GCSE

Chemistry A

Twenty First Century Science Suite

Teacher Support

OCR GCSE in Chemistry A J634

Contents

Managing Skills Development and Assessment in Twenty First Century Science

An education in science means different things for different people. *The report Beyond 2000 – science education for the future* [Robin Millar and Jonathan Osborne, eds; King's College, London 1998, ISBN 1 871984 78 5] identified two main purposes for science education at secondary level:

- The first stage in training for future scientists.
- A preparation for life in a modern society for all pupils.

The new assessment structure for GCSE Science in the National Curriculum recognises that these two purposes require courses with different content and different approaches. Thus, the former "Double Award" science, which tried to combine the different purposes into a single course, has been replaced by "Dual Science" – two separate specifications, taught with different aims in view, and leading to two independent qualifications.

The Twenty First Century Science suite of specifications has been designed from the beginning to address both purposes in a way which allows the maximum curriculum flexibility. It provides valid, meaningful and motivating learning experiences for the widest possible variety of students, regardless of interest, ability or career intentions.

The key to this flexibility is provision of a full suite of single subject specifications, which can be combined in many different ways.

The National Curriculum core requirement for science is a minimum of single award science. This must provide a basis of scientific literacy: Science for citizenship, for all young people, based on sufficient knowledge of science content to comprehend major issues in modern society.

This coverage is provided through the specification

- Science (J630), which provides an education for all students, based on scientific contexts and issues in contemporary society.

It is anticipated that the majority of students will wish to learn more about science. In this suite, two alternative varieties of Additional Science are offered:

- Additional Science (J631), which extends knowledge and understanding of science to provide a sound basis for more advanced study
- Additional Applied Science (J632), which provides a work-oriented experience of how science is applied in chosen manufacturing or service areas

These three specifications are designed to suit different populations with different needs. Thus, the assessment of skills through coursework is different in each specification and designed to match the different objectives of each specification. Because many students will take one of the additional sciences as well as Science, the assessments for the Additional Science specifications are designed to be complementary to those for Science, not merely to repeat similar activities.

The three schemes of assessment are different, but each is based on activities which should occur as a normal part of teaching and learning in the course. The general procedures followed in awarding, recording and submitting assessment marks follow the same pattern for all of the specifications.

In addition the suite includes single subject specifications in each of Biology (J633), Chemistry (J634) and Physics (J635). These specifications include the relevant subject content from each of Science and Additional Science plus additional content. The skills developed in the separate science qualifications are identical to those developed in Science and Additional Science and this is reflected in the assessment.

An Introduction to Skills Assessment for Twenty First Century Science

Where a centre is introducing several of the schemes at the same time, it may be helpful to ask different staff to 'lead' on different schemes, thus sharing out the load of developing new techniques and learning new marking criteria.

The key features of the schemes are summarised in table 1.

Table 1: *Key features of each skills assessment scheme.*

Specification	Science A J630	Additional Science A J631	Additional Applied Science J632
Abilities to be developed	Responding to science in the media and in society	Practical investigative skills	Workplace skills and activities
Assessment activities	Analysis of first-hand experimental data + A case study of science in the media	A complete practical investigation	Standard procedures + Suitability test + Work-related report

For each separate science subject (J633:Biology, J634:Chemistry or J635:Physics), each candidate may offer –

either: (A329) a case study and data exercise, as for Science

or: (A330) a practical investigation, as for Additional Science

Staff at a centre may decide to allow candidates to carry out both types of activity, thus developing the full range of skills, and then submit whichever gives the higher mark; or to concentrate on just the one type of assessment.

Marking Internally Assessed Work

Strands and aspects of performance

The method of marking the skills assessment is the same across all specifications in this Science suite. The award of marks is based on the professional judgement of the science teacher, working within a framework of descriptions of performance which are divided into strands and aspects. Within each strand there are different aspects of performance, which in turn have four descriptions of performance illustrating what might be expected from candidates working at different levels.

For example, in the assessment of Data Analysis, Strand I: Interpreting Data

Aspect of performance	Strand I Mark			
	2	4	6	8
(a) graphical or numerical processing of data	Display limited numbers of results in tables, charts or graphs, using given axes and scales.	Construct simple charts or graphs to display data in an appropriate way, allowing some errors in scaling or plotting.	Correctly select scales and axes and plot data for a graph, including an appropriate line (normally a line of best fit) or construct complex charts or diagrams (e.g. stacked histograms, species distribution maps).	Additionally, indicate the spread of data (e.g. through scatter-graphs or error bars) and give clear keys for displays involving multiple data-sets.
	Select individual results as a basis for conclusions.	Carry out simple calculations e.g. correct calculation of averages from repeated readings.	Use mathematical comparisons between results to support a conclusion.	Use complex processing to reveal patterns in the data e.g. statistical methods, use of inverse relationships, or calculation of gradient of graphs.

Each aspect in turn should be considered, comparing the work first against the two mark performance descriptor, then the four mark, then six etc until the best match is found.

Where performance significantly exceeds that required by one descriptor, but does not sufficiently match the next, the intermediate mark (1, 3, 5 or 7) should be awarded.

Note the implication that performance descriptors indicate the quality of performance required, as distinct from mark criteria which look for mechanical matching and too easily lead to ‘hoop jumping’ for its own sake.

Thus, the level of performance in each aspect is decided. The single, overall, mark for the whole strand is then taken as the best fit to the level of performance shown. This would normally be the average of the levels judged for the individual aspects.

In a few instances, dotted lines on the assessment scheme are used to indicate alternative ways of accessing credit. For example, some work may be best described by graphical display of results, and other work by numerical processing – either can be used as the basis for the mark, allowing a wider variety of different types of investigation to match the criteria. Where it is possible to award some credit under both of the alternatives, the better of the two should be taken as the mark to count.

With these few exceptions, all the aspects must be taken into account in reaching the final mark for the strand. If there is no evidence of achievement for an aspect, a mark of zero should be recorded and included in calculation of the overall strand mark.

Candidates may not always report their work in a particular order, so evidence of achievement in a strand may be located almost anywhere in the work. Thus, it is necessary to look at the whole piece of work for evidence of each strand.

Where a decision is based partly on teacher observation of the candidate at work, the work should be suitably annotated at the appropriate point in the report.

Marking grids

Marking decisions should be recorded on marking grids. A master copy for Unit A329 is provided in Appendix K. A master copy for Unit A330 is provided in Appendix L. The completed grid serves as a cover-sheet for the work if it is required for moderation.

Within any one strand, each aspect should be considered in turn. A tick on the grid should be used to indicate the performance statement that best matches the work.

When each aspect of performance within a strand has been assessed in this way the pattern of achievement is interpreted by a 'best-fit' judgement to give a mark for that strand. For example,

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
I	(a) graphical or numerical processing of data					✓					5
	(b) summary of evidence					✓					
	(c) explanations suggested							✓			

This method of marking can be applied even where there is a wide variation between performance in different aspects. Thus, weak performance in one aspect need not depress marks too far if other aspects show better performance.

In some cases, in order to allow credit for the widest possible variety of activities, an aspect of performance is represented by two (or more) rows of performance descriptions (for example, graphical or numerical processing in the Strand I example above). In such cases, where a row is not relevant or appropriate for a particular activity, it should be left blank and not included in making any marking decision. If both rows are appropriate then the best mark for that aspect can be used.

Managing the activity in action

During the practical sessions ask what might be called enabling or checking questions to ensure progress for all students, independent of ability.

For example, questions such as

- Can you explain to me your basic method?
- How do you know that the experiment is a fair test?
- How accurate are your measurements?
- How reliable are your measurements?

The aim is to encourage students to reflect on their work and refine their procedure if necessary.

Writing up the activity and marking

During the time period of the activity it is suggested that students write up as they go along and show you the various stages. If the coursework is word processed changes, alterations, and additions can easily be done. If hand written then writing on one side of A4 allows the opportunity to include extra pieces of paper as and when needed.

The teacher should make **general** comments about aspects that are missing or need further development e.g. ‘is your results table complete?’ ‘is the range of measurements sufficient?’, ‘have you drawn a best fit line on your graph?’

At the end of the activity a suitable short deadline is set and the work handed in for marking.

The work should **not** be returned for further re-drafting.

Appendix H includes suggestions of suitable topics for Investigations. Appendix J provides some guidance notes that can be used with students. Appendix M provides specific guidance for supporting very weak students doing Investigations.

A Rationale for Skills Assessment in Chemistry A

A329 case study and data analysis

The National Curriculum Programme of Study specifies that science should be a course to develop scientific literacy. ‘Literacy’ in any subject area may be described as the ability to comprehend what is written about the subject – to take an informed part in discourse about the subject.

In everyday life, citizens most often become aware of science-related issues through reports in the media: newspapers, teenage magazines, television, etc. Work on this course should help candidates to develop capabilities in evaluating such reports, and the reliability of the evidence they are based on, and to increase awareness of appropriate ways of making decisions about the issues which are raised.

The skills assessment is designed to identify and reward these capabilities. Schemes of work should be designed to build up the skills gradually through suitable activities including study of topics where different views can be considered and compared. Coursework should arise naturally out of teaching, so that it can be assessed by teachers, internally standardised and then externally moderated by OCR. The skills assessment contributes 33.3% to the overall assessment of the specification.

The skills assessment comprises two components: the critical analysis of primary data, and a case study on a topical (scientific) issue.

Data analysis activity

First-hand experience of the problems of collecting valid and reliable data can give candidates a better sense of what the difficulties really are, a 'feel' for how great they are in specific cases, and provide a context for beginning to understand how to tackle and perhaps overcome them. The published scheme of work includes many experimental practical activities to ensure that candidates experience how scientific evidence is obtained.

It must be clear that the candidate has been personally involved in generating at least some of the data, but the collection of the data is not directly assessed. This avoids pressure to ‘drill’ particular techniques simply for assessment purposes. However, it must be clear that the candidate has been personally involved in generating at least some of the data.

The assessment is based on analysis and evaluation of data because these skills are necessary for deciding the merit of scientific claims made in the media, or in support of proposed actions. Analysing and interpreting data illustrates how scientists use experimental evidence to develop and test theories. Evaluating the procedures and data shows how the reliability of scientific findings can be assessed.

The mark-scheme used is identical to the two corresponding strands of the assessment of Investigations in Additional Science and Unit A330.

Case study

The case study is designed to motivate candidates and give them an insight into how science is reported to the public, and to teach them how to assess the validity of underlying research and claims or recommendations based on the research. Ideally, the study should arise from such a media source. Suitable topics involve some degree of controversy, or disagreement, either about the interpretation of the scientific evidence, or about how individuals or society should respond.

The title for a case study is best phrased as a question with a yes / no answer, to be answered by careful balancing of evidence and opinions from a variety of sources

Arriving at the final mark

The final mark for each candidate comprises the total for one practical data interpretation exercise plus one case-study. It is not permitted to aggregate part-marks from different activities as the assessment covers the candidate's ability to complete a task. Candidates should be given opportunities to develop their skills before completing the assignments for assessment.

Data Analysis (Assessment Unit A329)

Data from observations and measurement are of central importance in the various processes that lead to new scientific knowledge.

Throughout the course, candidates will carry out a variety of practical activities, to illustrate principles and to gather data as a basis for discussion or further work. Any activity in which students are personally involved in generating first-hand data is suitable as a basis for this assessment. Any such activity is also suitable for introducing ideas about quality and reliability of data, and the relationship between the data and how it can be explained.

Whenever data is being collected, attention should be drawn to the quality of the data.

Time should be taken to:

- analyse the data
- evaluate the reliability of the data
- discuss the conclusion
- discuss the level of confidence in the conclusions.

In this way, students will gradually develop familiarity with the terminology used, and the requirements of the assessment marking criteria. Every experiment should be a part of the preparation for this assessment.

The intention of these activities is to give an appreciation of the limitations to data, and develop understanding of accuracy and reliability in data. These are described in the specification as Ideas about Science. This part of the assessment highlights in particular

IaS 1: *Data and their limitations.*

IaS 2: *Correlation and cause.*

IaS 3: *Developing explanations.*

Ideas about Science are described more fully in Appendix N, where they are also linked to performance by a candidate, indicating the level of understanding expected.

The performance criteria used for marking this assessment form two of the five ‘strands’ of a complete investigation as defined in A330.

Many Centres use marks for this assessment from full investigations and in many ways candidates appear to be better placed to make realistic evaluations of their procedures and data collected. However, in the case of weaker candidates, the data collected is often poor in quality and quantity so that they find interpretation difficult. Therefore, in these cases, data collection activities involving whole class participation were generally the most successful. In these activities, the whole class can be involved in the planning stage. Each candidate takes some measurements, so that they are familiar with the practical difficulties involved. The total body of data collected can be very large, so that there is plenty for students to say about accuracy, validity and reliability.

Guidance in Marking the Data Analysis Task

Marks are awarded for two strands, Interpretation (Strand I) and Evaluation (Strand E). The two marks which make up the assessment total for this element of skills assessment must both come from the same activity.

The full criteria are given in Appendix C.

Strand I: Interpreting data

This aspect of the marking criteria relate to Ideas about Science 1.4, 2.1, 2.3, 2.4, 3.1, 3.3, 3.4.

Aspect (a) Revealing patterns in data

Students should be encouraged to look for patterns or relationships within the data they have available. This is often easier if a substantial amount of data is accumulated.

To save time, a class can share data. Each student or working group can collect a little data, to experience the practical problems involved. Pooling the data makes it easier to look for trends or patterns, or to establish the range covered by ‘repeat’ readings.

Some activities lend themselves to graphical display of results to give visual indications of any patterns or trends e.g. relationships between variables over a range of values. Others may be more easily analysed by numerical or statistical processing e.g. patterns of species distribution in a habitat. To allow for this, the mark scheme provides alternative sets of performance descriptors (two rows in the table of descriptors, separated by a dotted line). This allows a much wider variety of tasks to give access to the mark range. Where work allows aspects of both, then both should be assessed, and the higher of the resulting marks is taken.

Aspect (b) Summarising the evidence

As part of the conclusion students should be encouraged to give summaries of the patterns they find in their results. For higher marks, the conclusion should be quantitative or based on statistical analysis, and any limitations or uncertainties should be recognised.

Aspect (c) Explaining the evidence

A scientific explanation is a suggestion which involves a plausible mechanism to explain why the results turn out as they do. Students should be encouraged to refer to prior scientific knowledge to support their explanation.

Strand E: Evaluation

Candidates are expected to be able to look back at the experiment they have carried out, show what they have learned from doing it and explain how they would modify it in the light of this, were they to carry it out again.

This aspect of the marking criteria focus on the Ideas about Science 1.1, 1.2, 1.3, 2.2, 2.3, 2.5, 2.6, 2.7.

Aspect (a) Evaluation of procedures

Students review any practical difficulties encountered whilst collecting the data. They also review the extent to which they were able to control factors which might have interfered with their experiments and affected the accuracy or reliability of the data. They then consider whether they could make any improvements in the apparatus, materials or procedures.

Aspect (b) Reliability of evidence

Students review the consistency of the data, for example in respect of the closeness of ‘repeat’ measurements, or the ‘scatter’ evident on graphs of the data. They identify any results which appear to be ‘outliers’ and attempt to explain how these may have arisen.

Aspect (c) Level of confidence in the conclusion

Students consider how secure their conclusion is. This should be related to the precision and reliability of the data, to the adequacy of the ranges covered and, if relevant, whether there are real differences between data sets. They identify any areas of weakness in the data and suggest what extra work might be needed to strengthen these.

Appendix B includes a list of activities which might be used for the teaching and assessment of data analysis and evaluation skills.

Case Studies (Unit A329)

Each candidate entering A329 is required to present one case study, a report based on detailed study of a chosen topic.

The case study is designed to motivate candidates and give them an insight into how science is reported to the public, and how they can explore the validity of underlying research and claims or recommendations based on the research. The case study will draw on the Ideas about Science described in Appendix N.

These assignments should arise naturally from work on the course or from an issue that arises while candidates are following the course. They should be related to an aspect of science that involves an element of controversy, in terms either of the interpretation of evidence, or of the acceptability of some new development.

When should the assessment be done?

Assessment can take place at any time during the course. Some centres may wish to carry out a study early in the course, or at the end of year 9 to introduce the idea of case studies and the marking requirements. This would provide marks which could be counted. However, the course modules are designed to allow regular activities which illustrate and help to develop the necessary skills, so it is generally more effective to delay the assessment until several course modules have been covered.

If the course is being taught over two years, then the second half of summer term in the first year provides a suitable time. For a one-year course, an alternative time may be early in spring term.

Note that internally assessed units can only be submitted for moderation in the June examination season (not January). It is necessary to register for moderation. It is also necessary to notify OCR when unit marks are to be aggregated for award of GCSE certificates.

Some centres have devoted a short period of time entirely to case studies e.g. all science lesson time for a week. Others prefer to spread the task over a longer period. This would require some preliminary discussion with students – perhaps revisiting possible topics from modules already covered, in order to select questions for study. Some students may need to be given topics, but in most cases better motivation is achieved if each student can choose their own question to study. If possible, one or two lessons should be timetabled to give students individual access to the internet. If this is not possible, it will be important to negotiate access to the web for non-contact time e.g. via the school library. Finally at least one lesson, preferably two, should be allocated so that the majority of the final writing up can be done under classroom supervision.

Preparing Students for the Assessment of Case Studies

One main aim of the course is to help students make better sense of science stories or issues they encounter in the media. Most of the teaching modules include examples of issues for students to explore. These provide opportunities to gradually develop competency in

- searching for information,
- acknowledging sources,
- considering the scientific basis for claims or ideas they encounter,
- comparing different views and opinions,

- justifying their conclusion by reference to the evidence,
- presenting ideas effectively.

Format of the Case Study

Candidates will find it helpful to have a clear sense of audience in their writing – perhaps students in year 9, to encourage them to explain the basic science behind the topic.

Case studies will often take the form of a 'formal' written report. However, candidates should not be discouraged from other styles of presentation, for example:

- a newspaper or magazine article;
- a PowerPoint presentation;
- a poster or booklet;
- a teaching/learning activity such as a game;
- a script for a radio programme or a play.

In all cases, sufficient detail must be included to allow evaluation in all of the performance areas. Some types of presentation would require supporting notes to explain the choice of reporting medium chosen.

Choice of topic for a Case Study

Topics for study should be selected by candidates in discussion with teachers, and should be seen as an extension or consolidation of studies undertaken as a normal part of the course. The work should be capable of being completed within approximately 4-6 hours over a period of time, for example, one lesson per week for half a term, with some non-contact time.

Suitable topics often fall into one of three main types –

- Evaluating claims where there is uncertainty in scientific knowledge (e.g. "Does pollution cause asthma?") Controversies of this type focus attention on the relationship between data and explanations in science, and on the quality of research which underlies competing claims.
- Contributing to decision making on a science-related issue (e.g. "Should a shopping street be pedestrianised to reduce air pollution?") Studies in this category are more likely to involve elements of personal choice, values and beliefs, and may involve balancing of risks and benefits of any proposed action.
- Personal or social choices (e.g. "How can I reduce the amount of waste I produce?"). Ethical and personal issues are likely to figure in such studies, but it is important to evaluate these in relation to what is known about the science which underlies the issue.

In all cases, an important factor in choice of subject should be the availability of information giving a variety of views in forms that can be accessed by the candidate. Candidates may be provided with the initial stimulus for the study, but should be encouraged to search for a range of opinions in order to reach a balanced conclusion.

The subject need not be restricted to topics studied in the course. However, it is necessary for the candidate to apply some relevant scientific knowledge and understanding to discussion of the issues raised. This is most likely to be the case if the study arises naturally during normal work on the course.

Candidates need not all study the same, or related, topics. Motivation is greatest if they are given some degree of autonomy in the choice of topic. This may be achieved by allowing choice of different issues related to a general topic (e.g. different aspects of air pollution when studying Air

Quality) or by encouraging candidates to identify topics of interest and begin collecting resource materials over an extended period. At a time chosen by the centre, candidates then complete their Case Study, and may each be working on a different topic.

The assessment might be introduced in a lesson which reviews controversial topics in modules already studied (e.g. issues related to air pollution in Air Quality). This might also include a look forward to issues which will be met in later modules, especially if these turn out to be topical in the media at the time. Students can then choose the area of greatest interest to themselves, and define a question to address within that topic.

This initial lesson should at least define the questions to be studied, and if possible provide some initial ideas for sources of information.

It is then very helpful if one or two lessons can be time-tabled in a library or computer room, so that pupils can continue to research additional information with some supervision and help from staff.

Finally, one or two lessons should be provided when pupils can complete the majority of their writing-up under supervision (to avoid plagiarism or sharing of work).

Some centres prefer to provide these as successive lessons, completing the whole task within a week. Others prefer to spread them out, say one per week over 4/5 weeks. In either case, it should be remembered that this is **coursework** and so should be done within course time. The centre should provide the lesson time, supervision and support which is needed.

The total amount of class contact time required should be about 4 – 5 lessons.

Several of the teachers who took part in the pilot have contributed activities which help to develop case study skills. Jim Beresford, of Fartown High School has used a variety of activities:

- Distribute newspapers round the class (the free “METRO” is often a good source of science-related stories). Ask each group to find headlines which are ‘science-related’. When headlines are read back, encourage class discussion to identify which bits of science knowledge are linked to the story.
- Find a science-linked story in a paper. Distribute copies together with an activity to focus on the text e.g. highlight science claims or theories in green, supporting evidence in blue, opposing views in red. Then discuss how reliable the opinions in the article seem to be.
- Provide media stories as stimulus. Ask each student to generate two or three questions which could be answered as a case-study. Collect and display suggestions then prompt discussion of how suitable, or easily managed, each might be.
- Provide copies of (anonymous) case-studies from other classes or previous groups and ‘pupil-speak’ versions of the marking criteria. Ask each group to mark the case-study, then discuss the marks awarded and the good or weak features of the study.

Appendix D includes suggestions of topics studied by students in pilot schools. Appendix E provides some guidance notes that can be used with students. Appendix M provides specific guidance for supporting very weak students doing Science coursework.

Guidance in Marking Case Studies

A Case Study represents a major piece of work and it is not expected that students should attempt more than one full study during the course. If a student attempts more than one case study, then the mark for the assessment should be based on the highest-scoring single study. It is not permitted to aggregate marks from two or more different pieces of work, nor to add together marks taken from separate, limited range tasks, exercises or part studies.

Because of the risk of some studies becoming excessively long, it is important to link marks to the quality of the work done, rather than the quantity.

Appendix K shows the sheet used for recording the marks awarded which count towards the final assessment total. When work is selected as part of the sample for moderation, the work of each candidate in the sample should have one of these forms completed and attached as a cover-sheet to the work. The sheet will be used as a working document by the moderator.

Strand A: Selecting information

Where possible, students should use multiple and different types of sources of information e.g. web-sites, encyclopaedias, library books, course textbook and their own notes. There should be a list of the sources used and these should be detailed referring to, for example, book and page number and full URL, not just to the homepage of the particular website.

Material from the sources should be selectively used, not just a collection of ‘cut-and-paste’ extracts. This will usually include some direct quotation, but should also involve some re-structuring and comment on the information. Where sections of text are directly quoted, this should be made clear e.g. quote-marks or different font from the main body of the text if word processed.

To score well in this strand students must link information in the report to the sources used and evaluate the quality of the sources, recognising any discrepancy between sources.

Strand B: Quality of scientific understanding

Students should show their understanding of the background scientific knowledge and understanding which will help them evaluate the information in their sources. Students should explain the basic scientific facts, principles and concepts of the topic and their student textbook or own notes will be a good source. This can be backed up by extra information from more advanced or specialist books, encyclopaedias or web-sites.

It is often helpful, before marking begins, to think about what would represent excellent, good, fair or poor performance in each aspect for the particular title chosen by each student. This is particularly important in marking strand B.

The first aspect of strand B requires students to use scientific knowledge and understanding to provide a background for the study. This must be interpreted in relation to the knowledge available to the student through studies already completed on the course, together with what might reasonably have been found from the sources available for the study.

Most current science issues are likely to extend well beyond the limits of GCSE science. It should be made clear to students that they will not be required to recall any of this extra theory in their examinations. However, they will find it helpful to look up science knowledge beyond what they have done in lessons to help them understand the topic they are studying. Many students respond very positively to the experience of finding that they are able to follow a topic beyond the limits of what has been presented in class.

Marking trials during the pilot were used to develop agreement about the levels of science to be expected. The following examples were developed by pilot teachers as a result of marking work done by their pupils.

Table 2: *Related scientific knowledge and understanding for some case study topics*

Case study title	Related science knowledge and understanding
Who is to blame for obesity?	what is a balanced diet? major and minor nutrients respiration, metabolic rate, and fat storage health problems associated with obesity ‘junk food’, publicity and social pressure combined effects of exercise and diet
Should we add fluoride to water?	fluorine as a group 7 element; fluorides evidence for the effect for reducing tooth decay harmful or side effects alternative ways to administer fluoride opting in or opting out ethical issues related to compulsory medication

This sort of preliminary survey of a topic allows markers to develop judgement about the amount of science which would be expected at each mark level.

The second aspect of strand B requires students to recognise and evaluate the scientific basis of any claims they find in their sources – how much if any research was done, how clear and relevant are the results? Successful studies will show a critical approach to judging the reliability of the claims which are reported.

Strand C: Conclusions

There should be evidence that the sources used have been compared to check for consistency and to identify areas of conflict or disagreement. There should also be evidence that the underlying science has been used to try to resolve any differences.

There should be evidence that points ‘for and against’ have been compared and that candidates have given their own viewpoint or position in relation to the original question, and have justified this by reference to the sources.

Strand D: Presentation

Communication skills should be rewarded for effective presentation including use of different forms for presenting different types of information (e.g. pictures, tables, charts, graphs, etc.).

Suitable diagrams and graphics should be incorporated as appropriate to clarify difficult ideas and encourage effective communication. A table of contents gives structure to the report and also helps to guide readers quickly to particular sections.

Reports which are presented as PowerPoint should include notes to accompany each slide, enabling student to access the higher mark descriptions across other strands.

Appendix C shows the marking criteria for case-studies.

Appendix F gives marking commentaries for the example case-studies.

A330 Practical Investigation

This Chemistry specification is designed so that, when taught along with Physics and Biology, it will provide a suitable foundation for further studies of science. It is most suitable for candidates with an interest in becoming professional scientists, or for those who, in addition to understanding how science works, want to learn more about scientific facts and principles and the experimental work that they are based on.

In scientific research, investigations play an important part, especially those based on experimental work under carefully controlled conditions. Over the past 20 years, investigative work has increasingly formed the basis for coursework assessment in school science courses, as well as being a powerful teaching and learning process.

The use of practical investigations to assess skills in school science was based on work done by the APU, and research in a number of centres, particularly the University of Durham. For more than 10 years, it has formed the basis of coursework assessment for GCSE science.

Investigations require the drawing together of skills in planning, collecting data, interpreting data and evaluation. They provide an effective and valid assessment instrument for a course which is seen as a basis for further studies and possible future careers in science.

However, the assessment of investigations in the National Curriculum has led to an ever narrower range of activities being used, and to rather mechanical ‘criterion matching’ rather than genuine open-ended work. For this specification, the basic structure of investigations is retained, but the emphasis on prediction is removed, allowing a much wider range of activities and approaches. A different marking style, drawing more on professional judgment of teachers has also been developed. Rather than “mark criteria” which imply a formal, standard matching, we prefer the term “performance descriptors” which indicate the type and quality of performance expected at each level.

The coursework aims to motivate candidates and help them to appreciate the importance of having a clear and manageable question, to learn how to choose equipment and use it appropriately, and to design suitable apparatus for making observations and measurements. First-hand experience of the problems of collecting valid and reliable data can give candidates a better sense of what the difficulties really are, and a 'feel' for how great they are in specific cases, and provide a context for beginning to understand how to tackle and perhaps overcome these.

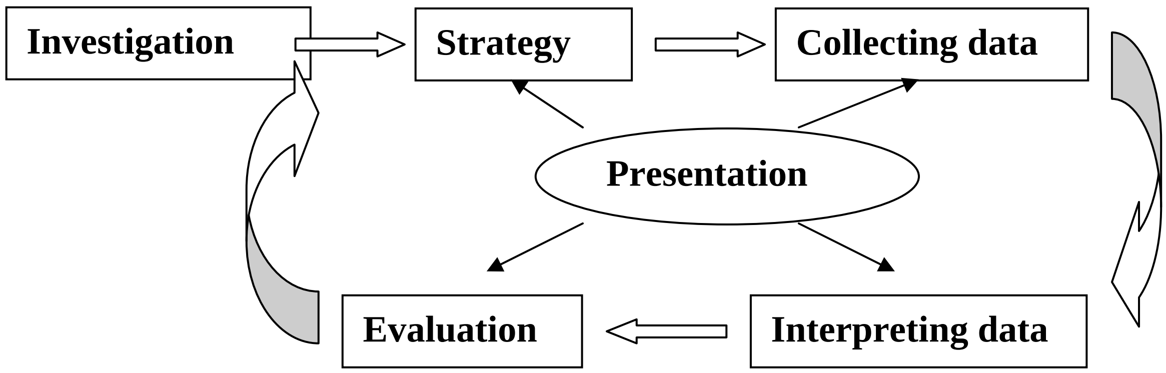
The changed approach to planning investigations is designed to avoid over-direction of students using given standard procedures. Hence, there is an increased emphasis on the autonomy shown by the student in considering factors to be controlled, and in preliminary testing to establish suitable conditions for the investigation.

Summary of differences between assessment of investigations in established GCSE courses (Sc1.2) and in 21st Century Science courses	
Former GCSE Courses (Sc1.2)	Additional Science A
Planning must be based on use of prior knowledge of relevant theory. This restricts access except to a small number of topics.	Students devise a strategy to ensure adequate, good quality evidence. Activities may be based on theory provided for them or may be exploratory.
Only studies across a range of values of a test variable can easily match the criteria.	Comparisons, distribution surveys or tests of reliability can also match the mark descriptors.
Investigations may be based on first hand or secondary evidence (e.g. simulations or web-searches).	Investigations must include collection of some first-hand practical evidence.
Individual marks for different skill areas may be collected from different activities and aggregated.	The final mark is the total for the best single piece of work.
Mark criteria must be matched in particular order, leading to mechanical 'hoop-jumping'	Performance descriptors allow 'best-fit' marking using professional judgement over a range of aspects of the work.

Presenting and marking investigations

The type of investigation used for this assessment is developed from those used in GCSE assessment for the past 10 years. This model in turn, was developed from work of the Assessment of Performance Unit in schools. The advancement of science knowledge and understanding through investigations is seen as a cyclic process – as each investigation progresses it becomes possible to review the progress made so far, and the results of each investigation inform the planning of the next.

In this model, the whole process of an investigation is made up of four stages – formulating the idea and deciding what to do, carrying out the work to collect the evidence, making sense of the evidence, and finally evaluating the whole process, either as a summation of the work, or in preparation for the next investigation.



We have retained this basic structure. However, assessment over the past few years has attached particular meanings to the labels used in Sc1, and now the emphasis is changed, so we have chosen new labels to allow a fresh approach. We have also added a fifth strand to the assessment, which provides credit for effective communication through the investigation report.

The five strands which make up the assessment are:

Strand S: Devising the strategy

Strand C: Collecting the evidence

Strand I: Interpreting and explaining the evidence

Strand E: Evaluating the evidence and the procedures used

Strand P: Presenting a report of the investigation

The full criteria are given in Appendix G.

Strand S: Devising the strategy

It is expected that normal teaching will have established the context for any investigation and have developed understanding of the underlying science. The task for the student is to decide how much evidence, and what quality of evidence will be needed to solve the problem or answer the question, and to select the most suitable equipment and procedures.

Students are no longer expected to predict the answer before they begin, so high marks are not restricted only to studies where suitable explanatory theory is available. This is intended to allow work on e.g. species distribution, behaviour patterns, or quality control to match the criteria.

In recent years, too much work in Sc1 has become simply using carefully-drilled standard procedures. Here, successful students will show some independence or autonomy in selecting the best ways to proceed and in deciding how much evidence to collect. Those who are less able to work in this way may be given guidance, or even provided with standard procedures to follow, but this will reduce the maximum mark they can access in this strand.

It is advised that more time should be made available for the planning stage than has been usual in the past. This should allow students to explore the background to the task, establishing what factors may be important and how to control or allow for them. It should also allow them to consider different approaches, and to carry out preliminary tests to establish suitable ranges to cover.

For example, in an investigation to determine the formula of a compound there can be discussion about the techniques that might be used in the analysis. Help in devising suitable strategies should be given where students need it, but this reduces the mark which can be given for “autonomy”. The level of help given to each student should be recorded.

The necessary skills can be encouraged whenever practical work is undertaken by allowing time for class discussion step-by-step as the work is planned, and linking this to the amount and quality of evidence which will be obtained as a result.

Strand C: Collecting evidence

In this strand, the assessment is not simply based on the data which is reported. Valuable indications can also be obtained from the detail given in the strategy, where students show their awareness of factors which might affect the results. Indications of the quality of the work can also be found by looking at graphical displays to see the quality and consistency of the final data.

Both students and markers should be encouraged to look at the quality of individual raw data, and the level of agreement between repeat readings, as well as looking at the overall pattern of results.

Strand I: Interpreting results

Three aspects of performance are considered:

- revealing patterns of behaviour in the data
- summarising or describing these in words
- explaining the patterns found

The first aspect allows alternative approaches. Much is best displayed graphically. Some e.g. heats of combustion, may be better described by suitable numerical processing. The scheme allows either approach to score.

Simple charts or histograms can be credited in the lower mark ranges. Line graphs with lines of best fit can score up to 6 marks (as previously in Sc1). To access 7 or 8 marks, something extra is required. The course places great emphasis on the quality of data. Progression to 7 or 8 marks may come from an indication of the underlying quality and reliability of the raw data (e.g. plotting all raw data in a ‘scatter-graph’ with a single line of best fit, or use of error bars) or display of multiple data-sets on common axes, or use of more complex data display formats.

The remaining two aspects spread the marks more widely than the former Sc1 criteria. In Sc1, a general statement of a trend scores 4 marks, and this can rise to 6 if supported by some scientific explanation. In these new regulations, the quality of the conclusion must improve for 6 marks, being more detailed and/or mathematical. In Sc1, no explanation was required until the 6 mark stage. Here, some attempt at explanation is required at all levels.

In Sc1, marks below 4 for this strand were very rare. In the pilot scheme, marks below 4 were more common. This provides a better spread of marks to allow more reliable grading, but teachers should be aware of the need to encourage clear conclusions and explanations to improve scores in this strand.

Strand E: Evaluation

There is a high level of continuity here from skill area E of Sc1. Students tend to consider their data separately from the procedures they used to obtain it. The final aspect encourages them to bring these two together as a basis for some overall judgement of reliability, and to think about what extra work might help to further improve the reliability. As with Sc1, the intention is NOT to simply suggest other, related investigations that might be done instead!

Strand P: Presentation

Scientific investigation reports should contain sufficient detail to allow later workers to repeat the experiments if necessary. Thus the method used should be described in detail, including explanations of why particular methods, equipment or test ranges were chosen. Reports should also provide full detail of all data obtained, and of any fixed parameters (e.g. concentrations of stock solutions, etc). Finally, reports should be clear and grammatically correct.

Managing the Assessment of Investigations

Sufficient coursework must take place under direct supervision to allow the teacher to authenticate each student's work with confidence.

There is a potential conflict between the normal role of teacher and that of someone who has to make an assessment of their students' work for an external public exam. Naturally different teachers vary in their procedures and the amount of help and guidance they give but a significant variation can cause uncertainty and it is essential that our students see that each teaching group is being treated uniformly.

The following guidelines represent a broad approach to the subject of managing internal assessment that should help to alleviate significant differences without affecting the autonomy of teachers.

Helping students to develop investigative skills

Every occasion when class practical work or a practical demonstration takes place provides an opportunity to demonstrate and discuss aspects of relevant investigative skills. Time should be taken to build up the design of any experiment or demonstration through class discussion – "What's the best way to measure this?", "How many times should I measure it?"

Students should also be involved in discussing what can be deduced from results obtained, and in looking for weaknesses in the evidence collected, or ways of improving procedures.

Essential preparation for the assessed task

- Choose a task appropriate to the ability of the set or to the development stage they are at.
- Ensure that the necessary scientific knowledge, practical/research skills have been covered.
- Ensure that the students are familiar with and understand the assessment criteria from first hand experience in a non-assessed situation.
- Circulate and discuss the departmental prompt/guidance sheets.

Introducing the activity

The essential aim is to encourage students to ask questions and put forward tentative ideas and suggestions. The teacher should aim to promote discussion without giving specific answers to direct questions to prevent blocking potential avenues of investigation. The teacher can give ideas about resources, reminders about relevant theory etc. and can steer the lesson to a particular title of task if appropriate. This might be done, for example:

- by a teacher demonstration/video/computer simulation
- from questions arising from a class discussion
- from a brainstorming session with the class
- by referring to the knowledge and skills gained from a previous lesson

Managing the activity in action

During the practical sessions ask what might be called enabling or checking questions to ensure progress for all students, independent of ability.

For example, questions such as

- Can you explain to me your basic method?
- How do you know that the experiment is a fair test?
- How accurate are your measurements?
- How reliable are your measurements?

The aim is to encourage students to reflect on their work and refine their procedure if necessary.

Writing up the activity and marking

During the time period of the activity it is suggested that students write up as they go along and show you the various stages. If the coursework is word processed changes, alterations, and additions can easily be done. If hand written then writing on one side of A4 allows the opportunity to include extra pieces of paper as and when needed.

The teacher should make **general** comments about aspects that are missing or need further development e.g. 'is your results table complete?' 'is the range of measurements sufficient?', 'have you drawn a best fit line on your graph?'

At the end of the activity a suitable short deadline is set and the work handed in for marking.

The work should **not** be returned for further re-drafting.

Appendix H includes suggestions of suitable topics for Investigations. Appendix J provides some guidance notes that can be used with students. Appendix M provides specific guidance for supporting very weak students doing Investigations.

Management and Administration of the Skills Assessment

The scheme of skills assessment is designed to award credit for capabilities which are developed as part of the normal teaching and learning process through the course.

In order to achieve this, schemes of work should –

- Make pupils familiar with the assessment requirements and the marking criteria
- Present activities in ways which emphasise aspects of the assessable skills
- Identify activities which will be suitable for formal assessment

The overall aims of the course include teaching the ability to assess the quality of scientific data, and of forming critical judgements about issues of public or personal policy which involve science-based decision-making. An important aspect of this is to provide regular activities involving these skills.

Record-keeping

Many practical activities throughout the course could provide evidence for assessment. Teachers may wish to award marks and record these, either as evidence of pupil progress or as a ‘fall-back’ source of marks if a more formal assessment later in the course is missed or not well done. The final mark submitted must come from either one investigation or one case study and one data analysis task, and evidence for this must be kept safely.

Appendix K and Appendix L provide master copies for the cover-sheets which should be kept with the marked scripts following assessment. It has spaces in which all marking decisions can be recorded as the work is marked. The sheet is then attached to the pupil work. If the work is later required for moderation, the pupil scripts and cover sheet are simply taken from the store and posted to the moderator. The cover sheet will be used by the moderator when checking the marks for the work. It will be retained by OCR as a complete record of all marking decisions made by both the centre and the moderator.

Internal Standardisation of Marks

It is the responsibility of the centre to make sure that the rank-order of pupils is secure. This requires that all work is consistently marked to the same standard.

Appendices F and I provide examples of completed case-studies and investigations with commentaries to explain the mark decisions. These can be used as a focus for discussion between all staff involved in the marking, to exemplify standards.

Internal standardisation should also be carried out. Some or all of the following procedures may be found to be effective –

- one member of staff moderates samples from all markers, thus providing a single reference standard for all
- copies of scripts are passed round for marking agreement trials at department meetings (it is essential that this is accompanied by discussion of reasons for any disagreements)
- a common approach to marking, or customised mark-scheme can be devised and agreed by all markers

- for data analysis or investigations, all scripts from all classes for the same activity, can be marked by one marker
- scripts from one cohort, which have been part of external moderation samples, can be kept and referred to, to help in carrying forward consistent standards from year to year

OCR provide a free consultancy service. As part of this, centres can send in up to three marked scripts and receive feedback on their marking standards.

External Moderation of Marks

After work has been marked in the centre, a sample of the work will be checked by an external moderator. The purpose of this is to ensure that the activities used are appropriate and match the specification requirements, and that the marking standards used in the centre are consistent and in line with national standards.

Shortly after entries are submitted for the skills assessment, OCR will provide form MS1 (mark-sheet) and instructions for what must be submitted from the centre (Appendix O). The mark sheet is in three layers and is self-carboning. The top copy is sent to OCR and will be used to enter raw marks on the computer. The second copy is sent to the moderator. The third copy is kept by the centre as a record.

The moderator will ask for the work of a sample of candidates. The work which counts towards the final total must be sent, together with information which shows what activities were used and how they were presented to pupils. In a few cases, the moderator may ask for further work or information to be sent.

The work will be returned, and a moderator's report will be sent to the centre when results are published. This will provide a commentary on the work seen. In the past, marks from the majority of centres have been in line with standards and have been accepted without change. Where any change has been required, this will be clearly stated and an explanation of the reasons for any changes will be given.

Authentication of Students' Assessed Work

Overall authentication

Samples of work sent for moderation must be accompanied by a signed copy of the centre authentication form. Staff involved in the assessment sign this form to certify that the work presented is the authentic work of the individual candidates.

Data Analysis

This assessment awards credit for interpretation and evaluation of data. It does not credit planning the experiments, or carrying them out to obtain the data.

It is necessary for each candidate to be involved in gathering at least part of the data first-hand. Thus, it is not acceptable to base these assessments on data entirely made up, or taken from a simulation or a secondary source.

Candidates may work in pairs or groups when collecting the data. Data may be pooled from whole classes or year-groups in order to provide a sufficiently large body of data for candidates to address issues of reliability or range. Provided that some direct experimental data is included this may be supplemented where necessary with secondary data, but the main intention of this assessment is that candidates should be aware through their own experience of how the data was collected.

The interpretation and evaluation must be carried out by each candidate working individually.

Case Studies

The case study is essentially an individual activity. In no case should candidates work together when collecting information. If it is felt that a particular study would benefit from some degree of joint work or collaboration, or from a joint presentation, the moderator consultancy service should be used in advance to obtain guidance on the acceptability of the collaboration.

Investigations

The Investigation is an individual activity where the candidate has carried out a whole investigation.

Candidate authentication

Candidates should complete an authentication statement as a cover sheet for their work, a master copy of this can be found in Appendix P.

Appendix A: Marking Criteria for Data Analysis (A329)

The marking criteria used are taken from the marking of Investigations. They cover strand I (Interpretation and explanation of results) and strand E (Evaluation).

Thus, the marking of these exercises provides a comparison of standards between those submitting the Case Study and Data Analysis and those submitting an Investigation. Where a candidate as carried out an complete Investigation, this will provide the marks and evidence for this component thus avoiding duplication of assessment and reducing the overall assessment burden.

Within each strand, different aspects of performance are identified. Achievement related to each of these is assessed, and the professional judgement of the teacher is then used to award an overall mark out of 8 for the strand.

Strand I: INTEPRETING DATA (I)

Each row represents increasing achievement in a different aspect of performance.

Within each row, the statements should be used hierarchically. Tick the highest level statement which can be matched by the work done. Intermediate awards (1, 3, 5 or 7) are made where performance exceeds one defined level but does not fully match the next. The mark (0-8) awarded for this strand should be a 'best-fit' from the overall pattern of statements matched.

In some cases, in order to allow credit for the widest possible variety of activities, an aspect of performance is represented by two (or more) rows of mark descriptors. In such cases, where a row is not relevant or appropriate for a particular activity, it should be left blank and excluded from the 'best-fit' marking judgement and the more appropriate alternative row used.

Aspect of Performance	Strand I Mark			
	2	4	6	8
a graphical or numerical processing of data	Display limited numbers of results in tables, charts or graphs, using given axes and scales.	Construct simple charts or graphs to display data in an appropriate way, allowing some errors in scaling or plotting.	Correctly select scales and axes and plot data for a graph, including an appropriate line (normally a line of best fit) or construct complex charts or diagrams (e.g. stacked histograms, species distribution maps).	Additionally, indicate the spread of data (e.g. through scatter-graphs or error bars) and give clear keys for displays involving multiple data sets.
	Select individual results as a basis for conclusions.	Carry out simple calculations (e.g. correct calculation of averages from repeated readings).	Use mathematical comparisons between results to support a conclusion.	Use complex processing to reveal patterns in the data (e.g. statistical methods, use of inverse relationships or calculation of gradient of graphs).
b summary of evidence	Note differences between situations/ cases, or compare individual results.	Identify trends or general correlations in the data.	Describe formal or statistical relationships within the cases/situations studied.	Review the extent of, or limitations to, formal conclusions in relation to the scatter evident in the data.
c explanations suggested	Link the outcomes to previous experience or 'common sense'.	Relate the conclusion to scientific ideas/ explanations.	Justify the conclusion by reference to relevant scientific knowledge and understanding.	Use detailed scientific knowledge to explain all aspects of the given conclusion.

Aspect of Performance	Strand E Mark			
	2	4	6	8
a evaluation of procedures	Make a relevant comment about how the data was collected and safety procedures.	Comment on the limitations to accuracy or range of data imposed by the techniques and equipment used.	Suggest improvements to apparatus or techniques, or alternative ways to collect the data, but without sufficient practical detail.	Describe in detail improvements to the apparatus or techniques, or alternative ways to collect the data, and explain why they would be an improvement.
b reliability of evidence	Make a claim for accuracy or reliability, but without appropriate reference to the data.	Note the presence or absence of results that are beyond the range of experimental error.	Use the general pattern of results or degree or scatter between repeats as a basis for assessing accuracy and reliability.	Consider critically the reliability of the evidence, accounting for any anomalies.
c reliability of conclusion	Relate judgement of the reliability (or otherwise) of the conclusions only to techniques used, not to data collected.	Link confidence in the conclusion to the apparent reliability of the data collected.	Discuss the precision of apparatus and techniques, the range covered and reliability of data to establish a level of confidence in the conclusions.	Identify weaknesses in the data and give a detailed explanation of what further data would help to make the conclusion more secure.

Appendix B: Activities Which Might Be Used for Teaching or Assessment of Data Interpretation and Evaluation Skills

C1 Air quality

Investigate how concentrations, including students' own measurements, of particular atmospheric pollutants change with time and/or location.

e.g. Pollution by particulate matter from road vehicles. Sticky tape mounted on poles used to collect particles in the air at different distances from a busy road. Each student set up a sampling point, and classified and counted the particles collected using a microscope. Results from the whole year group were collected and students plotted scatter graphs.

C2 Material choices

Measure and compare properties of selected materials in relation to their uses such as a range of polymer films, or a polymer compared to metal, glass or pottery or rubber.

e.g. what material is most suitable for a bicycle brake, a sole of a shoe etc.

Investigate 'stretching' of materials

e.g. stretching nylon thread, cotton thread, plastic bags, cling film, springs, rubber bands

Compare the effectiveness of different materials for drinking vessels

e.g. insulating properties of different types of plastic/paper cups.

What is the best material for a squash ball?

How to make the best concrete?

How do shampoos and conditioners affect the strength of hair?

C3 Food matters

Investigate the effect of a variable (e.g. temperature, enzyme concentration, substrate concentration) on the digestion of starch and/or protein by enzymes or other suitable enzyme systems.

e.g. breakdown of starch using amylase/clotting of milk – the usual experiments give results which show considerable variation. By pooling results across a class, sufficient data is collected to show a more reliable interpretation.

Identifying food colours using chromatography

e.g. identifying colours in sweets (Smarties)

Which 'food' produces the most energy / fastest when it reacts with oxygen?

Investigate the effect of fertilisers on plant growth.

Use DCPIP to compare vitamin C in different foods.

Compare the sugar content of drinks.

C4 Chemical patterns

Investigate the changes at the electrodes during electrolysis of aqueous solutions.

C5 Chemicals of the natural environment
Effect of temperature on the solubility of salts.
C6 Chemical Synthesis
Measuring pH / temperature changes during neutralisation reactions
C7 Further Chemistry
Use a titration to find the concentration of an alkali.

Appendix C: Marking Criteria for Case Studies (A329)

A	1 mark	2 marks	3 marks	4 marks
Planning the use of sources of information	Very little information is given beyond that provided by the original stimulus material.	Information from a limited range of additional sources is included, although some may be irrelevant or inappropriate to the study.	Relevant information is selected from a variety of sources.	Sources of information are assessed for reliability as a basis for selection of relevant information from a wide variety of sources.
Acknowledgement of sources used		Sources are identified by incomplete or inadequate references.	References to sources are clear, but limited in detail.	References to these sources are clear and fully detailed.
Linking information to specific sources		Direct quotations are rarely indicated as such.	Direct quotations are generally acknowledged.	The sources of particular opinions are indicated at appropriate points in the text of the report.
B	**2 marks**	**4 marks**	**6 marks**	**8 marks**
Making use of science explanations	Only superficial mentions of science explanations, often not correctly applied to the case	Provides a basic outline of the main scientific ideas which are relevant to the case.	Provides a detailed review of the scientific knowledge needed to understand the issues studied.	Considers how different views described in the study can be supported by detailed scientific explanations.
Recognition and evaluation of scientific evidence	Sources are uncritically quoted without distinguishing between scientific evidence and unsupported claims.	Science content and data in sources is recognised.	Claims and opinions are linked to the scientific evidence they are based on.	The quality of scientific evidence in sources is evaluated in relation to the reliability of any claims made.
C	**2 marks**	**4 marks**	**6 marks**	**8 marks**
Comparing opposing evidence and views	Information is unselectively reported without taking any clear view about any course of action.	Claims for a particular idea, development or course of action are reported without critical comment.	Claims and arguments for and against are reported, but with little attempt to compare or evaluate them.	Details of opposing views are evaluated and critically compared.
Conclusions and recommendations	A conclusion is stated without reference to supporting evidence.	A conclusion is based on evidence for one view only.	Some limits or objections to the conclusion are acknowledged.	Alternative conclusions are considered, showing awareness that different interpretations of evidence may be possible.

D	1 mark	2 marks	3 marks	4 marks
Structure and organisation of the report	The report has little or no structure or coherence, or follows a pattern provided by worksheets.	The report has an appropriate sequence or structure.	Information is organised for effective communication of ideas, with contents listing, page numbering etc. as appropriate to aid location of key elements.	Considerable care has been taken to match presentation and format to present issues and conclusions clearly and effectively to a chosen audience.
Use of visual means of communication	There is little or no visual material (charts, graphs, pictures, etc) to support the text.	Visual material is merely decorative, rather than informative.	Visual material is used to convey information or illustrate concepts.	Pictures, diagrams, charts and or tables are used appropriately and effectively to convey information or illustrate concepts.
Spelling, punctuation and grammar	Spelling, punctuation and grammar are of generally poor quality, with little or no use of appropriate technical or scientific vocabulary.	Spelling, punctuation and grammar are of variable quality, with limited use of appropriate technical or scientific vocabulary.	Spelling, punctuation and grammar are generally sound, with adequate use of appropriate technical or scientific vocabulary.	The report is concise, with full and effective use of relevant scientific terminology. Spelling, punctuation and grammar are almost faultless.

Appendix D: Suggestions for Topics for Case Studies

Developing the skills for case studies

These activities make it possible to develop and practice the techniques which will lead to successful case studies. They provide opportunities to introduce the marking criteria which will be used for assessment.

The **Air Quality** module includes an activity on hay fever. Students plot data about prescriptions for hay fever treatments. This can lead to discussion of apparently anomalous results, and the importance of repeating measurements to check reliability. They then sort through information about the illness and use it as a basis for a report or poster showing how the evidence supports the theory that hay fever is an allergic response to pollen in the air. This exercise allows a focus on judging the strength and reliability of evidence, and on organising items of information to present a coherent argument. Other topics in the module which could provide a basis for a case study include use of (a chosen) renewable energy resource for power generation to reduce dependency on fossil fuels, or issues related to nitrogen oxides in air from car exhausts.

Successful Topics for Case Studies

C1: Air quality
Should smoking be banned in public places?
Does traffic pollution cause asthma?
C2: Material choices
Sustainable development – what is best?
C3: Food matters
Is organic food better for us?
Diet – are young children eating unhealthily?
Who is to blame for obesity?
Do food colours cause problems for children?
Should GM crop research continue?
GM foods – a help or hindrance to society?
Is chocolate addictive?
GM foods – harmful or helpful?
Are calorie controlled diets effective?
Do diets really work?
Do we need food additives in our food?
C4: Chemical patterns
Should chemicals that affect the ozone layer be banned?
C5: Chemicals of the natural environment
Is it worth recycling aluminium cans?
C6: Chemical Synthesis
Should a new chemical works be built near the school?
C7: Further Chemistry
Is natural always better than synthetic?

Appendix E: Guidance for Students Writing a Case Study

We live in a developing technological age. People in governments, industry and other institutions have to make decisions that can have a significant effect on our lives. Newspapers, journals, television and other forms of media often report science-related stories where there is some disagreement about how we should react.

In doing your case study, you will learn how to find out what a variety of different people think about the story you have chosen, and how to use your science knowledge to reach a balanced judgment about how to respond.

Choose a story which interests you and where you can find enough information from people with different points of view. The title for your case study is probably best as a question that you can answer by balancing evidence and opinions from the information you have gathered.

Assessment

The case study will be marked, and this contributes 20% to your final GCSE grade so it is worth putting some effort into this activity. It could have a significant effect on your final grade. However, do not make your report too long as it is quality not quantity that counts!

Your teacher will mark your case study under four main headings:

A How good was your research:

- how did you find the story?
- have you looked for more information from other sources?

B Do you understand the science:

- have you described science ideas which help you to understand what is important in the study?
- have you checked what science data or ideas are used in the articles you looked at?

C Have you compared different views and formed a conclusion

- have you considered arguments for and against?
- have you thought about the risks and benefits of the action that is suggested?
- have you said clearly what you think (and why)?

D Have you presented your report in an attractive and interesting way?

- is the report well-organised so that it is easy to follow the story?
- are your spelling, punctuation and grammar correct?
- have you used pictures, charts, tables, graphs or explanatory diagrams to help make information easier to understand?

A Quality of selection and use of information: (maximum 4 marks)

- You should use different types of sources of information that contain relevant information for your Case Study e.g. course book, web-sites, library books and your own notes.
- Give a list of the sources used and these should be detailed referring to, for example, book and page number and full website address not just to the homepage of the website.
- Material from the sources should be selectively used, not just a collection of 'cut-and-paste' extracts. This will usually include some direct quotation, but should usually also involve some re-structuring of information.
- In the body of the report, make it clear where each particular piece of information came from e.g. "The Daily Mail of 21st Sept said…" or "these results came from Prof X. Smith at the University of …."
- Where sections of text are directly quoted, this should be made clear e.g. quote-marks or italic script. This allows the reader to see which source a particular claim or piece of information has come from.
- At the 4 mark level, any obvious disagreement between sources should be recognised.
- It is important to say how reliable you think each of your sources is. This is particularly important for data from web-sites, which vary widely in the reliability and authority of the opinions expressed.

B Quality of Understanding of the Case: (maximum 8 marks)

- This section lets you show what you understand of the background scientific knowledge and understanding which will help you evaluate the information from your sources.
- You should assume that your target audience is intelligent, but doesn't know anything about the topic. You should explain the basic ideas of the topic and your student textbook or own notes will be a good source. This can be backed up by extra information from more advanced or specialist books, encyclopaedias or web-sites.
- Think carefully about whether the articles you read are based on scientific evidence or not, and explain how reliable you think these claims are.

C Quality of Conclusions: (maximum 8 marks)

- There should be evidence that the sources you used have been compared to check for consistency and to identify areas of conflict or disagreement. There should also be evidence that the underlying science has been used to try to resolve any differences.
- There should be evidence that points 'for and against' have been compared.
- You should describe your view-point or position in relation to the original question, and justify this by reference to the sources.

D Quality of Presentation: (maximum 4 marks)

- Think about who you want to look at your report – make it attractive and interesting for them.
- Give the report a good clear structure by using headings and/or sub-headings and a table of contents. This helps to break up the report and guides readers quickly to particular sections.
- Reports should also include suitable tables, diagrams and graphics to clarify difficult ideas or to present large amounts of data in a quick and easy way. Do not include graphics just to decorate your report, they must provide useful information.
- Be careful to write clearly, with correct spelling and grammar.

Case Study checklist

Title page:

- Title of case study written in the form of a question

Contents page:

- Sections, sub-sections and appropriate page numbers included

Introduction:

- Explanation of what the case study is about and how the report is structured

Scientific theory:

- Relevant background science included

Evidence:

- Relevant information from sources collected with detailed references in each case
- Evidence from both sides of the case
- Authenticity and reliability of the evidence recognised; explanation of the evidence using underlying science

Conclusion:

- Evidence compared and evaluated
- Conclusion written and justified, pointing out any limitations or alternative interpretations

Bibliography:

- References listed in detail

Presentation:

- Report clearly organised into appropriately headed sections and in a suitable sequence
- Report includes diagrams, data tables, graphs etc. to illustrate ideas and concepts
- Report is concise, uses relevant scientific terminology and has correct spelling, punctuation and grammar

Script CS-06-CO1

Can levels of pollution affect a town's tourism?

Autumn/winter 2006

Can levels of pollution affect a town's tourism?

Towns like .... depend on tourists in order for their businesses to survive, that's why it is important for a town to be appealing to visitors.

<u>What does tourism mean?</u>

Noun: the business of providing services to tourists.

This means that towns have to not only make sure it has a varied type of businesses to please the tourists, such as shops and places to work, so that it stands out from other towns, but also to make sure its is a clean and pollutant free place from air pollution.

That is why I have chosen the question "Can levels of pollution affects a towns tourism?" To see weather a town needs a competitive range of shops or a pollution free air to lure tourists to their towns.

Pollutants can damage our health long and short term. People who have asthma can find that their symptoms become worse when there is pollution in the air, by chemicals from car fumes or factories giving off gases.

Pollutants can come in many forms but mostly invisible in exception to smoke which is made up of tiny bits of solid called particulates which can get into sufferers lungs.

Types of pollutants:

Much of air pollution comes from cars, buses and lorries

Sulphur dioxide SO2 – causes acid rain

Carbon monoxide CO – poisonous

Nitrogen dioxide NO2 – acid rain and asthma

Particulates – sort of soot, very small, causes lung problems

Ozone O3 – irritates eyes and nose

Air pollution can consist of smog, acid rain and CFCs plus other outdoor pollution, but air pollution can also be found inside because of chemicals and wear away at rock and brick making it less stable which can lead to the collapse of buildings.

Pollution can be heavily congested in cities such as New York. It can spread out as it is in such a small area. That is why pollution is found in cities rather than in the countryside.

Tourism is more in the cities though because of job opportunities and the range of shops. Even though the pollution levels are higher in cities than in the countryside.

Plants can die in the result of over exposure to pollution and can affect its growth.

Towns need beauty to attract tourists and if plants are being killed a town has no attraction to bring tourists to the town.

“Clean” smoke from dirty rubbish

Recycle everything – improve the environment

Pollution can also affect animals. To reduce the pollution levels, some things have been done, such as in Malasia after a forest fire that was caused by air pollution they started to take action in reducing the levels of air pollution and smog by cutting down on rubbish burning.

In the ZOOL newspaper from Malaysia in July 11th 2001

"First we cut down on home burning, this will reduce air pollution, and cut down on forest fires."

In the same article, a Mr Mowaba says:

"Not only does asir pollution affect a countries economy, material and vegetation damage, but it also reduces tourism."

This shows that some people agree that pollution affects a town's tourism; by the way that air pollution can affect a towns beauty by killing plants and animals, and damaging buildings.

So some people agree that with the question **"Can pollution affect a towns tourism?"**

The PDEQ says:
"Air pollution can affect tourism and the ability of businesses and institutions to recruit quality workers to save the problem"

H Josef Hebert, Associated Press writer says: *"The growing problem of polluted air in towns is disappointing tourists and keeping some away."*

Some people that disagree with the question
"Can air pollution affect a towns tourism?"

Francis Sherman – head of Europe's tourist board "Pollution in no way affects a tourist's decision to visit a place, it is clearly down to the level of facilities in a town"

Air quality graphs of Edinburgh London and Oxford all show levels of pollution in the air

In Edinburgh it shows –

Carbon Monoxide	Nitric oxide	Nitrogen oxide	Nitrogen dioxide	Sulphur dioxide	Mean particles
high	low	medium	medium	low	high

London, Westminster pollution levels

Carbon Monoxide	Nitric oxide	Nitrogen oxide	Nitrogen dioxide	Sulphur dioxide	Mean particles
medium	high	medium	low	low	medium

Oxford pollution levels

Carbon Monoxide	Nitric oxide	Nitrogen oxide	Nitrogen dioxide	Sulphur dioxide	Mean particles
low	medium	high	low	medium	low

This shows that pollution may be high in an area of high tourism, but this does not affect how many tourists that visit a town. As there is a high level interest in the town to overcome the level of pollution in the air.

These points shows that pollution takes a big part in the tourism business as it affects how a town is perceived, in how clean and well presented it is, I think that pollution does affect a towns tourism as it shows here that a town needs beauty in plants and structural buildings to attract tourists and if this is affected by pollution, **then this means that it affects a towns tourism**.

www.ask.co.uk/pollution/tourism

www.pdeq.com

www.zool/2001/pollution.com

Can levels of pollution affect a town's tourism?

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
A	Sources used			✓							3
	Listing of sources			✓							
	Acknowledgement of quotes					✓					
B	Background science				✓						3
	Recognition of evidence			✓							
C	Comparison of views				✓						3
	conclusions				✓						
D	Structure & organisation			✓							2
	Illustrations/tables/graphs			✓							
	QWC				✓						
	Overall total mark for the investigation										11

Aspect	Mark	Comment
Strand A: Quality of research		
(a)	2	Although some unusual sources are featured, the range is small. Material selected is generally opinion rather than evidence-based.
(b)	2	Not all sources are identified, and some references are only to 'home pages' or to publications without dates.
(c)	4	Where particular material is quoted, the extent of the quotation is clear and the source is (usually) identified.
Strand B: Quality of scientific understanding		
(a)	3	Some common pollutants from car exhausts are listed but with little detail of how they are formed or what effects they cause. Other pollutants (e.g. litter or chimney smoke) are mentioned but not explained.
(b)	2	Quotations from sources are mostly opinions rather than evidence. The city pollution data is not linked to its source.
Strand C: Quality of conclusions		
(a)	3	Views for and against have been selected, although they are not evaluated or directly contrasted.
(b)	3	Comments on both sides are given. The final conclusion is not linked to any comparison of the conflicting views.
Strand D: Quality of presentation		
(a)	2	The overall structure (introduction – views for-views against – conclusion) is sound but there is little in the way of "navigation aids" for the reader.
(b)	2	The photographs are purely illustrative rather than informative.
(c)	3	Spelling, punctuation and grammar are generally good, but with rather limited use of technical terms.

Are the Government doing enough to reduce Air pollution

Introduction

In my case study I have been asked to investigate both sides of a controversial question about air quality.

And see whether the amount of air pollution has decreased as an outcome of Government policies.

Air content

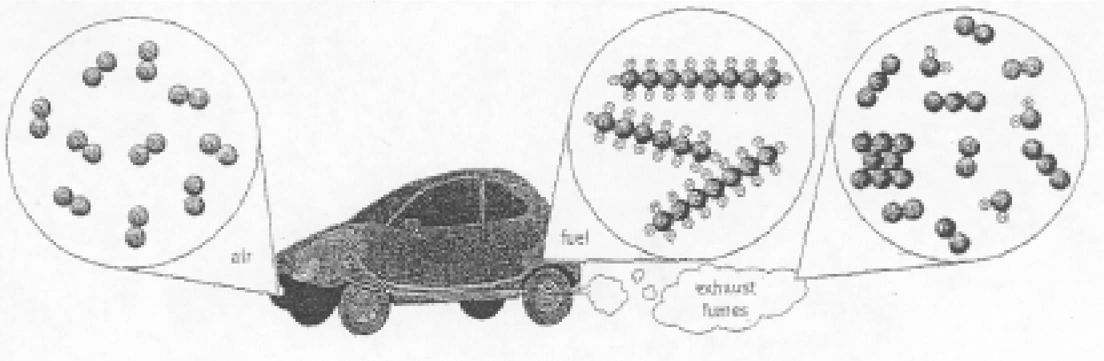
Gas	**Percentage by volume**
Nitrogen (N_2)	78
Oxygen (O_2)	21
Argon (Ar)	1
Carbon Dioxide (CO_2)	0.03
Water (H_2O)	Variable 0-4

What is Air pollution?

Air pollution is the contamination of air by the discharge of harmful substances. Air pollution can cause health problems including burning eyes and nose, itchy irritated throat, and breathing problems. Some chemicals found in polluted air can cause cancer, birth defects, brain and nerve damage, and long-term injury to the lungs and breathing passages in certain circumstances. Above certain concentrations and durations, certain air pollutants are extremely dangerous and can cause severe injury or death.

Air pollution can also damage the environment and people's properties. Trees, lakes, and animals have been harmed by air pollution. Air pollution has thinned the protective ozone layer above the Earth. Air pollution can damage buildings, monuments, statues, and other structures. Air pollution also can form haze, which reduces visibility, and can sometimes interfere with aviation.

The Major Air Pollutants.



The chemicals going into and coming out of a car engine.

Carbon Monoxide (CO) is an odourless, colourless gas. After being inhaled, CO molecules can enter the bloodstream, where they inhibit the delivery of oxygen throughout the body. Low concentrations can cause dizziness, headaches and fatigue; high concentrations can be fatal. CO is produced by the incomplete burning of carbon-based fuels, including gasoline, oil, and wood. It is also produced from incomplete combustion of natural and synthetic products, such as cigarette smoke. It can build up in high concentrations in enclosed areas such as garages, poorly ventilated tunnels, and even along roadsides in heavy traffic.

Carbon Dioxide (CO2) is the principal greenhouse gas emitted as a result of human activity (e.g., burning of coal, oil, and natural gas). CO2 can cause burns, frostbite, and blindness if an area is exposed to it in solid or liquid form. If inhaled, it can be toxic in high concentrations, causing an increase in the breathing rate, unconsciousness, and death.

Chlorofluorocarbons (CFCs) are chemicals used in great quantities in industry, for refrigeration and air conditioning, and in consumer products. CFCs, when released into the air, rise into the stratosphere (a layer of atmosphere high above the Earth). In the stratosphere, CFCs take part in chemical reactions that result in reduction of the stratospheric ozone layer, which protects the Earth's surface from the sun. Reducing the release of CFC emissions and eliminating the production and use of ozone-destroying chemicals is very important to the Earth's atmosphere.

Hazardous Air Pollutants (HAPs) are chemicals that cause serious health and environmental effects. Health effects include cancer, birth defects, nervous system problems, and death due to massive accidental releases, such as the disaster that occurred at a pesticide plant in Bhopal, India. Hazardous air pollutants are released by sources such as chemical plants, dry cleaners, printing plants, and motor vehicles including cars, trucks, buses, planes.

Lead is a highly toxic metal that produces a range of adverse health effects particularly in young children. Lead can cause nervous system damage and digestive problems, and some lead-containing chemicals cause cancer. Lead can also harm wildlife.
Lead has been phased out of gasoline, which has considerably reduced the contamination of air by lead. However, lead can still be inhaled or ingested from other sources. The sources for lead include paint (for houses and cars), smelters, manufacture of lead batteries, fishing lures, certain parts of bullets, some ceramic ware, mini blinds, water pipes, and a few hair dye products.

Ozone (O3) is a gas that is a variety of oxygen. Oxygen consists of two oxygen atoms; ozone consists of three. Ozone in the upper atmosphere, where it occurs naturally in what is known as the ozone layer, shields the Earth from the sun's dangerous ultraviolet rays. However, at ground level where it is a pollutant with highly toxic effects, ozone damages human health, the environment, crops, and a wide range of natural and artificial materials. Ground-level ozone can irritate the respiratory tract, cause chest pain, persistent cough, an inability to take a deep breath, and an increased susceptibility to lung infection. Ozone can damage trees and plants and reduce visibility.
Ground-level ozone comes from the breakdown (oxidation) of volatile organic compounds found in solvents. It is also a product of reactions between chemicals that are produced by burning coal, gasoline, other fuels, and chemicals found in paints and hair sprays. Oxidation occurs readily during hot weather. Vehicles and industries are major sources of ground-level ozone.

Nitrogen Oxide (NO) is a major contributor to smog and acid rain. Nitrogen oxides react with volatile organic compounds to form smog. In high doses, smog can harm humans by causing breathing difficulty for asthmatics, coughs in children, and general illness of the respiratory system. Acid rain can harm vegetation and run into lakes and rivers, which changes the chemistry of the water, and makes it potentially uninhabitable for all but acid-tolerant bacteria.
Nitrogen oxides are produced from burning fuels, including gasoline and coal. (NO) acid aerosols can reduce visibility.

Particulate Matter is any type of solid in the air in the form of smoke, dust, and vapours, which can remain suspended for extended periods. Aside from reducing visibility and soiling clothing, microscopic particles in the air can be breathed into lung tissue becoming lodged and causing increased respiratory disease and lung damage. Particulates are also the main source of haze, which reduces visibility.
Particulates are produced by many sources, including burning of diesel fuels by trucks and buses, fossil fuels, mixing and application of fertilizers and pesticides, road construction, industrial processes such as steel making, mining, agricultural burning, and operation of fireplaces and woodstoves.

Sulphur Dioxide (SO2) is an odourless gas at low concentrations, but can have a very strong smell at high concentrations. SO2 is a gas that is produced by burning coal, most notably in power plants. Some industrial processes, such as production of paper and smelting of metals, produce Sulphur dioxide.
Like nitrogen oxides, SO2 is a major contributor to smog and acid rain. SO2 is closely related to sulphuric acid, a strong acid. It can harm vegetation and metals and can cause lung problems, including breathing problems and permanent damage to lungs.

Volatile Organic Compounds (VOCs) are organic chemicals. All organic compounds contain carbon, and organic chemicals are the basic chemicals found in all living things and in all products derived from living things. Many organic compounds we use do not occur in nature, but were synthesized by chemists in laboratories. Volatile chemicals produce vapours easily. At room temperature vapours readily escape from volatile liquid chemicals. VOCs include gasoline, industrial chemicals such as benzene, solvents, such as toluene and xylene, and perchloroethylene (principal dry cleaning solvent). VOCs are released from burning fuel, such as gasoline, wood, coal, solvents and paints, glues, and other products used at home or work. Vehicle emissions are an important source of VOCs. Many VOCs are hazardous air pollutants; for example, benzene causes cancer.

Method

I am investigating Air pollution and its effects and what the Government are doing to reduce it.

What the Government are doing

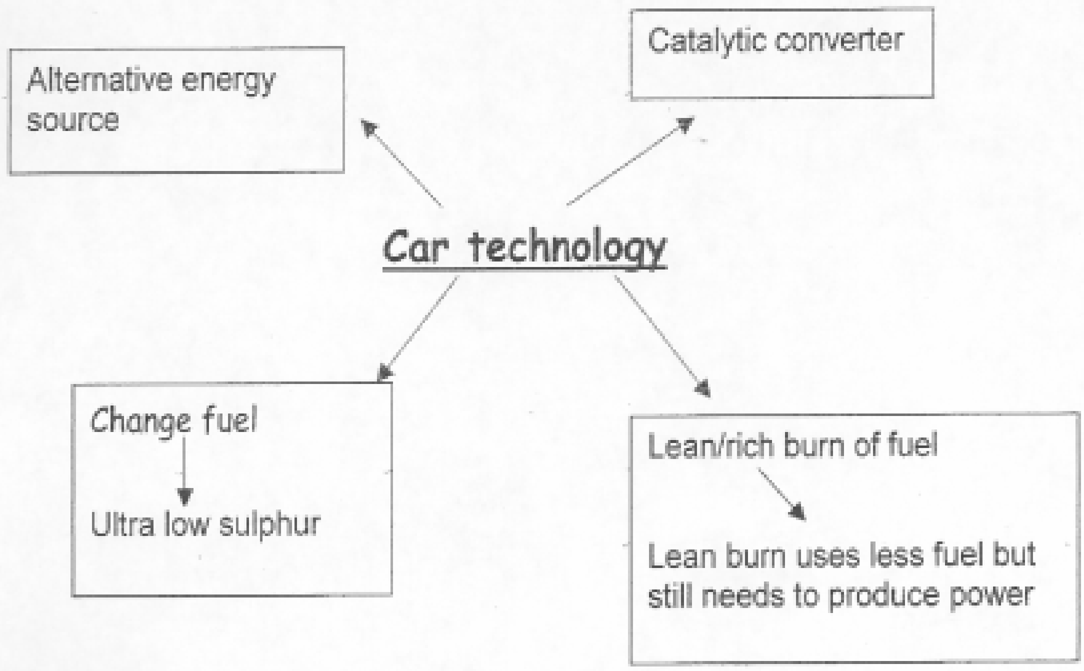
The government are releasing policies, which will hopefully reduce the amount of harmful gases, which contribute to the green house effect.

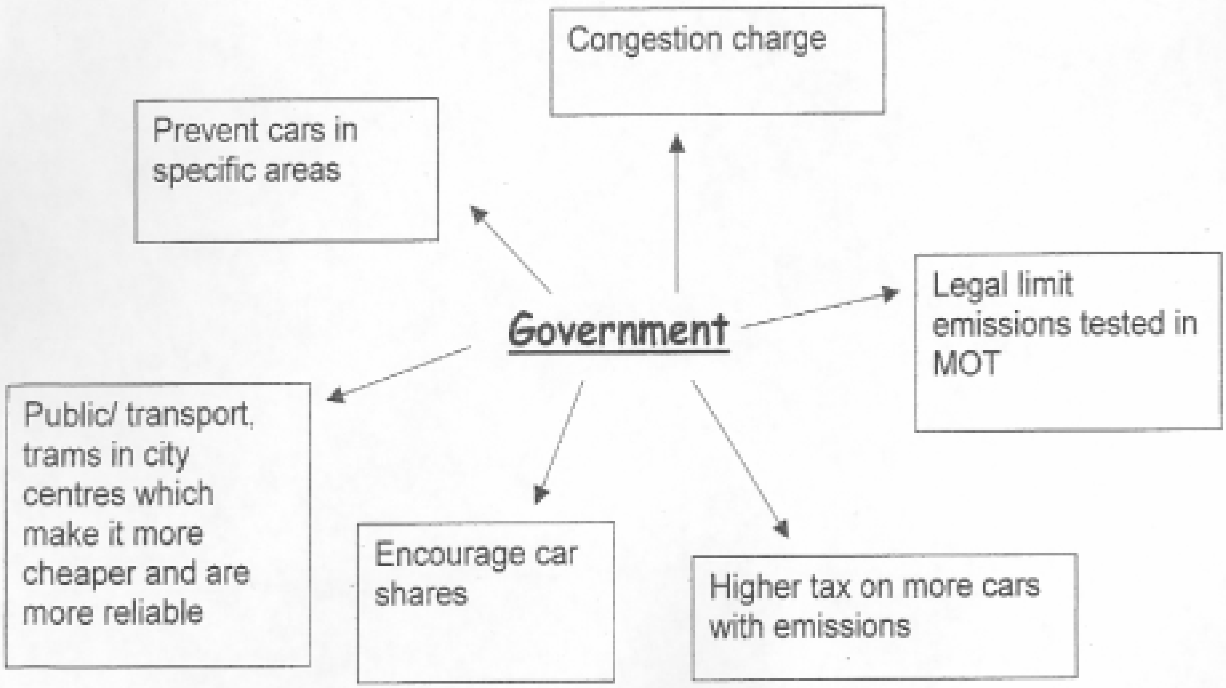
The Government have started to Environmentally label cars; this shows the cars, which are more environmentally friendly.

The table below shows some of the cars that have to be labelled.

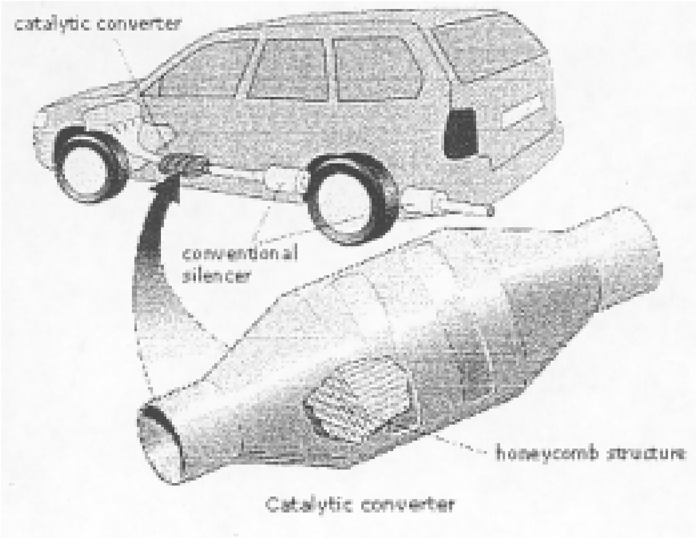
Rating Band	Co2 Emissions	Examples
A	<100g/km	Battery Electric cars
B	101-120 g/km	Toyota Prius 1.5 Petrol-electric hybrid
C	121-150 g/km	Fiat panda 1.2 petrol (manual)
D	151-165 g/km	Mini one 1.6 petrol, (manual)
E	166-185 g/km	Rover 75 1.8 petrol
F	>185 g/km	Bmw x5 4.8 petrol

How can we solve the problem of air pollution?





7



The picture above is of a catalytic converter. The catalytic converter is used to reduce the amount of harmful emissions produced.

<u>What can Governments do?</u>

New technology is being produced to reduce emissions from factories, but these usually cost more, so people and industries may resist using them. If this happens there are certain regulations in place, which ensure the use of these new resources.
These regulations made by the government/ laws are also known as in Britain as acts.

The Industrial revolution began in the 18^{th} century; this led to large amounts of air pollution being produced, and in 1845 parliament passed a law aimed at controlling the level of smoke produced from railway engines, and another in 1847 to combat the smoke produced by factories.

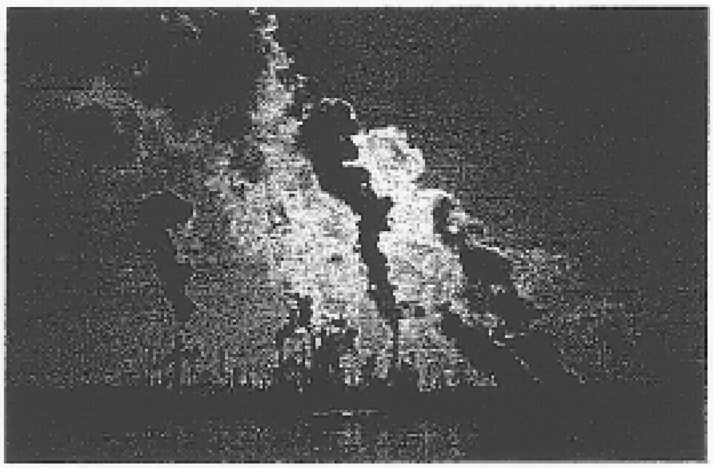
In more modern instances the Government uses financial incentives to encourage people and industries to use fuels in a more sustainable way. They do this by taxation; cars with larger engines, which use more fuel and produce larger amounts of emissions, are taxed more than cars with smaller engines, which are more environmentally friendly. On a larger scale the government use subsidies and taxes to encourage power companies to use fuels that result in less pollution.

Motor Vehicles are now the biggest source of air pollution in Britain. In 1991 the government made the MOT test check that the emissions of carbon monoxide and hydrocarbons are below certain levels.

Also in 1997 the Kyoto agreement set targets for international carbon dioxide emissions. These targets influenced the development of the 1997 National Air quality strategy in the UK. This strategy set new targets for local authorities to meet by 2005.

Recently the government have introduced a new system where people are encouraged to take public transport to commute to towns, for work and general visits, this is set up by charging people to bring their cars into town and city centres, this new system was set up to try to reduce the amount of pollution in main towns, cities such as London and Manchester.

Have the Government done enough?



Some people would argue that the government have not done enough to reduce the amounts of air pollution in the UK.

The reason behind this is that there is still pollution in the UK and in some areas the levels are still high.

The government are wanting the general public to use public transport more to help to reduce the amount of cars on the road and reduce emissions but people would argue that public transport is unreliable and too expensive both of these deter people from using the transport provided, also it is less convenient than walking out of the house and getting in a car.

The congestion charge in city centres didn't deter most people from using their cars either. If the car they drove was a company car the congestion charge was paid by the company.

Also company car tax was less on diesel cars because they produce less CO2 but they still produced the other emissions.

As the government continues to reduce air pollution but still trying to keep the general public happy, local governments are given air pollution targets to meet before certain dates. If these targets were too high, people would have to completely change their living habits.

The government are also keen to introduce the car share system where people share their cars if there is only one person in a car at a time.

Car companies are all continually using new technology to try to reduce the amount of emissions that their cars produce and some car companies are building cars that run completely on electricity. Not everyone is 100% sure about these new concepts and believe that emissions are still going to be produced in the process of creating the electricity to power these cars.

London has tried to reduce pollution by charging extra to drive on congested roads.

Conclusion

In conclusion the government ARE doing enough to reduce the level of air pollution in the UK and world-wide but Air pollution is still going to be produced every day, so therefore the government will have to introduce more policies and targets to help to keep the level of air pollution low in the UK.

In my opinion I believe that the government are doing everything possible to redue the levels of air pollution, and that the policies that they introduce will continue to produce benefits.

Commentary on case study CS-06-CO2

Are the government doing enough to reduce air pollution?

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
A	Sources used				✓						1
	Listing of sources	✓									
	Acknowledgement of quotes	✓									
B	Background science							✓			4
	Recognition of evidence			✓							
C	Comparison of views						✓				5
	conclusions					✓					
D	Structure & organisation				✓						4
	Illustrations/tables/graphs					✓					
	QWC					✓					
	Overall total mark for the investigation										14

Aspect	Mark	Comment
Strand A: Quality of research		
(a)	3	Information beyond that originally supplied has been reported, but there is no indication of where it came from, or what type of sources were used. The information given is relevant, but there is no assessment of reliability.
(b)	0	There is no reference or acknowledgement of any sources. The lowest performance descriptor given covers the range of 1 and 2 marks. In this case, since there is no positive achievement to be recognised, even an award of one mark should not be considered.
(c)	0	Again, there is no acknowledgement of sources within the text.
Strand B: Quality of scientific understanding		
(a)	6	There is a detailed listing of major air pollutants, with information about their sources and effects.
(b)	2	There is no indication of the evidence which supports claims for the effects of these pollutants.
Strand C: Quality of conclusions		
(a)	5	The increasing role of government is reviewed historically. A number of possible actions are suggested, but there is no attempt to compare different views about the cost/value aspects of any actions.
(b)	4	There is a clear conclusion that pollution should be reduced, and a judgement that current proposals are appropriate. Again there is no clear indication of how different measures would work or who would be most affected.
Strand D: Quality of presentation		
(a)	3	With page numbering, and division into sections, it would have been helpful to give an index.
(b)	4	A table of data and schematic diagrams are used to convey information, the general level of visual presentation is high.
(c)	4	The general quality of English is high. Technical terms are used where appropriate.

Are the rise in asthma attacks caused by the air pollution?

Contents:

Introduction

I have been asked to do a Case Study on the subject of "Air Quality". I was asked to think of a question in relation to the subject and the question I came up with is ***"Are the rise in Asthma Attacks Caused by the Air Pollution Levels in the Air?"***

Firstly I will be finding out some background information about, what the air is made up of and what Asthma is. I will also be trying to find out whether the pollution levels in the air affects asthmatic patients.

There will be two sides of the argument to whether the pollution levels causes the rise in more ill patients so I will be researching information from the Internet, looking in science text books, using scientific knowledge and getting some useful articles and quotes from scientist or doctors to back each side of the argument.

At the end of the Case Study I will conclude by giving my own opinion of what I think causes the rise in Asthma Attacks.

Resources:

www.twentyfirstcenturyscience.com
www.bbc.co.uk
www.abd.ord.uk/asthma
www.news.bbc.co.uk/1/hi/health/1099418.stm
www.airquality.co.uk/archive/what_causes.php
www.yamoa.natural-remedies-clinic.co.uk/airpollution.htm
Twenty first century science, module 1-3 Core Book

What is Air Pollution?

When people think about air pollution they usually think about smog, acid rain and other forms of outdoor air pollution, but air pollution can also exist inside homes and other buildings. Chemical substances and air pollutants arise from a wide variety of sources, although they are mainly a result of the combustion process. The largest sources include motor vehicles and industry, cars and trucks. They pollute the air during manufacturing; oil refining and distribution, refuelling Motor vehicles cause both primary and secondary pollution. Primary pollution is emitted directly into the atmosphere; secondary pollution results from chemical reactions between pollutants in the atmosphere. The following are the major pollutants from motor vehicles: Ozone (O3), Particulate (PM) Nitrogen Oxides (NOx) Carbon monoxide (CO) Sulfur Dioxide (SO2) Hazardous air pollutants (Toxics)

Pollutant	Source	What effect does it have?
Carbon Monoxide A colourless, odourless , tasteless and relatively inet gas which slowly converts to carbon monoxide over a period of about a month	• Vehicles burning petrol • Domestic Fires	• Interferes with the ability of the blood to absorb and circulate oxygen • Can affect people with heart conditions and can impair co-ordination and attention • Causes headaches and vomiting • Large amounts can kill
Nitrogen Dioxide A reddish, brown, pungent, acidic gas	• Vehicles burning diesel petrol • Domestic fires • Power stations burning fossil fuels • Major industry • Lightning	• Can lead to throat and lung infections • Low level exposure can affect growth a cause damage to plants • Contributes to the formation of hazes and smog
Ozone A colourless gas with a distinctive pungent, acidic gas, which readily reacts in the air to form sulphuric acid and other compounds. It is usually oxidized in the air within a few days.	• Vehicles exhaust fumes • Formed from other air pollutants in the presence of sunlight	• Causes runny eyes, nose and throat irritation and breathing difficulties • Affects the functioning of the heart.

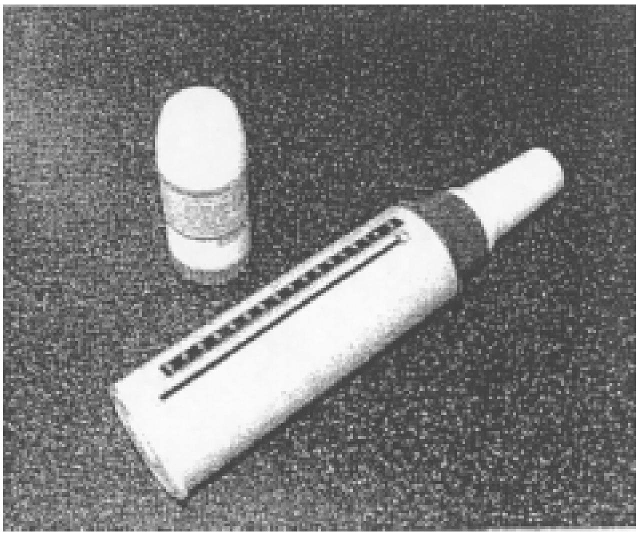
Sulphur Dioxide A colourless, pungent, acidic gas which readily reacts in the air to form sulphuric acid and other compounds. It is usually oxidized in the air within a few days.	• Vehicles burning diesel • Coal burning • Power stations and industries • Oil refineries	• Irritates the lungs • Is toxic to some plants and is corrosive to surfaces and meals in moist conditions
Fine Particulate (dust) This is not visible to the human eye but does create a visible haze in the air	• Diesel engines • Industry • Windblown dust • Domestic fires • Backyard burning • power plants	• Can be inhaled into the throat and lungs • Can lead to asthma, bronchitis and lung disease • Can carry carcinogenic materials into the lungs • Affects visibility by creating a haze, and can contribute to the soiling and corrosion of buildings

Air is meant to be invisible, so haziness is a sign that the air quality is not what it should be, air quality depends on the amount of pollution and the rate it is dispersed. Poor air quality occurs when winds are very light and the pollution hangs around in the air. This often happens in winter when pollution is trapped close to the ground on calm winter nights by temperature inversions.

Harmful pollutants emitted into the atmosphere can affect the health of many people, especially people who suffer from bad asthma Pollutants dumped into the air can eventually get into your body when you eat, drink and breathe. Air pollution can affect our health in many ways with both *short-term* and *long-term* effects. Different groups of individuals are affected by air pollution in different ways. Some individuals are much more sensitive to pollutants than are others. Young children and elderly people often suffer more from the effects of air pollution. People with health problems such as asthma, heart and lung disease may also suffer more when the air is polluted.

What is Asthma?

Asthma is a condition that affects the airways – the small tubes that carry air in and out of the lungs. When a person with asthma comes into contact with an asthma trigger, the muscle around the walls of the airways tightens so that the airway becomes narrower. The lining of the airways becomes inflamed and starts to swell. Often sticky mucus or phlegm is produced. All these reactions cause the airways to become narrower and irritated – leading to the symptoms of asthma.



<u>What does it feel like?</u>

The usual symptoms of someone with asthma are:

- Coughing
- Wheezing or a whistling noise in the chest
- Getting short of breath
- A tight feeling in the chest

Not everybody will get all these symptoms. Some people experience them from time to time; a few people may experience these symptoms all the time. Medical evidence shows that asthma attacks may happen in response to many different substances. Different things affect different people.

These is no clear link between concentrations of air pollutants and people starting to get asthma, however, people who already have asthma have sensitive breathing tubes, so, anything that causes irritation or makes breathing harder, is likely to trigger an attack or make symptoms worse.

<u>Things that can trigger asthma:</u>

- Tree or gas pollen
- Animal skin flakes
- Dust mite droppings
- **Air pollution**
- Nuts shellfish
- Food additives
- Dusty material

Two people of different ages with asthma are interviewed about how there asthma affects them in their lives.

Elaine (14) – *I use my inhaler before I go swimming, or when it is very cold. When I first noticed my asthma I used to feel very panicky and frightened because I felt as though I couldn't breathe. But now I have an inhaler so it isn't so bad.*

Dave (27) – *I had my first asthma attack when I was cross-country running at school. The doctor gave me an inhaler for more than a year; I gave up sports and was very miserable. Gradually I learnt that the inhaler could control my wheezing and I started to play football again. Now I drive an ambulance rushing round helping other people and my asthma seems to have almost faded away.*

"The groups most affected by air pollution include children and the elderly. People with chronic diseases such as emphysema, heart disease and asthma are also more susceptible than the general population." ***Quoted by Dr. Nathan Rabinovitch.***

Fors

Many people agree that the main reasons why the increase of asthma attacks are due to the atmospheric pollutants. The UK and Ireland have the highest rates of asthma in the whole of the European, 13% of the UK adult population has asthma, says a new report by the European Respiratory Society. The UK and Ireland has the highest death rate from respiratory diseases in the European Union.

Friends of the Earth Society says that:

One of the most well known health impacts of air pollution is an increase in asthma attacks. The incidence of asthma appears to have more than doubled in the last 15 years. Some of this increase may be due to changes in how doctors categorize asthma, but it is now widely accepted that the incidence of asthma has increased considerably. Asthma is the most common chronic disease of childhood with around 1 in 7 children affected.

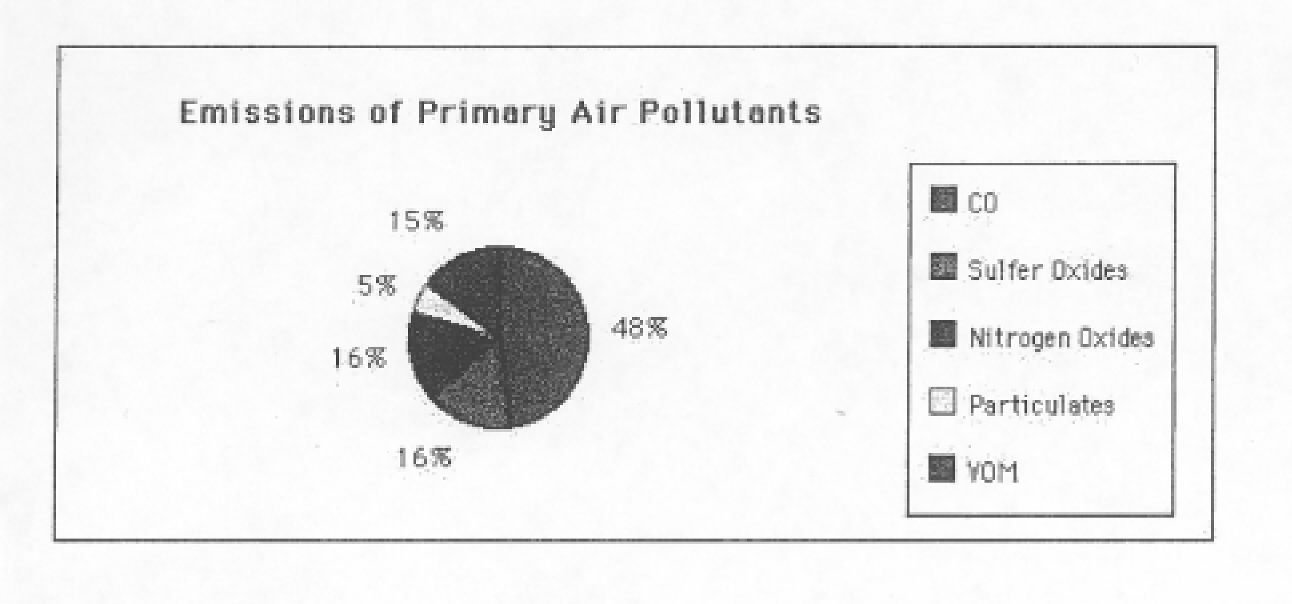
Evidence of a link between pollution and asthma is certainly accumulating, but there is no proof yet of a causal relationship. ***What we do know, however, the problem is, is that pollution can aggravate asthma symptoms and can also trigger an asthma attack in people who are already asthmatic.*** There is evidence that use of asthma medication and hospital admissions diagnosed as asthma increase during severe pollution episodes.

The pollutants, which are of most concern in relation to asthma, are ozone, particulates and nitrogen oxides, (shown in the table on page 4 & 5). Mixtures of pollutants (secondary pollutants) may also be particularly damaging.

Particulates: Consistent correlation between particle levels and death rates. High levels of particles have also been linked with increased hospital admissions and asthma attacks. Smaller particles can carry carcinogenic particles into the lungs.
Nitrogen dioxide: May aggravate asthma symptoms. Can cause a tightening of the chest and reduced lung function. Can make airways more sensitive to allergens such as house dust mite, By disrupting the body's natural cleansing mechanisms nitrogen dioxide may increase the body's susceptibility to viral infections.

There are several theories on how pollution might trigger asthma attacks. One is that ozone may damage the lining of the airways and allow other allergens, such as pollen or substances from house dust mite etc, to enter and thereby set up the allergic response.

But air pollution is only one suspected factor in the increased incidence of asthma. Many other factors, such as changes in domestic heating and ventilation, diet and exposure to cigarette smoke, have also been implicated.



Above is the percentage of each type of pollutant that is released into the atmosphere

"It's very clear that air pollution can make asthma worse, so if you live in a city with a lot of air pollution, chances are you will have worse asthma than if you lived in a cleaner environment" – **Dr. Nathan Rabinovitch**

This evidence from the "friends of the earth" society and quotes by Dr. Rabinovitch proves that there is a correlation between the air pollution and the rise in asthma attacks.

Against

Many people disagree that air pollution is the reason why asthma attacks have risen. Some people believe that air pollution is not responsible and therefore are against the question.

"Air pollution does not cause asthma"

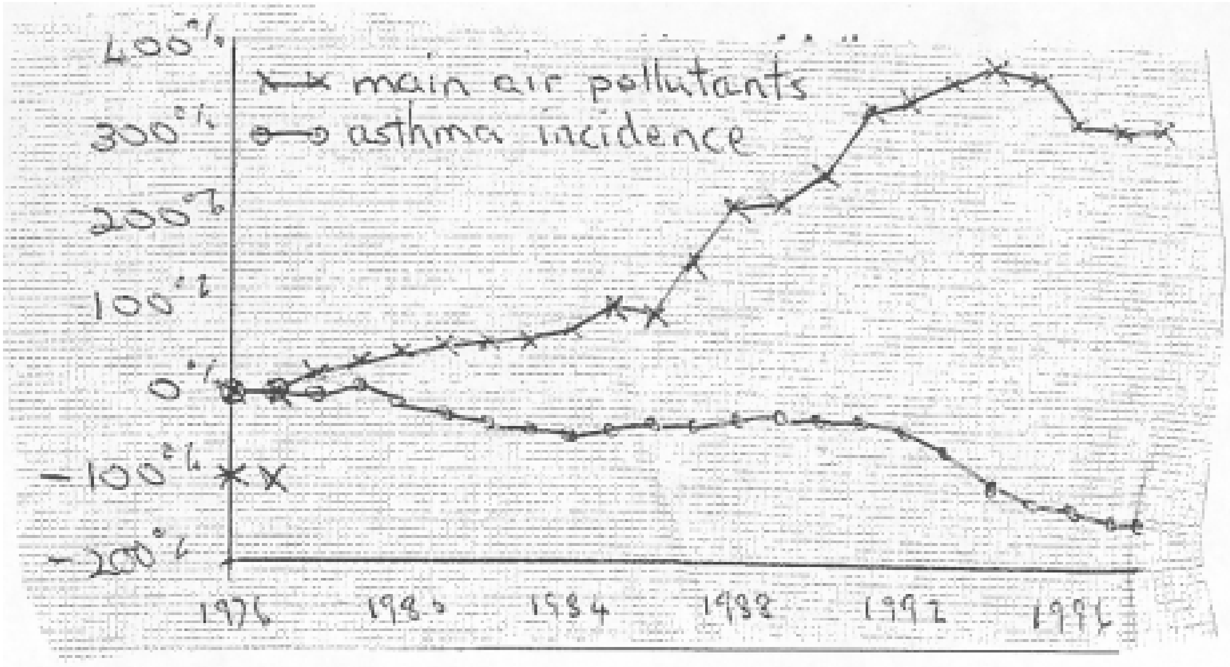
"There is no correlation between levels of vehicle emissions and asthma incidence"

1995 department of Health Study on the causes of asthma – **Dr Kenneth Calman Government chief Medical Officer**

Dr Martin Stern of the British Allergy foundation has categorically rejected that asthma is linked to outdoor air pollution. Instead, he links it to the household dust mite and its excreta. Modern living, with central heating, draught-free double-glazing, fitted carpets and poor diet plus lack of exercise provide the ideal environment for the dust mite and its effects on out respiratory system. The proportion of homes with fitted carpets in England, France and Italy is directly proportional to the incidence of asthma in each country.

Allergies are the biggest cause of asthma. Allergies are triggered by reaction of the immune system to allergens, which are materials of biological origin, specifically proteins; common allergens are:

A. Waste from house mites – 23% of American homes have levels sufficient to cause asthma
B. Particles from bacteria, fungi, plant fragments, pollen, mould, etc
C. Rubber in latex gloves, the dust from tyres, and elsewhere



The above graph shows the national trends in the incidence of asthma.

Another quote to back up argument against pollution causing rise in asthma attacks:

"In the last 40 years the level of (outdoor) air pollution has decreased dramatically"

"Nevertheless the incidence of asthma has risen"
"Pollution does not cause bronchitis or asthma, nor does wearing a so-called anti-pollution mask do anything except identify the wearer as a sucker" – **medical expert Professor Emeritus Stanley Feldman**

What can we do to improve the air quality?

Air quality is very important for people's health; it is vital that the air quality is clean as it can harm our bodies; people can do many things to improve air quality. When we think about air quality there are 3 main approaches available.

- What can scientists and technologists do? Can technological development improve air quality?
- What can scientists and technologists do? Can regulations and taxes help control pollution?
- What can individual people do? Are people prepared to change their life style if it improves air quality?

All 3 approaches are needed it we are to have good air quality for ourselves and for the future generations.

Air pollution can be reduced in different ways. As vehicles causes the most air pollution it can be reduced by fitting a Catalytic Converter in the engine where it converts Carbon Monoxide + Oxygen produced to a safer gas which is Carbon Dioxide.

The chemical reactions that occur in Catalytic Converters are:
Carbon Monoxide + Oxygen = Carbon Dioxide
2CO + O2 = 2CO2

Hydrogen Fuel cell engines are being developed, using hydrogen as fuel and reducing the amount of CO2 into the atmosphere.

Scientists can also remove almost all sulfur from power stations and chimney compounds from natural gas before it is used for power stations and domestic heating.

Here are lists of things you can do to reduce air pollution;

- Walk or ride a bike
- Ride public transit.
- Obey the speed limit.
- Replace your car's air filter.
- Look for the most efficient, lowest polluting model or even a zero-polluting electric car.
- Paint with a brush, not a sprayer.
- Use a push or electric lawn mower.
- Choose Air-Friendly Products

There are many more ways to reduce air pollution; the list will go on forever. These are just a few examples.

Conclusion

From all the information I have collected about the causes of asthma, I have come to a conclusion. In my opinion I think that air pollution is not highly responsible for the increase in asthma attacks because I agree with Dr. Nathan Rabinovitch that air pollution makes asthma worse, air pollution is one of the main triggers however I don't think that the death rates of asthma is caused by the air pollution, I also agree with Dr Martin Stern that allergies are the main cause of asthma. I believe that more indoor pollution such as particulates in the air and dust mites are the main reason for the rise in asthma attacks as also said by Dr Martin Stern. The graph showing the trends in the incidence of asthma shows that the 4 main pollutants do not cause more incidence of asthma. On the other hand I disagree with "The Friends of The Earth Society" because they do not have enough evidence to prove that deaths of asthma are related to air pollution and their resources are slightly biast and are not very reliable as they have just used any information to back there argument, I would rather believe what a doctor or a scientist would say as they are more experienced and have scientific knowledge to support there views. I have also found out that asthmatic people are sensitive to breathing and different people are affected by asthma in different ways, some people are triggered by different things such as grass pollen, dust mite droppings and animal hair, so this tells us that not just air pollution causes the rise in asthma attacks. Scientific evidence such as graphs and quotes by scientists and doctors helps me to make this decision so therefore I am also against the question.

Are the rise in asthma attacks caused by the air pollution?

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
A	Sources used				✓						3
	Listing of sources				✓						
	Acknowledgement of quotes					✓					
B	Background science								✓		7
	Recognition of evidence								✓		
C	Comparison of views								✓		7
	conclusions								✓		
D	Structure & organisation					✓					4
	Illustrations/tables/graphs					✓					
	QWC					✓					
	Overall total mark for the investigation										21

Aspect	Mark	Comment
Strand A: Quality of research		
(a)	3	Information has been drawn fro the student book and a range of web sources. Although the conclusion shows some awareness of possible bias in sources, this is not enough to fully match the 4-mark descriptor.
(b)	3	The references lack the detail needed to easily check the relevant pages of the sources.
(c)	4	Several views are quoted and assigned to their authors.
Strand B: Quality of scientific understanding		
(a)	7	There is a review of major sources of air pollution. The nature and effects of major pollutants are described. There is an explanation of what asthma is, and why it might be associated with air quality.
(b)	7	Extracts from sources include the evidence for any conclusions quoted.
Strand C: Quality of conclusions		
(a)	7	Arguments are balanced against one another but there is not quite sufficient attention to the relative reliability of sources to justify 8 marks.
(b)	7	Possible course of action for different groups are listed. There is a balanced discussion leading to a conclusion carefully linked to the evidence given.
Strand D: Quality of presentation		
(a)	4	An attractive layout (with good use of colour in the original). There is a clear structure, with sub-headings, page numbers and a contents list.
(b)	4	Photographs, schematic diagrams, charts and graphs are all used appropriately to convey information effectively.
(c)	4	Technical language is used correctly and there are few, if any, grammatical errors.

Appendix G: Marking Criteria for Investigation (A330)

Within each strand, different aspects of performance are identified. Achievement related to each of these is assessed, and the professional judgement of the teacher is then used to award an overall mark out of 8 for the strand.

Strand S: Strategy

Practical investigations are likely to arise out of work on most or all of the course modules. Suitable tasks might be suggested to candidates, but they should also have opportunities to modify or extend these, or to suggest questions or tasks to investigate in topic areas they are studying. Candidates can (and should) obtain more credit for tackling somewhat more demanding tasks, and for being involved in devising the question/task, rather than 'playing safe' with a given, or routine task, or one involving little skill in the use of equipment.

Whilst candidates should be encouraged to plan an investigation before starting, there is limited value in requiring them to produce a detailed written plan – as their actions should be open to modification as they proceed. Indeed, it is good practice to try taking a few measurements or making a few observations to get a 'feel' for the equipment and the system being investigated, before planning a detailed data collection strategy. For that reason, the candidate's understanding of issues concerning data is better assessed from the final data set they present (see strand C below), rather than from an initial plan.

Assessment of the quality of strand S focuses on:

- the complexity and demand of the task and approach chosen;
- the choice of equipment, materials and techniques;
- the degree of independence shown in formulating the task and the approach to it.

Aspect of performance	Strand S Mark			
	2	4	6	8
a complexity and demand of task	Simple measurement or comparison task, based on straight-forward use of simple equipment.	Routine task requiring only limited precision or range of data to be collected.	Straightforward task of limited complexity, but requiring good precision or a wide range of data.	Complex task requiring high levels of precision/reliability in the data collected.
b techniques used	Follow a given technique, but with very limited precision or reliability.	Select and use basic equipment to collect a limited amount of data.	Select and use techniques and equipment which are appropriate for the range of data required.	Justify the choice of equipment and technique to achieve data which is precise and reliable.
c autonomy and independence	The task has been set by the teacher and/or is based on specific, task-related structured worksheets.	The task is closely defined by the teacher, but is carried out with little further guidance.	The task is defined by the candidate from a more general brief, then carried out independently.	The topic is reviewed by the candidate to justify a choice of task. The work is completed independently.

Strand C: Collecting Data

Candidates are expected to be able to collect a set of data in a manner which shows understanding of how to ensure (and assess) quality.

The quality of a data set depends on:

- the quality of individual data points, which in turn depends on:
    - how carefully the measurements have been taken, and how accurate the available instruments are (IaS 1.1-2);
    - how much variation or scatter there is in repeated measurements and the steps that have been taken to assess and deal with this (IaS 1.1-4);
    - whether the instruments used, or the way they are used, results in measurements that differ from the 'true' value of the quantity (IaS 1.1-2).
- the extent and design of the set of data points collected, that is:
    - whether enough data points have been collected (IaS 2.1, 2.3, 2.7);
    - whether these cover an adequate range (of cases, or situations, or values of an independent variable) (IaS 2.3);
    - (if a relationship is being explored) whether the design of the data set enables the effect of other variables to be excluded (e.g. (IaS 2.2-3, 2.6-7).

Candidates should use preliminary experiments or other information to confirm that their choices of techniques and range of values to be tested will lead to results of good quality.

The statements are written to refer to primary data that the candidate has collected. Where this is supported by data from secondary sources, the statements should be read as referring to the data 'selected' (as opposed to 'collected'). The mark awarded should be based on all of the data considered as a whole.

Aspect of performance	Strand C Mark			
	2	4	6	8
a identification and control of interfering factors	Little or no care has been taken to identify or control outside influences.	Identifies some factors which may affect the outcomes and need to be controlled or accounted for.	Identifies the majority of factors which may affect the outcomes and need to be controlled or accounted for.	Reviews factors which might affect the outcomes and describes how they have been controlled or accounted for.
b extent and design of data set	The data is very limited in amount (e.g. isolated individual data points, with no clear pattern), covering only part of the range of relevant cases/ situations, with no checking for reliability.	An adequate amount or range of data is collected, but with little or no checking for reliability.	Data is collected to cover the range of relevant cases/ situations, with regular repeats or checks for reliability.	Values tested are well-chosen across the range, with regular repeats and appropriate handling of any anomalous results. Preliminary tests are used to establish the range.
c quality/ precision of manipulation	Little care evident in use of apparatus. Data generally of low quality.	Use of techniques and apparatus generally satisfactory. Data of variable quality, with some operator error apparent.	Sound techniques in use of apparatus/ equipment. Data of generally good quality.	Consistent precision and skill shown in use of apparatus/ equipment. Where appropriate, checks or preliminary work are included to confirm or adapt the apparatus or techniques to ensure data of high quality.

Strand I: Interpreting Data

Candidates are expected to be able to:

- present or process a set of data in such a manner as to bring out any 'patterns'[1] that are present;
- state conclusions based on these patterns;
- relate their conclusions to scientific theories or understanding;

In the following table, each row represents increasing achievement in a different aspect of performance.

Aspect of Performance	Strand I Mark			
	2	4	6	8
a graphical or numerical processing of data	Display limited numbers of results in tables, charts or graphs, using given axes and scales.	Construct simple charts or graphs to display data in an appropriate way, allowing some errors in scaling or plotting.	Correctly select scales and axes and plot data for a graph, including an appropriate line (normally a line of best fit) or construct complex charts or diagrams (e.g. stacked histograms, species distribution maps).	Additionally, indicate the spread of data (e.g. through scatter-graphs or error bars) and give clear keys for displays involving multiple data-sets.
	Select individual results as a basis for conclusions.	Carry out simple calculations e.g. correct calculation of averages from repeated readings.	Use mathematical comparisons between results to support a conclusion	Use complex processing to reveal patterns in the data e.g. statistical methods, use of inverse relationships, or calculation of gradient of graphs.
b summary of evidence	Note differences between situations/cases, or compare individual results.	Identify trends or general correlations in the data.	Describe formal or statistical relationships within the cases/situations studied.	Review the extent of, or limitations to, formal conclusions in relation to the scatter evident in the data.
c explanations suggested	Link the outcomes to previous experience or 'common sense'.	Relate the conclusion to scientific ideas/explanations.	Justify the conclusion by reference to relevant scientific knowledge and understanding.	Use detailed scientific knowledge to explain all aspects of the given conclusion.

[1] 'Patterns' here means similarities, or differences, or the presence or absence of a relationship (e.g. a correlation between a factor and an outcome, or a trend linking two variables)

Strand E: Evaluation

Candidates are expected to be able to look back at the investigation they have carried out, showing what they have learned from doing it and explaining how they would modify it in the light of this, were they to carry it out again. These suggestions may demonstrate understanding of:

- difficulties in collecting valid and reliable data;
- weaknesses in the design of the data set collected, such as imperfect control of other variables, or the size and matching of samples compared;
- assessing the level of confidence that can be placed in these conclusions.

Aspect of Performance	Strand E Mark			
	2	4	6	8
a evaluation of procedures	Make a relevant comment about how the data was collected and about safety procedures.	Comment on the limitations to accuracy or range of data imposed by the techniques and equipment, used.	Suggest improvements to apparatus or techniques, or alternative ways to collect the data, but without sufficient practical detail.	Describe in detail improvements to the apparatus or techniques, or alternative ways to collect the data, and explain why they would be an improvement.
b reliability of evidence	Make a claim for accuracy or reliability, but without appropriate reference to the data.	Note the presence or absence of results that are beyond the range of experimental error.	Use the general pattern of results or degree of scatter between repeats as a basis for assessing accuracy and reliability.	Consider critically the reliability of the evidence, accounting for any anomalies.
c reliability of conclusion	Relate judgement of the reliability (or otherwise) of the conclusions only to techniques used, not to data collected.	Link confidence in the conclusion to the apparent reliability of the data collected.	Discuss the precision of apparatus and techniques, the range covered and reliability of data to establish a level of confidence in the conclusions	Identify weaknesses in the data and give a detailed explanation of what further data would help to make the conclusions more secure.

Strand P: Presentation

The ability to report clearly and effectively on one's work is essential in order to demonstrate understanding of the Ideas about Science that relate to practical investigations.

Credit is awarded for three aspects of reporting and communicating a practical investigation:

- completeness of the report, with all practical procedures clearly described, all parameters and evidence reported, a full analysis of the evidence, and an evaluation of both procedures and evidence;
- presentation of the report, including layout and effective sequencing, use of illustrations as appropriate and use of graphs and charts to present information;
- correct use of English, including accurate grammar, punctuation and appropriate use of scientific terms.

Aspect of Performance	Strand P Mark			
	2	4	6	8
a description of work planned and carried out	The purpose/ context of the investigation is not made clear. Key features of experimental procedures are omitted or unclear.	The purpose of the work is stated. Main features of the work are described, but there is a lack of detail.	There is a clear statement of the question/task and its scope. Practical procedures are clearly described.	All aspects of the task are reviewed. Practical procedures are discussed critically and in detail.
b recording of data	Major experimental parameters are not recorded. Some data may be missing.	Most relevant data is recorded, but where repeats have been used, average values rather than raw data may be recorded.	All raw data, including repeat values, are recorded.	All relevant parameters and raw data including repeat values are recorded to an appropriate degree of accuracy.
	Labelling of tables is inadequate. Most units are absent or incorrect.	Labelling is unclear or incomplete. Some units may be absent or incorrect.	All quantities are identified, but some units may be omitted.	A substantial body of information is correctly recorded to an appropriate level of accuracy in well-organised ways.
	Observations are incomplete or sketchily recorded.	Recording of observations is adequate but lacks detail.	Observations are adequate and clearly recorded.	Observations are thorough and recorded in full detail.
c general quality of communication	Spelling, punctuation and grammar are of generally poor quality. Little or no relevant technical or scientific vocabulary is used.	Use of appropriate vocabulary is limited. Spelling, punctuation and grammar are of very variable quality.	Appropriate scientific vocabulary is used. Spelling, punctuation and grammar are generally sound.	There is full and effective use of relevant scientific terminology. Spelling, punctuation and grammar are almost faultless.

Appendix H: Activities Which Might be Used for Teaching or Assessment of Investigations

The chemistry specification provides opportunities for investigative work in every module of the course. Some of these activities can be used to introduce and develop procedural understanding of how to carry out investigations.

The suggestions given here indicate some activities related to the specification content which could be used either for developing understanding or for assessment. In a few cases some brief notes have been added in italics. These offer suggestions as to how the activity might be used and/or particular aspects of investigative work which could be brought out.

A useful early stage in planning investigative skills development and assessment would be to work up similar notes to a good range of the activities as a preliminary screening stage in selecting which ones may be of most value with particular teaching groups.

Candidates who are entered for Unit A329 could use the marks from Strands I and E of the Investigation to provide the marks for the Data Analysis assessment.

C1 Air quality
Investigate the concentrations of pollutants from car exhausts under different running conditions
C2 Material Choices
Investigate the strength of a range of plastic carrier bags
C3 Food matters
Measure the amount of Vitamin C in a batch of oranges
C4 Chemical patterns
Investigation by observation of the changes at the electrodes during electrolysis if aqueous solutions
C5 Chemicals of the natural environment
Effect of temperature on the solubility of salts
Electrolysis of aqueous solutions *e.g. in the electrolysis of aqueous copper salts is the amount of copper deposited always in proportion to the quantity of electricity transferred?*
Investigate the relationship between conductivity and concentration of aqueous salts
Is magnesium oxide always the same? *e.g. measuring the mass of magnesium oxide formed by burning different masses of magnesium requires readings to 1/100th of a gram.*
Measuring small concentrations of transition metal compounds *e.g. copper/iron/cobalt ions catalyse the iodide/persulphate reaction and using suitable calibration curves students can determine ionic concentrations by a clock reaction.*

C6 Chemical Synthesis
Measuring pH/temperature changes during neutralisation reactions
Which brand of vinegar/bleach is the best value? *e.g. using suitable dilution and titration techniques and cost analysis*
Rates of reaction *e.g. any of the popular investigations acid/limestone, magnesium/acid, thiosulphate/acid*
C7 Further Chemistry
Use chromatography to determine the components of a mixture

Appendix I: Example of Investigations with Commentaries

Script A

The Formula of Magnesium Oxide

Magnesium is a soft, silvery metal. We were shown two reactions. If strongly heated it burns to form magnesium oxide

Magnesium + Oxygen = magnesium oxide.

Magnesium also reacts with acid to form hydrogen

Magnesium + Acid = Magnesium salt + Hydrogen (gas)

We could choose which one of these we would investigate. I chose to investigate burning of magnesium to form magnesium oxide.

<u>Introduction:</u>

We were shown that magnesium burns with a white light which is so strong it was done behind a sheet of dark glass. The magnesium oxide ash is a white powder. A lot of it was blown up in the flame, and most got spread on the bench. If we could collect it, we could weigh it to see how much magnesium and how much oxygen combined together.

Next we were shown that if the magnesium burned in a crucible with a lid, no smoke of ash escaped. But the magnesium didn't all burn, so you had to keep just lifting the lid a little bit to let in more oxygen. When the magnesium doesn't flare up any more, it is done.

<u>Theory</u>

All magnesium atoms are the same as every other magnesium atom. All oxygen atoms are the same as every other oxygen atom – they all react in the same way and form the same number of bonds.

So, suppose that the formula of magnesium oxide is Mg_xO_y Every molecule of magnesium oxide will have the same formula, so the percent of oxygen in the oxide will always be the same.

If we burn different weights of magnesium, the amount of oxide formed should always be directly proportional to the amount of magnesium burned.

Strategy:

I will burn different weights of magnesium and see how much oxide is formed.

Preliminary test:

The easy way to get different weights of magnesium is to measure out (roughly) different lengths. Then they can be weighed. We measured out one metre of magnesium ribbon and weighed it. It weighed 1.05 g. This means each 10 cm of ribbon weighs about 0.1g. If we take very small weights, there will be an error in the weighing (because we can only tell to the nearest 0.01g). So, the shortest length we will take will be 30 cm. We will also test 40 cm, 50cm, 60cm and 70 cm.

We weighed an empty crucible, then cut off 30 cm of magnesium ribbon and folded it into a tight knot and put it in the crucible then weighed again.

We put the crucible on a pipe-clay triangle and heated with a blue Bunsen flame. We could see a white light when the magnesium started to burn. When this faded out, we gently lifted the lid, but smoke came out so we put it down again. We did this four times until the magnesium didn't spark up when we lifted the lid. We let the crucible cool down, then weighed it again. Then we put it back onto the triangle and heated it again for 3 minutes. When it had cooled, we weighed it again. We kept on doing this until the weight didn't change any more.

What was weighed	Total weight (g)	Wt of magnesium (g)	Wt of oxide (g)
Empty crucible	11.12	-	-
Crucible + magnesium not heated	11.42	0.30	-
Crucible + magnesium heated once	11.57	-	0.45
Crucible + magnesium heated twice	11.61	-	0.49
Crucible + magnesium heated three times	11.62	-	0.50
Crucible + magnesium heated four times	11.62	-	0.50

11.61 is as near to 11.62 as you can get with our balance, so it was really finished after two heatings.

We noticed in the first heating when you took the lid off, the magnesium sparkled a bit but didn't flare up or make smoke. We decided that we would heat once, lifting the lid, until no more smoke formed, then take of the lid and heat for three more minutes. This should be enough to get the magnesium all burned.

The lengths of magnesium we will use will be –

20cm, 30cm, 40cm, 50cm, 60 cm, 70cm. We will do each length twice. Because there are two of us, we can take it in turns and heat the next crucible while the last one is cooling down.

Method:

Put a heat-proof mat on the bench. Stand a tripod on it and put a pipe-clay triangle on the tripod.

Find a crucible with a lid that just fits over the top. Clean out any loose dust inside.

Weigh the crucible with its lid on and write down the weight.

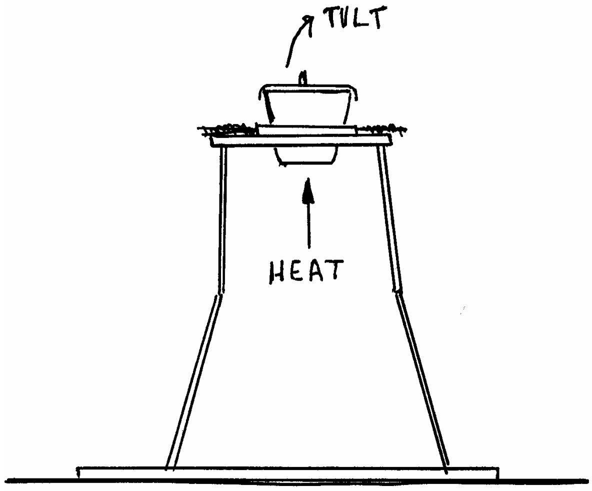
Cut off the right length of magnesium ribbon. Wrap it up into a tight knot and push down in the bottom of the crucible so it will get really hot. Put on the lid. Weigh it.

Put the crucible on the triangle. Heat strongly with a blue Bunsen flame.

When the magnesium has finished flaring, use tongs to just lift one side of the lid a little bit. Don't let any smoke out. Put down the lid again and go on heating for 1 minute.

After about three times, the magnesium does not glow or flare up. Take off the lid, but go on heating for three minutes.

Using tongs, carefully put the crucible down on the mat to cool. While it is cooling, the next one can be heated.



Test by holding your hand above the crucible (**not** touching). If it is still hot, you can feel hot air rising. When it is cool, weigh again.

Gently scrape out all of the loose ash, ready for the next test.

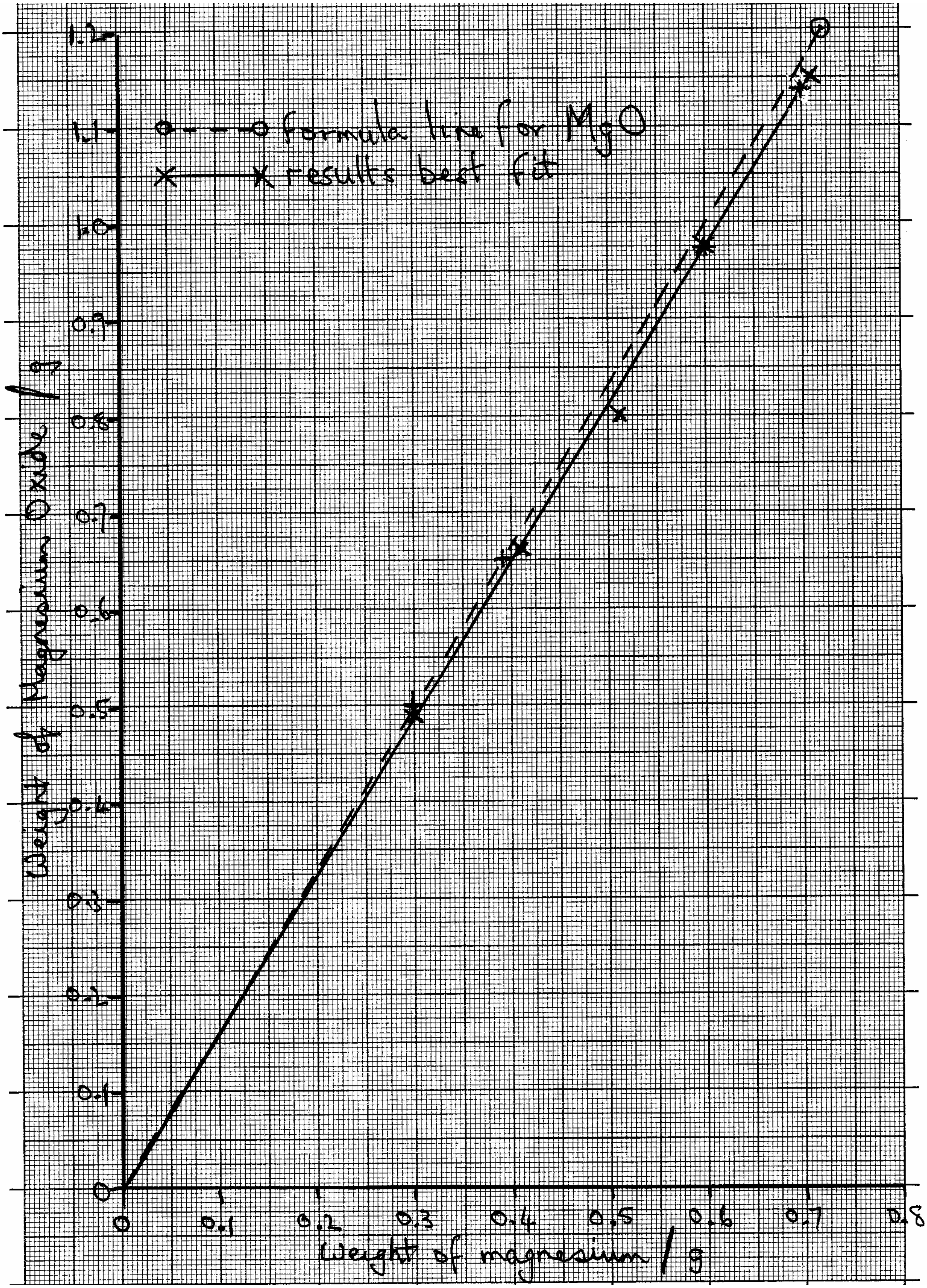
Safety:

Wear goggles. Keep loose clothes or hair away from the flames. Do not touch hot crucibles. Do not look directly at burning magnesium.

Results:

Length of ribbon / cm	empty crucible / g	crucible + ribbon / g	crucible + ash / g	weight of Mg / g	weight of oxide / g
30	11.14	11.44	11.63	0.30	0.49
	use the results from preliminary test				
40	12.21	12.62	12.87	0.41	0.66
	11.17	11.56	11.82	0.39	0.65
50	12.25	12.76	13.05	0.51	0.80
	11.16	11.66	crucible broke while heating		
60	12.24	12.84	12.21	0.60	0.97
	11.79	12.39	12.76	0.60	0.97
70	12.26	12.97	13.41	0.71	1.15
	11.82	12.52	12.96	0.70	1.14

Graph of amount of magnesium oxide made.



Summary of the results:

On the graph showing weight of oxide formed against weight of magnesium burned, all of the points lie on or very close to a straight line through the origin (0.0g of magnesium would give 0.0g of oxide).

This shows that the mass of oxide formed is directly proportional to the mass of magnesium burned.

Interpreting the results:

The mathematical formula for a straight line is $y = mx + c$

If the line goes through the origin, then $c = 0$. So in this graph, $y = mx$

For the graph, $y = (1.15 – 0)$ and $x = (0.71 – 0)$ so $m = 1.15/0.71 = 1.62$

This can be compared to the result expected for different formulas. On the atomic weight scale, Mg = 24 and O = 16

Formula	weight of magnesium	weight of oxygen	weight of oxide	ratio oxide/Mg
Mg_2O	24x2=48	16	64	1.33
MgO	24	16	40	1.67
Mg_2O_3	24x2 = 48	16x3 = 48	96	2.00
MgO_2	24	16x2 = 32	56	2.33

The line for MgO is drawn on the graph. It is very close to the best fit line for our results. This shows that magnesium oxide has always the same amount of oxygen to magnesium, and it is the right amount for the formula to be MgO – one atom of magnesium to one atom of oxygen.

$$2Mg_{(s)} + O_{2(g)} = 2MgO_{(s)}$$

This works because magnesium oxide is a pure compound. All of the molecules have the same numbers of each type of atom in them.

Evaluation:

We could tell the weights to 0.01g. Even for the shortest piece of magnesium, this was only about 3% of the real weight, so this would be the limit of how precise the results could be. This could only be improved by using a better balance to get weights to 0.001g

The magnesium was not very clean and shiny, the surface was darker down the middle, so it may have had some of it turned to oxide already by reacting with air. This would make our results at the end a bit less than they should be.

The magnesium didn't burn up unless the lid was lifted a bit to let in more air. When we did this, bits of smoke sometimes came out. This would be dust of magnesium oxide, so it would also make the final result too low.

The bottom of the crucible got burned and it wasn't possible to get rid of all the ash after each test.

The graph shows that all of our final results were a little bit less than they should be, but only a very little bit, so it was a good result.

If we did more tests with really long bits of magnesium, the bigger weights could be weighed more accurately to confirm the same results.

Commentary on Script A: The formula of magnesium oxide

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
S	Complexity & demand of task								✓		7
	Techniques used								✓		
	Autonomy & independence							✓			
C	Identification and control of interfering factors								✓		7
	Extent and design of data								✓		
	Quality/precision of manipulation								✓		
I	Graphical processing of data									✓	7
	Numerical processing data										
	Summary of evidence								✓		
	Explanations suggested							✓			
E	Evaluation of procedures						✓				4
	Reliability of evidence					✓					
	Reliability of conclusion				✓						
P	Description of work planned and carried out								✓		7
	Recording data								✓		
	Labelling tables & units										
	Observations										
	General quality of communication								✓		
	Overall total mark for the investigation										31

Aspect	Mark	Comment
Strand S: Strategy		
(a)	7	A task approached by the student involving some complexity and the need for reliable data.
(b)	7	Equipment and techniques justified although heating to constant mass could be developed more fully.
(c)	6	Teacher demonstration used as a stimulus by the candidate to select and develop the investigation.
Strand C: Collecting Data		
(a)	7	Length of magnesium/heating to constant mass controlled.
(b)	7	Measurements repeated to check for reliability but preliminary work did not establish range. Up to 70cm length appears rather excessive?
(c)	7	Preliminary work used to adapt the method, data of good quality judged from inspection of the graph.
Strand I: Interpreting Data		
(a)	8	Graph drawn with suitably labelled axes, points plotted correctly, best fit line. All raw data plotted to show reliability. Theoretical line for MgO plotted with key.
(b)	7	Describes formal relationship in terms of the MgO formula using the data collected and compares with other ‘possible’ formulae.
(c)	6	Justifies the MgO formula using relative atomic masses and ratios.
Strand E: Evaluation		
(a)	5	Identified limitations in the method but improvements involved only the use of longer lengths.
(b)	4	Although the match to the predicted values is noted, there are no specific references to close repeat values, or good fit of each data point to the line.
(c)	3	This aspect has been almost completely overlooked. There is plenty of evidence to support the reliability of the outcome, but little comment about it.
Strand P: Presentation		
(a)	7	Clear statement of task, practical procedures clearly described, not all aspects reviewed (e.g. use of air rather than oxygen etc.)
(b)	7	All raw data and repeats recorded to a suitable degree of accuracy although no units included in table 2.
(c)	7	Spg very good, occasional inappropriate use of word ‘molecule’.

How good are heart-burn tablets?

Our stomachs make hydrochloric acid to help digest food. Sometimes too much acid is made. One of the effects this can cause is heart-burn, a painful burning sensation in the chest.

Tablets for indigestion contain anti-acids to neutralise this acid and cure the pain.

One anti-acid that can be used is sodium bicarbonate (sodium hydrogencarbonate, bicarbonate of soda). I will find out how much sodium bicarbonate is needed to neutralise 20cm^3 of 0.1M hydrochloric acid, then find out how much of the crushed-up anti-acid tablet will neutralise the same amount of acid. I will use the same amount of acid each time.

Method:

Apparatus: 25 cm^3 measuring cylinder

100 cm^3 beaker

glass rod

accurate balance

filter papers

wooden splint with the tip bent up

sodium hydrogencarbonate

hydrochloric acid (0.1M)

methyl orange solution

Use the measuring cylinder to put 20 cm3 of hydrochloric acid in the beaker.

Add 2 drops of methyl orange. This goes pink in acid and will go orange or yellow when all the acid is used up. It is an indicator to tell when all the reaction is finished

$$NaHCO_3 + HCl = NaCl + H_2O + CO_2$$

Put a heap of sodium hydrogencarbonate on a filter paper and weigh it.

Use the splint to add a little bit of sodium hydrogencarbonate to the acid and stir with the glass rod.

Keep adding solid a little bit at a time until the acid in the beaker turns orange or yellow.

Weigh the filter paper again to see how much has been used.

Rinse out the beaker with water.

Repeat as many times as necessary to make sure of the right answer.

Now put 20cm3 of the hydrochloric acid in the beaker and add 2 drops of methyl orange.

Crush up some indigestion tablets onto a filter paper and weigh it.

Add the powder a little at a time to the acid and stir until it goes orange or yellow.

Weigh the paper again to see how much has been used.

Results:

Using sodium hydrogencarbonate

Expt	Acid (cm3)	wt at first (g)	wt after (g)	wt used (g)
1	20	8.51	8.34	0.17
2	20	8.34	8.12	0.22
3	20	8.12	7.96	0.16
4	20	7.96	7.76	0.20
5	20	7.76	7.58	0.18

These are all quite close together and none of them are outliers. So all of the results can be used to calculate the best estimate.

Also there are enough results to show that the method is reliable.

Average = (0.17 + 0.22 + 0.16 + 0.20 + 0.18) / 5

= 0.93/5 = 0.186 g

So if the tablet is made of pure sodium hydrogen carbonate, it will take 0.186 g of it to make the acid go yellow.

Results with crushed up indigestion tablet

Expt	Acid (cm3)	wt at first (g)	wt after (g)	wt used (g)
6	20	10.23	9.78	0.45
7	20	9.78	9.30	0.48
8	20	9.30	8.83	0.47
9	20	8.83	8.29	~~0.54~~
10	20	8.29	7.87	0.42

Four of these experiments gave close answers, but experiment 9 gave a different answer and was a lot more powder than the others. Experiment 9 was crossed out and not used for the best estimate.

Wt used = (0.45 + 0.48 + 0.47 + 0.42) / 4

= 1.82 / 4 = 0.455 g

Interpretation:

0.455 g of the indigestion tablet uses up the same amount of acid as 0.186 g of sodium hydrogencarbonate.

So, if the active chemical in the tablet is sodium hydrogen carbonate, the percentage of it is

(0.186 / 0.455) x 100% = 40.88%

This ingredient is put in to kill off acid in the stomach. The other ingredients may be to bind the powder together in the tablet, or to make it taste nice or look nice. Of course it might be a different anti-acid in the tablet, but whatever it is it does the same as 40% of sodium hydrogencarbonate.

Evaluation:

The measuring cylinder was an easy way to measure out the acid, but you couldn't drain every drop of acid out. Perhaps we could have done the reaction in the measuring cylinder instead of using a beaker, then all the acid would have been used. Or we could use a syringe.

The results all except number 9 all agreed very well, which shows that they were reliable.

I am confident that this would be a good way to compare different types of indigestion tablet to see which gave best value for money. The experiment could be extended by testing more different types of tablets.

Commentary on Script B: How good are heart-burn tablets?

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
S	Complexity & demand of task					✓					4
	Techniques used						✓				
	Autonomy & independence					✓					
C	Identification and control of interfering factors					✓					5
	Extent and design of data						✓				
	Quality/precision of manipulation						✓				
I	Graphical processing of data							✓			4
	Numerical processing data										
	Summary of evidence			✓							
	Explanations suggested						✓				
E	Evaluation of procedures				✓						4
	Reliability of evidence					✓					
	Reliability of conclusion					✓					
P	Description of work planned and carried out						✓				6
	Recording data							✓			
	Labelling tables & units										
	Observations										
	General quality of communication							✓			
	Overall total mark for the investigation										23

Aspect	Mark	Comment
Strand S: Strategy		
(a)	4	Limited precision involving adding a solid from a splint to an acid.
(b)	5	Uses balance, measuring cylinder and indicator to collect a reasonable range of data.
(c)	4	From evidence provided task closely defined by the teacher but carried out with little further guidance.
Strand C: Collecting Data		
(a)	4	Uses constant volume of acid and same number of drops of indicator but not how much solid added each time.
(b)	5	Range of data collected is limited but repeat measurements taken.
(c)	5	Simple technique lacking in precision.
Strand I: Interpreting Data		
(a)	6	Simple averages and percentage of active ingredient calculated.
(b)	2	Notes difference between NaHCO3 and indigestion tablet.
(c)	5	Writes equation of the reaction, recognises other ingredients in tablet causing different results.
Strand E: Evaluation		
(a)	3	Comments on limitations in simple way e.g. draining of measuring cylinder.
(b)	4	Identifies anomalous result.
(c)	4	Links quality of data to confidence level in conclusion and also suggests extending investigation to other types of tablet.
Strand P: Presentation		
(a)	5	Purpose of work identified, practical procedures described.
(b)	6	Raw data and repeat measurement recorded with appropriate units.
(c)	6	Spg sound and appropriate use of scientific vocabulary.

How much Hydrogen?

For my experiment I had to find out how much hydrogen you get if you disolve magnesium ribbon in acid.

We will use different amounts of magnesium in the same amount of acid each time to make a fair test and we will do it twice.

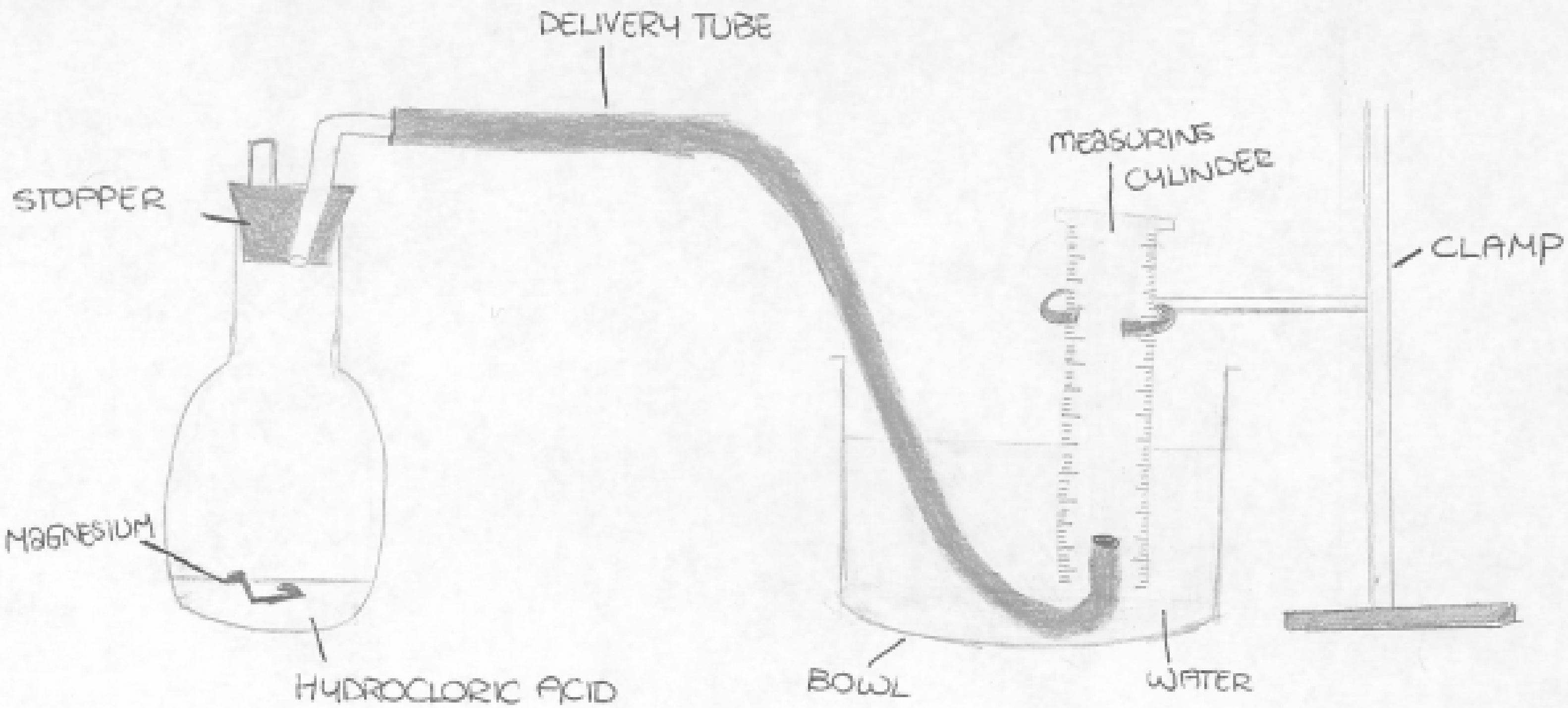
We were told that we can't weigh the magnesium because it hasn't got enough density. So we mesured how long and used different lengths. Then we did (length in cm divided by 100 = weight in gm) to find out how much it weighs.

By measuring out repeatedly 20 cm3 of hydrochloric acid for each test I made each test fair. I mesured out a strip of magnesium and balanced it on the tip of the flask with the acid in.

Then I pushed the stopper in so that the magnesium dropped into the acid and fizzed. The hydrogen bubbles that came out went through the delivery tube to the mesuring cylinder.

I did this many times and each time twice so I could get a second opinion on the results.

A DIAGRAM TO SHOW THE SET UP OF MY EXPERIMENT.



Results:

Length of magnesium	weight of magnesium	amount of gas
25cm	0.25	256
25cm	0.25	258
20cm	0.2	224
20cm	0.2	238
16cm	0.16	182
16cm	0.16	175

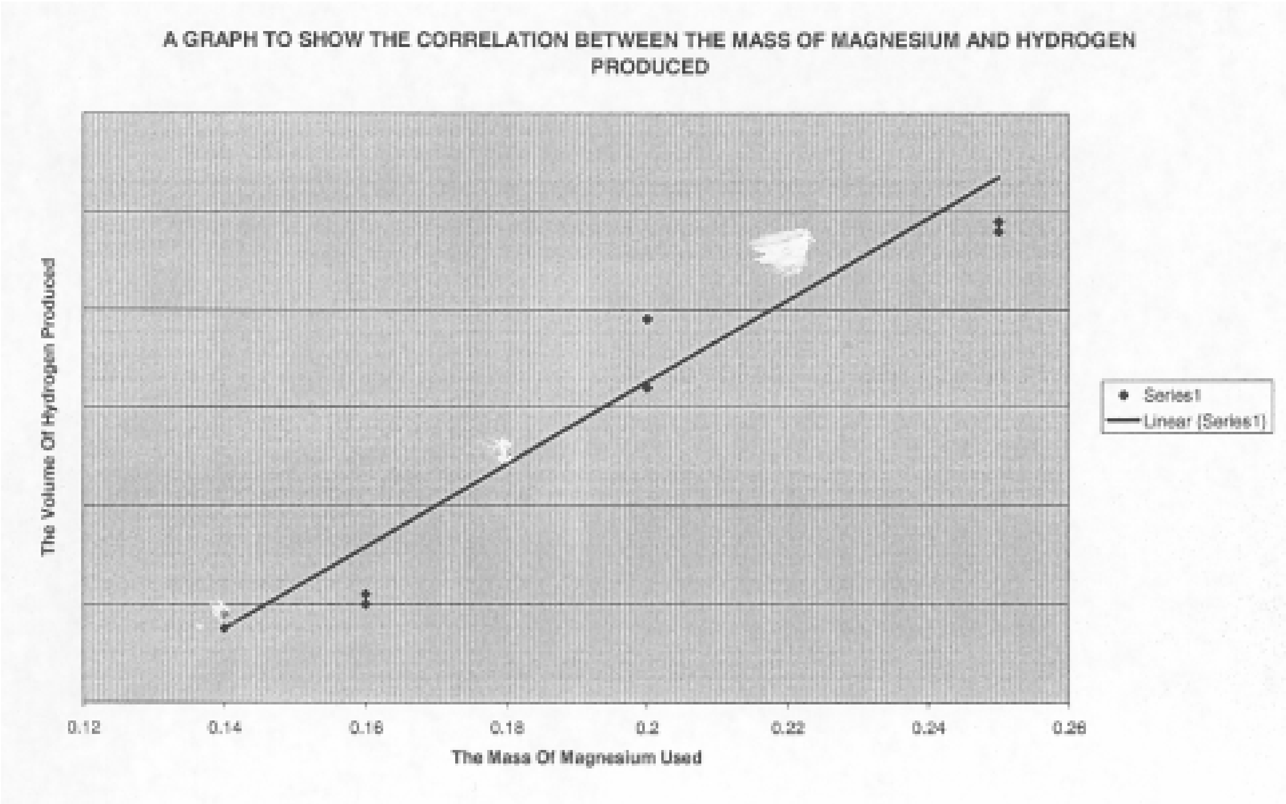
Evaluation:

In conclusion I think the experiment went very well and I managed to conclude some very good results.

The results in that experiment were not all that reliable even though we followed the guidelines well. This is because I should have done a greater amount of tests but there was a limit in time of how much I could do.

There were many improvements to the apparatus that were vital. I changed the way I held the measuring cylinder so water would not spill out when I turned it over. I started off using my thumb and then thought it would be easier to use a sheet of paper as it was more secure and tight.

These are my results shown in a graph. There is a trend line and I find this makes my results easier to understand.



From looking at my graph of results, there is enough evidence to be able to judge if there is a relationship between the mass of magnesium and the volume of hydrogen used. It is clear that the gradient for my experiment is 987.5. It is not perfect because the perfect gradient is 1000. I know that because of the average.

Commentary on Script C: How much hydrogen?

Strand	Aspect of performance	Level of performance related to mark scale									Mark for Strand
		0	1	2	3	4	5	6	7	8	
S	Complexity & demand of task						✓				4
	Techniques used						✓				
	Autonomy & independence				✓						
C	Identification and control of interfering factors				✓						4
	Extent and design of data					✓					
	Quality/precision of manipulation					✓					
I	Graphical processing of data					✓					3
	Numerical processing data										
	Summary of evidence					✓					
	Explanations suggested	✓									
E	Evaluation of procedures				✓						2
	Reliability of evidence		✓								
	Reliability of conclusion			✓							
P	Description of work planned and carried out					✓					4
	Recording data					✓					
	Labelling tables & units		(✓)								
	Observations										
	General quality of communication						✓				
	Overall total mark for the investigation										17

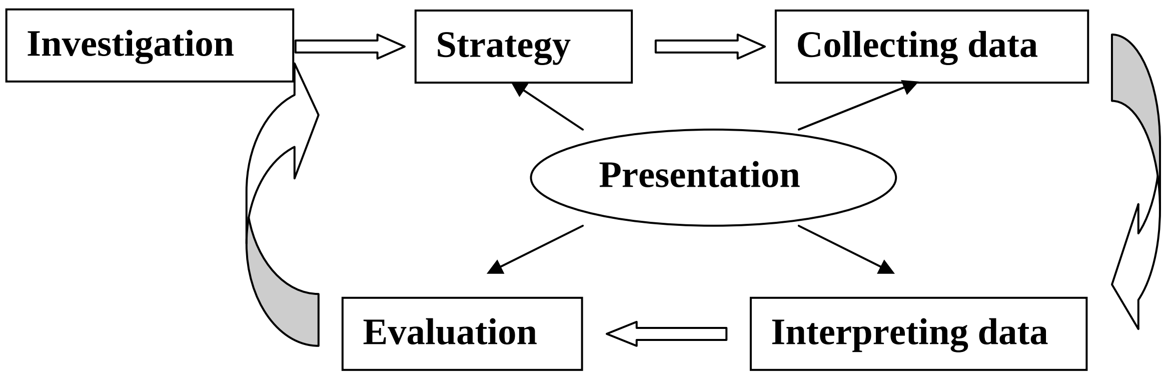
Aspect	Mark	Comment
Strand S: Strategy		
(a)	5	Technique was demonstrated. Only a limited number of tests attempted.
(b)	5	Basically sound technique, but of fairly low demand.
(c)	3	The task was closely defined for candidates, and the technique was demonstrated.
Strand C: Collecting Data		
(a)	3	There is some idea of 'fair testing' and the amount of acid is standardised, but no other factors are considered.
(b)	4	A range of three values is not sufficient, but each is repeated to check. 4 is the 'best fit', considering the 2, 4 and 6 mark descriptors.
(c)	4	Both the repeat values and the graph show considerable variation in the results.
Strand I: Interpreting Data		
(a)	4	The display is small, with no grid for ease of location of the points. One axis has no scale shown, the other scale does not start from the origin. However, all raw data is plotted.
(b)	4	A trend is identified. Although there is reference to the "gradient", there is no clear expression of direct proportionality.
(c)	0	There is no attempt to explain the results.
Strand E: Evaluation		
(a)	3	There is no consideration of the limits imposed by the methods used. However, there is one comment about an improvement in technique.
(b)	1	The claim that results were "not all that reliable" is not linked to the data.
(c)	2	The first two sentences make a claim for confidence in the conclusion, but this is not effectively linked to the evidence.
Strand P: Presentation		
(a)	4	The method is described in outline only.
(b)	4	A limited amount of data is recorded, but most units are omitted.
(c)	5	Grammar is generally sound, but there are a number of spelling errors and little technical vocabulary is used.

Appendix J: Guidance for Students - Investigations

During this science course, you will be asked to design experiments to investigate many practical questions. The assessment of the course includes marks for how well you can complete an investigation. Any of the investigations you do could be used to judge these marks. The mark you are given at the end of the course will be the total mark for your most successful investigation.

This part of the investigation counts for one-third of the total marks for the whole subject, so it is really worth-while learning how to carry out and record investigations as well as possible.

For the assessment, marks are awarded for each of five ‘strands’ in the investigation:



Each strand is marked out of 8 marks so the maximum mark possible is 40.

Read through and consider the following advice and guidance.

Strategy (Strand S):

Do not rush this part; your whole investigation depends on how good your strategy is!

- Your teacher will introduce investigations which could be used for assessment. You may be allowed some choice of what to investigate, and you have to decide how to set about the task!
- Look at the information in the topic(s)/module(s) that is (are) relevant to your investigation. Find out what sort of things (factors) might affect the results you get.
- If you ask your teacher what to do then you might not be able to obtain the highest marks in this strand. The more ideas you have yourself the higher marks you might be able to achieve. If you write the title to your investigation in terms of a question this sometimes helps to provide a clear focus for your work and makes you answer it when writing your conclusion!

Initial method

- Think about the factors involved; select the one you are going to change and how you are going to control the others. Think about the range of values you are going to use for the factor that you might change.
- Think about how to make sure that the data you collect is accurate and reliable so that you have good quality evidence on which to base your conclusion. Write down your thoughts.

- Do some preliminary work to get a 'feel' for what you will do before committing yourself to a detailed plan.
- Include reasons why you have selected the particular apparatus that you have done. Draw diagrams as appropriate. If you are only using simple apparatus and techniques then you may be limiting yourself to the maximum mark that you can obtain.
- Record your results, do an initial interpretation and evaluation and modify your method as appropriate.

Collecting Data (Strand C)

Make sure you keep a record of all your results, including results of preliminary tests

- describe the factors involved.
- identify the factor you are going to investigate and record the measurements of the others that you have controlled.
- On the basis of your preliminary work include the range of values you have chosen for the factor you are changing.
- Make sure that the data you collect includes enough measurements, is accurate and reliable, repeating any measurements that you think necessary, so that you have data of the best quality.
- Record your data in a suitably labelled table, paying attention to units and numbers of significant figures.
- Whilst you are doing the experiment think about any problems that you having and note them down for the evaluation stage.

Interpreting Data (Strand I)

Process your data, identify patterns, draw conclusions and explain them using your scientific knowledge and understanding

- Process your data by doing some analysis using calculations and/or plotting your data on a line graph. Consider the errors on each point, drawing error bars if you can before you draw a line of best fit. Is the best fit line straight, a curve or something else? You can produce a graph using a computer but it is probably best to draw the line of best fit yourself. If a line graph is not appropriate then draw a histogram, bar chart or scatter graph.
- Record trends and patterns in your data doing mathematical calculations if this helps in any comparisons that you make.
- Make a conclusion and try to express it in a quantitative way if this is appropriate.
- Look carefully at the scatter in your data to see if it limits your conclusion in anyway.
- Explain your conclusion using your scientific knowledge and understanding.

Evaluation (Strand E)

This area is generally regarded as the most difficult. It is probably best to focus on your data and methods separately and then discuss any limitations and confidence levels you have in your conclusion pointing out what further data you could collect.

Evaluating the data that you have collected

- How many results did you collect – were these enough to draw a conclusion?
- How accurate were your results?
- Do all your results clearly fit a trend/pattern, or do some look wrong e.g. look at your graph, the best fit line and identify any anomalous results.
- Are there any results that you think should be repeated?
- If some of your results didn't fit the trend/pattern can you explain why?
- Look at the differences between your repeat measurements. Are the differences important or do you think your results are sufficiently reliable?
- Does your conclusion explain all your results or did you leave some out?
- Have your results covered a big enough range to support a firm conclusion?
- Have you collected a sufficient number of accurate and reliable results to support a firm conclusion?

Evaluating your method/procedure

- Did you have any problems with your method?
- Was your equipment appropriate for the task?
- How well did you control the other factors that you didn't investigate- did they vary during the experiment?
- How precise were your results e.g. did you judge by eye or use an instrument?
- How big were the divisions on the scale of the equipment and were they adequate for the readings needed?
- How accurate can the readings be from the equipment you used?
- What improvements to your method would you suggest to make the results more accurate and reliable?

Reliability of conclusion

- What extra measurements might you do to make your conclusion more certain?

Presentation (Strand P)

Your report must be organised and presented clearly with full details of all aspects of your investigation using relevant scientific words with good spelling, punctuation and grammar.

- Make sure that your tables of data have suitable headings with units and your data is correctly recorded to the appropriate degree of accuracy with the correct numbers of significant figures.
- Make sure your graph has a title, is of a suitable size (no miniature Excel graphs), labelled axes with units and points correctly plotted.

Investigation checklist

Strategy	• Topic(s) reviewed and investigation suggested • Investigation is of appropriate complexity • Strategy includes attention to accuracy and reliability • Equipment and techniques are justified
Collecting data	• Factors involved identified and either controlled or varied • Range of values of factor under investigation established from preliminary work • Modifications to method made if required • Data collected is sufficient, accurate and reliable • Anomalous results repeated
Interpreting data	• Data is processed using graphs or mathematical methods • Graphs have axes labelled, correct units, accurate plotting, line of best fit and estimate of errors • Mathematical methods involve comparisons between results and possibly statistical or inverse relationships • Trends and patterns identified in the results • Qualitative or quantitative relationships stated as a conclusion • Limitations to the conclusion due to scatter in results are identified • Conclusion explained using scientific knowledge and understanding
Evaluation	• Problems in method affecting quality of results are described • Improvements to method are suggested and justified • Results are assessed for accuracy and reliability • Anomalous results are identified and explained • Level of confidence in the conclusion is described
Presentation	• Aim of investigation is clear • Report is well organised with all procedures described in detail • Observations and measurements are fully and clearly recorded with labelling and units correct • Data recorded to appropriate degree of accuracy • Scientific terminology is relevant and correctly used • Spelling, punctuation and grammar are correct

Appendix K: Cover Sheet for Work for Moderation of Case Study and Data Analysis

	Chemistry A Twenty first century science Subject J634 Skills assessment Unit A329	200_

Centre No: | | | | | | Centre Name:

Candidate No: | | | | | Candidate Name:

A329 Marks for data exercise (strands I and E)

Title of activity (as shown on the work): …………………………………………………………………………….

Use ticks in the boxes (one per row) to indicate the level of performance as judged by the centre, and enter the mark awarded for each strand. The final two columns must be left blank for the moderator.

Strand	Aspect of the work	0	1	2	3	4	5	6	7	8	Strand mark	Mod	T/L
I	Graphical display **or** Processing data												
	Summary of evidence												
	Explanations												
E	Evaluation of procedures												
	Reliability of evidence												
	Reliability of conclusion												

Tick here if these marks are taken from the **same** activity which is counted for assessment of the Investigation in Additional Science.

A329 Marks for the Case Study:

Title of the Case-study (as shown on the script): ……………………………………………………………………….

Use ticks in the boxes (one per row) to indicate the level of performance as judged by the centre, and enter the mark awarded for each strand. The final two columns must be left blank for the moderator.

Strand	**Aspect of the work**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Strand mark**	**Mod**	**T/L**
A	Planning use of sources												
	Acknowledgements												
	Internal referencing												
B	Using science knowledge												
	evaluating scientific evidence												
C	Comparing arguments												
	Conclusions												
D	Structure and organisation												
	Visual communication												
	Quality of language												

Centre overall total mark		Moderator overall total mark		Difference	

Appendix L: Cover Sheet for Work for Moderation of Investigation

OCR RECOGNISING ACHIEVEMENT	**Chemistry A J634** **Unit A330 Investigation**	**200_**

Student Name: ……………………………………………… Candidate No: ………………

Title of Investigation: ………………………………………………………… Date: ……………………

Marked by: ………………………………………………… Centre No: …………………..

This completed form should be attached to the front of the investigation report

Strand	Aspect of performance	Level of performance related to mark descriptors									Mark	Moderator
		0	1	2	3	4	5	6	7	8		
S	Complexity & demand											
	Techniques chosen											
	Autonomy/independence											
C	Control of other factors											
	Range & design of data											
	Quality of manipulation											
I	Graphical display											
	Processing data											
	Conclusions											
	Explanations											
E	Evaluating procedures											
	Evaluating the data											
	Judging reliability											
P	Description of the work											
	Recording data											
	Labeling and units											
	Qualitative observations											
	Quality of communication											

Moderator comments	**Total mark (sum of strand marks)**		

Appendix M: Support for Very Weak Students to Produce Coursework

Value of preparation for weak candidates

The preparation of extra materials and the careful administration needed to support very weak candidates should be given a high priority within the Science Department, because these resources can also be used in cases of extended staff absence, or for candidates who miss the normal opportunities for preparing their coursework in lessons. As the coursework is worth a high proportion of the marks for the whole GCSE it is very important that all candidates attempt every component.

Organising the work

A strict timetable improves the pace of work. A clear, achievable outcome for each lesson builds confidence and makes supervision and guidance much more manageable. An A4 or A3 tick chart for each group can be displayed and updated to confirm completion of each outcome and to indicate work that is incomplete or missing.

Collecting all work in each lesson for checking helps to ensure an appropriate rate of progress. Rough work should also be collected as it may prove useful later. Support staff can help to ensure that all work is named and handed in. A brightly-coloured and clearly labelled folder for coursework emphasizes its value and significance.

It is important to check that individual Support staff understand the internal assessment; and especially that they understand that it is the candidates' own ideas that are being assessed, so that telling them what to write, may stop them from getting marks.

Case Study

The Case Study allows weak candidates to be given very structured tasks, with guidance. The assessment criteria take account of the extent of guidance provided whilst crediting the work of the candidate.

Choosing a topic

Candidates will be better motivated if they have some choice, but in order to provide adequate support for weak candidates this needs to be limited to a couple of titles. When the coursework is first introduced, a short list of possible titles can help to illustrate the idea of the project. A brief class discussion of these titles to select the two most popular can give more ownership to the project. The short listed titles must refer to an issue which is familiar to the candidates so they can understand the extra information they find whilst producing their report. They need to refer to science explanations (Strand B), so it is better for the topics to be based on science ideas which are important in the Units.

The best title is a question which demands an answer, so the candidates have a clear target of deciding on their own answer to the question.

For example, the title 'Should smoking be banned?' has been successful for weak candidates.

Strand A: Quality of selection and use of information

Aspect (a) planning the use of sources of information

A Case Study for a weak candidate could be based on one or two paper sources of information. Preparing the information in advance of starting the Case Study makes it much easier to manage the task. It is important to avoid a classroom situation where some pupils cannot proceed with their work because they do not have access to information that they understand.

Two or three websites could be suggested to the candidates for them to select illustrations and /or further information.

This would allow them to gain a mark in Strand A.

The information given to them should include:

- the science explanations for the topic
- an opinion for the suggestion or question in the title, with a reason for this opinion
- an opinion against the suggestion or question in the title, with a reason for this opinion

Aspect (b) acknowledgement of sources used

This is not expected of the weakest candidates.

Aspect (c) linking information to specific sources

This is not expected of the weakest candidates.

Strand B: Quality of Understanding of the Case

Aspect (a) making use of science explanations

It is unlikely that weak candidates will be able to tell which parts of a science topic are relevant to the case they are studying, but it would help them to describe a relevant science topic; for example, for a Case Study on smoking, a revision lesson could cover the respiratory and circulatory systems.

The key scientific words and phrases for the topic should be listed so candidates can learn them and use them correctly when writing their report.

Aspect (b) recognition and evaluation of scientific evidence

It is safer for the candidates' understanding of the case if the stimulus material includes scientific evidence rather than unsupported claims, as weak candidates find the distinction difficult.

If candidates enter a blog site that discusses a contentious issue, they are likely to find many unsupported claims. Caution is needed in using such sites because unsupported claims and opinions could make too deep an impression, especially if expressed by peers.

Strand C: Quality of Conclusions

Aspect (a) comparing opposing evidence and views

Very weak candidates may be unable to recognize whether ideas that are opposed to, or linked to, different points of view. Other candidates may recognize this, but have difficulty in articulating their views. They may be helped by physical means of sorting information from their extracts; for example by cutting out statements and sorting into different envelopes, by using distinct colours of paper on which to paste or write the information, or by highlighting using different colours.

Aspect (b) conclusions and recommendations

If the coursework title is a question with a yes / no answer, then candidates can provide a yes / no answer as their conclusion.

Once the conclusion is written, candidates can be asked to add a reason for their view.

Strand D: Quality of presentation

Aspect (a) structure and organisation of the report

The Case Study can be structured by the use of worksheets or writing frames which can guide them through the process so that their efforts are linked to the criteria by which they are assessed. They need to include: an introduction, explaining why they have chosen the topic; the science involved in the topic; the arguments for and against the issue; and their own conclusion.

Aspect (b) use of visual means of communication

Two or three websites can be suggested to the class, where they can find suitable illustrations for their work. It may be better to do this once the written work is complete, in order to avoid distractions.

Aspect (c) spelling, punctuation and grammar

A revision lesson can be used to remind candidates of the key words for the topic and a literacy-based homework could be set so they can practice using these words. They should be reminded of the importance of correct spelling and punctuation and reminded to use the spell checker if using a word processing package. If the work is to be hand written, writing on alternate lines leaves space for corrections and improves the appearance of the Report.

Data Analysis

Weak candidates need a familiar topic for this task so that they know how to collect the data and how to interpret the results. Whilst only strands I and E are assessed, the experience from the Pilot shows that students need to be involved in planning and carrying out the test so they can understand the scientific ideas before interpreting the data.

Worksheets with detailed writing frames can be used to guide candidates through each stage in their work, but the work for assessment must be their own.

It is important to check that individual support staff understand the internal assessment; and especially that they understand that it is the candidates' own work that is being assessed, so that doing work for them, may stop them from getting marks. It would be helpful to have clear instructions on how to support individuals who may have particular difficulties with practical tasks.

Choosing a topic

The work should involve a very simple practical task. The meaning of the results should be very clear to the candidates; for example, if you soak a piece of potato in a glucose solution, its mass changes. It is better to avoid tasks where candidates have to think about the meaning of the quantity they measure; for example, measuring pH; because if they do not understand the scientific idea, they cannot interpret the results.

Strand I: Interpreting Data

The candidate’s data should be part of the data set used for this it can be supplemented by the data from other members of the class.

Aspect (a) graphical or numerical processing of data

The candidates must display results in a table, chart or graph. A template for a graph, with the appropriate axes and scales, can be prepared by the teacher and duplicated for use by weaker candidates.

Aspect (b) summary of evidence

The candidate needs to compare the results from two different situations. Two individual results can be compared.

The differences in the results must be recorded.

Aspect (c) explanations suggested

Weak candidates struggle to explain their observations using scientific knowledge. They should be encouraged first to write an explanation based on previous experience. When that has been completed, they could describe simply the scientific idea underpinning the test.

In the case of the leaking can, this would be the fact that pressure increases with depth and that that more pressure causes a faster flow.

If they succeed in relating the conclusion to scientific ideas the score would be higher than a mark of 2.

Strand E: Evaluation

Aspect (a) evaluation of procedures

Most candidates find it hard to evaluate their procedures and very weak candidates may be unable to make a comment about the how the data was collected. They could be helped by being given incomplete sentences to finish, and rewarded with a single mark for doing this successfully.

Aspect (b) reliability of evidence

Candidates can be prompted into writing an opinion by being given a menu of options, for example, ‘I think my data is very reliable / reliable / not very reliable. They could then be asked to give a reason for their opinion. A sensible opinion, which does not refer appropriately to the data, would be worth 2 marks.

Aspect (c) reliability of conclusion

A question such as “Are you sure your conclusion is right?’ can be used to help candidates consider the reliability of their conclusion. This can be followed with other questions, for example, ‘What did you do, to make sure you got a good result?’

Pilot Centres have found the Evaluation to be the hardest part of the task and weak candidates have often scored 1 in this Strand.

Investigation

Choosing a topic

The work should involve a very simple practical task. The meaning of the results should be very clear to the candidates; for example, if you soak a piece of potato in a glucose solution, its mass changes. It is better to avoid tasks where candidates have to think about the meaning of the quantity they measure; for example, measuring pH; because if they do not understand the scientific idea, they cannot interpret the results.

Organising the work

Allow a series of at least six lessons to prepare for the Investigation. In this time several candidates are likely to have short absences, and the rate of progress will vary, so careful management is needed.

One example of a suitable investigation is to study a 'leaking container'. The rate of flow of water out of a hole in a container depends on the water level above the hole. This works well with a large (300 ml) polystyrene drinking cup with a small puncture hole in its base. It is filled with water and the water which leaks out in 30 seconds is collected when the cup is full, half full and almost empty. The time of 30 seconds does not demand quick reactions for the timing and collection, but is not too long for keeping attention on the task. Water with food dye added could be provided for easier measurements.

In the introductory lesson, the scientific ideas should be revised. In this case these would be ideas about pressure. It would be sensible to give the opportunity to practice using appropriate vocabulary such as 'pressure', 'depth', 'force' and 'gravity'. The idea of 'rate' is very difficult so it is better to talk about how much water leaks out in a set time. A demonstration such as the 'water fountain' could be used to link these ideas with the ideas of the investigation.

A low-level explanation of the observed effects can be based on prior experience, so the introductory lesson should always include demonstrations of the effect to be studied and reminders of any everyday applications which may be familiar to the students.

Strand S: Strategy

A task like this can be based on highly structured worksheets. If the candidate follows these instructions, they can gain credit at 2 marks if the work is of very limited precision or reliability.

Strand C: Collecting Data

Each candidate must record their own data. Make sure no-one relies on a friend to do this, and ensure that the data is collected for safe keeping. If candidates follow the given practical procedure and record their own results, they may earn 2 marks in Strand C.

It is advisable for the teacher to prepare some sets of data for use in Strands I and E as it is likely that the data collected by weak candidates may not be good enough to interpret.

Strand I: Interpreting Data

The candidate's own work should ideally be used for this, but it may be of very poor quality; the teacher's data should then be used as well as, or instead of, the candidate's results.

Aspect (a) graphical or numerical processing of data

The candidates must display results in a table, chart or graph. A template for a graph, with the appropriate axes and scales, can be prepared by the teacher and duplicated for use by weaker candidates.

Aspect (b) summary of evidence

The candidate needs to compare the results from two different situations. Two individual results can be compared.

The differences in the results must be recorded.

Aspect (c) explanations suggested

Weak candidates struggle to explain their observations using scientific knowledge. They should be encouraged first to write an explanation based on previous experience. When that has been completed, they could describe simply the scientific idea underpinning the test.

In the case of the leaking can, this would be the fact that pressure increases with depth and that that more pressure causes a faster flow.

If they succeed in relating the conclusion to scientific ideas the score would be higher than a mark of 2.

Strand E: Evaluation

Aspect (a) evaluation of procedures

Most candidates find it hard to evaluate their procedures and very weak candidates may be unable to make a comment about the how the data was collected. They could be helped by being given incomplete sentences to finish, and rewarded with a single mark for doing this successfully.

Aspect (b) reliability of evidence

Candidates can be prompted into writing an opinion by being given a menu of options, for example, 'I think my data is very reliable / reliable / not very reliable. They could then be asked to give a reason for their opinion. A sensible opinion, which does not refer appropriately to the data, would be worth 2 marks.

Aspect (c) reliability of conclusion

A question such as "Are you sure your conclusion is right?' can be used to help candidates consider the reliability of their conclusion. This can be followed with other questions, for example, 'What did you do, to make sure you got a good result?'

Pilot Centres have found the Evaluation to be the hardest part of the Investigation and weak candidates have often scored 1 in this Strand.

Strand P Presentation

Very weak candidates will need worksheets or writing frames to remind them to include all aspects of their task in their report. At the level of two marks, complete descriptions are not expected.

The assessment is on the communication skills used to present the work. Many candidates like to make their work look pleasing, and this can encourage them to work carefully. However, they are not assessed on the appearance of the report.

Aspect (a) description of work planned and carried out

The description of the work has been attempted, but is incomplete.

Aspect (b) recording of data

The data has been recorded, but labelling, units and observations may be incomplete.

Aspect (c) general quality of communication

Candidates should be encouraged to use the scientific words relevant to the test, and to check their work for spelling errors. However, at the level of 2 marks there is no penalty if they are unsuccessful.

Appendix N: Ideas about Science

In order to deal sensibly with science as we encounter it in everyday life, it is important not only to understand some of the fundamental scientific explanations of the behaviour of the natural world, but also to know something about science itself, how scientific knowledge has been obtained, how reliable it therefore is, what its limitations are, and how far we can therefore rely on it – and also about the interface between scientific knowledge and the wider society.

The kind of understanding of science that we would wish pupils to have by the end of their school science education might be summarised as follows:

The aim of science is to find explanations for the behaviour of the natural world. A good explanation may allow us to predict what will happen in other situations, and perhaps to control and influence events.

There is no single 'method of science' that leads automatically to scientific knowledge. Scientists do, however, have characteristic ways of working. In particular, data, from observations and measurements, are of central importance.

One kind of explanation is to identify a correlation between a factor and an outcome. This factor may then be the cause, or one of the causes, of the outcome. In complex situations, a factor may not always lead to the outcome, but increases the chance (or the risk) of it happening. Other explanations involve putting forward a theory to account for the data. Scientific theories often propose an underlying model, which may involve objects (and their behaviour) that cannot be observed directly.

Devising and testing a scientific explanation is not a simple or straightforward process. First, we can never be completely sure of the data. An observation may be incorrect. A measurement can never be completely relied upon, because of the limitations of the measuring equipment or the person using it.

Second, explanations do not automatically 'emerge' from the data. Thinking up an explanation is a creative step. So, it is quite possible for different people to arrive at different explanations for the same data. And personal characteristics, preferences and loyalties can influence the decisions involved.

The scientific community has established procedures for testing and checking the findings and conclusions of individual scientists, and arriving at an agreed view. Scientists report their findings to other scientists at conferences and in special journals. Claims are not accepted until they have survived the critical scrutiny of the scientific community. In some areas of enquiry, it has proved possible to eliminate all the explanations we can think of but one – which then becomes the accepted explanation (for the time being).

Where possible scientists choose to study simple situations in order to gain understanding. But it can then be difficult to apply this understanding to complex, real-world situations. So there can be legitimate disagreements about how to explain such situations, even where there is no dispute about the basic science involved.

The application of scientific knowledge, in new technologies, materials and devices, greatly enhances our lives, but can also have unintended and undesirable side-effects. An application of science may have social, economic and political implications, and perhaps also ethical ones. Personal and social decisions require an understanding of the science involved, but also involve knowledge and values beyond science.

This is, of course, a simplified account of the nature of science, which omits many of the ideas and subtleties that a contemporary philosopher or sociologist of science might think important. It is intended as an overview of science in terms which might be accessible to 14-16 year old candidates, to provide a basic understanding upon which those who wish may later build more sophisticated understandings. It is important to note that the language in which it is expressed may well not be that which one would use in talking to candidates of this age.

The following pages set out in more detail the key ideas that such an understanding of science might involve, and what candidates should be able to do to demonstrate their understanding.

Data and their limitations

Data are the starting point for scientific enquiry – and the means of testing scientific explanations. But data can never be trusted completely, and scientists need ways of evaluating how good their data are.

	Ideas about science	A candidate who understands this…
1.1	Data are crucial to science. Explanations are sought to account for known data, and data are collected to test proposed explanations.	uses data rather than opinion in justifying an explanation
1.2	We can never be sure that a measurement tells us the true value of the quantity being measured.	can suggest reasons why a measurement may be inaccurate
1.3	If we make several measurements of the same quantity, the results are likely to vary. This may be because we have to measure several individual examples (e.g. the height of cress seedlings after 1 week), or because the quantity we are measuring is varying (e.g. amount of ozone in city air, time for a vehicle to roll down a ramp), and/or because of the limitations of the measuring equipment or of our skill in using it (e.g. repeat measurements when timing an event).	can suggest reasons why several measurements of the same quantity may give different results when asked to evaluate data, makes reference to its reliability (i.e. is it repeatable?)
1.4	Usually the best estimate of the value of a quantity is the average (or mean) of several repeat measurements.	can calculate the mean of a set of repeated measurements from a set of repeated measurements of a quantity, uses the mean as the best estimate of the true value can explain why repeating measurements leads to a better estimate of the quantity
1.5	The spread of values in a set of repeated measurements give a rough estimate of the range within which the true value probably lies.	can make a sensible suggestion about the range within which the true value of a measured quantity probably lies **can justify the claim that there is/is not a 'real difference' between two measurements of the same quantity**
1.6	If a measurement lies well outside the range within which the others in a set of repeats lie, or is off a graph line on which the others lie, this is a sign that it may be incorrect.	can identify any outliers in a set of data, and give reasons for including or discarding them

Correlation and cause

Scientists look for patterns in data, as a means of identifying possible cause-effect links, and working towards explanations.

	Ideas about science	A candidate who understands this…
2.1	It is often useful to think about processes in terms of factors which may affect an outcome (or input variable(s) which may affect an outcome variable).	in a given context, can identify the outcome and the factors that may affect it in a given context, can suggest how an outcome might be affected when a factor is changed
2.2	To investigate the relationship between a factor and an outcome, it is important to control all the other factors which we think might affect the outcome (a so-called 'fair test').	can identify, in a plan for an investigation of the effect of a factor on an outcome, the fact that other factors are controlled as a positive feature, or the fact that they are not as a design flaw **can explain why it is necessary to control all factors thought likely to affect the outcome other than the one being investigated**
2.3	If an outcome occurs when a specific factor is present, but does not when it is absent, or if an outcome variable increases (or decreases) steadily as an input variable increases, we say that there is a correlation between the two.	can give an example from everyday life of a correlation between a factor and an outcome
2.4	A correlation between a factor and an outcome does not necessarily mean that one causes the other; both might, for example, be caused by some other factor.	uses the ideas of correlation and cause appropriately when discussing historical events or topical issues in science **can explain why a correlation between a factor and an outcome does not necessarily mean that one causes the other, and give an example to illustrate this**
2.5	In some situations, a factor increases the chance (or probability) of an outcome, but does not invariably lead to it, e.g. a diet containing high levels of saturated fat increases an individual's risk of heart disease, but may not lead to it. We also call this a correlation.	can suggest factors that might increase the chance of an outcome, but not invariably lead to it can explain that individual cases do not provide convincing evidence for or against a correlation
2.6	To investigate a claim that a factor increases the chance (or probability) of an outcome, we compare samples (e.g. groups of people) that are matched on as many other factors as possible, or are chosen randomly so that other factors are equally likely in both samples. The larger the samples the more confident we can be about any conclusions drawn.	can evaluate the design for a study to test whether or not a factor increases the chance of an outcome, by commenting on sample size and how well the samples are matched **can use data to develop an argument that a factor does/does not increase the chance of an outcome**
2.7	Even when there is evidence that a factor is correlated with an outcome, scientists are unlikely to accept that it is a cause of the outcome, unless they can think of a plausible mechanism linking the two.	**can identify the presence (or absence) of a plausible mechanism as significant for the acceptance (or rejection) of a claimed causal link**

Developing explanations

Scientific explanations are of different types. Some are based on a proposed cause-effect link. Others show how a given event is in line with a general law, or with a general theory. Some theories involve a model, which may include objects or quantities that cannot be directly observed, which accounts for the things we can observe.

	Ideas about science	A candidate who understands this…
3.1	A scientific explanation is a conjecture (a hypothesis) about how data might be accounted for. It is not simply a summary of the data, but is distinct from it.	can identify statements which are data and statements which are (all or part of) an explanation can recognise data or observations that are accounted for by, or conflict with, an explanation
3.2	An explanation cannot simply be deduced from data, but has to be thought up imaginatively to account for the data.	can identify imagination and creativity in the development of an explanation
3.3	A scientific explanation should account for most (ideally all) of the data already known. It may explain a wide range of observations. It should also enable predictions to be made about new situations or examples.	can justify accepting or rejecting a proposed explanation on the grounds that it: • accounts for observations • **and/or provides an explanation that links things previously thought to be unrelated** • **and/or leads to predictions that are subsequently confirmed**
3.4	Scientific explanations are tested by comparing predictions made from them with data from observations or experiments.	can draw valid conclusions about the implications of given data for a given explanation, in particular: • recognises that an observation that agrees with a prediction (derived from an explanation) increases confidence in the explanation **but does not prove it is correct** • recognises that an observation that disagrees with a prediction (derived from an explanation) indicates that either the observation or the prediction is wrong, **and that this may decrease our confidence in the explanation**
3.5	For some questions that scientists are interested in, there is not yet an answer.	can identify a scientific question for which there is not yet an answer, **and suggest a reason why**

The scientific community

Findings reported by an individual scientist or group are carefully checked by the scientific community before being accepted as scientific knowledge.

	Ideas about science	A candidate who understands this…
4.1	Scientists report their findings to other scientists through conferences and journals. Scientific findings are only accepted once they have been evaluated critically by other scientists.	can describe in broad outline the 'peer review' process, in which new scientific claims are evaluated by other scientists can recognise that new scientific claims which have not yet been evaluated by the scientific community are less reliable than well-established ones
4.2	Scientists are usually sceptical about findings that cannot be repeated by anyone else, and about unexpected findings until they have been replicated.	can identify absence of replication as a reason for questioning a scientific claim **can explain why scientists regard it as important that a scientific claim can be replicated by other scientists**
4.3	Explanations cannot simply be deduced from the available data, so two (or more) scientists may legitimately draw different conclusions about the same data. A scientist's personal background, experience or interests may influence his/her judgments. (e.g. data open to several interpretations; influence of personal background and experience; interests of employers or sponsors).	can suggest plausible reasons why scientists involved in a scientific event or issue disagree(d)
4.4	A scientific explanation is rarely abandoned just because some data are not in line with it. An explanation usually survives until a better one is proposed. (e.g. anomalous data may be incorrect; new explanation may soon run into problems; safer to stick with ideas that have served well in the past).	**can suggest reasons for scientists' reluctance to give up an accepted explanation when new data appear to conflict with it**

Risk

Every activity involves some risk. Assessing and comparing the risks of an activity, and relating these to the benefits we gain from it, are important in decision making.

	Ideas about science	A candidate who understands this…
5.1	Everything we do carries a certain risk of accident or harm. Nothing is risk free. New technologies and processes based on scientific advances often introduce new risks.	can explain why it is impossible for anything to be completely safe can identify examples of risks which arise from a new scientific or technological advances can suggest ways of reducing specific risks
5.2	We can sometimes assess the size of a risk by measuring its chance of occurring in a large sample, over a given period of time.	can interpret and discuss information on the size of risks, presented in different ways.
5.3	To make a decision about a particular risk, we need to take account both of the chance of it happening and the consequences if it did.	**can discuss a given risk, taking account of both the chance of it occurring and the consequences if it did**
5.4	People are often willing to accept the risk associated with an activity if they enjoy or benefit from it. We are also more willing to accept the risk associated with things we choose to do than things that are imposed, or that have short-lived effects rather than long-lasting ones.	can suggest benefits of activities that have a known risk can offer reasons for people's willingness (or reluctance) to accept the risk of a given activity can discuss personal and social choices in terms of a balance of risk and benefit
5.5	If you are not sure about the possible results of doing something, and if serious and irreversible harm could result from it, then it makes sense to avoid it (the 'precautionary principle').	**can identify, or propose, an argument based on the 'precautionary principle'**
5.6	Our perception of the size of a risk is often very different from the actual measured risk. We tend to over-estimate the risk of unfamiliar things (like flying as compared with cycling), and things whose effect is invisible (like ionizing radiation).	**can distinguish between actual and perceived risk, when discussing personal and social choices** **can suggest reasons for given examples of differences between actual and perceived risk**
5.7	Reducing the risk of a given hazard costs more and more, the lower we want to make the risk. As risk cannot be reduced to zero, individuals and/or governments have to decide what level of risk is acceptable.	**can explain what the ALARA (as low as reasonably achievable) principle means and how it applies in a given context**

Making decisions about science and technology

To make sound decisions about the applications of scientific knowledge, we have to weigh up the benefits and costs of new processes and devices. Sometimes these decisions also raise ethical issues. Society has developed ways of managing these issues, though new developments can pose new challenges to these.

	Ideas about science	A candidate who understands this…
6.1	Science-based technology provides people with many things that they value, and which enhance the quality of life. Some applications of science can, however, have unintended and undesirable impacts on the quality of life or the environment. Benefits need to be weighed against costs.	In a particular context, can identify the groups affected and the main benefits and costs of a course of action for each group
6.2	Scientists may identify unintended impacts of human activity (including population growth) on the environment. They can sometimes help us to devise ways of mitigating this impact and of using natural resources in a more sustainable way.	can explain the idea of sustainable development, and apply it to specific situations
6.3	In many areas of scientific work, the development and application of scientific knowledge are subject to official regulations and laws (e.g. on the use of animals in research, levels of emissions into the environment, research on human fertility and embryology).	shows awareness that scientific research and applications are subject to official regulations and law
6.4	Some questions, such as those involving values, cannot be addressed by scientists.	can distinguish questions which could be addressed using a scientific approach, from questions which could not
6.5	Some applications of science have ethical implications. As a result, people may disagree about what should be done (or permitted).	where an ethical issue is involved, can: • say clearly what this issue is • summarise different views that may be held
6.6	In discussions of ethical issues, one common argument is that the right decision is one which leads to the best outcome for the majority of people involved. Another is that certain actions are unnatural or wrong, and should not be done in any circumstances. A third is that is that it is unfair for a person to choose to benefit from something made possible only because others take a risk, whilst avoiding that risk themselves.	in a particular context, can identify, and develop, arguments based on the ideas that: • the right decision is the one which leads to the best outcome for the majority of people involved • certain actions are never justified because they are unnatural or wrong
6.7	In assessing any proposed application of science, we must first decide if it is technically feasible. Different decisions on the same issue may be made in different social and economic contexts.	**in a particular context, can distinguish what can be done (technical feasibility), from what should be done (values)** **can explain why different courses of action may be taken in different social and economic contexts**

Appendix O: Advice to Centres on Preparation of Sample for Moderation

Specification J634: Assessment units A329 and A330

This is to remind you of the stages in preparation of a sample of coursework for moderation. If you have any further queries about coursework, or any aspect of the assessment, please contact the science team, tel. 01223 553311.

The notes which follow summarise the materials and evidence required for moderation of the coursework assessment, and explain how to use the documentation which is also enclosed.

Each candidate is required to complete **either** a Data interpretation and evaluation exercise and a Case-study **or** a Practical Investigation

Unit A329: Data analysis + case-study

Each candidate is required to complete a data interpretation and evaluation exercise and a Case-study. The evidence for these will consist of a report of the interpretation and evaluation, and the completed case study report. In each case, candidates may complete more than one, but the final mark is the mark for the best single piece of work. It is **not** permitted to aggregate part marks from different pieces of work.

The centre will be provided with self-carboning mark sheets (MS1). Enter the overall total mark (one data analysis + one case-study). The top copy of the completed MS1 form is sent to OCR, the second copy to the moderator, to arrive not later than 15th May, and the third copy is retained by the centre.

The moderator will ask for the work of a sample of candidates. The work of these candidates should be sent as quickly as possible to the moderator. The list will identify the names and candidate numbers for each candidate whose work is required by the moderator. This list may be kept to provide a record for you of what work has been sent.

The sample sent to the moderator should contain:

- Brief notes about the activities used for assessment.
- A description of procedures used within the centre to ensure internal standardisation of marking
- The sample of work (one case study and one data exercise) for each candidate in the sample.
- A completed cover-sheet for each candidate in the sample.

Recording of marks for assessed work

The cover sheet may be photocopied to make sufficient copies to provide for each candidate in the sample. The sheet should be used by the teacher to record marking decisions when marking the work. The pages in each piece of work should be stapled together. A paper-clip provides a convenient way of linking the piece of work and the completed mark sheet.

It is essential that a completed sheet is sent for each sample of work which is called for moderation. Enter the centre name and number and the candidate name and number at the top of the sheet.

The sheet also includes spaces which should be left blank. These will be used as a working document by the moderator when checking the work. The sheets will be retained by OCR as a complete record of all judgments related to the moderation.

The centre should also keep its own record of the work done and marks awarded.

'Double counting' of marks for the data exercise

For candidates who are also taking Additional Science A (J631) it is permissible to use an investigation from Additional Science to provide the marks for data interpretation and evaluation. If the same piece of work is called for from both specifications, tick the space on the cover-sheet to indicate this. Copies of the work should be included in both Single and Additional Science samples of work.

Special consideration candidates

If a special consideration application regarding internally assessed marks has been made for any candidate, the work of the candidate(s) concerned should be added to the sample, with a note to explain that they are for special consideration.

The sample of work will be returned to the centre, normally early in July. A report on the moderation will be sent with the notification of results.

I hope that these guidelines are clear and will help the process of moderation to run smoothly. Please do not hesitate to get in contact if you have any queries.

Unit A330: Practical Investigation

Each candidate is required to complete a practical investigation. The evidence for this will consist of a written report. Candidates may complete more than one Investigation, but the final mark is the mark for the best single piece of work. It is **not** permitted to aggregate part marks from different pieces of work.

The centre will be provided with self-carboning mark sheets (MS1). The top copy of the completed MS1 form is sent to OCR, the second copy to the moderator, to arrive not later than 15th May, and the third copy is retained by the centre.

The moderator will ask for the work of a sample of candidates. The work of these candidates should be sent as quickly as possible to the moderator. The list will identify the names and candidate numbers for each candidate whose work is required by the moderator. This list may be kept to provide a record for you of what work has been sent.

The sample sent to the moderator should contain:

- Brief notes about the activities used for assessment.
- A description of procedures used within the centre to ensure internal standardisation of marking
- The sample of work (one case study and one data exercise) for each candidate in the sample.
- A completed cover-sheet for each candidate in the sample.

Recording of marks for assessed work

The cover sheet may be photocopied to make sufficient copies to provide for each candidate in the sample. The sheet should be used by the teacher to record marking decisions when marking the work. The pages in each piece of work should be stapled together. A paper-clip provides a convenient way of linking the piece of work and the completed mark sheet.

It is essential that a completed sheet is sent for each sample of work which is called for moderation. Enter the centre name and number and the candidate name and number at the top of the sheet.

The sheet also includes spaces which should be left blank. These will be used as a working document by the moderator when checking the work. The sheets will be retained by OCR as a complete record of all judgments related to the moderation.

The centre should also keep its own record of the work done and marks awarded.

‘Double counting’ of marks for the data exercise

For candidates who are also taking Science A (J630) it is permissible to use the investigation to provide the marks for data interpretation and evaluation. If the same piece of work is called for from both specifications, tick the space on the cover-sheet to indicate this. Copies of the work should be included in both Single and Additional Science samples of work.

Special consideration candidates

If a special consideration application regarding coursework marks has been made for any candidate, the work of the candidate(s) concerned should be added to the sample, with a note to explain that they are for special consideration.

The sample of work will be returned to the centre, normally early in July. A report on the moderation will be sent with the notification of results.

I hope that these guidelines are clear and will help the process of moderation to run smoothly. Please do not hesitate to get in contact if you have any queries.

Appendix P: Candidate Authentication Statement

OCR
RECOGNISING ACHIEVEMENT

Candidate Authentication Statement

The completed form should be retained within the Centre and should not be sent to the moderator or OCR unless specifically requested.

NOTICE TO CANDIDATE

The work you submit for assessment must be your own.

If you copy from someone else or allow another candidate to copy from you, or if you cheat in any other way, you may be disqualified from at least the subject concerned.

1. Any help or information you have received from people other than your subject teacher(s) must be clearly identified in the work itself.
2. Any books, information leaflets or other material (e.g. videos, software packages or Information from the Internet) which you have used to help you complete this work must be clearly acknowledged in the work itself. To present material copied from books or other sources without acknowledgement will be regarded as deliberate deception.

Declaration by candidate

Centre name		Centre No	
Session		Year	

Specification of Unit title

Candidate Name		Candidate Number	

I have read and understood the **Notice to Candidate** (above). I have produced the work without any help from other people apart from that which I have declared in the work itself.
I have acknowledged all source materials in the work itself.

Candidate's signature:

Date:

Notes:

The Candidate Authentication statement once completed should be stored securely within the centre. A copy of this authentication form must be available upon request for each coursework/portfolio submission.

Standard Candidate Authentication Statement

Appendix Q: Centre Authentication Form

OCR
RECOGNISING ACHIEVEMENT

Centre Authentication Form

OCR Advanced GCE GCSE Entry Level

One copy of this form must be completed for **each** unit or coursework component and signed by the appropriate person(s). The completed form **must** accompany the coursework or portfolios submission to the moderator/examiner or be inspected by the visiting moderator for Entry Level, GCSE, GNVQ, VCE and GCE qualifications.

It is now a requirement of the Code of Practice that this authentication form is signed.

*'**Authentication of candidates' work** – The internal assessor must present a written declaration that the candidates' work was conducted under the required conditions as laid down by the specification.'*

Centre Name ______________________ **Centre No** | | | | | |

Specification or Unit title ______________________

Qualification or Unit number/component code | | | | | | |

Session ______________________ **Year** | 2 | 0 | 0 | |

Moderated unit
(Please tick box if yes) ☐

In this case this form must accompany the sample posted to the moderator or inspected by the visiting moderator

or

Examined unit
(Please tick box if yes) ☐

In this case this form must accompany the packet of coursework which is posted to the examiner or assessed by the visiting examiner.

Signature(s) of internal assessor(s) – i.e. person(s) responsible for carrying out internal assessment and/or supervision (in the case of examined coursework) of work:

I/We the undersigned confirm that the candidates' work was conducted under the required conditions as laid down by the specification.

Signature:.. Print name:..

Signature:.. Print name:..

Signature:.. Print name:..

Please continue on a separate sheet if required.

In order to support internal assessors in authenticating their students' work an **example** of a standard Candidate Authentication Statement is provided on the OCR Website (www.ocr.org.uk). Alternatively centres may wish to continue to use their own internal arrangements for candidate authentication, but these must provide equivalence to the standard Candidate Authentication Statement.

Notes

In the case of private candidates or distant tutored candidates, the centre must ensure that:

- *the tutor/teacher has acquainted themselves thoroughly with the general standard of candidates' work before accepting coursework for Internal Assessment. Work submitted by candidates that is atypical or inconsistent with their general standard may raise concerns over authenticity.*
- *sufficient on-going regular monitoring of the candidates' examination coursework has taken place.*
- *Centres are reminded that they must comply with restrictions that may apply to entries e.g. the exclusion of Private candidates from a specification.*

CCS160 Revised July 2005 **Centre Authentication Form**

Oxford Cambridge and RSA Examinations

Appendix R: Health and Safety Information

In UK law, health and safety is the responsibility of the employer. For most centres entering candidates for GCSE examinations this is likely to be the Local Education Authority or the Governing Body. Teachers have a duty to co-operate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 1996 and the Management of Health and Safety at Work Regulations 1992, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment.

A useful summary of the requirements for risk assessment in school or college science can be found in Chapter 4 of Safety in Science Education. For members, the CLEAPSS guide, Managing Risk Assessment in Science offers detailed advice.

Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

- Safety in Science Education, DfEE, 1996, HMSO, ISBN 0 11 270915 X
- Topics in Safety 3rd edition, 2001, ASE ISBN 0 86357 316 9
- Safeguards in the School Laboratory, 10th edition, 1996, ASE ISBN 0 86357 250 2
- Hazcards, 1995 with 2004 updates, CLEAPSS School Science Service*
- CLEAPSS Laboratory Handbook, 1997 with 2004 update, CLEAPSS School Science Service*
- CLEAPSS Shorter Handbook (CLEAPSS 2000) CLEAPSS School Science Service*
- Hazardous Chemicals, A manual for Science Education, (SSERC, 1997) ISBN 0 9531776 0 2

*Note that CLEAPSS publications are only available to members or associates.

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual Centre then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment. Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely.

The significant findings of such risk assessment should then be recorded, for example on schemes of work, published teachers guides, work sheets, etc.

There is no specific legal requirement that detailed risk assessment forms should be completed, although a few employers require this.

When candidates are planning their own investigative work the teacher has a duty to check the plans before the practical work starts and to monitor the activity as it proceeds.