FOCUS NEET/JEE 2019

Class XI

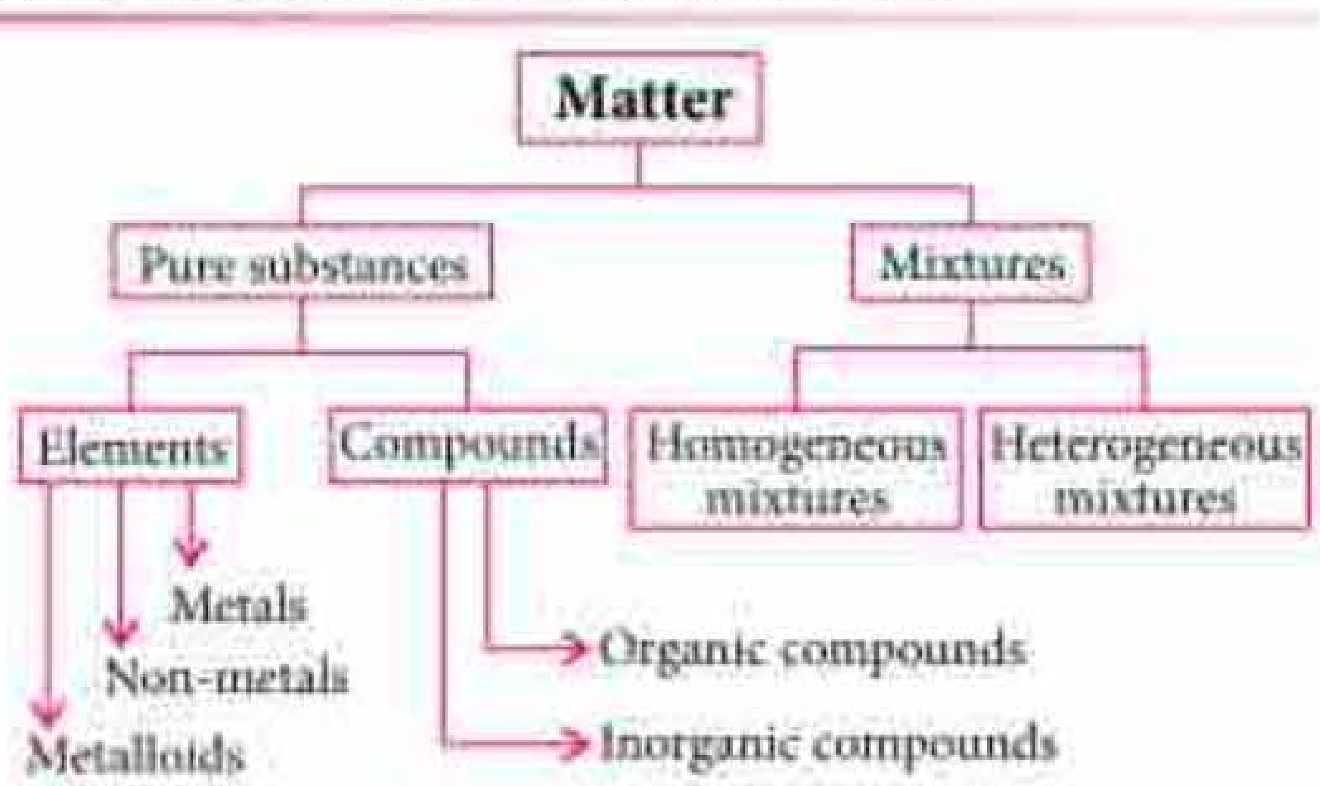
Focus more to get high rank in NEET, JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

UNIT - 1 : Some Basic Concepts of Chemistry / Structure of Atom

SOME BASIC CONCEPTS OF CHEMISTRY

- Chemistry deals with the composition, structure and properties of matter which can be described and understood in terms of basic constituents of matter *i.e.*, *atoms* and *molecules*.
- Anything which has mass and occupies space is called *matter*.

Chemical Classification of Matter



Laws of Chemical Combination

- **Law of conservation of mass :** It states that during any physical or chemical change, total mass of products is equal to the total mass of reactants.

  e.g., $C + O_2 \longrightarrow CO_2$

  12 g 32 g 44 g

  Mass of CO_2 = Mass of C + Mass of O_2
- **Law of definite proportion :** It states that a compound always contains the same elements combined in the same definite proportion by weight. *e.g.*, water (H_2O) obtained from any source always contains 2 g of hydrogen in combination with 16 g of oxygen.
- **Law of multiple proportion :** It states that when two or more elements combine to form two or more compounds, the different weights of one of the elements which combine with the fixed weight of the other, bear a simple whole number ratio to one another.

  e.g., The ratio between the weights of oxygen in different compounds which combine with the same weight of N (14 parts) is

8 :	16 :	24
1 :	2 :	3
N_2O	NO	N_2O_3
- **Law of reciprocal proportion :** It states that when two elements combine separately with a fixed mass of third element, then the ratio between their masses in which they combine will be either same or simple multiple of the ratio in which they combine with each other.
- **Gay Lussac's law of combining volumes :** It states that under similar conditions of temperature and pressure, whenever gases react together, the volumes of the reacting gases as well as products bear a simple whole number ratio.

Atomic Mass

- Atomic mass $= \dfrac{\text{Mass of one atom of the element}}{\frac{1}{12}\text{ mass of one atom of }^{12}\text{C isotope}}$
- Number of gram atom or mole of atoms $= \dfrac{\text{Mass of element in gram}}{\text{Gram atomic mass}}$
- Atomic mass = Equivalent mass × Valency
- Atomic mass $= \dfrac{6.4}{\text{Specific heat}}$ (approx)

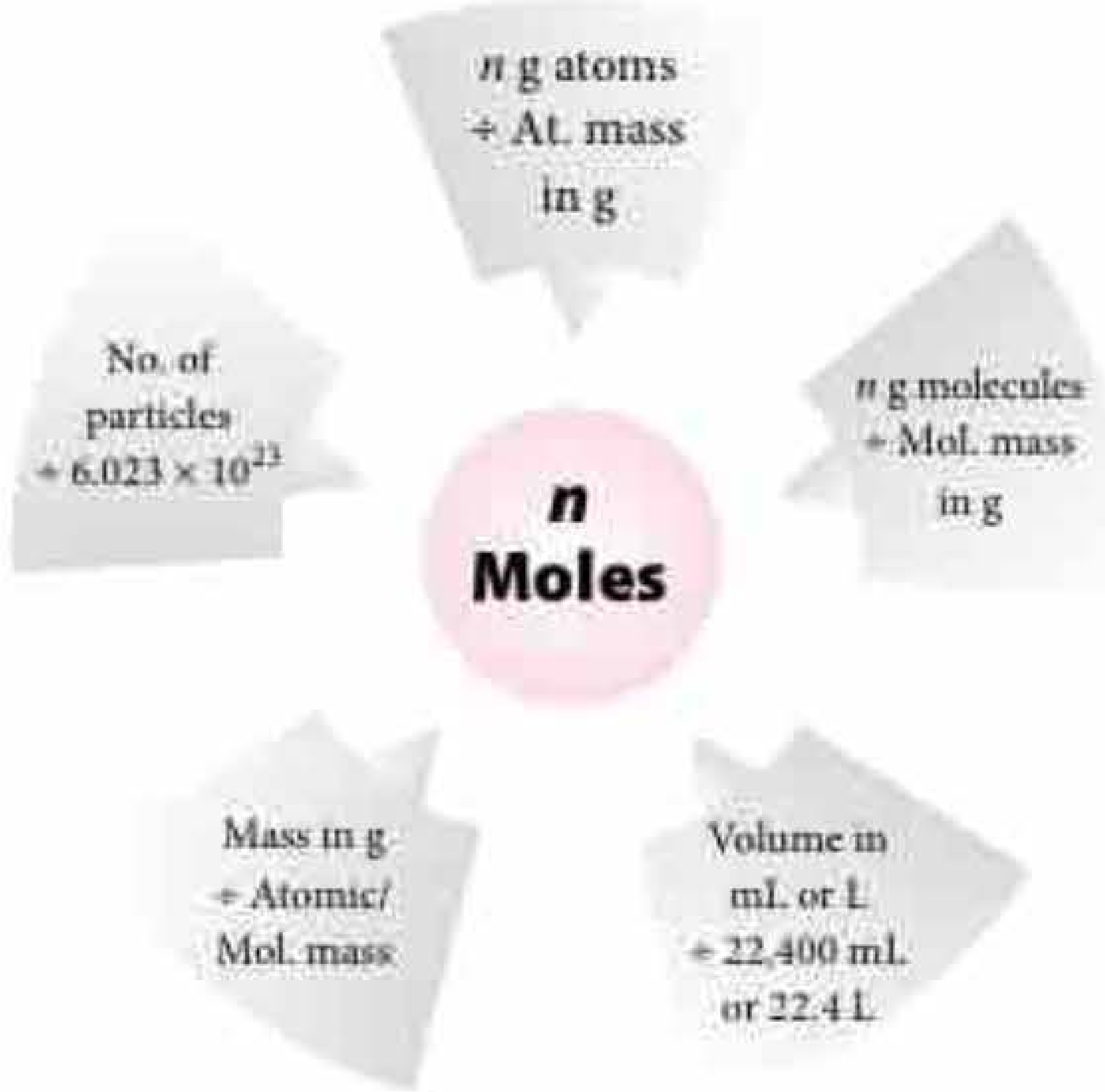
Molecular Mass

- Molecular mass $= \dfrac{\text{Mass of one molecule of a substance}}{\frac{1}{12}\times\text{Mass of one atom of }^{12}\text{C isotope}}$
- Molecular mass = 2 × Vapour density

Equivalent Weight

- Equivalent weight of an element in a redox reaction $= \dfrac{\text{Atomic weight}}{\text{No. of electrons lost or gained by one atom of that element}}$
- Equivalent weight of an element $= \dfrac{\text{Atomic weight of the element}}{\text{Valency of the element}}$
- Equivalent weight of an acid $= \dfrac{\text{Molecular weight of the acid}}{\text{Basicity}}$
- Equivalent weight of a base $= \dfrac{\text{Molecular weight of the base}}{\text{Acidity}}$

Mole Concept



Determination of Chemical Formula

- Empirical formula gives the simple whole number ratio of the atoms of various elements present in one molecule of the compound.
- Molecular formula gives the actual number of atoms of various elements present in one molecule of the compound.
- Molecular formula = n (Empirical formula), where n = 1, 2, 3, ...

Stoichiometry

- In balanced chemical equation, the quantitative relationship between various reactants and products in terms of moles, masses, molecules and volumes is called stoichiometry. Stoichiometry is the Greek word meaning to measure an element. The coefficient of balanced chemical equation are called stoichiometric coefficients.

  For example :

  $$\underset{3\text{ moles}}{3SO_2} + \underset{2\text{ moles}}{2H_2S} \rightarrow \underset{2\text{ moles}}{2H_2O} + \underset{3\text{ moles}}{3S} + \underset{2\text{ moles}}{2O_2}$$

  3 moles of SO_2 react with 2 moles of H_2S to give 2 moles of water, 3 moles of sulphur and 2 moles of O_2.

Limiting Reagent

- The reactant which is completely consumed in the reaction and hence limits the amount of product formed is called limiting reagent.
- In case where there is a limiting reagent, the initial amount of the limiting reagent must be used to calculate the amount of product formed.

Reactions in Solution

- Normality = Number of gram equivalents of the solute/volume of the solution (in L)
- Molarity = Number of moles of the solute/volume of the solution (in L)
- No. of gram equivalents

$$= \frac{\text{Weight of the solute (in g)}}{\text{Equivalent weight of the solute}}$$

- No. of milliequivalents

$$= \frac{\text{Weight of solute}}{\text{Equivalent weight of solute}} \times 1000$$

- No. of moles $= \frac{\text{Weight of the solute (in g)}}{\text{Molecular weight of the solute}}$
- Molality = Number of moles of solute/Weight of solvent (in kg)
- Normality equation or molarity equation

$N_1 \times V_1 = N_2 \times V_2$

$M_1 \times V_1 = M_2 \times V_2$

- When the solutions of two substances (an acid and a base or an oxidizing and a reducing substance) react completely, we apply normality equation *viz.*

$$\underset{\text{(Solution 1)}}{N_1 \times V_1} = \underset{\text{(Solution 2)}}{N_2 \times V_2}$$

- In terms of molarity equation, for the reaction

$n_1A + n_2B \rightarrow$ Products, we apply

$$\underset{(A)}{\frac{M_1V_1}{n_1}} = \underset{(B)}{\frac{M_2V_2}{n_2}}$$

Relations between Different Concentration Units

Concentration units	Relation
Molarity and Normality	$M \times$ Mol. mass of solute = $N \times$ Eq. mass of solute
Molarity and Mass percent	$M = \frac{\% \times d \times 10}{\text{Mol. mass}}$
Molarity and Molality	$m = \frac{100 \times M}{1000 \times d_{soln} - M \times GMM_{solute}}$

STRUCTURE OF ATOM

- Dalton's atomic theory proposed that matter is composed of small, indivisible particles called atoms.
- However, atoms are further composed of fundamental particles *i.e.*, electrons, protons and neutrons.

PROPERTIES OF ELECTRON, PROTON AND NEUTRON

Properties	Electron, *e*	Proton, *p*	Neutron, *n*
Mass	9.101×10^{-31} kg	1.67262×10^{-27} kg	1.67495×10^{-27} kg
Charge	-1.6022×10^{-19} C	$+1.6022 \times 10^{-19}$ C	0
Mass relative to the electron	1	1836	1839
Spin	1/2	1/2	1/2
Charge relative to the proton	-1	+1	0
Discovery	J. J. Thomson	Goldstein	Chadwick

Some Important Terms

- **Atomic number :** It is the number of protons present in the nucleus of an atom.
- **Mass number :** It is the total number of protons and neutrons (called nucleons) in an atom.

Term	Description	Examples
Isotopes	Different atoms of same element having same atomic number but different mass numbers.	^1_1H, ^2_1H, ^3_1H; $^{35}_{17}Cl$, $^{37}_{17}Cl$
Isobars	Atoms of different elements having same mass number but different atomic numbers.	$^{40}_{18}Ar$, $^{40}_{19}K$, $^{40}_{20}Ca$
Isotones	Atoms of different elements containing same number of neutrons.	$^{14}_6C$, $^{15}_7N$, $^{16}_8O$
Isodiaphers	Atoms having same isotopic number (*i.e.*, no. of neutrons – no. of protons = same)	$^{235}_{92}U$, $^{231}_{90}Th$
Isosters	Molecules having same number of atoms and electrons.	CO_2, N_2O
Isoelectr-onics	Those species which have same number of electrons.	Na^+, Mg^{2+}, F^-, Ne

Atomic Models

Thomson Model of Atom

J.J. Thomson proposed that, positive charge is spread over a sphere of radius $\approx 10^{-8}$ cm and electrons are embedded in it. This model explains the electrical neutrality of atom but not the other observations like spectra and α-scattering experiment.

Rutherford's Model of Atom

Rutherford proposed that, the nucleus of atom is hard, dense core and consists of protons while electrons revolve around the nucleus. It could not explain the line spectra of elements.

Bohr's Model of Atom

- Atom consists of a small, heavy and positively charged nucleus in centre, and electrons revolve around the nucleus in fixed paths called orbits.
- The electron can revolve only in those orbits whose angular momentum is an integral multiple of $h/2\pi$ *i.e.*,

  $mvr = \frac{nh}{2\pi}, n = 1, 2, 3, ...$
- Energy of an electron in the orbit does not change with time.
- When elelctron jumps from one level to another, energy is either emitted or absorbed.

  The energy difference between two states is given by

  $\Delta E = E_2 - E_1$

  As the distance of the orbits increases from the nucleus, the energy gap goes on decreasing, *i.e.*,

  $E_2 - E_1 > E_3 - E_2 > E_4 - E_3 > ....$
- **Derivations from Bohr's Theory (for n^{th} orbit)**

	For hydrogen	For H– like particles
Energy (E_n)	$\frac{-1312}{n^2}$ kJ/mol	$\frac{-1312\,Z^2}{n^2}$ kJ/mol
Radius (r_n)	$0.529 \times n^2$ Å	$\frac{0.529\,n^2}{Z}$ Å
Speed (v_n)	$\frac{2.18 \times 10^8}{n}$ cm sec^{-1}	$\frac{2.18 \times 10^8}{n} \times Z$ cm sec^{-1}

Drawbacks of Bohr's Model

- Fails to explain electronic repulsions in multielectronic atoms.
- Does not support to the assumption,

  $mvr = \frac{nh}{2\pi}$
- Does not explain Stark effect and Zeeman effect.
- Does not explain the distribution of electrons in orbits.
- Against de-Broglie and Heisenberg's uncertainty principle.

Nature of Electromagnetic Radiations

- **Electromagnetic wave theory :** Energy is emitted continuously from any source in the form of radiations travelling in the form of waves and associated with electric and magnetic fields, oscillating perpendicular to each other and to the direction of radiations.
- All electromagnetic radiations have wave characteristics and do not require any medium for their propagation.
- The arrangement of various radiations in the decreasing order of their frequencies or increasing order of their wavelengths is called electromagnetic spectrum.

Cosmic rays, γ-rays, X-rays, UV rays, visible, IR, microwaves, radiowaves →

Decreasing frequency

Atomic Spectra of Hydrogen

- Atomic spectra represent the radiation or energy absorbed or emitted by an atom.
- **Rydberg formula :** $\bar{v} = \frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)Z^2$

where, R_H is Rydberg constant and has a value equal to 109,677 cm^{-1}.

- Radiations emitted by hydrogen in discharge tube experiments when passed through prism gives five series of lines named after the researchers.

	Name of series	Wavelength	n_1	n_2	Region
1.	Lyman	$\frac{1}{\lambda} = R_H\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$	1	$n > 1$	UV
2.	Balmer	$\frac{1}{\lambda} = R_H\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$	2	$n > 2$	Visible
3.	Paschen	$\frac{1}{\lambda} = R_H\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$	3	$n > 3$	IR
4.	Brackett	$\frac{1}{\lambda} = R_H\left[\frac{1}{4^2} - \frac{1}{n^2}\right]$	4	$n > 4$	IR
5.	Pfund	$\frac{1}{\lambda} = R_H\left[\frac{1}{5^2} - \frac{1}{n^2}\right]$	5	$n > 5$	far IR
6.	Humphrey	$\frac{1}{\lambda} = R_H\left[\frac{1}{6^2} - \frac{1}{n^2}\right]$	6	$n > 6$	far-far IR

Towards Quantum Mechanical Model of the Atom

Dual Behaviour of Matter

- Every material particle in motion has dual nature *i.e.*, particle nature and wave nature and the relation between them is called de-Broglie relation.

Wavelength of wave $(\lambda) = \frac{h}{mv}$

Heisenberg's Uncertainty Principle

- According to Heisenberg's uncertainty principle, it is impossible to determine simultaneously the exact position and exact momentum (or velocity) of an electron.

$\Delta x \times \Delta p \geq \frac{h}{4\pi}$

Quantum or Wave Mechanical Model of Atom

- Quantum mechanics developed by Erwin Schrodinger is based on the wave motion associated with the particles.
- Schrodinger wave equation : $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$
- The wave function ψ for an electron in an atom has no physical significance as such but ψ^2 gives the intensity of electron wave at that point or the probability of finding the electron at that point.
- An atomic orbital may be defined as three dimensional space around the nucleus where the probability of finding an electron is maximum (upto 90-95%).

Quantum Numbers

Principal quantum number, *n* : It corresponds to the main energy level or shell in which the electron is present.

The value of n :	1	2	3	4
Corresponding shell :	K	L	M	N

Azimuthal quantum number, *l* : It gives the orbital angular momentum and corresponds to the subshell in a given principal energy shell.

$l = 0, 1, 2, 3, ..., (n - 1)$

The various subshells are designated by the letters s, p, d, f.

The value of l :	0	1	2	3
Designation :	s	p	d	f

Magnetic quantum number, m_l : It describes the behaviour of an electron in magnetic field and it corresponds to the number of orbitals in a subshell.

$m_l = -l$ to 0 to $+l = (2l + 1)$ values.

Subshell :	s	p	d	f
No. of orbitals :	1	3	5	7

Spin quantum number, m_s : It corresponds to the direction of electron spin in each orbital.

m_s can have only two values, *i.e.*, $\pm 1/2$, represented as $\uparrow$ and $\downarrow$.

Rules for Distribution of Electrons

Rules

Aufbau Principle

Orbitals are filled in the order of increasing energy.

Lower $(n + l)$ value, lower is the energy. For same $(n + l)$ value, lower n value has lower energy.

Pauli Exclusion Principle

An orbital can accommodate maximum of two electrons and the electrons must have opposite spins.

Hund's Rule of Maximum Multiplicity

Pairing of electrons does not occur in orbitals of the same energy until each of them is singly filled.

SPEED PRACTICE

1. The equivalent weight of an acid is equal to
   (a) molecular weight/acidity
   (b) molecular weight/basicity
   (c) molecular weight × basicity
   (d) molecular weight × acidity.

2. It is known that atom contains protons, neutrons and electrons. If the mass of neutron is assumed to half of its original value whereas that of proton is assumed to be twice of its original value then the atomic mass of $^{14}_{6}C$ will be
   (a) same
   (b) 14.28% less
   (c) 14.28% more
   (d) 28.56% less

3. A light source of wavelength λ, illuminates a metal and ejects photo-electrons with $(K.E.)_{max} = 1$ eV. Another light source of wavelength $\frac{\lambda}{3}$, ejects photo-electrons from same metal with $(K.E.)_{max} = 4$ eV. Find the value of work function.
   (a) 1 eV
   (b) 2 eV
   (c) 0.5 eV
   (d) None of these

4. The kinetic energy of an electron in n^{th} of a single electron species of atomic number Z is $13.6\frac{Z^2}{n^2}$ eV .