Welcome students in Unit 2 many electronic atoms, we Will be seeing total angular momentum, LS coupling, JJ coupling. At the end of the module; students will be able to evaluate total angular momentum. Understand the concept of LS coupling and JJ coupling.

Total angular momentum.

Each electron in an atom has a certain orbital angular momentum L and a certain spin angular momentum s.

Hence, total angular momentum is given by J is equal to L + S. J is quantized in magnitude and direction. It's magnitude, as you know, is given by J is equal to root of J into J plus one h cross.

The component J_z of $\vec{J}$ is given by $J_z = m_j\hbar$

m_j = -j, -j+1, -j+2,…….. j-1, j

According to Pauli exclusion principle, the total angular momentum and the total magnetic momentum of a closed shell is 0.

So for atoms having one electron in the outermost shell, the total angular momentum is the same as that of the single electron in the outermost shell examples. Atoms of Group One of periodic table hydrogen, lithium, sodium, etc and ions He+ Be plus, AL2 plus and so on.

Since all three vectors J, L and S are quantized, they have only some specific orientation with respect to one another.

In the case of 1 electron atom, There are only two relative orientations possible.

One relative orientation corresponds to J is equal to L + S. Which is equal to L plus half.

In this case, J is greater than L.

And the other is J is equal to L minus s which is L minus half .

The following figure shows the two possible orientations for this case of L is equal to 1.

You can see that J value is 3 by two in one case and J is half in the other case.

There is an interaction between the magnetic moments due to the orbital motion and the spin of the electron. The total angular momentum J is conserved in magnitude and direction.

Due to this interaction, even in the absence of magnetic field.

L and S Precess around J. You can see in the diagram that L vector and s vector precess around J.

In the case of magnetic field is present, J precesses about B. &L and S recess around J.

So here again in the diagram you can see L vector and S vector precessing around J and the resultant J precessing around Magnetic field B.

LS coupling.

For an atom which consists of two or more electrons, The total angular momentum J of the atom is a result of the contributions due to the orbital and spin angular momenta of each of the electrons. The way their individual momenta, orbital and spin add to give J depends upon many factors.

The usual pattern for all but the heaviest atoms is that the orbital angular momenta Li of the various electrons are coupled together into a single resultant L. The spin angular momenta Si are coupled together into another single resultant S. This angular momenta L&S then combinedue to the spin orbit coupling to give the total angular momentum J. This is known as LS coupling.

The scheme LS coupling can be summarized as follows.

L is obtained by summation of a Li, S is obtained by summation of Si.

J is. Equal to L + S. Here L as J and their components are all quantized.
This diagram shows the LS coupling. Here you can see that L1 and L2 is coupled to give resultant L. S1 and S2 has coupled to give resultant S. And the resultants S and L Gives the final resultant J.

JJ coupling

JJ coupling occurs in heavy atoms.

It is observed much less frequently than LS coupling. In lighter elements, the electrostatic force is responsible for coupling the orbital angular momenta Li to give a single vector L and the spin angular momenta Si into another vector, S are much stronger than the magnetic spin orbit forces which couple L&S to form J.

In lighter elements this situation prevails even in the presence of moderate magnetic fields. In heavier elements, the nuclear charge is large and hence the magnitude of the spin orbit interaction becomes comparable to those of the electrostatic forces which are responsible in coupling Li into single L&SI into single S. Now the LS scheme begins to breakdown similarly when strong magnetic fields are present. This scheme breaks down in such a situation, the total angular momenta Ji of the individual electrons combined together directly to form the angular momenta momentum J of the entire atom.

This is referred to as JJ coupling.

Hence in JJ coupling we have Ji is equal to Li plus SI. and J vector is obtained by summation of Ji

This diagram shows the JJ coupling. Here you can see that L1 and S1 has coupled to give J1 and L2 and S2 is coupled to give J2 and J1 and J2 gives the resultant J.

Here are some references.

Thank you.