

Investigating Solubility

Background

When a sparingly soluble ionic compound is allowed to stand in contact with water a saturated solution is formed. A chemical equilibrium is established between the undissolved solid and the ions in solution. We can use equilibrium laws to write a mathematical expression relating the solubility of the ions to a constant known as the solubility product. This investigation explores the nature of this relationship.

Practical Techniques

You will need to find out about volumetric analysis (titrations) and how to make up accurate solutions.

Where to start

Investigate the solubility of calcium hydroxide. When excess calcium hydroxide is allowed to stand in water the following equilibrium is established.



Plan an experiment to find the concentration of hydroxide ions in the solution.

From this the solubility product for calcium hydroxide can be determined.

Possible Investigations

- Investigate the effect of common ions on the solubility. In this case you could investigate the effect of additional calcium ions by adding measured amounts of anhydrous calcium chloride to the water. You could investigate the effect of additional hydroxide ions by dissolving the calcium hydroxide into solutions of sodium hydroxide (try $0.025 \text{ mol dm}^{-3}$, 0.5 mol dm^{-3} , 0.1 mol dm^{-3}) – the hydroxide ion concentration from the sodium hydroxide is known so any excess is due to dissolved hydroxide from the calcium hydroxide.
- Investigate the effect of “uncommon ions” on the solubility of the calcium hydroxide. In this case you could try sodium chloride.
- Investigate the effect of temperature on the solubility of calcium hydroxide.

- Investigate the method of determining the solubility product using electrochemical cells. Compare the accuracy of using this method with volumetric analysis. (e.g. methods for silver chloride can be found in text books)

Sources of Information

- The Chemistry Video Consortium and The Royal Society of Chemistry (2000) *Practical Chemistry for Schools and Colleges* CD ROM
- Thorpe A., Making a standard solution, *Chemistry Review*, November 2002
- Ferguson M., Volumetric Analysis. *Chemistry Review*, September 1996
- Lainchbury A., Stephens J., Thompson A., (1997), *Advanced Practical Chemistry*, John Murray
- Vokins M. (ed), (1994), *Nuffield Advanced Science Chemistry Students Book*, Longman (Third edition)
- Battye P., Titrations, *Chemistry Review*, February 2003
- Thorpe A., Colorimetry, *Chemistry Review*, February 2003
- Thorpe A., Assessing the risks in practical work, *Chemistry Review*, September 2000
- Thorpe A., Experimental error and error analysis: just how good are those results, *Chemistry Review*, November 2001
- <http://chem.lapeer.org/Chem2Docs/LeadIodide.html>

Teachers' Notes

General

This investigation is based around a standard titration experiment and full details of the titration can be found in many practical chemistry books. Each run of the experiment will probably be take about 30 minutes and data can be obtained quickly.

Chemical Principles

Equilibrium, solubility products

Essential Equipment

Burettes, pipettes,

Essential Chemicals

Calcium Hydroxide, Hydrochloric Acid, methyl orange or phenolphthalein

Safety

No risk assessment has been given. It is essential that students prepare a detailed risk assessment before they start. Teachers should check all plans and must be satisfied that this is suitable for the proposed investigation.

Starter Experiment Sheet – Investigating Solubility

You need to prepare the following solution

- 0.1 mol dm⁻³ hydrochloric acid

You will need to think about how much of this solution to prepare. This will depend on how much of the solution is used in each experiment and how many experiments you do (including any repeats).

You may wish to “standardise” this solution to find an exact concentration – this will help make your experiment more accurate. Details of this procedure can be found in many practical books.

Shake an excess of calcium hydroxide with about 100 cm³ of water. Allow this to stand, with occasional agitation, for as long as possible to allow an equilibrium to be established.

Titrate portions of the calcium hydroxide solution (take care not to withdraw any solid) with the hydrochloric acid using methyl orange or phenolphthalein as an indicator.

Use your results to calculate the concentration of the hydroxide ion.

Deduce the concentration of the calcium ions and calculate the solubility of the calcium hydroxide in the water at room temperature

You should also be able to calculate the solubility product and compare the value with a data book value.