1) Describe what happens during the hybridization of the bromine atom in SF₄.
   - Include orbital diagrams and details about the promotion of electrons.

   Sulfur enters an excited state where one of the paired electrons in a 3p orbital is promoted to an empty 3d orbital.

   \[
   \begin{array}{c}
   \text{S: } \uparrow \downarrow \\
   \text{3s} \\
   \end{array} \quad \begin{array}{c}
   \text{3p} \\
   \text{3d} \\
   \end{array} \quad \text{ground state}
   \]

   \[
   \begin{array}{c}
   \text{S: } \uparrow \downarrow \\
   \text{3s} \\
   \end{array} \quad \begin{array}{c}
   \text{3p} \\
   \text{3d} \\
   \end{array} \quad \text{excited state}
   \]

   The 3s, three 3p, and 3d orbitals that contain electrons morph into five sp³d hybrid orbitals.

   \[
   \begin{array}{c}
   \text{S: } \uparrow \uparrow \uparrow \uparrow \uparrow \\
   \text{sp}^3 \text{d} \\
   \end{array} \quad \text{hybridization}
   \]

   This gives four bonding sites and one lone pair. Sulfur can now bond with four fluorine atoms.

2) Describe what happens during the hybridization of the first two carbon atoms in the structure below.
   - Include orbital diagrams and details about the promotion of electrons.

   a. The hybridization of the first carbon atom.

   Carbon enters an excited state where an electron is promoted from the 2s orbital to an empty 2p orbital.
The 2s and the two 2p orbitals morph into three identical sp\(^2\) hybrid orbitals. One unmorphed 2p orbital remains.

Carbon now has three bonding sites, which will allow it to bond with one carbon and two hydrogen atoms. The unmorphed 2p orbital will form a \(\pi\) bond with the second carbon.

b. The hybridization of the second carbon atom.

Carbon enters an excited state where an electron is promoted from the 2s orbital to an empty 2p orbital.

The 2s orbital and one 2p orbital morph into two identical sp hybrid orbitals. Two unmorphed 2p orbitals remain.

Carbon now has two bonding sites, which will allow it to bond with two carbon atoms. One unmorphed 2p orbital will form a \(\pi\) bond with the first carbon and the other will form a \(\pi\) bond with the third carbon – making two double bonds.

3) Is chlorine trifluoride polar or non-polar? Explain by discussing shape, dipolar bonds, and whether dipoles cancel.

The bromine trifluoride molecule has a T-shaped geometry where the chlorine atom is bonded to three fluorine atoms and has two lone pairs. The individual bonds are polar, as fluorine is more electronegative than chlorine. The overall compound is also polar, as the dipoles do not cancel.
4) Is the methane (CH₄) polar or non-polar? Explain by discussing shape, polar bonds, and whether dipoles cancel.

Methane has a tetrahedral geometry where the carbon atom is bonded to four hydrogen atoms and has no lone pairs. The individual bonds are polar, as carbon is more electronegative than hydrogen. However, the overall compound is **non-polar**, as the dipoles cancel. (The structure is perfectly symmetrical.)

5) Is NBr₃ polar or non-polar? Explain by discussing shape, dipolar bonds, and whether dipoles cancel.

NBr₃ has a trigonal pyramidal geometry where the nitrogen atom is bonded to three bromine atoms and has one lone pair. The individual bonds are polar, as bromine is less electronegative than nitrogen. The overall compound is also **polar**, as the dipoles do not cancel. The nitrogen end is slightly negative and the bromine ends are slightly positive.