Molecular-orbital theory is a powerful tool for understanding and predicting the reactivity of main-group and transition-metal complexes. The attached paper (*[Beilstein J. Org. Chem.](http://www.beilstein-journals.org/bjoc/single/articleFullText.htm?publicId=1860-5397-8-177)***[2012](http://www.beilstein-journals.org/bjoc/single/articleFullText.htm?publicId=1860-5397-8-177)**[, 1554–1563](http://www.beilstein-journals.org/bjoc/single/articleFullText.htm?publicId=1860-5397-8-177)) examines the concept of "frustrated" Lewis acid-base pairs and argues that a similar description can be applied to many species with metal–ligand multiple bonds. Read the attached paper and use it as a basis for answering the following questions.

1. The author cites Dewar-Chatt-Duncanson interaction of H2 and alkenes as a paradigm for the importance of orbital cooperation in small-molecule activation. What is the Dewar-Chatt-Duncanson (DCD) model? Draw a simplified diagram for the molecular-orbital interactions in the DCD model. Why is it important to have both filled and empty *d* orbitals cooperating in the DCD model?
2. Frustrated Lewis pairs (FLPs) have also been shown to activate molecules like H2 and alkenes without the use of transition metals. What are FLPs? Provide one example (from this paper or another) and draw out the reaction with H2 or an alkene.
3. How is the mechanism by which FLPs activate substrates different from the DCD model? How is it similar?
4. The author argues that an FLP description can be applied to certain molecules containing metal–ligand multiple bonds. What are the conditions that must be met in order to apply this description? Why are these restrictions imposed on M=E FLPs?
5. Molecular-orbital diagrams are shown for two types of M=E FLPs in Figure 1 of the paper. Are the most reactive (highest-energy) electrons primarily M- or E-based in each case? Support your answer. How might this affect which site (M or E) is a better Lewis base (nucleophile)?
6. The reactions in Schemes 3 and 4 show an oxygen-atom transfer from carbon to a metal with formation of a C=C or C=N bond. What famous (named) organic reaction is quite similar to these transformations?
7. Mδ+=Eδ– FLPs can also react with saturated bonds (e.g., C–H and H–H bonds). Construct a mechanism by which H2 can be cleaved at a Mδ+=Eδ– species exhibiting FLP-type reactivity, especially noting similarities to the activation of H2 by a normal FLP in Scheme 1. What product would you generate from the reaction of Cp2Zr=N–Ph with H2 (1 equiv)?
8. A second type of M═E FLP is described with a π-acidic ligand, where the system is formulated as Mδ–═Eδ+. Why might this bonding situation be less common than the
Mδ–═Eδ+ described earlier (*HINT:* think about how metal–ligand bonds are normally categorized and about the electronegativities of transition metals)? What types of metals and ligands are described in this review that fall into the Mδ–═Eδ+ FLP category?
9. There are several strategies suggested for applying M═E FLPs in catalytic transformations, including 1,2-addition of a hydrocarbon C–H bond across a metal–ligand double bond, followed by reductive elimination (top pathway in Scheme 13). In fact, this pathway has never been observed. Why might the reductive elimination step be particularly unfavorable for these systems?
10. Can you think of any routes other than the ones described in this review for using polarized metal–ligand multiple bonds in catalytic C–H functionalization schemes?
11. After having read this review, do you agree with the author's assertions about the similarities between "normal" frustrated Lewis pairs and certain inorganic species with polarized metal–ligand multiple bonds? What advantages are there to examining these types of systems side-by-side? What is lost in the comparison? Would you have recommended that this review be accepted for publication? Why or why not?