

Chapter 9. Exercises

1. Recall that a filled or half-filled p, d or f shell has spherical symmetry. Accordingly, go through the periodic table up to $Z = 54$ and predict which atomic ground states should have spherically-symmetrical electronic distributions (multiplet-S term symbols).
2. Give the electronic configurations and term symbols of the first excited electronic states of the atoms up to $Z = 10$.
3. Find an excited state of carbon atom which is spherically symmetrical. It will turn out that a similar state is responsible for the tetravalence of carbon.
4. It has been suggested that the ground-state electronic configurations of atoms are approximately consistent with the “ $n + \ell$ rule”. According to this, atomic orbitals are filled in the order of increasing $n + \ell$. For orbitals with the same values of $n + \ell$, the one with the lower n fills first. Find at least one exception to this ordering. On the basis of these rules, predict the ground- state electronic configuration of Rn ($Z = 86$).

Chapter 9. Solutions

1. Spherically symmetrical (S) state whenever valence shell contains only (i) all s-electrons, (ii) half filled shells, (iii) filled shells. Group IA, configuration ns: H, Li, Na, K, Rb. Group IIA, ns^2 : Be, Mg, Ca, Sr. Group VB, ns^2np^3 : N, P, As, Sb. Group 0: He, Ne, Ar, Kr, Xe. Transition elements: Cr $4s3d^5$, Mn $4s^23d^5$, Mo $5s4d^5$, Tc $5s^24d^5$. Also Cu, Zn, Pd, Ag, Cd, all with d^{10} .

2. First excited states: H $2s\ ^2S$; He $1s2s\ ^3S$; Li $1s^22p\ ^2P$; Be $1s^22s2p\ ^3P$; B $1s^22s2p^2\ ^2S$. For C, N and O, the electron configuration is the same as for the ground state but the occupation of degenerate p-orbitals is not optimal. C $2s^22p^2\ ^1D$; N $2s^22p^3\ ^2D$; O $2s^22p^4\ ^1D$; F $2s2p^6$; Ar $2s^22p^53s$.

3. Promote one of the 2s electrons to the empty 2p orbital. If the four valence electrons have parallel spins, this is a 5S state, which can form four bonds.

4. Rn ($Z = 86$): $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^{10}5p^66s^24f^{14}5d^{10}6p^6$. The 4s-3d and 5s-4d order can, in some cases, be reversed.