I. Aufbau Diagrams

<table>
<thead>
<tr>
<th>Element</th>
<th>1s^1</th>
<th>1s^2 2s^1</th>
<th>He</th>
<th>1s^2 2s^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td></td>
<td></td>
<td>He</td>
<td></td>
</tr>
<tr>
<td>Li</td>
<td>1s^1</td>
<td>2s^1</td>
<td>Na</td>
<td>1s^2 2s^2 2p^6 3s^1</td>
</tr>
<tr>
<td>Be</td>
<td>1s^2</td>
<td>2s^2</td>
<td>Mg</td>
<td>1s^2 2s^2 2p^6 3s^2</td>
</tr>
<tr>
<td>B</td>
<td>1s^2</td>
<td>2s^2 2p^3</td>
<td>Al</td>
<td>1s^2 2s^2 2p^6 3s^2 3p^1</td>
</tr>
<tr>
<td>C</td>
<td>1s^2</td>
<td>2s^2 2p^3</td>
<td>Si</td>
<td>1s^2 2s^2 2p^6 3s^2 3p^2</td>
</tr>
<tr>
<td>F</td>
<td>1s^2</td>
<td>2s^2 2p^5</td>
<td>P</td>
<td>1s^2 2s^2 2p^6 3s^2 3p^6</td>
</tr>
</tbody>
</table>

B. Paramagnetic: at least 1 unpaired e^-

Diamagnetic: all e^- paired

Diamagnetic does not exist
#3.

K atom: $[Ar]4s^1$
K$^+$ ion: $[Ar]$

Ti atom: $[Ar]4s^2 3d^2$
Ti$^{2+}$ ion: $[Ar]3d^2$

There are only 2 atoms on the periodic table for which 4s is lower in energy than 3d: K and Ca. We know this because for K and Ca there is at least one electron in the 4s orbital and NO electrons in 3d. E$^-$ go to the lowest energy orbital.

Starting with Sc, Ti, and the rest of the transition metals (and beyond!), the e$^-$ in the 3d orbitals are lower in energy than any of the e$^-$ in the 4s orbitals. This is because the increased # of protons pull the 3d e$^-$ closer to the nucleus and lower in energy.
4. A. Cs atom: $5s^2 5p^6 6s^2 6p^6 6d^{10} 7s^2 7p^6 8s^2 8p^6$
   B. Se atom: $3s^2 3p^6 4s^2 4p^6 5s^2 5p^6$
   C. Ni atom: $ls^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$

7. A. Mg atom: $[Ne] 3s^2$
   B. Sn atom: $50e^- [Kr] 5s^2 5p^6$
   C. Au atom: $[Xe] 6s^2 5p^6$

10. A. Cr atom: $[Ar] 4s^1 3d^5$
   Cr$^{3+}$ ion: $[Ar] 3d^3$
   B. Cl atom: $[Ne] 3s^2 3p^5$
   Cl$^-$ ion: $[Ar]$
   C. Ag atom: $[Kr] 5s^1 4d^{10}$
   Ag$^+$ ion: $[Kr] 4d^{10}$

11. $\Delta H_{IE_1} = Cl(g) \rightarrow Cl^+(g) + e^-$
    $\Delta H_{IE_2} = Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$

13. $\Delta H_{E_1} = O(g) + e^- \rightarrow O^-(g)$
    $\Delta H_{E_2} = O^-(g) + e^- \rightarrow O^{2-}(g)$
17. A. Cl atom
   1s^2 2s^2 2p^6 3s^2 3p^5
   \[ \begin{array}{c}
   3p \\
   3s \\
   2p \\
   2s \\
   1s
   \end{array} \]

B. Cs^+ ion

\[ \begin{array}{c}
6s \\
5p \\
5s \\
4d \\
[Kr]
\end{array} \]
19. The energy required to move an electron from one level to another in any one-electron system can be approximated as:

\[ E = -2.18 \times 10^{-18} J \left( \frac{1}{n_2^2} - \frac{1}{n_1^2} \right) \]

where \( Z \) is the atomic number. The first ionization energy for helium is shown in the table below.

<table>
<thead>
<tr>
<th>Ionization</th>
<th>Enthalpy kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>2372.3</td>
</tr>
</tbody>
</table>

\[ Z = 2 \]

A. Write the first ionization energy reaction for helium. Underneath each atom or ion in the reaction, write out its electron configuration.

B. Fill in the following "ladder" energy diagram with energy values for each line. The "zero point" energy for this ladder diagram is DEFINED as the energy of the He\(^{2+}\) ion. All other chemical species will have lower (more negative) energies.

\[ E = -2.18 \times 10^{-18} (2)^2 \left( \frac{1}{4^2} - \frac{1}{\infty^2} \right) \]

\[ = 5.45 \times 10^{-19} J/\text{photon} \]

\[ = 328 \text{ kJ/mol} \]

\[ E = -9.69 \times 10^{-19} J/\text{photon} \]

\[ = -583 \text{ kJ/mol} \]

\[ E = -2.18 \times 10^{-18} J/\text{photon} \]

\[ = -1313 \text{ kJ/mol} \]

\[ E = -8.72 \times 10^{-18} J/\text{photon} \]

\[ = -5251 \text{ kJ/mol} \]

\[ 2372.3 \text{ kJ/mol} \]

\[ 5.45 \times 10^{-19} J \]

\[ = 6.022 \times 10^{23} \text{ photons/mole} \]

\[ -328 \text{ kJ/mol} \]

\[ \frac{1 \text{ mol photons}}{1000 \text{ J}} \]
21. A. From left to right across the periodic table, the sizes of the atoms decrease due to increasing effective nuclear charge and the fact that the valence $e^-$ in the same period are in the same principal energy level.

\[ \text{Li} \]
\[ 1s^2 2s^1 \]

\[ \text{F} \]
\[ 1s^2 2s^2 2p^5 \]

larger effective nuclear charge leads to smaller atom

B. From top to bottom the size of an atom increases because $n$, the principal energy level, increases. As $n$ increases, the $e^-$ are farther from the nucleus.

\[ \text{Li} \]
\[ 1s^2 2s^1 \]

\[ \text{Cs} \]
\[ [\text{Xe}] 6s^1 \]

As $n$ increases, the $e^-$ are farther from the nucleus.