Multiple choice questions: Circle the letter corresponding to the best answer for each multiple choice question. Each is worth two points.

1. Which of the following indicates that we cannot put two electrons into the same orbital if they have the same spin?
   a. Heisenberg Uncertainty Principle
   b. Aufbau Principle
   c. Hund’s Rule
   d. Pauli Exclusion Principle
   e. Rydberg Principle

2. Which of the following transitions in a hydrogen atom would produce a photon with the highest energy?
   a. \( n = 2 \rightarrow n = 1 \)
   b. \( n = 3 \rightarrow n = 1 \)
   c. \( n = 4 \rightarrow n = 1 \)
   d. \( n = 5 \rightarrow n = 1 \)
   e. \( n = 6 \rightarrow n = 1 \)

3. Which of the following is an invalid set of quantum numbers?
   a. \( n = 5, \ell = 5, m_\ell = 3, m_s = +1/2 \)
   b. \( n = 3, \ell = 2, m_\ell = -1, m_s = -1/2 \)
   c. \( n = 2, \ell = 0, m_\ell = 0, m_s = +1/2 \)
   d. \( n = 4, \ell = 2, m_\ell = 1, m_s = +1/2 \)
   e. \( n = 1, \ell = 0, m_\ell = 0, m_s = +1/2 \)

4. The 4f subshell contains how many orbitals?
   a. 0
   b. 3
   c. 5
   d. 7
   e. 16
5. Which quantum number is associated with the shape of an individual orbital?
   a. n
   b. ℓ
   c. \( m_\ell \)
   d. \( m_s \)

6. Arrange the following species in increasing order of atomic size.
   a. F < S < Ge < In < Ba
   b. S < F < Ba < Ge < In
   c. In < Ge < Ba < F < S
   d. Ba < In < Ge < S < F
   e. Ge < In < Ba < F < S

7. Arrange the following isoelectronic series in order from smallest ionic radius to largest ionic radius.
   a. As\(^{3-}\) < Se\(^{2-}\) < Br\(^-\) < Rb\(^+\) < Sr\(^{2+}\)
   b. Sr\(^{2+}\) < Rb\(^+\) < Br\(^-\) < Se\(^{2-}\) < As\(^{3-}\)
   c. Sr\(^{2+}\) < Rb\(^+\) < As\(^{3-}\) < Se\(^{2-}\) < Br\(^-\)
   d. Rb\(^+\) < Sr\(^{2+}\) < As\(^{3-}\) < Se\(^{2-}\) < Br\(^-\)
   e. As\(^{3-}\) < Se\(^{2-}\) < Br\(^-\) < Sr\(^{2+}\) < Rb\(^+\)

8. Arrange the following in order from the highest ionization energy to the lowest ionization energy.
   a. I > Te > Sn > Rb
   b. Rb > Te > Sn > I
   c. Rb > Sn > Te > I
   d. Sn > Te > I > Rb
   e. I > Sn > Te > Sn

9. Which of the following would be expected to be the most difficult to remove an electron from?
   a. P\(^{3-}\)
   b. Cl\(^-\)
   c. Ca\(^{2+}\)
   d. K\(^+\)
   e. S\(^2-\)

10. The most common charge on the ions in ionic compounds formed from the Group 16 (VIB) elements is:
    a. 2+
    b. +
    c. -
    d. 2-
    e. 6
Multiple answer types: Point totals are indicated in parentheses to the right of each problem number.

11. (4 points) Write the electron configuration for the following species. You may use the noble gas short cut notation if you would like.

   a. As

   b. Te^2-

12. (4 points) Describe Rutherford’s gold foil experiment. Include a brief description of what was done, what was found, and how it affected our view of the atom.

13. (5 points) Place a checkmark in each box corresponding to an element in the following list.

   - O_3
   - NH_3
   - P_4
   - H_2O
   - PCl_5

14. (5 points) Place a checkmark next to all of the species below that are isoelectronic with Kr.

   - Cl^-
   - Se^{2-}
   - Y^{3+}
   - P^{3+}
   - As^{3-}
15. (10 points) Write the formula for and name the compounds formed between each of the following species.

<table>
<thead>
<tr>
<th>Species 1</th>
<th>Species 2</th>
<th>Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ba</td>
<td>P</td>
<td>_________</td>
<td>____________________</td>
</tr>
<tr>
<td>Li</td>
<td>S</td>
<td>_________</td>
<td>____________________</td>
</tr>
<tr>
<td>Cu(^{2+})</td>
<td>N</td>
<td>_________</td>
<td>____________________</td>
</tr>
<tr>
<td>Cr(^{3+})</td>
<td>Cl</td>
<td>_________</td>
<td>____________________</td>
</tr>
</tbody>
</table>

16. (2 points) Name the following compounds.
   
   a. CuO  ___________________
   
   b. PbS\(_2\)  ___________________

17. (4 points) What is the wavelength in nm of light that has a frequency of \(3.48 \times 10^{13} \text{ s}^{-1}\)? Show your work.
\[ c = \lambda \nu \quad \quad c = 3 \times 10^8 \text{ m s}^{-1} \]

\[ \frac{1}{\lambda} = 1.097 \times 10^7 \text{ m}^{-1} \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \quad \text{where } n_2 > n_1 \]
If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.