Question #61742 – Chemistry – Inorganic Chemistry

Question:

[Cu(H2O)6]2+ is light blue, by adding NH3 to the hexahydro species, it forms [Cu(NH3)4]2+ and the colour turns dark blue, why?

Answer:

The factors affecting the colour of a transition metal complex ion

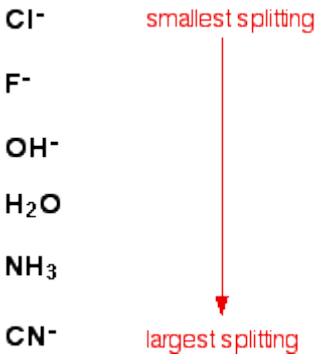
In each case we are going to choose a particular metal ion for the centre of the complex, and change other factors. Colour changes in a fairly haphazard way from metal to metal across a transition series.

The nature of the ligand

Different ligands have different effects on the energies of the d orbitals of the central ion. Some ligands have strong electrical fields which cause a large energy gap when the d orbitals split into two groups. Others have much weaker fields producing much smaller gaps.

Remember that the size of the gap determines what wavelength of light is going to get absorbed.

The list shows some common ligands. Those at the top produce the smallest splitting; those at the bottom the largest splitting.

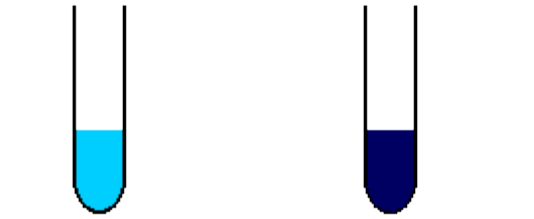


The greater the splitting, the more energy is needed to promote an electron from the lower group of orbitals to the higher ones. In terms of the colour of the light absorbed, greater energy corresponds to shorter wavelengths.

That means that as the splitting increases, the light absorbed will tend to shift away from the red end of the spectrum towards orange, yellow and so on.

There is a fairly clear-cut case in copper(II) chemistry.

If you add an excess of ammonia solution to hexaaquacopper(II) ions in solution, the pale blue (cyan) colour is replaced by a dark inky blue as some of the water molecules in the complex ion are replaced by ammonia.



$[Cu(H_2O)_6]^{2+}$ $[Cu(NH_3)_4(H_2O)_2]^{2+}$

absorbing red light absorbing yellow light

The first complex must be absorbing red light in order to give the complementary colour cyan. The second one must be absorbing in the yellow region in order to give the complementary colour dark blue.

Yellow light has a higher energy than red light. **You need that higher energy because ammonia causes more splitting of the d orbitals than water does.**