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AS AND A LEVEL

Delivery Guide

CHEMISTRY A

H032/H432

For first teaching in 2015

Acids and Redox

Version 2

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.

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

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2.1.4 Acids

- (a) the formulae of the common acids (HCl , H_2SO_4 , HNO_3 and CH_3COOH) and the common alkalis (NaOH , KOH and NH_3) and explanation that acids release H^+ ions in aqueous solution and alkalis release OH^- ions in aqueous solution
- (b) qualitative explanation of strong and weak acids in terms of relative dissociation
- (c) neutralisation as the reaction of:
 - (i) H^+ and OH^- to form H_2O
 - (ii) acids with bases, including carbonates, metal oxides and alkalis (water-soluble bases), to form salts, including full equations
- (d) the techniques and procedures used when preparing a standard solution of required concentration and carrying out acid-base titrations
- (e) structured and non-structured titration calculations, based on experimental results of familiar and non-familiar acids and bases.

2.1.5 Redox

- (a) rules for assigning and calculating oxidation numbers for atoms in elements, compounds and ions
- (b) writing formulae using oxidation numbers
- (c) use of a Roman numeral to indicate the magnitude of the oxidation number when an element may have compounds/ions with different oxidation numbers
- (d) oxidation and reduction in terms of:
 - (i) electron transfer
 - (ii) changes in oxidation number
- (e) redox reactions of metals with acids to form salts, including full equations (see also 2.1.4 c)
- (f) interpretation of redox equations in (e), and unfamiliar redox reactions, to make predictions in terms of oxidation numbers and electron loss/gain.

The following activities can be used to assess students prior knowledge before embarking on the teaching of this content:

Learner Activity 1**Name that salt**

To be used to review the products of neutralisation reactions from GCSE, or to consolidate understanding of Salts once it has been re-taught at AS Level.

Mini whiteboard quiz where students guess the salt produced from the neutralisation reaction between the acid and base displayed in the Teacher Resource PowerPoint: Name that salt.

Learner Activity 2**Acids, bases and pH**

This short video summarises the neutralisation reaction and pH. This covers the KS3 and KS4 knowledge as well as setting it into a context and applications of the science.

https://www.youtube.com/watch?v=A_URRb5mk5Q

Learner Activity 3**Neutralisation role play**

This quick activity allows you to assess students' knowledge of neutralisation and pH and gives them an opportunity to move around and generate discussions. Possibly convert into a 'card sort' if you have a small class. See [Teacher Resource 1: Neutralisation role play](#).

Approaches to teaching the content

Students will be familiar with acids and alkalis, but they may not have a grasp of all the key concepts involved. However, redox will be new to most students and is sometimes a real sticking point.

Section 2.1.4 has four main parts:

- Formulae
- Neutralisation
- Preparing a standard solution
- Titrations.

Section 2.1.5 has four main parts:

- Oxidation numbers
- Formulae
- Meanings of oxidation and reduction
- Redox reactions.

In order for students to successfully grasp the content of these topics, start by teaching oxidation numbers; this will help students to know the charges of common ions, thus enabling them to deduce formulae. In addition to this, ensure that students commit to memory the following positive and negative ions: Cl^- , SO_4^{2-} , NO_3^- , OH^- , CO_3^{2-} ; this will further enable them to predict formulae. Confidence in writing formulae will aid in determining products in reactions, so with this in place, creating equations for neutralisation reactions will come with greater ease. Once able to deduce oxidation numbers and formulae, students can progress to the remainder of the acids or the redox sections. Interpreting redox reactions requires students to understand oxidation and reduction in terms of loss/gain of electrons and change in oxidation state as well as oxidising and reducing agents.

Common misconceptions or difficulties students may have*Strength of acid*

Students struggle to distinguish between concentration and strength of acid. A combination of videos and chemical demonstrations can be used to reinforce the concept that strength is due to relative dissociation.

Titration calculations – where to start?

Some students will have had experience with burettes while some will not have. This technique is important as a competency in the practical.

When doing any calculation, students often know how to do each part of the calculation, like

calculating moles, but do not know where to start. There are two possible approaches to this:

- 1) Steps – teach students steps to learn that will work for any titration calculation.
- 2) Grids – teach students to draw a table under the equation where they must fill in information they are given in the question about Moles, Concentration and Volume and use it to determine the final thing the question asks for.

Oxidation numbers

Do not assume students can interpret roman numerals; test them on their understanding before using roman numerals to indicate magnitude of the oxidation state. There is sometimes confusion over whether or not to consider the coefficient or the subscript when deducing oxidation state (e.g. $2\text{Cr}_2\text{O}_7^{2-}$) so teach students to determine oxidation states of species in chemical equations with coefficients.

Definitions of oxidation and reduction

Care must be taken when teaching students terminology relating to oxidation and reduction, as these keywords can be used in many ways. Students must understand oxidation and reduction in three separate forms: a) in terms of loss/gain of electrons; b) in terms of increase/decrease in oxidation number; c) in terms of a reducing or oxidising agent.

For a) and b), choose a mnemonic to teach oxidation state in terms of number of electrons and stick to it, e.g. OIL RIG (Oxidation Is Loss Reduction Is Gain) or LEO goes GER (Loss of Electrons is Oxidation, Gain of Electrons is Reduction). Students will know that electrons are negative and that in general terms if an atom gains an electron, it will gain a negative charge; likewise, if an atom loses an electron, it will lose a negative charge, thus becoming less negative, e.g. if the oxidation state of Cr is +6, it is as if it has lost 6 electrons. Number lines can be useful in understanding the change in the number of electrons and oxidation number. Get students to determine oxidation and reduction from half equations so that they become more familiar with them before moving on to redox equations.

For c), reinforce the idea that an agent is something that makes something happen, e.g. mustard gas is a blistering agent; it isn't blistered itself, but causes other things to blister. Allow students to use their knowledge of oxidation and reduction to deduce oxidising/reducing agents on a case-by-case basis.

Writing redox equations

The recommended method to use in writing redox equations from half equations:

- 1) If necessary add H_2O on one side to balance the number of oxygen atoms. If it's not necessary, then proceed to step 3.

- 2) Add H^+ to the opposite side to balance the hydrogen atoms.
- 3) Add electrons to balance the charges.
- 4) If the electrons either side of the equation are not the same, multiply the half equation so that they are the same.
- 5) Add equations together.
- 6) Cancel out.

Learner Activity 1**Writing chemical formulae template – the cross-over rule (TES)**

<http://www.tes.co.uk/teaching-resource/Writing-chemical-formulae-cross-over-method-6389755/>

A step-by-step guide to determining chemical formulae using the cross-over rule, with a template for students to use.

Learner Activity 2**Roman numerals conversion tables**

<https://www.romannumerals.org/converter>

These roman numeral conversion tables can be used to familiarise your students with the numerals used in the naming of transition metal compounds.

Learner Activity 3**Gridlocks (Royal Society of Chemistry)**

<http://www.rsc.org/learn-chemistry/resources/gridlocks/teachers-area.html>

Available online, as a game, or downloadable as a worksheet. These are based on the Sudoku principle where students must use their knowledge to complete boxes with words, numbers or pictures.

There are a range of these available for use as a means of consolidating knowledge within the lesson, or as homework.

Learner Activity 4**Gridlocks: Acids 2 (Royal Society of Chemistry)**

Use this to consolidate students' understanding of acid formulae and salts produced from neutralisation reactions.

Worksheet:

<http://www.rsc.org/learn-chemistry/resources/gridlocks/downloads/Acids2.pdf>

Answer:

<http://www.rsc.org/learn-chemistry/resources/gridlocks/downloads/answers/Acids%202%20ans.pdf>

Learner Activity 5**Gridlocks: Alkalis 2 (Royal Society of Chemistry)**

Use this to consolidate students' understanding of alkali formulae and salts produced from neutralisation reactions.

Worksheet:

<http://www.rsc.org/learn-chemistry/resources/gridlocks/downloads/Alkalis2.pdf>

Answer:

<http://www.rsc.org/learn-chemistry/resources/gridlocks/downloads/answers/Alkalis%202%20ans.pdf>

Learner Activity 6**Gridlocks: Concentration of Solutions 1 (Royal Society of Chemistry)**

Could be used to review concentration calculations before starting carrying out titrations and subsequent titration calculations.

Worksheet:

<http://www.rsc.org/learn-chemistry/resources/gridlocks/downloads/ConcentrationofSolutions1.pdf>

Answer:

<http://www.rsc.org/learn-chemistry/resources/gridlocks/downloads/answers/Concentration%20of%20Solutions%201%20ans.pdf>

Learner Activity 7**Gridlocks: Oxidation number rules (Royal Society of Chemistry)**

Use to consolidate understanding of oxidation number rules, before or whilst students calculate oxidation states.

Worksheet:

<http://www.rsc.org/learn-chemistry/resources/gridlocks/downloads/OxidationNumberRules.pdf>

Answer:

<http://www.rsc.org/learn-chemistry/resources/gridlocks/downloads/answers/Oxidation%20Number%20Rules%20ans.pdf>

Learner Activity 8**Visualising strong and weak acids**

<https://www.youtube.com/watch?v=B-P7NJelfLU>

This video briefly summarises the difference between strong and weak acids using equations and simple diagrams.

Learner Activity 9**Titration calculation steps**

This is a list of steps to be given to students, to follow when carrying out titration calculations. Due to changes in mathematical requirements, many titration calculations will be less structured than they have been in the past. This means that students will need strategies to tackle these questions. Encouraging students to come up with their own model answer/help sheet can help embed this learning.

- 1) Write out a balanced symbol equation for the reaction.
- 2) Calculate the number of moles in the known solution using Moles = Concentration (mol dm^{-3}) \times Volume (dm^3).
- 3) Use the chemical equation to work out the stoichiometry/ratio between the known and unknown solutions. Do they react in a 1:1 ratio or a 2:1 etc.
- 4) Calculate the number of moles in the unknown solution by using the ratios you worked out in point 3. E.g. if you have 0.5 moles of the known solution and you know from the equation that for every 1 mole of known, you have 2 moles of the unknown solution, you will have 0.5×2 moles of the unknown solution.
- 5) Ensure that your volume is in the correct form (dm^3).
- 6) Calculate the concentration of the unknown solution by dividing the number of moles by the volume required to neutralise the known solution.

Learner Activity 10**Titration calculations – the grid method**

[Learner resource 1](#)

This is a step-by-step guide to carrying out titration calculations using a more structured and visual method.

Learner Activity 11**Oxidation and Reduction Number Line**

A slide to be used as part of a lesson in defining reduction and oxidation in terms of number of electrons lost/gained and change in oxidation number.

Learner Activity 12**Redox equations video**

<http://www.youtube.com/watch?v=6aGlxahIMCw>

Video which uses the recommended method for writing redox equations from half equations. It is quite fast, so may be better set as a homework exercise in order for students to watch and pause in their own time.

Learner Activity 13**Reducing agents video**

http://wn.com/reducing_agents

Several videos showing one after the other, explaining the workings of redox reactions. Helps to interpret redox reactions by using two examples and working through to assign oxidation and reduction agents to the appropriate species.

Video 1 (7 min 41 sec) Uses the acronym LEO goes GER (Loss of Electrons is Oxidation, Gain of Electrons is Reduction).

Video 2 (7 min 26 sec) Uses the acronym OIL RIG (Oxidation Is Loss Reduction Is Gain) and works through the examples at a slower pace. Be aware that the oxidation number of sulphide (-2) is used to determine the oxidation number of copper in copper sulphide. Students are not required to know this oxidation number.

There are many possible contexts in which you could introduce or extend learners' understanding of these topics.

Redox titrations

In order to stretch, challenge, consolidate and prepare: encourage students to determine which sub-shells the electrons have been lost or gained from. This will prepare them for the redox reactions of halogens and trends in ionisation energies.

Transition metal complexes

When teaching students how to calculate oxidation numbers, you could set some calculating oxidation numbers of complex ions as a stretch and challenge task.

Acids, bases and indicators

When doing titrations, allow students to choose which indicators to use when given information about the range of each one.

pH calculations

Dissociation of weak/strong acids/bases.

Group 2 metal hydroxides

When teaching neutralisation reactions, encourage students to learn the reactions of $\text{Ca}(\text{OH})_2$ in agriculture to neutralise acidic soil and $\text{Mg}(\text{OH})_2$ and CaCO_3 as acids in treating indigestion.

When teaching acid-base reactions use:

- Relief of indigestion by neutralisation of stomach acid with antacids.
- Flue gas desulphurisation.
- The effect of acid rain on limestone statues.

Students can do a redox titration to determine the % of iron in iron tablets or the % of iron in steel wool.

Learner Activity 1**Neutralisation of indigestion tablets practical (Royal Society of Chemistry)**

<https://edu.rsc.org/experiments/using-indigestion-tablets-to-neutralise-an-acid/698.article>

Titration practical where the concentration of alkali in an indigestion tablet is found by titrating against hydrochloric acid. This helps students to consider the practical application of titrations, by relating them to an everyday remedy.

Learner Activity 2**Determination of Fe in dietary supplement through redox titrations (Collin College)**

<https://practical-chemistry.com/practical-work/chemistry/quantitative-chemistry/titration-redox-iron-tablet/>

Practical where students use a redox titration to determine the purity of an iron tablet. This is useful in that it allows students to use their experimental techniques to investigate a household item.

Learner Activity 3**A range of redox resources (Royal Society of Chemistry)**

<https://edu.rsc.org/searchresults?qkeyword=Redox>

A range of resources including videos, articles, and practical suggestions to help with teaching aspects of redox chemistry.

Learner Activity 4**Homework that prepares**

In addition to setting homework that consolidates learning from the lesson, set homework that will prepare students for the following lesson. This can be GCSE questions about the topic, or open-ended tasks. Inform students that the more effort they put into their homework, the more they will get out of the next lesson. Open-ended tasks allow students to use their creativity, be more independent in their learning and enable differentiation by outcome. In many cases, the less structure you provide, the more independent the learning. Undoubtedly, it can mean that the task is more difficult to mark and that for certain topics, some may come armed with very complex chemistry, which will stretch and challenge them, but could test your memory!

If students are prepared with **some** knowledge before they enter each lesson, it will result in deeper understanding within the lesson. Ensure that part of the homework that you set before a new topic ensures that they revise what they have learned at GCSE and prepares them for the new content. See [Teacher Resource 2](#).

Titration calculations – the grid method

In a titration, 20 cm³ of 1.14 mol dm⁻³ HCl reacted with 25 cm³ of NaOH. What was the concentration of the sodium hydroxide?

- 1) Write a balanced chemical equation for the reaction.
- 2) Convert any units into the appropriate ones (e.g. cm³ to dm³).
- 3) Create a grid with all possible components, or just the ones you know that you will need.
- 4) Circle the box that you are trying to find out – this is the box you are aiming for.
- 5) Fill in any of the boxes you are able to, using the information from the question.

	HCl	NaOH
Concentration	1.14 mol dm ⁻³	
Volume	0.02 dm ³	0.025 dm ³
Moles		

- 6) Calculate the number of moles in the known solution using Moles = Concentration (mol dm⁻³) × Volume (dm³) and add it to the table.

	HCl	NaOH
Concentration	1.14 mol dm ⁻³	
Volume	0.02 dm ³	0.025 dm ³
Moles	0.0228	

- 7) Use the chemical equation to work out the stoichiometry/ratio between the acid and base. HCl and NaOH react in a 1:1 ratio.
- 8) Calculate the number of moles in the unknown solution by using the ratios you have just worked out. They react in a 1:1 ratio, so there are also 0.0228 moles of NaOH

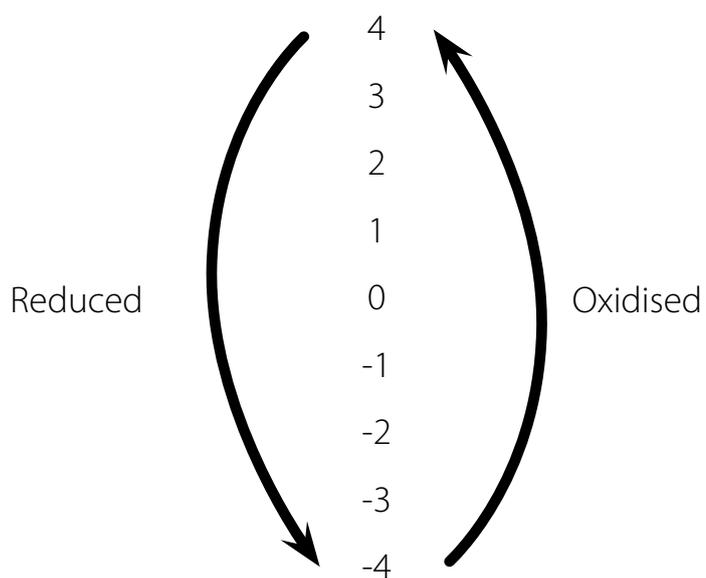
	HCl	NaOH
Concentration	1.14 mol dm ⁻³	
Volume	0.02 dm ³	0.025 dm ³
Moles	0.0228	0.0228

- 9) Calculate the concentration of the NaOH solution by dividing the number of moles by the volume.

	HCl	NaOH
Concentration	1.14 mol dm ⁻³	0.91 mol dm ⁻³
Volume	0.02 dm ³	0.025 dm ³
Moles	0.0228	0.0228

Oxidation and Reduction Number Line

OIL RIG

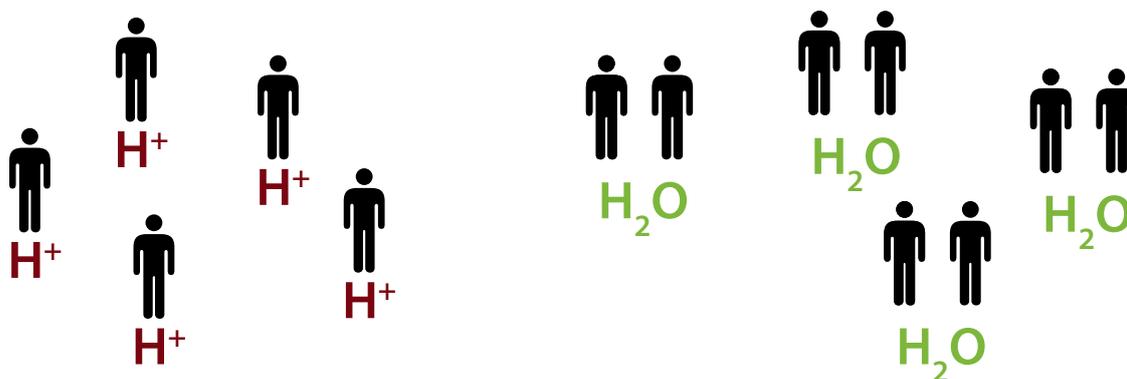
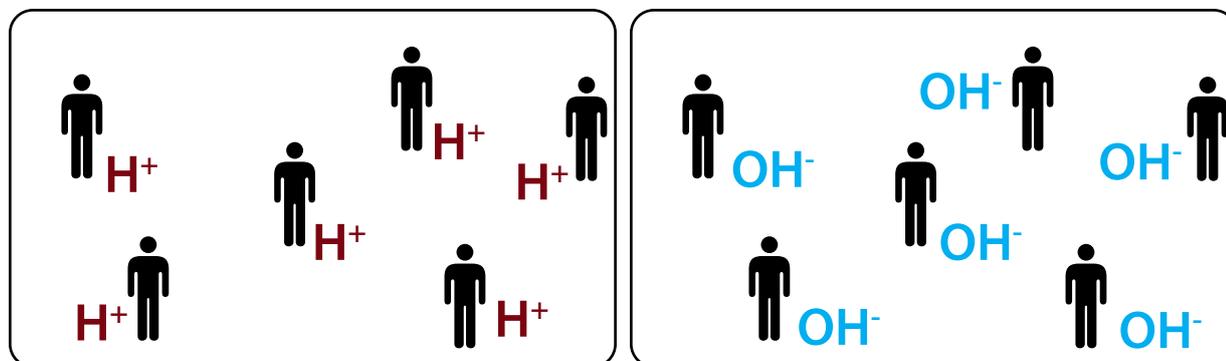


Reduction – if the species has reduced, it has **gained** electrons and its oxidation state **decreases**.

Oxidation – if the species has been oxidised, it has **lost** electrons and its oxidation state **increases**.

Neutralisation role play

A visualisation of this process will aid student understanding. Although students may have visited this at KS3 and again at KS4, there is no harm in them revisiting it at the beginning of A Level.



Split the students into two groups.

Label one group H^+ and other OH^- .

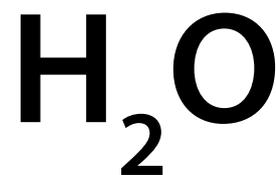
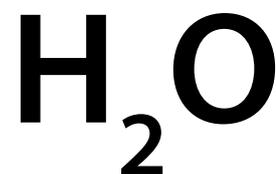
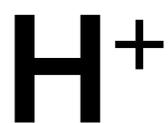
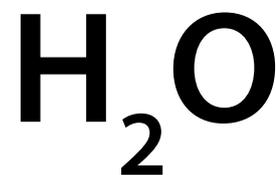
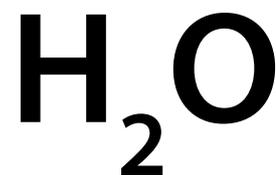
Ask each student to pair up with someone with an opposite label.

If there are any H^+ left over you can lead the discussion to acidic.

If there are any OH^- left over then lead the discussion to alkaline.

Students can then be asked to explain this process using the science that they know.

If you have a small class, then this can be a card sorting activity.



Homework Ideas

Acids and alkalis:

1. List names of and formulas for five acids and five alkalis.
2. Write your own definition of an acid and a base.
3. Find a definition of an acid and a base.
4. Write a paragraph explaining what happens to the 'H' from HCl in a neutralisation reaction.
5. Find an example of neutralisation from everyday life.

Titration:

1. Write a method for a titration between NaOH and HCl.
2. Write a paragraph explaining how a titration might help you to find the out the concentration of an acid. Use the equation for the neutralisation in your answer.
3. Create your own titration calculation with a mark scheme.

Oxidation states

1. Write a paragraph explaining what oxidation and reduction are.
2. Complete GCSE exam questions on electrolysis.
3. Give students some half equations to balance.
4. Get students to learn the oxidation numbers for the ones they must know before they know what they mean.

Redox reactions

1. Find an example of a redox reaction.
2. Find a video that explains redox reaction.
3. Find a video clip that shows a cool redox reaction.
4. Give students a list of redox reactions and they should highlight which species have been oxidised and which have been reduced.
5. Find a use in medicine or industry of a redox titration.

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