1. For each of the following molecules, draw a Lewis structure that also indicates reasonable 3-dimensional positioning for all atoms and electron pairs.

(a) \( \text{H}_3\text{COH} \)

(b) \( \text{H}_3\text{C}^+ \)

(c) \( \text{H}_3\text{CCN} \)
2. Consider the hydrogen peroxide molecule, H–O–O–H.
   (a) Draw a Newman projection, looking down the O–O bond, in which the dihedral angle between the two hydrogens is 180°. Be sure to indicate the positions of the oxygen lone pairs.

   ![Newman projection](image)

   (b) Translate your Newman projection from part (a) into a wedge-and-dash depiction.

   ![Wedge-and-dash depiction](image)

   (c) Draw a wedge-and-dash picture of the conformation of hydrogen peroxide in which the H's eclipse each other.

   ![Wedge-and-dash conformation](image)

   (d) What hybridization did you pick for the oxygens in the above drawings?

   \[ \text{SP}^3 \]

   (e) Adjacent to your drawings in parts (b) and (c) above, clearly indicate the overall dipole moment for the \( \text{H}_2\text{O}_2 \) molecule in that particular conformation.

   see above
3. By drawing appropriate resonance structures, rationalize the observation that the nitrate anion ([NO$_3^-$]) contains three identical nitrogen–oxygen bonds. Use the arrow formalism to interconvert the resonance structures.
4. Imagine two $2p_z$ orbitals, each containing a single electron, interacting as they approach each other along the $y$-axis. Take the coordinate axes to be as defined below.

(a) Construct a diagram that shows the following:
   1. The starting $2p_z$ orbitals
   2. The molecular orbitals formed by the side-to-side interaction of the two $2p_z$ orbitals
   3. The relative energies of the starting $2p_z$ orbitals and the resulting molecular orbitals. (Do this by including an energy axis on your diagram.)
   4. Whether the resulting molecular orbitals are bonding or anti-bonding
   5. Any new nodes formed when the two $2p_z$ orbitals combine in side-to-side fashion to form molecular orbitals.

(b) Fill in the electrons in your molecular orbital scheme.

(c) Is this two-electron system stabilized or destabilized by the side-to-side interaction of the two $2p_z$ orbitals?

(d) Are the molecular orbitals that you’ve created $\sigma$-type orbitals? Very briefly explain why or why not.

No, not cylindrically symmetric along the internuclear axis.
5. Look down the $C_1-C_2$ bond of 1-chloropropane (also known as $n$-propylchloride).

(a) Draw a Newman projection in which the dihedral angle between the $-Cl$ and $-CH_3$ groups is $180^\circ$.

(b) Change the dihedral angle in $60^\circ$ increments, drawing each Newman projection, until you have completed a full rotation about $C_1-C_2$.

(c) Label each of your Newman projections in (a) and (b) with the corresponding $Cl\rightarrow CH_3$ dihedral angle.

(e) Construct an energy versus dihedral angle diagram for a full rotation about the $C_1-C_2$ bond of 1-chloropropane. You need show only relative energies.