**Hund's Rules**

**2S+1 = MULTIPLICITY**

**L = TOTAL ORBITAL MOMENTUM**

**J = TOTAL ANGULAR MOMENTUM**

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| The term with **maximum multiplicity lies lowest in energy** | . | | |
| For a given multiplicity, the term with **the largest value of L lies lowest in in energy.** |
| For atoms with less than half-filled shells, the level with **the lowest value of J lies lowest in energy.** |
| **\*Hund's rules assume combination to form S and L, or imply** [**L-S (Russell-Saunders) coupling**](http://hyperphysics.phy-astr.gsu.edu/hbase/atomic/lcoup.html#c1).  **Rules for Defining Terms:**  **S** = s1+s2+s3 +… Using the ***Branching Diagram*** to see S values 🡺2S+1  **L**= (l1+l2+l3+…) …… | l1-l2-l3| or lowest 0 in steps of 1 { SPDFG }  **J** = L+S …… |L-S| in steps of 1 | |  |  |

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| **Hund's Rule #1**  **The term with the maximum multiplicity lies lowest in energy**.   |  |  |  |  | | --- | --- | --- | --- | | *Example* configuration p2 |  | we expect the order |  |   The explanation of the rule lies in the effects of the [spin-spin interaction](http://hyperphysics.phy-astr.gsu.edu/hbase/atomic/atstruct.html#c2). Though often called by the name spin-spin interaction, the origin of the energy difference is in the coulomb repulsion of the electrons. It's just that a symmetric spin state forces an antisymmetric spatial state where the electrons are on average further apart and provide less shielding for each other, yielding a lower energy.   |  |  | | --- | --- | |  |  | |

**Hund's Rule #2**

**For given multiplicity, term with the largest value of L lies lowest in energy.**



The basis for this rule is essentially that if the electrons are orbiting in the same direction (and so have a large total angular momentum) **they meet less often than when they orbit**. Hence their repulsion is less on average when L is large. These influences on the atomic electron energy levels is sometimes called the [orbit-orbit interaction](http://hyperphysics.phy-astr.gsu.edu/hbase/atomic/atstruct.html#c3). The origin of the energy difference lies with differences in the coulomb repulsive energies between the electrons.

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|  | For large L value, some or all of the electrons are orbiting in the same direction. That implies that they can stay a larger distance apart on the average since they could conceivably always be on the opposite side of the nucleus. For low L value, some electrons must orbit in the opposite direction and therefore pass close to each other once per orbit |

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| **Hund's Rule #3**  **For atoms with LESS than half-filled shells, the level with the LOWEST value of J lies lowest in energy.**    **For atoms with MORE than half-filled shells, the level with the HIGHEST value of J lies lowest in energy.**  The basis for the rule is the [spin-orbit coupling](http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/hydfin.html#c2). The scalar product **S·L** is negative if the spin and orbital angular momentum are in opposite directions. Since the coefficient of **S·L** is positive, lower J is lower in energy. |

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| **J-J Coupling**  In **light atoms**, the interactions between the orbital angular momenta of individual electrons is stronger than the spin-orbit coupling between the spin and orbital angular momenta. These cases are described by "L-S coupling".  However, for **heavier elements** with larger nuclear charge, the [spin-orbit interactions](http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/hydfin.html#c2) become as strong as the interactions between individual spins or orbital angular momenta. In those cases the spin and orbital angular momenta of individual electrons tend to couple to form individual electron angular momenta.    Another case where the overall L and S are decoupled is the case where there is a very strong external magnetic field is applied. This is called the [Paschen-Back effect](http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/paschen.html#c1). |

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| **Influences on Atomic Energy Levels**  t |