12. ATOMS

Single Page Simple Synopsis

This chapter **Atoms** explores the historical and physical evolution of various atomic models.

Key concepts :

1. **J.J. Thomson's Plum Pudding model:** The first model of an atom was proposed by J.J. Thomson in 1898. This model described the atom as a static, electrically neutral sphere of uniform positive charge along with negatively charged electrons embedded inside it, like seeds in a watermelon.
2. **Rutherford's Alpha Particle Experiment:** This experiment proved that an atom has a tiny, dense, positively charged center called the **nucleus**, with electrons revolving around it.
3. **Bohr's Model of the Hydrogen Atom:** Bohr proposed that electrons revolve around the nucleus in specific, stable, discrete energy levels (orbits) without radiating energy, and only emit or absorb energy when jumping between these levels.
   - **Hydrogen Spectrum:** When electrons transition between energy levels, they produce specific line spectra (**Ex:** Lyman, Balmer, Paschen, Brackett, and Pfund series).
4. **de Broglie's Quantization of Angular Momentum:** Louis de Broglie explained Bohr's second postulate by showing that an electron orbit must contain an exact integral multiple of electron wavelength

IMP. IPE POINTS

1. **An atom** contains equal amounts of positive and negative charges to make the atom as a whole **neutral**.

2. In **Thomson's model of atom**, positive charge is distributed all over the atom and the electrons are embedded in it like seeds in a watermelon.

3. In **Rutherford's model of atom**, the central part of the atom is called nucleus. The nucleus contains almost total mass and total positive charge of the atom. Electrons revolve around the nucleus like planets revolve around the sun.

4. Drawbacks of Rutherford's model of atom are (i) it could not explain the stability of atom (ii) it could not explain the spectral emissions from the atoms.

5. The hydrogen atom emits different spectral series. The frequencies of their spectral lines are given by

Lyman series: $\nu = Rc\left(\frac{1}{1^2}-\frac{1}{n^2}\right); n = 2, 3, ...$

Balmer series: $\nu = Rc\left(\frac{1}{2^2}-\frac{1}{n^2}\right); n = 3, 4.....$

Paschen series: $\nu = Rc\left(\frac{1}{3^2}-\frac{1}{n^2}\right); n = 4, 5......$

Brackett series: $\nu = Rc\left(\frac{1}{4^2}-\frac{1}{n^2}\right); n = 5, 6.......$

Pfund series: $\nu = Rc\left(\frac{1}{5^2}-\frac{1}{n^2}\right); n = 6, 7.......$

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

Rhydberg constant: $R \simeq 1.097\times10^7\,m^{-1}$

6. **Bohr's 1st postulate (Stationary Orbits):** Electrons can only orbit in specific, stable orbits without radiating energy.

7. **Bohr's 2nd postulate (Quantized Angular Momentum):** An electron can only revolve if its orbital angular momentum is an integral multiple of $h/2\pi$.

$$L = n\left(\frac{h}{2\pi}\right) \text{(or)}\ mvr = \frac{nh}{2\pi}, \ n=1,2,3,...$$

8. **Bohr's 3rd postulate (Energy Transitions):** Radiation is emitted or absorbed only when an electron jumps from one stationary orbit to another. $\Delta E = E_i - E_f = h\nu$

9. Expression for radius of electron orbit (rn) in terms of Bohr's second postulate is

$$r_n = \frac{\varepsilon_0 h^2 n^2}{\pi m e^2};\ r_n \propto n^2;\ r_n \approx 0.529\times n^2 \text{Å}$$

10. Relation between radius of electron orbit (rn) and velocity of the electron in the orbit (vn) is

$$r_n = \frac{e^2}{4\pi\varepsilon_0 m v_n^2}$$

11. Expression for velocity of electron in n^{th} orbit of hydrogen atom is

$$v_n = \frac{e^2}{2\varepsilon_0 hn};\ v_n \propto \frac{1}{n}$$

12. Expression for kinetic energy of electron in n^{th} orbit of hydrogen atom is

$$K_n = \frac{me^4}{8\varepsilon_0^2 h^2 n^2};\quad K = \frac{e^2}{8\pi\varepsilon_0 r}$$

13. Expression for potential energy of electron in n^{th} orbit of hydrogen atom is

$$U_n = -\frac{me^4}{4\varepsilon_0^2 h^2 n^2};\quad U = \frac{-e^2}{4\pi\varepsilon_0 r}$$

14. Expression for total energy of electron in n^{th} orbit of hydrogen atom is

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