1. The bifluoride anion \([\text{HF}_2]^–\) exemplifies the so-called **three-center two-electron** (3c-2e) bond.

   (a) Give a general definition of “3c-2e bond”.

   (b) Provide a qualitative MO analysis of \([\text{HF}_2]^–\) and explain how it fits within your definition.

2. Dunbar and coworkers recently reported\(^1\) the synthesis and characterization of the heptacyanotungstate(IV) anion, i.e. \([\text{W(CN)}_7]^–\), which adopts a \(D_{5h}\) geometry as shown below. How many \(\equiv\text{N}\) stretching bands do you expect to be observable by IR spectroscopy? A \(D_{5h}\) character table is provided for your reference.

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3. Recently, Buchwald and coworkers conducted stoichiometric C-N reductive elimination studies using isolated arylpalladium(II) amido complexes that were identified as resting states during Pd-catalyzed C-N coupling. As shown below, Hammett studies indicated that Pd(II) intermediates derived from electron-deficient aryl halides undergo reductive elimination more slowly than those derived from electron-rich aryl halides.

(a) Provide an explanation for this observation that takes into account the factors generally impacting rates of reductive elimination.

(b) Give your hypothesis for how ortho-substitution on the aryl halide would impact the rate of reductive elimination.

4. The neutral and cationic states of ferrocene, i.e. FeCp₂ and [FeCp₂]⁺, are used as standards for nonaqueous electrochemistry because they are so stable and well understood. The dicationic state of ferrocene is comparatively elusive. Meyer and coworkers recently reported the synthesis and characterization of the decamethylferrocene dication, i.e. [FeCp*₂]²⁺ (where Cp* = η⁵-C₅Me₅). Give the following information about [FeCp*₂]²⁺: (a) oxidation state of Fe, (b) d-electron count of Fe, (c) total valence electron count of Fe, and (d) number of unpaired electrons in [FeCp*₂]²⁺. For part (d), give a qualitative d-orbital splitting diagram to show how you arrived at your answer.

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