Investigating the dissolved oxygen content of water

Background

The solubility of oxygen in water is quite low and the level of oxygen in water is often an indication of its quality. The more oxygen dissolved the better the quality. The solubility of oxygen will decrease with increasing temperature. Nitrates and phosphates can contaminate water and lead to a decrease in the oxygen content. Water contaminated with organic material will demand a high level of oxygen to bring about its decomposition and thus lead to lower levels.

Practical Techniques

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

Where to start

Find out about the Winkler method for determining the dissolved oxygen content of water and plan an experiment to find the amount of oxygen in a sample of water.

Winkler's method involves the oxidation of manganese(II) hydroxide by the dissolved oxygen to form manganese(III) hydroxide. This is then reacted with iodide ions to liberate iodine. The amount of iodine produced can be determined by titration with sodium thiosulphate. The amount of iodine that is measured can be related the amount of dissolved oxygen by the following equations.

$$O_{2\ aq)} + 4Mn(OH)_{2\ (s)} + 2H_2O_{\ (l)} \qquad 4Mn(OH)_{3\ (s)}$$

$$2Mn(OH)_{3\ (s)} + 6HCl_{\ (aq)} + 2KI_{\ (aq)} \qquad 2MnCl_{2(aq)} + 2KCl_{\ (aq)} + I_{2\ aq)} + 6H_2O_{\ (l)}$$

$$I_{2\ aq)} + 2Na_2S_2O_{3(aq)} \qquad Na_2S_4O_{6\ (aq)} + 2NaI_{\ (aq)}$$

Possible Investigations

- Investigate how the amount of oxygen in water varies with temperature.
- Investigate the amount of oxygen in different types of water e.g. sea water and river water.
- Investigate the effect of the presence of nitrates and phosphates on the oxygen content of water

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

- Shipton M,. *Water, Unilever Educational Booklet: Advanced Series* (2000), Unilever

- 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

- *Vogel's Textbook of Practical Inorganic Chemistry,* (1989,) Longman Scientific and Technical

- Denby D., What's in Water?, *Chemistry Review*, November 1995

- Canle Lopez M. and Santaballa J.A., Investigating oxygen in natural waters, *Education in Chemistry*, November 1999

Teachers' Notes

General

There is a detailed method for estimating the amount of dissolved oxygen in the article by Canle Lopez and Santaballa (Investigating oxygen in natural waters), *Education in Chemistry*, November 1999.

Chemical Principles

Volumetric analysis, redox,

Essential Equipment

Burettes, pipettes, volumetric flasks.

Essential Chemicals

manganese (II) chloride, sodium thiosulphate, starch indicator , sodium hydroxide, hydrochloric acid, potassium iodide

Timing

Results can be obtained within a reasonable time.

Safety

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

Experiment Starter Sheet

You should prepare the following solutions

- 25 cm^3 of 40% manganese (II) chloride solution
- 25 cm^3 of 30% sodium hydroxide solution containing 2g of potassium iodide
- 0.0125 mol dm^{-3} sodium thiosulphate solution
- starch indicator solution

You should place 70 cm^3 of your water sample into a conical flask. Add to this 5 cm^3 of the manganese (II) chloride solution and 0.1cm^3 of the sodium hydroxide/ potassium iodide solution.

Top up the flask with air –free distilled water and mix. Allow to stand for 10 minutes. Brown manganese (III) hydroxide should be precipitated.

Transfer the contents of the flask to a larger flask and add 2-3 cm^3 of concentrated hydrochloric acid and shake to dissolve the precipitate. Titrate 25cm^3 of the mixture with sodium thiosulphate using starch as an indicator.

An alternative method is given by Canle Lopez and Santaballa in their article.

Quantities are

- 150cm^3 of water sample
- 1cm^3 of a 2 mol dm^{-3} solution of Manganese sulphate
- 1cm^3 of a 1.8 mol dm^{-3} potassium iodide solution and 12 mol dm^{-3} sodium hydroxide solution
- 1cm^3 of 5 mol dm^{-3} sulphuric acid solution
- 0.01 mol dm^{-3} sodium thiosulphate solution