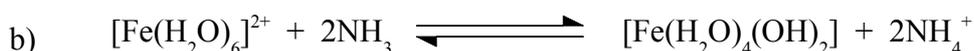


## Chemguide – answers

### COMPLEX IONS: REACTIONS OF HEXAAQUA IONS WITH AMMONIA SOLUTION

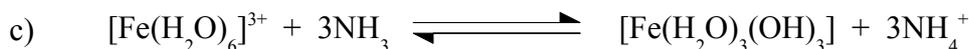
1. a) You would start with a very pale green solution which would produce a pale green precipitate when you add the ammonia solution. The precipitate darkens on standing, and turns orange around the top.



The hexaaquairon(II) ion is slightly acidic because there is a movement of electrons in the various bonds towards the positively charged iron in the centre of the complex. That leaves the hydrogens on the water molecules more positive than they would otherwise be.

The ammonia is basic because of the lone pair on the nitrogen atom. The two ammonia molecules involved in the reaction remove a hydrogen ion from each of two different water molecules to produce ammonium ions and leave the neutral complex.

(You could also explain all this in terms of reaction between the ammonia molecules and hydrogen ions (hydroxonium ions) in the slightly acidic solution, followed by shifting equilibria, but the above is *much* easier, and the more likely reaction sequence to happen anyway!)



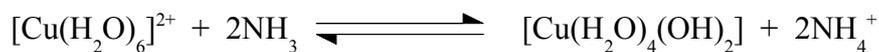
(The chloride ions from the iron(III) chloride are just spectator ions. Don't confuse things by including them.)



b) A base (or if you want to be precise – a Bronsted-Lowry base).

c) A ligand. (It is also a Lewis base, because it is acting as a lone pair donor. But you can't just use the term “base”.)

d) Equation 1:



Equation 2:



Both of these are equilibria, but the second one is more strongly to the right than the first. That means that the concentration of  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  ions in the solution falls dramatically.

According to Le Chatelier, the effect of that is to move the position of equilibrium of the first equation to the left to replace those ions. If it moves far enough to the left, there won't be enough of the neutral complex formed to give a precipitate. Therefore the precipitate dissolves.

## Chemguide – answers

3. a) original solution:  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$   
precipitate:  $[\text{Cr}(\text{H}_2\text{O})_3(\text{OH})_3]$   
final solution:  $[\text{Cr}(\text{NH}_3)_6]^{3+}$  (with some precipitate still there)
- b) original solution:  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$   
precipitate:  $[\text{Ni}(\text{H}_2\text{O})_4(\text{OH})_2]$   
final solution:  $[\text{Ni}(\text{NH}_3)_6]^{2+}$
- c) original solution:  $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$   
precipitate:  $[\text{Zn}(\text{H}_2\text{O})_4(\text{OH})_2]$   
final solution:  $[\text{Zn}(\text{NH}_3)_4]^{2+}$  (or  $[\text{Zn}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$  )