THE ROYAL SOCIETY OF CHEMISTRY

93. Complexes of nickel(II) with ethylenediamine

Topic

Transition metal chemistry, complex ions.

Timing

About five min.

Level

Post-16.

Description

The ions $[Ni(H_2O)_6]^{2+}(aq)$, $[Ni(H_2O)_4(en)]^{2+}(aq)$, $[Ni(H_2O)_2(en)_2]^{2+}(aq)$ and $[Ni(en)_3]^{2+}(aq)$ are produced and their colours are seen to be distinctly different.

Apparatus

- Seven 250 cm^3 beakers.
- One 0 –100 cm^3 measuring cylinder.
- Dropping pipette.
- Access to an overhead projector (optional).

Chemicals

The quantities given are for one demonstration.

- 9.52 g of **nickel(II) chloride-6-water** ($NiCl_2.6H_2O$).
- 12 g of **ethylenediamine** (1,2-diaminoethane, $NH_2CH_2CH_2NH_2$).
- About 20 cm^3 of **concentrated hydrochloric acid**.
- About 1.5 dm^3 of deionised water.

Method

Before the demonstration

Make up a 0.2 mol dm^{-3} solution of nickel(II) chloride by dissolving 9.52 g of nickel(II) chloride-6-water in deionised water and making it up to 200 cm^3.

Make up a 0.2 mol dm^{-3} solution of ethylenediamine by dissolving 12 g of ethylenediamine in deionised water and making it up to 1 dm^3.

The demonstration

Pour 50 cm^3 of the green nickel(II) solution into each of four 250 cm^3 beakers.
To the first beaker add 50 cm^3 of the ethylenediamine solution. This will turn pale blue as the tetraaqua(1,2-diaminoethane)nickel(II), $[Ni(H_2O)_4(en)]^{2+}(aq)$, ion is formed.

To the second beaker add 100 cm^3 of the ethylenediamine solution. This will turn blue-purple as the diaquabis(1,2-diaminoethane)nickel(II), $[Ni(H_2O)_2(en)_2]^{2+}(aq)$, ion is formed.

To the third beaker add 150 cm^3 of the ethylenediamine solution. This will turn violet as the tris(1,2-diaminoethane)nickel(II),$[Ni(en)_3]^{2+}(aq)$, ion is formed.

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Take each of the solutions of the complexes and pour about half into an empty beaker. Add concentrated hydrochloric acid dropwise to each solution. The colour changes will be reversed back to the green hexaaqua ion. This is because the ligands exchange fairly easily with water molecules and the acid protonates their lone pairs, leaving them unable to co-ordinate with the metal ion.

Visual tips

A white background is important for the colour changes to be seen clearly. Alternatively, the beakers can be placed on an overhead projector to show the colours.

Teaching tips

Point out that ethylenediamine is being added to the nickel(II) ions in 1:1, 2:1 and 3:1 molar ratios respectively.

The point that the protonated ethylenediamine is no longer a ligand is worth stressing.

Theory

The series of reactions is:

$[Ni(H_2O)_6]^{2+}(aq) + en(aq) \rightarrow [Ni(H_2O)_4(en)]^{2+}(aq) + 2H_2O(l)$

$[Ni(H_2O)_4(en)]^{2+}(aq) + en(aq) \rightarrow [Ni(H_2O)_2(en)_2]^{2+}(aq) + 2H_2O(l)$

$[Ni(H_2O)_2(en)_2]^{2+}(aq) + en(aq) \rightarrow [Ni(en)_3]^{2+}(aq) + 2H_2O(l)$

Further details

Ethylenediamine solutions are not stable for any length of time as, being strongly basic, they pick up atmospheric carbon dioxide. Make up the solution freshly before each demonstration.

Safety

Wear eye protection.

It is the responsibility of teachers doing this demonstration to carry out an appropriate risk assessment.