IIT-JEE / MEDICAL

PHYSICS

KEY TERMS

Atoms & Nuclei

By

BHARAT BHUSHAN @ B. K. NAL
Assistant Professor (Computer Science)
Director, BSTI, Kokar

&

SUPRIYA BHARATI
Assistant Professor (Computer Science)
Asst. Director, BSTI, Kokar

Buddha Science & Technical Institute
Kokar, Ranchi-834001, Jharkhand, India
www.bharatsir.com

1. **Distance of Closest Approach.** The minimum distance up to which an energetic α -particles travelling directly towards the nucleus can move before coming to rest and then retracing its path is known as distance of closest approach. This distance estimates the size of the nucleus.
2. **Impact Parameter (b).** The perpendicular distance of the velocity vector ($\vec{u}$) of the particle from the nucleus when it is far away from the nucleus is known as impact parameter. It is denoted by b.
3. **Mass number**.The sum of the number of protons (Z) and the number of neutrons (N) is called **Mass number (A).**
4. **Isotopes.** The atoms of an element having same atomic number (Z) but different mass number (A) are called isotopes. Isotopes have same number of electrons and protons but different number of neutrons.
5. **Isobars.** The atoms of elements having same mass number (A) but different atomic number (Z) are called Isobars.
   Isobars have same number of total nucleons but different number of protons, electrons and neutrons.
6. **Isotones.** The atoms of the elements whose nuclei have the same number of neutrons are called Isotones**. For example.**(i)$_4$ Be^9 and , B,^{10} (ii) $_6$ C^{13} and $_7$N^{14} (iii) $_9$F^{19} and $_{10}$Ne^{20} (iv) $_{11}$Na^{23}and $_{12}$Mg^{24}.
7. **Nuclear Density.** Mass per unit volume of a nucleus is called nuclear density.
8. **Mass Defect** is defined as the difference between the mass of the constituent nucleons of the nucleus in the free state and the mass of the nucleus. It is denoted by Δm
9. **Natural Radioactivity.** The phenomenon of spontaneous emission of radiations by heavy elements is called radio-activity. The elements which show this phenomenon are called radioactive elements.
10. **α-particle.** An α-particle is a helium nucleus ($_2$He^4) having two protons and two neutrons.
11. **β-particle**. A β-particle is a fast moving electron ($_{-1}$e^0) due to decay of a radioactive nucleus.
12. **γ-rays**. γ-rays are the packets of electromagnetic radiation and are known as photons. They do not have any charge and their rest mass is zero.

13. **Laws of Radioactive Decay (i.e. disintegration)**

    1. **Radioactive decay(i.e. disintegration)** is a spontaneous process and is not affected by the external conditions such as temperature, pressure etc.
    2. When a radioactive element decays by emitting an α-particle, its position goes down by two places in the periodic table.

$$\text{i.e.} \quad {}_{z}X^{A} \xrightarrow[({}_{2}He^{4})]{\alpha-particle} {}_{Z-2}Y^{A-4}$$

The original radioactive element (${}_{Z}X^{A}$) is called **parent element** and the product element (${}_{Z-2}X^{A-4}$) obtained after α-decay is called **daughter element.**

    3. When a radioactive element decays by emitting a β-particle, its position is raised by one place in the periodic table.

$$\text{i.e.} \quad {}_{z}X^{A} \xrightarrow[(-1e0)]{\beta-particle} {}_{Z+1}Y^{A}$$

    4. When a radioactive element decays by emitting a γ-rays, its position remains the same in the periodic table. The radioactive element in the excited state comes to its ground state by emitting the energy in the form of a photon or γ-ray.

$$\text{i.e.} \quad {}_{Z}X^{A} \longrightarrow {}_{Z}X^{A}$$

    5. The rate of disintegration of a radioactive substance is directly proportional to the number of atoms remained undecayed in the substance. This law is called **radioactive decay law or disintegration law.**

14. **Radioactive Decay Constant or Disintegration Constant (λ).** Radioactive decay constant (λ) is the reciprocal of the time during which the number of atoms in the radioactive substance reduces to 36.8% of the original number of atoms in it. **Units of decay constant.** Decay constant is expressed in s^{-1} or **min^{-1}** or **day^{-1}** or **$year^{-1}$**

15. Half **Life of a radioactive substance.** The time during which half of the atoms of the radioactive substance disintegrates is called **half life** of a radioactive substance.

16. **Mean-life i.e. Average life of a Radioactive substance**. It is defined as the sum of lives of all atoms divided by the total number of atoms.

$$\text{i.e. Mean-life, } T_m \text{ or } T_{av} = \frac{\text{Sum of lives of all atoms}}{\text{Total number of atoms}}$$

17. **Activity of a Radioactive Substance.** It is defined as the rate of disintegration of the substance.

    i.e. Activity, A = Number of atoms disintegrated per second.

18. **Curie.** The activity of a given sample of a radioactive substance is said to be 1 curie if it has 3.7×10^{10} disintegrations second.
19. **Rutherford.** The activity of a given sample of a radioactive substance is said to be 1 Rutherford if it has 10^6 disintegration per second.
20. **Becquerel (Bq).** The activity of a given sample of 1 becquerel if it has 1 disintegration per second.
21. **Artificial Radioactivity (Radio-Isotopes).** The process by which stable nuclei are made unstable by bombarding them with high energy particles and then these unstable nuclei are made to emit nuclear radiations is called **artificial radioactivity**.

    The artificially made unstable nuclei are called **radio-isotopes.**
22. **Tracer Technique.** In this technique, a small quantity of radio isotope is introduced into the substance to be investigated and the path of radioisotope is traced by means of a sensitive detector (G.M counter).
23. **Atomic mass unit (a.m.u.).** The General conference on Weights and Measures introduced the unified mass unit known as atomic mass unit (a.m.u.or simply u) to express the masses of electrons, protons and neutrons.

    1 a.m.u. is equal to $1/12^{th}$ mass of carbon-12 ($_6C^{12}$) atom
24. **Binding Energy.** The total energy required to disintegrate the nucleus into its constituent particles (i.e. nucleons) is called **binding energy** of the nucleus.
25. **Binding energy per nucleon.** The average energy required to release a nucleon from the nucleus is called binding energy per nucleon.

Binding energy per nucleon =

$$\frac{\text{Binding energy}}{\text{Total number of nucleons in the nucleus (i.e. Mass number)}}$$

26. **Packing Fraction.** Packing fraction is defined as the mass defect per nucleon.
27. **Nuclear Reaction.** The process by which the identity of a nucleus is changed when it is bombarded by an energetic particle is called **nuclear reaction.**
28. **Q-value or Energy of Nuclear Reaction**. The energy absorbed or released during nuclear reaction is known as Q-value of Nuclear reaction.

    Q-value is defined as the difference between the mass of reactants and the mass of products

    Q value of a nuclear reaction may also be defined as the difference between the kinetic energy of reactant and products.
29. **Nuclear Fission.** It is a process of splitting a heavy nucleus into two nuclei of comparable masses along with the emission of large amount of energy.
30. **Chain Reaction in Nuclear Fission.** In nuclear fission, three neutrons are produced along with the release of large amount of energy .These newly produced neutrons can cause further fission of more nuclei, producing large number of neutrons. The process continues and the number of fission taking place stage goes on increasing at a fast rate. This process is called uncontrolled chain reaction.
31. **Nuclear reactor.** Nuclear reactor is a device in which nuclear fission is maintained as a self-supporting yet controlled chain reaction.
32. **Moderator**. Moderator is used to slow down the fast moving neutrons. Most commonly used moderators are graphite and heavy water.
33. **Coolant.** Coolant is a cooling material which removes the heat generated due to fission in the reactor. Commonly used coolants are water, CO_2, nitrogen etc.
34. **Nuclear fusion.** A process in which two very light nuclei ($A \leq 8$) combine to form a nucleus with a large mass number along with simultaneous release of large amount of energy is called nuclear fusion.
35. **Nuclear Holocaust**. The radioactive waste or dust hanging like clouds in the sky or atmosphere of earth due to heavy use of nuclear weapons etc. is called **nuclear holocaust.**

36. **Postulates of Bohr's atom Model**

1. An atom has a small positively charged core where whole of the mass of an atom is supposed to be concentrated. This core is called nucleus of the atom.

2. The electrons revolve round the nucleus in fixed orbits of definite radii. As long as the electron is in a certain orbit, it does not radiate any energy..

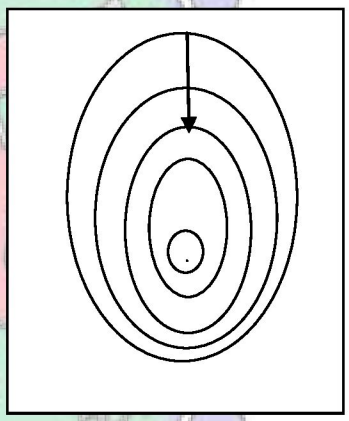
Therefore, the orbits in which electrons move are called stationary states.

3. The electrons can revolve only in those orbits, in which its angular momentum is an

integral multiple of $\frac{h}{2\pi}$

i.e. $L = m\upsilon r = \frac{nh}{2\pi}$ (Bohr's quantization condition for angular momentum) …(1)

Here, m = mass of an electron, υ = velocity of an electron, r = radius of the orbit, h = planck's constant and n=1, 2, 3,....is an integer called **principal quantum number.**



4.The energy is radiated in the form of a photon, only when an electron jumps from higher energy orbit to lower energy orbit.

If E_i and E_f are the energies associated with the orbits of principal quantum numbers n_i and n_f respectively ($n_i > n_f$), then the amount of energy radiated in the form of a photon is given by

$$h\nu = E_i - E_f$$

where, ν is the frequency of the emitted radiation.

37. **Bohr's Radius**. The radius of the innermost orbit (n = 1) in the hydrogen atom is called Bohr's radius (a_o).

38. **Spectral Line.** When electron jumps from higher state (orbit) to the lower energy state (orbit)in the hydrogen atom, the radiation of a particular wavelength or frequency is emitted. This radiation is called spectral line.

39. **Spectral Series.** The spectral lines arising from the transition of electron from the higher energy states to a particular lower energy state form a **spectral series**

40. **Lyman Series.** The spectral lines emitted due to the transition of an electron from any outer orbit (n_i = 2,3,4,5,....) to the first orbit (n_f =1) form a spectral series known as **Lyman** series.
41. **Balmer Series.** The spectral lines emitted due to the transition of an electron from any outer orbit (n_i =3, 4, 5, 6,.....) to the second orbit (n_f = 2) form a spectral series known as Balmer series
42. **Paschen Series.** The spectral lines emitted due to the transition of an electron any outer orbit (n_i = 4,5,6,....) to the third orbit (n_f = 3) form a spectral series known as **Paschen series.**
43. **Brackett Series.** The spectral lines emitted due to the transition of an electron from any outer orbit (n_i = 5, 6, 7,.....) to the fourth orbit (n_f = 4) form a spectral series known as **Brackett series**
44. **Pfund Series.** The spectral lines emitted due to the transition of an electron from any outer orbit (n_i = 6,7, 8,.....) to the fifth orbit (n_f = 5) form a spectral series known as **Pfund** series.
45. **Excitation.** Excitation is a process of absorption of energy by an electron of an atom when it goes from lower energy state to the higher energy state.
46. **Excitation Energy.** The amount of energy absorbed by the electron to go from the ground state to the higher energy state is called the excitation energy.
47. **Excitation Potential.** Potential difference through which an electron in an atom must be accelerated so that it may go from the ground state to the excited state is called excitation potential of atom.
48. **Ionisation.** The process of detaching or knocking out an electron from the atom is called ionization.
49. **Ionisation Energy.** The energy required to knock an electron from an atom is called ionization energy of the atom.
50. **Ionisation potential.** The potential difference through which an electron of the atom is accelerated so that it is knocked out of the atom.
51. **Emission Spectra.** The spectra obtained from the radiation emitted, when the atoms of the substance return to their ground states from their excited states is called emission spectra.
52. **Line emission spectrum.** A spectrum consisting of lines of various wavelengths emitted by the atomic gas or vapour which is excited by suitable means is called Line Emission Spectra.

53. **Band spectrum.** The spectrum consisting of bands (each band is sharp at one end and diffused at the other) is called balled band spectra.
54. **Continuous Spectrum**. A spectrum which contains radiation of all possible wavelengths emitted by a substance is called continuous spectrum.
55. **Fraunhoffer's Lines**. Fraunhoffer studied the spectrum of sun and observed few dark lines in the sun's visible spectrum. These dark lines are known as Fraunhoffer's Lines.

Note : if any mistake on this, kindly inform on the mail id :

bknal1207@gmail.com

Your Observation! Our Correction !!