Answer all of the questions in the spaces provided. Point values are in parentheses. Be sure to read the questions carefully.

1. (15) Propose the best possible Lewis-dot structures for the following species. Use lines for covalent bonds, show any formal charges where appropriate, and indicate the hybridization of each atom other than hydrogen or halogen.

   a) C₂O₂Cl₂
   \[ \begin{array}{c}
   \text{C} \\
   \text{O} \\
   \text{Cl}
   \end{array} \]
   \[ \begin{array}{c}
   \text{C} \\
   \text{C} \\
   \text{Cl}
   \end{array} \]
   \[ \begin{array}{c}
   \text{sp}{}^2 \\
   \text{sp}{}^2 \\
   \text{sp}{}^2
   \end{array} \]

   b) CH₂O₂⁻
   \[ \begin{array}{c}
   \text{C} \\
   \text{O} \\
   \text{O}
   \end{array} \]
   \[ \begin{array}{c}
   \text{H} \\
   \text{sp}{}^2 \\
   \text{sp}{}^2
   \end{array} \]

   c) HNO₂
   \[ \begin{array}{c}
   \text{H} \\
   \text{O} \\
   \text{H}
   \end{array} \]
   \[ \begin{array}{c}
   \text{O} \\
   \text{N} \\
   \text{O}
   \end{array} \]
   \[ \begin{array}{c}
   \text{sp}{}^3 \\
   \text{sp}{}^2 \\
   \text{sp}{}^2
   \end{array} \]
   \[ \text{best with no formal charges} \]

2. (10) For the following reactions identify the acid, base and both conjugate species. Also determine whether or not the reaction proceeds to the right as written. (pKa values in general: alcohols 15-18; alkanes 49-55; carboxylic acids 4-6; phosphoric acid 2.)

   a) (CH₃)₃Cl⁻ + OH⁻ \[ \rightarrow \] \[ \text{CH₃CH₂OH} \]
   base \[ \text{acid} \] \[ \text{c.b.} \] \[ \text{c.a.} \]

   b) \[ \text{C₆H₅COOH} \] + KH₂PO₄ \[ \leftrightarrow \] \[ \text{C₆H₅COOK} \]
   Acid \[ \text{base} \] \[ \text{c.b.} \] \[ \text{c.a.} \]
3.(10) Draw the resonance structure for each of the species below using the arrows indicating the electron flow.

\[ \text{O} \]

\[ \text{O} \]

a) \[ \text{\includegraphics{resonance_structure_a.png}} \]

b) \[ \text{\includegraphics{resonance_structure_b.png}} \]

4.(12) Identify and name all of the functional groups in aspartame (Nutrasweet®) and Effexor® (antidepressant Vanlafaxine) shown below:

Aspartame

Venlafaxine

5.(12) The molecule shown below is an extremely unusual, unstable and unsaturated hydrocarbon. In the diagram below, identify all orbitals (e.g. px, sp²) and bond types (e.g. \(\pi\), \(\sigma\)). Additionally, propose a Lewis structure (lines for all bonds) for this hydrocarbon.
6.(15) Using Kekulé structures (zig-zag), draw 7 unique structural isomers with the formula of \( \text{C}_7\text{H}_{16} \). There are 9 possible isomers.

7.(16) Give the names for the following compounds using I.U.P.A.C. nomenclature.

a) \((\text{CH}_3)_2\text{CH}(\text{CH}_2)_3\text{CH}(\text{CH}_3)_2\)

2,6-dimethylheptane

b) \begin{align*} &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \end{align*}

5-ethyl-3,5-dimethyloctane

c) \begin{align*} &\text{CH}_3\text{CHCH}_2\text{CH}_2\text{CCH}_3 \\ &\text{CH}_3\text{CHCH}_3 \\ &\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl} \end{align*}

1,4-dichloro-4,7,8-trimethylnonane

d) \begin{align*} &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \\ &\text{CH}_2\text{CH}_3 \end{align*}

cis 1,4-diethylcyclobutane
8.(10) Compare BF$_3$ and BH$_3$. Which do you suppose is the stronger Lewis acid. Draw accurate depictions of both structures (make sure the bond angles are reasonable) and explain why you feel one is a stronger Lewis acid than the other.

very small bond moments

Both are Lewis acids but BF$_3$ is stronger because the Boron is more electron-deficient thus its empty p orbital is more likely to act as an electron-pair acceptor.

Draw the product of the Lewis acid-base reaction between boron trifluoride and ammonia.