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AS AND A LEVEL

Delivery Guide

CHEMISTRY A

H032, H432
For first teaching in 2016

Theme: Patterns (Group 2 and 17)

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

3.1.2 Group 2

(a) the outer shell s^2 electron configuration and the loss of these electrons in redox reactions to form 2+ ions

(b) the relative reactivities of the Group 2 elements Mg ⟶ Ba shown by their redox reactions with:

(i) oxygen

(ii) water

(iii) dilute acids

(c) the trend in reactivity in terms of the first and second ionisation energies of Group 2 elements down the group (see also 3.1.1c)

(d) the action of water on Group 2 oxides and the approximate pH of any resulting solutions, including the trend of increasing alkalinity

(e) uses of some Group 2 compounds as bases, including equations, for example (but not limited to):

(i) $Ca(OH)_2$ in agriculture to neutralise acid soils

(ii) $Mg(OH)_2$ and $CaCO_3$ as 'antacids' in treating indigestion.

3.1.3 The halogens

(a) existence of halogens as diatomic molecules and explanation of the trend in the boiling points of Cl_2, Br_2 and I_2, in terms of induced dipole–dipole interactions (London forces) (see also 2.2.2k)

(b) the outer shell s^2p^5 electron configuration and the gaining of one electron in many redox reactions to form 1– ions

(c) the trend in reactivity of the halogens Cl_2, Br_2 and I_2, illustrated by reaction with other halide ions

(d) explanation of the trend in reactivity shown in (c), from the decreasing ease of forming 1– ions, in terms of attraction, atomic radius and electron shielding

(e) explanation of the term disproportionation as oxidation and reduction of the same element, illustrated by:

(i) the reaction of chlorine with water as used in water purification

(ii) the reaction of chlorine with cold, dilute aqueous sodium hydroxide, as used to form bleach

(iii) reactions analogous to those specified in (i) and (ii)

(f) the benefits of chlorine use in water treatment (killing bacteria) contrasted with associated risks (e.g. hazards of toxic chlorine gas and possible risks from formation of chlorinated hydrocarbons)

(g) the precipitation reactions, including ionic equations, of the aqueous anions Cl^-, Br^- and I^- with aqueous silver ions, followed by aqueous ammonia, and their use as a test for different halide ions.

As an introduction to the reactivity of Group 2 metals, it may be necessary to recap the reactivity of Group 1 metals. Students may have seen this many times, but it is a good discussion point; the reactivity across a period could then be discussed in later experiments.

Curriculum content

Alkali metals demonstration (Royal Society of Chemistry)
https://edu.rsc.org/resources/reactivity-trends-of-the-alkali-metals/731.article

This resource is the classic demonstration of the reactivity of alkali metals with water; the products of the reaction should also be discussed. If the institution does not have alkali metals then videos of the reaction can be viewed on YouTube.

Alkali Metals – 20 Reactions of the alkali metals with water (YouTube; Royal Society of Chemistry)

https://www.youtube.com/watch?v=eaChisV5uR0

This video lecture shows the reaction of all the alkali metals with water, again a good starting point and performed in a slightly different way than would otherwise be shown.

Properties of group 2 elements

This is a micro-scale activity that could be used to show Group 2 compounds and their reactions with halide ions.

http://www.nationalstemcentre.org.uk/elibrary/resource/9563/the-periodic-table-properties-of-group-2-elements

The reactivity of the halogens should then be explored. The classic experiment for showing this is reacting the gases dissolved in water with solutions of the potassium salts of the halides.

Reactions of aqueous solutions of the halogens (Royal Society of Chemistry)
https://edu.rsc.org/experiments/halogens-in-aqueous-solution-and-their-displacement-reactions/733.article

Students and teachers should use this resource to ascertain the relative reactivity from which halogens are displaced from their compounds. Students should know the colours produced and also what this means in terms of oxidising power.

Identification of halides using silver nitrate (Royal Society of Chemistry)
https://edu.rsc.org/resources/silver-and-lead-halides/1770.article

This resource can be used to help students identify the halides by the colour of their precipitates with silver nitrate and their solubility in ammonia.

Thinking conceptually

Approaches to teaching the content

When starting to teach reactions of Group 2 it is important to have first taught periodicity in terms of ionisation energies and reactivity.

The general reactivity should be discussed in terms of how easy it is for the atoms to lose electrons going down the group, and this can be explained by increasing atomic radius; more shielding electrons and so the nuclear attraction is less on the outermost electrons, making it easier for the atom to lose electrons.

It's best to look first at the reactions of the metals with water as this is where a good comparison can be made with the alkali metals, firstly in terms of the products produced and also regarding the general trend in reactivity. The reactions with oxygen and acid, along with the products of these reactions, can then be explored.

The next concept to explore is the reaction of the Group 2 oxides with water. Students will need to know that the resulting solution is a hydroxide of the metal and that the trend in pH increases as you go down the group. The trend in thermal stability need not be explored although it could be mentioned as an additional piece of learning; some teachers may choose to discuss this anyway.

When studying the trends in Group 17 the starting point could be at any point: reactivity; oxidising power; uses of chlorine in water; the production of bleach from sodium hydroxide; the reaction of the halides with silver nitrate. To introduce the topic and to help engage students, a practical looking at the displacement reactions of the halogens and the potassium salts of the halides would be a good discussion point and would lead into the other topics as well as being able to cover the redox equations for the displacement reactions.

Common misconceptions or difficulties students may have

Students find it very difficult to write the ionic equations for the displacement reactions of the halogens and the halides and the idea of precipitation reactions generally. Crash Course Chemistry on YouTube is a fun and light-hearted way of getting students' attention. https://www.youtube.com/playlist?list=PL8dPuuaLjXtPHzzYuWy6fYEaX9mQQ8oGr

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

The trend of Group 2 metals reactivity follows on from the topics of periodicity studied earlier in the course. Atomic radius, electron shielding and nuclear attraction to the outermost electrons should be discussed prior to studying this topic, and how these affect the reactivity of the Group 2 metals and also the halogens.

Intermolecular forces are a key feature in studying the trend in physical properties of the Group 17 elements. The increase in induced dipole–dipole interactions going down the group is due to the size of the atom – periodicity also is an important point to discuss again in terms of atomic radius, electron shielding and nuclear attraction.

Once Group 2 metals have been introduced, their reactivity with acids, oxygen and water should be explored and discussed and if necessary compared with the reactivity of Group 1 metals.

The reactivity of the Group 2 metals (Royal Society of Chemistry)
http://www.rsc.org/learn-chemistry/resource/res00000409/the-reactivity-of-the-group-2-metals?cmpid=CMP00000479

This resource demonstrates the reaction of magnesium and calcium with acids and shows that the reactivity of Group 2 metals increases going down the group. This can be used either as an introduction or as a reinforcement of the points made during a theoretical session.

The reaction of Group 2 metals with oxygen should also be explored.

Reacting elements with oxygen (Royal Society of Chemistry)
http://www.rsc.org/learn-chemistry/resource/res00000705/reacting-elements-with-oxygen?cmpid=CMP00000783

This resource explains the demonstration of a selection of elements with oxygen. It isn't necessary to show them all, but rather to choose the relevant elements, namely Group 2 metals. Again a good introduction.

Reaction of magnesium with steam

The reaction of magnesium with water is difficult to demonstrate; moreover it is difficult to demonstrate the production of magnesium hydroxide and hydrogen gas.

https://edu.rsc.org/exhibition-chemistry/the-reaction-of-magnesium-with-steam/4012602.article

This video demonstrates the reaction of magnesium with steam, and also includes technician's notes for carrying out the demonstration yourself.

Thinking contextually

The reactivity of the halogens should then be explored. The classic experiment for showing this is reacting the aqueous gases of the halogens with solutions of the potassium or sodium salts of the halides, students noting the colour change in both aqueous and cyclohexane layers.

Reactions of aqueous solutions of the halogens (Royal Society of Chemistry)
https://edu.rsc.org/experiments/halogens-in-aqueous-solution-and-their-displacement-reactions/733.article

Students and teachers should use this resource to ascertain the relative reactivity from which halogens are displaced from their compounds. Students should know the colours produced and also what this means in terms of oxidising power. The students will also need to be able to write ionic equations of these reactions.

This could make a good starting point to introducing precipitation reactions of the halides with silver nitrate.

Precipitation Reactions (Crash Course Chemistry)
http://www.youtube.com/watch?v=Ilu16dy3ThI

Precipitation reactions, along with the corresponding ionic equations, can be difficult to understand. This is a light-hearted approach to introducing the concept, that may perhaps be used as part of a flipped learning lesson.

Forming silver and lead halides

Once the idea of precipitation has been explored, the students should be allowed an opportunity to explore the concepts for themselves using this resource, previously mentioned above in the introduction practicals:

https://edu.rsc.org/resources/silver-and-lead-halides/1770.article

Thinking contextually

The reaction of Group 2 metals and Group 17 elements provides a backdrop for several everyday processes ranging from agricultural to industrial uses.

Calcium hydroxide is used to reduce the pH of arable land; magnesium hydroxide is used as an antacid. Why these need to be used would make a good discussion point, or students could research why these are necessary and perhaps produce a presentation of the facts and the chemistry behind the processes.

Chlorine is added to drinking water in the purification process; it is there to kill bacteria and to keep the water potable as it travels around the network and is stored in people's homes. A lot of people go to great lengths to remove chlorine before they drink the water; there is a risk of chlorinated hydrocarbons in the drinking water (caused by the reaction of chlorine with organic molecules in the water) causing cancer. This is a matter that could be debated; people also object to the taste of chlorine. On the other hand there is an incidence of chlorine being removed from drinking water, causing a cholera epidemic; this too could be discussed and provides another opportunity for independent study or presentation.

Bromine is an important additive to products such as furniture foam to improve their fire resistance. It is also used as a food additive, especially in Brominated Vegetable Oil (BVO), because it prevents artificial from colours separating. Coca-cola has recently removed it from its drinks because of health concerns. Again a debate could be had about whether the risk posed outweighed any advantages gained by adding it.

The best context within which to teach about chlorine is the discussion around 'should chlorine be added to drinking water?'

How is water purified? (Severn Trent Water)
http://www.youtube.com/watch?v=9z14l51ISwg

This is a video showing the purification of water using chlorine. Students could be asked questions like 'Why does the pH need to be adjusted at the end of the process?' in order to elicit the idea that there is a chemical reaction between the chlorine and the water and that it is not just a means to kill bacteria.

The use of bromine in brominated fire retardants gives a good debate and also a useful context. It is true that bromine in its elemental form is very corrosive and highly dangerous, but when used as a compound these dangers are all but eliminated.

Brominated Fire Retardants
http://www.youtube.com/watch?v=V7e33Hs18hg

Perhaps this video is a one-sided view of the topic, but it could still be used as a teaching tool and as a starting point for discussion of the chemistry behind fire retardants.

This is a useful set of resources showing how chlorine is extracted from sodium chloride. It consists of questions along with a video.

Chemicals from Salt (Royal Society of Chemistry)
http://www.rsc.org/learn-chemistry/resource/res00000018/chemicals-from-salt#!cmpid=CMP00001683

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