Lower 6th Chemistry

.1.3 Bonding

The physical and chemical properties of compounds depend on the ways in which the compounds are held together by chemical bonds and by intermolecular forces. Theories of bonding explain how atoms or ions are held together in these structures. Materials scientists use knowledge of structure and bonding to engineer new materials with desirable properties. These new materials may offer new applications in a range of different modern technologies.

Prior knowledge:

GCSE Chemistry

- Structure and bonding (re-visited here).

3.1.3.1 Ionic bonding

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand ionic bonding. Write formulas of ionic compounds.	0.2 weeks	**Students should be able to:** • describe the structure of ionic compounds • explain the properties of ionic compounds using an understanding of ionic bonding • predict the formula of simple ions based on the position of the element in the Periodic Table and knowledge of common compound ions • write the formula of ionic compounds.	• Students explain the properties of ionic compounds (AO2 - Apply knowledge and understanding). • Students write the formula of ionic compounds, including those with common compound ions (AO2 - Apply knowledge and understanding). • Rich question: Which of the following ionic compounds have the highest and lowest melting points: sodium chloride, potassium chloride; magnesium chloride – explain your reasoning?	• Write the formula of ionic compounds • January 2012 Unit 1 Question 5 (QW12.1.05)	Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510

3.1.3.2 Nature of covalent and dative covalent bonds

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand covalent bonding, including co-ordinate bonds. Draw molecules with lines/arrows showing covalent/co-ordinate bonds.	0.4 weeks	**Students should be able to:** • describe the nature of covalent bonds, including co-ordinate and multiple bonds • represent molecules by diagrams where lines represent each covalent bond, with an arrow to represent a co-ordinate bond • describe the structure of molecular substances • explain the properties of molecular substances.	• Students describe differences between ionic and covalent bonding (AO1 - Demonstrate knowledge and understanding of scientific ideas). • Students describe similarities and differences between covalent and co-ordinate bonds (AO1 - Demonstrate knowledge and understanding of scientific ideas). • Students draw diagrams of molecules showing covalent and co-ordinate bonds as lines/arrows respectively ("stick" diagrams) (AO2 - Apply knowledge and understanding). • Students explain the properties of molecular substances (AO2 - Apply knowledge and understanding). • Rich question: The ammonium ion has three covalent N–H bonds and one co-ordinate N–H bond – how does the strength of the covalent bonds compare to the co-ordinate bond – explain your reasoning?	• Draw "stick" diagrams of molecules.	Animation showing covalent bonding http://www.chemit.co.uk/resource/Details/87

3.1.3.3 Metallic bonding

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand metallic bonding.	0.2 weeks	**Students should be able to:** • describe the nature of metallic bonding • describe the structure of metals • explain the properties of metals.	• Students describe differences between metallic, ionic and covalent bonding (AO2 - Apply knowledge and understanding). • Students explain the properties of metals (AO2 - Apply knowledge and understanding). • Rich question: Which metals have the highest and lowest melting points – sodium, potassium, magnesium – explain your reasoning?		Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510

3.1.3.4 Bonding and physical properties

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand the structure of ionic, molecular, giant covalent and metallic substances. Describe and sketch details of the structures of diamond, graphite, ice, iodine, magnesium and sodium chloride.	1 week	**Students should be able to:** • describe and explain the properties of ionic, molecular, giant covalent and metallic substances, in terms of melting/boiling points and conductivity • describe in detail and draw the structures of diamond, graphite, ice, iodine, magnesium and sodium chloride.	• Practical opportunity: investigate the melting point, solubility and conductivity of substances with different structure types (AO2 - Apply knowledge and understanding; PS 1.1 - Solve problems set in practical contexts). • Students create a summary table to describe and explain the structure and properties of ionic, molecular, giant covalent and metallic substances (AO2 - Apply knowledge and understanding). • Students sketch the structures of diamond, graphite, ice, iodine, magnesium and sodium chloride as solids and label the diagrams to explain their melting/boiling points and conductivity (AO2 - Apply knowledge and understanding). • Students determine which type of structure a substance has from its properties using data and/or experimentally (eg to test solubility, conductivity and ease of melting (AO2 - Apply knowledge and understanding).	• June 2013 Unit 1 Question 3 (QS13.1.03) • June 2011 Unit 1 Question 4 (QS11.1.04) • June 2010 Unit 1 Question 7 (QS10.1.07) • June 2006 Unit 1 Question 2 (QS06.1.02) • January 2006 Unit 1 Question 6 (QW06.1.06) • January 2005 Unit 1 Question 5a (QW05.1.05A) • January 2003 Unit 1 Question 1e (QW03.1.01)	Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510 *Chemistry Review* article: Graphene (Volume 19, edition 2) *Chemistry Review* article: The disguises of carbon (Volume 18, edition 1)

3.1.3.5 Shapes of simple molecules and ions

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Work out, name and sketch the shape of molecules and ions. Explain why molecules and ions have the shapes that they have.	0.6 week	**Students should be able to:** • work out, name and sketch the shape of molecules and ions with up to six electron pairs surrounding the central atom, including bond angles • explain using VSEPR theory why molecules and ions have the shapes that they do, including the effect on the bond angles of the great repulsion by lone (non-bonding) pairs.	• Make models of molecular shapes (AO2 - Apply knowledge and understanding; MS4.3 - Understand the symmetry of 2D and 3D shapes). • Use balloons to represent electron pairs to demonstrate shapes (AO2 - Apply knowledge and understanding). • Deduce, sketch and name the shapes of given molecules and ions, including bond angles (AO2 - Apply knowledge and understanding; MS4.1 - Use angles and shapes in regular 2D and 3D structures; MS4.2 - Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects; MS4.3 - Understand the symmetry of 2D and 3D shapes).	• June 2011 Unit 1 Question 3 (QS11.1.03) • January 2010 Unit 1 Question 6 (QW10.1.06) • June 2006 Unit 1 Question 5b (QS06.1.05B) • June 2005 Unit 1 Question 4 (QS05.1.04) • January 2004 Unit 1 Question 6a (QW04.1.06)	Rotatable shapes https://people.ok.ubc.ca/wsmcneil/vsepr.htm Molymod molecular models RSC exercise on VSEPR theory: http://www.rsc.org/learn-chemistry/resource/res00000648/shapes-of-molecules-and-ions

3.1.3.6 Bond Polarity

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Definition of electronegativity. How polar covalent bonds originate and deducing whether a bond is polar. How polar molecules originate and deducing whether a molecule has a permanent dipole.	0.4 week	**Students should be able to:** • define and understand the concept of electronegativity • understand why some covalent bonds are polar and deduce whether a bond is polar • understand why some molecules are polar and deduce whether a molecule has a permanent dipole.	• Predict and explain the trend in electronegativity down a group and across a period (AO2 - Apply knowledge and understanding). • Predict whether covalent bonds are polar or not (AO2 - Apply knowledge and understanding). • Predict whether molecules have permanent dipoles or not (AO2 - Apply knowledge and understanding; MS4.3 - Understand the symmetry of 2D and 3D shapes).	• January 2013 Unit 1 Question 3 (QW13.1.03) • June 2004 Unit 1 Question 6a (QS04.1.06A)	Rotatable shapes https://people.ok.ubc.ca/wsmcneil/vsepr.htm Molymod molecular models.

3.1.3.7 Forces between molecules

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
The three types of intermolecular force: van der Waals' forces, permanent dipole-dipole forces; and hydrogen bonds. How melting and boiling points of molecular substances depend on the relative strength of intermolecular forces. The impact of hydrogen bonding on the density of ice and melting/boiling points.	0.4 week	**Students should be able to:** • understand that there are three types of intermolecular force • explain how each of the intermolecular forces arise • explain how the melting points are influenced by these intermolecular forces • explain the anomalous nature of ice and how its low density can be explained through a knowledge of hydrogen bonding.	• Students produce a summary to compare the three types of intermolecular force (AO2 - Apply knowledge and understanding). • Students explain trends in Group 4, 5, 6 and 7 hydrides (to show relative strength of the three types of force and the effect of M_r on van der Waals' forces) (AO2 - Apply knowledge and understanding). • Practical opportunity: Students could try to deflect jets of various liquids from burettes to investigate the presence of different types and relative size of intermolecular forces (AO2 - Apply knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; PS 1.2 - Apply scientific knowledge to practical contexts). • Students explain why ice floats on water by reference to hydrogen bonding (AO2 - Apply knowledge and understanding).	• June 2013 Unit 1 Question 4 (QS13.1.04) • January 2012 Unit 1 Question 1 (QS12.1.01) • June 2011 Unit 1 Question 3 (QS11.1.03) • January 2011 Unit 1 Question 1 (QW11.1.01) • January 2010 Unit 1 Question 3 (QW10.1.01) • June 2005 Unit 1 Question 5 (QS05.1.05) • June 2004 Unit 1 Question 6b (QS04.01.06)	Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510 RSC AfL exercise on hydrogen bonding: http://www.rsc.org/learn-chemistry/resource/res00000129/afl-what-are-hydrogen-bonds-and-where-are-they-found *Chemistry Review* article: All things Ice (Volume 22, edition 3) RSC Kitchen Chemistry: The Structure of Ice and Water http://www.rsc.org/learn-chemistry/resource/res00000813/kitchen-chemistry-the-structure-of-ice-and-water

					Chemistry Review article: Gecko glue (Volume 21, edition 1)
Extension			Rich question – Why is there no hydrogen bonding between molecules of HCl gas even though Cl is more electronegative than N yet NH_3 has hydrogen bonding?		

3.1.4 Energetics

The enthalpy change in a chemical reaction can be measured accurately. It is important to know this value for chemical reactions that are used as a source of heat energy in applications such as domestic boilers and internal combustion engines.

Prior knowledge:

GCSE Chemistry

- Exothermic and endothermic reactions.

3.1.4.1 Enthalpy change

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Know that reactions can be exothermic or endothermic. Know what an enthalpy change and is and about standard conditions. Define standard enthalpies of formation and combustion.	0.2 weeks	**Students should be able to:** • define enthalpy change and standard conditions • define standard enthalpy changes of combustion and formation.	• Students list examples of endothermic and exothermic reactions (AO2 - Apply knowledge and understanding). • Students draw enthalpy profiles for exothermic and endothermic reactions (AO2 - Apply knowledge and understanding). • Write balanced chemical equations, to include state symbols, to represent the changes shown by standard enthalpy changes of formation and combustion (AO2 - Apply knowledge and understanding).	• June 2002 Unit 2 Question 1a and 1b (QS02.2.01)	Some everyday examples of exothermic and endothermic reactions: http://antoine.frostburg.edu/chem/senese/101/thermo/faq/exothermic-endothermic-examples.shtml

3.1.4.2 Calorimetry

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand and be able to use the equation $q = mc\Delta T$ to calculate molar enthalpy changes. **Required practical 2** Measurement of an enthalpy change. Students could research value. Different precision of thermometers. Construct all tables and graphs	1.5 weeks	**Students should be able to:** • recall the equation $q = mc\Delta T$ • Calculate ΔH for reactions using calorimetry experiment data.	• Students calculate molar enthalpy changes using provided data from calorimetry experiments (AO2 - Apply knowledge and understanding; MS0.0 - Recognise and make use of appropriate units in calculation ; MS1.1 - Use an appropriate number of significant figures; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities). • Practical Opportunity: Students find ΔH for a reaction by calorimetry eg • dissolution of potassium chloride • dissolution of sodium carbonate • neutralising NaOH with HCl • displacement reaction between $CuSO_4$ + Zn • Combustion of alcohols (AO2 - Apply knowledge and understanding; MS1.3 - Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined; MS3.2 – Plot two variables from experimental data; PS 3.1 - Plot and interpret graphs; PS 3.2 - Process and analyse data using appropriate mathematical skills; PS 3.3 - Consider margins of error, accuracy and precision of data). • Students could research how accurate values are found for the energy content in food and fuels.	• January 2011 Unit 2 Question 9b and 9d (QW11.2.09) • June 2009 Unit 2 Question 3 (QS09.2.03) • June 2006 Unit 2 Question 1d (QS06.2.01) • June 2002 Unit 2 Question 2 (QS02.2.02)	Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510

3.1.4.3 Applications of Hess's law

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Understand Hess's law. Use Hess's law to calculate enthalpy changes using enthalpies of formation and combustion. **Required practical 2** Measurement of an enthalpy change. Enthalpy of formation of MgO.	1.5 weeks	**Students should be able to:** • Recall the equation $q = mc\Delta T$ • Calculate ΔH for reactions using calirometry experiment data	• Students calculate Hess's law plus enthalpies of formation and enthalpies of combustion (AO2 - Apply knowledge and understanding). • Practical Opportunity: Students could be asked to find ΔH for a reaction using Hess's law and calorimetry, then present data in appropriate ways. Examples of reactions could include: • thermal decomposition of $NaHCO_3$ • hydration of $MgSO_4$ • Enthalpy of formation of $CaCO_3$ (AO2 - Apply knowledge and understanding; AT a - Use appropriate apparatus to record a range of measurements (to include mass, time, volume of solutions, temperature); MS1.3 - Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined; MS3.2 – Plot two variables from experimental data; PS 3.1 - Plot and interpret graphs; PS 3.2 - Process and analyse data using appropriate mathematical skills; PS 3.3 - Consider margins of error, accuracy and precision of data).	• January 2013 Unit 2 Question 3a (QW13.02.03) • January 2013 Unit 2 Question 4 (QW12.2.04) • June 2012 Unit 2 Question 2a (QS12.2.02) • June 2011 Unit 2 Question 2 (QS11.2.02) • June 2009 Unit 2 Question 2a (QS09.2.02) • June 2002 Unit 2 Question 1 (QS02.2.02)	Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510

3.1.4.4 Bond enthalpies

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources

Understand the term mean bond enthalpy. Use mean bond enthalpies to calculate approximate values for ΔH for reactions Understand why most bond enthalpies are mean values.	0.5 weeks	**Students should be able to:** • calculate enthalpy changes using mean bond enthalpies • understand why most bond enthalpies are mean values.	• Students calculate ΔH for reactions using mean bond enthalpies (AO2 - Apply knowledge and understanding).	• January 2013 Unit 2 Question 6 (QW13.2.06) • January 2006 Unit 2 Question 1 (QW06.2.01) • June 2005 Unit 2 Question 1 (QS05.2.01) • January 2003 Unit 2 Question 2 (QW03.2.02) • January 2011 Unit 2 Question 9d	Nuffield Science Data Book (free download): http://www.nationalstemcentre.org.uk/elibrary/resource/3402/nuffield-advanced-science-book-of-data-second-edition Chemistry Data Book (Starck, Wallace, McGlashan) ISBN: 9780719539510