1. (45) Choose the one alternative that best completes the statement or answers the question. 3 points each.

1) What is the oxidation number of the chromium atom in K2Cr2O7?
   A) +6       B) -2       C) +7       D) +2
   1) __A__

2) The greater the energy of a photon, the
   A) shorter the wavelength and the lower the frequency.
   B) longer the wavelength and the higher the frequency.
   C) shorter the wavelength and the higher the frequency.
   D) longer the wavelength and the lower the frequency.
   2) __C__

3) Which molecular orbitals for homonuclear diatomic molecules are degenerate?
   A) $\sigma$ molecular orbitals
   B) $\pi$ molecular orbitals
   C) $\pi$ molecular orbitals and $\sigma$ molecular orbitals
   D) neither $\pi$ molecular orbitals nor $\sigma$ molecular orbitals
   3) __B__

4) For an electron in a given atom, the larger $n$, the
   A) larger the average distance from the nucleus and the higher the orbital energy.
   B) larger the average distance from the nucleus and the lower the orbital energy.
   C) smaller the average distance from the nucleus and the lower the orbital energy.
   D) smaller the average distance from the nucleus and the higher the orbital energy.
   4) __A__

5) Which species functions as the oxidizing agent in the following reduction-oxidation reaction:
   $5 \text{Fe}^{2+}(aq) + \text{MnO}_4^-(aq) + 8 \text{H}^+(aq) \rightarrow \text{Mn}^{2+}(aq) + 5 \text{Fe}^{3+}(aq) + 4 \text{H}_2\text{O}(l)$?
   A) $\text{Fe}^{2+}(aq)$          B) $\text{MnO}_4^-(aq)$          C) $\text{Mn}^{2+}(aq)$          D) $\text{H}^+(aq)$
   5) __B__

6) Which molecule contains a triple bond?
   A) $\text{F}_2$         B) $\text{H}_2\text{CO}$         C) $\text{HCN}$         D) $\text{O}_3$
   6) __C__

7) Arrange the following spectral regions in order of increasing wavelength:
   infrared, microwave, ultraviolet, visible.
   A) ultraviolet < infrared < visible < microwave
   B) microwave < visible < infrared < ultraviolet
   C) microwave < infrared < visible < ultraviolet
   D) ultraviolet < visible < infrared < microwave
   7) __D__

8) What are the possible values of $n$ and $m_l$ for an electron in a 5d orbital?
   A) $n = 5$ and $m_l = 2$
   B) $n = 1, 2, 3, 4, 5$ and $m_l = -2, -1, 0, +1, +2$
   C) $n = 5$ and $m_l = -2, -1, 0, +1, +2$
   D) $n = 1, 2, 3, 4, 5$ and $m_l = 2$
   8) __C__

9) List all the elements that have a ground-state configuration with five unpaired electrons in the 3d subshell.
   A) Cr and Mn        B) Mn        C) Mn, Fe, Co, Cu, and Zn        D) Cr
   9) __A__

10) Which has the highest $Z_{eff}$ for its valence electrons?
    A) K         B) Na         C) Si         D) Cl
    10) __D__
11) Using the following portion of the activity series for oxidation half reactions

\[ \text{K(s)} \rightarrow \text{K}^+(aq) + e^- \]
\[ \text{Al(s)} \rightarrow \text{Al}^3+(aq) + 3e^- \]
\[ \text{Fe(s)} \rightarrow \text{Fe}^2+(aq) + 2e^- \]
\[ \text{Sn(s)} \rightarrow \text{Sn}^2+(aq) + 2e^- \]

determine which reaction will occur.

A) Al(s) with Sn(s)  
B) K(s) with Sn^2+(aq)  
C) Al^3+(aq) with Fe(s)  
D) K^+(aq) with Fe^2+(aq)

12) Which of the following represent electron configurations that are allowed but do not represent ground-state configurations?

(A) [Ne]3s^13p^5  
(B) [Kr]4d^125s^25p^3  
(C) [Ar]3d^104s^24p^2  
A) only (A)  
B) only (B)  
C) (A) and (B)  
D) (B) and (C)

13) Which atom in each group (I and II) has the smallest atomic radius?

(I) Sr, Zn, I  
(II) N, P, As  
A) Sr; N  
B) I; N  
C) Sr; As  
D) I; As

14) The pH of 0.5 M Ca(OH)_2 is

A) 14  
B) 1  
C) 7  
D) 0

15) The paramagnetism of O₂ is explained by

A) covalent bonding.  
B) valence bond theory.  
C) molecular orbital theory.  
D) resonance.

2. (11) Balance the following redox equation in basic solution.

\[ \text{Cr}_2\text{O}_7^{2-} + \text{Cl}^- \rightarrow \text{Cr}^{3+} + \text{Cl}_2 \]

\[ 6\text{C}^- + 14\text{H}^+ + \text{Cr}_2\text{O}_7^{2-} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} \]

\[ (2\text{Cl}^- \rightarrow 3\text{Cl}_2 + 2e^-) \times 3 \]

\[ \frac{14\text{OH}^- + 14\text{H}^+ + \text{Cr}_2\text{O}_7^{2-} + 6\text{Cl}^-}{\text{H}_2\text{O}} \rightarrow 2\text{Cr}^{3+} + 3\text{Cl}_2 + 7\text{H}_2\text{O} + \text{HCl} \]

A-3
3. (10) Complete the table.

<table>
<thead>
<tr>
<th></th>
<th>PCl₃</th>
<th>IF₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most favorable Lewis structure</td>
<td>:Cl - P - Cl:</td>
<td>:I - e - e:</td>
</tr>
<tr>
<td>Electron pair geometry</td>
<td>tetrahedral</td>
<td>trig. bipyramidal</td>
</tr>
<tr>
<td>Molecular geometry</td>
<td>trig. pyramidal</td>
<td>T-shaped</td>
</tr>
<tr>
<td>Bond angle</td>
<td>&lt; 109.5°</td>
<td>&lt; 90°</td>
</tr>
<tr>
<td>Sketch of shape, including lone pairs.</td>
<td><img src="image" alt="Sketch of PCl₃" /></td>
<td><img src="image" alt="Sketch of IF₃" /></td>
</tr>
</tbody>
</table>

4. (9)  
- a. Below, construct a molecular orbital diagram for cyanide, CN⁻. 
- b. Rank in terms of increasing bond strength (#1 weakest), #3 strongest:  
  ![Molecular Orbital Diagram](image)  
  - CN⁻ #2  
  - CN⁻ #3  
  - CN⁻ #1  
  - BO : CN⁻ = 2.5  
  - CN⁻ = 2  
  - CN⁻ = 3  
- c. Where you listed your ranking, circle any compound that is paramagnetic.  

5. (10) Draw 3 non-equivalent resonance contributors for SCN⁻ that have all shells filled. Circle the most stable.

- [Resonance Contributors](image)