CONCEPT MAP

Atoms and Nuclei

Atomic Models

Bohr's Model: Bohr developed a theory of hydrogen and hydrogen-like atoms which have only one orbital electron.

$$L = \frac{nh}{2\pi} \text{ or } mvr = \frac{nh}{2\pi}$$

Bohr's Formulae:

$$r_n = \frac{4\pi\varepsilon_0 n^2 h^2}{4\pi^2 mZe^2} = \frac{0.53n^2}{Z}\text{Å}$$

Composition of Nucleus: The nucleus of an atom contains protons and neutrons which are collectively known as nucleons.

Isotopes: Isotopes of an element are the atoms of the element which have the same atomic number but different mass numbers. *e.g.* $_1H^1$, $_1H^2$, $_1H^3$

Isotones: Isotones are the nuclides which contain the same number of neutrons *e.g.* $_{17}Cl^{37}$ and $_{19}K^{39}$.

Isobars: Isobars are the atoms of different elements which have the same mass number but different atomic numbers. *e.g.* $_{11}Na^{22}$ and $_{10}Ne^{22}$

Mass Defect: The difference in mass of a nucleus and its constituents is known as the mass defect.

$$\Delta m = [Zm_p + (A-Z)m_n - m_N]$$

Nuclear Radius:

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

Nuclear Density:

$$\rho = \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}}$$

Spectral Series of Hydrogen atom:

Lyman Series:

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

Balmer Series:

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

Paschen Series:

$$\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n_2^2}\right]$$

Brackett Series:

$$\frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{n_2^2}\right]$$

Pfund Series:

$$\frac{1}{\lambda} = R\left[\frac{1}{5^2} - \frac{1}{n_2^2}\right]$$

Rutherford's Model of Atom: The entire positive charge and most of the mass of the atom is concentrated in a small volume known as nucleus with electrons.

Impact Parameter:

$$b = \frac{Ze^2 \cot(\theta/2)}{4\pi\varepsilon_0 K}$$

Rutherford's Scattering Formula:

$$N(\theta) = \frac{N_i nt Z^2 e^4}{(8\pi\varepsilon_0)^2 r^2 K^2 \sin^4(\theta/2)}$$

Radioactivity: Radioactivity is the spontaneous disintegration of nuclei of some nuclides (called radionuclides) with the emission of alpha particles or beta particles some accompanied by gamma rays.

Alpha Decay: It is represented by

$$^A_Z X \rightarrow ^{A-4}_{Z-2} Y + ^4_2He$$

Beta Decay: It is represented by

$$^A_Z X \rightarrow ^A_{Z+1} Y + e + \bar{\nu}$$

Gamma Decay: It is represented by

$$^A_Z X' \rightarrow ^A_Z X + \gamma$$

Binding Energy:

$$E_b = \Delta mc^2 = [Zm_p + (A-Z)m_n - m_N]c^2$$
$$= [Zm_p + (A-Z)m_n - m_N] \times 931.49 \text{ MeV/u}$$

Nuclear Reaction: A nuclear reaction is represented by

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

Nuclear Fusion: It is the phenomenon of fusing two or more lighter nuclei to form a single heavy nucleus.

$$_1H^2 + _1H^2 \rightarrow _2He^4 + 24 \text{ MeV}$$

Nuclear Fission: It is the phenomenon of splitting a heavy nucleus into two or more smaller nuclei.

e.g.

$$_{92}U^{235} + _0n^1 \rightarrow _{56}Ba^{141} + _{36}Kr^{92} + 3_0n^1 + Q$$

Symbols Used:

$N(\theta)$ = number of α particles per unit area
K = kinetic energy of the alpha particles
b = impact parameter
m = mass of the electron
t = foil thickness
E_b = binding energy
N_i = total number of alpha particles that reach the screen
v = velocity of electron
Δm = mass defect
X = nucleus before decay
X' = nucleus in excited state.
Y = nucleus after decay
Z = atomic number of the foil atoms
λ = wavelength
r = distance of the screen from the foil
h = Planck's constant
L = angular momentum
R = Rydberg's constant
n = number of atoms