

2. Explain the all parts of the following statement as clearly and as concisely as you can using material learned in this course. **Use diagrams, calculations, chemical equations, etc. to support your answers whenever possible. You are significantly more likely to get full credit when these are included!** (8 pt each)

$\text{Ni}(\text{H}_2\text{O})_6^{2+}$ is green and $\text{Ni}(\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2)_3^{2+}$ is purple. However, the corresponding octahedral Pt^{2+} complexes of the same ligands are colorless or yellow (Note: $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2 = \text{en}$).

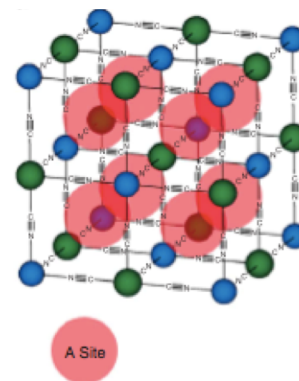
3. Give answers to the following:

- The name of the compound MgH_2
- A +2 cation with the electron configuration $[\text{Ar}]3d^7$
- The designation (label) for an orbital with the quantum numbers $n=6$ and $l=2$
- The **formula** for the **octahedral** complex formed between Fe^{2+} and the bidentate ligand oxalate (for full credit give the formula rather than the abbreviation for oxalate)
- The period 4 element with the highest ionization energy
- A species that will oxidize Cr^{2+} but not Cr^{3+}
- The name of the geometry with 1 lone pair and 4 bonded atoms
- The **formula** of a weak acid and the name of its conjugate base
- The closest packing structure with an "ababab" arrangement of layers

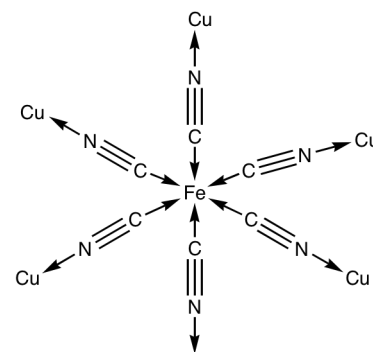
4. (19 pt total) A recent issue of *Nature Communications* (Nov 22, 2011) contains an article by researchers from the Materials Science Dept. at Stanford University describing a highly efficient new type of battery derived from a metal-organic framework built from coordination complexes of metal ions. The formula for the initial complex $\text{KCuFe}(\text{CN})_6$ is actually pretty similar to something you made in Laboratory 4! The overall structure of one unit cell of the compound is shown in color below, with an enlarged structure showing how more clearly how the individual ions interact at the right. In this structure, the Fe ions are green, the Cu ions are blue and the K ions occupy the large pink spheres (note: the color version is projected at the front of the room). The cyanide ions are located between each pair of Fe and Cu ions.

- Propose reasonable charges on the Fe and Cu based on the formula above and your knowledge of the periodic table. Explain briefly. (2 pt)
- How many Fe ions are there in a unit cell? Show your work clearly. (2 pt)
- This unit cell is considerably bigger than the ones we've looked at previously, but it is not so hard to understand! In this case, the structure can be described as one set of cations forming the lattice and the other cations filling some of the holes, and then the whole thing being connected (between those holes) by the cyanide ligands. If the Cu ions are viewed as forming the lattice (and the cyanides are ignored), what kind of holes are the green Fe ions occupying? (2 pt)

- What kind of holes are the pink K ions occupying? (2 pt)
- What is the coordination number of the Fe ions on the edges of the cube (the cyanides are the closest things to the Fe!)? (2 pt)
- What kind of ligand (classify using one or more of the 4 types we discussed in class) is cyanide? (2 pt)



- This battery works by having K^+ ions move back and forth between two different compounds (like the Li^+ ion battery we talked about in class). If extra K^+ migrate into the structure (without changing the overall charge), is the compound oxidized or reduced? (2 pt)
- If a battery is made using the $\text{KCuFe}(\text{CN})_6$ as one of the electrodes, based on your answer to f. above, which electrode is it, the anode or the cathode? (2 pt)



- One of the reasons that this battery is so effective is that it can be charged and recharged multiple times without it losing power. Discuss this observation in terms of what must be true about the reactions involved. (3 pt)

5. (14 pt) In a recent issue of *Inorganic Chemistry* (*Inorg. Chem.*, **2012**, 51 (23), pp 12603–12605, DOI: 10.1021/ic302071e), Ken Karlin and his research group at John's Hopkins report the following complicated reaction scheme. His group is attempting to mimic the chemical behavior of copper enzymes that process molecular oxygen species and lead to a number of different important intermediates. He isolates structure (2) at -90°C !

- Examine structure (2) below. What is the coordination number of the Cu? (2 pt)
- Clearly identify each of the ligands in structure (2) by circling them and classifying the type of ligand (monodentate, etc) (3 pt)
- What is the charge on each of the ligands in structure (2) and what is the charge on the Cu? Note the + charge on the overall complex! (4 pt)
- For structure (3), what kind of ligand is the O_2 ? Based on the structure drawn in (3) (with single bonds), what is the likely charge on the O_2 ? How would you name it? (5 pt)

