Teaching ideas for Chapter 9, *Redox*

Questions

Two worksheets of questions are provided:

- the first worksheet deals with the Standard Level part of the syllabus
- the second worksheet is for Higher Level only.

There are also a large number of questions available in the Coursebook and on the accompanying CD-ROM.

Teaching ideas

- The importance of redox reactions in the world around us can be discussed. These include all combustion reactions, the reactions in which energy is obtained in the body and reactions in batteries.
- Rusting, as an extremely important redox reaction, could be discussed. The nature of the reaction could be investigated, as well as ways of preventing rusting. Sacrificial protection could be discussed with regard to the reactivity series. The economic cost of rusting to various countries around the world could be discussed.
- Students could research how various batteries work, from simple dry cells to lithium ion batteries (see also Option C, *Chemistry in industry and technology*). The importance to our technological society of developing more efficient and longer-lasting batteries could be discussed. We are using ever more powerful electronic devices (laptops, mobile phones, etc.) but these are severely limited by battery life. Also the environmental impact of disposing of batteries could be discussed. Many countries have legislation in place to control how batteries are disposed of. The advantages of rechargeable batteries could be discussed.
- The application of redox reactions to the extraction of important metals such as iron or aluminium could be discussed. This could lead on to a discussion of how the discovery of electricity made aluminium available and how aluminium has replaced iron/steel in many applications. The environmental impact of the extraction of metals such as aluminium could be discussed. This could be linked to a discussion of the disaster at the Ajka alumina plant in Hungary in 2010.
- Aluminium is extracted by what is called the Hall–Héroult process. This process was discovered independently, and almost simultaneously, by Charles Hall in the USA and Paul Héroult in France. Is it likely, in the age of modern communication, that a situation like this could happen again? This could lead on to a discussion of how scientists communicate the details of their work to other scientists (papers, conferences, etc.). Why do scientists publish their work and why might some scientists choose not to publish data? You could also discuss to what extent work needs to be published in English to be noticed by the wider scientific community.
- The reactivity of metals could be related to the date of their discovery.
- Students could research the chlor-alkali industry, one of the world's most important industrial processes. The differences between the various processes and the importance of the products could be discussed. The environmental impact of the various processes could be considered. Why are different processes used in different countries? This is also covered in Option C.
- The importance of electroplating could be discussed, e.g. chrome plating objects and zinc plating for electrolysis. The environmental impact of electroplating could be investigated.

- Electrolysis of water is one method that has been investigated for the commercial production of hydrogen as a fuel. The process, however, is not very environmentally friendly unless the electricity can be produced without the use of fossil fuels. The redox reactions in hydrogen fuel cells could be investigated and the rise of hydrogen fuel cell vehicles discussed. Many major automobile manufacturers are producing hydrogen-powered cars. The advantages and disadvantages of these vehicles could be discussed.

Pratical activities

Safety

Extreme care must be exercised when carrying out any practical activities in the classroom and a risk assessment should be conducted before carrying out the experiments.

Demonstrations

- There are various demonstrations that can be carried out to demonstrate the idea of a redox reaction. These range from spectacular examples involving combustion (the reaction between magnesium/zinc and copper oxide or between zinc and sulfur) to test-tube reactions involving colour changes such as the reaction between acidified dichromate(VI) solution and Fe^{2+}(aq) or I^- ions, or the disproportionation reaction that occurs when copper sulfate solution reacts with potassium iodide solution:
  http://www.practicalchemistry.org/experiments/the-reaction-between-zinc-and-copper-oxide,303,EX.html
  http://www.practicalchemistry.org/experiments/advanced/redox-reactions/topic-index.html
  http://www.practicalchemistry.org/experiments/intermediate/oxidation-and-reduction/topic-index.html
- The idea of a reactivity series could be introduced by demonstrating reactions between metals and salt solutions or reactions between halide ions and halogen solutions (see below).
- The basis of voltaic cells can be demonstrated by starting with a simple displacement reaction between a reactive metal and a salt solution, discussing the electron transfer involved, then building the cell in which the same reaction occurs:
  http://www.funsci.com/fun3_en/electro/electro.htm
  http://www.nistepkscience.com/Chemistry/9Electriccell.pdf
- Simple test-tube reactions can be used to illustrate how the electrode potential can be used to predict the feasibility of a redox reaction. Reactions that could be used are those between acidified dichromate(VI) solution and solutions containing chloride, bromide or iodide ions, or displacement reactions between halide ions and halogen solutions.
- Electrolysis can be demonstrated using molten lead bromide/zinc chloride or various aqueous solutions. How gas is collected should be demonstrated. The relationship between the number of electrons transferred and the volume of gas produced can be demonstrated using the electrolysis of acidified water in a Hoffman voltameter:
  http://www.practicalchemistry.org/experiments/intermediate/electrolysis/electrolysis-of-zinc-chloride,50,EX.html
- The electrolysis of copper sulfate solution using different electrodes should be demonstrated:
  http://www.practicalchemistry.org/experiments/intermediate/electrolysis/electrolysis-of-copperii-sulfate-solution,108,EX.html

Student practicals

There are several practicals that can be carried out on this topic.

- Students could put metals into a reactivity series using the reactions with acid (hydrochloric or sulfuric) or displacement reactions using salt solutions. The reactivity of the halogens could be investigated using displacement reactions between halogen solutions and solutions containing halide ions:
  http://www.practicalchemistry.org/experiments/displacement-reactions-between-metals-and-their-salts,304,EX.html
  http://www.lgschemistry.org.uk/PDF/C3.1_Displacement_of_metals.pdf
  http://www.creative-chemistry.org.uk/alevel/module2/documents/N-ch2-05.pdf
- Establishing a reactivity series for some non-metals:
  http://www.practicalchemistry.org/experiments/displacement-series-for-non-metals,259,EX.html
- Students could carry out a redox titration. There are various suitable titrations:
  - for example $KMnO_4$ with iron(II) ammonium sulfate (0.10 mol dm^{-3} iron(II) ammonium sulfate and 0.020 mol dm^{-3} potassium manganate(VII) with 10 cm^3 of 2 mol dm^{-3} sulfuric acid)
  - iodine with sodium thiosulfate (0.10 mol dm^{-3} iodine in potassium iodide solution and 0.10 mol dm^{-3} sodium thiosulfate, using starch indicator).

  http://web1.uct.usm.maine.edu/~tracy/chy116sumfolder/chy116s2011labsfolder/RdxTi.html
  http://faculty.ccri.edu/eterezakis/1100%20Exp%205,%20Iron%20Analysis%20by%20Redox%20Titration%20_egt_.pdf
  http://www.lahc.edu/classes/chemistry/arias/Exp%208%20-%20Redox.pdf
  http://chem.lapeer.org/Chem2Docs/RedoxTitration.html
  http://www.outreach.canterbury.ac.nz/chemistry/documents/salt_iodate.pdf
- Students can construct voltaic cells using metal electrodes and appropriate solutions. A simple salt bridge can be made by soaking a strip of filter paper in an ionic solution such as saturated potassium chloride. A variation on this is to make cells using lemons or potatoes, for example, as the electrolytes. A practical investigation can be carried out looking at a factor that affects the voltage of a voltaic cell:
  http://virtual.yosemite.cc.ca.us/danielm/102/data/VoltaicExp.htm
- Electrolysis can be carried out fairly easily on aqueous solutions. Students could collect gases or measure changes in mass of electrodes.
- Electrolysis experiments can be found at:
  http://www.practicalchemistry.org/experiments/intermediate/electrolysis/topic-index.html
  http://aquarius.nasa.gov/pdfs/electrolysis.pdf
  http://www.saskschools.ca/curr_content/chem30_05/6_redox/labs/electrolysis.htm
- Students could electroplate various metallic objects, e.g. copper plate a key or a nail. The object to be plated should be cleaned beforehand with steel wool (or with nitric acid). Detailed procedures are given in:
  http://www.hkbu.edu.hk/~micschem/emanual/Expt%2010-Electroplating-english.pdf
  http://www.woodrow.org/teachers/ci/1986/exp30.html
  http://www.wellesley.edu/Chemistry/Chem&Art/Topics/Metals/pdf_files/echemjewels02.pdf
  http://www.chemtopics.com/unit13/plating.pdf

Common problems

- Balancing oxidation/reduction half equations and redox equations is something that students often find difficult and will require quite a bit of practice. Many examples for practising balancing half equations can be found in any standard data book.
- HL students also have difficulty with electrolysis of aqueous solutions and understanding the connection between electrode potentials and the various products obtained.

ICT

There are many opportunities for using IT in this topic. Many of the excellent websites listed below contain simulations or videos.

- Redox demonstrations:
  http://www.chem.umn.edu/services/lecturedemo/
  http://www.chem.uiuc.edu/clcwebsite/demos.html
- Oxidation number calculator for transition metal complexes:
  http://winter.group.shef.ac.uk/chemputer/oxidation-number.html
- Redox reactions:
  http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/PbAgtransfer.html
  http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/ZnCutransfer.html
- Redox titration:
  http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/redoxNew/redox.html
- Redox – electrochemical cells:
  http://chemmac1.usc.edu/resources/105b/resources/electrochemistry/galvanic.php
  http://chemmovies.unl.edu/ChemAnime/Electro.htm
  http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/galvan5.swf
  http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/volticCell.html
  http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/SHECu.html
- Database about electrode potentials:
  http://www.rsc.org/Education/Teachers/Resources/Databook/data/databases/electrode.zip
- Electrolysis:
  http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/electrolysis10.html

Theory of knowledge (TOK)

Are oxidation numbers are real?

Why have scientists developed a systematic way of naming compounds based on oxidation numbers?