1. (6 pts) Write the electronic configuration and indicate the number of unpaired electrons for each of the following species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Electronic Configuration</th>
<th>Number of Unpaired Electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co^{2+}</td>
<td>[Ar] 3s^2 3d^5 [Ar] 3d^7</td>
<td>3</td>
</tr>
<tr>
<td>S</td>
<td>[Ne] 3s^2 3p^4</td>
<td>2</td>
</tr>
<tr>
<td>Fe</td>
<td>[Ar] 4s^2 3d^6</td>
<td>4</td>
</tr>
</tbody>
</table>

Won't be on this year's exam

2. a) (2 pts) Draw the Lewis structures CO_{3}^{2-} and CO_{2}.

\[ \text{CO}_{3}^{2-} \]

b) (2 pts) Which one has the shortest CO bond length. Circle the answer.

\[ \text{CO}_{2} \]

3. (20 pts) Circle the formula that best fits each of the following descriptions:

a) smallest atomic radius

b) largest ionic radius

c) least polar bond

d) longest bond length

e) greatest electronegativity

f) contains two \( \pi \)-bonds

g) lowest viscosity

h) highest vapor pressure at 25°C

i) lowest freezing point

j) ionic

Chem. 1C Exam 1 (white version)
April 25, 2001
4. (8 pts) Indicate the hybridization on the carbon and nitrogen atoms.

\[
\begin{align*}
&\text{Hybridization on first carbon: } \text{SP}^3 \\
&\text{Hybridization on second carbon: } \text{SP}^2 \\
&\text{Hybridization on third carbon: } \text{SP}^2 \\
&\text{Hybridization on nitrogen: } \text{SP}^3
\end{align*}
\]

5. (4 pts) Indicate the bond angles, a, b, c and d.

\[
\begin{align*}
&\text{Angle a: } 120 \\
&\text{Angle b: } 120 \\
&\text{Angle c: } \sim 109 \\
&\text{Angle d: } 120
\end{align*}
\]

6. a) (2 pts) Draw the Lewis structure for N₂H₄.

b) (2 pts) Draw the most stable molecular geometry.

\[
\begin{align*}
&\text{minimize repulsion between lone pairs}
\end{align*}
\]

7. (6 pts) For each of the following molecules, write the Lewis structure, predict the molecular geometry, and indicate the hybridization on the central atom. S is the central atom in SO₃²⁻ and C is the central atom in HCN.

<table>
<thead>
<tr>
<th>Lewis structure</th>
<th>molecular geometry</th>
<th>hybridization on central atom</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) SO₃²⁻</td>
<td>[\text{trigonal pyramid}]</td>
<td>\text{SP}^3</td>
</tr>
<tr>
<td>b) HCN</td>
<td>\text{linear}</td>
<td>\text{SP}</td>
</tr>
</tbody>
</table>
8. (9 pts) Indicate the dominant intermolecular force for each of the following substances.
   a) Na₂SO₃  _ionic_   b) SO₃  _LDF_   c) C₆H₆  _LDF_
   d) HF  _H-bonding_   e) CH₂O  _dipole-dipole_   f) CO₂  _LDF_
   g) CH₃NH₂  _H-bonding_   h) CHCl₃  _dipole-dipole_   i) HCN  _dipole-dipole_

9. (4 pts) A substance does not conduct electricity unless it is melted. It is hard and has a high melting point. These properties are characteristic of which one of the following crystalline solids? Circle the correct answer.
   a) ionic   b) metallic   c) molecular   d) covalent (atomic network)

10. (6 pts) Indicate the type of crystalline solid formed for each of the following substances.
    a) Si  _covalent network_   b) P₄  _molecular_   c) HCl  _dipole-dipole_
    d) SiO₂  _covalent network_   e) CaCO₃  _ionic_   f) C₆H₆  _molecular_

11. a) (3 pts) Draw the Lewis structure for SCN⁻ including resonance structures. Carbon is the central atom.
    \[
    6 + 4 + 5 + 1 = 16 \text{ e}^\text{⁻}
    \]
    \[
    \frac{24 - 16}{2} = 4 \text{ bonds}
    \]
    \[
    [\vdash \ddash \ddash C \equiv N \vdash ]^- \\
    [\vdash \ddash S \equiv C - N \vdash ]^-
    \]
    \[
    [\vdash \ddash S = C = N \vdash ]^-
    \]
    b) (3 pts) Assign the formal charges on each atom for each of the resonance structures.
    \[
    [\vdash \ddash S - C \equiv N \vdash ]^- \\
    -1 \ 0 \ 0
    \]
    \[
    [\vdash \ddash S \equiv C - \ddash N \vdash ]^- \\
    +1 \ 0 \ -2
    \]
    \[
    [\vdash \ddash S = C = \ddash N \vdash ]^- \\
    0 \ 0 \ -1
    \]
    c) (3 pts) Which structure is least stable?
    \[
    [\vdash \ddash S \equiv C - \ddash N \vdash ]^-
    \]
12. (6 pts) Write the electron configuration and the bond order predicted by the MO model for each of the following species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Electron Configuration</th>
<th>Bond Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>B₂</td>
<td>((\sigma _{2s})^2 (\sigma _{2s}^*)^2 (\pi _{2p})^2)</td>
<td>1</td>
</tr>
<tr>
<td>Be₂</td>
<td>((\sigma _{2s})^2 (\sigma _{2s}^*)^2)</td>
<td>0</td>
</tr>
<tr>
<td>CN⁻</td>
<td>((\sigma _{2s})^2 (\sigma _{2s}^*)^2 (\pi _{2p})^4 (\sigma _{2p})^2)</td>
<td>3</td>
</tr>
</tbody>
</table>

10 valence e's

13. (6 pts) Draw the phase diagram for water and for carbon dioxide. Indicate the location of the triple point and the region in which each substance is a solid, liquid and gas.

Phase diagram for water

Phase diagram for CO₂

14. (6 pts) What pressure would have to be applied to steam at 350°C to condense the steam to liquid water? For water, \(\Delta H_{\text{vap}} = 44 \text{ kJ/mol}\).

\[
\ln \left( \frac{P_1}{P_a} \right) = \frac{\Delta H_{\text{vap}}}{R} \left[ \frac{1}{T_2} - \frac{1}{T_1} \right]
\]

\[
\ln \left( \frac{P_1}{1 \text{ atm}} \right) = \left( 44 \frac{\text{kJ}}{\text{mol}} \right) \left( \frac{1000 \text{ J}}{\text{kJ}} \right) \left[ \frac{1}{373 \text{ K}} - \frac{1}{623} \right]
\]

\[P = 296 \text{ atm}\]