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AS AND A LEVEL

Delivery Guide

CHEMISTRY A

H032, H432
For first teaching in 2015

Theme: Atoms and equations

Version 2

www.ocr.org.uk/chemistry

Introduction

AS AND A LEVEL
CHEMISTRY A

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

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Curriculum content

2.1.1 Atomic structure and isotopes

(a) isotopes as atoms of the same element with different numbers of neutrons and different masses

(b) atomic structure in terms of the numbers of protons, neutrons and electrons for atoms and ions, given the atomic number, mass number and any ionic charge

(c) explanation of the terms relative isotopic mass (mass compared with 1/12th mass of carbon-12) and relative atomic mass (weighted mean mass compared with 1/12th mass of carbon-12), based on the mass of a ^{12}C atom, the standard for atomic masses

(d) use of mass spectrometry in:

(i) the determination of relative isotopic masses and relative abundances of the isotope,

(ii) calculation of the relative atomic mass of an element from the relative abundances of its isotopes

(e) use of the terms relative molecular mass, M_r, and relative formula mass and their calculation from relative atomic masses.

2.2.1 Electron structure

(a) the number of electrons that can fill the first four shells

(b) atomic orbitals, including:

(i) as a region around the nucleus that can hold up to two electrons, with opposite spins

(ii) the shapes of s- and p-orbitals

(iii) the number of orbitals making up s-, p- and d-sub-shells, and the number of electrons that can fill s-, p- and d-sub-shells

(c) filling of orbitals:

(i) for the first three shells and the 4s and 4p orbitals in order of increasing energy

(ii) for orbitals with the same energy, occupation singly before pairing

(d) deduction of the electron configurations of:

(i) atoms, given the atomic number, up to $Z = 36$

(ii) ions, given the atomic number and ionic charge, limited to s- and p-blocks up to $Z = 36$.

2.1.2 Compounds, formulae and equations

(a) the writing of formulae of ionic compounds from ionic charges, including:

(i) prediction of ionic charge from the position of an element in the periodic table

(ii) recall of the names and formulae for the following ions: NO_3^{2-}, CO_3^{2-}, SO_4^{2-}, OH^-, NH_4^+, Zn^{2+} and Ag^+

(b) construction of balanced chemical equations, including state symbols, for reactions studied and for unfamiliar reactions given appropriate information.

Curriculum content

3.1.1 Periodicity

(a) the periodic table as the arrangement of elements:

(i) by increasing atomic (proton) number

(ii) in periods showing repeating trends in physical and chemical properties (periodicity)

(iii) in groups having similar chemical properties

(b) (i) the periodic trend in electron configurations across Periods 2 and 3 (see also 2.2.1 d)

(ii) classification of elements into s-, p- and d-blocks

(c) first ionisation energy (removal of 1 mol of electrons from 1 mol of gaseous atoms) and successive ionisation energy, and:

(i) explanation of the trend in first ionisation energies across Periods 2 and 3, and down a group, in terms of attraction, nuclear charge and atomic radius

(ii) prediction from successive ionisation energies of the number of electrons in each shell of an atom and the group of an element

Thinking conceptually

Approaches to teaching the content

When commencing an A Level Chemistry course students will arrive at the first lesson to hear that they will be studying, in the first few weeks, atomic structure, the periodic table and equations. They will feel some confidence in their understanding shortly before their legs are knocked out from underneath them and they are told that what they think they know isn't the reality. This approach to the teaching of basic chemical concepts as half truths which support the passing of examination at GCSE level can lead to students having to unlearn their understanding when they reach the A Level classroom and can lead to a rocky start (and sometimes even failure), on an A Level Chemistry pathway.

This guide looks at ways of helping students to bridge the gap between the student or school made misconceptions of these 'basic' concepts which have been introduced at GCSE level.

The specification contains two main areas which are broached at GCSE and then developed at A Level:

- Compounds, Formulae and Equations
- The structure of the Periodic Table and its links to atomic structure (including electron structure.)

The course will often commence with revisiting atomic structure and its links with Relative masses and the mole. However the activities suggested here commence with the humble equation and its importance to the understanding of what is happening within the chemical environment. This then allows the idea of formula to be introduced linking to atomic (and electron structure) before giving consideration to the structure of the periodic table.

Common misconceptions or difficulties students may have

Students may have varying degrees of confidence in dealing with balanced symbol equations and using them to recognise what is happening within a reaction.

They will have familiarity with the current view of the periodic structure and the link between properties and electron structure however they are unlikely to have given consideration to the idea that this is a 'best fit' model and like many other forms of classification may only deal with generalities, for example the misconception of Hydrogen as a typical atom.

Students may have a fixed view of the model of the atom, failing to appreciate that it is the development of scientific understanding that has allowed us to reach this view and that continuing investigation such as that in CERN may lead us to further change our view.

Within this one model of the atom viewpoint students may also have developed school-based misconceptions of the positioning of electrons within that structure based on the simplified model taught at GCSE. This will include ideas such as the solar system perception of electron structure. This understanding of electron structure then pervades their view of chemical bonding, favouring the 'octet rule' over 'minimum energy' explanations.

Useful further reading material:

Vanessa Kind, *Beyond Appearances:Students' misconceptions about basic chemical ideas* (2nd Edition): Royal Society of Chemistry, 2004
http://www.rsc.org/images/Misconceptions_update_tcm18-188603.pdf

K. Taber, *Chemical misconceptions – prevention, diagnosis and cure,* London: Royal Society of Chemistry, 2002.
http://www.rsc.org/shop/books/2002/9780854043866.asp

Thinking conceptually

Conceptual links to other areas of the specification – useful ways to approach this topic to set students up for topics later in the course

It is important that students are encouraged not only to learn new information relating to these concepts but to assimilate and apply it in appropriate contexts in order to overcome their retention of existing models from GCSE.

Balanced equations are fundamental to all chemistry and the ability to recognise the different types of reactions by identifying reactants and products will form the basis of most further study within the specification (for example, Enthalpy calculations; atom economy). Understanding periodicity will make links to other aspects such as electronegativity whilst understanding atomic and more specifically electron structure will give the building blocks for the work on bonding and reactivity.

Activities

Activities

Build an atom simulation

http://www.rsc.org/learn-chemistry/resource/res00001433/build-an-atom-simulation-rsc-funded

A quick simulation provided by the RSC. This allows students to review their prior knowledge of atomic structure as a good starting point into the topic.

Mass Spectrometry PowerPoint

http://www.knockhardy.org.uk/ppoints_htm_files/mspecpps.pps

A useful PowerPoint covering the mass spectrometer and also analysis of spectra. Easy to adapt and use in your teaching.

Isotopes simulation

http://phet.colorado.edu/en/simulation/isotopes-and-atomic-mass

A simulation that allows you to carry out a range of activities to do with isotopes. This could be a good starting point or an independent introduction.

Multiple choice quiz on Ions, Isotopes, and Electron Shells

http://www.visionlearning.com/en/library/Chemistry/1/Atomic-Theory-II/51/quiz

Nice activity to review prior learning and also practice multiple choice questions.

Constructing Chemical explanations

https://web.archive.org/web/20150327014643/http://www.rsc.org/images/Examples_of_chemical_explanations_tcm18-189308.pdf

Ideas about periodicity are explored using the principle that many chemical phenomena are founded on the basic concepts of charge density and core charge.

Electron configuration activities

http://www.teachnlearnchem.com/UPDATE%20WEB4-08/Atom/Atom%20PP/Electron%20Configurations.ppt

A simple PowerPoint which can be used to introduce the electron configurations

http://misterguch.brinkster.net/PRA014.pdf

A very straightforward electron configuration worksheet.

http://www.youtube.com/watch?v=IUP88y_xb60

Online electron configuration worksheet.

Dream journey into the atom

Using Alternative Science Theories (from Thinking Skills Through Science (12 Mar 2004) by Sue Duncan (Author), Don McNiven (Author), Chris Savory (Author) and David Leat (Author)). **Publisher:** Chris Kington Publishing (12 Mar 2004)

Language: English

ISBN-10: 1899857559

ISBN-13: 978-1899857555

Students are asked to consider how tenable alterative scientific theories are, providing evidence for or against the proposed theory.

http://www.nclark.net/AtomJourney.html

This PPARC resource explores the historic development of the atomic model through to more recent developments in CERN.

Atomic Structure and the Periodic Table

http://www.youtube.com/watch?v=ygR0IyD5Wsc

A link to the Modern Alchemist Christmas Lecture 2012 about atomic structure.

Activities

Models of atomic structure

https://www.compoundchem.com/2016/10/13/atomicmodels/

This poster highlights some of the different models of the atom that have been put forward over time, and identifies limitations of each. It can help students appreciate how models have been improved over time as scientific advances have developed our knowledge.

Trouble with the Periodic Table

To develop student understanding of the current structure of the Periodic Table and potential issues with its structure.

Students use the Gateway Contemporary Science issue lesson 12 property cards to develop their own periodic table and link properties to electron structure (as they currently understand it.) http://14729.stem.org.uk/chem_lesson_12.html

They then research key scientists involved in the development of the Periodic Table identifying their contribution to the development and present this to the group. (Students could be challenged to find an interesting way of conveying this information to students which may include recreating in model form some of the activities/investigations associated with these scientists:

Scientists to be included: Lavoisier; Newlands; Doberiener; Mendeleev; Rutherford; Seaborg

Students should then read 'Trouble in the Periodic Table' by Eric Scerri and produce a critique of the current structure.

http://www.rsc.org/education/eic/issues/2012January/trouble-in-the-periodic-table.asp

(Also useful is http://www.chemistryviews.org/details/ezine/1077259/Periodic_Debate.html)

Starters for Ten: Royal Society of Chemistry

http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten#!cmpid=CMP00001407

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 worksheet linked here covers 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

https://www.ocr.org.uk/qualifications/as-a-level-gce-chemistry-b-salters-h033-h433-from-2015/delivery-guide/Images/123-237438-asa-level-chemistry-b-atomic-structure-le2-instructions-v2.pdf

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.

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

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 Schrödinger 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.

Thinking contextually

Activities

The premise of this guide is to develop students' thinking skills through a range of individual and group activities involving Assessment for Learning.

Activities such as reproducing a diagram of a complex process can be a powerful aid to developing students' understanding, problem solving skills can also be encouraged through collaborating in order to transmit information to the group. Specific activities are also identified to target Gifted and Talented (or the more able) students.

Activities

Chemistry and Cooking
Learner Resource 1.1

A light hearted starter to encourage students to understand the value of the equation in formulating their understanding of a reaction. Students are given a series of recipes and asked to identify key information from them. This is then linked to a chemical equation where they are encouraged to make the same observations.

What's the reaction?
http://www.rsc.org/education/teachers/resources/aflchem/

This resource is a 14-16 AFL activity aimed at developing students' understanding of the different types of chemical reaction. It is a useful starting point for eliciting students' recall of common chemical reactions. This activity could be extended beyond the metal reactions on which it is based to include a wider variety of the six basic chemical reactions.

Similarities and Differences in Atoms (RSC)
Students question their own understanding and pool ideas connected with the structure of atoms. Throughout the activities the students reassess any shortcomings in their understanding by articulating the essential features of atomic structure. This process may include being challenged by their partner or by other pairs of students.

http://www.rsc.org/education/teachers/resources/aflchem/resources/53/53%20resources/53%20Similiar%20and%20different%20cards.pdf

Mass Spec Memory
Students collaborate to draw out details of the mass spectroscopy process and come up with a mnemonic to remember the activity (Victor is a daft duck being a common one used which could be shared as an example).

Learn Chemistry Starter for Ten. No 10 Analysis:

http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten#!cmpid=CMP00001414

Covalent Bonding
http://www.rsc.org/learn-chemistry/resource/res00000637/covalent-bonding?cmpid=CMP00000661

This activity seeks to develop an understanding of covalent bonding in terms of energetic stability rather than full shells. (An alternative or complementary activity on Ionic bonding may be found on the same website.)

Learner Resource 1.1

Learner resource 1.1 Cooking and Equations

Students are given set of six recipe cards and asked to identify what the card tells them.

Students should indicate the following:

- Name of meal recipe card is for; (Spaghetti Bolognaise; Chilli; Shepherd's Pie; Cupcakes; Bread and Butter pudding; Sausage Casserole.)
- Ingredients
- Volumes of ingredients
- State which ingredients should be used

Put an equation on the board and ask students to identify what the equation tells them.

Students should identify

- Type of reaction
- Reactants
- Products made
- Masses/Moles of reactants and products
- State in which reactants and products are found

500g Fresh Beef Mince.
1 Medium Onion, peeled and finely diced.
1 Carrot
1 kg Potatoes
Beef Stock
A little oil
Serves 6

8 oz Flour
8 oz Caster Sugar
8 oz Butter
4 Eggs
A dash of milk
Pinch of salt
10 oz Butter Icing
14 Cupcakes

6 Sausages
1 Onion
1 cup of peas
Small Tin of Baked Beans
14 oz tin tomatoes
½ pint hot water
Serves 3

500 g Fresh Beef Mince.
1 Tins of Plum/Chopped Tomatoes.
1 Medium Onion, peeled and finely diced.
2 Cloves of Garlic, peeled and finely diced.
Mushrooms
Green Pepper
Red Kidney Beans
Cayenne Pepper
A little oil
Serves 6

500 g Fresh Beef Mince.
1 Tins of Plum/Chopped Tomatoes.
1 Medium Onion, peeled and finely diced.
2 Cloves of Garlic, peeled and finely diced.
A little oil
Serves 4

1/2 loaf of Bread
4 oz Butter
1 pt Milk
2 Eggs
Sultanas
Serves 4

Learner Resource 1

Learner resource 1.1 Cooking and Equations

What's the reaction?

List what type the following reactions are:

1) $NaOH + KNO_3 \rightarrow NaNO_3 + KOH$

2) $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

3) $2\ Fe + 6\ NaBr \rightarrow 2\ FeBr_3 + 6\ Na$

4) $CaSO_4 + Mg(OH)_2 \rightarrow Ca(OH)_2 + MgSO_4$

5) $NH_4OH + HBr \rightarrow H_2O + NH_4Br$

6) $Pb + O_2 \rightarrow PbO_2$

7) $Na_2CO_3 \rightarrow Na_2O + CO_2$

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