

ATOMIC STRUCTURE AND THE PERIODIC TABLE

CHAPTER 5

1.Lights and spectroscopy

- Spectroscopy-It is the study of dispersion of the light of an object into the colors that make it up. It is concerned with the absorption, emission or scattering of electromagnetic radiation by atoms or molecules.

A. The characteristics of light.

- Rectilinear properties of light: light moves in a straight line.
- Its frequency does not change when it passes from one medium to another.
- It passes completely through transparent objects, partially through translucent objects and not at all in opaque objects.
- Its speed changes when it goes from one medium to another

The dual nature of light

- Light has a wave nature and a particle nature.
- When we say wave nature we mean that light acts like a wave. some common terms which are associated with this concept:
- **Amplitude:** - the height of the wave
- **Frequency:** - the number of waves to pass a point per minute
- **Wave speed:** - how fast the wave is moving
- **Wave length:** - the distance between successive waves
- $E(\text{energy}) = h(\text{Planck's constant})v(\text{velocity}) = hC(\text{speed of light})/\lambda(\text{ wave length})$
- Where $h = 6.62 \times 10^{-34} \text{J.S}$ and $C = 3 \times 10^8 \text{m/s}$

b. Quantization and photons

- Quantization: process of converting the sampled analogue signal into impulses of discrete values of amplitude.
- Energy is lost in small definite amounts called “quantum”
- $E = nh\nu$
- Where E is the energy, ν is the frequency, n is a positive integer called the quantum number and h is Planck's constant.

Quantum numbers

- The principal quantum number (n) - a positive number having the values; 1, 2, 3...
- The azimuthal quantum number(l)- also known as angular momentum or subsidiary quantum number and having values from 0 to $n-1$
- The magnetic quantum number(m_l)- also known as the orbital-orientation quantum number and having values from $-l$ to $+l$
- The electron spin quantum number(m_s) has values of either $+1/2$ (represented by $\uparrow$) or $-1/2$ (represented by $\downarrow$)

2. The structure of the hydrogen atom

a. **The spectrum of atomic hydrogen**

- certain properties of the electron in a hydrogen atom are quantized.
- Bohr proposed three postulates for his model:
- The hydrogen atom has stationary states. A stationary state is a certain allowable energy level which is associated with a fixed circular orbit of the electron around the nucleus.
- The atom does not radiate energy in a stationary state.
- $E_{ph} = E_f - E_i = h\nu$, where the subscripts f and i represent the final and initial states respectively

B. particles and waves

- wave-particle duality- this theory is that matter behaves both as particle or wave depending on the circumstances. What that means is that particles show behaviors like interference or diffraction.
- In reference to what we mentioned above we are not saying that matter displays different behavior in a macroscopic world in comparison to its behavior in a sub atomic world but, rather that as our views shift so does our notice of the behaviors.

3. The structure of many electron atoms

a. **Orbital energies**

- The energy of an electron in a hydrogen atom is determined by the quantum number 'n' and increases as follows:
- $1s < 2s < 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f < \dots$
- In many electron atoms however, the shielding effect (electron-electron repulsion causes the energy of 'p' sub shell to be higher than that of an 's' sub shell of the same shell and the energy of a 'd' sub shell to be higher than that of a 'p' sub shell of the same shell. The one with the lower energy is said to be more penetrating than the one with the higher energy.

b. The building up principle

- The principle states that electrons always occupy the lowest energy orbital before occupying a higher one.
- Except for hydrogen, the energies of orbital's with the same quantum number 'n' increases with 'l'.
- When sub shells have the same energy the building up principle is not based on the order of their energies but the total energy.
- Some exceptions to the building up principle are: $24\text{Cr} = [\text{Ar}]3\text{d}^54\text{s}^1$ and $29\text{Cu} = [\text{Ar}]4\text{s}^13\text{d}^9$

4.A survey of periodic table

a. **Blocks, periods and groups**

- **Periods**- the horizontal rows of elements in the periodic table.
- elements in the same period have the same number of shells.
- Periods 1, 2, 3 are short periods while 4, 5, 6 are long periods. Period 6 is the longest with more than 24 elements. Period 7 elements are radioactive or artificial elements.

Groups/ Families-

- are the vertical columns in the periodic table. There are 18 of them usually assigned to roman numbers.
- IA- VIIIA – main group (A group)
- IB- VIIB – sub group (B group)

Block

- ***s block elements*** - the last element to enter s- orbital.
- ***p-block elements***- the last electron enters the p- orbital.
- ***d-block (transition)*** - its found between s and p block.
- ***f-block (rare earth metals)***-The last valence electron is being added to the f- orbital

b. Periodicity of physical properties

- The periodicity of some physical properties in the periodic table is listed below:
 1. Atomic radius: the distance from the centre of an atom to the outer most edge. It is affected by 2 factors.
 - a. Number of protons- the greater the number of protons the smaller the atom.
 - b. Number of electron shells- the greater the number of shells, the greater the atom.
- Atomic radius decreases as we go across a period from left to right.
- 2. Melting point: the point at which a given solid melts. Melting point decreases across a period from left to right. It increases down a group because of an increase in metallic character.
- 3. Boiling point: is the temperature at which a liquid starts to vaporize.

c. Trends in chemical properties

- Some of the chemical periodic properties are:
- Metallic character: it depends on the ability of metallic elements to lose their outer valence electrons. It decreases across a period from left to right and decreases down a group.
- Electron negativity: it's the ability of a substance to attract shared electrons of a covalent bond towards itself. It increases across a period and decreases down a group.
- Ionization energy: it's the amount of energy require to remove an electron from the valence shell of an atom. It increases across a period and decreases down a group.