QUALIFICATION AWAITING ACCREDITATION

OCR
Oxford Cambridge and RSA

GCSE (9–1)
Delivery Guide

GATEWAY SCIENCE CHEMISTRY A

J248
For first teaching in 2016

Particles

Version 1

Can also be used for teaching:
GCSE (9–1) GATEWAY SCIENCE COMBINED SCIENCE A

www.ocr.org.uk/chemistry

Introduction

GCSE (9–1)
GATEWAY SCIENCE 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 learners may have, approaches to teaching that can help learners 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.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resources.feedback@ocr.org.uk

QUALIFICATION AWAITING ACCREDITATION

'These draft qualifications have not yet been accredited by Ofqual. They are published (along with specimen assessment materials, summary brochures and sample resources) to enable teachers to have early sight of our proposed approach.

Further changes may be required and no assurance can be given at this time that the proposed qualifications will be made available in their current form, or that they will be accredited in time for first teaching in 2016 and first award in 2018.'

a) Describe the main features of the particle model in terms of states of matter

Learners should have some familiarity with the use of the particle model to explain the different states of matter. They will therefore know that

I) solids comprise particles in fixed arrays with movement restricted to vibrations around fixed points
II) liquid particles have a greater freedom of movement and are able to move in any direction around each other allowing liquids to flow into and take the shape of their container
III) gas particles have a far greater freedom of movement and can be far apart from each other. Gas particles move to completely fill the container they are held in and will exert a pressure when held in a closed container by means of impact on the walls of the container.

Neither solids nor liquids can be compressed as the particles are very close together while the spaces between particles in a gas allow it to be compressed.

b) Explain in terms of the particle model the distinction between physical changes and chemical changes

Learners must be clear about the difference between a physical and a chemical change. Physical changes are brought about by differences in energy within a single substance. For example, as the energy increases, particles gain energy to the point that the number of attractions between particles become less. Therefore, a solid can change to a liquid or a gas, a liquid can change to a solid or a gas and a gas can become a solid or a liquid depending on whether energy is being gained or lost. These changes are all reversible with no change in the mass of the substance.

Chemical change results from collisions between particles at an appropriate energy level. The result of such collisions is the production of one or more new substances and a change in the nature of the particles present. While some reactions may be reversible, many are not. They also bring about changes in the mass and the properties of the new particles present.

c) explain the limitations of the particle model in relation to changes of state when particles are represented by inelastic spheres (e.g. like bowling balls)

To include

that it does not take into account the forces of attraction between particles, the size of particles and the space between them

Learners are required to understand that the particle model is simplistic in its treatment of changes in state and although it gives a clear idea of what might happen, in its most basic form it takes no account of the nature of the particles involved.

Particles can vary in many ways, such as size, mass and their power of attraction between themselves and other different particles. Larger particles with greater mass tend to have a greater momentum though they usually need more energy to acquire that momentum.

The forces of attraction that hold a material together can vary from the various types of bonding, from the very strong to the much weaker interatomic forces. Metals, with a few exceptions, have high melting and boiling points, as do those substances that exist in large lattice arrangements such as sodium chloride and diamond. Meanwhile, molecular and atomic substances such as sulfur and argon rely solely on Van der Waal's forces to hold them together and have low melting and boiling points as a result.

Approaches to teaching the content:

Particle theory is fundamental to understanding a wide range of chemical kinetic ideas and properties hence it is essential that learners get a clear sense of what particles are and how they interact. The basic idea of particles behaving with perfect elasticity needs to be extended to cover real-life situations where this is not the case. All matter differs in their properties depending on the interactions between the particles making up that matter.

Common misconceptions or difficulties learners may have:

Learners carry several misconceptions into their dealings with particles. These include the idea that matter is continuous. The particles involved are so small that any spaces between them cannot be observed therefore learners find it difficult to accept that there can be a huge amount of empty space between gas particles. Learners also think that particles expand as they are heated and that they change mass as they change between states. Activities 1 to 7 address these misconceptions.

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

Ideas of energy versus particle movement build into ideas regarding reaction kinetics and bond breaking and making during chemical reactions. A good grounding in particle theory allows learners the ability to cope with visualising collisions during reactions and the differences that might be seen between particles of different character. Building a strong mental image is a means of ensuring a higher level of understanding.

Approaches to teaching the content:

Activities 1 and 2 are designed to address our inability to see 'real' particles.

Activity 1 looks at the physical properties that we can see resulting from the arrangement of particles in the three states of matter and it should be clear that gas particles have space between them as they are compressible.

Activity 2 uses a model that the learners can build for themselves to observe the differences. When they draw diagrams they should be discouraged from putting spaces between liquid particles.

Activity 3 is a fully documented AfL activity from the RSC that looks at the language of particles and should encourage a deeper understanding of some of the differences between particles.

Activity 4 uses small segments of Dr Peter Wothers' RI Christmas lecture to highlight some fun aspects of particles (with a serious edge!).

Activities 5 and 6 both develop the ideas on particles further by looking into gas diffusion and mixing respectively and are designed to reinforce the idea of space between particles.

Activity 7 is a learner–produced YouTube video that gives a sound overview of this whole area which leads learners to other videos covering other areas of the specification.

Activity 1

Compression

Learners are provided with plaster of Paris, distilled water, air (or helium from a balloon cylinder), three 25 cm^3 syringes labelled 1, 2, 3, and Blue tac to seal the ends of the syringes.

- Mix the plaster of Paris as required and suck into syringe 1, wipe the inlet to the syringe and seal with blue tac. Put aside to set.
- Fill syringe 2 with 25 cm^3 of distilled water ensuring there is no air between the plunger and the liquid. Seal with blue tac.
- Fill syringe 3 either by connecting this to the helium cylinder or by sucking in 25 cm^3 of air. Seal with blue tac.
- When the plaster of Paris has set, compress each syringe in turn using the plunger and record the movement seen in cm^3 for each syringe.

Learners should be encouraged to discuss their hypothesis as to what will happen before carrying this out and subsequently discuss their findings using the particle model.

If using air, be sure to discuss the gases that might be present in the syringe to discourage the thought that it might be empty.

Risk

The reaction of plaster of Paris and water is exothermic; avoid any contact with eyes or skin while still wet.

If using helium, this must not be allowed to be inhaled as it may be harmful.

Supplies

For helium:

Normal laboratory suppliers

Activity 2

Particles in motion

- Take three identical 500 cm^3 glass jars and lids and a number of 19 mm polythene spheres. Label the jars 1, 2 and 3.
- Put 10 spheres into jar 1, fill jar 2 to one-third full and fill jar 3 to the top.
- Seal the lids using adhesive tape (insulation is best).

Jar 1 should be shaken vigorously and observations made of the behaviour of the spheres in terms of contact between the spheres themselves, the spheres and the walls of the container and the amount of space between them.

Jar 2 should be swirled around to show that the level of the 'liquid' remains constant while the learner observes the freedom of movement of the spheres and the continuous contact between them.

Jar 3 should be shaken gently to allow vibration to happen. Learners should see that the spheres stack into an arrangement showing layers stacked onto layers and when shaken the spheres should not be free to move beyond vibrating.

This activity is to demonstrate that particles do not expand but simply have a greater degree of freedom of movement due to having greater energy. It also demonstrates the difference in energy between the three states.

Activity 3

What do chemical words mean?

RSC – Learn Chemistry

http://www.rsc.org/learn-chemistry/resource/res00000085/afl-what-do-chemical-words-mean?cmpid=CMP00000113

A worksheet activity looking at the chemical words used in relevance to particles.

Activity 4

Teaching Resource – Chemical Change

RSC – Learn Chemistry

http://www.rsc.org/learn-chemistry/resource/res00001118/ri-christmas-lectures-2012-chemical-change

A teaching resource linked to Peter Wother's RI Christmas Lectures of 2012. Contains some dramatic moments.

Activity 5

Particles in motion

RSC – Learn Chemistry

http://www.rsc.org/learn-chemistry/resource/res00000421/particles-in-motion

Classic Chemistry Experiments No 37
An experiment looking at the movement of gas particles.

Activity 6

Experiments with Particles

RSC – Learn Chemistry

http://www.rsc.org/learn-chemistry/resource/res00000420/experiments-with-particles

Classic Chemistry Experiments No 36

Activity 7

A Simple Guide to IGCSE Chemistry – States of Matter

YouTube

https://www.youtube.com/watch?v=wWR6v_n-qd0

4 minute video on states of matter leading to changes of state in a further video.

a) describe how and why the atomic model has changed over time

Learners are required to be able to describe and explain the development of atomic theory through time. This involves knowledge of the experimental work of each scientist proposing a theory and the nature of the model each scientist describes as their knowledge increases. The main thrust of teaching here is to look at Working scientifically, particularly with respect to how this changes over time.

b) 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

To include

the models of Dalton, Thompson, Rutherford, Bohr, Geiger and Marsden

Using Rutherford's experimental results learners should gain an understanding of the nature of the atom. This gives a clear view of a large degree of space containing electrons surrounding a very dense and very small nucleus.

c) recall the typical size (order of magnitude) of atoms and small molecules

To include

the concept that typical atomic radii and bond length are in the order of 10^{-10} m

Learners are required to understand the very small dimensions involved for both the size of atoms and the length of the bonds between them. A variety of radii make this a confusing area of study and it must be made clear which of these radii is being discussed for which type of substance. Atomic radii may be empirically found by experiment or calculated from physical data. Whichever method is used, these are only approximations and should be treated as such. Empirical radii vary from 0.25×10^{-10} m to 2.60×10^{-10} m for hydrogen and caesium respectively. Bond lengths are calculated from the various types of radii but for guidance, the shortest is H-H at 0.74×10^{-10} m and the longest is Pb-I at 2.79×10^{-10} m.

d) recall relative charges and approximate relative masses of protons, neutrons and electrons

Learners should be aware that the size and charge for protons, neutrons and electrons tend to be so small that they are usually indicated relative to each other, mass being given in atomic mass units (amu) and charge being a unit charge which is either positive (+) or negative (-).

- protons have a mass of 1 amu and a charge of +1
- neutrons have a mass of 1 amu and a charge of 0 (neutral)
- electrons have a mass of 1/1840 amu and a charge of -1

e) calculate numbers of protons, neutrons and electrons in atoms and ions, given atomic number and mass number of isotopes

To include

definitions of an ion, atomic number, mass number and an isotope, also the standard notation to represent these

Learners should be given definitions for atomic number, mass number, ions and isotopes. These should then be used to help calculate the numbers of protons, neutrons and electrons in both atoms and ions. Learners should also know how to represent an isotope in standard notation (for example $^{16}_{8}O$).

Approaches to teaching the content:

Atomic theory is one of the more challenging areas of chemistry to teach since the number of visual aids is few and the dimensions involved are so small that they are at the edge of a learner's ability to comprehend. However, a good understanding of the development of atomic theory combined with an equally good understanding of the importance and relevance of the experiments carried out to extend ideas about the atomic model gives the learner a good grounding into the character of the three main particles involved. Therefore, detailed learner research into the development of atomic theory is time well spent.

Atomic radii and bond lengths involve numbers that are written in standard form and they do not convey a real sense of the sizes involved. An understanding of the huge magnification required to see just the shadows of atoms may be an avenue to understanding. Clear definitions for ions, isotopes and atomic and mass numbers will aid in comprehending the different contributions of the three particles to an isotope or an ion.

Common misconceptions or difficulties learners may have:

The approach to this topic needs to make it clear how charges are produced by the imbalance of protons and electrons; neutrons being neutral have no effect on charge within an atom. Where confusion may arise is in the treatment of diatomic molecules of elements. Learners may find it difficult to separate the properties of the atoms from the molecules. Care should be taken here to ensure understanding that atoms are single entities with distinct properties of their own. Clarity regarding the mathematics of calculating charges is required to ensure that learners are aware that changes producing charges are within the atom and are due to the loss or gain of electrons. Changes in the nucleus result from radioactive decay, not chemical changes, which produce new elements as a result.

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

The understanding of the nature of atoms leads to the understanding of the structure of the Periodic Table. This topic then extends into the use of the Bohr model to explain bonding. A sound framework upon which to understand the ways atoms form compounds is essential and is arrived at when learners are able to build the atoms used from their atomic data.

Approaches to teaching the content:

Learners involved in researching the timeline of the development of atomic theory can be encouraged to extend their research wherever possible to look at the scientists and their experiments to gain a better understanding of how science works.

Activity 1 gives a lesson plan, worksheets and a PowerPoint to deal with this with good attention to AfL.

The dimensions of particles are exceptionally small and activity 2, in addition to the video in activity 1, gives some idea as to some of the dimensions involved. Attention should be paid perhaps to looking at TEM and just how powerful this has to be to get the smallest glimpse of really large atoms such as gold or platinum.

Activity 3 is a warm up for a lot of practice at calculating the different ratios of the particles in atoms and ions and covers this well as an introduction.

Activity 1

Atomos

TES
education.jlab.org/jsat/powerpoint/atomos.ppt

Worksheets and a PowerPoint to build a timeline. Make sure to watch the YouTube video as this deals with sizes really well.

Activity 2

Have you ever seen an atom?

YouTube
https://www.youtube.com/watch?v=yqLlgIaz1L0

From 0 -1.45 is most useful as it shows platinum atoms. Beyond this, the video goes off-topic.

Activity 3

Isotope notation

YouTube
https://www.youtube.com/watch?v=BYiu0kIWd30

A sound and short video on notation and what it means. It also takes a look at ions.

The small print

We'd like to know your view on the resources we produce. By clicking on the 'Like' or 'Dislike' button you can help us to ensure that our resources work for you. When the email template pops up please add additional comments if you wish and then just click 'Send'. Thank you.

If you do not currently offer this OCR qualification but would like to do so, please complete the Expression of Interest Form which can be found here: www.ocr.org.uk/expression-of-interest

OCR acknowledges the use of the following content:
Square down & Square up: alexwhite/Shutterstock.com

Please get in touch if you want to discuss the accessibility of resources we offer to support delivery of our qualifications: resources.feedback@ocr.org.uk

We will inform centres about any changes to the specification. We will also publish changes on our website. The latest version of our specification will always be the one on our website (www.ocr.org.uk) and this may differ from printed versions.

ocr.org.uk/gcsereform

OCR customer contact centre

General qualifications

Telephone 01223 553998
Facsimile 01223 552627
Email general.qualifications@ocr.org.uk