

IGCSE

Science (Double Award)

Teacher's guide

Edexcel IGCSE in Science (Double Award) (4SC0)

First examination 2011

Issue 2



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This teacher's guide is Issue 2. Key changes are sidelined. We will inform centres of any changes to this issue. The latest issue can be found on the Edexcel website: www.edexcel.com

Acknowledgements

This guide has been produced by Edexcel on the basis of consultation with teachers, examiners, consultants and other interested parties. Edexcel would like to thank all those who contributed their time and expertise to its development.

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Introduction

The Edexcel International General Certificate of Secondary Education (IGCSE) in Science (Double Award) is designed for schools and colleges. It is part of a suite of IGCSE qualifications offered by Edexcel.

About this guide

This guide is for teachers who are delivering, or planning to deliver, the Edexcel IGCSE in Science (Double Award) qualification. The guide supports you in delivering the course content and explains how to raise the achievement of your students. The guide:

- gives essential information on the changes between this qualification and existing Edexcel and other international qualifications
- provides details of Assessment Objectives (AO) and criteria
- includes a list of command words that are directly linked to the Assessment Objectives
- gives you an example course planner
- provides experimental and investigative work that should be incorporated into teaching.

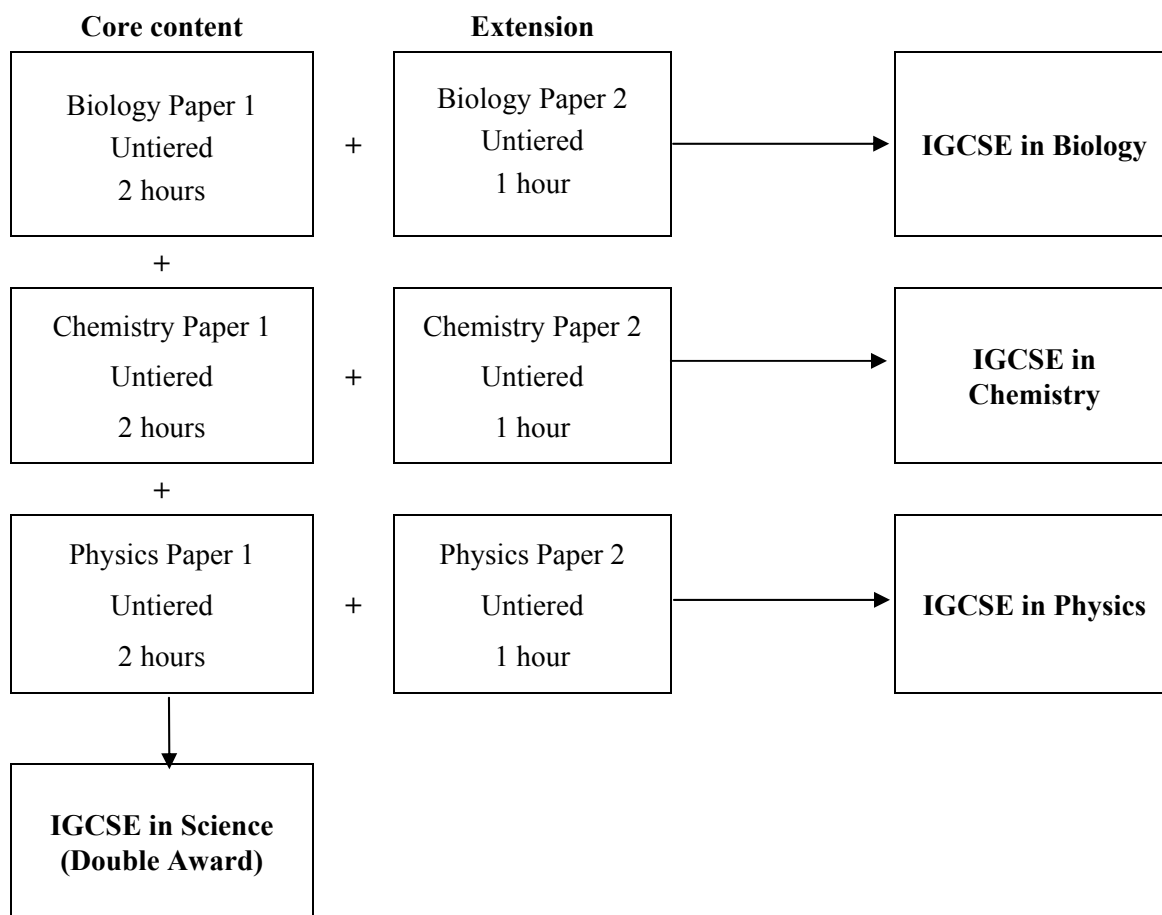
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Why choose this qualification?

The Edexcel IGCSE in Science (Double Award) is designed as a two-year course. It takes approximately two-thirds of the subject content of each of the Edexcel IGCSE Single Sciences (Biology (4BI0), Chemistry (4CH0) and Physics (4PH0)) qualifications and combines them into an IGCSE in Science (Double Award), qualification worth two IGCSEs. The Double Award is designed to be an interesting and inspiring modern science qualification. The course gives students the opportunity to experience science within the context of their general education. The design of the course provides a basis for further study in GCE Advanced Subsidiary and Advanced Level in Biology, Chemistry and Physics.

The relationship between assessment to the qualifications available is shown below.



Go to www.edexcel.com/igcse2009 for more information about this IGCSE and related resources.

This qualification's key features and benefits are:

- students are awarded two identical IGCSE grades, reflecting study of the required subject content
- clear, detailed and comprehensive subject content with straightforward linear assessment
- it requires less curriculum time than teaching the three sciences individually
- there are no tiered papers
- assessment of investigative skills integrated within the examinations
- a foundation for progression to Edexcel GCE Advanced Subsidiary (AS) and Advanced Level science qualifications.

Support from Edexcel

We are dedicated to giving you exceptional customer service. Details of our main support services are given below. They will all help you to keep up to date with IGCSE 2009.

Website

Our dedicated microsite www.edexcel.com/igcse2009 is where you will find the resources and information you need to successfully deliver IGCSE qualifications. To stay ahead of all the latest developments visit the microsite and sign up for our email alerts.

Ask Edexcel

Ask Edexcel is our free, comprehensive online enquiry service. Use Ask Edexcel to get the answer to your queries about the administration of all Edexcel qualifications. To ask a question please go to www.edexcel.com/ask and fill out the online form.

Ask the Expert

This free service puts teachers in direct contact with over 200 senior examiners, moderators and external verifiers who will respond to subject-specific queries about IGCSE 2009 and other Edexcel qualifications.

You can contact our experts via email or by completing our online form. Go to www.edexcel.com/asktheexpert for contact details.

Regional offices

If you have any queries about the IGCSE 2009 qualifications, or if you are interested in offering other Edexcel qualifications your Regional Development Manager can help you. Go to www.edexcel.com/international for details of our regional offices.

Head Office – London

If you have a question about IGCSE 2009 and are not sure who to ask, email us on IGCSE2009@edexcel.com or call our Customer Services Team on +44 (0) 1204770696.

Training

A programme of professional development and training courses, covering various aspects of the specification and examination is available. Go to www.edexcel.com for details.

Section A: Qualification content

Introduction

In developing the IGCSE in Science (Double Award) we have made a minimum amount of changes to the specification content of the legacy IGCSE in Science (Double Award) (4437) qualification. Some changes have been made to achieve a balance between the three sciences and to ensure consistency in the action verbs used in the specification. The main changes are listed below.

Changes to the content of the IGCSE in Science (Double Award), across all sciences, are:

- tiers have been removed
- investigative skills are embedded throughout.

Please note that the emboldened content in the separate sciences IGCSE specifications relates to paper 2 in the separate science only and is not assessed in the IGCSE Science (Double Award).

Biology

- No major revisions.

Chemistry

- Action verbs have been revised to be more appropriate.
- Sections on the *Group 2 elements of the periodic table*, and *Transition metals: iron and copper* have been removed.
- Tests for cations using ammonia have been removed.
- Specification content section on *Ethanol* has been removed from the core and is in IGCSE Chemistry only.
- Other minor revisions.

Physics

- New section on *Astronomy* including earth, planets and satellites, galaxies, and the universe; gravitational field strength, gravitational force, orbits of satellites and comets.
- New content on *digital signals*.

Comparison of the content from Cambridge International Examination (CIE) IGCSE in Combined Science (0653) to this qualification

Adapting from teaching the Cambridge International Examination (CIE) course is simplified, as much of the content of the CIE and Edexcel specifications is common to both courses. Resources that are suitable for the CIE IGCSE will also cover most of the Edexcel IGCSE. The additional content (particularly the quantitative work) is covered in a range of textbooks available at this level. Schools currently teaching the CIE IGCSE should be able to continue with the same schemes of work as long as they are modified to reflect the changes in content.

The tables below set out the relationship between the legacy CIE IGCSE in Combined Science qualification (0653) to this qualification.

Biology

Legacy CIE qualification content reference (0653)	This qualification content reference	New content/deleted content*
Biology Topic 1 – Cells	Section 1a), b)	N/A
Cell structure	Section 2a), b)	N/A
How substances enter and leave cells	Section 2d)	N/A
Enzymes	Section 2c)	N/A
Biology Topic 2 – Energy in living organisms	Section 2 e) – 2i)	N/A
Photosynthesis	Section 2e)	N/A
Human diet and digestion	Section 2 e), 2i)	N/A
Respiration	Section 2f), 2g)	N/A
Biology Topic 3 – Transport and coordination	Section 2h) – 2j)	N/A
Transport in humans	Section 2h)	N/A
Transport in plants	Section 2h)	N/A
Coordination and homeostasis	Section 2j)	N/A
Biology Topic 4 – Reproduction and genetics	Section 3a) – 3c) Section 5b), 5c)	N/A
Sexual and asexual reproduction	Section 3a), b)	N/A
Reproduction in humans	Section 3a), b)	N/A
Reproduction in plants	Section 3a), b) Section 5b), c)	Section 5d) Cloning
Variation and inheritance	Section 3b)	N/A

Legacy CIE qualification content reference (0653)	This qualification content reference	New content/<i>deleted content</i>*
Biology Topic 5 – Organisms and their environment	Section 4a) – d)	N/A
Food chains and nutrient cycles	Section 4a) – d)	Section 5a) Food production Section 5b) Selective breeding
Humans and the environment	Section 4d)	N/A

Chemistry

Legacy CIE qualification content reference (0653)	This qualification content reference	New content/deleted content*
Chemistry Topic 1 – Atomic Structure and Bonding	Section 1a) – g)	N/A
Atomic structure	Section 1c)	N/A
Elements, mixtures and compounds	Section 1b), c)	N/A
Bonding	Section 1f), g)	N/A
Chemistry Topic 2 – Periodic Table, Formulae, Equations	Section 1d), Section 2	N/A
Formulae and equations	Section 1d)	N/A
Further uses of the periodic table	Section 2a) – c)	<i>Transition elements</i> <i>Noble gases</i>
Chemistry Topic 3 – Metals and Non-metals	Sections 1, 2 and 5	N/A
Oxides of metals and non-metals	Section 2d)	N/A
Metals	Section 1h) Section 2f)	N/A
Extraction of metals	Section 5a)	N/A
Non-metals	Section 2a), c)	Section 5d) Industrial manufacture of chemicals
Rusting of iron	Section 2d)	N/A
Water	Section 2e)	N/A
Chemistry Topic 4 – Acids, bases and salts	Section 4a)	N/A
Chemistry Topic 5 – Chemical reactions	Sections 1, 2 and 4	N/A
Rates of reaction	Section 4c), d)	N/A
Oxidation and reduction	Section 2f)	N/A
Thermal decomposition	Section 4b)	N/A
Electrolysis	Section 1i)	N/A
Tests for ions and gases	Section 2g)	N/A
Chemistry Topic 6 – Fuels and polymers	Sections 3 and 5	N/A
Fuels and combustion	Section 3b), c)	N/A
Oils and polymers	Section 5b), c)	N/A

Physics

Legacy CIE qualification content reference (0653)	This qualification content reference	New content/deleted content*
Physics Topic 1 – Measurement and motion	Sections 1 and 5	N/A
Length and time	Section 1b)	N/A
Forces	Section 1c)	N/A
Mass and weight	Section 1c)	N/A
Density	Section 5b)	N/A
Speed, velocity and acceleration	Section 1b)	Section 1d) Astronomy
Physics Topic 2 – Energy	Section 4	N/A
Energy and work	Section 4b)	N/A
Sources of energy	Section 4b)	N/A
Power	Section 4c)	N/A
Physics Topic 3 – Electricity	Sections 2 and 3	N/A
Electric circuits and current	Section 2b)	N/A
Resistance	Section 2c)	N/A
Safety	Section 2b)	N/A
Electromagnetic effects	Section 6b) – d	N/A
Physics Topic 4 – Heat	Section 4b) Section 5c)	N/A
States of matter	Section 4b)	N/A
Thermal expansion and heat transfer	Section 4b) Section 5c)	N/A
Conservation of heat	Section 4b)	Section 4 Energy resources and electricity generation
Physics Topic 5 – Waves	Section 3b) – d)	N/A
Light	Section 3b), d)	N/A
Electromagnetic spectrum	Section 3b), c)	N/A
Sound	Section 3b), d)	N/A
Communication	Section 3d)	N/A

Legacy CIE qualification content reference (0653)	This qualification content reference	New content/<i>deleted content</i>*
Physics Topic 6 – Radioactivity	Section 7b), c)	N/A
Radioactivity	Section 7b)	N/A
Characteristics of three kinds of emission	Section 7b)	N/A
Detection of radioactivity	Section 7c)	N/A
Energy from nuclear sources	Section 7c)	N/A

Section B: Assessment

This section describes the nature of assessment for this qualification including the logistics of examinations and what you can expect from Edexcel examination papers.

The assessment for the Edexcel IGCSE in Science (Double Award) comprises of Paper 1 from each of the IGCSEs in Biology, Chemistry and Physics.

Assessment overview

The table gives you an overview of the assessment for this course.

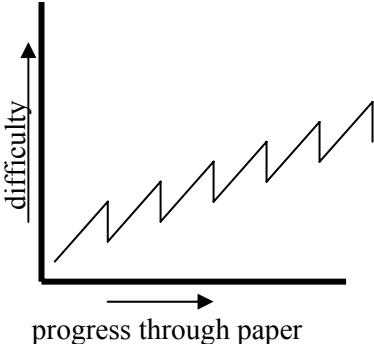
We recommend that you make this information available to students to help ensure they are fully prepared and know exactly what to expect in each assessment.

Paper 1	Percentage	Marks	Time	Availability
Biology	$33\frac{1}{3}$	120	2 hours	January and June examination series First assessment June 2011
Paper 1	Percentage	Marks	Time	Availability
Chemistry	$33\frac{1}{3}$	120	2 hours	January and June examination series First assessment June 2011
Paper 1	Percentage	Marks	Time	Availability
Physics	$33\frac{1}{3}$	120	2 hours	January and June examination series First assessment June 2011

Assessment Objectives and weightings

	% in Double Award IGCSE
AO1: Knowledge and understanding	45-55%
AO2: Application of knowledge and understanding, analysis and evaluation	25-35%
AO3: Investigative skills	20%
TOTAL	100%

Assessment summary

Paper 1	Description	Knowledge and skills
Biology Paper 1 Chemistry Paper 1 Physics Paper 1	<ul style="list-style-type: none"> The time allowed for each examination is 2 hours. There are 120 marks available per paper. Each paper consists of one section. All questions are compulsory – there is no choice of questions. All questions will be structured. As you progress through a question it will, in general, become more difficult. As you progress through the paper the questions will generally increase in difficulty.  <p>This means that the end of one question will often be more difficult than the start of the next question. Do not stop working just because you get stuck on one question.</p> <ul style="list-style-type: none"> This paper covers the full range of grades from G to A*. Although all questions will be structured, you can expect to find that some questions require longer answers towards the end of the paper. You should take the following into the examination: <ul style="list-style-type: none"> – black pen – pencil (for graphs) – a rule – an eraser – a calculator. 	<p>This assessment covers all three Assessment Objectives.</p> <p>For AO1 you will need to recall and show your understanding of facts, terminology, principles, concepts and practical techniques. You will need to draw on your knowledge to show you understand the applications and implications of science. You will need to make use of and present information logically, using appropriate vocabulary. No more than 50% of the marks for AO1 will be for direct recall.</p> <p>For AO2 you will need to explain phenomena and interpret data based on your knowledge of science. This may involve unfamiliar contexts and you should be able to use and apply your knowledge to work out the answer. You will need to carry out calculations and it is important that you show clearly all steps of your working.</p> <p>For AO3 you will not need factual recall of science. You will need to show that you are familiar with laboratory apparatus and its use, including the reading of scales. You may be asked to plan experimental procedures; to record results in a table and/or plot them on a graph and draw straight lines/curves of best fit. You will need to explain results and be able to spot anomalous results and suggest explanations for them. You are expected to evaluate data obtained from experiments and experimental methods and to suggest improvements.</p> <p>To obtain a high mark you will need to recall the factual content of the specification and apply those facts to novel situations. You will also need to be familiar with laboratory work and the way in which science is conducted in a practical situation.</p>

Command words

Terms used within the papers include the following.

- **Balance** – chemistry questions may require students to balance an equation.
- **Calculate** – students may be asked to perform calculations.
- **Compare** – students should give the similarities and differences between the items being compared. This should not be answered by writing two separate paragraphs that deal separately with the two items.
- **Describe** – student responses should include the fundamental facts about the item or process they have been asked to describe.
- **Design** – students may be asked to design an experiment.
- **Explain** – students' responses should utilise the underlying principles and concepts involved.
- **Name/give** – students should name the object or process in question. They should not describe or explain it.
- **Plot/draw/complete/measure** – students may be asked questions requiring them to, for example, plot data, draw diagrams, complete tables or measure drawn apparatus.
- **State/identify** – students should give a concise response with no explanation unless this is requested.
- **Suggest** – students will be expected to give a logical response, not based on recall of knowledge, by applying the principles and concepts learned during the course. These may be related to new or familiar situations where there is no single, correct response.

Using the mark scheme

The mark scheme gives the responses we expect from students. Indicative answers are given but during the standardisation of examiners process the mark scheme is updated and expanded to cover unexpected, correct student responses.

Section C: Planning and teaching

Course planner

The following schemes show how to plan teaching over five terms of 10 weeks each. They are based on a **minimum** of five hours per week being available for teaching, and divided equally between biology, chemistry and physics, which should be taught in parallel. It is assumed that time in Term 6 will be used for revision and mock examinations.

You may wish to plan your own scheme. This is perfectly acceptable and allows a degree of flexibility, but any approach must ensure full coverage of the specification content including practical work and student investigations.

In putting together a delivery strategy you need to consider a number of parameters when deciding the best way to teach the qualification.

Parameter	Details
Sequence	In order for students to tackle some topics successfully, they will need prior knowledge and understanding of other topics. Topics need to be taught so that the content of one builds on and extends the content of another.
Continuity	A good course should flow. Where possible you should establish links between different areas of the specification so students appreciate the general nature of many underlying concepts and how topics relate to each other.
Difficulty	With any subject, students will find some topics easier to understand than others. It would be extremely off-putting to start a course with a topic that is generally perceived to be difficult. This would demotivate students, and once interest in the subject is lost, it is difficult to re-establish. It is good practice to start with the easier topics, leaving the more difficult ones until student interest and confidence have grown.
Variety	The specification gives you opportunities to address the various topics in a way which maintains student interest. A good course will vary the content continually rather than focus on specific areas for long periods of time.
Balance	It is important that the amount of time spent studying the different areas of the specification reflects the amount of related content. There is no benefit in spending an excessive amount of time studying one particular topic whilst leaving insufficient time to cover another properly.
Practicalities	It may be that your centre does not have sufficient resources for you to deliver the course in exactly the way you would wish. Perhaps, for example, owing to a shortage of equipment, what should really be an individual student-based practical session might have to become a class demonstration. Although not ideal, a good demonstration can provide a better lesson than an ill-equipped practical session.

There is no definitive sequence to delivering the course. It is up to you to devise the route through the course content which you think will be most appropriate for you and your students, based on the parameters listed. In addition to the specification content, you also need to consider issues such as how much practical work will be carried out.

Biology

Term 1 of 5

Week	Topic	Specification reference	Practical work
1-4	Nutrition in humans and biological molecules	B2.21, B2.22, B2.23, B2.24, B2.25, B2.26, B2.27, B2.5, B2.6, B2.7, B2.8, B2.9, B2.10	Describe the tests for glucose and starch. Describe how to carry out simple controlled experiments to illustrate how enzyme activity can be affected by changes in temperature.
5	Respiration	B2.28, B2.29, B2.30, B2.31	N/A
6-7	Gas exchange in humans	B2.36, B2.37, B2.38, B2.32, B2.39, B2.40	Describe a simple experiment to investigate the effect of exercise on breathing in humans.
8-10	Transport in humans	B2.48, B2.49, B2.50, B2.51, B2.52, B2.53, B2.54, B2.55	Describe a simple practical on the effects of exercise on heart rate in humans.

Term 2 of 5

Week	Topic	Specification reference	Practical work
1-2	Cell structure and movement of substances into and out of cells	B2.1, B2.2, B2.3, B2.4, B2.11, B2.12, B2.13, B2.41, B2.42, B2.14	Describe simple experiments on diffusion and osmosis using living and non-living systems.
3-4	Human excretion	B2.57, B2.58, B2.59, B2.60, B2.61, B2.62, B2.63, B2.64, B2.65	N/A
5-6	Human coordination and response and homeostasis	B2.66, B2.67, B2.68, B2.77	N/A
7-8	Nerves and eye	B2.72, B2.73, B2.74, B2.75, B2.76	Describe a simple experiment to show how the sensitivity of skin differs on fingers, back of hand, wrist and forearm.
9-10	Plant coordination and response	B2.69, B2.70, B2.71	Recall controlled experiments to demonstrate phototropic and geotropic plant growth responses.

Term 3 of 5

Week	Topic	Specification reference	Practical work
1-2	Plant nutrition	B2.15, B2.16, B2.17, B2.18, B2.19, B2.20	Describe simple controlled experiments to investigate photosynthesis, showing the evolution of oxygen from a water plant, the production of starch and the requirements of light, carbon dioxide and chlorophyll.
3-4	Plant gas exchange	B2.33, B2.34, B2.35, B2.56	N/A
5	Plant transport	B2.43, B2.44, B2.45, B2.46, B2.47	Describe experiments that investigate the role of environmental factors in determining the rate of transpiration from a leafy shoot.
6-8	The organism in the environment and feeding relationships	B4.1, B4.2, B4.3, B4.4, B4.5, B4.6, B4.7	Use quadrats to estimate the population size of an organism in two different areas.
9-10	Carbon, nitrogen and water cycles	B4.8	N/A

Term 4 of 5

Week	Topic	Specification reference	Practical work
1-3	Reproduction	B3.1, B3.2, B3.3, B3.4, B3.5, B3.6, B3.7, B3.8	Practical exercise to compare structures in an insect-pollinated and a wind-pollinated flower using suitable local specimens.
4-6	Inheritance	B3.9, B3.10, B3.12, B3.13, B3.14, B3.15, B3.16, B3.17, B3.18, B3.22, B3.23, B3.24, B3.25, B3.26, B3.27, B3.28	N/A
7-8	Cell division	B3.19, B3.20, B3.21	N/A
9	Cloning	B5.15, B5.16, B5.17	N/A
10	Selective breeding	B5.9, B5.10	N/A

Term 5 of 5

Week	Topic	Specification reference	Practical work
1-2	Food production and fish farming	B5.1, B5.2, B5.3, B5.4, B5.8	N/A
3-4	Genetic modification	B3.11, B5.11, B5.12, B5.13, B5.14	N/A
5-6	Micro-organisms	B5.5, B5.6, B5.7	Describe a simple experiment to investigate carbon dioxide production by yeast, in different conditions.
7-9	Human influences on the environment	B4.9, B4.10, B4.11, B4.12, B4.13, B4.14	N/A
10	Revision		Use sample assessment materials papers as practice for the examination.

Chemistry

Term 1 of 5

Week	Content	Specification reference	Practical work
1-2	Atoms, states of matter	C1.1-C1.3, C4.1-C4.2	N/A
3	Atomic structure	C1.4-C1.5, C1.8-C1.10	N/A
4-5	Electron configuration Periodic Table	C1.12-C1.14, C2.1-C2.5, C2.7	N/A
6-7	Ionic compounds	C1.24-C1.30, C1.39, C1.41-C1.44, C2.6	Electrolysis of aqueous salt solutions. Experiments to show that ions move during electrolysis.
7-8	Covalent compounds	C1.31-C1.33, C1.34-C1.36, C1.40	
9-10	Chemical formulae, relative formula mass, molar volumes	C1.11, C1.15-C1.17, C1.20-C1.23	Experiments to prove chemical formulae Titrations.

Term 2 of 5

Week	Content	Specification reference	Practical work
1-2	Chemical equations (ongoing throughout the course)	C1.18, C1.45	N/A
3-4	Mixtures and compounds, separation of mixtures	C1.6-C1.7	Experiments to separate mixtures, eg salt and sand, distillation of ink solution, paper chromatography of inks or sweet dyes.
5-6	Air, oxygen and oxides	C2.15-C2.16, C2.17-C2.18, C2.19-C2.23, C2.24	Determination of % oxygen in air. Combination of elements in oxygen. Preparation of carbon dioxide.
7-8	Group 1 elements	C2.6-C2.7	The reactions of lithium and sodium(demo) with water.
9-10	Group 7 elements	C2.8-C2.9, C2.12-C2.14	Halogen displacement reactions.

Term 3 of 5

Week	Content	Specification reference	Practical work
1	Hydrogen chloride and hydrochloric acid	C2.10-C2.11	Compare the reactions of solutions of hydrogen chloride in water and in methylbenzene.
2-3	Acids and alkalis	C4.1-C4.4	Test solutions of acids and alkalis with indicators. Use universal indicator to determine the pH of solutions of some common substances.
4-6	Neutralisation, titrations, salt preparation	C4.5-C4.9	Preparation of salts by various methods: acid with metal, metal oxide, metal carbonate; acid – alkali titrations; precipitation.
7-10	Rates of reactions (including investigations)	C4.15-C4.19	Experiments that investigate the effect of changing concentration, temperature and surface area on the rate of a reaction, eg marble chips and hydrochloric acid.

Term 4 of 5

Week	Content	Specification reference	Practical work
1-3	Metals and reactivity series	C1.37-C1.38, C2.29-C2.33	Reactions of carbon with metal oxides; reactions of metals with water/steam and dilute acids; displacement reactions involving metals and salt solutions.
4	Rusting	C2.34-C2.36	Experiments with iron nails to show that air and water are necessary for rusting to occur.
5- 6	Natural gas and oil	C5.10-C5.16, C5.17-C5.18	N/A
7-8	Alkanes and alkenes	C3.1-C3.8	Use of bromine water to distinguish between alkanes and alkenes.
9	Synthetic polymers	C5.14-C5.16	N/A
10	Equilibria	C4.20-C4.23	Heat copper(II) sulphate crystals and ammonium chloride.

Term 5 of 5

Week	Content	Specification reference	Practical work
1-2	Extraction and uses of aluminium and iron	C5.1-C5.5	N/A
3-4	Energetics	C4.10-C4.14	Measure the temperature changes that occur when: <ul style="list-style-type: none">• solids are added to water to form a solution• a displacement reaction occurs between a metal and a salt solution• acids and alkalis are mixed.
5-6	The manufacture and uses of ammonia	C5.17-C5.20	N/A
7-8	Tests for cations, anions and gases	C2.37-C2.39	Flame tests, test tube reactions for cations and anions, tests for gases and water.
9-10	Revision		

Physics

Term 1 of 5

Week	Content	Specification reference	Practical work
1-2	Distance, speed acceleration	P1.2-P1.7	Measurement of speed and acceleration using a tickertape timer.
2-3	Types of forces, friction	P1.8-P1.10	Measuring various forces, eg that required to open a door, using a spring balance.
4-5	$F = m \times a$ Weight, stopping distance, terminal velocity	P1.11-P1.14	Observation and measurement of terminal speed for a ball bearing falling through a measuring cylinder containing oil.
6	Moment of a force, centre of gravity	P1.15-P1.16	Investigating the principle of moments using a metre rule, pivot and known masses and determining the position of the centre of gravity of an irregularly shaped lamina.
7	Hooke's Law	P1.17-P1.19	Determination of the force-extension graphs for a metal spring and a rubber band by suspension of masses.
8	Astronomy	P1.20-P1.25	N/A
9	Hazards of electricity, insulation, earthing, fuses, circuit breakers, electrical heating in domestic contexts	P2.2-P2.3	Plugs, fuses.
10	Electrical energy, a.c., and d.c.	P2.4-P2.5, P2.8	Observation of a.c. and d.c. outputs using an oscilloscope, low voltage power supply and dry cell.

Term 2 of 5

Week	Content	Specification reference	Practical work
1	Electrical heating, $P = I \times V$ applied to fuses $E = I \times V \times t$	P2.6-P2.7	Range of appliances with wattage stamped on them.
2	Series and parallel circuits	P2.9-P2.10	Construction of series and parallel circuits using light bulbs, switches and a power supply.
3	The change of current with voltage	P2.11	Determination of voltage-current graphs for a wire, filament wire and diode.
4	Change of resistance: with resistance and in LDRs and thermistors	P2.12-P2.14	Observation of change of resistance with level of illumination for an LDR and with temperature for a thermistor.
5-6	$R = V/I$, charge and electric current in solid metal conductors	P2.15-P2.19	Verification of $R = V/I$ for a fixed resistor.
7-8	Properties of waves	P3.2-P3.7	Use a slinky spring and ripple tank to demonstrate the wave length and amplitude of transverse and longitudinal waves.
9-10	Properties of the electromagnetic spectrum and uses and dangers of different parts	P3.8-P3.11	Use a microwave generator and detector to demonstrate the wave properties of microwaves.

Term 3 of 5

Week	Content	Specification reference	Practical work
1-2	Reflection of light	P3.12-P3.14	Investigate the law of reflection of light using a plane mirror and a ray box (or pins).
3-4	Refraction of light, refractive index	P3.15, P3.16-P3.17	Investigate the refraction of light using a ray box (or pins) and rectangular glass block or prism.
5	Total internal reflection, critical angle	P3.18, P3.19, P3.20	Measurement of critical angle using a semicircular glass block and a ray box (or pins).
6	Reflection of sound waves, human frequency range	P3.21-P3.22	Use an oscilloscope and a signal generator to determine the frequency of a sound wave.
7	Speed of sound	P3.23	Measurement of the speed of sound by a simple clapping method.
8	Energy transfer and efficiency	P4.2-P4.5	Measurement of efficiency using an electric motor lifting a weight attached to a string over a pulley.
9	Energy transfer by conduction, convection and radiation	P4.6-P4.8	Experiments to demonstrate conduction using metal rods. Convection using potassium manganate (VII) crystal in water. Radiation using an electric heater, shiny and dull black surfaces.
10	Work done, force and distance, kinetic energy, gravitational potential energy	P4.9-P4.13	Investigate the conversion of gravitational potential energy to kinetic energy using ticker tape timer, runway, pulley, thread and weights.

Term 4 of 5

Week	Content	Specification reference	Practical work
1	Power, work done and time	P4.14-P4.15	Determination of power generated by climbing a flight of stairs and timing the ascent of a known vertical height.
2	Electricity generation from renewable and non-renewable resources and by electromagnetic induction	P4.16	Use a dynamo and lamp to demonstrate the generation of electrical energy.
3-4	Density and pressure	P5.2-P5.6	Determination of the density of regularly and irregularly shaped objects; solid and liquid pressure
5	Brownian movement, absolute zero, Kelvin scale	P5.7-P5.9	Observing Brownian motion using a microscope, glass cell, lamp and glass rod.
6	Relationship between pressure and Kelvin temperature; relationship for pressure and volume	P5.10-P5.13	Investigate Boyle's Law.
7	Magnetic poles and field lines	P6.2-P6.4	Plotting magnetic fields using bar magnets, plotting compasses and iron filings.
8-9	Magnetic effect of an electric current. Force on a charged particle or conductor in a magnetic field. Direction and size of resultant forces	P6.5-P6.8	Build a model motor.
10	Electromagnetic induction	P6.9-P6.10	Sensitive centre-zero meter, bar magnet, solenoid.

Term 5 of 5

Week	Content	Specification reference	Practical work
1	Protons, neutrons electrons, isotopes	P7.2-P7.3	N/A
2-3	Nature and penetrating power of alpha, beta and gamma radiation. Detection of ionising radiation, background radiation.	P7.4-P7.5, P7.8-P7.9	Detection of background radiation and investigate the penetrating power of ionising radiation using radioactive sources, Geiger-Muller tube, lead sheet, thin aluminium sheet and paper.
4	Effect of decay on atomic number and mass number. Balanced nuclear equations.	P7.6, P7.7	N/A
5	Half-life	P7.10-P7.12	Simulation using dice.
6-7	Uses and dangers of ionising radiations	P7.13-P7.14	N/A
8	Alpha particle scattering	P7.15-P7.16	N/A
9-10	Nuclear fission, nuclear reactors	P7.17-P7.20	N/A

Although this work can be extended to 10 weeks, you may wish to include revision work in between sections of *P7: Radioactivity and particles*.

Teaching ideas – experimental and investigative work

Experimental work is an integral part of studying science so it is appropriate that assessment of experimental and investigative skills should form 20 per cent of the final assessment.

It is strongly recommended that 20 per of the teaching time should be devoted to practical work carried out by students themselves. However, there may be circumstances where it is possible for the work to be carried out in small groups or even by demonstration alone.

Many of the topics will be taught in a way that allows the facts to arise from practical work rather than practical work being used to demonstrate what students have already been taught. This allows development of scientific method where theories can be developed in order to explain the observed facts and experimental work planned to test these theories.

In the examination students will be expected to have experience of working in a laboratory. They should be able to:

- recognise and explain the use of common items of laboratory apparatus
- plan practical procedures
- use the idea of a fair test
- read scales to an appropriate degree of accuracy and perform simple mathematical operations (including finding the mean) on results obtained
- use correct units for values
- record results in tables and use data presented in a variety of formats
- draw and use bar charts
- plot and use graphs and draw straight lines and curves of best fit
- identify relationships from graphs
- comment on the reliability and accuracy of data
- draw conclusions and offer explanations
- identify anomalous results and explain how they may have arisen
- evaluate given procedures and suggest improvements
- suggest further experimental work that may be required.

Training students in practical skills

While there is no requirement for students to conduct a full investigation from planning through to evaluation, all the skills needed to do so form the basis of the assessment of AO3.

Students would benefit from being introduced to the concept of practical investigative work before they begin the course. Research evidence has shown that students take a considerable amount of time to gain the confidence needed for higher level investigative skills such as critical evaluation.

Many students will need considerable guidance in order to progress from simply carrying out a set of practical instructions by the teacher, to the point where they are able to plan and carry out a whole investigation themselves and critically evaluate the outcome. However, the effort required will be well rewarded, as students then fully understand the principles and parameters on which scientific method is based.

Students should be encouraged to participate in practical work wherever possible. The scheme is designed to encourage a wide variety of activities, including those based on the collection of first-hand evidence and those which depend on secondary evidence. (The term 'evidence' is used to mean observations, measurements or other data.)

The value of demonstration work must not be overlooked. Demonstrations are important in teaching good techniques and they enable students to see experiments they cannot do themselves due to restrictions imposed by resources or safety considerations.

Opportunities for developing individual skills within schemes of work could include the following.

Activity	Details
Part lessons	When you have introduced a new piece of theory, ask students to use it to write (or use a computer to produce) an explanation for an everyday effect, for example by using the newly described kinetic theory, explain why sugar dissolves more quickly in hot water than in cold water. This approach has two benefits. Firstly, it gives you feedback quickly as to whether or not the lesson on kinetic theory has achieved its aim. Secondly, students can practise one aspect of the use of scientific knowledge and understanding.
Homework	This can be used to give students experience of using a wide range of individual skills, for example a pre-prepared worksheet giving students the task of choosing scales, plotting data and drawing lines of best fit. These types of activity should be used from an early stage in order to draw clearly the distinction between the use of the word 'line' in science, which includes both straight and curved lines, and the common use of 'line' which implies only a straight line. This worksheet approach could also be used to challenge students by asking them to use their graphs to comment on the accuracy of the observations and to identify anomalous results.
Tests	These can be used to present reminder/revision opportunities for individual skills, for example reading analogue or vernier scales.
Practicals	These can also be used to visit/revisit a wide variety of skills, for example selecting equipment; how many observations should be made (and over what range); safety; factors to vary or control; recording observations accurately; when to repeat observations; processing evidence; drawing a conclusion; and suggesting improvements to procedures used.
Investigations	Whilst these will normally be used for integrating all the individual skills from the four skill areas, a good case can be made for using investigations to introduce one or two skill areas initially, for example as homework a student writes a plan for an experiment they subsequently carry out in class, exactly as it is written!

Practical work and student investigations

Biology

Suggestions for practical work

Advice on how to approach each of the experiments or investigations is given below. This is not prescriptive as there are many ways practical work could be carried out to fulfil the requirements for training in practical skills.

1 Tests for glucose, starch, lipid and protein

Tests that are expected:

- Benedict's test for glucose
- iodine test for starch
- the emulsion test for lipid (NB This test is not required for the exam)
- biuret reagent for protein (NB This test is not required for the exam).

Tests that could be carried out:

- on prepared samples of pure substances
- on foods that contain the substances
- in a context.

Example

- To demonstrate health applications, a fake 'urine sample' can be made by colouring water with iodine solution. A similar solution, with glucose added, could mimic the urine of an untreated diabetic. Students can use Benedict's test to identify the diabetic.
- The iodine test could be introduced when teaching that plants manufacture starch by photosynthesis, or when investigating the effect of amylase on starch digestion.

2 Controlled experiments to illustrate how enzyme activity can be affected by changes in temperature

The effect of amylase on starch digestion is a straightforward topic. At each temperature selected, from 0°C to 100°C, samples of amylase solution and starch solution are brought to temperature before being added together. The mixture is then kept at the same temperature. To measure the rate of reaction, drops of the mixture can be collected at one-minute intervals and added to individual iodine drops on a white tile. The time taken for the starch to disappear is recorded for each temperature.

Temperature-controlled water baths will help students, but stable temperatures can also be achieved by using beakers of water, thermometers, ice and Bunsen burners.

There is plenty of scope for students, working individually, to plan how to keep all variables, except for temperature, the same, to consider repetition, to display their results in tables and plot them as graphs, and to evaluate their results.

Catalase is another enzyme that can be used. There are a number of sources, but potato or liver are most commonly used. Catalase converts hydrogen peroxide into water and oxygen. The rate of oxygen production can be measured as an indication of enzyme activity. An upturned burette previously filled with water can be used to collect and measure the volume of evolved oxygen. Hydrogen peroxide is toxic and great care needs to be taken when using it.

3 Simple experiments on diffusion and osmosis using living and non-living systems

- a Cubes of agar jelly placed into solutions of methylene blue or potassium permanganate will absorb the pigment by diffusion. The cubes are left in the pigmented solution for different, measured periods of time and are then sliced open. The distance between the edge of each cube and the edge of the coloured agar may be used as a measure of the distance the pigment molecules have moved by diffusion.
- b A crystal of potassium permanganate can be dropped into a beaker of water and the appearance of the water noted over time.
- c To demonstrate osmosis, Visking tubing (dialysis tubing) can be tied at one end and filled with 20 per cent sucrose solution. The other end is attached to a capillary tube. The level of the sucrose can be noted before and after the tubing has been placed in a beaker of water for about 30 minutes.
- d Onion epidermis can be peeled away, cut into squares and mounted on slides in different concentrations of sucrose solution. Observation under a microscope will show the effects of osmosis.
- e Red blood cells in blood obtained from a butcher may be mounted on slides in hypotonic, isotonic and hypertonic saline, and observed under a microscope to show the effects of osmosis.
- f Osmosis can be demonstrated by using strips of potato. This basic experimental method provides a good opportunity for students to carry out individual, whole investigations. The osmosis concept can be difficult and it is better to keep this investigation until the latter part of the course so that students will have had previous experience of investigating simpler topics. Students enjoy the reference to ‘chips’, but should realise that it can be difficult to keep the size of the potato strips constant – to achieve consistency lengths of potato tissue can be drilled using a cork borer. The ‘chips’ are measured by mass or length and are placed into sucrose solutions of different concentrations for at least one hour. The percentage change in mass or length is a measure of the degree of osmosis that has occurred.
- g A variation on this theme is to cut potato cubes of different sizes, which have different surface area to volume ratios. After measuring and recording the masses of the cubes, they are immersed in water. After one hour, the cubes are blotted dry and their masses measured and recorded again. The percentage increase in the mass of cubes of different surface area to mass ratio can be compared in order to explore the concept of how surface area to volume ratio influences water uptake.

4 Controlled experiments to investigate photosynthesis, showing the evolution of oxygen from a water plant, the production of starch by leaves and the requirements for light, carbon dioxide and chlorophyll

- a The evolution of oxygen from a water plant can be seen by placing a water plant (typically *Elodea* or similar species) in a beaker of water and covering it with a glass funnel which has a water-filled test tube placed over its opening. After 24 hours, a colourless gas will have displaced water from the test tube – a test for oxygen can then be carried out.
- b To measure the rate of oxygen production, the stem of a water plant is cut under water and the plant kept immersed in water in a beaker or boiling tube. The number of bubbles of gas given off over a measured time period can be counted. This simple experiment gives students the opportunity to carry out individual investigations into the effect of different factors on the rate of bubble production. Suitable variables include: light intensity (the plant is exposed to a light source and the rate of bubble production measured at different light intensities by changing the distance between the light source and the water plant); colour/wavelength of light (coloured filters are placed between the plant and the light source); carbon dioxide availability (the plant is immersed in solutions of different concentrations of sodium hydrogen carbonate).
- c Starch production can be investigated by placing a plant in the dark for 24 hours to destarch the leaves. A starch test on a leaf will not give a blue-black colour, whereas a similar test on a control leaf from a plant kept in the light will give a blue-black colour.
- d A starch test on a variegated leaf can be used to demonstrate that chlorophyll is needed for photosynthesis.
- e To show that carbon dioxide is needed for photosynthesis a leaf on a plant may be surrounded by air without carbon dioxide by inserting it into a conical flask containing a small amount of potassium or sodium hydroxide. The plant is left in good light for 24 hours. The test leaf and a control leaf from the plant are then tested for starch*.

*To test leaves for starch:

- drop them into very hot/boiling water for one minute (to destroy the cell membranes so that chlorophyll molecules can pass through)
- drop into hot ethanol (to remove/dissolve the green chlorophyll)
- drop into water (to rehydrate and soften the leaf so that it can be spread out)
- drop iodine solution onto the leaf (test for starch) – blue-black colour will show the presence of starch.

These experiments provide opportunities for students to demonstrate safe handling of equipment and materials and in the use of controls.

5 A simple experiment to determine the energy content of a food sample

Fat-containing foods such as dried crisps work very well.

- A known mass of the food sample is weighed and the mass noted.
- A boiling tube, containing a known volume of water, is prepared. The water temperature is recorded.
- The food sample is put in a crucible or burning spoon and ignited (for example in the flame of a Bunsen burner).
- The food sample is quickly placed under the boiling tube. As soon as the food sample has burnt completely the water temperature in the boiling tube is re-measured.
- The equation used to calculate the energy content of the food is:

$$\frac{\text{Energy content of food sample (joules per gram)}}{\text{mass of water heated (g) x temperature rise (}^{\circ}\text{C) x 4.2 x 1/mass of food sample (g)}}$$

Warning! Peanuts should not be used as the food sample because some people have a serious allergic reaction to them.

To obtain an accurate result, all the energy in the food sample needs to be transferred to the water. Students could be asked to think of reasons why this method produces an inaccurate result and to suggest ways in which the apparatus could be modified to make the result more accurate.

6 Controlled experiments to demonstrate the evolution of carbon dioxide and heat from respiring seeds or other suitable living organisms

Vacuum flasks are needed for this activity. Surface sterilised seeds are put into a flask which is sealed with a bung. A glass tube runs from inside the flask, through the bung and into an indicator solution of either limewater or hydrogen carbonate. The carbon dioxide produced changes the colour of the indicator solution. To show heat production the flask needs a cotton wool bung with a thermometer going through the bung into the flask.

Students could demonstrate that they produce carbon dioxide by breathing out through a tube into limewater or a hydrogen carbonate indicator.

7 Simple controlled experiments to investigate the effect of light on net gas exchange from a leaf, using hydrogen-carbonate indicator

A water plant can be placed in a sealed tube of air-equilibrated hydrogen carbonate solution (red in colour) and placed in the light or the dark. The solution will turn purple if kept in the light and yellow if kept in the dark.

A variation could involve the use of water snails or, if not available, small land insects placed on a gauze platform above the indicator, with and without the water plant. This variation allows students to think about the balance between carbon dioxide used during photosynthesis and carbon dioxide produced by respiration.

A useful demonstration is to use four tubes containing hydrogen carbonate solution: one with a water plant only, one with animals only, one with both a water plant and animals and one with no living organisms. One of the tubes is exposed to light and left for 12 to 24 hours and another placed in the dark for the same length of time.

8 A simple experiment to investigate the effect of exercise on breathing in humans

Breathing rate can be measured at rest and after a period of exercise by counting the number of inhalations per minute.

To help students appreciate that exercise also influences the rate of breathing by increasing the volume of each breath, they can measure the volume of one exhalation before and after exercise. This can be done by breathing through a tube into a plastic container filled with water. The volume of displaced water can be measured. The breathing rate at rest and after exercise can be calculated as number of breaths per minute \times volume of each breath.

Students may need to work in pairs: one to carry out the investigation and take measurements and the other as the subject of the investigation.

Students' health must be considered if they are to be the subject of this investigation with regard to asthma or other breathing conditions.

9 Experiments to investigate the role of environmental factors in determining the rate of transpiration from a leafy shoot

A bubble potometer can be used to illustrate the effects of light, wind, temperature and air humidity. Plants covered with dark polythene bags to simulate darkness can be compared with plants covered with transparent polythene bags. Hairdryers can simulate wind. The use of potted plants is acceptable, where the pot and the soil are sealed with polythene and the mass of the potted plant is measured before and after a period of exposure to the environmental factor.

10 Controlled experiments to demonstrate phototropic and geotropic plant growth responses

Plant material such as wheat, maize, oat or cress seedlings can be used to demonstrate phototropism. Petri dishes containing moist cotton wool and the plant material can be put into light proof boxes such as shoe boxes. To create unilateral light, a small slit can be cut in one side of the box and light shone into the box. Control seedlings can either have aluminium caps put on their tips or be kept in a shoe box without a slit for light. A klinostat needs to be used to demonstrate geotropism.

11 The use of quadrats to estimate the population size of an organism in two different areas

Quadrats can be used to sample part of each area. Calculations will be needed to work out the estimated population size. For example, if 10 quadrats have been used and the total area amounts to 100 quadrats, the estimated population size will be the number of organisms counted in the 10 sample quadrats \times 10.

Students are expected to understand the importance of placing the sample quadrats randomly.

An interesting way to practise the technique is to throw plastic beads on the floor of the classroom and ask students to guess how many beads there are. The quadrat sampling procedure can be used to get an estimate. The beads can then be collected and counted. The actual number can be compared to the estimated number and used to see how accurate the estimation was.

12 A simple experiment to investigate carbon dioxide production by yeast, in different conditions

Students add yeast to glucose solution in a side-arm test tube. Anaerobic conditions are achieved by putting a drop of oil (cooking oil will do) onto the yeast and glucose mixture. A rubber tube is attached to the side-arm of the test tube and a glass pipette is inserted at the other end of the rubber tube. The pipette is placed under water to allow the bubbles of carbon dioxide gas to be counted. Temperature is the easiest condition to investigate. Glucose concentration and pH could also be investigated.

Chemistry

Suggestions for practical work

The following list of practical activities is not compulsory or exhaustive. Before any practical activity is undertaken a full risk assessment should be conducted. The practical activities carried out will depend on available resources, group sizes and the ability level and prior experience of students. The suggested practical activities will not be suitable in all cases but you may like to consider them. Details of how to carry out these activities should be available in textbooks or the internet.

1 Principles of Chemistry

- Diffusion of gases and in solutions
- Diffusion of $\text{NH}_3(\text{g})$ and $\text{HCl}(\text{g})$
- Physical properties of substances compared to structure and bonding
- Determination of the formula of copper oxide by reduction
- Determination of the volume of one mole of hydrogen
- Acid/alkali titrations
- Electrolysis of molten lead bromide
- Electrolysis of aqueous solutions

2 Chemistry of the Elements

- Determination of the oxygen content of the air
- Laboratory preparation of oxygen
- Burning elements in oxygen
- Laboratory preparation of carbon dioxide
- The thermal decomposition of copper(II) carbonate
- Group 1 metals with water
- Displacement reactions of metals (solutions and thermite type)
- Reduction of metal oxides using carbon
- Cause and prevention of rusting
- Anion and cation analysis
- Reaction of halogens with iron wool/‘dutch metal’
- Dissolving hydrogen chloride in water and methylbenzene
- Endothermic reactions – sodium carbonate decahydrate with citric acid crystals
- Measurement of enthalpy change (displacement reactions; combustion)

3 Organic Chemistry

- Fractional distillation of ‘artificial crude oil’
- Reaction of hexane with bromine in UV light
- Reaction of alkenes with bromine water

4 Physical Chemistry

- The effect of acids and alkalis on a selection of indicators
- Reactions of acids with metals, metal carbonate and metal oxides
- Making crystals of a soluble salt using an insoluble metal oxide or metal carbonate
- Making crystals of a soluble salt by titration
- Precipitation reactions
- Making dry samples of insoluble salts
- Effect of heat on ammonium chloride
- Effect of surface area on rate, using marble chips and hydrochloric acid
- Effect of concentration on rate (metals/marble chips with acid; thiosulfate with acid; clock reactions)
- Effect of temperature on rate (metals/marble chips with acid; sodium thiosulfate with acid; clock reactions)
- Catalytic decomposition of hydrogen peroxide

5 Chemistry in Society

- Making polystyrene
- Cracking long chain alkanes
- Reactions of ammonia

Physics

Suggestions for practical work

The following is a guide to practical work students could carry out themselves and the demonstrations you could use to amplify the teaching of the seven areas of content.

1 Force and motion

- Measurement of speed using a ticker tape timer and tape.
- Measurement of acceleration using a ticker tape timer and tape.
- Investigation of the momentum of bodies before and after collisions.
- Measuring various forces, for example that required to open a door, using a spring balance.
- Observation and measurement of terminal speed for a ball bearing falling through a measuring cylinder containing oil.
- Investigation of the principle of moments using a metre rule, pivot and two known masses.
- Determination of the position of the centre of gravity of an irregularly-shaped lamina using a plumb line.
- Determination of the force-extension graphs for a metal spring and a rubber band by suspension of masses.

2 Electricity

- Observation of a.c. and d.c. outputs using an oscilloscope, low voltage power supply and dry cell.
- Construction of series and parallel circuits using light bulbs, switches and a power supply.
- Determination of V-I graphs for a wire, filament wire and diode.
- Observation of variation of resistance with level of illumination for an LDR.
- Observation of variation of resistance with temperature for a thermistor.
- Verification of Ohm's Law for a standard resistor.
- Using a gold leaf electroscope to show the opposite charges on charged polythene and cellulose acetate rods rubbed with the same cloth.
- Using a Van de Graaf generator to show that an electric current consists of a stream of charges.

3 Waves

- Using a slinky spring to demonstrate the wavelength and amplitude of transverse and longitudinal waves.
- Using a ripple tank to demonstrate diffraction of water waves.
- Using a microwave generator and detector to demonstrate wave properties of microwaves.
- Investigating the law of reflection of light using a plane mirror and a ray box (or pins).
- Investigating the refraction of light using a ray box (or pins) and rectangular glass prism.
- Measuring critical angle using a circular glass block and a ray box (or pins).
- Measurement of the range of human hearing using a signal generator and loudspeaker.
- Measurement of the speed of sound by a simple clapping method using a stopwatch.
- Measurement of the speed of sound using a resonance tube and tuning forks.
- Measurement of the speed of sound using a microphone, signal generator and oscilloscope.
- Using an oscilloscope and a signal generator to determine the frequency of a sound wave.
- Using an oscilloscope, signal generator and speaker to investigate the dependence of loudness on amplitude and pitch on frequency for a sound wave.

4 Energy resources and energy transfer

- Measurement of efficiency using an electric motor to lift a weight attached to a string over a pulley.
- Using a falling mass connected to a dynamics trolley via a thread passing over a pulley to investigate the conversion of gravitational potential energy to kinetic energy.
- Determination of power generated by climbing a flight of stairs and timing the ascent of a known vertical height.
- Using a dynamo and lamp to demonstrate the generation of electrical energy.

5 Solids, liquids and gases

- Determination of the density of regularly and irregularly shaped objects.
- Determination of solid and liquid pressure.
- Plotting a cooling curve for ethanamide.
- Observing Brownian motion using a microscope, glass cell, lamp and glass rod.
- Investigating Boyle's Law and the Pressure Law.

6 Magnetism and electromagnetism

- Plotting magnetic fields using bar magnets, plotting compasses (and/or iron filings).
- Investigating the magnetic fields associated with a straight wire, coil and solenoid carrying an electric current.
- Investigating the factors affecting the strength of an electromagnet.
- Building a model motor.
- Investigating the factors affecting the size and direction of an induced voltage using a bar magnet, long solenoid and centre-zero meter.
- Investigating a transformer using C-cores, wiring, a low voltage a.c. supply, voltmeter and lamp.

7 Radioactivity and particles

- Detection of background radiation using a Geiger-Muller tube.
- Investigating the penetrating power of alpha, beta and gamma radiation using radioactive sources, absorbers and a Geiger-Muller tube.

Suggested titles for investigations

The experimental and investigative tasks below could be carried out using the resources recommended in the course planner, plus any other available resources.

- 1 Compare the insulating properties of different materials such as bubble wrap, cotton wool and plastic foam.
- 2 Investigate the effect of length on the resistance of a wire.
- 3 Investigate the effect of the height fallen by an object on the depth of the crater produced.
- 4 When light travels through a glass block, investigate how the length of the glass block affects the lateral displacement of the light ray.
- 5 Investigate the factors affecting the time period of a simple pendulum.
- 6 Investigate how the temperature of a squash ball affects the height it bounces off the floor.
- 7 Investigate the percentage energy losses of different bouncing balls.
- 8 Investigate how the weight of a body affects the size of the frictional force opposing its motion.
- 9 Investigate how the area of a model parachute affects its rate of descent.
- 10 Investigate how the depth of water affects the speed of water waves.

Appendices

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Appendix 1 – Periodic Table

THE PERIODIC TABLE

Period 1 2 3 4 5 6 7 0

1	2	3	4	5	6	7	0																								
7 Li Lithium 3	9 Be Beryllium 4	11 Na Sodium 11	12 C Carbon 6	13 Al Aluminium 13	14 N Nitrogen 7	15 P Phosphorus 15	16 S Sulphur 16	17 Cl Chlorine 17	18 Ar Argon 18																						
19 K Potassium 19	20 Ca Calcium 20	21 Sc Scandium 21	22 Ti Titanium 22	23 V Vanadium 23	24 Cr Chromium 24	25 Mn Manganese 25	26 Fe Iron 26	27 Co Cobalt 27	28 Ni Nickel 28	29 Cu Copper 29	30 Zn Zinc 30	31 Ga Gallium 31	32 Ge Germanium 32	33 As Arsenic 33	34 Se Selenium 34	35 Br Bromine 35	36 Kr Krypton 36														
37 Rb Rubidium 37	38 Sr Strontium 38	39 Y Yttrium 39	40 Zr Zirconium 40	41 Nb Niobium 41	42 Mo Molybdenum 42	43 Tc Technetium 43	44 Ru Ruthenium 44	45 Rh Rhodium 45	46 Pd Palladium 46	47 Ag Silver 47	48 Cd Cadmium 48	49 In Indium 49	50 Sn Tin 50	51 Sb Antimony 51	52 Te Tellurium 52	53 I Iodine 53	54 Xe Xenon 54														
55 Cs Caesium 55	56 Ba Barium 56	57 La Lanthanum 57	58 Ce Cerium 58	59 Pr Praseodymium 59	60 Nd Neodymium 60	61 Pm Promethium 61	62 Sm Samarium 62	63 Eu Europium 63	64 Gd Gadolinium 64	65 Tb Terbium 65	66 Dy Dysprosium 66	67 Ho Holmium 67	68 Er Erbium 68	69 Tm Thulium 69	70 Yb Ytterbium 70	71 Lu Lutetium 71	72 Hf Hafnium 72	73 Ta Tantalum 73	74 W Tungsten 74	75 Re Rhenium 75	76 Os Osmium 76	77 Ir Iridium 77	78 Pt Platinum 78	79 Au Gold 79	80 Hg Mercury 80	81 Tl Thallium 81	82 Pb Lead 82	83 Bi Bismuth 83	84 Po Polonium 84	85 At Astatine 85	86 Rn Radon 86
87 Fr Francium 87	88 Ra Radium 88	89 Ac Actinium 89																													

Key

Relative atomic mass
Symbol
Name
Atomic number

Appendix 2 – Physics formulae for relationships

The relationships listed below will **not** be provided for IGCSE students in any form.

- (i) the relationship between average speed, distance and time:

$$\text{average speed} = \frac{\text{distance}}{\text{time}}$$

- (ii) the relationship between force, mass and acceleration:

$$\text{force} = \text{mass} \times \text{acceleration}$$

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

- (iii) the relationship between density, mass and volume:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

- (iv) the relationship between force, distance and work:

$$\text{work done} = \text{force} \times \text{distance moved in direction of force}$$

- (v) the energy relationships:

$$\text{energy transferred} = \text{work done}$$

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$$

$$\text{gravitational potential energy} = \text{mass} \times g \times \text{height}$$

- (vi) the relationship between mass, weight and gravitational field strength:

$$\text{weight} = \text{mass} \times \text{gravitational field strength}$$

- (vii) the relationship between an applied force, the area over which it acts and the resulting pressure:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

- (viii) the relationship between the moment of a force and its distance from the pivot:
moment = force \times perpendicular distance from the pivot
the relationships between charge, current, voltage, resistance and electrical power:
- (ix) charge = current \times time
voltage = current \times resistance
electrical power = voltage \times current
- (x) the relationship between speed, frequency and wavelength:
wave speed = frequency \times wavelength
- (xi)
$$\frac{\text{input (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$$
- (xii) the relationship between refractive index, angle of incidence and angle of refraction:

$$n = \frac{\sin i}{\sin r}$$
- (xiii) the relationship between refractive index and critical angle:

$$\sin c = \frac{1}{n}$$
- (xiv) the relationship for pressure difference:
pressure difference = height \times density \times g

$$p = h\rho g$$

Appendix 3 – Electrical circuit symbols

Description	Symbol	Description	Symbol
conductors crossing with no connection		heater	
junction of conductors		thermistor	
open switch		light-dependent resistor (LDR)	
closed switch		relay	
open push switch		diode	
closed push switch		light-emitting diode (LED)	
cell		lamp	
battery of cells		loudspeaker	
power supply		microphone	
transformer		electric bell	
ammeter		earth or ground	
milliammeter		motor	
voltmeter		generator	
fixed resistor		fuse/circuit breaker	
variable resistor			

November 2009

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