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A LEVEL

Transition Guide

CHEMISTRY A AND CHEMISTRY B (SALTERS)

H432/H433
For first teaching in 2015

KS4–KS5 Focus
Atomic structure

Version 2

www.ocr.org.uk/chemistry

Contents

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.

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Key Stage 4 Content

Key Stage 4 National Curriculum Content*

Describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with most of the mass in the nucleus.

Describe how and why the atomic model has changed over time.

Recall relative charges and approximate relative masses of protons, neutrons and electrons.

Explain how the position of an element in the Periodic Table is related to the arrangement of electrons in its atoms and hence to its atomic number.

* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/303093/GCSE_single_science_content-.pdf

Key Stage 5 Content

Key Stage 5 GCE A Level Subject Content*

Structure and electronic configuration of atoms (up to Z = 36) in terms of main energy levels and s, p and d orbitals.

The organisation of elements according to their proton number and electronic structures. Classification of elements into s, p and d blocks.

* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/303026/A_level_science_subject_content-.pdf

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Comment

At GCSE students are required to present the Bohr Model of atoms and to use this model to explain fundamental concepts such as patterns of reactivity, ionic and covalent bonding and the trends within groups (such as the increasing reactivity of alkali metals). At A Level, students are required to adapt their model to include ideas about orbitals, sub-shells and discrete electronic energy levels. They are also taught to use the model to explain observations associated with the first ionisation energies of successive elements, although this content is sometimes left until later in the course.

At GCSE the subject of atomic structure is often introduced at a fairly late stage in the study of chemistry and there are several main consequences of this. Firstly, existing misconceptions and frameworks are often deeply rooted and difficult to overcome. The use of vocabulary becomes very sloppy as students, without any real understanding of what atoms, ions or molecules are, use the words interchangeably and often incorrectly. Finally, since several GCSE syllabuses position the atomic structure topic at a mid-point rather than at the start of the course, its importance in providing an underpinning for other topics is often overlooked.

At A Level, the topic is (quite rightly) prioritised and positioned at the start of the syllabus. The Bohr Model of the atom is revisited and its familiarity can sometimes lead students and teachers alike to rush through the topic, leaving existing misconceptions unaddressed. The introduction of sub-shells and orbitals is a challenge for students and they can often become demotivated and disheartened at the prospect that 'everything we learned at GCSE is wrong'. Many students even come into A Level 'pre-warned' by previous teachers or older students that they will have to throw out all their existing knowledge. To help overcome this, the Checkpoint Activity is designed to encourage students to realise that old models are supplemented by, rather than supplanted by, new ideas. It is also designed to foster the idea that new scientific theories come about as a result of new scientific evidence.

A suggested teaching sequence for the beginning of A Level would be to revise the Bohr Model of the atom, emphasising its strengths in explaining many chemical phenomena but also examining any areas of potential weakness. The 'Analogy of the Atom' worksheet listed in the KS4 activities could also be used at A Level. Following this period of consolidation students should be introduced to the idea of successive ionisation energies for individual elements as this will enhance their idea that the Bohr Model is valid. The first ionisation energies for successive elements can then be introduced, followed by the Atomic Model Checkpoint Activity. This will encourage students to use knowledge about scientific observations to test the validity of different atomic models, and to see the need for a new model in the face of the new evidence presented.

The 'Ionisation Energy – True or False?' worksheet is an invaluable tool for eliciting student misconceptions as they go through the topic. In particular students find it hard to apply their existing knowledge of electrical attraction and forces to something as abstract as an atom. This tendency to take atomic theory at face value (for example, even the most able students are very unlikely to question the idea of several positively charged particles coexisting within the confines of a nucleus, despite it going against everything they are taught in physics and a lot of what is taught in chemistry!) often results in students' written explanations being garbled and confused. The crossword activity should help students to think more carefully about their use of vocabulary, and the extension exercise on chemical definitions could also be used as a whole class activity.

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Activities

Starters for Ten: Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten#!cmpid=CMP00001408

These short worksheets can be used as a starter to test knowledge learned in a previous lesson, or alternatively can be used as a plenary activity. The first two are on the history of atomic structure and isoelectronic species and can be used at either GCSE or AS Level.

Build an Atom Simulator: PhET, University of Colorado
https://phet.colorado.edu/en/simulation/build-an-atom

This simulation can be used either independently by students or as the focus of a class activity via an interactive whiteboard or projector. A number of different worksheets are available in the links below the simulation but in particular it can be used to help students visualise the different properties of subatomic particles more clearly.

Analogy for the Atom: Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resource/res00001100/an-analogy-for-the-atom

These worksheets form the basis of an activity in which students consider the strengths and weaknesses of using analogies when describing the structure and behaviour of atoms. It encourages them to think in more detail about the commonly accepted 'solar system' analogy often used to explain electron shells.

Gridlocks: Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resources/gridlocks/puzzles/level-2/atomic-structure.html

http://www.rsc.org/learn-chemistry/resources/gridlocks/puzzles/level-3/SubAtomicParticles16_19.html

These worksheets are designed around the principle of 'Sudoku' puzzles. The minimum requirement is that students complete the first table on each worksheet as this then consolidates their knowledge of atomic number and subatomic particles. The Gridlock puzzles themselves can be challenging for students who are not familiar with the concept of Sudoku but other students can be used to explain. By allowing only a fixed length of time to work on the puzzles students often want to go back to them at a later stage, providing motivation to revise the topics.

Element Battleships
http://www.ocr.org.uk/Images/170278-element-battleships-teacher-instructions.pdf

http://www.ocr.org.uk/Images/170279-element-battleships-activity.docx

This activity is designed to help students to become more familiar with the use of notation used to depict electronic configurations at both GCSE and AS Level. The attached 'Battleship Grids' can be laminated or placed inside a plastic wallet to allow repeated use. Students try to find the location of their opponents' 'battleships' on a grid based on the first twenty elements of the periodic table. The catch is that students must use the electronic configurations rather than the names of elements (eg 2,8,1). This encourages them both to practice saying the configurations, and to associate the configurations with position on the periodic table. This resource can be adapted for AS Level, with students using the s, p and d notations on a grid that also includes d block elements.

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Checkpoint Task

Often students treat the history of the atomic model as an isolated lesson in fact finding and recall, without any appreciation of how development of the model relates to their own observations and understanding of chemistry. This is compounded by the fact that at GCSE the atomic model theories are often relegated to a homework or 'end of term' activity requiring little cognitive effort from students.

This task provides pupils with a selection of key scientists, in chronological order, accompanied by a brief reminder of their contributions towards the atomic structure model. Students are also given a selection of statements which describe experimental observations. Students should be familiar with most but not all of these experimental observations.

Working in groups of two or three, students read through the statements and decide upon the simplest model of the atom that is still sufficiently detailed to explain the observation. For example, the production of a beam of charged particles from the heating of a metal can be explained simply by the fact that atoms contain electrons, but periodic properties can only be explained if the Bohr model of the atom is used. Some of the statements are conceptually quite difficult at this stage – this allows extension for more able groups but you may want to inform the class that they might not be able to confidently place all the statements within the time limit given (approximately fifteen to twenty minutes is sufficient).

During the activity, circulation through the class allows the teacher to assess student knowledge and misconceptions of atomic structure. If some groups try to rush the activity, the teacher can challenge their reasoning behind putting cards in a certain box and encourage deeper discussion. Whole class discussion at the end of the activity can help steer students towards the realisation that they are not being told to 'throw out' ideas learned at GCSE level, but that new evidence must lead to adaptations and to increasingly sophisticated ideas and explanations.

Checkpoint task:

https://www.ocr.org.uk/Images/170275-atomic-structure-ks4-ks5-checkpoint-task.doc

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Activities

Starters for Ten: Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten#!cmpid=CMP00001408

These short worksheets can be used as a starter to test knowledge learned in a previous lesson, or alternatively can be used as a plenary activity. The first two are on the history of atomic structure and isoelectronic species and can be used at either GCSE or AS Level.

Knockhardy PowerPoints: Knockhardy Publishing
http://www.knockhardy.org.uk/ppoints.htm

Two PowerPoint files are of particular use – 'Electronic Configurations' and 'Ionisation Energies' (both found under the Physical Chemistry section). The slides are designed for either classroom use or independent study and are extremely clear and comprehensive. N.B. If you download the files directly from the website they will be saved as PowerPoint Show (.pps) files that cannot be edited. To edit the files, open them with PowerPoint and choose the 'save as' option to change to a .ppt file.

Ionisation Energy – True or False?: Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resource/res00001101/ionisation-energy

This activity is quite challenging and is designed to elucidate common student misconceptions and to prompt discussion. It is best to allow students to discuss the answers in small groups as this will make them challenge each other rather than simply guessing. The answers provided with the worksheet include explanations and discussion points. In particular the resource challenges the ideas held by students about some atoms 'wanting' to lose electrons and also challenges their use of terminology when discussing the forces of attraction that exist within atoms.

Atomic Structure Crossword
http://www.ocr.org.uk/Images/170277-atomic-structure-crossword-activity.docx

At the beginning of AS Level, many students seriously underestimate the rate at which they need to assimilate new terminology into their scientific vocabulary. This crossword is designed to be used at the end of the topic as a consolidation exercise. Once completed, students could be asked to make their own glossary or flashcards, choosing ten of the most important words.

N.B. Note that the answer to one of the clues in the crossword uses the term 'first ionisation enthalpy' as used in the GCE Chemistry B (Salters) specification. The GCE Chemistry A specification uses 'first ionisation energy'.

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Activities

Definitions in Chemistry: Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resource/res00001088/definitions-in-chemistry

Although not designed as an activity specifically directed at Gifted and Talented students, this activity is ideal for those students who find the work on electronic structure straightforward and do not require as much consolidation time. The activity is very open ended and encourages students to examine how commonly used chemical words are defined and to identify any flaws or misleading terminology within these definitions. This is particularly useful for those students who excel at the more quantitative and 'logical' aspects of chemistry but who often fall down when it comes to producing written explanations.

A New Kind of Alchemy: Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resource/res00000635/a-new-kind-of-alchemy-worksheet

This resource is designed to engage and challenge very able students and to inspire them by introducing the questions raised by cutting edge research into the behaviour of atomic 'clusters' or 'superatoms'. The questions included in the article are subjective and challenge those students who may think that chemistry (when compared with biology and physics) is a rather 'static' science in which no real developments have been made in the last century. The resource can be used as an individual or group activity, either in class or as a homework extension. An internet search of 'superatoms' will provide more related articles for particularly enthusiastic students.

Chemistry Vignettes – Advanced Physical Chemistry: Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resource/res00001376/chemistry-vignettes-advanced-physical-chemistry#!cmpid=CMP00003264

This is a series of screencasts which will help to satisfy the curiosity of students who want deeper explanations for the principles of electronic orbital theory. In particular the sections on Quantisation of Energy Levels and The Shroedinger Atom provide more detail on the wave-particle duality of electrons and on the links between the observed evidence (atomic absorption and emission spectra) and the move towards a more quantum mechanical view of electrons in atoms. Students should be encouraged to make notes as they watch the screencasts and identify areas that they want to research further, thus developing their ability to learn independently.

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