43. A chemical test for water

Topic
Indicators, qualitative analysis.

Timing
30–45 min.

Description
A cobalt(II) chloride solution is mixed with an equal amount of sodium chloride solution. Filter paper is dipped into the mixture and dried to make cobalt(II) chloride paper.

Apparatus and equipment (per group)
- One small beaker
- Filter paper
- Bunsen burner
- Gauze
- 250 cm$^3$ Beaker.

Chemicals (per group)
- Cobalt(II) chloride solution
- Sodium chloride solution.
(Cobalt(II) chloride solution is made by adding deionised water to 12 g of CoCl$_2$.H$_2$O to make 100 cm$^3$ of solution. Sodium chloride solution is made by adding deionised water to 6 g of NaCl to make 100 cm$^3$ of solution.)

Teaching tips
1. A small amount of solution goes a long way. Students can share the same beaker.
2. The concentrations of the solutions are not too important, as long as the pink colour is noticeable on the paper.
3. A hair dryer can be used to dry the papers (these should not be bought in from home). They can also be carefully dried over a Bunsen burner.
4. Students could place the blue paper in several places around the school and monitor humidities.

Background theory
Cobalt atoms in salts are positive ions with a 2+ charge. They attract negative particles such as Cl$^-$ and the lone pair on the oxygen in water molecules. When most of the negative species around the cobalt ion are water molecules, the ion absorbs light so that it appears pink. When the paper is dry, the water molecules have been driven off. The negative chloride ion sticks to the positive cobalt ions, and the cobalt appears blue. The cobalt complexes with the water and causes the electrons in the cobalt to absorb at different energies. These different energies result in different colours being absorbed by the cobalt.

\[
\text{Co(H}_2\text{O)}_{6}^{2+}(aq) + 4\text{Cl}^-(aq) \rightarrow \text{Co(Cl}_4)^{2-}(aq) + 6\text{H}_2\text{O}(l) \\
pink \quad \text{blue}
\]

Safety
Wear eye protection and protective gloves when preparing solutions, as CoCl$_2$ solid is a possible sensitiser.
Answers

1. Sodium chloride picks up moisture from the air.
2. Indefinitely, as long as the water does not wash the salts off the paper.
3. It can be used to monitor humidity or identify the presence of water anywhere. It can also be used to detect water in petrol samples and in certain chemicals.
A chemical test for water

Introduction

Some chemicals change colour when water is added to them. Some coloured chemicals owe their colour to the water molecules that are associated with them. Cobalt(II) chloride is one colour when dry and another colour when damp. In this experiment these colours are identified.

What to do

1. Add 4 cm$^3$ of cobalt(II) chloride solution to a small beaker.
2. Add 4 cm$^3$ of salt solution.
3. Dip half of the filter paper into the solution, using tongs.
4. Boil a beaker of water and carefully lift the beaker off the tripod onto the bench.
5. Allow the paper to dry. Wrap it around the beaker of hot water to speed up drying.
6. Observe differences in colour between the wet and the dry cobalt(II) chloride paper.
7. Place the dry cobalt(II) chloride paper near an open window on a humid day and observe what happens.

Safety

Wear eye protection.

Avoid contact with the cobalt(II) chloride paper and the cobalt(II) chloride solution. Cobalt(II) chloride is toxic.

Questions

1. For what other purposes might the sodium chloride be on the paper, in addition to supplying more chloride ions?
2. How many times can the cobalt(II) chloride paper cycle between colours?
3. Suggest a practical application for the cobalt(II) chloride paper.