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GCSE (9–1)
Transition Guide

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

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For first teaching in 2016

KS3–KS4 focus
Chemical analysis

Version 1

www.ocr.org.uk/chemistry

Contents

GCSE (9–1)

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

Key Stage 3 to 4 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 3 which will help prepare students for progression to Key Stage 4;
- 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 3 and 4 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 3 and assess their 'readiness for progression' to Key Stage 4 content on this topic. This checkpoint task can be used as a summative assessment at the end of Key Stage 3 teaching of the topic or by Key Stage 4 teachers to establish their students' conceptual starting point.

Key Stage 3 to 4 Transition Guides are written by experts with experience of teaching at both key stages.

Key Stage 3 Content

- use knowledge of solids, liquids and gases to decide how mixtures might be separated, including through filtering, sieving and evaporating
- understand the concept of a pure substance and how to identify a pure substance
- know about simple techniques for separating mixtures: filtration, evaporation, distillation and chromatography
- know about the pH scale for measuring acidity/alkalinity; and indicators.

Key Stage 4 Content

C5.1.1. explain that many useful materials are formulations of mixtures

C5.1.2. explain what is meant by the purity of a substance, distinguishing between the scientific and everyday use of the term 'pure'

C5.1.3. use melting point data to distinguish pure from impure substances

C5.1.4. recall that chromatography involves a stationary and a mobile phase and that separation depends on the distribution between the phases

C5.1.5. interpret chromatograms, including calculating Rf values

C5.1.6. suggest chromatographic methods for distinguishing pure from impure substances. Including the use of: a) paper chromatography; b) aqueous and non-aqueous solvents; c) locating agents

C5.1.7. describe, explain and exemplify the processes of filtration, crystallisation, simple distillation, and fractional distillation

C5.1.8. suggest suitable purification techniques given information about the substances involved

IaS1: Suggest equipment and techniques and a strategy to carry out qualitative analysis

IaS3: use the particle model to explain the idea of a pure substance

C5.2.1. describe the purpose of representative sampling in qualitative analysis (separate science only)

C5.2.2. interpret flame tests to identify metal ions, including the ions of lithium, sodium, potassium, calcium and copper (separate science only)

C5.2.3. describe the technique of using flame tests to identify metal ions (separate science only)

C5.2.4. describe tests to identify aqueous cations and aqueous anions and identify species from test results including:

a) tests and expected results for metal ions in solution by precipitation reactions using dilute sodium hydroxide (calcium, copper, iron(II), iron(III), zinc)

b) tests and expected results for carbonate ions (using dilute acid), chloride, bromide and iodide ions (using acidified dilute silver nitrate) and sulfate ions (using acidified dilute barium chloride or acidified barium nitrate) (separate science only)

Key Stage 4 Content

C5.2.5. interpret an instrumental result for emission spectroscopy given appropriate data in chart or tabular form, when accompanied by a reference set in the same form (separate science only)

C5.2.6. describe the advantages of instrumental methods of analysis (sensitivity, accuracy and speed) (separate science only)

C5.2.7. interpret charts, particularly in spectroscopy (separate science only)

IaS1: Suggest equipment and techniques and a strategy to carry out qualitative analysis

C5.3.1. recall and use the law of conservation of mass

C5.3.2. explain any observed changes in mass in non-enclosed systems during a chemical reaction and explain them using the particle model

C5.3.3. calculate relative formula masses of species separately and in a balanced chemical equation

C5.3.4. recall and use the definitions of the Avogadro constant (in standard form) and of the mole

C5.3.5. explain how the mass of a given substance is related to the amount of that substance in moles and vice versa and use the relationship:

$$\textbf{number of moles} = \frac{\textbf{mass of substance (g)}}{\textbf{relative formula mass (g)}}$$

C5.3.6. deduce the stoichiometry of an equation from the masses of reactants and products and explain the effect of a limiting quantity of a reactant

C5.3.7. use a balanced equation to calculate masses of reactants or products

C5.3.8. use arithmetic computation, ratio, percentage and multistep calculations throughout quantitative chemistry

C5.3.9. carry out calculations with numbers written in standard form when using the Avogadro constant

C5.3.10. change the subject of a mathematical equation

C5.3.11. calculate the theoretical amount of a product from a given amount of reactant (separate science only)

C5.3.12. calculate the percentage yield of a reaction product from the actual yield of a reaction (separate science only)

Key Stage 4 Content

C5.3.13. suggest reasons for low yields for a given procedure (separate science only)

C5.3.14. describe the relationship between molar amounts of gases and their volumes and vice versa, and calculate the volumes of gases involved in reactions, using the molar gas volume at room temperature and pressure (assumed to be 24 dm^3) (separate science only)

IaS1, IaS2: Using data to make quantitative predictions about yields and comparing them to actual yields.

C5.4.1. identify the difference between qualitative and quantitative analysis (separate science only)

C5.4.2. explain how the mass of a solute and the volume of the solution is related to the concentration of the solution and calculate concentration using the formula:

$$\text{concentration (g/dm}^3\text{)} = \frac{\text{mass of solute (g)}}{\text{volume (dm}^3\text{)}}$$

C5.4.3. explain how the concentration of a solution in mol/dm^3 is related to the mass of the solute and the volume of the solution and calculate the molar concentration using the formula

$$\text{concentration (mol/dm}^3\text{)} = \frac{\text{number of moles of solute}}{\text{volume (dm}^3\text{)}}$$

C5.4.4. describe neutralisation as acid reacting with alkali to form a salt plus water including the common laboratory acids hydrochloric acid, nitric acid and sulfuric acid and the common alkalis, the hydroxides of sodium, potassium and calcium

C5.4.5. recall that acids form hydrogen ions when they dissolve in water and solutions of alkalis contain hydroxide ions

C5.4.6. recognise that aqueous neutralisation reactions can be generalised to hydrogen ions reacting with hydroxide ions to form water

C5.4.7. describe and explain the procedure for a titration to give precise, accurate, valid and repeatable results

C5.4.8. evaluate the quality of data from titrations

C5.4.9. explain the relationship between the volume of a solution of known concentration of a substance and the volume or concentration of another substance that react completely together (separate science only)

IaS1, IaS2: Justify a technique in terms of precision, accuracy and validity of data to be collected, minimising risk. Use of range and mean when processing titration results, analysis of data

Comment

The Key Stage 3 part of the course provides the opportunity for learners to carry out some of the most motivating experiments. If the particle model is used to explain the differences, most learners should cope well with understanding them. Analysis tests, other than identifying acids and alkalis, will only usually have been carried out in biology lessons (for example, the starch test) whereas at Key Stage 4, analysis of metal and non-metal ions in ionic compounds is introduced. At Key Stage 3 the focus is on what is made during a chemical reaction, whereas at Key Stage 4, the quantities made become very important. Formula masses and moles are used to predict quantities of reactants or products in a reaction and Rf values are calculated in chromatography. Thus the development of mathematical skills, especially manipulation of equations, is important. *Chemistry for the gifted and talented: chromatography* is a useful resource for developing in-depth understanding of chromatography, including use of Rf values.

The mole can be a tricky concept, but if it is introduced at Key Stage 3 by talking about the numbers of atoms or molecules before any equations are introduced, understanding can be increased. The use of confusing terminology presents a barrier to many learners, particularly when teaching the mole, so it may be useful to read the article found at http://www.rsc.org/learn-chemistry/resource/res00001416/demystifying-the-mole. Neutralisation is extended to cover titrations and calculation of solution concentrations using the results of these titrations, so it is therefore advisable to work quantitatively wherever possible. For example, learners could find the percentage of salt in rock salt, rather than just separate the salt from the mineral. The demands of primary school maths means that most of the youngest learners should be able to cope with this approach. It also makes it clear that chemistry is a mathematical subject, which should encourage transfer of maths skills to chemistry throughout the Key Stage 3 course.

The other Key Stage 3 activities provide a variety of activities to investigate separation techniques. *Separating Mixtures* shows applications of techniques in the context of mineral separation. *Desert Survival* encourages lateral thinking by using commonly found containers to extract water from sandy water. *The Acids and Alkalis Pack* and *What's the Best Indigestion Cure?* activities provide useful teaching and practical information for this part of the topic. The *400m Event* shows how biochemistry affects the performance of athletes.

Some learners may think that neutralisation means an acid breaking down rather than being changed, while some learners may think that matter is continuous. It is therefore important to refer to particles such as acid particles and use symbol equations or molecular models to show what is happening at a particle level. Confusion can arise with the use of the word **base** as *alkali* is most commonly used up to GCSE. A base neutralises an acid, a soluble base is called an alkali. Many learners understand that acids can cause burns but don't know that alkalis such as sodium hydroxide are in fact more corrosive than acids. This can be demonstrated by adding laboratory acids and alkalis to solids such as paper and compared at the end of the lesson. This should encourage suitable care when using both acids and alkalis.

The Key Stage 4 activities *Titration Screen Experiment and Mole Calculations* provide useful homework activities. The *Titrations* activity provides a step by step approach to making a standard solution, while encouraging learners to think about why each step is required. The *Qualitative Analysis Quizzes* provide a useful review of the analysis part of the topic, while the *Understanding the Mole* activity builds on the understanding shown in the second checkpoint task.

The first checkpoint task 1.1 Acids and Alkalis could be carried out at the end of the Key Stage 3 topic on acids and alkalis or at the start of the Key Stage 4 course as a review. Any misconceptions should be addressed before starting the new topic. The second checkpoint task 1.2 Reaction Quantities is particularly useful if carried out at the start of the Key Stage 4 topic. This is to check that the reasoning behind predicting quantities is understood, before moles and equations are introduced.

Activities

Acids and Alkalis Pack

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000840/acids-and-alkalis

A resource designed to challenge more able learners, containing a mix of theoretical and practical activities. It will develop questioning skills through problem solving, explore the use of models to expand understanding, develop practical skills and dexterity while promoting independent learning and research skills.

Chemistry and Sport - Athletics: The 400m Event

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000857/chemistry-and-sport-athletics-400m

Discover the chemistry behind one of the toughest athletic events - the 400m race. Handouts and powerpoints to review acids and bases in the context of the 400m race.

Joint Earth Science Education Initiative: Separating Mixtures

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000499/separating-mixtures

This activity covers methods of separation including separating mixtures of minerals on the basis of their different physical properties. Hands-on practical activities or ideas for front of class demonstrations.

In Search of Solutions: desert survival

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00001192/desert-survival

How can clean water be separated from sand? In the context of a plane crash, limited non-laboratory apparatus is suggested to increase the challenge.

Chemistry for the gifted and talented: chromatography

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000620/chromatography-worksheet

This activity extends the learners' understanding of chromatography. It links chromatography with particle theory and develops the tools of analogy and modelling.

Checkpoint task

Task 1.1 Acids and Akalis

The first checkpoint task checks that learners can use the pH scale to classify chemicals as acids, alkalis or neutral and compare their strength. This then leads on to see if learners can interpret results of a neutralisation experiment, in the context of acid attack of tooth enamel. This is preparation for titration calculations at Key Stage 4. A simple extraction of a soluble solid from an insoluble solid is also included, in a realistic setting of a dropped glass container. Learners could attempt this part of the task individually as homework, then compare answers in pairs or small groups. The debated answers could then be shared with the class.

Task 1.2 Reaction Quantities

The second checkpoint task 1.2 (Reaction Quantities) checks that learners are confident with the molecular idea of chemical reactions as the rearrangement of atoms whose mass is conserved, as well as representing chemical reactions using formulae and equations. It is introduced within the familiar context of cooking, to work out how much of each ingredient is required and how this affects the number of flapjacks that can be made. It includes the idea of limiting quantities of one ingredient and how that affects the amount of product. It then moves on to use models of hydrogen and oxygen molecules to predict the number of molecules of water that will be made and also the weight. An understanding of reactions at the molecular level should facilitate the more formal approach of using the mole to calculate quantities of reactants and products at Key Stage 4.

http://www.ocr.org.uk/Images/379272-chemical-analysis-checkpoint-activity.doc

Activities

Understanding the mole

The Science Teacher website

Resources: http://thescienceteacher.co.uk/understanding-the-mole/

Worksheets, a video and lesson ideas to challenge learners aged 11 to 16 to think hard about mole calculations (GCSE and Key Stage 3).

Titrations

The Science Teacher website

Resources: http://thescienceteacher.co.uk/titrations/

Worksheets and lesson ideas to challenge learners aged 11 to 16 to think hard about titration calculations, standard solutions and molarity (GCSE and Key Stage 3).

Qualitative analysis quizzes

Wolfson Foundation/RSC

Resources: http://www.rsc.org/learn-chemistry/resource/res00002201/qualitative-analysis-quizzes-new-users-guide

The quizzes consist of 10 questions in each section and focus on providing formative feedback to learners. The range of question types includes text response, numerical response, drag and drop and multiple choice. Free registration required before use.

Titration screen experiment

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resources/screen-experiment/titration/experiment

The titration screen experiment is an interactive resource which allows you to run your own experiment. Each of the four levels take approximately 30 minutes to complete and are designed to be used as pre-lab activities in class or as homework.

Mole calculations

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/wiki/Quiz:GeneralA003:_Mole_Calculations

Mole calculations involving gases. Ten multiple choice questions which are marked on-line. The first three questions have a link to show how to work out the correct answer if an incorrect answer was given.

Activities

Streamwatch - a UK water analysis science project

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00002262/streamwatch-a-uk-water-analysis-science-project

The resource provides access to a water analysis kit and instructions on how to use these. Using this resource provides teachers with great potential to engage learners and enable them to see the purpose and benefits of chemical analysis.

pH scale advanced simulation

RSC and PhET Interactive Simulations, University of Colorado Boulder

Resources: https://phet.colorado.edu/en/simulation/ph-scale

A simulation which allows learners to investigate pH, including predicting (qualitatively and quantitatively) how dilution and volume will affect the pH and concentration of hydroxide, hydronium and water.

Gridlocks Moles Equations 14-16

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000878/gridlocks-can-you-unlock-the-grid

Gridlocks puzzles on the equations used to determine mass, volume of gas, number of particles, volume and concentration of solutions. Match boxes to their corresponding values or chemicals to complete the grid – similar to Sudoku. Gridlocks Walkthrough should be seen before starting the puzzles.

Resources, links and support

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