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IGCSE

London Examinations IGCSE

Science (Double Award) (4437)

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Teacher's Guide

London Examinations IGCSE

Science (Double Award) (4437)

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Contents

Introduction

This guide provides support and guidance for teachers and lecturers preparing students for IGCSE Science (Double Award). It provides helpful information about the course content, particularly practical work, the assessment model and course planning.

The purpose of the guide is

- to advise about the different patterns of entry that are possible in this flexible specification, both in terms of tier of entry and the assessment of experimental work
- to describe the assessment objectives and the weightings given to them in each component of the assessment
- to assist the teacher in planning the delivery of the specification by discussing some of the parameters which need careful consideration, and suggesting a possible timetable for teaching
- to advise the teacher on the procedures relating to coursework for those who wish to pursue this option. Important features such as task setting, assessment, recording marks and standardisation are all described in detail.

This guide will help the teacher to translate the specification content into a course that suits the conditions within each individual centre and reflects their preferred order of teaching.

The specification, specimen papers and mark schemes and teacher's guide together provide teachers with all the support they need to deliver this course successfully.

Tiers of entry

Students are entered for **either** Foundation Tier **or** Higher Tier.

The **Foundation Tier** written papers, 1F (Biology), 2F (Chemistry) and 3F (Physics), are designed for students who are unlikely to achieve a high grade, but whose achievement can still be recognised with a grade at the appropriate level. No matter how well students may do on the Foundation Tier paper, the highest grade they can be awarded is grade C. Students who fail to achieve grade G will be awarded 'Ungraded'.

The **Higher Tier** written papers, 4H (Biology), 5H (Chemistry), 6H (Physics), contain questions that are more demanding, and which cover some topics that are for Higher Tier students only. These topics are printed in **bold type** in the specification. The highest grade which can be awarded on the Higher Tier is A*, a grade reserved for only the highest achievers at the top of grade A. Questions on the Higher Tier are targeted at grades A* to D, but there is a 'safety net' for those who narrowly fail to achieve grade D. A grade E can be awarded to students who are within a few marks of grade D. Students who fail to achieve the safety net grade E will be awarded 'Ungraded'.

The Foundation and Higher Tier papers take place at the same time, so students cannot be entered for both examinations. This puts a responsibility on the teacher to ensure that a student is entered for the appropriate tier. Students who consistently achieve a grade C standard of work in practice tests would normally be entered for the Higher Tier, where they have the opportunity to achieve the higher grades.

Foundation Tier candidates **must** take papers 1F, 2F and 3F.

Higher Tier candidates **must** take papers 4H, 5H and 6H.

Because of the overlap at grades C and D between the two tiers, there are some questions common to both tiers. On the Foundation Tier papers this is 30 marks out of a total of 75 marks for each paper, and on the Higher Tier papers this is 30 marks out of a total of 90 marks for each paper.

Investigative skills are assessed either by the **written alternative to coursework** (papers 7, 8 and 9) or by internally assessed **coursework** (component 10). These assessment components are untiered and assess achievement in the whole range of grades from A* to G. They are taken by **both** Foundation and Higher Tier candidates who will enter for **two** of papers 7, 8 and 9 **or** submit coursework marks covering at least **two** sciences from biology, chemistry and physics.

The coursework submitted for assessment must meet the following requirements

- it must cover at least two of the sciences: Biology, Chemistry and Physics
- there must be two marks for each skill area (P, O, A and E)
- one mark must be taken from a whole investigation
- a minimum of two, and a maximum of four pieces of work are submitted

Further information about coursework can be found in the section starting on page 31.

Use of calculators is permitted in all written examinations.

Structure of specification

Foundation tier summary

Foundation Tier candidates must take papers 1F, 2F and 3F assessing Biology, Chemistry and Physics respectively. In addition, Foundation Tier candidates are entered for either

(a) a choice of **two** of the three written papers testing practical skills

OR (b) coursework (only available to centres approved by Edexcel International to offer coursework).

Paper / Component	Mode of assessment	Weighting and length
1	Examination Paper 1F (Biology), targeted at grades C – G (Foundation Tier).	The three equally weighted examination papers are worth 80% of the overall assessment. Each paper lasts 1 hour and 15 minutes.
AND		
2	Examination Paper 2F (Chemistry), targeted at grades C – G (Foundation Tier).	
AND		
3	Examination Paper 3F (Physics), targeted at grades C – G (Foundation Tier).	

AND

7	Examination Paper 7 (Biology), targeted at grades A* – G (common to both tiers).	Candidates are entered for **two** of the three written alternatives to practical coursework papers. Each paper lasts 1 hour and 15 minutes. The two papers account for 20% of the overall assessment.
AND / OR		
8	Examination Paper 8 (Chemistry), targeted at grades A* – G (common to both tiers).	
AND / OR		
9	Examination Paper 9 (Physics), targeted at grades A* – G (common to both tiers).	
OR		
10	Coursework, targeted at grades A* – G (common to both tiers). Assignments required in at least **two** science subjects.	20%

Higher tier summary

Higher Tier candidates **must** take papers 4H, 5H and 6H assessing Biology, Chemistry and Physics respectively. In addition, Higher Tier candidates are entered for either

(a) a choice of **two** of the three written papers testing practical skills

OR (b) coursework (only available to centres approved by Edexcel International to offer coursework).

Paper / Component	Mode of assessment	Weighting and length
4	Examination Paper 4H (Biology), targeted at grades A* – D (Higher Tier).	The three equally weighted examination papers are worth 80% of the overall assessment. Each paper lasts 1 hour and 30 minutes.
AND		
5	Examination Paper 5H (Chemistry), targeted at grades A* – D (Higher Tier).	
AND		
6	Examination Paper 6H (Physics), targeted at grades A* – D (Higher Tier).	

AND

7	Examination Paper 7 (Biology), targeted at grades A* – G (common to both tiers).	Candidates are entered for **two** of the three written alternatives to practical coursework papers. Each paper lasts 1 hour and 15 minutes. The two papers account for 20% of the overall assessment.
AND / OR		
8	Examination Paper 8 (Chemistry), targeted at grades A* – G (common to both tiers).	
AND / OR		
9	Examination Paper 9 (Physics), targeted at grades A* – G (common to both tiers).	
OR		
10	Coursework, targeted at grades A* – G (common to both tiers). Assignments required in at least **two** science subjects.	20%

Summary of the routes of assessment

Candidates are entered for **either** Foundation Tier **or** Higher Tier.

Foundation Tier questions are targeted at grades in the range C – G.

Higher Tier questions are targeted at grades in the range A* – D.

Foundation Tier Route

All Foundation Tier candidates must take papers 1F, 2F and 3F.

Foundation Tier, Coursework route

Candidates submit **two** coursework assignments covering at least two science subjects, e.g. Biology and Chemistry, Chemistry and Physics, Biology and Physics.

Foundation Tier, Non-coursework route

Candidates take **two** written papers assessing practical skills, i.e. **either** Papers 7 and 8 **or** Papers 7 and 9 **or** Papers 8 and 9.

Foundation Tier candidates can achieve grades C – G. Candidates who fail to achieve grade G will be awarded 'Unclassified'.

Higher Tier Route

All Higher Tier candidates must take papers 4H, 5H and 6H.

Higher Tier, Coursework route

Candidates submit **two** coursework assignments covering at least two science subjects, e.g. Biology and Chemistry, Chemistry and Physics, Biology and Physics.

Higher Tier, Non-coursework route

Candidates take **two** written papers assessing practical skills, i.e. **either** Papers 7 and 8 **or** Papers 7 and 9 **or** Papers 8 and 9.

Higher Tier candidates can achieve grades A* – D. There is a 'safety net' grade E for candidates who narrowly fail to achieve grade D. Candidates who fail to achieve grade E on Higher Tier will be awarded 'Unclassified'.

Assessment requirements

Assessment objectives

This specification requires that all candidates demonstrate the following assessment objectives in the context of the content and skills prescribed.

AO1 Knowledge and understanding

In the examination, students will be tested on their ability to

- recognise, recall and show understanding of specific scientific facts, terminology, principles, concepts and practical techniques including aspects of safety
- draw on existing knowledge to show understanding of the social, economic, environmental and technological applications and implications of Biology, Chemistry and Physics
- select, organise and present relevant information clearly and logically, using appropriate vocabulary.

AO2 Application of knowledge and understanding, analysis and evaluation

In the examination, students will be tested on their ability to

- describe, explain and interpret phenomena, effects and ideas in terms of the principles and concepts of Biology, Chemistry and Physics, presenting arguments and ideas clearly and logically
- interpret and translate, from one form to another, data presented as continuous prose or in tables, diagrams, drawings and graphs
- carry out relevant calculations
- apply the principles and concepts of Biology, Chemistry and Physics to unfamiliar situations, including those related to applications of these sciences in different domestic, industrial and environmental contexts
- evaluate scientific information and make informed judgements based on it.

AO3 Experimental and investigative skills

In the assessment of these practical skills, students will be tested on their ability to

- devise and plan investigations, selecting appropriate techniques
- demonstrate or describe appropriate experimental and investigative methods, including safe and skilful practical techniques
- make observations and measurements with appropriate precision, record these methodically, and present them in a suitable form
- analyse and interpret data from experimental activities to draw conclusions which are consistent with the evidence, using scientific knowledge and understanding, and communicate these findings using appropriate specialist vocabulary
- evaluate data and methods.

Weighting of assessment objectives

In the examination, the weighting given to each assessment objective will be as shown in the following table.

Assessment objective		Weighting
AO1	Knowledge and understanding (mainly assessed in papers 1F, 2F and 3F or 4H, 5H and 6H)	45 – 55% (of which no more than half will be recall)
AO2	Application of knowledge and understanding, analysis and evaluation (mainly assessed in Papers 1F, 2F and 3F or 4H, 5H and 6H)	25 – 35% (evenly distributed across all aspects of the objective)
AO3	Experimental and investigative skills (mainly assessed in Papers 7,8 and 9 or coursework)	20%

The percentages are not intended to provide a precise statement of the number of marks allocated to particular assessment objectives.

Course content

Summary

The content of this specification provides equal coverage of Biology, Chemistry and Physics. It takes approximately two-thirds of the subject content of each of the London Examinations IGCSE single sciences (Biology 4325, Chemistry 4335 and Physics 4420), and combines them into an IGCSE Science specification worth two IGCSEs.

The content for each of Biology, Chemistry and Physics is divided into several areas of content. Each area has associated with it sections that are essential for full understanding of the content. Some of the content is for **Higher Tier** candidates only and is printed in **bold**.

The areas of content for Biology, Chemistry and Physics are given below.

Biology

Section B1: Nature and variety of living organisms

Section B2: Structures and functions in living organisms

Section B3: Reproduction and inheritance

Section B4: Ecology and the environment

Section B5: Use of biological resources

Chemistry

Section C1: Principles of chemistry

Section C2: Chemistry of the elements

Section C3: Organic chemistry

Section C4: Physical chemistry

Section C5: Chemistry in society

Physics

Section P1: Forces and motion

Section P2: Electricity and electromagnetism

Section P3: Waves

Section P4: Energy resources and energy transfer

Section P5: Solids, liquids and gases

Section P6: Radioactivity and particles

Command words

The following command words used in the specification indicate the depth of knowledge and understanding required for a particular topic, and are also likely to be used in examination questions set on the topic.

Calculate	The student will be required to work out the numerical value of some quantity using given data.
Describe	The student will be required to write prose answers to demonstrate the facts remembered about a topic.
Evaluate	The student will be asked to analyse information and explain the underlying principle(s).
Explain	The student will need to comment on the underlying principle(s).
Predict	The student should be able to apply their understanding of similar substances or situations in order to work out answers.
Recall	The student will be expected to remember facts.
Recognise	The student will be expected to identify parts on a diagram.
Understand	The student will need to appreciate the importance and relevance of scientific facts. Where a student is required to understand a particular topic the student will also be required to recall it.

Course planning

The schemes that follow show a way to plan the teaching over five terms of ten weeks each. It is based on there being a **minimum** of 5 hours per week available for the teaching of the specification, to be divided equally between Biology, Chemistry and Physics, which should be taught in parallel. The scheme is described for teachers preparing candidates for the Higher Tier examination; teachers preparing candidates for the Foundation Tier examination can easily adapt the scheme by ignoring the topics in **bold type**.

Teachers may wish to plan their 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 compiling a strategy to deliver the specification a number of parameters need careful consideration by the teacher when deciding the best way to teach all of the specification.

Sequence	In order for students to tackle some topics successfully, they need prior knowledge and understanding of others. Topics need to be taught in a way that enables the content of one to build on and extend the content of another.
Continuity	A good course should flow. Where possible the teacher should establish links between different areas of the specification in order that students might appreciate the general nature of many underlying concepts and how topics relate to each other.
Difficulty	It is the nature of any subject that students 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. The effect would be to demotivate students and, once interest in the subject is lost, it is difficult to re-establish. A good course should commence with the easier topics, leaving the more difficult ones until student interest and confidence have grown.
Variety	The specification provides opportunities for the teacher to address the various topics in a way which maintains the interest of the student. A good course will provide a continuous variety of content rather than focus on specific areas of the specification 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 content. There is no benefit in spending an excessive amount of time studying one particular topic whilst leaving insufficient time to do another justice.
Practicalities	It may be that a centre does not have sufficient resources for the teacher to deliver the course in exactly the way that he or she 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 by the teacher. This is clearly less than ideal; however, a good demonstration may provide a better lesson than an ill-equipped practical session.

There is no definitive sequence to delivering the course. It is up to each individual teacher to devise the route through the course content which they think will be most appropriate for them and their students based on the parameters described above. In addition to the specification content the teacher also needs to consider other issues such as how much practical work will be undertaken.

Biology

Section B1 – The nature and variety of living organisms

Candidates will be assessed on their ability to understand that there is a wide variety of living organisms including plants, animals, fungi, bacteria, and viruses

The understanding required in Section B1 is fundamental to any study of Biology and it is recommended that this is not taught as a separate section but covered at appropriate points throughout the course. This section therefore is not included in the course plan outlined below, and this will enable teachers to incorporate the topics according to their own teaching preferences. Teachers are reminded that only a few of the final marks for the subject will be based on this section.

N.B. In the Biology term plans that follow those practicals given in *italics* correspond to statements in the specification. Further details about these practicals are given in Appendix 1.

Term 1

Week	Content	Specification reference	Practical Work
1 – 4	Nutrition in humans Biological molecules	*B2.4*, B2.17 – B2.22 B2.5, *B2.6*	*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	B2.23 – B2.26	
6 – 7	Gas exchange in humans	B2.30 – B2.34	describe a simple experiment to investigate the effect of exercise on breathing in humans
8 – 10	Transport in humans	B2.40 – B2.47	describe a simple practical on the effects of exercise on heart rate in humans

Term 2

Week	**Content**	**Specification reference**	**Practical Work**
1 – 2	Cell structure Movement of substances into and out of cells	B2.1 – B2.3 B2.7 - B2.8, **B2.9**, *B2.10*	 *describe simple experiments on diffusion and osmosis using living and non-living systems*
3 – 4	Human excretion	B2.49 – B2.54, **B2.55 - B2.56**, B2.57	
5 – 6	Human coordination and response **Homeostasis**	B2.58 - B2.59, **B2.67**, B2.68	
7 – 8	Nerves and eye	B2.63, **B2.64**, B2.65 - B2.66	
9 – 10	Plant coordination and response	B2.60, **B2.61**, *B2.62*	*recall a controlled experiment to demonstrate phototropic plant growth responses*

Term 3

Week	Content	Specification reference	Practical Work
1 – 2	Nutrition in plants	B2.11 – B2.15, *B2.16*	*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	Gas exchange in plants	B2.27, **B2.28**, B2.29, B2.48	
5	Transport in plants	B2.35 – B2.37, **B2.38**, *B2.39*	*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 Feeding relationships	B4.1, *B4.2*, B4.3 – B4.5, **B4.6**	*recall the use of quadrats to estimate the population size of an organism in two different areas*
9 – 10	Carbon and **nitrogen** cycles	B4.7, **B4.8**	

Term 4

Week	Content	Specification reference	Practical Work
1 – 3	Reproduction	B3.1 – B3.7	A practical exercise to compare structures in insect-pollinated flowers using suitable local specimens
4 – 6	Inheritance	B3.8 – B3.12, **B3.13 - B3.14**, B3.15, B3.18, B3.19	
7 – 8	Cell division	B3.16 - B3.17	
9	Cloning	B5.12 - B5.13	
10	Selective breeding	B5.6 - B5.7	

Term 5

Week	Content	Specification reference	Practical Work
1 – 2	Crop plants and **fish farming**	B5.1 - B5.2, **B5.5**	
3 – 4	Genetic modification	**B5.8 - B5.9**, B5.10 - B5.11	
5 – 6	Micro-organisms	B5.3, *B5.4*	*describe a simple experiment to investigate carbon dioxide production by yeast*
7 – 9	Human influences on the environment	B4.9 - B4.10, **B4.11**, B4.12	
10	Revision		Use specimen papers as practice for examination.

Chemistry

Term 1

Week	Content	Specification reference	Practical Work
1 – 2	Atoms, states of matter	C1.1 - C1.2, C4.1 - C4.2	
3	Atomic structure	C1.3 – C1.5, **C1.6**	
4 – 5	Electron configuration, Periodic Table	C1.7 – C1.10, C2.1 – C2.5, **C2.7**	
6 – 7	Ionic compounds	C1.19 – C1.23, **C1.24 - C1.27**, C2.6	Electrolysis of aqueous salt solutions Experiments to show that ions move during electrolysis
7 – 8	Covalent compounds	C1..28 - C1.29, **C1.30**, C1.31 – C1.33, **C1.34 - C1.35**	Experiments to show that ions move during electrolysis
9 – 10	Chemical formulae, relative formula mass, **molar volumes**	C1.11, **C1.12 - C1.14**	Experiments to show that ions move during electrolysis

Term 2

Week	Content	Specification reference	Practical Work
1 – 2	Chemical equations (on-going throughout the course)	C1.15 – C1.17, **C1.18**	
3 – 4	Mixtures and compounds, separation of mixtures	C4.3 - C4.4	Experiments to separate mixtures e.g. salt and sand, distillation of ink solution, paper chromatography of inks or sweet dyes.
5 – 6	Acids and alkalis	C4.5 – C4.8	Test solutions of acids and alkalis with indicators. Use universal indicator to determine the pH of solutions of some common substances
7 – 8	Group 1 elements	C2.8 – C2.9, **C2.10**	The reactions of lithium and sodium(demo) with water
9 – 10	Group 7 elements	C2.11, **C2.12**, C2.15, **C2.16**	Halogen displacement reactions

Term 3

Week	Content	Specification reference	Practical Work
1 – 2	Hydrogen chloride and hydrochloric acid	C2.13, **C2.14**	Compare the reactions of solutions of hydrogen chloride in water and in methylbenzene
3 – 6	Neutralisation, **titrations**, salt preparation	C4.9, **C4.10**, C2.31 – C2.33	Preparation of salts by various methods: acid with metal, metal oxide, metal carbonate; acid – alkali titrations; precipitation
7 - 10	Rates of reactions (including investigations)	C4.17 - C4.18, **C4.19**	Experiments that investigate the effect of changing concentration, temperature, surface area on the rate of a reaction e.g. marble chips and hydrochloric acid

Term 4

Week	Content	Specification reference	Practical Work
1 – 3	Reactivity series	C2.20 – C2.24, C5.9	Reactions of carbon with metal oxides; reactions of metals with water/steam and dilute acids; displacement reactions involving metals and salt solutions
4	Rusting	C2.25 - C2.26, **C2.27**	Experiments with iron nails to show that air and water are necessary for rusting
5 – 6	Natural gas and oil	C5.10 – C5.16, **C5.17 - C5.18**	
7 – 8	Alkanes and alkenes	C3.1 – C3.3, **C3.4**, C3.5 – C3.7	Use of bromine water to distinguish between alkanes and alkenes
9	Synthetic polymers	C5.19 - C5.20, **C5.21**, C5.22	
10	Equilibria	C4.20, **C4.21 - C4.22**	Heat copper(II) sulphate crystals and ammonium chloride

Term 5

Week	Content	Specification reference	Practical Work
1 – 2	Extraction and uses of aluminium and iron	C5.1 - C5.2, **C5.3**, C5.4 – C5.7	
3 – 4	Energetics	C4.11 – C4.14, **C4.15 - C4.16**	Measure the temperature changes that occur when 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, sodium hydroxide and chlorine	C5.23 – C5.27	
7 – 9	Tests for cations, anions and gases	C2.28 – C2.30	Flame tests, test tube reactions for cations and anions, tests for gases and water
10	Purification and uses of copper – a transition metal	C2.17 - C2.18, **C2.19,** C5.8	.

Physics

Term 1

Week	Content	Specification reference	Practical Work
1 – 2	Distance, speed acceleration	P1.2 – P1.6	Measurement of speed and acceleration using a ticker-tape timer
2 - 3	Types of forces, friction	P1.7 - P1.9	Measuring various forces, e.g. that required to open a door, using a spring balance
4 - 5	*F = m x a* Weight, stopping distance, terminal velocity	**P1.10**, P1.11 – P1.13	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	P1.14 - P1.15	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	P1.16 - P1.17	Determination of the force-extension graphs for a metal spring and a rubber band by suspension of masses
8 - 9	Hazards of electricity, insulation, earthing, fuses, circuit breakers, electrical heating in domestic contexts	P2.2 – P2.7	
10	**Electrical energy**, a.c., and d.c.	**P2.8**, P2.9	Observation of a.c. and d.c. outputs using an oscilloscope, low voltage power supply and dry cell

Term 2

Week	Content	Specification reference	Practical Work
1	Series and parallel circuits	P2.10 - P2.11	Construction of series and parallel circuits using light bulbs, switches and a power supply
2	The change of current with voltage	P2.12	Determination of voltage-current graphs for a wire, filament wire and diode
3	Change of resistance: with resistance and in LDRs and thermistors	P2.13 - P2.14	Observation of change of resistance with level of illumination for an LDR and with temperature for a thermistor
4 - 5	$R = V / I$, charge and **electric current in solid metal conductors**	P2.15 – P2.17, **P2.18**	Verification of $R = V / I$ for a fixed resistor
6 - 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

Week	Content	Specification reference	Practical Work
1 – 2	Reflection of light	P3.12 – P3.14	Investigating the law of reflection of light using a plane mirror and a ray box (or pins)
3	Refraction of light, **refractive index**	P3.15, **P3.16 - P3.17**	Investigating the refraction of light using a raybox (or pins) and rectangular glass block or prism
4	Total internal reflection, **critical angle**	P3.18, **P3.19, P3.20**	Measurement of critical angle using a semicircular glass block and a raybox (or pins)
5	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
6	Speed of sound	P3.23	Measurement of the speed of sound by a simple clapping method
7	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
8 - 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 – P4.11, **P4.12 - P4.13**	Investigate the conversion of gravitational potential energy to kinetic energy using ticker tape timer, runway, pulley, thread and weights

Term 4

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, P2.25 (part)	Use a dynamo and lamp to demonstrate the generation of electrical energy
3 - 4	Density and pressure	P5.2 – P5.5	Determination of: the density of regularly and irregularly shaped objects; solid and liquid pressure
5	Brownian movement, absolute zero, kelvin scale	P5.6 – 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 - P5.11, **P5.12**	**Investigating Boyle's Law**
7	Magnetic poles and field lines	P2.19	Plotting magnetic fields using bar magnets, plotting compasses and iron filings
8	Electromagnetism	P2.20	Investigating the magnetic fields associated with a straight wire, coil and solenoid carrying an electric current
9	Force on a charged particle or conductor in a magnetic field. **Direction and size of resultant forces**	P2.21, **P2.22 - P2.23**	Build a model motor
10	Electromagnetic induction	P2.24, P2.25 (part)	

Term 5

Week	Content	Specification reference	Practical Work
1	Protons, neutrons electrons, isotopes	P6.2 - P6.3	
2 - 3	Nature and penetrating power of alpha, beta and gamma radiation. Detection of ionising radiation, background radiation	P6.4 - P6.5, P6.8 - P6.9	Detection of background radiation and investigating 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**	**P6.6, P6.7**	
5	Half-life	P6.10 – P6.12	
6 - 7	Uses and dangers of ionising radiations	P6.13 - P6.14	
8	**Alpha particle scattering**	**P6.15 - P6.16**	
9 - 10	**Nuclear fission, nuclear reactors**	**P6.17 - P6.20**	

Although this work can be extended as shown to 10 weeks, teachers may wish to include revision work in between sections of P6: Radioactivity and particles.

Experimental and investigative work

Experimental work should be an integral part of the study of any scientific subject and consequently it is appropriate that the assessment of experimental work and investigative skills should form 20% of the final assessment.

The term 'experimental work' obviously covers a large number of activities, many of which are unsuitable for assessment and inclusion as part of a coursework portfolio. Tasks such as the preparation of salts, food tests, or simple experiments on reactivity series would be amongst these tasks. It is, however, of great importance that students undertake a wide range of experimental work, even if it is not to be assessed.

Some experimental work may be used to train students towards a coursework investigation, or it may be used to assess some of the skill areas (P, O, A and E).

The term 'investigation' is defined as a task that requires students to engage actively i.e. to produce some evidence in all four skill areas. Most investigations will be practically-based i.e. they will involve the gathering of evidence (data) through observation and measurement. Student investigations should involve a minimum of prompting from teachers, who should limit themselves to providing general guidance.

It is strongly recommended that 20% of the teaching time should be devoted to practical work carried out by the students themselves. It is envisaged that many of the topics in the specification will be taught in a way that allows the facts to arise from practical work rather than the practical work being used to demonstrate what the students have already been taught. Practical work should be carried out by all students, whichever assessment route is planned.

Candidates will be assessed on their ability to

- plan experimental procedures (P)
- describe practical techniques and take measurements (O)
- analyse evidence and draw conclusions, communicate findings using calculations, tables and graphs (A)
- evaluate evidence (E).

The mark descriptors for assessing practical skills are given in Appendix 2, and a 'student-speak' version for issue to students is provided as Appendix 3.

The two alternative assessment routes are outlined below, for reference.

Written alternatives to coursework – Papers 7, 8 and 9

Candidates must take **two** written alternatives to practical work as described on pages 2 - 5. The two papers are equally weighted and each paper carries a maximum of 50 marks. Combined, these two papers will be scaled to 20% of the final assessment.

The examination papers will consist of a range of compulsory questions targeted at grades A* - G and based on the skills listed in Assessment Objective 3.

Specimen papers and mark schemes (available on the website or from Edexcel Publications) have been produced to illustrate the types of questions that will be asked.

Coursework – Component 10

The coursework option is normally available only to candidates studying at centres that have been recognised by Edexcel International as International Teaching Institutions.

Candidates are required to submit coursework that will be assessed by the teacher and moderated by Edexcel International.

Candidates must produce two pieces of evidence in the four skill areas for at least **two** science subjects of Biology, Chemistry and Physics. The component carries a total of 60 marks that will be scaled to 20% of the assessment.

Further details about the coursework requirements are given on page 31.

Guidance for teachers on how to select work for assessment and how to complete the final mark aggregation sheet will be found in Appendices 4 and 5.

Papers 7,8 or 9 or coursework? Which is better?

There is no 'best way' to assess practical skills – both methods have their advantages and their drawbacks. Bearing in mind the limitations described below, it is for each centre to decide the most appropriate assessment method for their candidates.

Papers 7, 8 and 9 are written examinations. The questions are designed to assess the same four skill areas as the coursework to the same marking criteria, so the best way to prepare students for these papers is to give them the same opportunities to carry out experimental and investigative tasks as those students following the coursework option.

The same advice for training and guiding students should be followed, including the use of 'student-speak' marking criteria (Appendix 3) and the gradual introduction to carrying out whole investigations (see next page). Students should be offered several opportunities to plan and carry out experimental tasks and whole investigations themselves, and to practise the skills needed to achieve their highest potential in such work.

The specimen papers and mark schemes illustrate the range of question types that will be set on papers 7, 8 and 9.

The list of 'Suggested titles for coursework investigations' on page 40 can be regarded not only as a resource for centres entering candidates for coursework, but also as a list of experiments that should be covered during the course in order to prepare candidates for Papers 7, 8 and 9.

Training students in individual skills and practical skills

Opportunities for developing individual skills within schemes of work could include:

Part lessons When you have introduced a new piece of theory, get the students to use it to write (or use a computer to produce) an explanation for an everyday effect, e.g. 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 a fast feedback as to whether or not the lesson on kinetic theory has achieved its aim and, secondly, it enables the students to practise one aspect of the use of scientific knowledge and understanding.

Homework This can be used to give experience in a wide range of individual skills, e.g. a pre-prepared worksheet giving students the task of choosing scales, plotting data and drawing lines of best fit. These 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 extend the students by asking them to use their graphs to comment upon the accuracy of the observations and to identify anomalous results.

Tests These can be used to present reminder/revision opportunities for individual skills, e.g. reading analogue or vernier scales.

Practicals These can also be used for visiting / revisiting a wide variety of skills, e.g. 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 the procedure used.

Investigations Whilst these will normally be used for integrating all of the individual skills from the four skill areas, a good case can be made for introducing one or two skill areas initially, e.g. for homework, a student writes a plan for an experiment which is subsequently carried out in class, exactly as it is written!

Many students will need considerable guidance in order to progress from simply carrying out a set of practical instructions provided 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 the student will then more fully understand the principles and parameters upon which scientific method is based.

Whether the student will ultimately be assessed by coursework, or by the written alternatives to coursework (exam papers 7, 8 and 9), the course plan should allow for the gradual development of experimental skills over the two years (advisory minimum time).

Please note that it is beneficial to students to be introduced to the concept of practical investigative work well before they begin the two-year examination course: research evidence has shown that students take a considerable time to gain the confidence needed for higher level investigative skills such as critical evaluation.

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.)

Before attempting whole investigations, students should be given experimental tasks that test only one or two skill areas. For example, as an introduction to the concept of planning whole investigations, students could be asked to write a plan for an experiment that is subsequently carried out in class. Teacher feedback is essential during this early stage of learning.

Towards the second half of the course, students should be provided with several opportunities to develop their investigative skills to allow them to achieve their highest potential in such work.

A simpler, ‘student-speak’ version of the coursework criteria is given in Appendix 3 and it is recommended that this is given to all students at the start of the course, and thereafter referred to frequently.

Use of ICT

The use of ICT, where available, e.g. for word-processing, data-logging and graphical display (including lines of best fit) is to be encouraged. However, teachers are advised that some spreadsheet software does not properly produce a line of best fit on graphs.

Data-loggers might be used to carry out investigations. A comparison could be made using data-logging with more traditional techniques. The rate of a chemical reaction might be monitored by recording changes in pH, for example.

Formulae functions in a spreadsheet can be used to analyse data. Students could compare this with using a calculator or manual calculations.

Data-handling software could be used to create, analyse and evaluate charts or graphs.

The Internet or CD-ROM software could be used as a source of secondary evidence.

Students should develop the ability to judge when it is appropriate to use ICT in their work. All sources and references used must be clearly identified by the student.

Safe practice

Attention is drawn to the need for safe practice when candidates carry out laboratory investigations or observe demonstrations. Particular attention is drawn to the possible hazards associated with electrical equipment, the handling of microorganisms, and ionising radiations. Strict aseptic conditions should be used when undertaking practical work with microorganisms. Reference should be made to local health and safety regulations, and widely accepted publications such as

- *COSHH*; *Guidance for Schools* (HSC, 1989) (HMSO) ISBN 011 885 5115
- *Topics in Safety* – 3rd Edition, Association for Science Education (ASE, 2001) ISBN 086 357 3169
- *CLEAPSS Laboratory Handbook and Hazards*, available from Consortium of Local Education Authorities for the Provision of Service Sciences (CLEAPSS).

Coursework

The coursework option is normally only available to candidates studying at centres that have been recognised by Edexcel International as International Teaching Institutions.

Candidates who submit coursework are required to produce evidence in the four skill areas P, O, A and E. Candidates will be expected to

	Mark scale
Plan experimental procedures (P)	0 – 8
Obtain evidence (O)	0 – 8
Analyse this evidence and draw conclusions (A)	0 – 8
Evaluate evidence (E)	0 – 6

The coursework will be assessed by the school or college according to the principles described below and the mark descriptors in Appendix 2, and will be moderated by Edexcel International.

The evidence for assessment will be coursework carried out by the candidate, in the context of the specification content.

The coursework must be the candidate's own unaided work, carried out under the supervision of the teacher.

Candidates should undertake experimental and investigative work during the course, as described on page 26, and be assessed on several suitable occasions in both types of activity. The aim is to allow them to achieve their highest potential in such work.

An activity can take the form of experimental work or an investigation. Experimental work may be used to assess one, two or three skill areas.

A whole investigation consists of work that covers each of the four skill areas, although not all of these need to be used for the final assessment. The final mark for each candidate must include at least one mark taken from a whole investigation.

Applying the mark descriptors

As indicated above, the mark descriptors are given in Appendix 2.

Mark descriptors are provided for 2, 4, 6 and 8 marks in skill areas P (Planning), O (Obtaining evidence) and A (Analysing and considering evidence), and for 2, 4 and 6 marks in skill area E (Evaluating).

Although the general mark descriptors give guidance for the level of performance to be expected at levels 2, 4, 6 and 8, teachers may give marks of 1, 3, 5 and 7 for intermediate performance.

Whenever assessments are made, the mark descriptors should be used to judge which mark best fits the candidate's performance. The statements should not be taken as hurdles, all of which must be fulfilled for a mark to be awarded. Adjacent descriptors should be considered when making judgements and use made of the intermediate marks (3, 5 and 7) where performance exceeds one descriptor and partially satisfies the next.

The mark descriptors within a skill area are designed to be hierarchical. This means that, in general, a descriptor at a particular mark subsumes those at lower marks. It is assumed that activities that access higher marks will involve a more sophisticated approach and/or a more complex treatment.

A candidate who fails to meet the requirements for 2 marks but who has made a creditworthy attempt in a skill area should be given 1 mark for that skill. Zero marks should only be awarded for a skill area in the event of a candidate failing to demonstrate any achievement in that skill.

The professional judgement of the teacher in making these assessments is important.

Examples

Part of the mark descriptor for skill area O is shown below.

6 marks	O.6a	collect sufficient systematic and accurate evidence and repeat or check where appropriate
	O.6b	record clearly and accurately the evidence collected

Where a student fully satisfies the requirements of O.6a but fails to include units in the results table (thereby not meeting the requirements of O.6b) a mark of 5 should be given.

Intermediate marks may also be awarded to the student who partially satisfies both of the mark descriptors at a particular level.

Part of the mark descriptor for skill area A is shown below.

6 marks	A.6a	construct and use suitable diagrams, charts, graphs (with lines of best fit, where appropriate), or use numerical methods, to process evidence for a conclusion
	A.6b	draw a conclusion consistent with the evidence and explain it using scientific knowledge and understanding

At A.6a, a student might meet the descriptor except for mis-plotting a point, and at A.6b there might be an explanation containing a small error in the scientific knowledge. In this case, 5 marks should be awarded.

Each of the tables of mark descriptors in Appendix 2 has a vertical arrow running down the page to signify that an important consideration in designing appropriate assessment tasks is the level of demand expected.

Differentiation by outcome using a common task is appropriate for a group of students with similar ability, but difficult where a class is of mixed ability. However, students do need to be given appropriate tasks to match their abilities, and ones which fully challenge them. A possible solution is to present two or three similar activities (targeted at different abilities) and to allow students to make a guided choice as to which activity to engage in.

The ideal scenario is for students to work individually on their coursework assessments, as they are assessed individually. Group assessments are not allowed, though for practical purposes, students may have to work in pairs. **Where this is the case, students must still do their own work for assessment in skill areas P, A and E**. Pairs of students may use the same results in skill area O, but again teachers need to make individual assessments in skill area O – so teachers do need to see each student taking at least one measurement each. Most coursework tasks can be undertaken at any level, but some are more suited to potential grade A students, whilst others are more suited to less able students.

Activities based on these general topic areas are particularly suited to more able students (i.e. potential grade B/A/A*):

Biology	Chemistry	Physics
Osmosis in potatoes Enzyme reactions Transpiration Photosynthesis Activity of yeast	Reaction rates Burning Alcohols	Resistance in wires Motion of a trolley on a ramp

Activities based on these general topic areas are particularly suited to less able students (i.e. potential grade C or below):

Biology	Chemistry	Physics
Effect of exercise on pulse rates	Dissolving sugar or salt	Electromagnets Making a paper thickness testing gauge Stretching a spring/elastic band Comparing thermal insulators

Other examples of suitable coursework tasks which may be used for assessment appear on page 40 of this guide. The final choice will depend on the experience of the teacher, the abilities of the students, the size of each teaching group, the equipment available, and the time available for the assessment. There is no fixed time limit for coursework assessments – a reasonable amount of time for a coursework task would be about six hours in total (planning 2 hours, carrying out 2 hours, analysing and evaluating 2 hours).

The following tasks are **not** recommended as the basis for whole investigations:

• Food tests	• Flame tests
• Reflection/refraction tasks	• Titrations
• Testing or proving a Law, e.g. Hooke's Law	• Pendulum tasks
• Preparing salts	

Centres wishing to check the suitability of their potential coursework task may submit a broad outline to the International Customer Response Unit, who will liaise with the Assessment Leader and Senior Examiners to provide advice.

Coursework consultancy service

Edexcel International also offers a consultancy service for coursework, where a maximum of three pieces of marked work can be submitted for checking by one of Edexcel's external moderators. Details of this consultancy service can be found on the Edexcel International website.

Keeping records

Whenever a student's work is assessed by the teacher, a form such as the *Provisional Assessment Record* (Appendix 6) should be attached to the work. As the teacher reads the work, a tick is all that is needed to show that the particular mark description is achieved. There is enough space to write a few words to explain why a particular mark description may not have been fully satisfied.

The work with its attached form may then be returned to the student so that they can have an opportunity to consider their work, and redraft if appropriate. This procedure is perfectly acceptable so long as 'material help' is not given. For example, a teacher assessing P.8a might write:

'*not awarded – insufficient scientific knowledge provided'*

This is not 'material help', so a student could have the opportunity to revise the work. However, a comment such as

'*no reference to the distance of the plant from the light source'*

would be considered 'material help' by the centre's moderator.

When marking a candidate's work, the teacher should indicate in the margin alongside the appropriate part of the script, P.4a✓, etc. This annotation of each candidate's work is vital so that the external moderator can easily see where the teacher has allocated a particular mark descriptor.

Where there is any doubt about whether a particular mark should be awarded, external moderators appreciate a written comment to help them understand the rationale behind the teacher's decision.

Each time coursework is assessed by the teacher, the provisional marks awarded should be recorded.

Standardising teachers and submitting the coursework marks

It is in the centre's own interest to devise an efficient method of internal standardisation, so that all teachers apply the criteria in the same way. This is particularly important where work from several teaching groups and several teachers is being presented for moderation.

Once coursework marks have been internally standardised and agreed, the Final mark aggregation sheet (Appendices 4 and 5) may be completed for each student.

Examples of aggregation of marks

1. A student who has done **the minimum amount of coursework**.

Activity Title(s)	P	O	A	E
Effect of varying concentration on reaction rate (full investigation)	6	6	5	3
Motion of a trolley on a ramp (full investigation)	6	5	6	4
TOTALS	**12**	**11**	**11**	**7**

- The final centre mark for this student would be 12 + 11 + 11 + 7 = 41 (out of 60).
- Note that all of the marks are used in aggregation. Note also that all of the marks can come from any two of Biology, Chemistry or Physics. In this case marks have come from Chemistry and Physics.

2. A student who has done **the maximum amount of coursework**.

Activity Title(s)	P	O	A	E
Effect of varying concentration on reaction rate (full investigation)	**6**	**6**	**5**	3
Motion of a trolley on a ramp (full investigation)	**6**	5	5	3
Pulse rates (full investigation)	5	5	4	**4**
Stretching a spring (full investigation)	5	**6**	**6**	**4**
TOTALS	**12**	**12**	**11**	**8**

- The final centre mark for this student would be 12 + 12 + 11 + 8 = 43 (out of 60).
- Note that the best two marks are used in aggregation from each skill area. By setting four full investigations, the teacher has given the student the best possible opportunity to score high marks in the coursework component of the examination.

Difficulties in meeting the aggregation rules

1. A coursework mark may still be claimed for a student who has failed to complete the full requirements for the assessment.

Example 1

A candidate has a full laboratory based whole investigation, and an experimental task.

Activity	Whole Practical Investigation	Skill Area			
		P	O	A	E
Rates	Yes	6	6	6	4
Bouncing Balls	No	-	-	6	4
TOTALS		**6**	**6**	**12**	**8**

This candidate was absent when the Biology task was set, and so only has 6 coursework marks. All 6 skill area marks may be used in totalling (since the portfolio is incomplete – 8 marks are needed for a full portfolio) and no further penalty is imposed. The final mark is 6 + 6 + 12 + 8 = 32 out of 60.

2. A mark penalty will be applied by the moderators in each instance when:

- no mark from a practically based whole investigation is represented in the mark aggregation.

Example 2

This Double Award candidate has no mark from a practically-based whole investigation.

Activity	Whole Practical Investigation	Skill Area			
		P	O	A	E
Yeast	**No**	**6**	4	4	**-**
Rates	**No**		**6**	**6**	**4**
Bouncing Ball	**No**	**-**	**-**	**6**	**4**
Resistance	**No**	**6**	**6**		

The lowest mark (one of the skill area E marks) is removed since there is no whole investigation. The total mark is therefore 40 out of 60. (P12 + O12 + A12 + E4). Note that the marks for the Yeast task in skill areas O and A are not used in totalling since only 8 marks (two from each skill area) can be used in aggregation.

- marks for more than four pieces of work are included in the final mark aggregation.

Example 3

This candidate has a practically-based whole investigation and several skill area assessments.

Activity	Whole Practical Investigation	Skill Area			
		P	O	A	E
Yeast	**No**				**4**
Photosynthesis	**No**			**6**	
Rates	**No**		**6**		
Bouncing Ball	**No**	**8**			
Resistance	**Yes**	**6**	**6**	**6**	**3**

Five pieces of work have been used. This is one more than the allowed maximum. Therefore the mark for the Yeast task (the lowest mark) is removed (since otherwise five pieces of work would have been used in totalling), giving a total of 41 out of 60.

3. In addition, for **Double Award Science**, a further mark penalty is applied in each instance when:

- work from at least two of the sciences (Biology, Chemistry and Physics) is not represented
- the two marks for a skill area (P, O, A or E) are drawn form two contexts which are very similar, e.g.
  - the effect of light intensity on photosynthesis, <u>and</u> the effect of varying wavelength on photosynthesis
  - the effect of temperature on reaction rate, <u>and</u> the effect of varying concentration on reaction rate
  - the effect of length of wire on resistance, <u>and</u> the effect of varying the cross-sectional area on resistance.

Example 4

Here, there are two whole investigations, both based on contexts in the same science (Physics), but which are significantly different.

Activity	Whole Practical Investigation	Skill Area			
		P	O	A	E
Bouncing Balls	**Yes**	**8**	**6**	**6**	**4**
Resistance	**Yes**	**6**	**6**	**6**	**4**

Only one science subject (Physics) is represented, but in IGCSE Double Award Science at least two science subjects must be represented.

The usual penalty is to remove a mark from one of the skill areas – usually the lowest mark, in this case an E4. The total mark is therefore P14 + O12 + A12 + E4 = 42 out of 60.

Example 5

There are two whole investigations, both based on a single context in the same science (Physics).

Activity	Whole Practical Investigation	Skill Area			
		P	O	A	E
Resistance - length	**Yes**	**8**	**6**	**6**	**4**
Resistance - area	**Yes**	**6**	**6**	**6**	**4**

In this case two penalties are applied:

Firstly, because the reported marks are from only one science subject i.e. Physics (and at least two science subjects must be represented for IGCSE Double Award Science).

Secondly, because the reported marks are from the same context: they are both resistance tasks. The two lowest marks (from skill area E) are therefore removed, giving a total mark of P14 + O12 + A12 = 38 out of 60.

A teacher's checklist for final assessment of coursework

- Two marks from each skill area P, O, A and E should be identified.
- These eight marks are added together to form the final mark.
- The marks should be drawn from not more than four pieces of work.
- At least two of Biology, Chemistry and Physics must be represented.
- The work must be derived from the content of the specification.
- At least one mark must be from a practically-based, whole investigation.

  A *whole investigation* is defined as a piece of work, carried out by the student, in which all four skill areas are attempted. A *practically-based investigation* is one in which first-hand evidence is gathered by the student through observation or measurement.
- The *Final mark aggregation sheet* (see Appendices 4 and 5) is completed for the candidate and attached to the corresponding practical work.
- The work must be the candidate's own unaided work, carried out under the supervision of the teacher. The declaration of authentication on the bottom of the *Final mark aggregation sheet* (Appendix 4) must be signed by the candidate and the teacher.

Suggested titles for coursework investigations

The experimental and investigative tasks below could be performed using the resources recommended in the Course Planner plus other available resources.

Biology

- The effect of exercise on pulse rate.
- The effect of light intensity on rate of photosynthesis.
- Osmosis in e.g. potato chips.
- The effect of temperature or concentration on an enzyme-controlled reaction e.g. the digestion of starch by amylase.
- The activity of yeast.
- The energy content of different types of food.

Chemistry

- The trend in energy released on combustion of an homologous series of alcohols.
- How energy changes during displacement reactions relate to the reactivity series of metals / the concentrations of the solutions.
- Factors influencing the dissolving of solutes such as sugar or salt.
- Energy changes associated with neutralisation reactions.
- How concentration / surface area / temperature affects the rate of a reaction such as marble chips + acid; sodium thiosulphate + hydrochloric acid…

Physics

- The insulating properties of different materials such as bubble wrap, cotton wool and plastic foam.
- The effect of length on the resistance of a wire.
- The effect of the height fallen by an object on the depth of the crater produced.
- How the temperature of a squash ball affects the height it bounces off the floor.
- The percentage energy losses of different bouncing balls.
- How the weight of a body affects the size of the frictional force opposing its motion.
- How the area of a model parachute affects its rate of descent.
- How the depth of water affects the speed of water waves.

Applying mark descriptors to pupils' work

The following sections consider the individual skills and, where appropriate, suggest ways in which student performance could be improved, giving examples from actual pieces of work. Spelling and grammatical errors have been left in the extracts.

Planning

Outline a simple procedure (P.2a)

Below is an example from osmosis in a potato investigation:

> *We will cut a potato to a certain length we will then put the potato into a sugar solution and leave it there for about a minute or two. We will then take it out and measure it again.*

This example merits only 2 marks since the plan lacks details such as the strength of sugar solution, how the potato is to be measured etc. There is also no list of equipment.

Plan to collect evidence which will be valid (P.4a)

This mark description is normally achieved. It is at this stage that some investigations become too ambitious. Students decide, and in some cases are advised, to investigate two, three and on occasion four variables. This is not necessary and can often lower a candidate's marks because they do not give enough time to investigating any one variable fully.

For most investigations, a prediction is appropriate and therefore should be made. Some biological field studies may be too complex to expect a prediction.

Below is an example from the same osmosis investigation and follows on from the above extract.

> *We will use 4 different kind of solution like 0.0m, 0.2m, 0.4m and 0.8m and use potatoes of the same length.*
>
> *Prediction*
>
> *I believe that the 0.0m will make the potato chip larger because it has less sugar in and that the solution 0.8m will make the chip smaller.*

In this example the strengths of sugar solution are specified and there is an indication of fair testing. There is however, no indication of a scientific background to the task.

Plan the use of suitable equipment, or sources of evidence (P.4b)

Students sometimes fail to match this skill area mark description because they are presented with a tray of equipment, a list of equipment or a labelled diagram of the equipment in a prompt sheet in advance of their planning. Students may achieve this skill by a labelled drawing or annotation by the teacher or, as is more usual, by a list.

The example below is from a different investigation on the same topic.

Apparatus needed to measure the rate of osmosis in a potato.

potatoes
different concentrations of water
weighing machine
measuring cylinder
core borer
beaker
wooden board
petri dish

P.4b can be awarded, since the candidate has given a list of the apparatus, even though it is not clear what is meant by "different concentrations of water".

Use scientific knowledge and understanding to plan and communicate a procedure, to identify key factors to vary, control or take into account, and to make a prediction where appropriate (P.6a)

This is the first real hurdle for many students. The first questions to be asked are:

1. Is the required scientific knowledge and understanding (SKU) in the specification?
2. Has it been taught?
3. Has it been understood by the student?

If the answer to any one of these is no, then the candidate will find it difficult to achieve P.6a.

The second aspect is that many students require practice in using scientific knowledge and understanding (SKU) to plan and identify key factors. At this stage it is worth noting that many students still consider that presenting a great chunk of theory, sometimes at A level standard, is all that is required. In practice, it is not only the stating of the theory, but **also its clear use** in formulating the plan, which achieves the mark. The earlier comments as to the appropriateness of making a prediction apply. Candidates often need practice to be able to use SKU in formulating their prediction.

Below is an example from an investigation on vitamin C content.

I will use the same amount of orange juice in 4 flasks and place them in 4 different temperature conditions such as at room temperature, in a fridge, in a water bath and on a widow sill. This experiment will be left there for a week and I will test how much vitamin C there is in the juices using a dye called DC Pip which will be added to the orange juice.

This experiment is important because we need to know what conditions are best for preserving the vitamin C as it is very important vitamin for the body. By carrying out this experiment we can find out all such factors which maintain a good level of vitamin C in orange juice.

My experiment is quite safe as I am not dealing with very dangerous chemicals. Care has been taken with the DC Pip, so I will wash my hands using it and I will try not to get it into my mouth. I should wear overalls in case the dye falls.

I will try to make my experiment fair. So I will have to keep all the important factors in my experiment the same such as concentration of the orange juice, the size of the conical flasks and the type of orange juice. I will have to use the same type and amount of orange juice in the same container to keep all my measurements fair. If I put cling film on one of the tops of the flask I have to do the same for the others. The only factor I will have to change is the temperature surroundings.

I will also have to take precise and accurate readings. This means I will have to use a measuring cylinder to measure the orange juice. I will have to keep my eye level with the level of the orange juice to take precise readings. I will also have to do this when measuring the amount of DC Pip. I will have to come at the same time each day in order to take readings so that the experiment is fair. When I add the orange juice to the DC Pip I have to make sure that I shake the mixture carefully after each drop so I know when it turns orange. I have to make sure each drop is equal and that the mixture will have to turn completely orange before I stop adding drops of orange juice to the DC Pip.

I think the range of my readings should be taken 3 times a day for one week. This will give me accurate results and tell me when there is a decay in the vitamin c during a whole week. I will take these readings at the following times: 8:30 am, 1:00 p.m., and either 3:30 p.m. or 4:00 p.m. depending on when we finish school.

Vitamin C is destroyed by heating. As a result a lot of it can be lost during cooking and while food is being kept hot afterwards. In restaurants where food is kept hot for a long time, over 90% of vitamin C may be lost.

<u>Predictions</u>

I predict that the most vitamin C present will be in the orange juice react in the fridge. This means there will be less drops of orange juice needed to change the colour of the DC Pip to an orange colour. I think this because the temperature will be colder so the vitamin c has a better chance of surviving. Vitamin c is destroyed by heating so this means the orange juice kept in the water bath (where the temperature is high) will lose all of its vitamin c faster than the orange juice kept at room temperature or in the fridge. This is because if it is not exposed to high or low temperatures so it will be in the middle which means it will gradually lose its vitamin c. At the end of the week I think the juice will lose its vitamin c because over time vitamin c can only decay.

Although the plan is confused in places, P.6a can be awarded since the candidate has produced a reasonable plan, with an appreciation of fair testing. The plan includes a scientific basis both in the body of the text and also in the prediction.

Decide on a suitable number and range of observations or measurements to be made (P.6b)

Candidates frequently do not make any statement about this and rely upon their teacher looking at what observations they actually make. This is a high risk strategy as many students run out of experimental time and do not carry out the range or number of observations they intended. Thus, they can fail to achieve this mark by default.

The following is an example from an electrolysis investigation.

-the time interval will be five minutes for each test

the testing currents will be 0.8, 1, 1.2, 1.4, 1.6 A.

A simple statement like this is sufficient to achieve P.6b. The number and range of readings specified should be sufficient to establish the relationship between the variables being tested. Note that there is no single number of readings which can be applied to all investigations. The number of readings planned is dependent on the task.

Use detailed scientific knowledge and understanding to plan and communicate an appropriate strategy, taking into account the need to produce precise and reliable evidence, and to justify a prediction where appropriate (P.8a)

At this level of skill the SKU has to be from those concept areas of a specification which could be used to differentiate between A*, A and B grade candidates at IGCSE. Thus many familiar investigations will not normally give students access to this mark, e.g. Hooke's Law, Heart Rate, Simple Dissolving, Pendulums etc. Again, the word 'use' is crucial. Candidates also fail by not addressing both the need to produce reliable evidence and precise evidence.

Below is an example from an osmosis investigation.

The key Factor that I plan to Investigate and what I will do to Make My Experimental Work a Fair Test.

The key factor that I plan to investigate is sucrose concentration, and I will vary the sucrose concentration, and calculate the effects of this factor on osmosis in the potato chips by recording the mass before (before the chip is placed into the solution), the mass after (after the chip has been placed into the solution for a certain length of time of 1 hour), the difference between these masses, and then the percentage weight changes at each concentration. Also, at each concentration I will take two readings (one being an average), and then I will calculate the required averages.

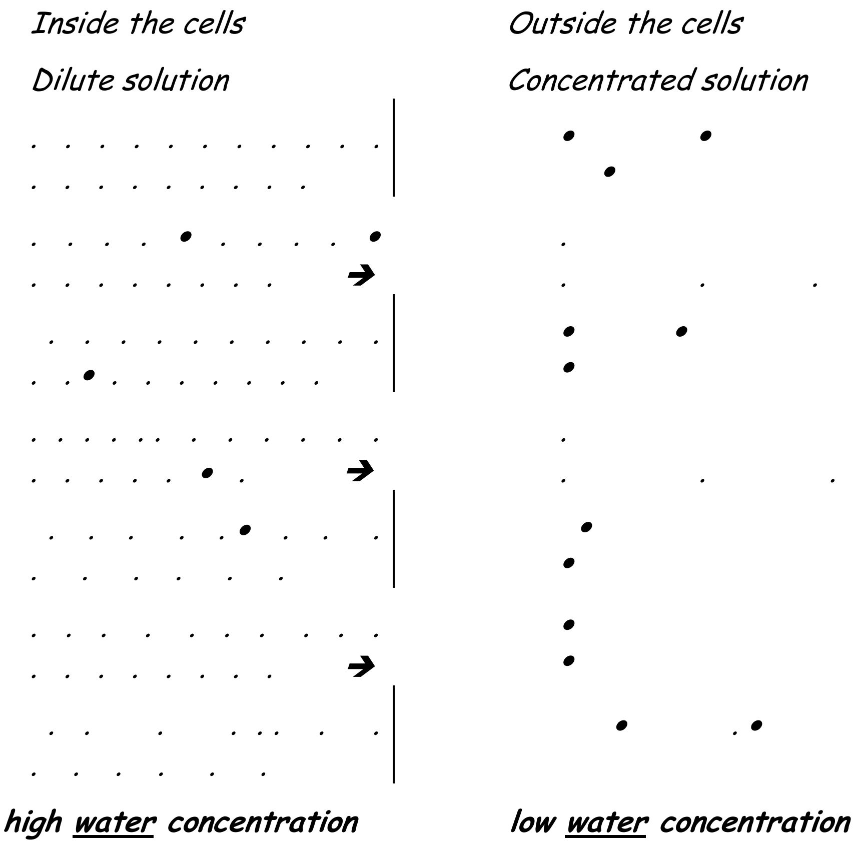
Because I am measuring osmosis, I will try to keep constant the other factors that effect osmosis, those other than the concentration of sucrose (and water). I will be using potato chips from the same variety of potato (assuming that the genetic makeup and therefore partially permeable membranes will be more similar in make-up). I will use the same volume of solution at each concentration of sucrose solution (that being 25 ml). I will leave the potato chips in solution for the same time at each solution concentration. I will use the same method at each concentration, and for each potato chip individually, in that I will dry the excess water off the chips in a similar manner, and use the same accuracy of the weighing scales, prepare the chips for use in the same way and other aspects. I will keep the surface area of the chips as constant as possible, this being that I will use chips of the same cross sectional area and length. I found in my preliminary work that the chips in the higher concentrations of sucrose solution tended to float thus excluding a certain part of their cross sectional area from the solution, I do not know how to remedy this. I will carry out all of my experimental work at room temperature and thus temperature will not affect my experiment. The time will not affect my results because I plan to leave my chips in solution for 1 hour at each concentration, I discovered that significantly enough results were obtained after this length of time in my preliminary work.

Obviously I will vary the sucrose concentration, using concentrations of 0.0 mol/litre (de-ionised water purely), 0.2 mol/litre, 0.4 mol/litre, 0.6 mol/litre, 0.8 mol/litre and 1.0 mol/litre. Apart from the concentration of 0.0 mol/litre the solutions have been made up before hand.

What I predict Will be the effect of Changing the Key factor that I Plan to Investigate and the Scientific Reasoning why I am Making This Prediction.

I predict that the effect of changing the sucrose concentration will be that as the concentration of the sucrose solution increases, first the mass of the chip will increase, and then the change in mass will gradually decrease until mass is lost and this mass loss will gradually increase in amount.

I think that the reason for this prediction is that when the sucrose concentration is low, the concentration of water outside the cells of the potato chips will be greater than that inside, and therefore water will osmose into the cells of the chip which will gain mass. As the concentration of sucrose increases, the concentration of water outside the cell will eventually become less than inside the cells of the chip, and thus the water will osmose out of the chip and mass will be lost. Here are diagrams to show how water osmoses across the partially permeable membranes of the chips, and in which direction in both high concentrations of sucrose solutions and low concentrations of sucrose solutions.



Key:

• = *Sucrose particle*

. = *water molecule*

➔ = *osmosis*

¦ = *partially permeable membrane*

In the higher sucrose concentrated solution, the net movement of water (osmosis) is to the outside of the cell, and the chip will lose mass, the cells will become plasmolysed.

The chip in a low concentration of sucrose solution, is the opposite of the diagram above, in that the water osmoses into the cells of the chip, mass is gained, through osmosis of water into the plant cells, the cells will become turgid.

In this example, the candidate has used a good understanding of the principles of osmosis to support the procedure. Variables are controlled to ensure fair testing, and the procedure planned should produce precise and reliable data.

Use relevant information from preliminary work, where appropriate, to inform the plan. (P.8b)

Note the word 'use' again.

Below shows an example from an electrolysis investigation.

> *Preliminary test*
>
> *Preliminary tests were conducted to determine an appropriate time interval for testing and an appropriate range of currents. The tests showed that a current higher than 2A cannot be reached with the apparatus provided. After the tests, it was decided that:*
>
> *- the time interval will be 5 minutes for each test*
>
> *- the testing currents will be 0.8, 1.0, 1.2, 1.4 and 1.6*

There are three routes to access P.8b. Preliminary work could mean

- the use of a secondary source, such as a text book, a CD-ROM, or the Internet. The information gleaned needs to be understood by the candidate, and then applied to the new task
- the use of some class-work (previously completed) which can be applied to the new task. The previous work must not be identical to the new task, but should have some bearing on it
- a pilot test. Normally the candidate selects some values to test (perhaps at the upper and lower extremities of the proposed range) in order to find out if the values proposed will, in fact, give reasonable data. The results of the preliminary test should be given, in order to see how the pilot test informs the planning for the main task.

Obtaining Evidence

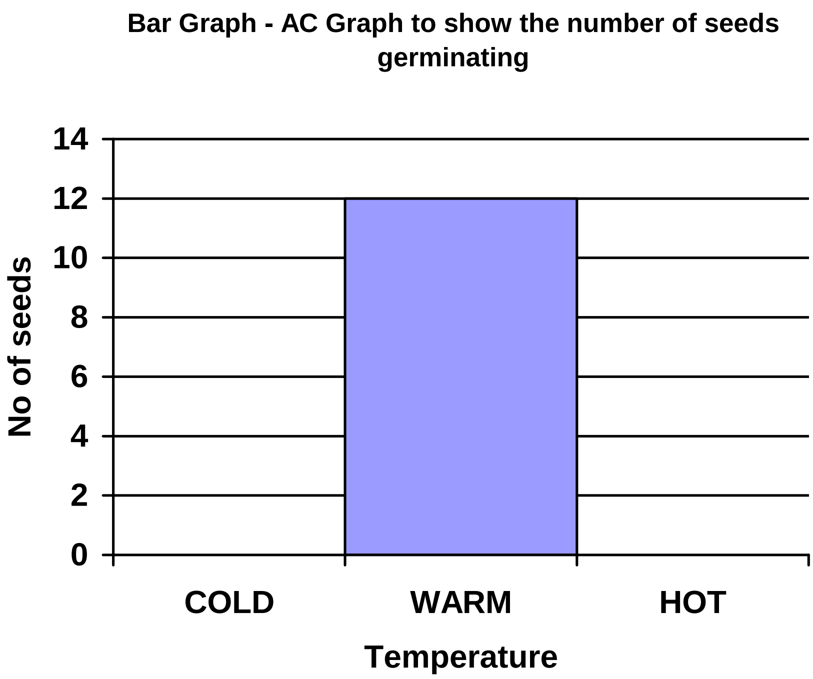
Collect some evidence using a simple and safe procedure (O.2a)

All candidates normally achieve this. At the simplest level it can be observed and annotated by the teacher. The presentation of any results shows that this has been achieved.

Collect appropriate evidence which is adequate for the activity (O.4a)

Most candidates will achieve this. Again annotation by the teacher can be accepted.

The extract below does not satisfy O.4a as there is no attempt to measure temperature and thus the measurements are inadequate given the investigation, which was 'Does temperature affect the germination of seeds?'. The actual temperatures should have been measured.



Record the evidence (O.4b)

Again, this is usually achieved. The above piece of work did not achieve O.4b, as there was no written record of the results, other than this chart.

Collect sufficient systematic and accurate evidence and repeat or check where appropriate (O.6a)

A limited number of measurements sometimes results in candidates failing to match this mark description. More often a failure to repeat measurements is the cause, particularly if an investigation has been set which produces a high degree of variability in the results. Students often fail to spot when anomalous results have been obtained and fail to repeat the measurements.

This extract from a rates of reaction investigation fails on both these counts.

Size of carbonate		*Time of reaction (secs)*	*2M hydrochloric acid*	*Volume of CO^2*
Large	*2.60 g*	*41.0*	*20 cm^3*	*20 cm^3*
Medium	*2.60 g*	*24.0*	*20 cm^3*	*20 cm^3*
Small	*2.60 g*	*7.0*	*20 cm^3*	*20 cm^3*
Powder	*2.60 g*	*2.0*	*20 cm^3*	*20 cm^3*

The evidence needs to be sufficient to establish the relationship between the variables. It should be collected systematically.

In this case, the nature of the task, with four particle sizes, and the lack of any repeat readings, are the deciding factors in not awarding O.6a.

Record clearly and accurately the evidence collected (O.6b)

This can be a real hurdle for even the most able candidates, more often than not due to carelessness; not in the recording of the results, but more usually that columns are not correctly titled, or that units are missing or incorrect.

Use a procedure with precision and skill to obtain and record an appropriate range of reliable evidence (O.8a)

Precision may be achieved from control of some of the secondary factors e.g. light levels in the lab when carrying out a photosynthesis investigation. To satisfy the mark description implies that there should be some skill involved in making the measurements e.g. possibly the use of a micrometer screw gauge to check the diameter of a wire is constant along its length (when investigating the resistance of a wire).

The appearance of the word reliability also implies that the results have been taken by independent repeats and are consistent e.g. independent repeats for the resistance of a wire implies not that two measurements were taken one after the other at each length, but that two or more measurements were taken at different settings of potential difference across the same length of wire.

This extract from a rates of reaction investigation does not satisfy this mark.

Temperature in ^0C	*Amount of water in ml displaced of gas*			
	1	*2*	*3*	*average*
Room temp	*2 ml*	*1 ml*	*1 ml*	*1.33 ml*
30 ^0C	*2 ml*	*3 ml*	*3 ml*	*2.66 ml*
40 ^0C	*4 ml*	*7 ml*	*6 ml*	*7.33 ml*
50 ^0C	*20 ml*	*15 ml*	*18 ml*	*17.66 ml*
60 ^0C	*15 ml*	*15 ml*	*20 ml*	*16.66 ml*

This extract from an osmosis investigation does satisfy O.8a.

Concentration (mol/litre)	*Mass before (g)*	*Mass after (g)*	*Percentage change in mass*
0.0 *0.0*	*1.73* *1.61*	*1.87* *1.70*	*8.1* *5.6*
0.2 *0.2*	*1.82* *1.70*	*1.92* *1.81*	*5.5* *6.5*
0.4 *0.4*	*1.73* *1.63*	*1.70* *1.61*	*-1.7* *-1.2*
0.6 *0.6*	*1.69* *1.63*	*1.52* *1.50*	*-10.1* *-8.0*
0.8 *0.8*	*1.52* *1.66*	*1.30* *1.45*	*-14.5* *-12.7*
1.0 *1.0*	*1.66* *1.65*	*1.42* *1.41*	*-14.5* *-14.5*

In the first example, the room temperature is not specified, and temperatures quoted only to the nearest 10 degrees raise some doubt as to the precision with which they were measured. Quoting averages to two decimal places with results which vary (see results for 50 and 60 degrees) is also doubtful.

In the second example, there is a slightly wider range of readings, masses are measured to three significant figures, and the repeats show reasonable consistency for this task. (The graph, not shown in this example, can also be used to judge the precision of the readings.)

Analysing evidence

State simply what is shown by the evidence (A.2a)

This is achieved by most candidates. Failure is usually because a bar chart or graph is the sole evidence for analysing evidence.

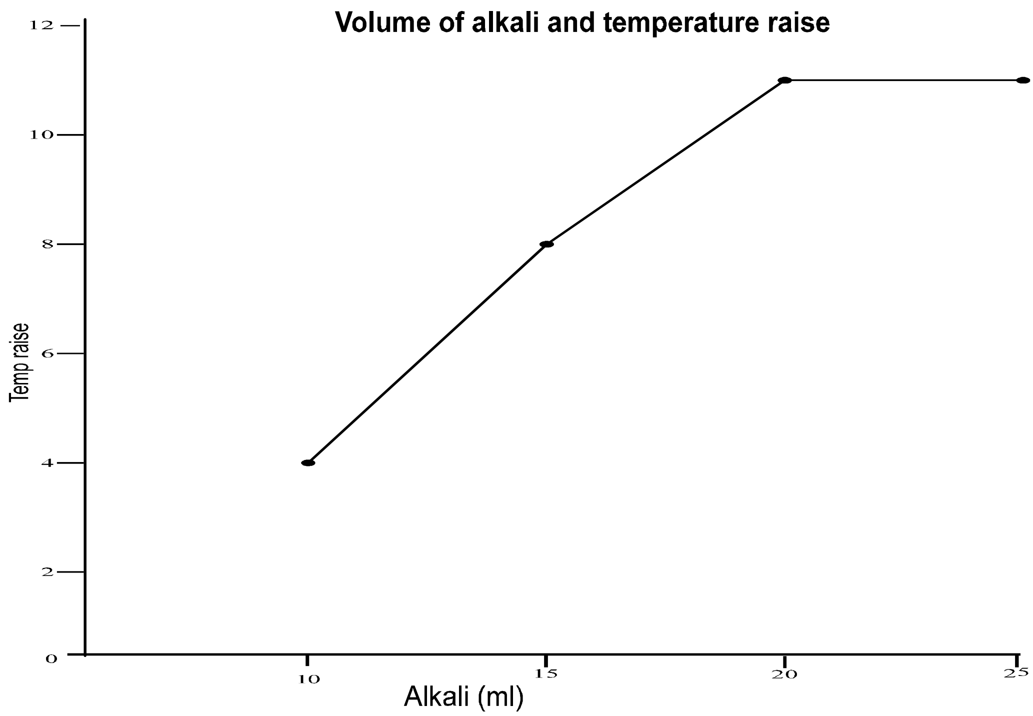
This extract from an apple browning investigation satisfies the A.2a mark description.

> *From my experiment I found that the sugar and salt stop the apple going brown*

A simple statement is all that is required.

Present findings in the form of simple diagrams, charts or graphs (A.4a)

Most candidates also achieve this mark description. Normally graphs are presented (at A.6a) but some bar charts are seen from weaker candidates.



Some centres prefer their candidates to hand draw the graphs, but computer processed graphs are acceptable. In this case the graph fails to access A.6a because there is no attempt at a best fit line, and there are no units on the *y* axis.

Identify trends and patterns in the evidence (A.4b)

A common failing is to state what was predicted rather than what was found.

This example from a pendulum experiment shows statement A.4b being matched.

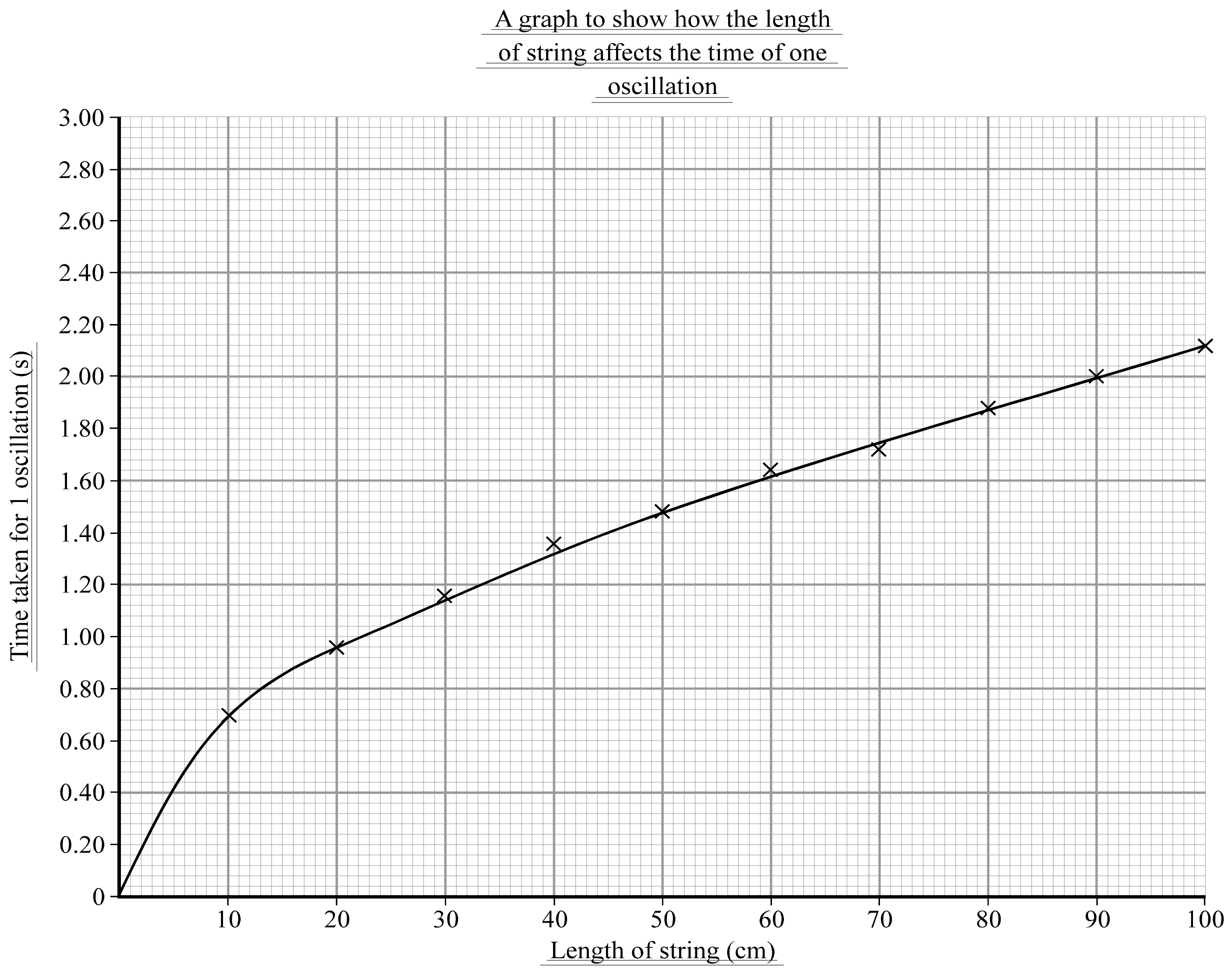
> *But on the other hand my prediction about the length of string was correct. When I increased the length of string the amount of time taken increased with it, this is because the pendulum has a lot larger distance to cover.*

In this example, the important phrase is "….When I increased the length of string the amount of time taken increased….."

Construct and use suitable diagrams, charts, graphs (with lines of best fit where appropriate), or use numerical methods, to process evidence for a conclusion. (A.6a)

As mentioned elsewhere, the most popular way of satisfying this statement is with graphs with lines of best fit. The problem is that many students do not understand the idea of a line of best fit and go for a saw tooth, point to point joining, or a straight line when a curve is more appropriate. The use of computer software in plotting graphs can also lead to problems as mentioned elsewhere. Numerical methods usually involve the use of equations, but note that averages on their own do not satisfy this statement.

This graph from a pendulum investigation satisfies A.6a.



Note that the axes are labelled, with correct units, and that the graph has a correct best-fit line.

A.6a could also have been satisfied with a simple substitution into a formula, such as V/I = R (assuming that the calculations are correct).

Draw a conclusion consistent with the evidence and explain it using scientific knowledge and understanding. (A.6b)

This is another hurdle for many students in that they can make a conclusion but fail to explain it using SKU. If the SKU is in the planning then appropriate references can satisfy this statement as shown in this excerpt from a 'huddling sheep' keeping warm investigation, which contained considerable reference to good quality theory in the planning.

> *This proves that the huddling of sheep, helps to slow down the loss of heat energy, which is lost from an isolated sheep by convection, radiation and conduction to the atmosphere, and to prevent the decrease of the sheep's internal body temperature. The rate at which huddling can slow heat loss to, depends entirely on the number of sheep in the huddle, the surface area to volume ratio of the huddle, and the surface area to volume ratio of the individual sheep.*

The important points here are the references to conduction, convection and radiation, and also the references to surface area to volume ratio.

Use detailed scientific knowledge and understanding to explain a valid conclusion drawn from processed evidence. (A.8a)

The evidence must be processed in some way, normally by the drawing of a graph, followed by some mathematical processing such as the calculation of gradients or plotting the rate of a reaction (ie the inverse of time).

The scientific explanation of the data must be valid, and must come from the more advanced aspects of the specification and is usually at or about the A grade standard.

Explain the extent to which the conclusion supports the prediction, if one has been made. (A.8b)

This statement is often integrated with A.8a.

This extract from an osmosis investigation shows both A8a and A8b satisfied.

> *As you can see from my tables and graph, I gathered one set of results at each concentration of sucrose solution, and also one repeat. I then proceeded to take an average between these two values at each concentration, and I constructed a further table of average mass before, average mass after, and average percentage mass change. Next I plotted a graph of average percentage mass change against sucrose concentration.*

From the graph, you can see that as sucrose concentration increases, first (at a concentration of 0.0 mol/litre which is de-ionised water) the percentage mass change is a large gain of 6.90%. This falls to an increase of 6.00% at a concentration of 0.2 mol/litre. The mass change = 0.0 at a concentration of 0.38 mol/litre. The percentage change in mass continues to fall rapidly, and at a concentration of 0.4 mol/litre, the mass decreases by 1.50%, this decrease continues, and at a concentration of 0.6 mol/litre, the decrease in mass is 9.10%. When the concentration is 0.8 mol/litre, the decrease becomes slightly less rapid and the percentage mass lost is 13.6%. The decrease further evens out, and at a concentration of 1.0 mol/litre the mass lost is 14.5%, and the curve evens out substantially.

The reason for these changes in mass is osmosis (see plan for definition), and the rate and direction of osmosis is different at varying concentrations. When the concentration of the sucrose is 0.0 mol/litre (no sucrose is present) the water concentration is higher outside the potato chip (and its cells). This concentration gradient therefore causes water molecules to osmose down the concentration gradient, across the partially permeable membrane and into the plant cells (those of the potato chips). This was the case at concentrations of 0.0 and 0.2 mol/litre, where mass was gained by the chips. This causes the cells to become turgid (the chips that gained mass were physically stiff, because their cells are filled with water).

At a concentration of 0.38 mol/litre, the concentration of water inside the chip (and it's cells) and outside the chip are the same, because the net movement of water is 0.0, and no mass is gained or lost by the chip.

At concentrations of 0.4, 0.6, 0.8 and 1.0 mol/litre, mass is lost by the chips, this is because the concentration of water inside the cell is greater than that outside the cell, therefore water osmoses out of the cell. At the concentration of 0.4, 0.6, 0.8 and 1.0 mass is lost because of this, and the cells of the chips became plasmolysed (and the chips quite soft) because the cells had lost water.

The trend of my graph I have already explained, in that firstly the mass is gained, then the mass increase decreases until it becomes a mass decrease, it continues to rapidly decrease, and then it evens out at the end. This analogy is as the sucrose concentration increases.

The graph does support my original prediction (as I have explained) that I stated in my planning.'

The discussion of the results is at about grade A standard, in terms of the scientific knowledge used, and the student has related the results from the task to the prediction (although that is not given in this extract).

Evaluating

Makes a relevant comment about the procedure used or the evidence obtained (E.2a)

Comments such as 'I could not do better' or 'It went all right' are worthy of zero marks but are genuine attempts at the skill area and thus can ensure there is a mark from an investigation.

N.B. An investigation is defined as a genuine attempt by the candidate at all four skill areas in the same task.

This example satisfies the mark description for E.2a since there is a valid comment on the procedure.

> *If time was available I would have done three experiments on each piece of the carbonate marble and then taken an average which would have given me more accurate results but from the time I had I got the best result possible.*

Comment on the quality of the evidence, identifying any anomalies (E.4a)

If all the results lie on a smooth line then clearly stating this satisfies the mark description. Identifying any anomalous results normally by circling the point(s) is a requirement. The following extract satisfies the description for E.4a

> *I thought that my experiment went well although I had to repeat a few of the temperatures because my results were a long way out, so I discarded the odd result and wrote in the fourth result. This gave me a better average. I thought that my measurements were quite accurate because I used the same amount of acid (25 ml) and I used the same size chips (size 6-9). I found that my results for 60°C was an odd result. This means that the gas must have escaped before I could get the bung in the top of the boiling tube. This happened a few times but I re-did some experiments because the bung wasn't in the boiling tube properly and it wasn't bubbling as much as it should. I think that at 60°C the reaction went so quickly that most of the gas escaped before I could put the bung in the top of the boiling tube. This means that the reaction slowed down and the hydrogen irons began to move around slower and the chips had been eaten away quite a bit by the acid.*

Comment on the suitability of the procedure and, where appropriate, suggest changes to improve it (E.4b)

The following extract shows this being achieved.

> *I think my results were quite reliable and accurate enough because they seemed logical and fit in with the scientific knowledge. They gave me a conclusion however I could have obtained some wrong readings because a limiting factor was the dropping pipette because it did not give the same amount of liquid in each drop. Sometimes I took the result five minutes earlier or later than I was meant to but I do not think this altered the results very much.*

I think the method I chose was the easiest and safest way of carrying out the experiment. However I could have taken even more results, repeated my results to make the experiment fair and accurate. My experiment did take a long time but nothing could be done to speed up the process.

There are comments on the procedure, although the suggestions for improvement are rather vague. Normally candidates indicate the use of a specific piece of equipment which would improve the reliability of the procedure.

Consider critically the reliability of the evidence, and whether it is sufficient to support the conclusion, accounting for any anomalies (E.6a)

This example shows E.6a being achieved.

The graph shows the effect of current size on the amount of copper deposit at the cathode. The graph is a straight line going through the origin, showing a directly proportional relationship between current and copper deposit at the cathode.

The graph tapers off at the last point for the current of 1.6A. There are various reasons for this

i) the same copper sulphate solution had been used throughout the entire experiment and although copper from the anode does replace that lost to the cathode, the gain and loss is not always consistent, as shown in the table of results and the solution may have become slightly more dilute in this last test.

ii) The same anode had been in used several tests and had almost been completely worn away, so, as shown in the table of results, the copper from the anode replacing that lost from the solution was 0.02 g less than the gain at the cathode, so the solution may have again been slightly diluted, and

iii) as mentioned in the observations, the current dropped quite low and took almost the entire 5 min to rise back up to 1.6 A so it is not a very good representation of electrolysis at a current of 1.6 A.

However, seeing as this is the only point where the graph tapers off and that, if conditions were otherwise, it would be different, a conclusion can still be drawn on the directly proportional relationship between the current and the amount of copper deposit at the cathode.

The anomalous result at 1.6A is adequately explained and the sufficiency of the data is commented upon.

Describe, in detail, further work to provide additional relevant evidence (E.6b)

The following excerpt shows E.6b being achieved.

<u>Evaluating Evidence</u>

On a whole I think that my procedure was quite reliable and suitable (evidence of this in my repeats), but there were a few certain aspects of my experimental work that I think I could have improved.

Perhaps my methods of drying the chips after use could have been changed and made more uniform, that meaning water that showed the effects of osmosis would not be unnecessarily moved from the chips.

If I could have in some way prevented the potato chips from floating (at concentrations of 0.8 mol/litre and 1.0 mol/litre) thus none of the surface area of the chips would not, be submerged in water, thus the same surface area as with the other chips would be in contact with the solutions.

If the natural potato chips could have been cut and measured by a precise machine, again my results may have been more accurate due to a more uniform surface area. Some of the chips had obvious grooves in them, again affecting the surface area of the chips but I tried where possible to discard these deformed chips.

As I stated in my analysis, and will confirm now, I feel that my results definitely go to support a firm conclusion and my prediction (originally). On my graph, I myself cannot identify any anomalous results, and feel that my curve fits ideally a trend of which I have explained.

To change this particular procedure, perhaps I would use different sizes and shapes of potato chip (thus investigating the effect of surface area on osmosis). I would also probably leave the chips in the solutions for a great deal longer time (thus being able to compare the results with those of this experiment to check whether the results are different over longer periods of time.

I may, therefore, as further work investigate into the effects of the other factors that affect osmosis in potato chips and again compare my results with these and I would investigate the effect of the temperatures at which the osmosis occurred, the surface area of the chips, I would also use perhaps more concentrated sugar solutions, and take more repeat results to improve the accuracy of my experiment. I may also use different plants or types of potato, perhaps using adapted species of plant (to hot weather etc).

This candidate has been awarded E.6b primarily for the comments about further work.

An equally acceptable approach would be to look at the data points on the graph and suggest where further readings should have been taken in order to be sure of the shape of the graph. This usually applies to either end of the range tested, or to a peak or trough in the graph.

Subject-specific information

Chemistry

A copy of the Periodic Table will be provided with each examination paper. It would be an advantage to candidates to be familiar with the format of Edexcel International's version of this table. This can be found in the Specimen papers, the Specification and in Appendix 6 of this Teacher's Guide.

The nomenclature used in the written papers will conform to that found in 'Signs, Symbols and Systematics' published by the ASE. Details of how to obtain this publication can be obtained from the ASE website at http://www.ase.org.uk. It is expected that, where appropriate, candidates will use modern conventional nomenclature in responding to examination questions.

Some of the calculations that periodically appear on written papers will require the use of an electronic calculator. Candidates should be familiar with the operation of a basic four-function calculator.

Physics - Using and recalling equations

Some formulae will appear inside the examination paper and candidates may be expected to use these equations.

For example :

- **use the relationship between energy transferred, current, voltage and time:**

  energy transferred = current × voltage × time

  $E = I \times V \times t$ **(2.7)**

Candidates are expected to recall and use the equations shown in Appendix 3 of the Science (Double Award) 4437 specification.

For example

- recall and use the relationship

  power = current × voltage

  $P = I \times V$

  and apply the relationship to the selection of appropriate fuses (2.6)

Support and training

Training

A programme of INSET courses covering various aspects of the specifications and assessment will be arranged by London Examinations on a regular basis. Full details may be obtained from

International Customer Relations Unit
Edexcel International
190 High Holborn
London
WC1V 7BE
United Kingdom

Tel: +44 (0) 190 884 7750

Edexcel publications

Further copies of this teacher's guide and other support materials such as specifications, and past papers can be obtained from

Edexcel International Publications
Adamsway
Mansfield
Notts NG18 4LN
UK

Tel: +44 (0) 1623 450 781

Fax: +44 (0) 1623 450 481

E-mail: intpublications@linneydirect.com

Other materials available are

- *Specimen papers and mark schemes (Publication code: UG014359)*
- *Specification (Publication code: UG014358)*

In addition, Longman are publishing textbooks to support IGCSEs in Biology, Chemistry and Physics; as well as in Double Award Science.

Appendices

Appendix 1: Additional guidance for Biology practical work

A checklist for teachers of required practical work and student investigations

1. Tests for glucose and starch
2. Controlled experiments to illustrate how enzyme activity can be affected by changes in temperature
3. Simple experiments on diffusion and osmosis using living and non-living systems
4. 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
5. A simple experiment to investigate the effect of exercise on breathing in humans
6. Experiments to investigate the role of environmental factors in determining the rate of transpiration from a leafy shoot
7. Controlled experiments to demonstrate phototropic and geotropic plant growth responses
8. The use of quadrats to estimate the population size of an organism in two different areas
9. An experiment to investigate carbon dioxide production by yeast, in different conditions.

Practical work and student investigations

The list below gives all the practical work in the order in which it appears in the specification (not in the order in which it appears in the course plan in this guide). Advice on how to approach each of these experiments or investigations is given in each case. The advice is not obligatory; it is recognised that there are many ways in which the practical work could be carried out to fulfil the requirements.

Tests for glucose and starch

The tests that are expected

- Benedict's test for glucose
- iodine test for starch.

These tests 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

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

The effect of amylase on starch digestion is a particularly easy system to use. At each temperature selected, from 0°C to 100°C, samples of amylase solution and of 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 intervals of one minute 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 help the 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 to 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 oxygen evolved. Hydrogen peroxide is toxic and so great care needs to be taken with its use.

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% 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 thirty 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, and this basic experimental method provides a good opportunity for students to carry out individual whole investigations. Because of the difficulty of the osmosis concept, it is better to keep this investigation until the latter part of the course so that students will have had previous experience of carrying out investigations on simpler topics. Students enjoy the reference to ‘chips’, but should quickly realise that it can be difficult to keep the size constant - to achieve consistency lengths of potato tissue can be drilled from a potato using a cork borer. The ‘chips’ are measured by mass or by 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 mass for cubes of different surface area to mass ratio can be compared, to explore the concept of how surface area to volume ratio influences water uptake.

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 if a water plant (typically *Elodea* or similar species) is placed in a beaker of water and covered 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 is then 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 experimental set up can provide an opportunity for students 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 concentration of sodium hydrogencarbonate).

(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 with no 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

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

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

The 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 x volume of each breath.

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 simulate darkness and can be compared with plants covered with transparent polythene bags. Hair dryers can simulate wind. The use of potted plants is also acceptable, but the pot and the soil is sealed with polythene and the mass of the potted plant is measured before and after a period of exposure to the environmental factor.

A simple experiment to investigate the effect of exercise on heart rate in humans

Students should be shown how to measure and record their pulse. They can measure this at rest. A short period of exercise can follow, stepping on and off a low stool, or running up and down a flight of stairs for five minutes. (Safety note: careful supervision is required.)

The pulse rate should now be recorded for five minutes or until it returns to its rest level. This experiment can provide a great deal of interesting data on the variation in resting heart rate, the effects of exercise and how quickly the heart recovers. Discussion can include measures of fitness, heart disease, cardiac output and the effects of long-term exercise on stroke volume.

A practical exercise comparing floral structure in insect-pollinated flowers

Most areas should have access to suitable specimens. Insect-pollinated flowers can be examined and the various structures observed. Teachers should demonstrate the features.

Controlled experiments to demonstrate phototropic 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 can be shone into the box. Control seedlings can either have aluminium caps put on their tips or can be kept in a shoe box without a slit for light.

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. Calculation will be needed to work out the estimated population size. For example, if ten 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 ten sample quadrats x 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 the students to guess how many beads there are. The quadrat sampling procedure can be used in front of the students 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.

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.

Appendix 2: Mark descriptors for the four skill areas

Skill Area P: Planning

Skill Area P
Candidates should be encouraged to **a** use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to plan an appropriate strategy **b** decide whether to use evidence from first-hand experience or secondary sources **c** carry out preliminary work and make predictions, where appropriate **d** consider key factors that need to be taken into account when collecting evidence, and how evidence can be collected in contexts in which the variables cannot readily be controlled **e** decide the extent and range of data to be collected, and the techniques, equipment and materials to use.

Mark descriptors for internal assessment			
The mark descriptors are designed to be hierarchical. All work should be assessed in the context of the specification content.			
Candidates			Increasing demand of activity
2 marks	P.2a	outline a simple procedure	↓
4 marks	P.4a	plan to collect evidence which will be valid	
	P.4b	plan the use of suitable equipment or sources of evidence	
6 marks	P.6a	use scientific knowledge and understanding to plan and communicate a procedure, to identify key factors to vary, control or take into account, and to make a prediction where appropriate	
	P.6b	decide a suitable extent and range of evidence to be collected	
8 marks	P.8a	use detailed scientific knowledge and understanding to plan and communicate an appropriate strategy, taking into account the need to produce precise and reliable evidence, and to justify a prediction, when one has been made	
	P.8b	use relevant information from preliminary work, where appropriate, to inform the plan	

Skill Area O: Obtaining evidence

Skill Area O
Candidates should be encouraged to **f** use a wide range of equipment and materials appropriately, and manage their working environment to ensure the safety of themselves and others **g** make observations and measurements, to a degree of precision appropriate to the context **h** make sufficient observations and measurements to reduce error and obtain reliable evidence **i** judge the level of uncertainty in observations and measurements **j** represent and communicate qualitative and quantitative data using diagrams, tables, charts and graphs.

Mark descriptors for internal assessment			
The mark descriptors are designed to be hierarchical. All work should be assessed in the context of the specification content.			
Candidates			Increasing demand of activity
2 marks	O.2a	collect some evidence using a simple and safe procedure	↓
4 marks	O.4a O.4b	collect appropriate evidence which is adequate for the activity record the evidence	
6 marks	O.6a O.6b	collect sufficient systematic and accurate evidence and repeat or check where appropriate record clearly and accurately the evidence collected	
8 marks	O.8a	use a procedure with precision and skill to obtain and record an appropriate range of reliable evidence	

Skill Area A: Analysing and considering evidence

Skill Area A
Candidates should be encouraged to **k** use diagrams, tables, charts and graphs, and identify and explain patterns or relationships in data **l** present the results of calculations to an appropriate degree of accuracy **m** use observations, measurements or other data to draw conclusions **n** explain to what extent these conclusions support any predictions made, and enable further predictions to be made **o** use scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions.

Mark descriptors for internal assessment			
The mark descriptors are designed to be hierarchical. All work should be assessed in the context of the specification content.			
Candidates			Increasing demand of activity
2 marks	A.2a	state simply what is shown by the evidence	↓
4 marks	A.4a A.4b	use simple diagrams, charts or graphs as a basis for explaining the evidence identify trends and patterns in the evidence	
6 marks	A.6a A.6b	construct and use suitable diagrams, charts, graphs (with lines of best fit, where appropriate), or use numerical methods, to process evidence for a conclusion draw a conclusion consistent with the evidence and explain it using scientific knowledge and understanding	
8 marks	A.8a A.8b	use detailed scientific knowledge and understanding to explain a valid conclusion drawn from processed evidence explain the extent to which the conclusion supports the prediction, if one has been made	

Skill Area E: Evaluating

Skill Area E	
Candidates should be encouraged to	
p	consider anomalous data, giving reasons for rejecting or accepting them, and consider the reliability of data in terms of uncertainty of measurements and observations
q	consider whether the evidence collected is sufficient to support any conclusions or interpretations made
r	suggest improvements to the methods used
s	suggest further investigations.

Mark descriptors for internal assessment			
The mark descriptors are designed to be hierarchical. All work should be assessed in the context of the specification content.			
Candidates			Increasing demand of activity
2 marks	E.2a	make a relevant comment about the procedure used or the evidence obtained	↓
4 marks	E.4a	comment on the quality of the evidence, identifying any anomalies	
	E.4b	comment on the suitability of the procedure and, where appropriate, suggest changes to improve it	
6 marks	E.6a	consider critically the reliability of the evidence and whether it is sufficient to support the conclusion, accounting for any anomalies	
	E.6b	describe, in detail, further work to provide additional relevant evidence	

Appendix 3: A student guide to science coursework criteria

Skill Area P: **Planning**	Skill Area O: **Obtaining Evidence**
❑ 2 marks ♦ Plan a simple procedure ❑ 4 marks ♦ Plan to collect valid evidence ♦ Make a list of the equipment or other sources of evidence ❑ 6 marks ♦ Produce a plan for your task using scientific knowledge and understanding ♦ Say what things will affect how well the investigation will work and say how you plan to change or control these ♦ Give scientific reasons for why you think these things are important ♦ Say what you think will happen and give scientific reasons ♦ Say what evidence you are planning to obtain and how much evidence you think will be needed ❑ 8 marks ♦ Give a detailed description of what you are planning to do ♦ Use detailed scientific reasons to explain why you think your plan is a good way of carrying out the task ♦ Explain how you will use the equipment to make sure the results you obtain will be correct and as precise as possible ♦ Say what you think will happen and give detailed scientific reasons to explain this ♦ Describe any earlier work that helped your planning ♦ Give any information that you have obtained from books, CD ROMs, the Internet, or other sources to help your planning	❑ 2 marks ♦ Collect some evidence in a safe way ❑ 4 marks ♦ When you carry out the task, make sure you have enough evidence so that you will be able to say what you have found out ♦ Keep a record of your results ❑ 6 marks ♦ Use the equipment to obtain the evidence as accurately as possible ♦ Make sure your evidence covers a good range ♦ Make sure you have enough evidence to allow you to draw a conclusion ♦ If you think your evidence varies a lot, then take some repeat readings if you can ♦ Use a clear way of accurately recording your evidence ♦ Consider using a table of results with clear headings and correct units ❑ 8 marks ♦ Use equipment that will help you obtain precise evidence ♦ Repeat results in order to obtain averages readings. Check that your evidence is reliable ♦ Record the evidence in a clear and accurate way

Skill Area A: **Analysing and considering evidence**	Skill Area E: **Evaluating**
❑ 2 marks ♦ Say what you have found out from your evidence ❑ 4 marks ♦ Choose a way of showing any pattern in your evidence more clearly ♦ Use a pie chart, bar chart, graph or a clearer way of showing your evidence ♦ Say what pattern or trend you can see in your evidence ❑ 6 marks ♦ Use the best way of displaying your evidence clearly e.g. by using a chart, diagram, line graph or by doing calculations that help you to make good use of your data ♦ Is a line of best fit appropriate? ♦ Make use of your evidence and any processing that you have done to write a sensible conclusion that explains what has been found out ♦ Using your evidence, include in your conclusion a scientific explanation ❑ 8 marks ♦ Use the best way of processing your evidence e.g. diagrams, graphs, calculations ♦ Use this work to draw a meaningful conclusion for the investigation ♦ Use scientific knowledge in a detailed way to explain the conclusion you have written ♦ If you have made a prediction of what you thought would happen, say if your results turned out the way you expected ♦ If the evidence did turn out as expected, explain how well the evidence matched your prediction ♦ If the evidence did not turn out as expected, explain why you think the evidence did not support your prediction	❑ 2 marks ♦ Say if you think the task worked out well or not, give a reason for what you have said based on what you did, or what evidence you got ❑ 4 marks ♦ Say if you think the evidence was accurate enough for the task – refer to your graph ♦ Were there any anomalous results? If so show where they are on the graph. If not, say something about the shape of your graph ♦ Suggest at least one improvement that you would like to make to the method to try to get more accurate evidence ❑ 6 marks ♦ Say whether your method gave evidence that is reliable and so could always be counted on to be correct – give detailed reasons for what you have said ♦ Point out any results that did not seem to fit in with the main pattern and explain why you think these differences happened ♦ Say if you think you have enough evidence to draw a conclusion – give detailed reasons for what you have said ♦ Think about your method and your evidence. How might you improve your method to obtain more evidence to support your conclusion?

Appendix 4: Assessment of practical skills – final mark aggregation sheet

Month and year of examination:	Specification title:
Specification number:	
Centre:	Candidate name:
	Teaching group:
Centre number:	Candidate number:

Marks should be reported for each of the skill areas P, O, A and E.

Two marks are required for **each** skill area. Thus eight marks are required in total to give a maximum mark of 60. These marks should be drawn from **not more than four** pieces of work. At least **one** mark must be from a practically based whole investigation. At least **two** science subjects (i.e. Biology, Chemistry and Physics) **must** be represented.

The reported marks from each activity should be ringed.

Activity title(s)	P	O	A	E

Please indicate whether the reported mark(s) are taken from an investigation by putting an asterisk next to the appropriate mark(s).

The skill area marks are reported in the appropriate Centre Mark boxes in the table below and then aggregated to give a total reported mark.

	Skill area P		Skill area O		Skill area A		Skill area E		Total mark	Max mark
Centre mark										60
Moderator mark										
Team Leader mark										

Declaration of Authentication

I declare that the work submitted for assessment has been carried out without assistance other than that which is acceptable under the scheme of assessment.

Candidate's signature: ………………………………………… Date: …………………

Teacher's signature: ………………………………………… Date: …………………

Appendix 5: Assessment of practical skills - an example of a completed final mark aggregation sheet

Month / year of examination: *May 2006*	Specification title:
Specification number: *4437*	*IGCSE Science (Double Award)*
Centre: *xyz International School*	Candidate name: *Fatima Khan*
	Teaching group: *5H*
Centre number: *9xxxx*	Candidate number: *xxxx*

Marks should be reported for each of the skill areas P, O, A and E.

Two marks are required for **each** skill area. Thus eight marks are required in total to give a maximum mark of 60. These marks should be drawn from **not more than four** pieces of work. At least **one** mark must be from a practically based whole investigation. At least **two** science subjects (i.e. Biology, Chemistry and Physics) **must** be represented.

The reported marks from each activity should be ringed.

Activity title(s)	P	O	A	E
The effect of pH on pepsin activity	8	6	-	-
The effect of length on the resistance of a wire	*7	6	*5	*4
The effect of surface area on the rate of a reaction	-	7	6	3

Please indicate whether the reported mark(s) are taken from an investigation by putting an asterisk next to the appropriate mark(s).

The skill area marks are reported in the appropriate Centre Mark boxes in the table below and then aggregated to give a total reported mark.

	Skill area P		Skill area O		Skill area A		Skill area E		Total mark	Max mark
Centre mark	8	7	6	7	5	6	4	3	46	60
Moderator mark										
Team Leader mark										

Declaration of Authentication

I declare that the work submitted for assessment has been carried out without assistance other than that which is acceptable under the scheme of assessment.

Candidate's signature: *F. Khan* Date: *12 / 01 / 05*

Teacher's signature: *A. Master* Date: *16 / 2 / 05*

Appendix 6 – Provisional assessment record

Student Name…………………………………… Group/Set ……………………..………..

Task ……………………………………………………………………………………

P.2a ………………………………………………………………………………

P.4a ………………………………………………………………………………

P.4b ………………………………………………………………………………

P.6a ………………………………………………………………………………

P.6b ………………………………………………………………………………

P.8a ………………………………………………………………………………

P.8b ………………………………………………………………………………

O.2a ………………………………………………………………………………

O.4a ………………………………………………………………………………

O.4b ………………………………………………………………………………

O.6a ………………………………………………………………………………

O.6b ………………………………………………………………………………

O.8a ………………………………………………………………………………

A.2a ………………………………………………………………………………

A.4a ………………………………………………………………………………

A.4b ………………………………………………………………………………

A.6a ………………………………………………………………………………

A.6b ………………………………………………………………………………

A.8a ………………………………………………………………………………

A.8b ………………………………………………………………………………

E.2a ………………………………………………………………………………

E.4a ………………………………………………………………………………

E.4b ………………………………………………………………………………

E.6a ………………………………………………………………………………

E.6b ………………………………………………………………………………

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