

## 4.1: Shapes of Atomic Orbitals

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*Shapes of atomic orbitals play central roles in governing the types of directional bonds an atom can form.*

All atoms have sets of bound and continuum s, p, d, f, g, etc. orbitals. Some of these orbitals may be unoccupied in the atom's low energy states, but they are still present and able to accept electron density if some physical process (e.g., photon absorption, electron attachment, or Lewis-base donation) causes such to occur. For example, the Hydrogen atom has 1s, 2s, 2p, 3s, 3p, 3d, etc. orbitals. Its negative ion  $H^-$  has states that involve  $1s2s$ ,  $2p^2$ ,  $3s^2$ ,  $3p^2$ , etc. orbital occupancy. Moreover, when an  $H$  atom is placed in an external electronic field, its charge density polarizes in the direction of the field. This polarization can be described in terms of the orbitals of the isolated atom being combined to yield distorted orbitals (e.g., the 1s and 2p orbitals can "mix" or combine to yield sp hybrid orbitals, one directed toward increasing field and the other directed in the opposite direction). Thus in many situations it is important to keep in mind that each atom has a full set of orbitals available to it even if some of these orbitals are not occupied in the lowest energy state of the atom.

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