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AS AND A LEVEL

Transition Guide

CHEMISTRY A AND CHEMISTRY B (SALTERS)

H032/H432 and H033/H433
For first teaching in 2015

KS4–KS5 Focus
Bonding and structure

Version 2

www.ocr.org.uk/chemistry

Contents

AS and A LEVEL

CHEMISTRY A AND CHEMISTRY B (SALTERS)

Key Stage 4 to 5 Transition guides focus on how a particular topic is covered at the different key stages and provide information on:

- Differences in the demand and approach at the different levels;
- Useful ways to think about the content at Key Stage 4 which will help prepare students for progression to Key Stage 5;
- Common student misconceptions in this topic.

Transition guides also contain links to a range of teaching activities that can be used to deliver the content at Key Stage 4 and 5 and are designed to be of use to teachers of both key stages. Central to the transition guide is a Checkpoint task which is specifically designed to help teachers determine whether students have developed deep conceptual understanding of the topic at Key Stage 4 and assess their 'readiness for progression' to Key Stage 5 content on this topic. This checkpoint task can be used as a summative assessment at the end of Key Stage 4 teaching of the topic or by Key Stage 5 teachers to establish their students' conceptual starting point.

Key Stage 4 to 5 Transition Guides are written by experts with experience of teaching at both key stages.

Key Stage 4 Content

Main ideas in KS4 Chemistry include:

- atoms bond either by transferring electrons from one atom to another or by sharing electrons
- the shapes of molecules (groups of atoms bonded together) and the way giant structures are arranged is of great importance in terms of the way they behave

Students at KS4 should be taught:

- types of chemical bonding: ionic, covalent, and metallic
- bulk properties of materials related to bonding and intermolecular forces
- bonding of carbon leading to the vast array of natural and synthetic organic compounds that occur due to the ability of carbon to form families of similar compounds, chains and rings
- structures, bonding and properties of diamond, graphite, fullerenes and graphene.

Key Stage 5 Content

- Interpretation of ionic and covalent bonding in terms of electron arrangements. Examples of simple covalent, giant covalent, ionic and metallic structures.
- Permanent and induced dipole–dipole interactions between molecules, including hydrogen bonding. Electronegativity and its application to bond type. Interpretation of the physical properties of materials interms of structure and bonding.
- Shapes of simple molecules and ions with up to six outer pairs of electrons (any combination of bonding pairs and lone pairs). Interpretation in terms of electron pair repulsion theory.

Comment

On examination of the criteria for A Level Chemistry, it appears that not much has changed from their knowledge of ionic and covalent bonding at Key Stage 4. As such it can be tempting to quickly skip over the concepts of *dot-and-cross* diagrams and lattice structures, moving on to 'new' concepts such as dative bonding and intermolecular forces. The danger of this approach is that misconceptions introduced at GCSE level become further ingrained and result in real conceptual difficulties later in the course. The most likely issues faced when teaching this topic to learners who have already encountered the topic of bonding are summarised below – this is a simplified view and there are several sources which provide a more detailed overview.

1. The 'molecular framework' problem[1]

Although learners are aware on some level that ionic compounds exist as lattice structures, there is often a misconception that a 'special bond' occurs between the atoms where electron transfer took place. This often results in confused phrases such as 'sodium chloride molecules within the lattice'.

It is not enough to expect that learners will automatically identify the difference between type of bonding (ionic, covalent or metallic) and type of structure (lattice or molecule) and these distinctions should be applied as early and as frequently as possible.

2. Over-reliance on the 'octet rule'[2]

When trying to teach such an abstract concept, it is understandable that anthropomorphism is rife. Generalisations such as 'atoms want to gain full outer shells' or even 'atoms react in order to gain full outer shells' can cloud learners' understanding of why chemical reactions happen at all. Learners are told that when sodium and chlorine react, sodium loses one electron and chlorine gains one. However, within the same topic they are told that sodium atoms have already formed positive ions as part of the metallic lattice, and that chlorine is diatomic in order to gain a full outer shell!

There is no problem with introducing even at Key Stage 4 some simple examples of molecules that do not satisfy the octet rule, such as BF_3 or SF_6. Learners are often taught about the endothermic and exothermic nature of bond breaking and making respectively; this is a useful link to the idea that bond making is a thermodynamically favourable process even if the octet rule cannot be satisfied. The checkpoint task 'Unbreakable Rule or Rule of Thumb' is a very useful tool in eliciting misconceptions in this area.

3. The nature of chemical bonding[2]

When asked to differentiate between ionic and covalent bonding, learners are usually quick to state that 'in ionic bonding, electrons are transferred and in covalent bonding, electrons are shared'. While a useful guideline, this statement in no way explains the electrostatic attractions that hold molecules or lattices together. The Royal Society of Chemistry (RSC) 'Spot the Bonding' activity has some useful depictions of a range of different structures and encourages learners to think more widely about the forces both between and within molecules. A practical demonstration of diffusion and precipitation of ionic compounds encourages learners to think about the microscopic phenomena underlying macroscopic observations; this can be used alongside the 'Ionic Bonding vs Electron Transfer' activity.

Finally, as learners progress from Key Stage 4, they may suffer from a very discrete view of bonding – that atoms either combine by ionic or covalent bonding with no middle ground. At Key Stage 4 the example of hydrogen chloride and hydrochloric acid is a useful example of how elements can bond in different ways under different conditions.

At A Level, the reaction between aluminium and iodine can be an engaging introduction to the idea of a continuum of bonding, as it is an example of a covalent compound involving a metal. Links should be made at every step along the way between the difference in electronegativity and the likely extent of covalent or ionic character. Although Born–Haber cycles are usually covered in the second year of A Level, the occurrence of ionic compounds with a degree of covalent character should be mentioned at the same time as teaching covalent bond polarity, in order to avoid the development of very 'one-sided' ideas amongst learners.

[1] Tan, K.C.D. and Treagust, D.F. (1999) Evaluating students' understanding of chemical bonding. *School Science Review*, 81(294), 75–83

[2] RSC Chemical Misconceptions I – http://www.rsc.org/learn-chemistry/resource/res00001140/chemical-bonding

Activities

Atoms, elements, molecules, compounds and mixtures, RSC

http://www.rsc.org/learn-chemistry/resource/res00000617/atoms-elements-molecules-compounds-and-mixtures

Printable worksheets designed to elicit misconceptions and encourage accurate use of scientific terms. Learners use Venn diagrams to build on their understanding of key chemical vocabulary.

The Chemistry Journey (video resource), Fuse School

https://www.youtube.com/user/virtualschooluk/search?query=bonding

A series of short and informative videos related to bonding and structure that can be used to consolidate or introduce different topics.

Gridlocks, RSC

http://www.rsc.org/learn-chemistry/resources/gridlocks/puzzles/level-2/types-of-bonding.html

This resource can be used as either an online game (does not usually work on mobile devices) or as a printable worksheet. By filling in the blanks on each puzzle, learners use problem solving skills but are also consolidating what they have learned.

Allotropes of carbon, RSC

http://www.rsc.org/learn-chemistry/resource/res00001121/ri-christmas-lectures-2012-allotropes-of-carbon?cmpid=CMP00002102

A collection of worksheets and corresponding video clips from the 2012 Chemistry Christmas Lectures, exploring the different forms of carbon and placing the information in engaging and relevant contexts.

Bonding Bingo, RSC

http://www.rsc.org/learn-chemistry/resource/res00000093/afl-bonding-bingo

An Assessment for Learning Resource that can be used with the whole class and encourages learners to voice their opinions and ideas about chemical bonding and structure, allowing for formative assessment by the teacher.

Checkpoint Task

This is a card sort/discussion based activity that provides learners with twenty statements about bonding and the 'octet rule'. The card sort can be used at the start of the A Level course in order to gain a better understanding of how learners have been taught and what misconceptions they may have acquired at Key Stage 4; this is particularly useful when dealing with a mixed class from different secondary backgrounds.

The learners are asked to consider each statement and decide whether it is an 'unbreakable rule' that always applies in every circumstance, or whether it is a 'rule of thumb' – a useful guideline that usually applies but for which there can be exceptions. Depending on the class, you may offer learners an option of a third 'not sure' pile. Plenty of time should be allowed for learners to discuss their ideas and if possible provide whiteboards for their 'exceptions' explanations so that they can adjust their ideas as they talk to each other. They should also be encouraged to consult textbooks, data books and revision guides for ideas.

There are ten statements which have exceptions; going through all of these at once at the start of the course is likely to push learners past their conceptual limit and make them frustrated. An alternative strategy is to take a photo of their answers or record them in some other way. They can then be used to inform teaching strategies and, every time an exception is met, learners can be encouraged to re-evaluate their answers. For example, following a demonstration and discussion of the formation of aluminium chloride (including dimer formation) learners can be asked to re-evaluate their ideas about covalent bonding and the octet rule.

Checkpoint task:

https://www.ocr.org.uk/Images/350142-bonding-and-structure-ks4-ks5-checkpoint-task.doc

Activities

Spot the Bonding, RSC

http://www.rsc.org/learn-chemistry/resource/res00001097/spot-the-bonding

Good open-ended worksheet in which learners identify the types of bonding present within structures. It forces learners to identify bonding within solids and liquids as well as within and between individual molecules. Assumes knowledge of the different intermolecular forces but could be done without this (i.e. learners could just label 'intermolecular forces' where present rather than explicitly identifying them).

Starters for Ten, RSC

http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten#!cmpid=CMP00001408

A series of enjoyable ten-mark starter activities (which can also be used as plenaries) on a range of different topics including bonding. Some challenging examples of dot-and-cross diagrams.

Demo: Reaction between aluminium and iodine, RSC/Nuffield Foundation

http://www.rsc.org/learn-chemistry/resource/res00000715/reaction-between-aluminium-and-iodine

A very memorable demonstration – must be carried out in a fume cupboard or outside. Can be used as a starting point for the discussion of 'rule-breakers' – a metal-containing covalent compound which does not satisfy the Octet Rule. Can also be used to discuss intermediate bonding and dative covalent bonding (in the dimer structure).

Diffusion in liquids practical, RSC/Nuffield Foundation

http://www.rsc.org/learn-chemistry/resource/res00000685/diffusion-in-liquids?cmpid=CMP00006662

Although this practical is designed to be used to demonstrate diffusion, there is a lot of chemistry here relating to ionic compounds that could be explored. Learners should be challenged to represent each stage of what they observe (dissolving, diffusion and precipitation) with chemical equations and/or diagrams.

Assessment for Learning: Bonding and Structure, RSC

http://www.rsc.org/learn-chemistry/resource/res00000119/afl-structure-and-bonding

In this activity, learners match cards that describe properties, structures, bonding and particles with particular substances. It allows learners to differentiate between structure and bonding and how these distinctions lead to different properties.

Gridlocks - shapes of molecules, RSC

http://www.rsc.org/learn-chemistry/resources/gridlocks/puzzles/level-3/ShapesOfMolecules_geometry.html

These puzzles can be completed online (not tablet enabled) or printed out. Printing out is recommended as learners then obtain lots of practice in drawing molecule shapes. At the bottom of the page are links to two other related puzzles.

Activities

Molecule polarity – simulation, Phet

https://phet.colorado.edu/en/simulation/legacy/molecule-polarity

This is a great interactive simulation for learners to investigate how electronegativity and the shape of the molecule affects its overall polarity. The simulations need Java to be enabled so will not work on most mobile devices.

Shapes of molecules – simulation, Phet

https://phet.colorado.edu/en/simulation/molecule-shapes

https://phet.colorado.edu/en/simulation/molecule-shapes-basics

These simulations explore the effect of adding bonds and lone pairs and can be used as a classroom resource or for independent learning. Both simulations are available as HTML 5 (tablet enabled) or Java (PC enabled) versions and come with worksheets and suggestions for activities.

Electron Transfer vs Ionic Bond Formation

Learner Resource 1

https://www.ocr.org.uk/Images/350146-bonding-and-structure-ks4-ks5-student-resource-1.doc

This short worksheet encourages learners to clearly differentiate between the separate processes of ion formation (electron transfer) and ionic bond formation. By referring to changes in state where appropriate, learners will need to clarify their understanding of how ions exist in aqueous solution compared with solid lattices. This exercise can be used in conjunction with the diffusion in liquids practical above.

Activities

Bonding Models, RSC

http://www.rsc.org/learn-chemistry/resource/res00000626/bonding-models

Often learners see *dot-and-cross* diagrams as a representation of the 'real thing' rather than a model which has strengths and weaknesses like any other. In this resource learners investigate alternatives to the '*dot-and-cross*' approach, including some of Lewis's original ideas. Challenging but worthwhile.

Metals, RSC

http://www.rsc.org/learn-chemistry/resource/res00000845/metals#!cmpid=CMP00000956

This is a resource for able learners which includes a lot of interesting and challenging questions about metallic structure, along with some important concepts about reactivity and chemical stability.

Understanding Chemistry – Bonding, Chemguide

http://www.chemguide.co.uk/atoms/bondingmenu.html#top

The Chemguide website gives a comprehensive overview of A Level Bonding topics and provides plenty of detail for more able students to research and self-study.

Why do ions form?

Learner resource 2

https://www.ocr.org.uk/Images/350150-bonding-and-structure-ks4-ks5-student-resource-2.doc

This worksheet encourages learners to think more deeply about why different elements form ions with fixed charges. It moves away from the oversimplified 'full outer shell' to make links between the energy changes during ion formation and the energy changes associated with forming an ionic lattice.

Resources, links and support

Science Spotlight – Our termly update Science Spotlight provides useful information and helps to support our Science teaching community. Science Spotlight is designed to keep you up-to-date with Science here at OCR, as well as to share information, news and resources. Each issue is packed full with a series of exciting articles across the whole range of our Science qualifications: www.ocr.org.uk/qualifications/by-subject/science/science-spotlight/

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To find out more about GCSE and A Level reform please visit: http://www.ocr.org.uk/qualifications/gcse-and-a-level-reform

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