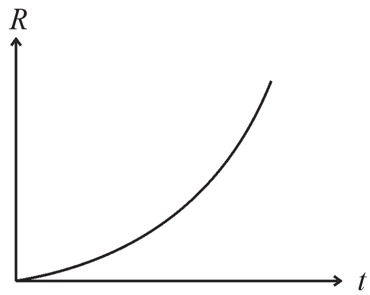
(A) 10 min (B) 15 min (C) 5 min (D) 7.5 min

(117) A radio active element $X$ decayed into new element $Y$. If creation rate of element $Y$ is R then the graph of $R \rightarrow t$ would be.

(A)



(B)



(C)



(D)



(118) Undecayed part of radio active sample in half time of half life is ________.

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

**Ans. : 95 (A), 96 (C), 97 (C), 98 (D), 99 (D), 100 (A), 101 (B), 102 (C), 103 (D), 104 (D), 105 (D), 106 (D), 107 (A), 108 (D), 109 (B), 110 (C), 111 (C), 112 (A), 113 (C), 114 (D), 115 (C), 116 (C), 117 (C), 118 (A)**

**Assertion - Reason type Question :**

**Instruction : Read assertion and reason carefully, select proper option from given below.**

(a) Both assertion and reason are true and reason explains the assertion.

(b) Both assertion and reason are true but reason does not explain the assertion.

(c) Assertion is true but reason is false.

(d) Assertion is false and reason is true.

---

(119) **Assertion** : ${}_{Z}X^{A}$ undergoes two $\alpha-$decay, two $\beta-$decays and two $\gamma-$decays and the daughter product is ${}_{Z-2}X^{A-8}$ .

**Reason** : In $\alpha-$decay the mass number decreases by 4 and atomic number decreases by 2. In $\beta-$ decay the mass number remain unchanged, but atomic number increases by 1 only.

(A) (a) (B) (b) (C) (c) (D) (d)

(120) **Assertion** : All nuclei are not of same size.

**Reason** : Size depends on atomic mass.

(A) (a) (B) (b) (C) (c) (D) (d)

(121) **Assertion** : X - rays are used for studying the structure of crystals.

**Reason** : The difference between the atoms of crystal is of the order of wavelength of X - ray.

(A) (a) (B) (b) (C) (c) (D) (d)

(122) **Assertion** : If half life and mean life of radio active element are $\tau_{\frac{1}{2}}$ and $\tau$ $\left(\tau_{\frac{1}{2}} < \tau.\right)$

**Reason** : Mean life $= \dfrac{1}{\text{decay constant}}$

(A) (a) (B) (b) (C) (c) (D) (d)

(123) **Assertion** : Isobars are the nuclei having same mass number A but different atomic number Z.

**Reason** : Neutrons and Protons are present inside nucleus.

(A) (a) (B) (b) (C) (c) (D) (d)

(124) **Assertion** : The ionisation potential of Hydrogen is 13.6 eV, the ionised potential of double ionised lithium is 122.4 eV.

**Reason** : Energy in $n^{th}$ state of Hydrogen atom is $E_n = \dfrac{13.6}{n^2}$ eV.

(A) (a) (B) (b) (C) (c) (D) (d)

(125) **Assertion** : Radio active nuclei emit $\beta^{-}$ particle.

**Reason** : Electrons exist inside the nucleus.

(A) (a) (B) (b) (C) (c) (D) (d)

(126) **Assertion** : If the half life of radio active substance is 40 days, then 25 % substance decays in 20 days.

**Reason** : $N = N_0 \left(\frac{1}{2}\right)^n$ Where $n = \frac{t}{\tau_{\frac{1}{2}}}$.

(A) (a) (B) (b) (C) (c) (D) (d)

(127) **Assertion** : Balmar series lies in the visible region of electro magnetic spectrum.

**Reason** : $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$ Where, $n = 3, 4, 5$.

(A) (a) (B) (b) (C) (c) (D) (d)

(128) **Assertion** : A certain radio active substance has a half life of 30 days. Its disintegretion constant is 0.0231 $day^{-1}$.

**Reason** : Decay constant varies inversly as half-life.

(A) (a) (B) (b) (C) (c) (D) (d)

(129) **Assertion** : Energy is released in nuclear fission.

**Reason** : Total binding energy of the fission fragments is larger than the total binding energy of the parent nucleus.

(A) (a) (B) (b) (C) (c) (D) (d)

(130) **Assertion** : Heavy water is preferred over ordinary water as a moderator in reactors.

**Reason** : Heavy water, used for slowing down the neutrons, has lesser absorption probability of neutrons than ordinary water.

(A) (a) (B) (b) (C) (c) (D) (d)

**Ans. : 119 (B), 120 (B), 121 (A), 122 (B), 123 (B), 124 (B), 125 (C), 126 (D), 127 (A), 128 (B), 129 (A), 130 (A)**

**Comprehension Type Questions :**

**Passage :**

A single electron orbits arounds a stationary nucleus of charge + *Ze*, Where Z is a constant and *e* is the magnitude of the charge. It requires 47.2 eV to excite the electron from the second orbit to the third orbit. (The ionization energy of Hydrogen atom = 13.6 eV. radius = $5.3 \times 10^{-11}$ m, $c = 3 \times 10^8$ $ms^{-1}$, $h = 6.6 \times 10^{-34}$ Js) Based on the above facts, answer the following questions :

(131) The value of $Z$ is = ________.

(A) 1 (B) 2 (C) 3 (D) 5

(132) The energy required to excite the electron from the second excited state to the third excited state is = ________ eV.

(A) 47.2 eV (B) 14.53 eV (C) 16.53 eV (D) 18.53 eV

(133) The energy required to excite the electron from the first excited state to the second excited state is = ________ eV.

(A) 47.2 eV (B) 16.53 eV (C) 255 eV (D) none of these

(134) The minimum wavelength of the electromagnetic radiation required to deport the electron first orbit to an upper orbit is ________.

(A) 48.5 $\mathring{A}$ (B) 36.4 $\mathring{A}$ (C) 45.8 $\mathring{A}$ (D) 34.6 $\mathring{A}$

(135) The kinetic energy, potential energy, total energy and angular momentum of the electron in the first orbit have respective values given by.

(A) $340\ \text{eV},\ -340\ \text{eV},\ -680\ \text{eV},\ 1.05\times10^{-34}$ Js

(B) $340\ \text{eV},\ -680\ \text{eV},\ -340\ \text{eV},\ 1.05\times10^{-34}$ Js

(C) $680\ \text{eV},\ -340\ \text{eV},\ -680\ \text{eV},\ 2.05\times10^{-34}$ Js

(D) $680\ \text{eV},\ -1360\ \text{eV},\ -680\ \text{eV},\ 2.05\times10^{-34}$ Js

(136) The radius of the first Bohr's orbit is = ________ .

(A) 0.53 $\mathring{A}$ (B) 0.106 $\mathring{A}$ (C) 5.3 $\mathring{A}$ (D) 1.06 $\mathring{A}$

**Passage :** For identical Hydrogen gas has some atoms in the lowest energy level A and some in a upper energy level B. The atoms of the gas make transition to a higher energy level by absorbing photon of energy 2.7 eV. Subsequently, the atoms emit radiation of only six different photon energies. Some of the emitted photons have an energy of 2.7 eV, some have more energy and some less than 2.7 eV. Based on the above facts, answer the following questions :

(137) The principle quantum number of the initially excited level *B* is ________.

(A) 2 (B) 4 (C) 6 (D) 8

(138) The ionization energy for the gas atom is ________ *e*V.

(A) 14.4 eV (B) 13.6 eV (C) 3.4 eV (D) 1.51 eV

(139) The emitted photons will have energy value E (in eV). The photons emitted have maximum and minimum energy values E and *e* respectively.

(A) $e = 1.35$ eV and E = 13.5 eV (B) $e = 0.7$ eV and E = 1.35 eV

(C) $e = 0.7$ eV and E = 13.5 eV (D) none of these

**Passage :**

Nuclei of a radio active element *A* are being produced at a constant rate $\alpha$. The element has a decay constant $\lambda$. At time $t = 0$, there are $N_0$, nuclei of the element. At time *t*, number of nuclei of *A* is *N*. Also for $\alpha = 2N_0\lambda$, the number of nuclei of *A* after one half life is $N_{\frac{1}{2}}$ and the limiting value of N as $t \to \infty$ is $N_\infty$. Based on the above facts, answer the following questions :

(140) *N* as a function of *t* is given by,

(A) $N = N_0 + \frac{\alpha}{\lambda}\left(1-e^{-\lambda t}\right)$ (B) $N = N_0\, e^{-\lambda t}$

(C) $N = N_0 - \frac{\alpha}{\lambda}\left(1-e^{-\lambda t}\right)$ (D) $N = \frac{1}{\lambda}\left[\alpha - \left(\alpha - \lambda N_0\right)e^{-\lambda t}\right]$

(141) The value of $N_{\frac{1}{2}}$ in terms of $N_0$ is = ________.

(A) $N_{\frac{1}{2}} = \frac{N_0}{2}$ (B) $N_{\frac{1}{2}} = \frac{3N_0}{2}$ (C) $N_{\frac{1}{2}} = \frac{3N_0}{4}$ (D) $N_{\frac{1}{2}} = \frac{3N_0}{8}$

(142) The value of $N_\infty$ in terms of $N_0$ is = ________.

(A) $N_\infty = 3N_0$ (B) $N_\infty \to 0$ (C) $N_\infty = N_0$ (D) $N_\infty = 2N_0$

**Passage :** In the Bohr model of the Hydrogen atom, the electron revolves in a circular orbit of radius $r_o = 0.53 \mathring{A}$ around the nucleus. Based on the above facts, answer the following question.

(143) The velocity of electron is nearly ________ $ms^{-1}$.

(A) $2.2 \times 10^6$ (B) $2.6 \times 10^6$ (C) $2.8 \times 10^6$ (D) $2.9 \times 10^6$

(144) The velocity of electron is *n* times the velocity of light. The value of *n* is = ________.

(A) $\frac{1}{81}$ (B) $\frac{1}{101}$ (C) $\frac{1}{137}$ (D) $\frac{1}{337}$

(145) The electric potential energy in ________ eV.

(A) –13.6 (B) –27.2 (C) –36 (D) –54

(146) The kinetic energy in eV is ________.

(A) 13.6 (B) –27.2 (C) –36 (B) –54

(147) The total energy in eV is ________.

(A) 13.6 (B) –13.6 (C) 27.2 (D) –27.2

**Ans. : 131 (D), 132 (C), 133 (A), 134 (B), 135 (B), 136 (B), 137 (B), 138 (A), 139 (C), 140 (D), 141 (B), 142 (D), 143 (A), 144 (C), 145 (B), 146 (A), 147 (B)**

**Match the columns :**

Match the column-1 with column-2 :

| column-1 | | column-2 | |
|---|---|---|---|
| (*a*) | In this reaction mass of product is less than the mass of reactants. | (*p*) | $\alpha$ – decay |
| (*b*) | Energy per nucleon Increases. | (*q*) | $\beta$ – decay |
| (*c*) | Conservation of atomic mass number. | (*r*) | Nuclear Fission |
| (*d*) | Conservation of charge. | (*s*) | Nuclear Fusion |

(A) $(a) \rightarrow (p, q, r, s)$, $(b) \rightarrow (p, q)$, $(c) \rightarrow (r, s)$, $(d) \rightarrow (p, q, r, s)$

(B) $(a) \rightarrow (q)$, $(b) \rightarrow (r)$, $(c) \rightarrow (p)$, $(d) \rightarrow (s)$

(C) $(a) \rightarrow (s)$, $(b) \rightarrow (r)$, $(c) \rightarrow (q)$, $(d) \rightarrow (p)$

(D) $(a) \rightarrow (p)$, $(b) \rightarrow (s)$, $(c) \rightarrow (q)$, $(d) \rightarrow (r)$

(149)

| | column-1 | | column-2 |
|---|---|---|---|
| (*a*) | Nuclear - Fusion | (*p*) | Some matter converts into energy |
| (*b*) | Nuclear - Fission | (*q*) | Generally, possible for the nucleus with less atomic number |
| (*c*) | $\beta$ – decay | (*r*) | Generally, possible for the nucleus with high atomic number |
| (*d*) | Endo thermic reaction | (*s*) | Possible due to weak nuclear force |

(A) $(a) \rightarrow (p, r)$, $(b) \rightarrow (q, r)$, $(c) \rightarrow (p, q, s)$, $(d) \rightarrow (r, s)$

(B) $(a) \rightarrow (q, s)$, $(b) \rightarrow (p, s)$, $(c) \rightarrow (q, r, s)$, $(d) \rightarrow (p, q, r, s)$

(C) $(a) \rightarrow (s)$, $(b) \rightarrow (s, p)$, $(c) \rightarrow (p, q, r, s)$, $(d) \rightarrow (r)$

(D) $(a) \rightarrow (p, q)$, $(b) \rightarrow (p, r)$, $(c) \rightarrow (p, s)$, $(d) \rightarrow (p, q, r)$

(150)

| | column-1 | | column-2 |
|---|---|---|---|
| (*a*) | Transition between two energy levels of an atom. | (*p*) | Characteristics of X-ray |
| (*b*) | emission of electron from the matter. | (*q*) | Photo-electric effect |
| (*c*) | Moseley's law. | (*r*) | Hydrogen spectrum |
| (*d*) | Conversion of energy of photon in to energy of an electron | (*s*) | $\beta$ – decay |

(A) $(a) \rightarrow (p, r)$, $(b) \rightarrow (p, q, s)$, $(c) \rightarrow (p)$, $(d) \rightarrow (q)$

(B) $(a) \rightarrow (p)$, $(b) \rightarrow (s)$, $(c) \rightarrow (r)$, $(d) \rightarrow (q, s)$

(C) $(a) \rightarrow (p, q, r, s)$, $(b) \rightarrow (s)$, $(c) \rightarrow (p)$, $(d) \rightarrow (s)$

(D) $(a) \rightarrow (s, r)$, $(b) \rightarrow (r)$, $(c) \rightarrow (s, p)$, $(d) \rightarrow (q, r)$

**Ans. : 148 (A), 149 (D), 150 (A)**