1. Which element has the electron configuration 1s$^2$2s$^2$2p$^6$3s$^2$3p$^2$?

   (a) Mg  
   (b) S  
   (c) Si  
   (d) Se  
   (e) Ga

2. The X$^{3-}$ ion with the following electron configuration is formed from:

   [Ne]  
   \[
   \begin{array}{c}
   \uparrow \\
   3s \\
   \hline
   \end{array}
   \begin{array}{c}
   \uparrow \uparrow \uparrow \\
   3p \\
   \hline
   \end{array}
   \]

   (a) oxygen.  
   (b) nitrogen.  
   (c) phosphorus.  
   (d) aluminum.  
   (e) magnesium.

3. The figure is a portion of a plot of:

   ![Graph showing Atomic Number vs. another variable]

   (a) Highest principal quantum number vs. atomic number.  
   (b) 1$^{st}$ ionization energy vs. atomic number.  
   (c) Electron affinity vs. atomic number.  
   (d) Atomic radius vs. atomic number.  
   (e) Atomic charge vs atomic number.

4. Place the following atoms in order of INCREASING atomic radii: Ca, Mg, P, and Cl.

   (a) Ca < Cl < P < Mg  
   (b) Mg < P < Cl < Ca  
   (c) Ca < Mg < P < Cl  
   (d) P < Cl < Mg < Ca  
   (e) Cl < P < Mg < Ca
5. An element in period 2 has the following values of its first four ionization energies:

\[ IE_1 = 0.80 \text{ MJ/mol} \]
\[ IE_2 = 2.42 \text{ MJ/mol} \]
\[ IE_3 = 3.66 \text{ MJ/mol} \]
\[ IE_4 = 25.02 \text{ MJ/mol} \]

What is the element?

(a) Be  
(b) B  
(c) C  
(d) N  
(e) O

6. What is the formula of the oxide of Al?

(a) AlO  
(b) AlO\(_2\)  
(c) AlO\(_3\)  
(d) Al\(_2\)O\(_2\)  
(e) Al\(_2\)O\(_3\)

7. Consider the following data for lattice energies of alkaline earth oxides:

<table>
<thead>
<tr>
<th>Metal Oxide</th>
<th>Lattice Energy (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MgO</td>
<td>-3795</td>
</tr>
<tr>
<td>CaO</td>
<td>-3414</td>
</tr>
<tr>
<td>SrO</td>
<td>-3217</td>
</tr>
<tr>
<td>BaO</td>
<td>-3029</td>
</tr>
</tbody>
</table>

The trend in this data can best be explained by the following:

(a) The electron configuration of each atom  
(b) The electron affinity of each atom.  
(c) The radius of each atom.  
(d) The radius of each ion.  
(e) The charge on each ion.
8. Use the following information to calculate the first ionization energy of Li.

\[
\begin{align*}
\text{LiF(s)} &\rightarrow \text{Li}^+(g) + \text{F}^-(g) & 1050 \text{ kJ/mol LiF} \\
\text{Li(s)} + \frac{1}{2} \text{F}_2(g) &\rightarrow \text{LiF(s)} & -617 \text{ kJ/mol Li} \\
\text{F}_2(g) &\rightarrow 2 \text{F}(g) & 160 \text{ kJ/mol F}_2 \\
\text{Li(s)} &\rightarrow \text{Li}(g) & 161 \text{ kJ/mol Li} \\
\text{F}(g) &\rightarrow \text{F}^- (g) & -328 \text{ kJ/mol F}
\end{align*}
\]

(a) 216 kJ/mol Li  
(b) 346 kJ/mol Li  
(c) 426 kJ/mol Li  
(d) 440 kJ/mol Li  
(e) 520 kJ/mol Li

9. Determine the bond length of F\(_2\) from the Morse curve:

\[
\begin{align*}
\text{(a) 52 pm} \\
\text{(b) 128 pm} \\
\text{(c) 384 pm} \\
\text{(d) -120 kJ/mol} \\
\text{(e) 155 kJ/mol}
\end{align*}
\]

10. Which of these molecules is NOT planar?

(a) NI\(_3\)  
(b) XeF\(_4\)  
(c) BF\(_3\)  
(d) SO\(_3\)  
(e) CF\(_2\)=CF\(_2\)
11. Use VSEPR theory to predict the electron-pair geometry and the molecular geometry of iodine trichloride, $\text{ICl}_3$.

<table>
<thead>
<tr>
<th>Electron-pair Geometry</th>
<th>Molecular Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Trigonal planar</td>
<td>Trigonal pyramidal</td>
</tr>
<tr>
<td>(b) Tetrahedral</td>
<td>Trigonal planar</td>
</tr>
<tr>
<td>(c) Tetrahedral</td>
<td>Trigonal planar</td>
</tr>
<tr>
<td>(d) Trigonal bipyramidal</td>
<td>Trigonal</td>
</tr>
<tr>
<td>(e) Trigonal bipyramidal</td>
<td>T-shaped</td>
</tr>
</tbody>
</table>

12. Identify the geometry about atoms $X$ and $Y$:

```
CH₃—CH₂—CH₂—CBr=CH₂
  \uparrow       \uparrow
atom X          atom Y
```

<table>
<thead>
<tr>
<th>Atom X</th>
<th>Atom Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) linear</td>
<td>T-shaped</td>
</tr>
<tr>
<td>(b) Bent</td>
<td>trigonal planar</td>
</tr>
<tr>
<td>(c) tetrahedral</td>
<td>trigonal planar</td>
</tr>
<tr>
<td>(d) tetrahedral</td>
<td>trigonal pyramidal</td>
</tr>
<tr>
<td>(e) linear</td>
<td>trigonal pyramidal</td>
</tr>
</tbody>
</table>

13. What are the O–S–O bond angles in $\text{SO}_3$?

(a) All equal to 109.5 degrees.
(b) All equal to 120 degrees.
(c) All smaller than 109.5 degrees.
(d) Two are greater than 120 degrees and one is less than 120 degrees.
(e) Two are less than 120 degrees and one is greater than 120 degrees.
14. Which compound contains both ionic and covalent bonds?

(a) CaCl₂
(b) CH₃CO₂H
(c) ClNO₂
(d) K₂S
(e) NaNO₂

15. Which is the structure for butene?

(a)  
(b)  
(c)  
(d)  
(e)  

16. What is the formal charge on the C atom in this structure of the CNO⁻ ion?

\[
\text{C} = \text{N} = \text{O}^{-}
\]

(a) -2
(b) -1
(c) 0
(d) +1
(e) +2

17. What is the molecular formula for the following structure?

(a) C₅H₁₁
(b) C₄H₅
(c) C₅H₁₀
(d) C₄H₁₀
(e) C₅H₉
18. What can you say about the energy change in the following reaction?

\[ \text{H}_2 + \text{H}_2\text{C}==\text{CH}_2 \rightarrow \text{H}_3\text{C}==\text{CH}_3 \]

\[
\begin{align*}
\text{C}==\text{C} & = 346 \text{ kJ/mol} \\
\text{C}==\text{C} & = 610 \text{ kJ/mol} \\
\text{C}==\text{H} & = 413 \text{ kJ/mol} \\
\text{H}==\text{H} & = 436 \text{ kJ/mol}
\end{align*}
\]

(a) This reaction is isothermic.
(b) This reaction is endothermic.
(c) This reaction is exothermic.
(d) This reaction is energy neutral (\(\Delta H = 0\)).
(e) The energy change will depend on which isomer is present.

19. Identify an isomer of the following molecule:

\[
\text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}-\text{CH}_3
\]

(a) \[\text{Diagram of isomer (a)}\]
(b) \[\text{Diagram of isomer (b)}\]
(c) \[\text{Diagram of isomer (c)}\]
(d) \[\text{Diagram of isomer (d)}\]
(e) \[\text{Diagram of isomer (e)}\]
20. Which of the functional groups listed are present in the following molecule?

\[
\begin{align*}
\text{HO} & \quad \text{NH}_2 \\
\text{O} & \\
\text{I. hydroxyl} & \quad \text{III. carboxylic acid} \\
\text{II. carbonyl} & \quad \text{IV. amine}
\end{align*}
\]

(a) I, IV
(b) I, II, IV
(c) I, III, IV
(d) II, III, IV
(e) III, IV

END OF EXAM

1) Please make sure that you have entered 20 answers on your scan sheet.
2) Make sure that you have entered your name, ID number, and lab section number (4 digits).
3) You MUST turn the scan sheet in to your TA before leaving the exam!