Answers to Hour examination #1, Chemistry 301-301A, 2003

1.

(a) yes
(b) no - atoms moved
(c) yes
(d) no - valence violated
(e) no - valence violated
(f) yes
(g) yes
(h) no - atoms moved

2.

\[
\begin{align*}
\text{CH}_3\text{O} & \quad \text{H} \\
\text{C} & \quad \text{C} \\
\text{H} & \quad \text{C} - \text{N(CH}_3\text{)}_2 \\
& \quad \text{O} \\
\end{align*}
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& \quad \text{O} \\
\end{align*}
\]
3. One of many c/t pairs. This is also a pair of diastereomers.

![Diagrams of molecular structures]

A meso compound

4. Each carbon must form two sigma bonds, one to the H and one to the other C. Accordingly, sp hybridization is appropriate. There are two perpendicular pi bonds, shown as wedges.

![Diagrams of sigma and pi systems]
Alkynes are relatively strong acids because the lone pair electrons of the anion reside in a relatively low energy \textit{sp} hybrid orbital, rather than in a relatively high energy \textit{sp}^3 orbital (alkanes).

\[
\text{H--C\equiv C--H} \quad \text{--B:} \quad \text{BH} + \quad \text{H--C\equiv C}\quad \text{sp hybrid}
\]

6. That filled C-H bond “wants” to line up with the empty 2\textit{p} orbital of the carbocation. Interactions between filled and empty orbitals are stabilizing (see diagram).

The C-H bond leans toward the other carbon because that helps increase the overlap between the C-H bond and the 2\textit{p} orbital.
\[
\alpha \sim 109^\circ
\]
\[
\alpha \sim 90^\circ
\]

poorer overlap - less stabilization

aligned for better overlap more stabilization
5.
a) Easy points...

b) When a distortion occurs that lengthens a bonding interaction, orbital energy goes up. When a distortion occurs that lengthens an antibonding interaction, orbital energy goes down. An analogy is to compare $\Phi_A$ of $H_2$ with the nonbonding orbital of linear $H_3$...both have two lobes (derived from 1s orbitals) that are out of phase with each other. But, the nonbonding orbital of $H_3$ is lower than $\Phi_A$ of $H_2$ since the lobes are further apart, making the antibonding interaction weaker. So...

What you can see is that the two nonbonding orbitals of square $H_4$ have become one bonding and one antibonding orbital of rectangular $H_4$. Whereas square $H_4$ has only two electrons in bonding orbitals, rectangular $H_4$ has four electrons in bonding orbitals...so more electrons hold the molecule together than in the square case. This is the "motivation" for the Jahn-Teller distortion...more electrons in bonding orbitals when compared to what we started with, making rectangular $H_4$ lower in energy than square $H_4$. 