2.5 The n quantum number designates the electron shell.

The l quantum number designates the electron subshell.

The m_l quantum number designates the number of electron states in each electron subshell.

The m_s quantum number designates the spin moment on each electron.

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2.6 For the *L* state, $n = 2$, and eight electron states are possible. Possible l values are 0 and 1, while possible m_l values are 0 and ±1; and possible m_s values are $\pm\frac{1}{2}$. Therefore, for the *s* states, the quantum numbers are $200(\frac{1}{2})$ and $200(-\frac{1}{2})$. For the *p* states, the quantum numbers are $210(\frac{1}{2})$, $210(-\frac{1}{2})$, $211(\frac{1}{2})$, $211(-\frac{1}{2})$, $21(-1)(\frac{1}{2})$, and $21(-1)(-\frac{1}{2})$.

For the *M* state, $n = 3$, and 18 states are possible. Possible l values are 0, 1, and 2; possible m_l values are 0, ±1, and ±2; and possible m_s values are $\pm\frac{1}{2}$. Therefore, for the *s* states, the quantum numbers are $300(\frac{1}{2})$, $300(-\frac{1}{2})$, for the *p* states they are $310(\frac{1}{2})$, $310(-\frac{1}{2})$, $311(\frac{1}{2})$, $311(-\frac{1}{2})$, $31(-1)(\frac{1}{2})$, and $31(-1)(-\frac{1}{2})$; for the *d* states they are $320(\frac{1}{2})$, $320(-\frac{1}{2})$, $321(\frac{1}{2})$, $321(-\frac{1}{2})$, $32(-1)(\frac{1}{2})$, $32(-1)(-\frac{1}{2})$, $322(\frac{1}{2})$, $322(-\frac{1}{2})$, $32(-2)(\frac{1}{2})$, and $32(-2)(-\frac{1}{2})$.

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2.7 The electron configurations for the ions are determined using Table 2.2 (and Figure 2.6).

P^{5+}: $1s^2 2s^2 2p^6$

P^{3-}: $1s^2 2s^2 2p^6 3s^2 3p^6$

Sn^{4+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10}$

Se^{2-}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

I^-: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6$

Ni^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

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The Periodic Table

2.9 Each of the elements in Group IIA has two *s* electrons.

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2.11 (a) The $1s^2 2s^2 2p^6 3s^2 3p^5$ electron configuration is that of a halogen because it is one electron deficient from having a filled *p* subshell.

(b) The $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$ electron configuration is that of a transition metal because of an incomplete *d* subshell.

(c) The $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ electron configuration is that of an inert gas because of filled 4*s* and 4*p* subshells.

(d) The $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ electron configuration is that of an alkali metal because of a single *s* electron.

(e) The $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^5 5s^2$ electron configuration is that of a transition metal because of an incomplete *d* subshell.

(f) The $1s^2 2s^2 2p^6 3s^2$ electron configuration is that of an alkaline earth metal because of two *s* electrons.

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Bonding Forces and Energies

2.13 The attractive force between two ions F_A is just the derivative with respect to the interatomic separation of the attractive energy expression, Equation 2.8, which is just

$$F_A = \frac{dE_A}{dr} = \frac{d\left(-\frac{A}{r}\right)}{dr} = \frac{A}{r^2}$$

The constant A in this expression is defined in footnote 3. Since the valences of the Ca^{2+} and O^{2-} ions (Z_1 and Z_2) are both 2, then

$$F_A = \frac{(Z_1 e)(Z_2 e)}{4\pi\varepsilon_0 r^2}$$

$$= \frac{(2)(2)(1.6 \text{ x } 10^{-19} \text{ C})^2}{(4)(\pi)(8.85 \text{ x } 10^{-12} \text{ F/m})(1.25 \text{ x } 10^{-9} \text{ m})^2}$$

$$= 5.89 \text{ x } 10^{-10} \text{ N}$$

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2.14 (a) Differentiation of Equation 2.11 yields

$$\frac{dE_N}{dr} = \frac{d\left(-\frac{A}{r}\right)}{dr} + \frac{d\left(\frac{B}{r^n}\right)}{dr}$$

$$= \frac{A}{r^{(1\,+\,1)}} - \frac{nB}{r^{(n\,+\,1)}} = 0$$

(b) Now, solving for r (= r_0)

$$\frac{A}{r_0^2} = \frac{nB}{r_0^{(n\,+\,1)}}$$

or

$$r_0 = \left(\frac{A}{nB}\right)^{1/(1\,-\,n)}$$

(c) Substitution for r_0 into Equation 2.11 and solving for E (= E_0)

$$E_0 = -\frac{A}{r_0} + \frac{B}{r_0^n}$$

$$= -\frac{A}{\left(\frac{A}{nB}\right)^{1/(1\,-\,n)}} + \frac{B}{\left(\frac{A}{nB}\right)^{n/(1\,-\,n)}}$$

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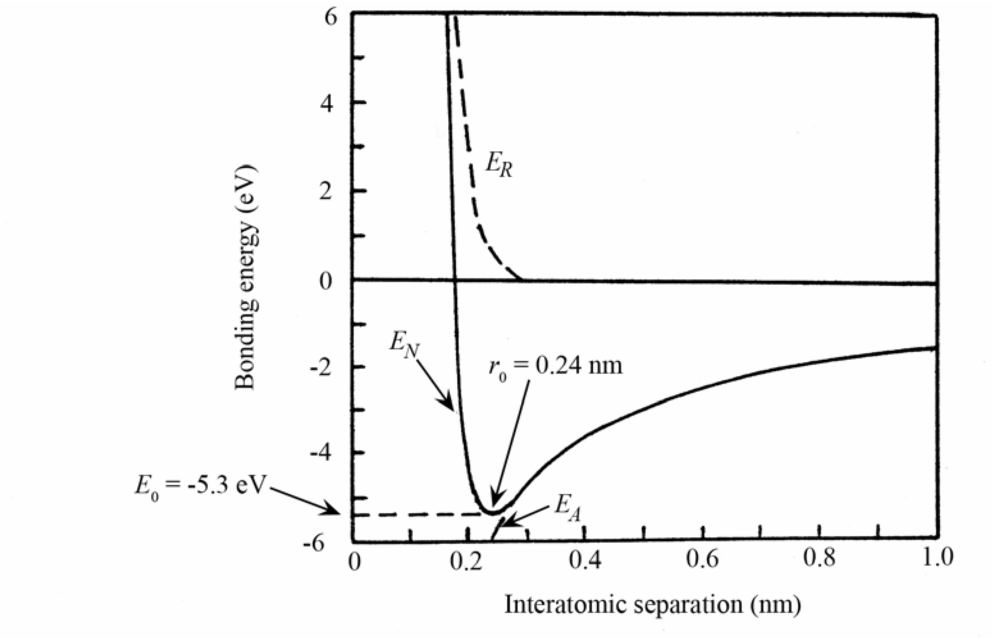
2.15 (a) Curves of E_A, E_R, and E_N are shown on the plot below.



(b) From this plot

$r_0 = 0.24$ nm

$E_0 = -5.3$ eV

(c) From Equation 2.11 for E_N

$A = 1.436$

$B = 7.32 \times 10^{-6}$

$n = 8$

Thus,

$$r_0 = \left(\frac{A}{nB}\right)^{1/(1-n)}$$

$$\left[\frac{1.436}{(8)(7.32 \times 10^{-6})}\right]^{1/(1-8)} = 0.236 \text{ nm}$$

and

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$$E_0 = -\frac{1.436}{\left[\dfrac{1.436}{(8)\left(7.32 \times 10^{-6}\right)}\right]^{1/(1-8)}} + \frac{7.32 \times 10^{-6}}{\left[\dfrac{1.436}{(8)\left(7.32 \times 10^{-6}\right)}\right]^{8/(1-8)}}$$

$$= -5.32 \text{ eV}$$

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Primary Interatomic Bonds

2.18 (a) The main differences between the various forms of primary bonding are:

Ionic--there is electrostatic attraction between oppositely charged ions.

Covalent--there is electron sharing between two adjacent atoms such that each atom assumes a stable electron configuration.

Metallic--the positively charged ion cores are shielded from one another, and also "glued" together by the sea of valence electrons.

(b) The Pauli exclusion principle states that each electron state can hold no more than two electrons, which must have opposite spins.

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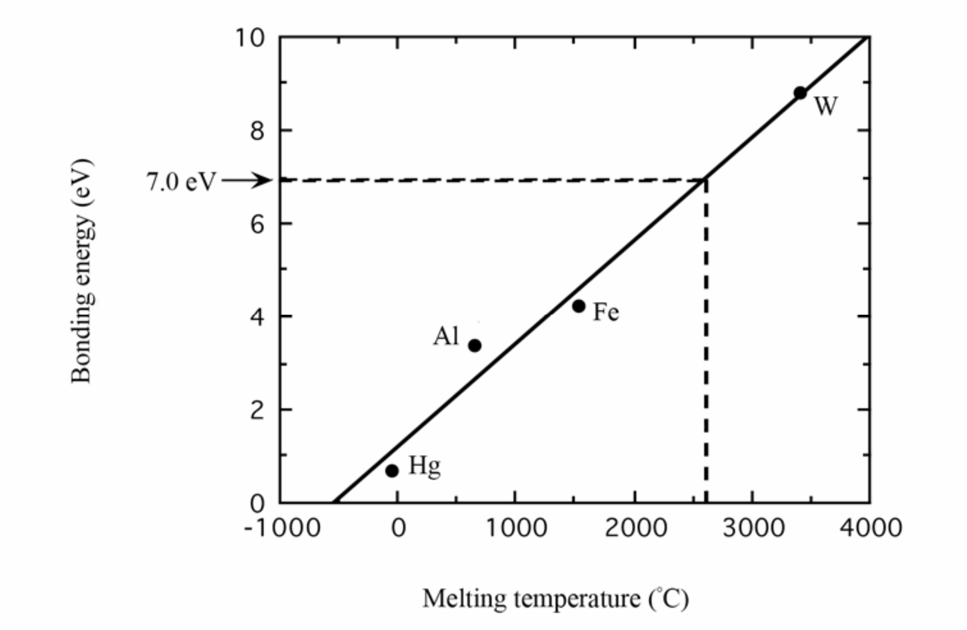
2.20 Below is plotted the bonding energy versus melting temperature for these four metals. From this plot, the bonding energy for molybdenum (melting temperature of 2617°C) should be approximately 7.0 eV. The experimental value is 6.8 eV.



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2.21 For silicon, having the valence electron structure $3s^2 3p^2$, N' = 4; thus, there are 8 – N' = 4 covalent bonds per atom.

For bromine, having the valence electron structure $4s^2 4p^5$, N' = 7; thus, there is 8 – N' = 1 covalent bond per atom.

For nitrogen, having the valence electron structure $2s^2 2p^3$, N' = 5; thus, there are 8 – N' = 3 covalent bonds per atom.

For sulfur, having the valence electron structure $3s^2 3p^4$, N' = 6; thus, there are 8 – N' = 2 covalent bonds per atom.

For neon, having the valence electron structure $2s^2 2p^6$, N' = 8; thus, there are 8 – N' = 0 covalent bonds per atom, which is what we would expect since neon is an inert gas.

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2.22 For solid xenon, the bonding is van der Waals since xenon is an inert gas.

For CaF_2, the bonding is predominantly ionic (but with some slight covalent character) on the basis of the relative positions of Ca and F in the periodic table.

For bronze, the bonding is metallic since it is a metal alloy (composed of copper and tin).

For CdTe, the bonding is predominantly covalent (with some slight ionic character) on the basis of the relative positions of Cd and Te in the periodic table.

For rubber, the bonding is covalent with some van der Waals. (Rubber is composed primarily of carbon and hydrogen atoms.)

For tungsten, the bonding is metallic since it is a metallic element from the periodic table.

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