1. VESPR model
For each compound below draw the Lewis Structure and fill in the blanks

<table>
<thead>
<tr>
<th>#Bonded Pairs</th>
<th>#Lone Pairs</th>
<th>e- domain Shape</th>
<th>Molecular Shape</th>
<th>Polar/nonpolar?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H$_2$S</td>
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<tr>
<td>SeO$_3^{2-}$</td>
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<tr>
<td>IF$_4^+$</td>
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<tr>
<td>SF$_6$</td>
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</tbody>
</table>

2. Valence Bond model and Hybridization
For each compound below:

a. Draw the Lewis Structure (including resonance forms if appropriate)
b. Determine the number and label the sigma and pi bonds.
c. For each atom with more than one neighbor
   - Determine the hybridization
   - Give the approximate bond angles
   - Determine the hybridization at each central atom

CO$_3^{2-}$
3. Molecular Orbitals and Bond Order
Use the MO given to describe the bonding in $O_2^+$, $O_2$, and $O_2^-$. Which of the three should be stable? What is the bond order of each? Which contain unpaired electrons?

4. There are three possible structures (called “isomers”) for dichloroethylene, $C_2H_2Cl_2$, two of which are polar and one which is not.
   a) Draw the three Lewis structures (use the name to help you), predict an overall shape for each and explain why one is nonpolar and the others are polar.
   b) Two of the three structures can be interconverted by a process called cis-trans* isomerization, in which rotation about the central carbon-carbon bond takes places upon irradiation with UV light. If light with a wavelength of approximately 200 nm is required for isomerization, how much energy (in kJ/mol) is this?
   c) Finally, sketch the orbitals involved in the carbon-carbon bond, and explain why so much energy is necessary for the bond rotation to occur.

*“Cis” refers to the chlorines being on the same side of the molecule and ‘trans’ means they are on opposite sides.
5. Imagine your sister is majoring in chemistry at OSU and is completing her last lab experiment before graduating. She was given an unknown and asked to determine its molecular formula and crystal structure using X-ray fluorescence and X-ray diffraction. The notes in her lab book read as follows:

**X-ray fluorescence spectroscopy** reveals that the stoichiometry is \( MX_4 \), but the resolution of the instrument is not sufficient to distinguish between neighboring elements. Your sister only knows that \( M \) is either: \( \text{Te}, \text{I} \) or \( \text{Xe} \), and that \( X \) is either: \( \text{O} \) or \( \text{F} \).

**X-ray diffraction analysis** reveals that crystal structure contains planar \( MX_4 \) molecules, with the \( M \) in the center of the molecule, \( M-X \) bond distances of 2.02 Å and the \( X-M-X \) bond angles that are all either 90° or 180°.

As a lowly freshman or sophomore can you help your sister graduate by identifying her unknown compound, thereby freeing up your parents tuition money next quarter to be lavished upon you.

**Additional thought—provoking questions**

What is the more common name for 'square bipyramidal' geometry?