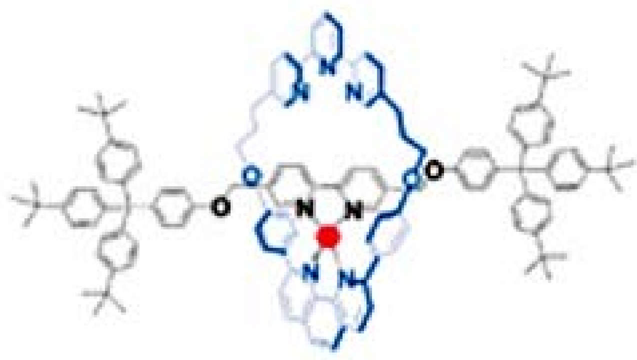
Caffeine Problem for Week 7: Chem 1C (Kahn)

Copper is one of the transition metals with unusual electronic structure. In particular, the high stability associated with completely filled shell of d-electrons makes the $4s^13d^{10}$ configuration of electrons more stable than the naively-expected $4s^23d^9$ configuration. Loss of the single 4s electron gives Cu^+ ion, which has properties of both an oxidant and reductant. For example, two Cu^+ ions undergo a disproportionation reaction in which a single electron is transferred from Cu^+ atom to Cu^+ atom to give Cu^{2+} and Cu^0.

The Cu^+ and Cu^{++} ions support different number of coordinating ligands: Cu^+ typically binds four ligands while Cu^{++} ion binds five or six ligands. If Cu^+, bound to four ligands, is oxidized to Cu^{++}, the central ion will attempt to acquire additional ligands. If Cu^{++}, bound to five ligands, is reduced to Cu^+, the central ion will give up one ligand. This allows constructing **molecular machines**: molecules that perform work (undergo directional motion) in response to chemical reaction. The picture below (from Poleschak et al, ChemCommun., 2004 474-476) illustrates one such molecular machine:



Analyze this molecular machine and identify a **correct** statement

1) If the red atom is Cu^+, then the reduction of this compound by one electron will lead to a 180° rotation of the blue macrocyclic ring
2) If the red atom is Cu^{++}, then the reduction of this compound by one electron will lead to a 180° rotation of the blue macrocyclic ring
3) If the red atom is Cu^+, then the oxidation of this compound by one electron will lead to a 180° rotation of the blue macrocyclic ring
4) If the red atom is Cu^{++}, then the oxidation of this compound by one electron will lead to a 180° rotation of the blue macrocyclic ring
5) It does not matter if the red atom is Cu^+ or Cu^{++}; the blue ring will slip off the black axel and the molecular machine will be broke.