1. (30 pts) Provide an example for each of the following terms. Use structures where appropriate. (5 pts each)

(a) A polar covalent bond

C-Cl, C-F, H-Cl, C=O, ….

(b) A typical Brønsted acid

HCl, $H_2SO_4$, $CH_3COOH$, …

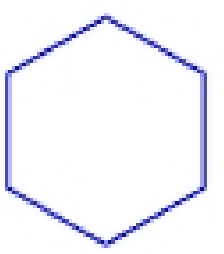
(c) The line-angle drawing of the linear constitutional isomer of *n*-butane

(d) A cycloalkane in which C-H bonds on adjacent carbon atoms are always eclipsed

cyclopropane

(e) A cycloalkane that is strain-free

cyclohexane



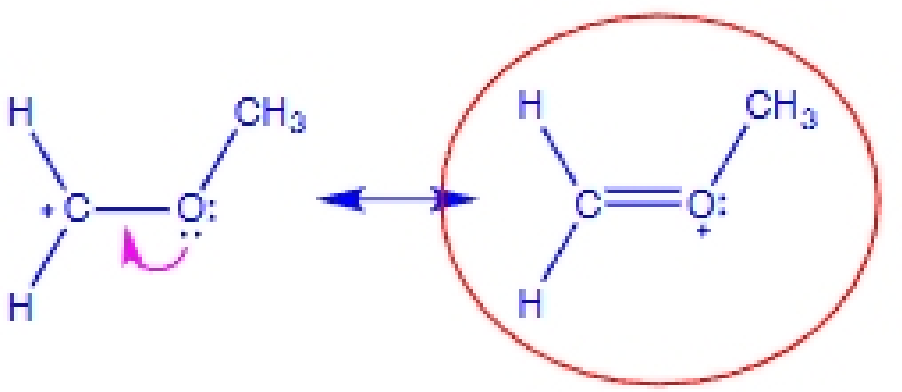
(f) A molecule that has a linear shape

diamtomic molecules, carbon dioxide, acetylene, acetonitrile…

2. Lewis structures and resonance (20 points)

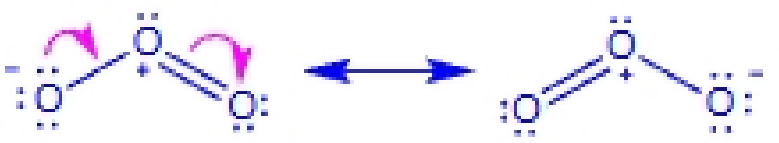
(a) For the ion shown, draw two valid resonance structures and CIRCLE the more important contributor. Use the curved arrow formalism to indicate electron movement. (6 points)

$^{+}CH_2OCH_3$



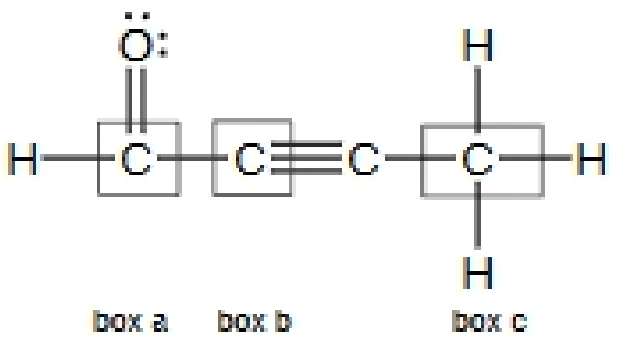

(b) Draw resonance structures for the ozone molecule ($O_3$). Is the length of each O-O bond in ozone longer or shorter than that of the O-O double bond in molecular oxygen? Use the curved arrow formalism to indicate electron movement. (6 points)

$O_3$




The length of the O-O bond in ozone is longer than the O-O double bond of $O_2$. (2 pts)

(c) Use VSEPR model to predict the shape and hybridization of the atoms in highlighted boxes a, b, and c in the following structure. (8 points)



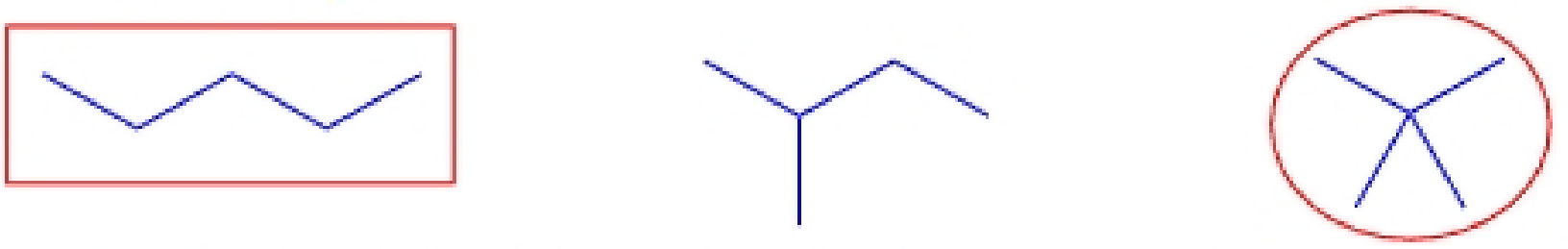

**box a**: shape trigonal planar hybridization $sp^2$

**box b**: shape linear hybridization sp

**box c**: shape tetrahedral hybridization $sp^3$

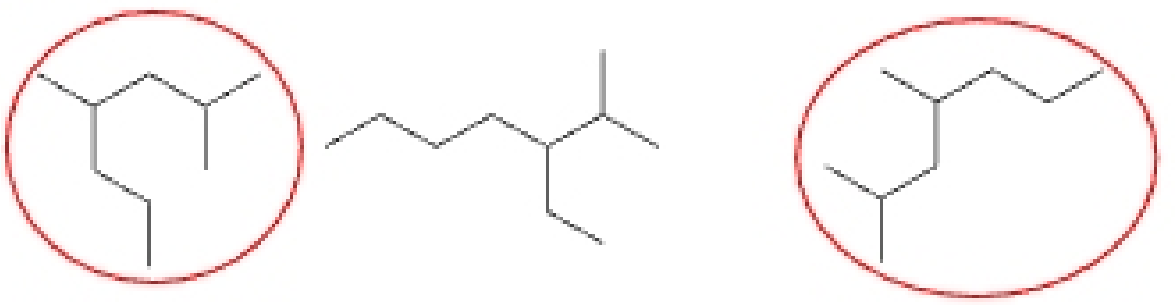
3. Organic molecules (20 pts)

(a) Draw the line-angle formulas of all isomeric alkanes of molecular $C_5H_{12}$. CIRCLE the isomer with the lowest boiling point and BOX the one with the highest boiling point. No explanation is needed. (6 pts)

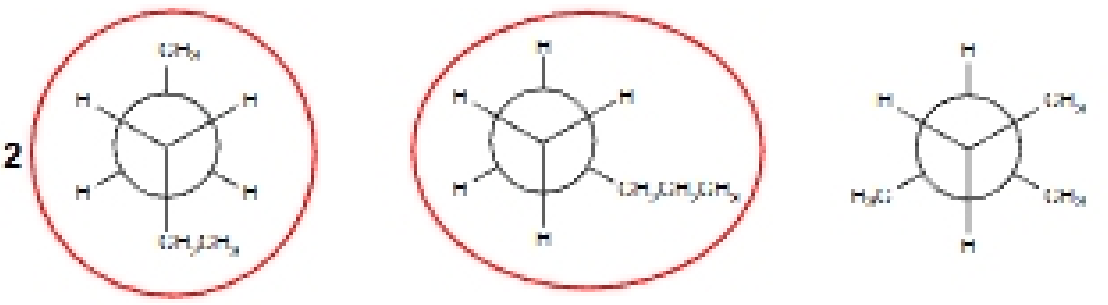


(b) Within each of the following sets, CIRCLE the two structures that represent the same compound. (6 pts)

Set 1



Set 2



(c) In the in the following four molecules, CIRCLE the one molecule that you expect to have a dipole moment of zero. (4 pts)

$CHCl_3$ $CH_2Cl_2$ $BF_3$ $NH_3$

(d) CIRCLE the solvent in which cyclohexane would have the lowest solubility: (4 pts)