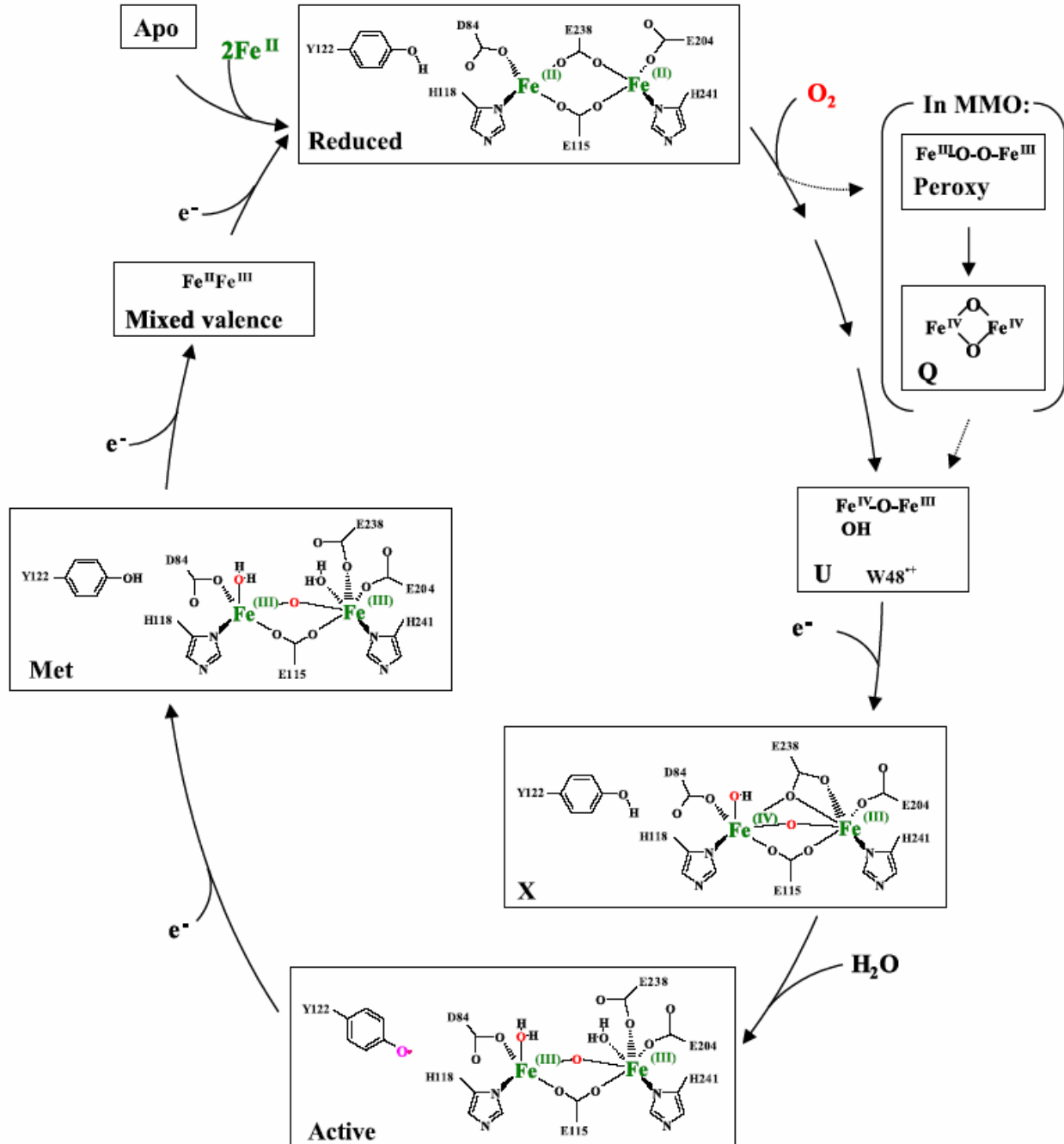


## Chapter 12 Solutions

1) Mechanism reprinted without permission from Andersson, et. al. *Biochim. Biophys. Acta* 2004, 1699, 1.



2) For a good discussion of blue copper proteins, see Gray, et. al. *J. Biol. Inorg. Chem.* **2000**, *5*, 551. The coordination geometries and bond lengths in azurin and  $[\text{CuL}_2]^{n+}$  change very little when going between Cu(I)/Cu(II). Based on a consideration of the *primary* coordination sphere, one would expect the reorganization energy for azurin to be similar to the model complex. Structural studies show that apoazurin and holoazurin have similar structures, and that the blue copper center is buried in a hydrophobic pocket that excludes water. Thus, there will be little reorganization in the secondary/tertiary/etc coordination sphere of copper in azurin during a redox process. However, the secondary coordination sphere for  $[\text{CuL}_2]^{n+}$  consists of solvent molecules and will undergo reorganization during a redox process. Thus, the model complex will have a higher reorganization energy than the blue copper center in azurin due to the secondary coordination sphere. The lower reorganization energy of the non-primary coordination sphere in azurin causes it to transfer electrons with a faster rate constant than the inorganic complex.

3) A dioxygen transport protein should have only one “empty” coordination site for dioxygen binding. In the case of iron, this would correspond to an octahedral geometry with one readily exchangeable ligand. The erroneous azido structure showed a four-coordinate iron bridged to a four coordinate iron (one ligand being exchangeable to allow  $\text{O}_2$ /azide binding). This low-coordinate environment at iron would be more likely to activate irreversibly than to bind reversibly dioxygen. The correct crystal structure shows the expected octahedral binding geometry at iron.

4) Zinc-containing hydrolytic enzymes catalyze the hydrolysis of esters by increasing the nucleophilicity of the water oxygen or by activating the substrate. Coordination to  $\text{Zn}^{2+}$  decreases of the  $\text{pK}_a$  of the water, facilitating the formation of a hydroxide (even if transient) for nucleophilic attack on a carbonyl carbon. The substrate can be activated in two ways: 1) other residues in the peptide can hydrogen bond to the carbonyl oxygen on the ester, thus increasing the partial positive charge on the carbonyl carbon and/or 2) positioning the substrate near the water/hydroxide bound to the zinc.