Chapter 1

THE ELECTRONIC STRUCTURE OF THE ATOM: A REVIEW

Exercises

1.2 (a) Region in space around a nucleus where the probability of finding an electron is high.
(b) Orbital energy levels of the same energy.
(c) When occupying orbitals of equal energy, it is energetically preferable for the electrons to adopt a parallel spin arrangement.

1.4 5.

1.6 6*s*.

1.8 The quantum number *l* relates to the orbital shape.

1.10 The pairing energy for the double occupancy of the 2*s* orbital is less than the energy separation of the 2*s* and 2*p* orbitals.

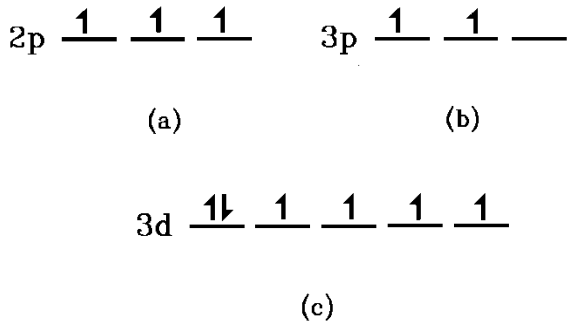
1.12 (a) [Ar]$4s^2$; (b) [Ar]$4s^1 3d^5$; (c) [Xe]$6s^2 4f^{14} 5d^{10} 6p^2$.

1.14 (a) [Ar]; (b) [Ar]$3d^7$; (c) [Ar]$3d^3$.

1.16 2+ and 4+. Tin has a noble gas core ground-state electron configuration of [Kr]$5s^2 4d^{10} 5p^2$. The two 5*p* electrons are lost first, giving an ion of 2+ charge; the two 5*s* electrons are lost next, giving an ion of 4+ charge.

1.18 4+. Zirconium has a noble gas core ground-state electron configuration of [Ar]$4s^2 3d^2$. Thus loss of both the two 4*s* electrons and the two 3*d* electrons will give a 4+ ion.

1.20 (a) 3; (b) 2; (c) 4.



1.22 (a) and (d).

Beyond the Basics

1.24 The Dirac wave equation was developed by the English physicist P. A. M. Dirac. He applied the ideas of Einstein's special theory of relativity to quantum mechanics. Dirac's model requires four quantum numbers, not the three of the Schrödinger model (where the spin quantum number is not part of the solution to the equation). A fourth quantum number results from the special theory of relativity where events are defined by the three spatial coordinates plus a time coordinate.

In the Dirac model, like the Schrödinger model, the principal quantum number, *n*, determines the size of an orbital. The other quantum numbers have different meanings—the third and the fourth (instead of the second) determine the shape of the orbitals. The shapes of the orbitals themselves differ from those using the Schrödinger equation, and there are no nodes. This removes the conceptual problem of how an electron moves from one lobe of a *p* orbital to the other if there is a zero probability in between. The answer is that the "simplistic" Schrödinger equation is in error. For high-atomic-number atoms, relativistic effects become of increasing importance and the Schrödinger equation becomes inadequate; the Dirac equation must be used.

For a good introduction to the Dirac equation, see R. E. Powell, Relativistic Quantum Chemistry, *J. Chem. Educ*. **45** (1968): 558–563.

1.26 Curium. $[Rn]7s^2 5f^7 6d^1$.

1.28 Of course, one can argue that orbitals are human constructs only! This question is a good topic for debate, but these authors veers toward the view that an orbital actually exists only when it is populated. Empty orbitals only potentially exist.