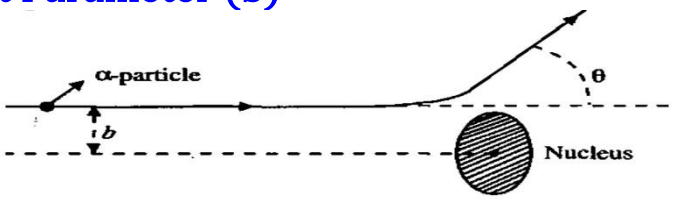
Chapter 12
Atoms

1.Write the postulates of Rutherford's nuclear model of the atom

- Most of an atom is empty space.
- The entire positive charge and most of the mass of the atom are concentrated in the nucleus with the electrons some distance away.
- The electrons would be moving in orbits about the nucleus just as the planets do around the sun.
- The size of the nucleus to be about 10^{-15} m to 10^{-14} m.
- The electrostatic force of attraction, between the revolving electrons and the nucleus provides the centripetal force to keep them in their orbits.

2.Define Impact Parameter (b)



Impact parameter is the perpendicular distance of the initial velocity vector of the α particle from the centre of the nucleus.

3.What is the importance of impact parameter on determining the trajectory of α particle

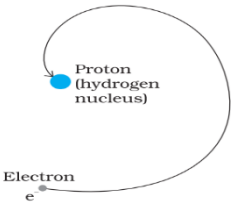
- For head on collision, the impact parameter b=0 and α particle rebounds back ie,
- For large impact parameter, the angle of scattering will be small ($\theta \approx 0^0$) and such α particles go undeviated.

4.What is the angle of scattering for an impact parameter=0

angle of scattering $\theta = 180^0$.

5.Write the limitations of Rutherford Model

(a) Rutherford model could not explain stability of matter. The accelerated electrons revolving around the nucleus loses energy and must spiral into the nucleus. This contradicts the stability of matter.



(b) It cannot explain the characteristic line spectra of atoms of different elements.

6.Write the postulates of Bohr atom model.

First postulate : An electron in an atom revolves in certain stable orbits without the emission of radiant energy.

Second postulate :The orbital angular momentum of electon is an integral multiple of h/2π

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

Third postulate : When an electron make a transition from higher energy level to lower energy level a photon is emitted having energy equal to the energy difference between the initial and final states.

$$h\nu = E_i - E_f$$

7. Write the expression for radius of Hydrogen atom.

$$r_n = \frac{n^2h^2\varepsilon_0}{\pi me^2} \qquad \text{or} \qquad r_n = 0.53\ n^2 Å$$

8.Write the expression for energy of Hydrogen atom

$$E_n = \frac{-me^4}{8n^2\varepsilon_0{}^2h^2} \qquad \text{or} \qquad E_n = \frac{-13.6}{n^2}\ eV$$

The negative sign of the total energy of an electron moving in an orbit means that the electron is bound with the nucleus.

9.Derive the expression for Energy of Hydrogen Atom

Total Energy = KE + PE

$$E = \frac{e^2}{8\pi\varepsilon_0 r} + \frac{-e^2}{4\pi\varepsilon_0 r}$$

$$\mathbf{E = \frac{-e^2}{8\pi\varepsilon_0 r}}$$

For the $\boldsymbol{n^{th}}$ energy level

$$\mathbf{E_n = \frac{-e^2}{8\pi\varepsilon_0 r_n}}$$

Substituting for $r_n = \frac{n^2h^2\varepsilon_0}{\pi me^2}$

$$\mathbf{E_n} = \frac{-e^2}{8\pi\varepsilon_0\ (\frac{\mathbf{n^2h^2\varepsilon_0}}{\mathbf{\pi me^2}})}$$

$$\mathbf{E_n = \frac{-me^4}{8n^2\varepsilon_0{}^2h^2}}$$

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

10.Find the energy of different energy levels

For ground state(First energy level)

$$n=1 \qquad E_1 = \frac{-13.6}{1^2}\ eV = -13.6\ eV$$

For first excited state (second energy level)

$n = 2$, $E_2 = \frac{-13.6}{2^2}$ eV = -3.4 eV

For second excited state (third energy level)

$n = 3$, $E_3 = \frac{-13.6}{9^2}$ eV = -1.51 eV

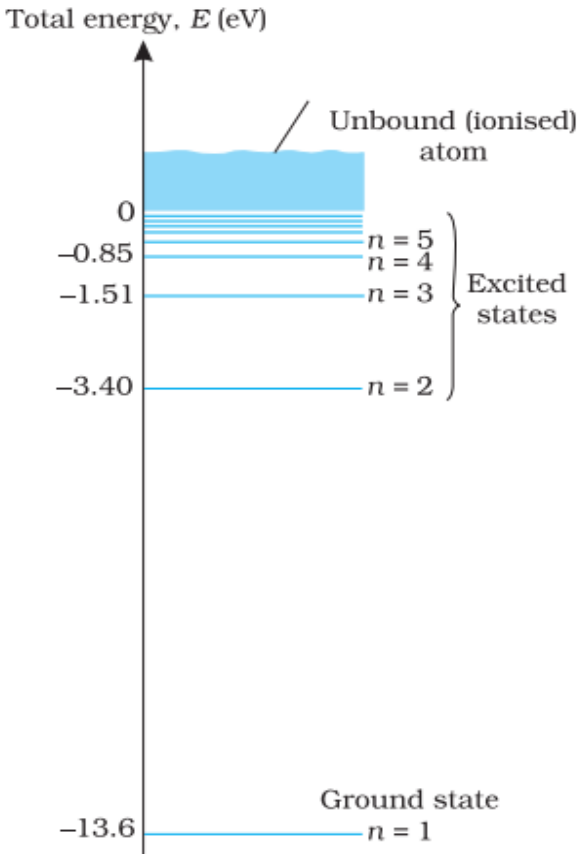
11. Define Ionisation Energy

The minimum energy required to free the electron from the ground state of the atom is called the Ionisation energy.

12. Write the Ionisation energy of Hydrogen atom.

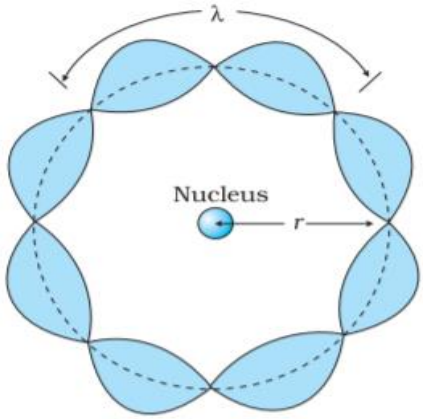
Ionisation energy of Hydrogen atom is +13.6 eV

13.Draw the energy level diagram for the hydrogen atom



14.Explain how de Broglie Explained Bohr's second postulate of Quantisation.

De Broglie argued that electron in its circular orbit behaves as a particle wave. The particle wave can produce standing wave under resonant condition.



For n^{th} orbit of radius r_n , the resonant condition is

$$2\,\pi\, r_n = n\,\lambda \text{---------- (1)}$$

Where n=1,2,3.....

But by de Broglie hypothesis , for matter waves

$$\lambda = \frac{h}{mv} \text{----------(2)}$$

Substituting eqn (2) in eqn (1),

$$2\,\pi\, r_n = n\,\frac{h}{mv}$$

$$mv\, r_n = \frac{nh}{2\,\pi} \quad \text{where n=1,2,3.....}$$

This Bohr's second postulate of Quantisation.

15.Write the limitations of Bohr Atom Model

(i) The Bohr model is applicable to hydrogenic atoms. It cannot be extended two or more electron atoms.

(ii) The Bohr model is unable to explain the intensity variations of the frequencies in hydrogen spectrum