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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
Making useful chemicals

Version 1

www.ocr.org.uk/chemistry

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

- explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible
- represent chemical reactions using formulae and using equations
- define acids and alkalis in terms of neutralisation reactions
- describe the pH scale for measuring acidity/ alkalinity; and indicators
- recall reactions of acids with metals to produce a salt plus hydrogen and reactions of acids with alkalis to produce a salt plus water
- know what catalysts do
- know about energy changes on changes of state (qualitative)
- know about exothermic and endothermic chemical reactions (qualitative).

Key Stage 4 Content

C6.1.1. recall that acids react with some metals and with carbonates and write equations predicting products from given reactants

C6.1.2. describe practical procedures to make salts to include appropriate use of filtration, evaporation, crystallisation and drying

C6.1.3. use the formulae of common ions to deduce the formula of a compound

C6.1.4. recall that relative acidity and alkalinity are measured by pH including the use of universal indicator and pH meters

C6.1.5. use and explain the terms dilute and concentrated (amount of substance) and weak and strong (degree of ionisation) in relation to acids including differences in reactivity with metals and carbonates

C6.1.6. use the idea that as hydrogen ion concentration increases by a factor of ten the pH value of a solution decreases by one

C6.1.7. describe neutrality and relative acidity and alkalinity in terms of the effect of the concentration of hydrogen ions on the numerical value of pH (whole numbers only)

C6.2.1. describe the effect on rate of reaction of changes in temperature, concentration, pressure, and surface area on rate of reaction

C6.2.2. explain the effects on rates of reaction of changes in temperature, concentration and pressure in terms of frequency and energy of collision between particles

C6.2.3. 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

C6.2.4. describe the characteristics of catalysts and their effect on rates of reaction

C6.2.5. identify catalysts in reactions

C6.2.6. explain catalytic action in terms of activation energy

C6.2.7. suggest practical methods for determining the rate of a given reaction including:

For reactions that produce gases:

i. gas syringes or collection over water can be used to measure the volume of gas produced

ii. mass change can be followed using a balance

Key Stage 4 Content

Measurement of physical factors:

iii. colour change

iv. formation of a precipitate

C6.2.8. interpret rate of reaction graphs

C6.2.9. interpret graphs of reaction conditions versus rate (separate science only) (an understanding of orders of reaction is not required)

C6.2.10. use arithmetic computation and ratios when measuring rates of reaction

C6.2.11. draw and interpret appropriate graphs from data to determine rate of reaction

C6.2.12. determine gradients of graphs as a measure of rate of change to determine rate

C6.2.13. use proportionality when comparing factors affecting rate of reaction

C6.2.14. describe the use of enzymes as catalysts in biological systems and some industrial processes

C6.3.1. recall that some reactions may be reversed by altering the reaction conditions including:

a) reversible reactions are shown by the symbol ⇌

b) reversible reactions (in closed systems) do not reach 100% yield

C6.3.2. recall that dynamic equilibrium occurs when the rates of forward and reverse reactions are equal

C6.3.3. predict the effect of changing reaction conditions (concentration, temperature and pressure) on equilibrium position and suggest appropriate conditions to produce a particular product, including:

a) catalysts increase rate but do not affect yield

b) the disadvantages of using very high temperatures or pressures

C6.4.1. recall the importance of nitrogen, phosphorus and potassium compounds in agricultural production (separate science only)

C6.4.2. (separate science only) explain the importance of the Haber process in agricultural production and the benefits and costs of making and using fertilisers, including:

Key Stage 4 Content

a) the balance between demand and supply of food worldwide

b) the sustainability and practical issues of producing and using synthetic and natural fertilisers on a large scale

c) the environmental impact of over-use of synthetic fertilisers (eutrophication)

C6.4.3. (separate science only) explain how the commercially used conditions for the Haber process are related to the availability and cost of raw materials and energy supplies, control of equilibrium position and rate including:

a) the sourcing of raw materials and production of the feedstocks; nitrogen (from air), and hydrogen (from natural gas and steam)

b) the effect of a catalyst, temperature and pressure on the yield and rate of reaction

c) the separation of the ammonia and recycling of unreacted nitrogen and hydrogen

C6.4.4. explain the trade-off between rate of production of a desired product and position of equilibrium in some industrially important processes (separate science only)

C6.4.5. define the atom economy of a reaction (separate science only)

C6.4.6. (separate science only) calculate the atom economy of a reaction to form a desired product from the balanced equation using the formula

$$\text{atom economy} = \frac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants}}$$

C6.4.7. use arithmetic computation when calculating atom economy (separate science only)

C6.4.8. explain why a particular reaction pathway is chosen to produce a specified product given appropriate data such as atom economy (if not calculated), yield, rate, equilibrium position, usefulness of by-products and evaluate the sustainability of the process (separate science only)

C6.4.9. (separate science only) describe the industrial production of fertilisers as several integrated processes using a variety of raw materials and compare with laboratory syntheses. including:

Key Stage 4 Content

a) demand for fertilisers (including ammonium sulfate) is often met from more than one process

b) some fertilisers are made as a bi-product or waste product of another process

c) process flow charts are used to summarise industrial processes and give information about raw materials, stages in the process, products, by-products and waste

d) lab processes prepare chemicals in batches, industrial processes are usually continuous

C6.4.10. compare the industrial production of fertilisers with laboratory syntheses of the same products (separate science only)

IaS2: Make predictions from data and graphs about yield of chemical products

IaS3: Use the particle model to explain factors that affect rates of reaction

IaS4: Consider the risks and costs of different operating conditions in an ammonia plant.

IaS4: Evaluation of industrial processes in terms of sustainability, risk, costs and benefits

IaS4: Production of fertilisers to enhance the quality of people's lives

IaS4: The use of catalysts supports more sustainable industrial processes

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Comment

At KS3 chemical reactions are thought to be irreversible, and reversible reactions are not discussed in detail. The process by which new materials are formed and extracted is not covered in detail, and possibly not linked to the idea of chemical reactions at all. For example, at KS3 methods of separation are taught, such as filtration and evaporation, but usually in the context of extracting one material such as salt from seawater. The link is not necessarily made to chemical reactions whereby synthesised products are separated from unreacted substances or by-products. Acid, alkalis and the pH scale are taught at KS3, but there is no discussion of what differentiates an acid from an alkali, or strong and weak acids, as concentration of hydrogen ions is not taught at KS3.

Although learners will encounter catalysts, there is little exploration of factors which affect the rate of reactions at KS3. Learners are unlikely to have collected any gases produced through chemical reactions using the "over–water" method, and probably will not have seen a gas syringe or understand its use. Learners will not have interpreted any graphical representations of rates of reactions at this stage.

The use of nitrogen, potassium, and phosphorous in fertilisers is covered in KS3, but only as far as knowing that plants need fertilisers for growth. Further understanding of fertilisers, synthetic or natural, will not have been introduced to learners yet, especially not production of fertilisers by the Haber process.

One particular difficulty learners will have with the topic is the differentiation between strong and weak, and concentrated and diluted acids, even before hydrogen concentration is explained. They need to understand that a dilute strong acid can be safe to use, but a concentrated weak acid could pose a danger. Another misconception is that because catalysts are used to speed up a reaction, they must be included in the word equation. As they return to their original chemical form at the end of the reaction they should not be included. In summary, although catalysts take part in a reaction, they are not a reactant.

To prepare learners for GCSE content while at KS3 level, learners should try to think about chemical reactions by using Lego models, taking them apart and recombining them to build new products. It often helps to represent the chemicals as particle diagrams or even molymods as early as possible to reinforce this. This can then prepare them to understand collision theory, as they will be used to considering the particles taking part in the reaction.

The activities given to support both KS3 and GCSE in the transition guide can be used as teaching aids. Videos and animations are a useful addition to carrying out learning from practicals/demonstrations. The practical investigation into rates of reaction can be used to introduce the idea of collecting a gas produced in order to measure a rate of reaction at KS3, something which isn't usually taught at KS3 but required at KS4. It also provides a visual representation of how the rates of reaction can vary. The "Preparing a soluble salt by neutralisation" practical would be an excellent introduction to the topic at KS4, using the basics of neutralisation from KS3.

Checkpoint task 1 can be used at the end of the KS3 topic on acids and alkalis to check understanding before the KS4 content is introduced. It can be used as an independent assessment task, or a group task involving discussion between learners before the written answers are completed.

Checkpoint task 2 consists of a demonstration of a catalyst's effect on the rate of reaction and a learner task to explain it. This could be used at the end of the KS3 content on rates of reaction as a way of deepening learning before introducing new factors that affect rates of reaction.

Checkpoint task 3 is a class practical for learners to carry out themselves under supervision. The learners will observe a chemical reaction producing an obvious new product in the form of carbon dioxide bubbles, and less obvious products of sodium citrate and water. This is also an endothermic reaction, so a change in temperature can be observed. The learners can demonstrate their understanding through a written conclusion and answering questions given at the end of the task.

Activities

Interactive simulation

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00001459/ph-scale-basics-simulation

An interactive simulation where the pH of acids and alkalis can be tested. Good for showing liquids not normally available for testing such as blood and vomit. Can be used to recap the basics of the pH scale.

Video clips

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000378/faces-of-chemistry-catalysts#!cmpid=CMP00000445

A series of videos on the use of catalysts in catalytic converters in vehicles to reduce emissions. This is an everyday example of the use of catalysts which can be used to put the scientific ideas into a real life context.

Teacher guide and worksheets

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00001087/word-equations

A teacher resource which includes instructions for teaching word equations as well as worksheets for learners on word equations in the context of making salts, neutralisation and reactions of metals and acids.

Practical with instructions

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000564/acids-bases#!cmpid=CMP00000576

An experiment for learners to test various solutions given in the instructions with indicator, to determine whether they are acids or alkalis.

Checkpoint task

The first checkpoint task is designed to determine whether learners understand the use of the pH scale and the role of indicators. Learners can use knowledge of universal indicator and the pH scale or knowledge of other indicators such as litmus paper to answer one of the questions. It does require knowledge of the general word equation for neutralisation to check that learners understand a salt is formed.

The second checkpoint task, comic strip catalyst, addresses the misconception that catalysts are used up the reaction when in fact they are necessary for a chemical reaction to occur but are neither reactants or products, and can be used again. The teacher should demonstrate hydrogen peroxide being broken down using the catalyst catalase (contained within a piece of liver from the butchers or supermarket) by placing the liver in hydrogen peroxide. Once the reaction has occurred, the teacher then removes the piece of liver using forceps, and places it into a fresh measuring cylinder of hydrogen peroxide and learners observe that the reaction is repeated. The learners task is to then present the demonstration as a comic strip, complete with commentary that explains what is happening in the demonstration, including why the reaction happens a second time with the same piece of liver.

The third checkpoint task is a class practical for learners to carry out. The learners will observe a chemical reaction producing an obvious new product in the form of carbon dioxide bubbles, and less obvious products of sodium citrate and water. This is also an endothermic reaction, so a change in temperature can be observed. The learners can demonstrate their understanding through a written conclusion and answering questions given at the end of the task.

Checkpoint task:
www.ocr.org.uk/382401-making-useful-chemicals-checkpoint-activity.doc

Activities

Preparing a soluble salt by neutralisation - practical

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00001760/preparing-a-soluble-salt-by-neutralisation

The resource gives step by step instructions for how to neutralise an acid with an alkali to form a salt, recovered by crystalisation. There are also learner questions after the practical which contain the full symbol equation which could be given in parts for learners to complete.

Rates of reaction

BBC bitesize

Resources: http://www.bbc.co.uk/education/clips/zptkq6f

A video exploring the factors which affect rates of reaction including adding a catalyst, and changing temperature, concentration and surface area. This video uses CG animation over narrators to show the effect of the condition change on the movement of particles.

Rates of reaction video and worksheet

The science teacher website

Resources: http://thescienceteacher.co.uk/rates-of-reaction-graphs/

A video of sodium thiosulphate reacting with hydrochloric acid to accompany a worksheet linked to a description below the video. The worksheet allows the learners to sketch rates of reaction graphs, and a modelling practical for rates of reaction using toy building blocks.

PowerPoint for teaching

TES

Resources: https://www.tes.com/teaching-resource/fertilisers-11434998

A presentation containing information on how fertilisers are made using nitrogen, phosphorous and potassium. The presentation goes through the key learning points in a visual way, supporting teacher knowledge and delivery.

Video

BBC

Resources: http://www.bbc.co.uk/education/clips/zrdvcdm

Rates of reaction are explored in the video using different practical demonstrations such as the Iodine Clock and Glow sticks. Some of these practicals can't be done in class so students get a wider variety of practical experience through the video. Each factor affecting the rate of reaction is explored with a new practical experiment.

Teacher pack

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000017/ammonia#!cmpid=CMP00001797

Teacher pack on ammonia, its uses and production using the Haber process. This resources provides information for teachers, as well as diagrams and video clips that could be used in class.

Activities

Practical activity Chemistry for the gifted and talented

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000621/universal-indicators

A practical activity regarding universal indicators and single indicators to develop understanding that a mixture of colours may produce a recognised colour on the pH scale. The challenge is predicting the colours that will be observed during the experiments as described in the document.

Revision Map

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00001086/revising-acids

Concept mapping activities on the topic of acidity, with different levels of scaffolding available.

Diagrams, learner sheets and handouts

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000903/challenging-plants-fertilisers-practicals

A resource produced in conjunction with industry, relevant for nutrients essential for plant growth. Discusses the idea of nutrients in soils becoming depleated and the necessity of fertilisers for specific requirements such as nutrient deficiencies.

Worksheet

TES

Resources: https://www.tes.com/teaching-resource/-pc-atom-economy-calculations-6086690

A worksheet for students to practice calculating percentage atom economy in chemical reactions.

Learner and teacher packs

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000842/energy

Whilst particularly suited to the more able and enthusiastic learners, this pack can be used with all learners to explore the energetics of reactions. It will develop knowledge of bond energies linked to energy loss or gain, identifying energy in forms other than heat. There is a specific section which explores how activation energy can be lowered using a catalyst, explained in the teacher pack.

Practical

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000001/the-equilibrium-between-two-coloured-cobalt-species

Instructions for a teacher led demonstration of equilibrium using coloured cobalt species for clear observations by learners.

Resources, links and support

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