Atoms

1 Mark Questions

1.The ground state energy of hydrogen atom is – 13.6 eV. What are the kinetic and potential energies of electron in this state? [All India 2014C; HOTS; All India 2010]

Ans. Given, total ground state energy (TE) = (-13.6eV)

.-. Kinetic energy = – TE

= -(-13.6 eV) =13.6 eV Potential energy = 2 (TE)

= 2 x(-13.6) = -27.2 eV

2.When is H_a-line of the Balmer series in the emission spectrum of hydrogen atom obtained? [Delhi 2013C]

Ans. H_a-line of the Balmer series in the emission spectrum of hydrogen atom is obtained in visible region.

3.Why is the classical (Rutherford) model for an atom of electron orbitting around the

nucleus not able to explain the atomic Structure? [Delhi 2012]

Ans. The classical method could not explain the atomic structure as the electron revolving around the nucleus are accelerated and emits energy as the result, the radius of the circular paths goes on decreasing. Ultimately electrons fall into the nucleus, which is not in practical.

4.Define ionisation energy. What is its value for a hydrogen atoms? [All India 2010]

Ans. Ionisation energy The minimum amount of energy required to remove an electron from the ground state of the atom is known as ionisation energy.

Ionisation energy for hydrogen atom $= E_\infty - E_1$

$$= -(-13.6\text{eV}) = -13.6\text{ eV} \quad \textbf{(1)}$$

5.Find the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its

- **second permitted energy level to the first permitted level and**
- **the highest permitted energy level to the first permitted level. [All India 2010]**

Ans.

(*i*) Since, the second permitted energy level to the first level $= E_2 - E_1 =$ energy of photon released $= (-3.4\text{ eV}) - (-13.6\text{ eV}) = 10.2\text{ eV}$

(*ii*) The highest permitted energy level to the first permitted level

$$= E_\infty - E_1 = 0 - (-13.6) = 13.6\text{ eV}$$

$\therefore$ Ratio of energies of photon

$$= \frac{10.2}{13.6} = \frac{3}{4} = 3:4 \quad \textbf{(1)}$$

6.What is the ratio of radii of the orbits corresponding to first excited state and ground state, in a hydrogen atom? [Delhi 2010]

Ans.

For first excited states $n = 2$

Ground state occurs for $n = 1$

$\because \quad r_n = r_0 n^2$

$\because \quad r \propto n^2$

$$\Rightarrow \quad \frac{r_1}{r_2} = \left(\frac{n_1}{n_2}\right)^2 = \left(\frac{2}{1}\right)^2$$

$\therefore \quad r_1 : r_2 = 4:1$

where, r_1 and r_2 are radii corresponding to first excited state and ground state of the atom. **(1)**

7.The radius of innermost electron orbit of a hydrogen atom is 5.3x 10-^{11} What is the radius of orbit in the second excited state?

Ans.

The radius of atom whose principal quantum number is n is given by

$$r = n^2 r_0$$

where, r_0 = radius of innermost electron orbit for hydrogen atom and $r_0 = 5.3 \times 10^{-11}$ m

For second excited state, $n = 3$

$$\therefore \quad r = 3^2 \times r_0 = 9 \times 5.3 \times 10^{-11}$$

$$r = 4.77 \times 10^{-10} \text{ m.}$$ **(1)**

8.Write the expression for Bohr's radius in hydrogen atom. [Delhi 2010]

Ans.

Expression for Bohr's radius in hydrogen atom

$$r = \frac{n^2h^2}{4\pi^2 mkZe^2}$$

$$r = \frac{n^2h^2}{4\pi^2 mke^2}$$

where, n = principal quantum number,

m = mass of electron

$$k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N-m}^2/\text{C}^2$$

Z = atomic number of atom = 1

h = Planck's constant **(1)**

9.State Bohr's quantisation condition for defining stationary orbits. [Foreign 2010]

Ans.

According to Bohr's quantisation condition, electrons are permitted to revolve in only those orbits in which the angular momentum of electron is an integral multiple of $\frac{h}{2\pi}$ i.e.

$$mvr = \frac{nh}{2\pi} \qquad \text{where } n = 1, 2, 3, \ldots$$

m, v, r are mass, speed and radius of electron and h being Planck's constant. **(1)**

10.In the Rutherford scattering experiment, the distance of closest approach for an a-particle is do. If a-particle is replaced by a proton, then how much kinetic energy in comparison to a-particle will be required to have the same distance of Closest approach do ? [Foreign 2009]

Ans.

> When α-particle is replaced by proton, then there will be change in atomic number and mass of the particle.

Distance of closest approach

$$d_0 = \frac{2kZe^2}{k_x} \qquad \left(\text{where, } k = \frac{1}{4\pi\varepsilon_0}\right)$$

∵ For given distance of closest approach,

kinetic energy ∝ Z (atomic number)

$$\Rightarrow \qquad \frac{K_{proton}}{K_\alpha} = \frac{Z_{proton}}{Z_\alpha} = \frac{1}{2}$$

$$\Rightarrow \qquad K_{proton} : K_\alpha = 1 : 2$$