Mid-Term 1

Do all questions. If you think that you may wish to have an answer re-graded, it must be done in permanent ink. No liquid paper/white-out or other such correction tools should be used in the answer area - if an answer is wrong, just put a line through it. You may use a calculator and a ruler, but no additional material may be used. Answer all questions on the test - if more space is required, use the back of the page and indicate that your answer is not complete.

Question #1 [20 points]

(a) What is Hund’s rule? [2]

(b) What does effective nuclear charge $Z^*$ indicate (use your own words and the equation relating it to $\sigma$)? [4]

(c) Provide an equation that defines the 2$^{nd}$ ionization energy for any element (E) AND indicate the group for which the second ionization energies are the greatest. [4]

(d) How are “orthogonal” and “normal” defined in the context of wave functions $\Psi_n$ and $\Psi_m$? [2]

(e) Provide a definition of electronegativity (use your own words not an equation): [4]

(f) List four of the types of symmetry operations (include a general symbol for the corresponding symmetry element): [4]
Question #2 [20 points]

(a) Fill in the blanks: [4]

<table>
<thead>
<tr>
<th>Orbital</th>
<th># of radial nodes</th>
<th># of angular nodes*</th>
<th>description of angular nodal surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>5(p_y)</td>
<td>1</td>
<td>2</td>
<td>the xz plane and the yz plane</td>
</tr>
<tr>
<td>4s</td>
<td>3</td>
<td>1</td>
<td>the yz plane</td>
</tr>
</tbody>
</table>

*give the appropriate quantum number

(b) Write an acceptable set of LCAO equations for sp\(^2\) hybrid orbitals. Include drawings to indicate the orientation of each hybrid orbital: [9]

(c) Draw reasonable representations of the following orbitals {specify the direction of the axes used and include sign of the phase (+ or -) of each lobe}: [7]
   (i) 2p\(_x\)  
   (ii) 3p\(_z\)  
   (iii) 3d\(_{yz}\)
(a) What is the ground state electron configuration of B(+4)? [1]

(b) What is the ground state electron configuration of arsenic? [1]

(c) What is the difference in energy between the ground state and the third excited state of Li(+2)?[3]

(d) Balance the following equation:[5]

\[ \text{Cu} + \text{HNO}_3 \rightarrow \text{Cu(NO}_3\text{)} + \text{NO} + \text{H}_2\text{O} \]

(e) Use the Frost diagram at the end of the test to predict the outcome of the following reactions (there is no need to balance the equations):[5]

(i) Ni (+2) + Cu

(ii) Cl\textsubscript{2} + H\textsubscript{2}S

(iii) I\textsubscript{2} + V(+3)
Question #4 [10]
(a) What is the trend in atomic radii for the group 17 elements (use “>”, “<” or “.”)? [2]

(b) Why do the atomic radii for the group 17 elements vary in this way? [4]

(c) Is the trend in atomic radii for the group 13 elements the same? Briefly, why or why not? [4]

Question #5 [25]
Use the localized bonding models (Lewis, VSEPR, and valence bond theory) to describe the bonding in the following molecules:
(*remember to indicate the geometry, shape and hybridization of all non-terminal atoms; * you only have to draw one example of the orbital overlap for each different type of bond)

(a) XeF₄ [8]
(b) $[\text{ClO}_4]^-$ (what is the bond order of the Cl-O bonds and what is the formal charge on each oxygen atom) [9]

(c) Acetaldehyde, $\text{H}_3\text{C}(\text{O})\text{H}$ (the oxygen atom is terminal and the H is bonded to the carbon atom) [8]
**Question #6 [10 points]**

In the table below insert the correct symbols for the elements:

Sodium, Krypton, Vanadium, Bromine, Sulphur, Silicon, Aluminum, Beryllium, Nickel, Selenium.

If you choose to fill in the symbols for all the first 36 elements, be sure to emphasize the symbols of the elements that were required.