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GCSE (9–1)
Transition Guide

GATEWAY SCIENCE CHEMISTRY A

J248
For first teaching in 2016

KS3–KS4
Monitoring and controlling chemical reactions

Version 1

www.ocr.org.uk/chemistry

Contents

GCSE (9–1)

GATEWAY SCIENCE CHEMISTRY A

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 4 which will help prepare students for progression to Key Stage 5;
- 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 4 and 5 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 4 and assess their 'readiness for progression' to Key Stage 5 content on this topic. This checkpoint task can be used as a summative assessment at the end of Key Stage 4 teaching of the topic or by Key Stage 5 teachers to establish their students' conceptual starting point.

Key Stage 4 to 5 Transition Guides are written by experts with experience of teaching at both key stages.

Key Stage 3 Content

- The properties of the different states of matter (solid, liquid and gas) in terms of the particle model, including gas pressure
- Chemical symbols and formulae for elements and compounds
- Conservation of mass, changes of state and chemical reactions
- Mixtures, including dissolving
- Chemical reactions as the rearrangement of atoms
- Representing chemical reactions using formulae and using equations
- The pH scale for measuring acidity/alkalinity; and indicators
- What catalysts do

Key Stage 4 Content

Sub-Topic C5.1 Monitoring chemical reactions

Mathematical learning outcomes

CM5.1i calculations with numbers written in standard form when using the Avogadro constant

CM5.1ii provide answers to an appropriate number of significant figures*

CM5.1iii convert units where appropriate **particularly from mass to moles***

CM5.1iv arithmetic computation, ratio, percentage and multistep calculations permeates quantitative chemistry*

CM5.1v arithmetic computation when calculating yields and atom economy*

CM5.1vi change the subject of a mathematical equation*

Learning outcomes

C5.1a explain how the concentration of a solution in mol/dm3 is related to the mass of the solute and the volume of the solution*

C5.1b describe the technique of titration*

C5.1c 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 (to include titration calculations)*

C5.1d describe the relationship between molar amounts of gases and their volumes and vice versa*

C5.1e calculate the volumes of gases involved in reactions using the molar gas volume at room temperature and pressure (assumed to be 24dm3)*

C5.1f explain how the mass of a solute and the volume of the solution is related to the concentration of the solution

C5.1g calculate the theoretical amount of a product from a given amount of reactant*

. . . continues

Key Stage 4 Content

C5.1h calculate the percentage yield of a reaction product from the actual yield of a reaction*

C5.1i define the atom economy of a reaction*

C5.1j calculate the atom economy of a reaction to form a desired product from the balanced equation*

C5.1k explain why a particular reaction pathway is chosen to produce a specified product given appropriate data (to include data such as atom economy (if not calculated), yield, rate, equilibrium position and usefulness of by-products)*

Sub-Topic C5.2 Controlling reactions

Mathematical learning outcomes

CM5.2i arithmetic computation, ratio when measuring rates of reaction

CM5.2ii drawing and interpreting appropriate graphs from data to determine rate of reaction

CM5.2iii determining gradients of graphs as a measure of rate of change to determine rate

CM5.2iv proportionality when comparing factors affecting rate of reaction

Learning outcomes

C5.2a suggest practical methods for determining the rate of a given reaction

C5.2b interpret rate of reaction graphs (to include 1/t is proportional to rate and gradients of graphs)

C5.2c describe the effect of changes in temperature, concentration, pressure, and surface area on rate of reaction

C5.2d explain the effects on rates of reaction of changes in temperature, concentration and pressure in terms of frequency and energy of collision between particles

. . . continues

Key Stage 4 Content

C5.2e explain the effects on rates of reaction of changes in the size of the pieces of a reacting solid in terms of surface area to volume ratio

C5.2f describe the characteristics of catalysts and their effect on rates of reaction

C5.2g identify catalysts in reactions

C5.2h explain catalytic action in terms of activation energy (to include reaction profiles)

C5.2i recall that enzymes act as catalysts in biological systems

Sub-Topic C5.3 Equilibria

Mathematical learning outcomes

CM5.3i arithmetic computation, ratio when measuring rates of reaction

CM5.3ii drawing and interpreting appropriate graphs from data to determine rate of reaction

CM5.3iii determining gradients of graphs as a measure of rate of change to determine rate

CM5.3iv proportionality when comparing factors affecting rate of reaction

Learning outcomes

C5.3a recall that some reactions may be reversed by altering the reaction conditions

C5.3b recall that dynamic equilibrium occurs in a closed system when the rates of forward and reverse reactions are equal

C5.3c predict the effect of changing reaction conditions on equilibrium position and suggest appropriate conditions to produce as much of a particular product as possible (to include Le Chatelier's principle concerning concentration, temperature and pressure)

**Separate Chemistry Statements only*

Comment

The Key Stage 3 course offers lots of possibility for stimulating practical work to encourage learners to think deeply about the key ideas of particle theory, acids and alkalis, as well as the usefulness of chemical reactions in the world around us. At Key Stage 4 the ideas are extended in a quantitative way, so the development of mathematical skills, especially graph work and manipulation of equations are important. Neutralisation is extended to cover titrations and calculation of solution concentrations using the results of these titrations. Particle theory is the underpinning idea behind collision theory, which is used to explain the effects of temperature, surface area, concentration of solutions, catayst and enzymes on the rates of reactions. Learners are introduced to the idea of reversible chemical reactions and how understanding of these equilibrium reactions can lead to greater yields of valuable products such as ammonia.

Difficulties can arise with the particle theory, even though it will probably have been introduced at primary school. The scale of the size of atoms is hard to understand and some learners use their observations to adapt their own view of the particle theory, with ideas such as *particles expand when heated* or *particles contract when cooled* being fairly common. Some also think that particles spread out when warmed and so there are gaps between liquid particles. Some learners may think that matter is continuous, so it is 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. Other misconceptions include *the space between particles is filled and solids disappear when they dissolve*. This can be disproved by weighing a beaker of water before and after adding a solid like salt. Although evaporation of the water will prove that the solid was there, the different appearance of the solid before and after dissolving can be confusing for some.

The stereotypical view of scientists can lead to the view that acids are more dangerous than alkalis, and that acids can burn and eat material away. Some learners may think that neutralisation means an acid breaking down rather than being changed. Reversible reactions may be a new idea to many, although they will have encountered reversible physical changes such as melting. It is important that correct terminology is used to prevent confusion between reversible chemical and physical reactions.

Once the particle theory is well established, dissolving a sugar cube can be investigated as an introduction to the collision theory. It can be explained by reference to collisions between sugar and water: the more collisions the faster the dissolving. Once one variable has been explained by the class with reference to collisions, groups could be encouraged to suggest why sugar size, stirring and amount of water also affect the speed of dissolving. This should be a useful stepping stone to use of the collision theory at Key Stage 4 to explain chemical reactions, rather than the physical reaction studied here in dissolving.

Learner Task 1.1 Heating particles can be used at the start of the topic in either key stage to establish what learners know already about the particle theory, or any misconceptions that they may have. It could be set as individual homework which is then reviewed in groups and discussed in class. If at Key Stage 3 their answers show good understanding they could move straight to the practical work on dissolving and using the collision theory to explain their results. The States of Matter activity and Particle Pictures activity could be carried out if misconceptions are found.

The Chemical Solutions activity has some useful ideas for introducing what really happens during dissolving. Learner Task 1.1 Particles and Dissolving should be carried out after the Key Stage 3 practical work to check that the collision theory has been understood. Learner Task 1.2 Neutralisation should be used after practical work on pH classification and neutralisation has been carried out at Key Stage 3 or at the start of the titrations part of the topic at Key Stage 4. 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.

Activities

States of Matter Activity: The Concord Consortium
Resources: https://authoring.concord.org/activities/1074/single_page/89c4e53f-cb65-4f7c-9ce4-9594287f527a

Simulations to illustrate the differences in forces and attractions between atoms in the three primary states of matter. Snapshots of different states are taken and compared. Includes career information.

Acids and Alkalis Pack: The Royal Society of Chemistry (RSC)
Resources: http://www.rsc.org/learn-chemistry/resource/res00000840/acids-and-alkalis#!cmpid=CMP00000947

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

Particle Pictures: Thescienceteacher.co.uk
Resources: http://thescienceteacher.co.uk/particle-pictures/

Lesson ideas to challenge learners aged 11 to 16 to think hard about solids, liquids and gases.

Chemical Solutions: Thescienceteacher.co.uk
Resources: http://thescienceteacher.co.uk/solutions/

Lesson ideas (such as comparing dissolving and melting) to challenge learners aged 11 to 16 to think hard about solids, liquids and gases. The temperature investigation is a good opportunity to practise graph skills.

What's the best indigestion cure?: RSC
Resources: http://www.rsc.org/learn-chemistry/resource/res00001151/what-is-the-best-indigestion-cure

Learners devise tests to compare indigestion cures and write a report for a magazine. Titrations could be introduced here so learners become familiar with the apparatus.

Checkpoint task

The first checkpoint task (Particles and Collisions) has two sections. The first (Heating Particles) checks that learners have an understanding of the particle theory that will support an extension of the ideas into the collision theory. It focuses on getting learners to explain how particle movement changes as heating occurs before a change of state. They then need to apply these ideas to explain a practical situation. 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, before deciding on the answers that best fit the theory.

The second part (Particles and Dissolving) checks whether learners can use collisions of a liquid into a solid to explain ways to speed up dissolving. This could be used both before and after practical work on a similar theme, to see how the learners' ideas have changed. It is important that learners have been encouraged to discuss why their chosen method worked so well with reference to collisions, as misconceptions are common with ideas about particles which cannot be seen.

The second checkpoint task (Neutralisation) 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 and use their mathematical skills to compare the strength and cost-effectiveness of the cure. This is preparation for titration calculations at Key Stage 4.

Link to checkpoint task

Activities

Catalysts: The Concord Consortium
Resources: http://concord.org/stem-resources/catalysts

Simulations to show the effect of catalysts on a reaction. Energy diagrams are also used to explain catalysis.

Rates of reaction: The science teacher website
Resources: http://thescienceteacher.co.uk/rates-of-reaction/

Lesson ideas to challenge learners to think hard about rates of reaction, graphs and collision theory.

Equilibria: The science teacher website
Resources: http://thescienceteacher.co.uk/equilibria/

Lesson ideas to challenge learners to think hard about equilibria and reversible reactions.

Gas laws: The Concord Consortium
Resources: http://concord.org/stem-resources/gas-laws

Simulations illustrating the gas laws, working up to explaining why a heated can collapses when put into cold water.

Titrating sodium hydroxide with hydrochloric acid: RSC with the Nuffield Foundation
Resources: http://www.rsc.org/learn-chemistry/resource/res00000697/titrating-sodium-hydroxide-with-hydrochloric-acid

In this experiment sodium hydroxide is neutralised with hydrochloric acid to produce the soluble salt sodium chloride in solution. This solution is then concentrated and crystallised to produce sodium chloride crystals.

Activities

Random force and Brownian motion video: Smart learning
Resources: http://smart-learning.co.uk/teachers-club/science/free-video-random-force-brownian-motionin-video-professor-bowley-university-nottingham-discusses-understanding-brownian-motion-developed-first-re/

The video gives a history of our understanding of Brownian motion. In the second half of the video, the science is more in-depth than is required at Key Stage 3. However, it is a great video to extend the more able.

Challenging Plants: Fertilisers – Practicals Rate of hydrolysis of urea (learner and teacher sheets): RSC with Reckitt Benckiser
Resources: http://www.rsc.org/learn-chemistry/resource/res00000903/challenging-plants-fertilisers-practicals#!cmpid=CMP00001154

A practical investigation of the urease catalysed hydrolysis of urea. Learners could investigate how the rate of hydrolysis depends upon the concentration of urea, urease, temperature, metal ions such as $Cu^{2+}(aq)$ or $Pb^{2+}(aq)$ or organic molecules such as ethanol or sucrose.

pH scale advanced simulation: RSC and PhET Interactive Simulations, University of Colorado Boulder
Resources: http://www.rsc.org/learn-chemistry/resource/res00001458/ph-scale-advanced-simulation

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.

Resources, links and support

Science Spotlight – Our termly update Science Spotlight provides useful information and helps to support our Science teaching community. Science Spotlight is designed to keep you up-to-date with Science here at OCR, as well as to share information, news and resources. Each issue is packed full with a series of exciting articles across the whole range of our Science qualifications: www.ocr.org.uk/qualifications/by-subject/science/science-spotlight/

Find resources and qualification information through our science page: www.ocr.org.uk/qualifications/by-subject/science/

Contact the team: science@ocr.org.uk

Continue the discussion on the science community forum: http://social.ocr.org.uk/

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To find out more about GCSE and A Level reform please visit: http://www.ocr.org.uk/qualifications/gcse-and-a-level-reform

The small print

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