

Chemguide – answers

COMPLEX IONS: LIGAND EXCHANGE REACTIONS

1. a) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$
- b) $[\text{CuCl}_4]^{2-}$ $[\text{CoCl}_4]^{2-}$
- c) Copper: pale blue solution to green solution
 Cobalt: pink solution to dark blue solution
- d) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightleftharpoons [\text{CuCl}_4]^{2-} + 6\text{H}_2\text{O}$
 $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightleftharpoons [\text{CoCl}_4]^{2-} + 6\text{H}_2\text{O}$

Both reactions are reversible, and adding water to each will tip the position of equilibrium to the left (Le Chatelier's Principle). Both solutions will go back to their original colours (although paler because they are now more dilute).

2. a) Before: $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ After: $[\text{Co}(\text{NH}_3)_6]^{2+}$
- b) Before: $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ After: $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$
- c) Before: $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ After: $[\text{Cr}(\text{NH}_3)_6]^{3+}$

3. Adding potassium thiocyanate solution to a solution containing iron(III) ions produces a very deep blood red solution. This is a ligand exchange reaction in which one of the water ligands in the hexaaquairon(III) ion, $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$, is replaced by a thiocyanate ion, SCN^- , to give the complex ion $[\text{Fe}(\text{SCN})(\text{H}_2\text{O})_5]^{2+}$.

(Make sure that you have changed the charge on the ion. You are adding a 1- ion to a 3+ ion. The net charge is now 2+.)

4. a) green
- b) This is a ligand exchange reaction in which one of the water molecules in the original hexaaqua ion, $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$, is replaced by a sulphate ion to give a new complex, $[\text{Cr}(\text{H}_2\text{O})_5(\text{SO}_4)]^+$.

(Again, make sure that you have the correct charge on the new complex.)