Teaching ideas for Chapter 3, *Bonding*

Questions

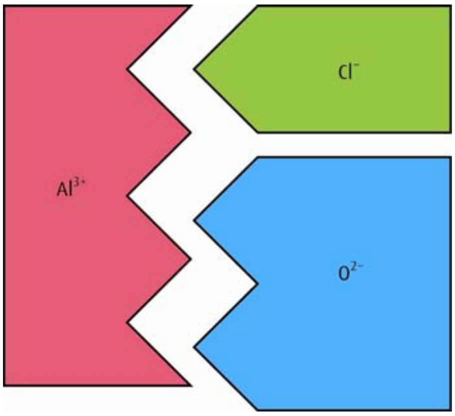
Two worksheets of questions are provided:

- 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

- Molecular models may be used to illustrate shapes of molecules.
- The idea of van der Waals' forces involving an induced dipole can be compared to charging a balloon by rubbing and then 'sticking' it to a wall or ceiling. A charge is induced on the wall by the charge on the balloon. This charge is opposite to the charge on the balloon and therefore the balloon is attracted to the wall/ceiling.
- Molecular models may be used to demonstrate the structure of diamond, graphite and fullerene.
- The formulas of ionic compounds can be investigated using a set of cards with valencies marked in some ways, e.g. 3 slots in the card for Al and 2 in that for Mg, with the negative ions fitting into the positive ions.



- Students can use matchsticks and cards with element symbols to work out Lewis structures for nitrogen oxides, O_3, CO, etc. using the alternative method for working out Lewis structures described on page 98 of the Coursebook. The matches represent the number of pairs of valence electrons. The central atoms are joined to the outer one using one match each. The matches are then arranged so that each outer atom is connected to four matches (usually just one bond and three lone pairs), then any remaining matches are put around the central atom. The matches are then re-arranged (usually just moving the lone pair on an outer atom to become the second component of a double bond) so that all atoms are connected to four matches.
- Students can investigate shapes of molecules using modelling balloons. Each student will need three modelling balloons – have these all blown up beforehand using a pump. The balloons are twisted several times in the centre and then twisted together to make an octahedron. Then half a balloon is burst using a sharp object to produce a trigonal bipyramid. The second half of the balloon is burst to make a tetrahedron, etc., all the way down to just having one whole balloon left, which represents the linear structure.
- Students can research the importance of hydrogen bonding and present their findings. They could investigate ice, DNA, proteins, solubility, etc. This gives a lot of scope for students to follow up interests and to extend the brighter students. It could be suggested that life as we know it is only possible because of hydrogen bonding – water is only a liquid at the temperature of the Earth due to the presence of hydrogen bonding!

- Students could research the properties of metals and how they relate to the uses of metals. They could look at different types of steel and how the carbon content and alloying with different metals affects properties and uses. Further ideas relevant to the extraction and uses of metals are discussed in the teaching ideas for Option C, *Chemistry in industry and technology*. Students could look up the prices of various metals on the international metal markets and discuss the international and economic factors that affect these: http://www.metalmarkets.org.uk/
- Students could research the life and work of Gilbert Newton Lewis.
- 'Atom Bond', a parody on James Bond, and other videos about bonding are available from: http://www.classroomvideo.co.uk/
  Note: this website requires users to register.
- The following video describes the work of Kekulé on the structure of benzene: http://videos.howstuffworks.com/science-channel/27865-100-greatest-discoveries-august-kekules-written-model-video.htm
- A major use of silicon is for making computer chips, otherwise known as silicon chips. An area of California, USA, with a very high proportion of leading IT firms is often referred to as 'Silicon Valley'. The name 'Silicon Valley' is also used for other areas around the world with a large number of IT companies, e.g. the city of Bangalore is sometimes referred to as the 'Indian Silicon Valley'. Students could research the extraction, purification and use of silicon and how the computer industry has developed in various parts of the world.

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

There are various demonstrations that can be carried out to demonstrate the formation of ionic bonds. Examples are the reaction between zinc and sulfur (a mixture of zinc and sulfur is heated on a tin lid/evaporating basin in a fume hood) or the reaction between magnesium and oxygen.

- The zinc and sulfur demonstration is described further at:
  http://www.angelo.edu/faculty/kboudrea/demos/zinc_sulfur/zinc_sulfur.htm
  http://boomeria.org/grades/demos/zinc.html
  http://boyles.sdsmt.edu/znsulf/zincsul.htm
  https://www.chem.wisc.edu/deptfiles/genchem/demonstrations/Gen_Chem_Pages/02atomsmolpage/reaction_of_zinc_and_sulfu.htm
  Care – this is a highly exothermic reaction and should be performed in a fume hood or well-ventilated area.
- Magnesium and oxygen demonstration
  A piece of magnesium ribbon about 15 cm long is folded in two and held, using tongs, in a Bunsen flame until it ignites. Quickly remove the lid from the gas jar of oxygen and then hold the burning magnesium in the gas jar. Try not to drop the burning magnesium ribbon as it can crack the gas jar. **Care -** students should be told to try to avoid looking directly at the bright white light.
- The conductivity of molten ionic salts can be demonstrated using molten lead bromide or zinc chloride:
  http://www.practicalchemistry.org/experiments/electrolysing-molten-leadii-bromide,106,EX.html
  http://www.rsc.org/images/electrolysislead_tcm18-188816.pdf
  Care – lead bromide is toxic and zinc chloride is corrosive. Some bromine may be given off on melting lead bromide.

- The polarity of water may be demonstrated using a charged rod and holding it near a thin stream of water from a tap or burette. The stream of water is attracted to the rod. This can be compared to other liquids:
  http://chemistry.slss.ie/resources/downloads/ch_pr_polaritydemo.pdf
  http://chemed.chem.purdue.edu/demos/demosheets/24.14.html

Student practicals

The properties of ionic substances can be investigated, e.g. solubility in water, solubility in organic solvents such as hexane, conductivity of electricity by aqueous solutions, melting point. The properties can be compared with those of covalent molecular substances:

- http://teacherweb.com/TX/BoerneHighSchool/TraciCronauer/bondinglab.pdf
- http://www.sas.upenn.edu/~justinpb/Files/inquirylabteacher.pdf
- http://www.practicalchemistry.org/experiments/structure-and-bonding/

Common problems

- Students often have difficulties with the idea that the melting points and boiling points of covalent molecular compounds depend on the strength of intermolecular forces and not on the covalent bonds present. This idea should be stressed whenever possible.
- It must be stressed, when teaching hydrogen bonding, that although a covalent bond between N/O/F and a hydrogen atom is required for hydrogen bonding, this is not a hydrogen bond – the hydrogen bond is the intermolecular force. Students often ask about chlorine and whether an H–Cl bond can result in hydrogen bonding (which would be predicted based on Pauling electronegativity differences). This illustrates the idea that there is more to hydrogen bonding than just a simple electrostatic interaction. Chlorine does not participate in hydrogen bonding because the lone pair is a 3p orbital and, as such, is quite high in energy and diffuse so that a good interaction with the H is not obtained.
- Hybridisation is a conceptually difficult idea but students usually deal with it well if it is related just to the distribution of electron pairs/shape of the molecule.

ICT

- Lewis structures and other things:
  http://treefrog.fullerton.edu/chem/index.htm#at
- Animations showing the structures of crystalline solids:
  http://www.molsci.ucla.edu/pub/explorations.html - Crystalline%20Solids
- Hybridisation:
  http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/hybrv18.swf
  http://www.learnerstv.com/animation/animation.php?ani=52&cat=chemistry
- Hydrogen bonding animation:
  http://www.northland.cc.mn.us/biology/biology1111/animations/hydrogenbonds.html
- Video on ionic bonding:
  http://www.cosmolearning.com/videos/ionic-and-covalent-bonding-animation/
- Metallic bonding animation:
  http://www.drkstreet.com/resources/metallic-bonding-animation.swf
- Dog bonding – bonding by analogy to dogs fighting over bones:
  http://library.tedankara.k12.tr/webchem/Chemical%20bonding%20and%20intermolecular%20forces/ICSD%20Bonding/Bonding%20by%20Analogy%20Dog%20-%20Bone%20Bonds.mht
- VSEPR animations:
  http://www.mhhe.com/physsci/chemistry/animations/chang_7e_esp/bom3s2_7.swf
  http://intro.chem.okstate.edu/1314f00/lecture/chapter10/vsepr.html
  http://people.bath.ac.uk/ch3tam/inorganic/vsepr/html/vseprmolecularshapes.htm
  http://www.wiredchemist.com/anim-vsepr

Theory of knowledge (TOK)

Students could discuss whether hybridisation is real. Also they could look at more advanced theories of bonding and consider the relationship between complexity of a theory and ease of use.

Students should consider whether we know or believe the shapes of molecules and consider what is actually meant by the 'shape' of a molecule.

Students could discuss the use of models in chemistry by reference to ionic bonding and how models can be tested by comparison with experimental data.

