**2. ATOMIC STRUCTURE – FAQ**

***Q: Why is the angle of deflection directly proportional to charge of the particle?***  
A: The greater the charge of the particle, the greater would be the attractive force exerted  
on it from the oppositely charged plate. Hence greater would be the deviation from its  
original direction of motion.

***Q: Why is the angle of deflection inversely proportional to the mass of the particle?***  
A: If two particles are moving at the same speed but one is more massive than the other,  
the heavier particle would have a greater kinetic energy. Thus it requires more energy  
to be exerted on the heavier particle to cause it to deflect. Since the applied electric  
field is exerting the same amount of force on these two different particles with different  
masses, the heavier particle would be deflected to a lesser extent.

***Q: Why do isotopes react similarly?***

A: This is because in chemical reaction, it is the electrons that are transferred between differentatoms; atoms either gain or loose or share electrons. The nucleus remain intact

***Q: What is the meaning of this symbol 8O2–?***

A: This represents an oxide ion. The subscript on the left is the atomic number whereas  
the superscript on the right indicates the extra electrons the oxygen has acquired. For  
this 8O2– species, the number of protons (8) is not equal to the number of electrons  
(10). The number of electrons would be the same as the number of protons for a  
neutral atom only.

***Q: What is the meaning of this symbol O2 2–?***  
A: This represents a peroxide ion. The subscript on the bottom right indicates that there are  
2 oxygen atoms in this species covalently bonded to each other. The superscript on the  
right indicates the number of extra electrons this species have acquired.

***Q: It seems that the relative isotopic mass is a whole number. Is it really so?***  
A: The word ‘relative’ means that the value obtained is measured with respect to some  
other thing, hence this number has no physical unit. In this case here, the relative  
isotopic mass of an isotope is the mass measured with respect to 1/12 of the mass of a  
12C atom, which has a value of 1 unit (1/12 × 12). As the mass of an atom arises mainly  
from the nucleus and since the total number of nucleons in 35Cl is 35, the relative  
isotopic mass seems to have a value of 35 too. But in reality, the actual relative isotopic  
mass is less than the mass of all nucleons added up. This phenomenon is known as  
mass defect. The differences in the two masses (less than 1%) arise because part of the  
mass has been converted to binding energy (according to E = mc2) which is necessary  
to hold the nucleons together.

***Q: Why does the energy of an electron increase as we move away from the nucleus?***

A: By convention, when an electron is ‘free’, that is, not subjected to any other  
electrostatic interactive forces (attractive or repulsive), it has an assigned zero energy.  
This is when the electron is infinitely away from the nucleus. But now if you want to  
bring an electron from n=1 Principal Quantum Shell to infinity, you got to do work  
against the attractive force of the nucleus, you got to ‘break’ the ‘bond’ between the  
electron and the nucleus. Breaking bond needs energy. The energy that you put in while  
doing work (energy is conserved from Law of Conservation of Energy) is gained by  
this electron, hence its energy has increased. When an electron moves from infinity and  
is attracted by the nucleus, a ‘bond’ is formed, and energy will be released. The  
following diagram would help in the explanation.

***Q: Why does the 4s sub-shell have a lower energy than the 3d sub-shell given that n=4***  
***Principal Quantum Shell should have a higher energy than n=3 Principal Quantum***  
***Shell ?***  
A: n=4 should have a higher energy than n=3. But the s sub-shell has a relatively lower  
energy than the d sub-shell for the same Principal Quantum Shell. These 2 different  
opposing factors counteract each other, resulting in the 4s sub-shell having a lower  
energy than the 3d sub-shell. The same explanation account for the relative energies of  
the 5s and 4d sub-shells.

***Q: Does that mean that the 4s sub-shell is now closer to the nucleus than the 3d sub-shell?***  
A: No. On the average, n=4 Principal Quantum Shell is still further away from the nucleus  
than n=3. So although the energy of 4s sub-shell is lower than the 3d sub-shell, it does  
not imply that the distances have changed. Remember a Principal Quantum Shell is  
actually a band, not a single discrete line.

***Q: Why do we need to know the electronic configuration of an element?***  
A: Knowing the correct electronic configuration would enable us to know which electron  
is to be removed and which orbital does it reside in. This is important as the removal of  
different electrons from different orbitals need different amounts of energy.

***Q: What is electron spin?***  
A: You can imagine an electron like the Earth, rotating at a particular axis.

***Q: Why can’t two electrons in the same orbital have the same spin?***  
A: Well, when an electron spins, this spinning charged-particle creates a magnetic field. If  
two electrons spin in the same direction, the magnetic field created would be repulsive  
in nature and the energy level of these two electrons would be higher as compare to if  
they spin in opposite directions to create an attractive magnetic field. An analogy can  
be used here: Picture a spinning electron as moving in one particular direction. Two  
such spinning electrons will be moving in opposite directions and the chances of them  
‘meeting’ will be lower. This results in lesser inter-electronic repulsion.

***Q: Why do we need to first place electrons in empty orbitals of the same sub-shell before***  
***pairing them in an orbital?***  
A: Well, electrons repel each other. By occupying different orbitals, the electrons remain  
as far apart as possible from one another, thus minimizing electron-electron repulsion.  
Take note that each orbital represent a particular region of space, hence two different  
orbitals would be two different region of space separated from each other. Take for  
instance the three p orbitals in a p sub-shell, each is oriented perpendicularly from each  
other, occupying different regions in space.

***Q: Why is the electronic configuration of 25Mn not 1s2 2s2 2p6 3s2 3p6 3d7?***  
A: The 4s orbital is filled first before the 3d orbitals. This is because the 4s orbital has a  
lower energy level as compared to the 3d orbitals.

***Q: If the 4s is filled before the 3d, why the electronic configuration of 25Mn not***  
***1s22s2p63s23p63d54s23d5?***  
A: The electronic configuration is always written in the order of increasing Principal  
Quantum Number. This also indicates the order of increasing energy level of the  
various sub-shells.

***Q: Why is symmetrical distribution of similar charge preferred?***  
A: If similar charges are distributed symmetrically, this would mean that all charges are  
spread out evenly and as far apart as possible. Such situation would result in a similar  
amount of electrostatic repulsion at each point in space. Consequently, such state  
would have a lower energy as compared to a state of asymmetrical distribution.

**Q: Why must the atom be in the gaseous state?**  
A: When we carry out ionization, the species must be gaseous atoms. In the gaseous  
state, the atoms have very minimal interaction with each other. Thus the energy input  
would solely be responsible for removing the electron and not in overcoming other  
types of bond. So remember that the gaseous state symbol is very important here.

***Q: What is a valence electron?***  
A: Valence refers to the outermost. Thus a valence electron ‘sits’ in the outermost  
Principal Quantum Shell and is furthest from the nucleus. The Principal Quantum  
Number for the valence shell corresponds to the Period Number of the element. All  
other Principal Quantum Shell of electrons before the valence Principal Quantum  
Shell are known as the inner core electrons.

***Q: What is the Effective Nuclear Charge ENC on each of the valence electrons of an oxygen atom?***  
A: The electronic configuration of an O atom is 1s22s22p4. The nuclear charge consists of 8  
protons and the number of inner core electrons is 2 (since there is only one Principal  
Quantum Shell of electrons before the n=2 valence shell), therefore the ENC is ≈ 6.

***Q: Does that mean that each of the 6 valence electrons is attracted by 1/6 of the ENC,***  
***which is 1 proton?***  
A: No. Each of the 6 valence electrons is attracted by 6 protons. This is because the 6  
valence electrons are moving round the nucleus within the same distance from the  
nucleus and the nucleus is considered a point charge. Therefore, the ENC is the same  
on each of the valence electrons.

***Q: Does that mean that the ENC on each the two 1s electrons is equivalent to 8 protons?***  
A: Yes. There are no other inner core electrons before the n=1 Principal Quantum Shell,  
therefore there is no shielding effect. The ENC on each of the electron in the n=1 subshell  
is the same, i.e. equivalent to 8 protons.

***Q: The ENC of an O atom is greater than the N atom. So shouldn’t this cause the O atom***  
***to have a higher 1st I.E.?***  
A: Yes, the ENC of O atom is greater than the N atom and this should cause it to have a  
higher 1st I.E. But experimentally, it has been found that O atom has a lower 1st I.E that  
what was expected. There must be some other factors that have yet to be considered.  
The only reason we can use to explain the data collected would be to employ the interelectronic  
repulsion factor. As shown here, there is the interplay of two opposing  
factors but it seems that the inter-electronic repulsion is a more dominant factor than  
the ENC effect.

***Q: Why is the domineering effect of the inter-electronic repulsion over the ENC factor***  
***being observed in the oxygen versus nitrogen case but not in the beryllium-lithium***  
***scenario?***  
A: Remember we mention before that a p orbital is 1/3 the size an s orbital from the same  
Principal Quantum Shell? Thus because of this different in size, the inter-electronic  
repulsion is more prominent in a p orbital than the much bigger s orbital.

***Q: The ENC of a B atom is higher than that of a Be atom but there is inter-electronic***  
***repulsion faced by the electrons in the 2s sub-shell of Be. Are these two factors less***  
***dominant than the ‘difference in energy level’ factor?***  
A: You are right. Based on the ENC factor, B is expected to have a higher 1st 1.E. than Be.  
But this not what experimental data makes of it. If we are to consider inter-electronic  
repulsion factor, Be should have a lower 1st I.E but observed data proves otherwise.  
Hence, the only factor that could be used to account for the observed experimental data  
would be because the 2p electron is at a higher energy level than the 2s electron.

***Q: Why would attractive force be weaker, the further the electron is from the nucleus?***

A: The electrostatic force (F) between the nucleus and electron can be approximated to F ∝1/r2, where r is the distance of separation between the charges. Thus, as r increases, thestrength of the electrostatic force decreases drastically.