Problem Set 1

(1) (a) Indicate the formal charge of nitrogen and oxygen in the following structure. If an atom is formally neutral, indicate a charge of zero.

CH₃–C≡N–O⁻:

N: ___+1____

O: ___-1____

(b) Indicate the formal charge of boron and nitrogen in the following structure. If an atom is formally neutral, indicate a charge of zero.

\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \text{--B--N--H} \\
\text{H} \\
\text{H}
\end{array}
\]

B: ___-1____

N: ___+1____

(c) Indicate the formal charge of oxygen in the following structure. If the oxygen is formally neutral, indicate a charge of zero.

\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \text{C=O}. \\
\text{H} \\
\text{H}
\end{array}
\]

O: ___+1____

(d) Draw an alternative (and valid!) Lewis structure for the compound indicated in part (c). Be sure to indicate any formal charges in your structure.

\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \text{C}=\text{O} \\
\text{H} \\
\text{H}
\end{array}
\]

\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \text{C}^+\text{O} \\
\text{H} \\
\text{H}
\end{array}
\]

(2) (a) Consider the following structures. Circle each molecule that is expected to have a ZERO dipole moment.

\[
\begin{array}{c}
\text{CF₃CH₃} \\
\text{AlCl₃} \\
\text{NH₃} \\
\text{CH₂O} \\
\text{H₂O} \\
\text{CS₂}
\end{array}
\]

(b) What is the Cl–C–N bond angle in the molecule cyanogen chloride (CICN)? Briefly explain how you arrived at your answer (a structure will do).

\[
\text{Cl--C≡N}: 
\]

After distributing the valence electrons to form a molecule with no formal charge, the central carbon has two centers of electron density. This means it has a linear geometry and the bond angle is 180°.
(c) What is the bond angle in the molecule phosgene (Cl₂CO)? Briefly explain how you arrived at your answer (a structure will do).

\[ \text{O} \]
\[ \text{C} \]
\[ \text{Cl} \quad \text{Cl} \]

Central carbon has three centers of electron density. Planar geometry, bond angle is 120°.

(d) Consider a compound known as acrylonitrile: CH₂=CHC≡N.

(i) How many \( \sigma \)-bonds does this molecule contain? 6

(ii) How many \( \pi \)-bonds does this molecule contain? 3

(iii) How many unshared electrons does this molecule contain? 2 (one lone pair)