Teaching ideas for Chapter 8, *Acids and bases*

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 acids and bases in everyday life can be discussed. This can be related to practical work by looking at the pH of household substances.
- The origins and usefulness of the pH scale could be discussed. The pH scale was first developed in 1909 by Søren Sørensen (1868–1939) when working for the Carlsberg brewery. There seems to be some disagreement about what the 'p' in pH actually stands for!
- Students could research the causes of acid deposition and investigate the effects on limestone buildings and statues and on trees and lakes: http://www.epa.gov/acidrain/index.html
- The international implications of acid rain can be discussed. Acidic gases can be produced in one country but can result in acid rain in other countries. Acid deposition is discussed further in Option E, *Environmental chemistry*.
- The importance of soil pH could be discussed, along with the use of lime in controlling this. Soil pH is discussed further in Option E, *Environmental chemistry*.
- Hydrangeas are different colours depending on the pH of the soil. They tend to be blue at lower pH and pink at higher pH. This is, however, not a simple acid–base effect and the pH affects the availability of aluminium to be taken up by the plant.
- Students could research the role of acids in murder cases, such as the acid bath murders: http://www.crimeandinvestigation.co.uk/crime-files/john-haigh-the-acid-bath-murderer/biography.html;jsessionid=33ED84B5329C5A446497CA5875F7E136
- Over the years, acids have been a popular method of murdering people or disposing of victims. John George Haigh (1909–1949) was known as the 'acid bath murderer'. He disposed of the bodies of his victims by placing them in oil drums full of concentrated sulfuric acid. However, he did not destroy every piece of incriminating evidence; items such as dentures and gall stones were recovered by forensic investigators. More recently, Larissa Shuster, a biochemist, was sentenced to life imprisonment for murdering her husband, a co-owner with her of a chemical company, by putting him in a barrel of hydrochloric acid.
- The use of buffer solutions in everyday life and/or the buffering action of the components of blood could be discussed.

Practical 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

The ideas given here could be carried out as demonstrations or laboratory practicals, depending on the equipment and resources available.

- Reactions can be demonstrated to illustrate the classic reactions of acids and bases, such as reactions of acids with metals, carbonates, alkalis, etc.
- The differences between strong and weak acids and bases can be demonstrated by measuring the conductivity and pH of equal concentrations of a weak acid/base and a strong acid/base. Magnesium turnings/calcium carbonate powder could also be added to the strong/weak acid to illustrate differences in reactivity.
  http://www.uni-regensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/D-Carboxylic_acid-e.htm
- A pH meter could be used to demonstrate the effect of diluting acids and bases.
- Acid–base titrations can be carried out using a pH meter to generate titration curves. Different indicators may also be added to illustrate the different pH ranges and to find the most suitable indicator for a titration.
  This is best done using a data-logger so that the pH curve can be generated in real time.
  25 cm^3 of 1 mol dm^{-3} acid is put in a beaker on a magnetic stirrer. A pH probe (and a temperature probe if desired) is put in the beaker and the initial pH recorded. An alkali of the same concentration is added from a burette. The initial pH, the shape of the curve, the pH and volume of alkali at the equivalence point and final pH should all be discussed.
- The pH of various salt solutions can be measured, in order to demonstrate the idea of salt hydrolysis. Suitable examples are sodium ethanoate, ammonium chloride and iron(III) chloride. The idea that 3+ ions in solution are acidic seems to come up a lot in IB exams!
- The function of a buffer solution can be illustrated by adding small amounts (e.g. 5 cm^3) of hydrochloric acid (0.1 mol dm^{-3}) or sodium hydroxide (0.1 mol dm^{-3}) to 100 cm^3 of buffer solution (made by mixing equal volumes of 1 mol dm^{-3} ethanoic acid and 1 mol dm^{-3} sodium ethanoate) or to 100 cm^3 of water. Adding the acid/alkali to the water should produce a large change in pH but there should be very little effect on the buffer solution.

Student practicals

There are many practical laboratory exercises that can be carried out on this topic. The demonstrations described above could also be carried out by students as laboratory exercises.

- Details of some practicals/demonstrations are given at:
  http://www.practicalchemistry.org/experiments/intermediate/acids-alkalis-and-salts/topic-index.html
- Students could use indicators or pH meters to investigate the acid/base nature of various household substances. They could also make and test indicators, for example using the liquid extracted from red cabbage:
  http://scifun.chem.wisc.edu/homeexpts/acidbase.html
- Drinks such as white wine could be titrated against 0.10 mol dm^{-3} sodium hydroxide solution. Phenolphthalein can be used as the indicator.
- The enthalpy change of neutralisation could be measured for various combinations of acids and alkalis. This can be related to the work done on thermochemistry in Chapter 5.
- Students could investigate the effectiveness of various antacid tablets using a titration method. Various procedures are available:
  http://serendip.brynmawr.edu/sci_edu/farber/pdf/antacid.pdf
  http://fcw.needham.k12.ma.us/~Janet_Fasano/FOV1-00108AC5/Antacid%20Lab%20.pdf
  http://www.usna.edu/ChemDept/plebeChem/manual/Ex17%20Antacids.pdf
- Students can investigate the properties of buffer solutions:
  http://www.profpaz.com/Files/chem52/Exp_9.pdf
  http://www.usna.edu/ChemDept/plebeChem/manual/Ex32.pdf
- **Practical 1 – Chapter 8: *Buffer solutions***
  Students could investigate how changing the composition of a buffer or diluting it affects how good a buffer it is. This practical could also be used as an assessed practical for Design. Students could be asked to investigate a factor that affects buffering capacity.

Common problems

- Students can struggle with the mathematical aspects of this topic and may need to be given extra help with the use of logarithms.
- For Higher Level, this topic requires a great deal of practice of calculation-type questions. Students do find difficulty with calculations due to the numbers of different equations involved. They usually have a great deal of difficulty with calculations on buffers.

ICT

There are many opportunities for using IT in this topic. Some of the websites listed below contain simulations.

- Simulations included on the Coursebook CD-ROM cover the following areas:
  - looking at the effect of making approximations in acid–base calculations (Application 1)
  - the effect of changing the composition of a buffer on its pH and effectiveness (Application 2)
  - the effect of diluting a buffer on its pH and effectiveness (Application 3).
- Proton transfer, pH meter, buffers and acid/base titration simulations:
  http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animationsindex.htm
  http://chemmovies.unl.edu/ChemAnime/acid_base.htm
- Titration curve simulations:
  http://www.freezeray.com/chemistry.htm
  http://chemmac1.usc.edu/resources/105b/resources/titration.php
  http://chemmac1.usc.edu/bruno/java/Titrate.html
  http://www.wfu.edu/~ylwong/chem/titrationsimulator/index.html
  http://chem-ilp.net/labTechniques/AcidBaseIdicatorSimulation.htm
- Buffers:
  http://michele.usc.edu/java/acidbase/acidbase.html
  http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/buffer12.swf
- Buffers quiz:
  http://science.widener.edu/svb/tutorial/bufferscompcs.html
- Database about equilibrium constants for acids and bases
  http://www.rsc.org/Education/Teachers/Resources/Databook/data/databases/equilibrium.zip

Theory of knowledge (TOK)

The relationship between depth and simplicity can be discussed with reference to the Brønsted–Lowry and Lewis theories of acids and bases. The Lewis theory is more sophisticated, but have we got a more sophisticated theory at the expense of losing an understanding/picture of what an acid–base reaction is?