

DYSPROSIUM ELECTRON CONFIGURATION

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References: Griffiths, David J. (2005), Introduction to Quantum Mechanics, 2nd Edition; Pearson Education - Problem 5.14.

The rare-earth element dysprosium has atomic number 66, and its ground state is listed as 5I_8 . This means that $S = 2$, $L = 6$ (since after $F = 3$, the labels go in alphabetical order, so $G = 4$, $H = 5$ and $I = 6$), and $J = 8$. This isn't enough information on its own to determine the electron configuration, since the outer shells don't fill in strict order of n and L due to shielding effects. For these shells, the s shell of level $n + 1$ is filled before the p shell of level n , and the d shell of $n + 1$ before the p of n and so on. Given the maximum populations of the various shells (s has a maximum of 2, p of 6, d of 10 and f of 14), a possible configuration for dysprosium is

$$(1s)^2 (2s)^2 (2p)^6 (3s)^2 (3p)^6 (4s)^2 (3d)^{10} (4p)^6 (5s)^2 (4d)^{10} (5p)^6 (6s)^2 (4f)^{10}$$

We can check this against the given values. The last shell ($4f$) contains 10 out of a possible 14 electrons. According to Hund's first rule, these should be arranged to give the maximum possible spin, which would mean 3 pairs and 4 unpaired electrons with parallel spin. This gives $S = 4 \times \frac{1}{2} = 2$ which matches the listing above. The value of L is difficult to check, since it depends on symmetry requirements which would be difficult (though possible, if you're persistent) to calculate for the 4 unpaired electrons. However, the 4 unpaired electrons in the $4f$ shell have a maximum possible L of $L = 12$, so $L = 6$ is certainly possible. Having L and S , we can apply Hund's third rule which in this case says that $J = L + S$ since the last shell is more than half full.