OCR ADVANCED SUBSIDIARY GCE
IN CHEMISTRY (SALTERS) (3887)

OCR ADVANCED GCE
IN CHEMISTRY (SALTERS) (7887)

Teacher Support: Coursework Guidance

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This Teacher Support: Coursework Guidance booklet is intended to accompany the OCR Advanced Subsidiary GCE and Advanced GCE in Chemistry (Salters) specifications for teaching from September 2004.

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1 General introduction

This coursework guide has been written to assist teachers in setting suitable coursework tasks and in assessing candidates' work. The guide should be read in conjunction with the specification itself. However, all relevant sections of the specification relating to coursework assessment are included here.

While this guide is concerned with the assessment of coursework, it cannot be emphasised too strongly that before candidates are assessed on their experimental and investigative skills, these skills must be taught and candidates must have opportunities to practise and to develop their abilities.

Experimental and Investigative skills are assessed internally by coursework. The skills may be assessed at any time during the course using suitable practical activities, based on laboratory work.

In Advanced Subsidiary the skills should be assessed in the context of separate practical exercises, although more than one skill may be assessed in any one exercise. In A2 they should be assessed in the context of a single individual investigation in which each candidate pursues his or her own assignment.

The skills are assessed in Unit 2852, Component 02 in AS and in Unit 2855 in A2.

In AS Unit 2852, Component 02, marks contribute towards Assessment Objective AO3: Experiment and Investigation.

In A2 Unit 2855, marks contribute to Assessment Objective AO3 and to Assessment Objective AO4: Synthesis of Knowledge, Understanding and Skills. There is assessment of AO4 because:

- candidates are required to use chemical knowledge and understanding from different modules of the specification in planning their experimental and investigative work, and in analysing evidence and drawing conclusions;
- in the assessment of all four experimental skills in Unit 2855, candidates are expected to draw on their experience of such work throughout the course and, in particular, on the outcome of the assessment of these skills in Unit 2852, Component 02.

Practical work provides many opportunities to develop key skills and to collect evidence that may contribute towards the assessment of key skills. Full details are given in Appendix A of the specification and links are identified throughout the content of the specification booklet. Teachers are advised to discuss such opportunities with colleagues and with the students concerned.

2 Coursework Assessment

Unit 2852, Component 02 – Experimental Skills **(45 Marks)**
Unit 2855 – Individual Investigation **(90 Marks)**

Assessment of candidates' experimental and investigative work is made by the teacher (as coursework) and moderated externally by OCR.

Skills **P**, **A** and **E** are each marked out of 11 and Skill **I** is marked out of 12. One mark per skill must be submitted for each candidate for Advanced Subsidiary (Unit 2852, Component 02) and for A2 (Unit 2855). Hence, a mark out of 45 is initially calculated. In A2 the mark is doubled so that the final mark submitted for Unit 2855 is out of 90.

When a skill has been assessed on more than one occasion, in Advanced Subsidiary, the better or best mark for that skill should be submitted. However, Centres are recommended **not** to assess the skills on more than two occasions since this may take up time which might better be devoted to other aspects of the specification.

A different set of mark descriptors are used for Advanced Subsidiary and A2. These descriptors have been written to provide clear continuity from the assessment of Sc1 in GCSE Science. The difference in standard of Advanced Subsidiary and A2 is a product of the level of demand of the related scientific knowledge and understanding expected and the complexity and level of demand of the tasks undertaken. Also, the mark descriptors for Skills **P** and **A** in A2 include synoptic elements.

Marks submitted for coursework assessment must have been generated from candidates' individual work. Group work is not suitable for assessment unless the work of the individual candidate can be quite clearly identified both by the teacher and the moderator. In some cases, in Advanced Subsidiary, it may be necessary for candidates to work collectively in order to collect sufficient data for analysis. In these circumstances, planning and implementing should not be assessed but the work of candidates may be assessed in analysing and evaluating their results, when they are working independently.

The submission of proposed coursework tasks for approval by OCR is not a requirement of the scheme. However, Centres wishing to obtain guidance on whether a coursework task is suitable, should send details to OCR. A contact address is given in Section 12. Guidance may also be obtained on the marks awarded to candidates' work prior to moderation by sending details of the task set, any background information and marked examples of candidates' work to the same address. Teachers are asked not to send large quantities of material.

A programme of INSET meetings is arranged to provide detailed guidance on coursework assessment. Details are circulated to Centres and a contact number for OCR Training and Customer Support is given in Section 12.

The length of time to be devoted to the assessment of AS experimental skills is entirely at the discretion of the teacher. In A2, it is expected that candidates will spend between 15 and 20 hours of laboratory time on their individual investigations. A similar amount of time will be required outside the laboratory to write up the investigation report.

2.1 Standards at AS and A2

A different set of assessment descriptors are used for the assessment of coursework in AS and A2.

Assessments at AS and A2 are differentiated by the complexity of the tasks set and the contexts of the underlying scientific knowledge and understanding. In A2, candidates are required to apply knowledge, understanding and skills from the AS and A2 parts of the specification in planning experimental work and in the analysis of results to reach conclusions.

At AS, experimental and investigative work is likely to require processing in a context that is familiar to candidates.

- **Planning** exercises focus on apparatus and techniques which have previously been encountered and are based on knowledge and understanding from a limited part of the AS specification.
- **Implementing** involves the manipulation of simple apparatus and the application of easily recognised safety procedures.
- **Analysing and concluding** involve simple data handling, reaching conclusions based on a limited part of the AS specification.
- **Evaluation** expects recognition of the main limitations of experimental procedures and the calculation of uncertainties associated with measurements.

At A2, assessments expect a greater level of sophistication and higher levels of skill.

- **Planning** requires research to identify the underlying chemical background and to develop the necessary practical methods to undertake the individual investigation. The underlying knowledge, understanding and skills are likely to be drawn from several different parts of the AS and A2 specifications.
- **Implementing** involves a detailed risk assessment and the careful use of techniques and apparatus to obtain results that are of appropriate quantity and quality, are precise and reliable, and will help achieve the aims of the investigation.
- **Analysing and concluding** involve detailed processing of data and the synthesis of several strands of evidence. In developing conclusions, candidates will have the opportunity to demonstrate their skills in drawing together principles and concepts from different parts of the AS and A2 specifications.
- **Evaluation** requires recognition of the key experimental limitations and the calculation of uncertainties associated with all types of measurements used during the investigation. Candidates will be expected to evaluate the significance of these limitations and uncertainties and hence suggest how the investigation might be modified to increase the accuracy and reliability of data collected.

2.2 Assessment and Moderation

All coursework is marked by the teacher and internally standardised by the Centre. Marks are then submitted to OCR by a specified date, after which postal moderation takes place in accordance with OCR procedures. The purpose of moderation is to ensure that the standard for the award of marks in coursework is the same for each Centre, and that each teacher has applied the standards appropriately across the range of candidates within the Centre.

Coursework submissions should be clearly annotated by the Centre to support the marks awarded to the candidates.

The sample of work that is submitted to the Moderator for moderation must show how the marks have been awarded in relation to the marking criteria.

2.3 Minimum Coursework Requirements

If no work is submitted by a candidates for a coursework component or unit, the candidate should be indicated as being absent from that component or unit on the coursework mark sheets submitted to OCR. Any work submitted by a candidate should be assessed according to the mark descriptors and marking instructions and the appropriate mark awarded, which may be 0 (zero).

2.4 Authentication of Coursework

As with all coursework, the teacher must be able to verify that the work submitted for assessment is the candidate's own. Sufficient work must be carried out under direct supervision to allow the teacher to authenticate the coursework marks with confidence.

2.5 Special Arrangements for Coursework

For candidates who submit some coursework but are unable to complete the full assessment, or whose performance may be adversely affected through no fault of their own, teachers should consult the *Inter-Board Regulations and Guidance Booklet for Special Arrangements and Special Consideration*. In such cases, advice should be sought from OCR as early as possible during the course.

2.6 Differentiation

In coursework, differentiation is by task and/or by outcome. Candidates will undertake assignments which enable them to display positive achievement.

3 Introduction to each skill

The experimental and investigative skills to be assessed are:

Skill P - Planning

Candidates should:

- appreciate and/or identify and define the nature of a question or problem using available information and knowledge of chemistry;
- choose effective and safe procedures, selecting appropriate apparatus and materials and deciding the measurements and observations likely to generate useful and reliable results.
- Communicate chemical information and ideas clearly in appropriate ways using accurate technical vocabulary, spelling, punctuation and grammar

In AS, for each task, it is suggested that candidates are asked to complete a plan which is assessed by the teacher. Planning must be carried out individually. However, Skill **P** may be assessed with Skill **I** and/or Skills **A** and **E**.

At A2, there are additional statements that relate to synoptic assessment to take into account in the assessment. Thus, to achieve the highest marks, the tasks set must offer opportunities for candidates to make use, in their planning, of scientific knowledge and understanding from both AS and A2 modules.

Skill I- Implementing

Candidates should:

- use apparatus and materials in an appropriate and safe way;
- carry out work in a methodical and organised way with due regard for safety;
- make and record detailed observations in a suitable way, and make measurements to an appropriate degree of precision, using IT where appropriate.

In AS, for candidates to achieve the highest marks for this skill, the techniques used should be familiar and well understood. The tasks set should involve techniques that require precision and skill and that make sufficient demands on a candidate's ability to manipulate apparatus.

Skill **I** may be assessed in isolation, or in combination with Skills **P** and/or **A** and **E**.

At A2, candidates may use several different techniques or a single technique in greater depth. Data collected should be of an appropriate quality and quantity and should be recorded clearly, precisely with appropriate units.

Skill A - Analysing Evidence and Drawing Conclusions

Candidates should:

- process collected data using clearly explained calculations and/or suitable graphs as appropriate to the task undertaken.
- recognise and comment on trends and patterns in data.
- draw valid conclusions by applying chemical knowledge and understanding.
- Communicate chemical information and ideas clearly in appropriate ways using accurate technical vocabulary, spelling, punctuation and grammar

In AS, for candidates to achieve the highest marks in this skill, the tasks set must provide sufficient data or information to make the analysis demanding,

Skill **A** may be assessed in isolation, or in combination with Skills **P**, and/or **I** and **E**.

At A2, there are additional statements that relate to synoptic assessment to take into account in the assessment. Thus, to achieve the highest marks, the tasks undertaken must offer opportunities for candidates to make use, in their analysis, of scientific knowledge and understanding from in both AS and A2 modules.

Skill E - Evaluating Evidence and Procedures.

Candidates should:

- assess the uncertainties associated with experimental evaluate the procedures used in the experimental activity, recognising their limitations.
- Evaluate the relative significance of the limitations in experimental procedures and the uncertainties associated with measurements

In AS, for candidates to achieve the highest marks in this skill it is advisable that they either carry out the experimental activity themselves or have seen the techniques demonstrated. Only in this way will they be able to evaluate experimental procedures effectively. The tasks set should be sufficiently complex to allow detailed evaluation of the experimental procedure and the data collected should permit calculation of the uncertainty associated with the data. Skill **E** is best assessed together with Skill **A**, in which case the experimental procedure should have been carried out by the candidates themselves, or demonstrated to them. Where the experimental procedures are such that individual working is not possible, candidates could carry out the task working in groups but then be assessed for Skills **A** and **E** on their individual work.

At A2, candidates are also expected to suggest, taking account of the relative significance of the limitations of experimental procedures and the uncertainties associated with measurements, how they might modify their approach to the investigation in order to improve the accuracy and reliability of data.

4 Notes for Guidance on Coursework Submission and Assessment

These notes are intended to provide guidance for teachers in assessing experimental and investigative skills, but should not exert an undue influence on the methods of teaching or provide a constraint on the practical work undertaken by candidates. It is not expected that all of the practical work undertaken by candidates would be appropriate for assessment.

It is expected that candidates will have had opportunities to acquire experience and develop the relevant skills before assessment takes place.

4.1 The Demand of an Activity

The demand of an activity is an important feature of the assessment. From the bottom to the top of the mark range in a skill area the activity should involve increasing demands of associated scientific knowledge and understanding, manipulation, precision and accuracy and complexity.

The difference in standard of Advanced Subsidiary and A2 is a product of the time spent on practical work, level of demand of the related scientific knowledge and understanding, together with the complexity and level of demand of the tasks undertaken. In A2, candidates are required to apply knowledge, understanding and skills from the AS and A2 parts of the specification in planning experimental work and in the evaluation of data (synoptic assessment).

Teachers should appreciate that the choice of an activity that is comparatively undemanding (primarily in terms of the level of the scientific knowledge and understanding that can be linked to the activity, and in the planned scope of the activity) may prevent access to the highest marks. This may be relevant where a Centre chooses an activity for use in the assessment of AS Experimental Skills that is less demanding than the exemplar activities included within this booklet. It may also be relevant to particular candidates undertaking an A2 individual investigation.

Teachers should be aware of this feature of the assessment so that, when considering the award of higher marks, the activity should require a more sophisticated approach and/or complex treatment. Higher marks must not be awarded for work that is simplistic or trivial.

One of the factors that may determine the demand of an activity at AS is the level of guidance given to candidates. The use of a highly structured results table, or calculation worksheet, for example, will reduce the number of decisions and judgements required by the candidate and will limit the range of marks available.

4.2 Marking Candidates' Work

A different set of mark descriptors is used for Advanced Subsidiary and A2. The descriptors should be used to make a judgement as to which mark best fits a candidate's performance.

The descriptors have been written to provide clear continuity from the assessment of Sc1 for GCSE. This should ensure an effective continuation of the development of candidates' skills from GCSE to Advanced Subsidiary and A Level.

The mark descriptors within a skill area have been written to be hierarchical. Thus, in marking a piece of work, the descriptors for the lowest defined mark level should be considered first and only if there is a good match should the descriptors for the next level up be considered. Therefore, if a teacher is considering awarding a high mark for a piece of work, the work must have demonstrated a good match to all the lower mark descriptors.

For each skill, the scheme allows the award of intermediate marks (between the defined mark levels). An intermediate mark may be awarded when the work of a candidate exceeds the requirements of a defined mark level but does not meet the requirements of the next higher defined mark level sufficiently to justify its award. Thus, an intermediate mark could be awarded if the work meets only one of the two descriptors at the higher defined mark level, or provides a partial match to both descriptors, or provides a complete match to one and a partial match to the other.

A mark of zero should be awarded where there has been an attempt to address the skill but the work does not meet the requirements of the lowest defined mark level.

The marks awarded should be based on both the final written work and on the teacher's knowledge of the work carried out by the candidate. In assigning a mark, attention should be paid to the extent of any guidance needed by, or given to, the candidate.

4.3 Synoptic Assessment

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the Advanced GCE course. Assessment Objective AO4 relates specifically to synoptic assessment and marks from the A2 Individual Investigation (coursework) Unit 2855, contribute to the assessment of AO4.

During experimental and investigative work, synoptic assessment:

- allows candidates to apply knowledge and understanding of principles and concepts from different parts of the specification in planning experimental work and in the analysis and evaluation of data;
- allows candidates to apply skills and techniques learned during the course.

All practical work assessed internally by Centres for the A2 Unit 2855 should draw on the range of experience that the candidate has acquired during the AS and A2 courses. It is particularly important that planning skills should involve an element of research which goes beyond the repetition of an experiment that simply reflects the use of ideas or techniques met within the module currently being studied. Likewise, an assessment involving analysing evidence and drawing conclusions must require a candidate to use knowledge and understanding acquired outside the confines of a standard experiment recently practised. During the process of moderation, evidence will be sought that such breadth has been achieved.

The assessment descriptors for the skills of Planning (**P**) and Analysing Evidence and Drawing Conclusions (**A**), include statements that relate specifically to synoptic assessment. Thus, in A2, a candidate will not be able to achieve more than 4 marks in each of Skills **P** and **A** without demonstrating aspects of synoptic assessment. Candidates will also bring to the assessment of Skill **I** (Implementing) their experience of practical and investigative work from throughout the course. In Skill **E** (Evaluating Evidence and Procedures), aspects of Skills **P** and **A** are evaluated. Overall, in A2, approximately 15 of the 45 available marks can thus be identified as contributing to an assessment of AO4 (synoptic assessment).

4.4 Quality of Written Communication

Coursework must include an assessment of candidates' quality of written communication. At Level 3, candidates are required to:

- select and use a form and style of writing that is appropriate to the purpose and complex subject matter;
- organise relevant information clearly and coherently, using specialist vocabulary when appropriate;
- ensure the text is legible and that spelling, grammar and punctuation are accurate, so that the meaning is clear.

The mark descriptors for Skills **P** and **A** have been written to include these aspects.

4.5 Annotation of Candidates' Work

Each piece of assessed coursework must be annotated to show how the marks have been awarded in relation to the relevant skills.

The writing of comments on candidates' work can provide a means of dialogue and feedback between teacher and candidate, and a means of communication between teachers during internal standardisation of coursework. The main purpose of annotating candidates' coursework should be, however, to provide a means of communication between the teacher and the Moderator, showing where marks have been awarded and why. The sample of work which is submitted for moderation **must** show how the marks have been awarded in relation to the marking criteria.

Annotations should be made at appropriate points in the margins of the text. The annotations should indicate both where achievement for a particular skill has been recognised, and where the mark has been awarded. It is suggested that a brief paragraph is included at the end of the relevant section, or on the cover sheet of the candidates' work, which explains where specific descriptors have not been met and therefore why a particular mark has been awarded for each skill area.

For Skill I, Implementing, the Moderator will require evidence concerning candidates' use of practical techniques and safe working practice. This evidence could take the form of checklists or written notes.

4.6 Health and Safety

In UK law, health and safety is the responsibility of the employer. For most establishments entering candidates for GCE AS and A level this is likely to be the local education authority or the governing body. Employees, i.e. teachers and lecturers, 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* (see below). 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;

Safeguards in the School Laboratory, 10th edition, 1996, ASE ISBN 0 86357 250 2;

Hazcards, 1995, CLEAPSS School Science Service*;

Laboratory Handbook, 1988-97, CLEAPSS School Science Service*;

Topics in Safety, 2nd edition, 1988, ASE ISBN 0 86357 104 2;

Safety Reprints, 1996 edition, ASE ISBN 0 86357 246 4.

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

(Other publications have sometimes been suggested, e.g. the SSERC *Hazardous Chemicals Manual* or the DES *Microbiology, an HMI Guide for Schools and FE,* but both of these are now out of print).

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual school or college 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 that 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.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications these may well lead to the use of novel procedures, chemicals or micro-organisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting the CLEAPSS School Science Service (or, in Scotland, SSERC).

When candidates are planning their own practical activities, whether in project work or for more routine situations, the teacher or lecturer has a duty to check the plans before practical work starts and to monitor the activity as it proceeds.

5 Assessment of Experimental Skills (AS)

In Advanced Subsidiary, skills are assessed in the context of separate practical activities. The four skills may be assessed using one or more activities. One mark for each skill must be submitted for each candidate. The activities chosen for assessment may be those carried out as part of the course or may be replacement or additional activities.

Candidates should be given written instructions which make clear what they are expected to do.

In the assessment of Skill **P**, Planning, candidates are required to retrieve and evaluate information from an appropriate variety of sources, which may include preliminary work. Typical resources for this purpose in Advanced Subsidiary might include the students' own laboratory notebook, a chemical data book, notes on the use of acid/base indicators, 'Salters Storylines', 'Salters Chemical Ideas', and a publication on aspects of health and safety. Candidates are not expected to modify their plan after they have carried out the activity.

Candidates should not be asked to use the plan that they have devised as a basis for an assessment of Skill **I**, Implementing. Where the same activity is to be used to assess both planning and implementing a separate and common implementing worksheet should be given to all candidates.

Assessment of Skill **I**, Implementing, should be made on the basis of direct observation of candidates carrying out the activity and of the observations and measurements that they record. Teachers may wish to prepare a schedule of key aspects of Implementing which they are looking for prior to observation of candidates. It may well be helpful to include instructions in candidate worksheets that require them to request teacher observation of particular techniques.

When assessing Skill **A**, Analysing Evidence and Drawing Conclusions, candidates should have access to an appropriate body of evidence. This may require class data to be collected together or for a new and common set of data to be provided for all candidates.

When assessing Skill **E**, Evaluating Evidence and Procedures, candidates should have access to an appropriate body of evidence. This may require class data to be collected together or for a new and common set of data to be provided for all candidates.

6 Mark Descriptors for Experimental Skills

In defining the various mark descriptors, it is recognised that practical tasks vary widely, both in the experimental procedures used and in the nature of the observations and measurements which may be made by the candidate. The mark descriptors within each defined level are intended to provide guidance to teachers on how to recognise levels of achievement. It is acknowledged that the balance between the statements provided for a particular level of performance will vary with the nature of the activity. Whilst both statements for a particular level **must** be considered in awarding the marks, it is clear that teachers will need to judge for themselves the relative weightings they attach to each of the statements.

Candidates work must be judged to be a good match with **both statements at a defined level in order that the mark for this level is awarded.** Candidates work must be judged to be a good match with the descriptors for lower defined levels before a higher mark is awarded. From the bottom to the top of the mark range the activity should involve increasing demands of related scientific knowledge and understanding, manipulation, precision, accuracy and complexity.

Skill P:Planning Total 11

Mark Descriptor

The candidate:

1

2 **2a** identifies and defines the nature of a question or problem and devises a basic practical procedure to respond to the question or problem; describes only limited detail about procedure.

2b chooses equipment appropriate to basic practical procedure

3

4

5 **5a** identifies and defines the nature of a question or problem and devises a more developed practical procedure to respond to the question or problem; describes key details about the procedure

5b chooses equipment and materials that are likely to produce useful data; includes a brief list of sources consulted; devises a basic risk assessment

6

7

8 **8a** identifies and defines a question or problem and devises a more fully developed and coherent practical procedure to respond to the question or problem; describes most expected details about the procedure.

8b chooses equipment and materials that are likely to produce precise and reliable results; retrieves and evaluates information from appropriate sources; includes a list of sources consulted that is both extensive and detailed; devises a risk assessment that covers most aspects of the activity and includes most appropriate details; produces a generally clear account, using specialist vocabulary appropriately most of the time, and in which spelling, punctuation and grammar are generally accurate.

9

10

11 **11a** identifies and defines a question or problem and devises a practical procedure that is comprehensive and coherent to respond to the question or problem; describes fine detail about the procedure.

11b explains how the choice of procedures and/or equipment and/or materials will ensure that the data collected is precise and reliable; retrieves and evaluates information from multiple appropriate sources; devises a risk assessment that is comprehensive, detailed and relevant; produces a clear account using specialist vocabulary appropriately and in which spelling, punctuation and grammar are accurate.

Skill I: Implementing — Total 12

Mark Descriptor

The candidate:

Mark		Descriptor
1		
<u>2</u>	2a	demonstrates competence in simple practical procedures; adopts safe working practices some of the time.
	2b	records basic data; organises data in a simple manner.
3		
4		
<u>5</u>	5a	demonstrates competence in a wider range and/or in more complex aspects of the practical procedure; adopts safe working practices most of the time; resolves problems with assistance; demonstrates a sense of purpose in the collection of data; demonstrates ability to work in an organised manner and collects most data carefully.
	5b	records a range of data, organises data systematically; records some data precisely and with suitable units.
6		
7		
<u>8</u>	8a	demonstrates effective practice in all aspects of the practical procedure; works safely throughout the activity; resolves most problems without assistance; works methodically and in an organised manner and collects almost all data carefully.
	8b	records an appropriate amount and range of data; records data that are generally of an appropriate quality; makes effective use of tables, where appropriate, most of which have appropriate labels and headings; records most data precisely and with suitable units.
9		
10		
<u>11</u>	11a	demonstrates well developed skills in all aspects of the practical procedure; works safely throughout the activity; resolves almost all problems without assistance; pays attention to fine detail in the collection of data, works methodically, carefully and in a very organised manner and collects all data carefully.
	11b	records an appropriate amount and range of data including fine detail; records data that is of high quality and identifies any obviously poor quality data; makes effective use of tables, where appropriate, all of which have appropriate labels and headings; records all data precisely and with suitable units.
12		demonstrates highly developed skills in all aspects of practical procedures; works safely throughout the activity; pays particular attention to the fine detail in data collection; demonstrates a high degree of competence when handling equipment and materials and when recording data; is highly organised and resolves all problems without assistance.

Skill A: Analysing — Total 11

Mark Descriptor

The candidate:

1

<u>**2**</u> **2a** carries out basic calculations and/or draws basic graphs.

2b describes the outcomes of the activity in simple terms.

3

4

<u>**5**</u> **5a** carries out straight forward calculations correctly and/or draws simple graphs; makes some progress in more demanding calculations; explains some steps in calculations.

5b recognises simple patterns and trends in data where appropriate; describes the outcomes of the activity in some detail.

6

7

<u>**8**</u> **8a** carries out most expected calculations correctly and/or draws most expected graphs; includes appropriate units in most steps in calculations; explains most steps in calculations; draws most graphs of suitable quality and format.

8b recognises more detailed patterns and trends in data where appropriate; uses evidence from collected data to draw conclusions that are consistent with underlying chemical ideas; produces a generally clear account, using specialist vocabulary appropriately most of the time, and in which spelling, punctuation and grammar are generally accurate.

9

10

<u>**11**</u> **11a** carries out all expected calculations correctly and/or draws all expected graphs; includes appropriate units in all steps in calculations; explains all steps in calculations; draws all graphs of suitable quality and format;

11b recognises more complex patterns and trends in data where appropriate; uses evidence from collected data to draw conclusions which are soundly based on underlying chemical ideas; produces a clear account, using specialist vocabulary appropriately, and in which spelling, punctuation and grammar are accurate.

Skill E: Evaluating — Total 11

Mark Descriptor

The candidate:

Mark		Descriptor
1		
<u>2</u>	**2a**	comments in simple terms on some limitations of the practical procedure
	2b	comments in general terms on the uncertainty associated with measurements recorded during the activity or on limitations associated with equipment used during the activity.
3		
4		
<u>5</u>	**5a**	describes in reasonable detail some of the limitations of the practical procedure.
	5b	comments on the uncertainty associated with the use of specific equipment and/or calculates the uncertainty associated with some specific measurements.
6		
7		
<u>8</u>	**8a**	describes, including most appropriate detail, most limitations of the practical procedure and/or identifies some aspects of the procedure that are important in ensuring that the data collected is precise and reliable.
	8b	correctly calculates the uncertainty associated with specific examples of most types of measurements recorded during the activity.
9		
10		
<u>11</u>	**11a**	fully describes limitations of the practical procedure and/or identifies most aspects of the procedure that are important in ensuring that the data collected are precise and reliable; assesses the relative significance of the limitations of the practical procedures, where appropriate, in terms of their effect on the overall outcomes of the activity.
	11b	correctly calculates the uncertainty associated with specific examples of all types of measurements recorded during the activity; assesses the relative significance of uncertainties associated with measurements in terms of their effect on the overall outcomes of the activity.

7 Exemplar tasks and mark schemes for the assessment of Experimental Skills

Comparing the enthalpy changes of combustion of different alcohols

- Planning
- Implementing
- Analysing evidence and drawing conclusions
- Evaluating evidence and procedures

Finding out how much acid there is in a solution

- Planning
- Implementing
- Analysing evidence and drawing conclusions
- Evaluating evidence and procedures

Determination of the solubility of calcium hydroxide

- Planning
- Implementing
- Analysing evidence and drawing conclusions
- Evaluating evidence and procedures

Determination of the enthalpy change of a reaction

- Planning
- Analysing evidence and drawing conclusions
- Evaluating evidence and procedures

Note on safety:

The exemplar student worksheets provided below do not contain any references to hazards associated with chemicals or procedures or to any consequent safety precautions which should be taken. It is the responsibility of the Centre to ensure safe working practices.

COMPARING THE ENTHALPY CHANGES OF COMBUSTION OF DIFFERENT ALCOHOLS

PLANNING ASSESSMENT - STUDENT WORKSHEET

The enthalpy change of combustion of a fuel is a measure of the energy transferred when one mole of the fuel burns completely. A value for the enthalpy change can be obtained by using the burning fuel to heat water and using fact that 4.2J of energy are required to raise the temperature of 1g of water by 1^{o}C . In this activity you are going to find the enthalpy change of combustion of a number of alcohols so that you can investigate how and why the enthalpy change is affected by the molecular structure of the alcohol.

Write a plan of how you will find the enthalpy changes of combustion of alcohols so that you can draw conclusions about how these values are affected by their molecular structure.

In your plan you should include the following:

- An account of how you will do the experiment written in sufficient detail so that another student could use it to carry out the experiment with no other instructions - your account should include the apparatus, equipment and materials you will use and the quantities of materials you will use where this is relevant;
- An explanation of why the plan which you have devised is likely to provide precise and reliable results;
- A risk assessment which identifies hazards and makes clear the precautions which you will take;
- Details of the sources which you have used in devising your plan.

COMPARING THE ENTHALPY CHANGES OF COMBUSTION OF DIFFERENT ALCOHOLS

IMPLEMENTING ASSESSMENT - STUDENT WORKSHEET

The enthalpy change of combustion of a fuel is a measure of the energy transferred when one mole of the fuel burns completely. A value for the enthalpy change can be obtained by using the burning fuel to heat water and using fact that 4.2J of energy are required to raise the temperature of 1g of water by $1^{o}C$. In this activity you are going to find the enthalpy change of combustion of a number of alcohols so that you can investigate how and why the enthalpy change is affected by the molecular structure of the alcohol.

The following method describes what you should do in general terms but you are expected to carry out the method in ways which are safe and which are likely to ensure that your results are as precise and reliable as possible.

Put $200cm^3$ of cold water in a copper calorimeter and record its temperature

Support the calorimeter over a spirit burner containing the alcohol you are going to burn. Arrange a suitable draft exclusion system to reduce heat loss.

Weigh the burner and alcohol

Replace the burner under the calorimeter and light the wick

When the water temperature has risen by between 15 and $20^{o}C$ extinguish the burner and note the highest temperature reached

Weigh the burner to find the mass of the alcohol that has been burned

Record all of your measurements in a suitable table

Repeat the experiment with a burner containing a different alcohol. Keep all other conditions the same as with the first alcohol. Use the same apparatus, the same mass of water, the same start temperature and go on heating until you have reached the same finishing temperature. The only thing that should be different is the mass of alcohol that is used up. Add your results to your table.

Repeat the experiment in exactly the same way using burners containing other alcohols.

Add all of your results to your table.

COMPARING THE ENTHALPY CHANGES OF COMBUSTION OF DIFFERENT ALCOHOLS

ANALYSING EVIDENCE AND DRAWING CONCLUSIONS ASSESSMENT - STUDENT WORKSHEET

The enthalpy change of combustion of a fuel is a measure of the energy transferred when one mole of the fuel burns completely. A value for the enthalpy change can be obtained by using the burning fuel to heat water and using fact that 4.2J of energy are required to raise the temperature of 1g of water by 1°C. In this activity you are going to find the enthalpy change of combustion of a number of alcohols so that you can investigate how and why the enthalpy change is affected by the molecular structure of the alcohol.

Use you results to:

- Calculate the amount of heat absorbed by the water in each experiment
- Use your answers in part (a) to calculate a value for the enthalpy change of combustion of each alcohol

(In your calculations try to make sure that you have used units and significant figures in an appropriate way and that you have explained each step clearly)

- Use the information that you have found in part (b) to help you comment on how the enthalpy change of combustion of alcohols is affected by their molecular structure
- Explain the trends which you have identified

COMPARING THE ENTHALPY CHANGES OF COMBUSTION OF DIFFERENT ALCOHOLS

EVALUATING EVIDENCE AND PROCEDURES ASSESSMENT - STUDENT WORKSHEET

The enthalpy change of combustion of a fuel is a measure of the energy transferred when one mole of the fuel burns completely. A value for the enthalpy change can be obtained by using the burning fuel to heat water and using fact that 4.2J of energy are required to raise the temperature of 1g of water by $1^{o}C$. In this activity you have found the enthalpy change of combustion of a number of alcohols so that you could investigate how and why the enthalpy change is affected by the molecular structure of the alcohol.

You are now required to evaluate the results and the procedures involved in this activity.

Write a report that evaluates the measurements that you have taken and the procedures which you have used to make these measurements.

In your report you should do the following:

- Comment on any limitations of the practical procedures that you used
- Identify those aspects of the practical procedures that were particularly important in ensuring that the data that you collected was precise and reliable
- Comment on the uncertainty associated with all types of measurement that you made, calculating the percentage uncertainty where this is possible.
- Comment on the *relative* significance of aspects of the practical procedures and uncertainties associated with measurements in terms of their effect on the overall outcomes of the activity.

FINDING OUT HOW MUCH ACID THERE IS IN A SOLUTION

PLANNING ASSESSMENT - STUDENT WORKSHEET

During the extraction of a metal from its ore sulphur dioxide is often produced. This is converted to sulphuric(VI) acid and sold as a useful by-product. You are to be given a sample of the acid solution, thought to have a concentration between 0.05 and 0.15 mol dm^{-3}, and asked to find out its accurate concentration.

You are provided with solid, anhydrous sodium carbonate, a range of indicators and details about the suitability of indicators for different types of titration and access to laboratory glassware and equipment.

Write a plan of how you will find the accurate concentration of the sulphuric acid. In your plan you should include the following:

- An account of how you will do the experiment written in sufficient detail so that another student could use it to carry out the experiment with no other instructions - your account should include the apparatus, equipment and materials you will use and the quantities of materials you will use where this is relevant;
- An explanation of why the plan which you have devised is likely to provide precise and reliable results;
- A risk assessment which identifies hazards and makes clear the precautions which you will take;
- Details of the sources which you have used in devising your plan.

INFORMATION SHEET ON THE USE OF INDICATORS IN ACID ALKALI TITRATIONS

Acids and alkalis are classified as 'strong' or 'weak' depending on the extent to which they form ions when dissolved in water. Strong acids and alkalis are completely in the form of ions in dilute solution. For weak acids and alkalis this process is only partially complete.

Some examples of the different types of acid and alkali are as follows:

STRONG ACID	**WEAK ACID**
Hydrochloric acid	Ethanoic acid
Nitric acid	Ethanedioic acid
Sulphuric acid	

STRONG ALKALI	**WEAK ALKALI**
Sodium hydroxide	Ammonia solution
Potassium hydroxide	Sodium carbonate
Calcium hydroxide	Sodium hydrogencarbonate

To show the end point of a titration between an acid and an alkali an indicator is normally used. Different indicators are suitable for different combinations of strong and weak acids and alkalis as follows:

For a titration between a strong acid and a weak alkali, methyl orange is used as the indicator

For a titration between a weak acid and a strong alkali, phenolphthalein is used as the indicator

For a titration between a strong acid and a strong alkali, either methyl orange or phenolphthalein can be used as the indicator, although methyl orange is usually chosen

For a titration between a weak acid and a weak alkali, no indicator is suitable, and a pH meter, conductivity meter or temperature probe has to be used.

FINDING OUT HOW MUCH ACID THERE IS IN A SOLUTION

IMPLEMENTING ASSESSMENT - STUDENT WORKSHEET

During the extraction of a metal from its ore sulphur dioxide is often produced. This is converted to sulphuric(VI) acid and sold as a useful by-product. You are to be given a sample of the acid solution, thought to have a concentration between 0.05 and 0.15 mol dm^{-3}, and asked to find out its accurate concentration.

You are provided with solid, anhydrous sodium carbonate, a methyl orange indicator and access to laboratory glassware and equipment. The following method describes what you should do in general terms but you are expected to carry out the method in a ways which are safe and are likely to ensure that your results are as precise and reliable as possible.

(a) Using a weighing bottle or equivalent container, weigh out accurately about 2.65 g of anhydrous sodium carbonate and transfer it to a 250 cm^3 beaker. Record all balance readings and the exact mass of anhydrous sodium carbonate that has been transferred. Dissolve the solid in distilled water and make the solution up to 250 cm^3 in a graduated flask. Show your flask to your teacher at this point.

(b) Set up a burette and fill with the acid solution.

(c) Transfer your sodium carbonate solution to a 250 cm^3 beaker or conical flask.

(d) Use a pipette filler and pipette to transfer 25 cm^3 of this solution to a 250 cm^3 conical flask.

(e) Add 3 drops of methyl orange solution to the conical flask. Add the acid solution from the burette until the indicator changes colour, this will allow you to find an approximate value for the volume of acid needed to react with the sodium carbonate solution. Record all of your burette readings and your titre in a suitable table.

(f) Repeat your titration a number of times and **at least once** during the assessment ask your teacher to observe you performing a titration run. Repeat your titration until you feel that you have achieved results that will allow you to find the accurate concentration of the acid solution. Record all of your burette readings and your titres in your table.

FINDING OUT HOW MUCH ACID THERE IS IN A SOLUTION

ANALYSING EVIDENCE AND DRAWING CONCLUSIONS ASSESSMENT - STUDENT WORKSHEET

During the extraction of a metal from its ore sulphur dioxide is often produced. This is converted to sulphuric(VI) acid and sold as a useful by-product. You have been given a sample of the acid solution, thought to have a concentration between 0.05 and 0.15 mol dm^{-3}, and asked to find out its accurate concentration.

You are now required to analyse your results and to use them to draw conclusions.

Use your results to:

(a) calculate the concentration of the sodium carbonate solution which you made up

(b) calculate the concentration of the acid solution

Make sure that you have:

- used units and significant figures in an appropriate way
- clearly explained the steps in your calculations
- described the outcomes of your calculations clearly and in an appropriate format

FINDING OUT HOW MUCH ACID THERE IS IN A SOLUTION

EVALUATING EVIDENCE AND PROCEDURES ASSESSMENT - STUDENT WORKSHEET

During the extraction of a metal from its ore sulphur dioxide is often produced. This is converted to sulphuric(VI) acid and sold as a useful by-product. You have been given a sample of the acid solution, thought to have a concentration between 0.05 and 0.15 mol dm^{-3}, and asked to find out its accurate concentration.

You are now required to evaluate the results and the procedures involved in this activity.

Write a report that evaluates the measurements that you have taken and the procedures which you have used to make these measurements.

In your report you should do the following:

- Comment on any limitations of the practical procedures that you used
- Identify those aspects of the practical procedures that were particularly important in ensuring that the data that you collected was precise and reliable
- Comment on the uncertainty associated with all types of measurement that you made, calculating the percentage uncertainty where this is possible.
- Comment on the *relative* significance of aspects of the practical procedures and uncertainties associated with measurements in terms of their effect on the overall outcomes of the activity.

DETERMINATION OF THE SOLUBILITY OF CALCIUM HYDROXIDE

PLANNING ASSESSMENT- STUDENT WORKSHEET

Calcium hydroxide, $Ca(OH)_2$, dissolves only slightly in water to form an alkaline solution. You will have used the saturated solution produced labelled as lime water.

The solubility of the calcium hydroxide can be found by titrating the saturated solution against a solution of an acid whose concentration you know.

You will be given a sample of lime water that contains approximately 0.015 mol dm^{-3} of calcium hydroxide and a solution of hydrochloric acid whose concentration is 0.3 mol dm^{-3}. You may have to dilute one of these solutions before you carry out the titration.

You are also provided with a range of indicators and details about the suitability of indicators for different types of titration, as well as access to laboratory glassware and equipment.

Write a plan of how you will find the accurate concentration of the lime water. In your plan you should include:

- An account of how you will do the experiment written in sufficient detail so that another student could use it to carry out the experiment with no other instructions - - your account should include the apparatus, equipment and materials you will use and the quantities of materials you will use where this is relevant;
- An explanation of why the plan which you have devised is likely to provide precise and reliable results;
- A risk assessment which identifies hazards and makes clear the precautions which you will take;
- Details of the sources which you have used in devising your plan.

INFORMATION SHEET ON THE USE OF INDICATORS IN ACID ALKALI TITRATIONS

Acids and alkalis are classified as 'strong' or 'weak' depending on the extent to which they form ions when dissolved in water. Strong acids and alkalis are completely in the form of ions in dilute solution. For weak acids and alkalis this process is only partially complete.

Some examples of the different types of acid and alkali are as follows:

STRONG ACID	**WEAK ACID**
Hydrochloric acid	Ethanoic acid
Nitric acid	Ethanedioic acid
Sulphuric acid	

STRONG ALKALI	**WEAK ALKALI**
Sodium hydroxide	Ammonia solution
Potassium hydroxide	Sodium carbonate
Calcium hydroxide	Sodium hydrogencarbonate

To show the end point of a titration between an acid and an alkali an indicator is normally used. Different indicators are suitable for different combinations of strong and weak acids and alkalis as follows:

For a titration between a strong acid and a weak alkali, methyl orange is used as the indicator

For a titration between a weak acid and a strong alkali, phenolphthalein is used as the indicator

For a titration between a strong acid and a strong alkali, either methyl orange or phenolphthalein can be used as the indicator, although methyl orange is usually chosen

For a titration between a weak acid and a weak alkali, no indicator is suitable, and a pH meter, conductivity meter or temperature probe has to be used.

DETERMINATION OF THE SOLUBILITY OF CALCIUM HYDROXIDE

IMPLEMENTING ASSESSMENT - STUDENT WORKSHEET

Calcium hydroxide, $Ca(OH)_2$, dissolves only slightly in water to form an alkaline solution. You will have used the saturated solution produced labelled as lime water.

The solubility of the calcium hydroxide can be found by titrating the saturated solution against a solution of an acid whose concentration you know.

You are provided with a sample of lime water that contains approximately 0.015 mol dm^{-3} of calcium hydroxide, a solution of hydrochloric acid whose concentration is 0.3 mol dm^{-3}, methyl orange indicator and access to laboratory glassware and equipment.

The following method describes what you should do in general terms but you are expected to carry out the method in a ways which are safe and are likely to ensure that your results are as accurate as possible.

(a) Use a pipette filler and pipette to transfer 25 cm^3 of the acid solution into a 250 cm^3 volumetric flask. Make this solution up to the mark with distilled water. Show your flask to your teacher at this point.

(b) Set up a burette and fill with the acid solution

(c) Use a pipette filler and pipette to transfer 25 cm^3 of the lime water to a 250 cm^3 conical flask.

(d) Add 3 drops of methyl orange solution to the conical flask. Add the acid solution from the burette until the indicator changes colour. This will allow you to find an approximate value for the volume of acid needed to react with the lime water. Record your result in a suitable table.

(e) Repeat your titration a number of times and **at least once** during the assessment ask your teacher to observe you performing a titration run. Repeat your titration until you feel that you have achieved results that will allow you to find the accurate concentration of the lime water**.** Record all of your burette readings and your titres in your table.

DETERMINATION OF THE SOLUBILITY OF CALCIUM HYDROXIDE

ANALYSING EVIDENCE AND DRAWING CONCLUSIONS ASSESSMENT - STUDENT WORKSHEET

Calcium hydroxide, $Ca(OH)_2$, dissolves only slightly in water to form an alkaline solution. You will have used the saturated solution produced labelled as lime water.

The solubility of the calcium hydroxide can be found by titrating the saturated solution against a solution of an acid whose concentration you know.

You are now required to analyse your results and to use them to draw conclusions.

Use your results to:

(a) Calculate the concentration of the acid solution after dilution

(b) Calculate the concentration of the lime water solution

Make sure that you have:

- used units and significant figures in an appropriate way
- clearly explained the steps in your calculations
- described the outcomes of your calculations clearly and in an appropriate format

DETERMINATION OF THE SOLUBILITY OF CALCIUM HYDROXIDE

EVALUATING EVIDENCE AND PROCEDURES ASSESSMENT - STUDENT WORKSHEET

Calcium hydroxide, $Ca(OH)_2$, dissolves only slightly in water to form an alkaline solution. You will have used the saturated solution produced labelled as lime water.

The solubility of the calcium hydroxide can be found by titrating the saturated solution against a solution of an acid whose concentration you know.

You are now required to evaluate the results and the procedures involved in this activity.

Write a report that evaluates the measurements that you have taken and the procedures which you have used to make these measurements.

In your report you should do the following:

- Comment on any limitations of the practical procedures that you used
- Identify those aspects of the practical procedures that were particularly important in ensuring that the data that you collected was precise and reliable
- Comment on the uncertainty associated with all types of measurement that you made, calculating the percentage uncertainty where this is possible.
- Comment on the *relative* significance of aspects of the practical procedures and uncertainties associated with measurements in terms of their effect on the overall outcomes of the activity.

TO DETERMINE THE ENTHALPY CHANGE OF A REACTION

PLANNING ASSESSMENT - STUDENT WORKSHEET

When solid calcium carbonate is heated strongly, it decomposes to give calcium oxide and carbon dioxide.

$$CaCO_3 \rightarrow CaO + CO_2$$

The enthalpy change of this reaction is difficult to measure directly but can be found by an indirect method based on Hess' law. In this approach, calcium carbonate and calcium oxide are reacted separately with hydrochloric acid and the enthalpy changes of the two reactions are measured. These enthalpy changes are then used to calculate the enthalpy change for the decomposition of calcium carbonate using an enthalpy cycle.

You are required to plan an experiment in which you can measure the enthalpy changes of reaction when calcium carbonate and calcium oxide react separately with hydrochloric acid, so that the values you obtain can be used to calculate the enthalpy change for the decomposition of calcium carbonate.

You will be provided with between 2.4 g and 2.6 g of calcium carbonate. You will also be given a supply of 2.0 mol dm^{-3} hydrochloric acid and as much calcium oxide as you require. You will also have access to other equipment that you might need.

Write a plan of how you will find the enthalpy changes of these reactions. In your plan you should include:

- An account of how you will do the experiment written in sufficient detail so that another student could use it to carry out the experiment with no other instructions - your account should include the apparatus, equipment and materials you will use and the quantities of materials you will use where this is relevant;
- An explanation of why the plan which you have devised is likely to provide precise and reliable results;
- A risk assessment which identifies hazards and makes clear the precautions which you will take;
- Details of the sources which you have used in devising your plan.

TO DETERMINE THE ENTHALPY CHANGE OF A REACTION

IMPLEMENTATION - STUDENT WORKSHEET

IMPORTANT NOTE: This activity makes relatively little demand on the ability of candidates to manipulate and record and is therefore not suitable for use in the area of implementation where access to the full range of marks is required. Candidates may, however, carry out the activity so that they may be assessed on their ability to analyse and draw conclusions from their results and to evaluate their results and procedures.

When solid calcium carbonate is heated strongly it decomposes to give calcium oxide and carbon dioxide. The enthalpy change of this reaction is difficult to measure directly but can be found by an indirect method based on Hess' law. In this approach, calcium carbonate and calcium oxide are reacted separately with hydrochloric acid and the enthalpy changes of the two reactions are measured. These enthalpy changes are then used to calculate the enthalpy change on heating the calcium carbonate using an enthalpy cycle.

Carry out the experimental procedure described below.

(a) Weigh a weighing bottle containing between 2.4 g and 2.6 g of calcium carbonate. Record your results in table 1.

(b) Using a measuring cylinder place 50 cm^3 of 2 mol dm^{-3} hydrochloric acid (an excess) in a polystyrene cup.

(c) Measure the temperature of the acid using a thermometer and record this value in table 1.

(d) Add the calcium carbonate to the acid. Carefully stir the mixture in the cup with the thermometer and take the temperature again when the reaction is complete. Record this value in table 1.

(e) Weight the weighing bottle again and record this value in table 1.

Repeat steps one to five using an accurately weighed mass of calcium oxide in the range 1.3 g to 1.5 g instead of the calcium carbonate. Again the hydrochloric acid is in excess. Record all the results in table 2 on the following page.

TABLE 1	
Mass of calcium carbonate + weighing bottle	g
Mass of empty weighing bottle	g
Mass of calcium carbonate used	g
Initial temperature of the acid	°C
Temperature of the solution when reaction is complete	°C
Temperature change during reaction	°C

TABLE 2	
Mass of calcium oxide and weighing bottle	g
Mass of empty weighing bottle	g
Mass of calcium oxide used	g
Initial temperature of the acid	°C
Temperature of the solution when reaction is complete	°C
Temperature change during the reaction	°C

TO DETERMINE THE ENTHALPY CHANGE OF A REACTION

ANALYSING EVIDENCE AND DRAWING CONCLUSIONS ASSESSMENT - STUDENT WORKSHEET

When solid calcium carbonate is heated strongly it decomposes to give calcium oxide and carbon dioxide. The enthalpy change of this reaction is difficult to measure directly but can be found by an indirect method based on Hess' law. In this approach, calcium carbonate and calcium oxide are reacted separately with hydrochloric acid and the enthalpy changes of the two reactions are measured. These enthalpy changes are then used to calculate the enthalpy change on heating the calcium carbonate using an enthalpy cycle.

You are now required to analyse your results and to use them to draw conclusions.

You can assume that the specific heating capacity of the hydrochloric acid is 4.2 J g^{-1} K^{-1} and that the density of the hydrochloric acid is 1.0 g cm^{-3}.

Use your results to:

(a) Calculate the enthalpy change when one mole of calcium carbonate reacts with 2.0 mol dm^{-3} hydrochloric acid

(b) Calculate the enthalpy change when one mole of calcium oxide reacts with hydrochloric acid 2.0 mol dm^{-3}

(c) Use your answers to parts a and b and an appropriate energy cycle to calculate the enthalpy change when one mole of calcium carbonate is decomposes to form calcium oxide and carbon dioxide

Make sure that you have:

- used units and significant figures in an appropriate way
- clearly explained the steps in your calculations
- described the outcomes of your calculations clearly and in an appropriate format

TO DETERMINE THE ENTHALPY CHANGE OF A REACTION

EVALUATING EVIDENCE AND PROCEDURES ASSESSMENT - STUDENT WORKSHEET

When solid calcium carbonate is heated strongly it decomposes to give calcium oxide and carbon dioxide. The enthalpy change of this reaction is difficult to measure directly but can be found by an indirect method based on Hess' law. In this approach, calcium carbonate and calcium oxide are reacted separately with hydrochloric acid and the enthalpy changes of the two reactions are measured. These enthalpy changes are then used to calculate the enthalpy change on heating the calcium carbonate using an enthalpy cycle.

You are now required to evaluate the results and the procedures involved in this activity.

Write a report that evaluates the measurements that you have taken and the procedures that you have used to make these measurements.

In your report you should do the following:

- Comment on any limitations of the practical procedures that you used
- Identify those aspects of the practical procedures that were particularly important in ensuring that the data that you collected was precise and reliable
- Comment on the uncertainty associated with all types of measurement that you made, calculating the percentage uncertainty where this is possible.
- Comment on the *relative* significance of aspects of the practical procedures and uncertainties associated with measurements in terms of their effect on the overall outcomes of the activity.

8 Assessment of Individual Investigations (A2)

In A2, the four skills are assessed in the context of a single individual investigation in which each candidate pursues his or her own assignment.

The investigation may be based on any aspect of chemistry but candidates are required to bring together chemical knowledge, principles and concepts from different areas of the AS and A2 specifications and to apply them in the context of their investigation.

In the context of the individual investigation, assessment of planning and of analysing evidence and procedures contributes to the synoptic assessment component of the specification.

Synoptic assessment:

- requires candidates to make connections between different areas of chemistry, for example, by applying knowledge and understanding of principles and concepts of chemistry in planning experimental work and in the analysis and evaluation of data;
- includes opportunities for candidates to use, in contexts which may be new to them, skills and ideas which permeate chemistry, for example, writing chemical equations, quantitative work, relating empirical data to knowledge and understanding.

Candidates are required to produce an investigation report in which they express ideas clearly and logically and use specialist vocabulary correctly. The report should consist of four sections which cover planning, the recording aspect of implementing, analysing evidence and drawing conclusions, and evaluating evidence and procedures.

8.1 Time spent on the investigation

Candidates should spend between 15 and 20 hours of laboratory time on an extended and substantial investigation and a similar amount of time writing up their investigation report. If less time is spent on practical work, it will be more difficult for the candidate to access the higher mark ranges. In order that they make maximum use of this time candidates should plan what they are going to do well before they are due to start practical work. This is essential to ensure that the necessary chemicals and equipment are available and so that the teacher who is to supervise the investigation can be satisfied that an appropriate risk assessment has been carried out and it is safe to continue.

8.2 Choice of investigation

The individual investigation may be based on any aspect of chemistry as long as this allows the candidate to bring together chemical knowledge, principles and concepts from different areas of the AS and A2 specifications. The investigation topic chosen should, however, allow the candidate to demonstrate their abilities in all skill areas. In addition to planning, candidates are assessed on their ability to record evidence, to analyse it, to draw conclusions from it and to evaluate it. Investigations should therefore be chosen which will generate the necessary data.

The overall approach to practical work should show a clear progression from GCSE through AS to A2 investigations. It is expected that candidates will satisfy the points highlighted in the detailed mark schemes used in AS assessments and build upon this to explain and justify their approach using ideas taken from both the AS and A2 parts of the specification.

Some types of investigation may not easily generate the required body of evidence. A multi-stage organic preparation, for example, may lead to few observations or measurements and would not be a suitable activity for this assessment component.

All investigations must have a clear chemical content and must not drift into related disciplines such as biology or physics at the expense of the chemistry.

Candidates should work independently on their own investigation and should not work as part of a group for this assessment. Candidates may use the practical facilities of industry or a university to enrich their investigation but the major part of the investigation should be carried out at the Centre under the supervision of the teacher who will assess the investigation report.

Within a large Centre it is not essential that each candidate should carry out an investigation on a completely different topic and candidates in different teaching groups, for example, may choose to work on similar investigations. The individual investigation does, however, provide a unique opportunity for candidates to study in depth a topic that is of particular interest to them and this should lead to a diversity of investigation topics within each Centre.

8.3 Approaches to practical work in investigations

To access the higher mark levels it is expected that candidates will use techniques and approaches to practical work that reflect the chemical maturity of work at A2 level. It is not appropriate, for example, to use measuring cylinders for accurate measurement of volume. Thin layer chromatography, melting point and qualitative tests using iron(III) chloride, are less accurate methods of finding the purity of aspirin than titration or quantitative colorimetric methods. Better quality data is generated by measuring the volume of a gas evolved every 5 seconds rather than measuring the total volume collected in 3 minutes. If candidates are exploring the effect of temperature on rate of reaction they may well be expected to make use of the Arrhenius equation to draw a graph from which to calculate a value for the activation enthalpy.

The plans developed by some candidates that are insufficiently demanding or have too little scope limit the marks that can be awarded. 'The best conditions for extraction of copper from copper ore', 'Acid and thiosulphate' or 'Caffeine in cola' do not lend themselves to the depth of investigation expected at this level. Where candidates set out to find out how much of a component is in a set of samples such as vitamin C or aspirin, it is helpful if they can obtain some benchmarking of their data by using a second method of analysis or by using one sample whose composition they know about. Some candidates reduce the scope of their investigation because they repeat the same experiment many times even when it was clear on the second occasion that there is minimal variation in the outcome. Other candidates generate too few points with which to draw a meaningful graph.

The use of a preliminary experiment to determine appropriate amounts of materials or conditions can be a useful strategy that informs the rest of the investigation.

There is significant emphasis within the assessment descriptors on the need for the evidence collected by the candidate to be accurate and reliable. It is vital, therefore that candidates critically review each set of data as soon as it has been collected to help decide, for example, whether additional data points are required or whether particular experiments should be repeated. To achieve the highest mark levels, candidates should concentrate on the quality rather than the quantity of the evidence gathered.

8.4 Writing up the investigation report

The investigation report provides evidence upon which the assessment of all aspects of the investigation except for the manipulation part of implementing is based and through which the assessment made can be internally and externally moderated.

A clear division of the report into four distinct sections provides candidates with a helpful structure and assists teachers and moderators in making an appropriate assessment of the candidate's work.

Many candidates will word-process their reports and care should be taken that subscripts, superscripts and chemical equations are inserted correctly. Investigation reports should be sent for moderation in light-weight files.

Section 1 - Planning

In this section of the report it is expected that candidates will need to draw on chemical knowledge, principles and concepts drawn from different parts of the AS and A2 specifications.

The report should begin with a clear statement of the nature and aims of the investigation. Some candidates start their report with a hypothesis. This rarely helps the written report and often distracts the candidate and reduces the quality of the overall investigation. The notion of a fair test also tends to emphasise the GCSE type of approach to the investigation at the expense of the more sophisticated treatment expected at A2 level.

There should be two main parts of this section of the report. One part should be a detailed account of all the practical work carried out by the candidate. The candidate should include the method that they have devised. The method should be in sufficient detail so that another candidate could repeat the work using only this written record. It should therefore contain descriptions of the techniques used, should include exact details of amounts and conditions and be both comprehensive and coherent. While an initial plan will be devised before the investigation is started, candidates may well decide to modify their procedures in the light of their experience. Such modifications should be clearly shown. The second part of this section should be an account of the underlying chemical knowledge in support of the topic under investigation. To achieve the highest mark levels, this account should be chemically sound, coherent and relevant to the practical procedures that are to be used.

Candidates need to satisfy both strands of the descriptor requirements to be awarded marks at any level of performance. In some investigations candidates include a great deal of experimental detail but little theoretical background while in other cases they include much background but little experimental detail. In both cases, the mark achieved by candidates will be limited by the weaker performance.

In order to devise a suitable plan, candidates will need to consult a range of resources which will provide a background to their study and which will inform the choices which they make about the general and detailed nature of their plan. The sources used for these purposes should be indicated by bracketed numbers or by superscripts at appropriate points within the text which refer to a list of references at the end of this section of the report. The references should be in sufficient detail that another candidate could easily find them.

An essential part of the plan is an assessment of the hazards associated with the chemicals and processes to be used during the investigation. There should, therefore, be a written risk assessment in this section. It should be relevant and selective, and should include the specific hazards and consequent precautions to be taken during the investigation. It should not simply be a list of all the possible hazards associated with the chemicals and operations to be used.

Within this section of the report candidates should explain why the plan which they have devised is likely to generate precise and reliable results. This should comment on experimental procedures chosen and on the range and number of measurements made and recorded.

Some candidates included a grid as part of their plan which links the chemical Ideas that they had used during their investigation with the part of the course the ideas are met or re-visited. This has proved an excellent method of showing that the synoptic components of the descriptors in this skill area have been met.

Section 2 – Implementing

Centres are expected to provide written evidence to support the mark awarded in the manipulating strand of this skill area. This can take the form of comments about generic skills and abilities demonstrated by candidates during their practical work such as competence with apparatus, procedures and materials, safe working, time management, ability to solve problems, care and attention to detail in the collection of data and so on.

In this section candidates should record all of the observations and measurements which they have made. The data recorded by candidates should be comprehensive, and should be recorded in an appropriate format and to the expected precision for the equipment in use. Data should be recorded with appropriate units. All the raw data obtained by a candidate should be included in their report and not just averages and not as an appendix. The standards applied when awarding marks in the recording strand of manipulation should at least be those used at AS level.

The data should be of appropriate quantity and quality in order to access the higher mark levels. If candidates find that titration values are very low it is expected that they will make appropriate adjustments to the dilution of the solutions so that higher values can be achieved rather than moving on to another aspect of their investigation. In a reaction where the volume of a gas collected is measured against time, the timing intervals should be chosen with care so that changes in the reaction can be easily followed.

This recorded evidence should be clearly linked to the plan and should show a sense of progression and purpose as the investigation develops.

Section 3 - Analysing Evidence and Drawing Conclusions

In this section candidates are required to first analyse the evidence which they have collected and then to draw conclusions based on this evidence. It is expected that candidates will need to bring together chemical knowledge, principles and concepts drawn from different parts of the AS and A2 specifications in this section.

The analysis of some evidence may require the candidate to process data in calculations. Care should be taken to use appropriate units and significant figures. Key steps in any calculation should be clearly explained using chemical equations and structures where appropriate.

The analysis of some data may require the candidate to process data in the form of graphs. Bar charts do not normally illustrate the level of analysis of data expected at this level. Some computer generated graphs are very small which does not provide the expected accuracy. Sometimes computer packages draw inappropriate lines of best fit and it is better to let the computer plot the points and for the candidate to draw a line through them. Candidates should include titles and axis labels with appropriate units on graphs and make use of the 0,0 point where relevant.

Candidates are required to draw conclusions based on the original or processed evidence. This may involve the interpretation of the results of calculations, graphs or other forms of evidence. Candidates should clearly explain how the evidence that they have collected leads to the conclusions that they draw from it. The conclusions drawn by candidates from their results can often be superficial. To meet he higher level descriptors, the deductions drawn from the data collected in the investigation should be explained with the help of the chemical ideas that have been described in the plan.

In this section, candidates will attempt to explain what they can tell from their data. They can comment on trends they have identified, compare their results with data book or other available values and suggest the causes of any unexpected outcomes of their project. Where an investigation has made use of several different techniques to analyse particular samples, the candidate should comment on the relative accuracy of each technique.

The nature of the conclusions drawn in this section will depend on the type of investigation undertaken. Investigations of reaction kinetics, for example, may lead to precise conclusions about order of reaction, activation enthalpy or reaction mechanism. Analytical investigations may lead to conclusions about the composition of materials. Other types of investigation may lead to more general conclusions about the patterns identified in the evidence collected.

Section 4 - Evaluating Evidence and Procedures

In this section candidates are required to evaluate the procedures which they have used and the evidence which they have collected during their investigation.

When evaluating procedures, candidates should identify limitations of experimental procedure and discuss how these affect their results and/or identify those aspects of the procedures which were particularly important in ensuring the data collected was precise and reliable.

When evaluating the evidence that they have collected candidates should calculate the percentage uncertainty involved in each type of measurement in order to compare their relative importance. Where this is not feasible candidates should comment on the relative precision of the data.

Candidates should bring together the different strands of their evaluation to comment upon the relative impact of uncertainties associated with the measurements made and the limitations of experimental procedures on the accuracy of their data and the overall conclusions that can be drawn from their investigation.

In the light of experience gained by carrying out their investigation, candidates are required to suggest improvements which would help increase the precision and reliability of the evidence and/or identify those aspects of the techniques that they have used which are particularly important in ensuring the precision and reliability of results. Improvements should be realistic and make use of equipment that is likely to be available to them. Candidates should explain and justify their suggestions as far as possible. Candidates are not expected to propose additional extensions to their original investigation.

9 Mark descriptors for Individual Investigations

When marking AS Experimental Skills assessments, it is possible to devise a detailed mark scheme in advance of the assessment since all candidates are usually given the same assessment and the assessment involves a narrow and clearly defined activity. When marking A2 Individual Investigations, however, it is not possible to devise a detailed mark scheme in advance of the assessment. Each investigation is likely to be different and even where candidates choose a similar topic for their investigation their focus may well be different.

To mark individual investigations, therefore, the candidates work must be compared to the A2 mark descriptors at each level. The mark descriptors within a skill area have been written to be hierarchical. Thus, in marking a piece of work, the descriptors for the lowest defined mark level should be considered first and only if there is a good match should the descriptors for the next level up be considered. Therefore, if a teacher is considering awarding a high mark for a piece of work, the work must have demonstrated a good match to all the lower mark descriptors.

In defining the various mark descriptors, it is recognised that individual investigations vary widely, both in the experimental procedures used and in the nature of the observations and measurements which may be made by the candidate. The mark descriptors within each defined level are intended to provide guidance to teachers on how to recognise levels of achievement. It is acknowledged that the balance between the statements provided for a particular level of performance will vary with the nature of the activity. Whilst both strands for a particular level **must** be considered in awarding the marks, it is clear that teachers will need to judge for themselves the relative weightings they attach to each of the statements.

Skill P: Planning — Total 11

Mark — Descriptor

The candidate:

1

<u>2</u> **2a** identifies and defines the nature of a question or problem and devises basic practical procedures to respond to the question or problem and chooses equipment and materials appropriate to simple techniques; describes only limited detail about procedures.

2b describes basic chemical knowledge in support of the general topic under investigation.

3

4

<u>5</u> **5a** identifies and defines the nature of a question or problem and devises more developed practical procedures to respond to the question or problem; describes key details about procedures; chooses procedures, equipment and materials that are likely to produce useful data.

5b describes a wider range of chemical knowledge in support of the topic under investigation; uses chemical ideas drawn from more than one area of the specification; devises a basic risk assessment; includes a brief list of sources consulted; states or implies aims of investigation.

6

7

<u>8</u> **8a** identifies and defines the nature of a question or problem and devises practical procedures that are likely to produce a reasonable amount of useful data to respond to the question or problem; chooses procedures, equipment and materials that are likely to produce precise and reliable data; describes most expected details about procedures, equipment and materials.

8b describes most expected chemical knowledge in support of the topic under investigation, most of which is relevant to the devised practical procedures and is chemically sound; uses chemical ideas drawn from more than one module of the specification; devises a risk assessment that covers most aspects of the investigation and includes appropriate details; retrieves and evaluates information from appropriate sources; includes a list of sources consulted that is quite extensive and detailed; clearly states aims of the investigation; produces a generally clear account using specialist vocabulary appropriately most of the time, and in which spelling, punctuation and grammar are generally accurate.

9

10

<u>11</u> **11a** identifies and defines the nature of a question or problem and devises practical procedures that are comprehensive, coherent and likely to produce an appropriate amount of good quality data; describes fine detail about procedures, equipment and materials; explains how the choice of procedures and/or equipment and/or materials will ensure that the data collected is reliable, useful and of good quality.

11b describes chemical knowledge in support of all aspects of the topic under investigation that is chemically sound, comprehensive, coherent, detailed and relevant to the practical procedures; uses chemical ideas drawn from different parts of the AS and A2 parts of the specification; devises a risk assessment that is comprehensive, detailed and relevant; retrieves and evaluates information from appropriate sources; includes a list of sources consulted that is comprehensive, detailed and linked to appropriate sections of the investigation report; states the aims of the investigation clearly; produces a clear account using specialist vocabulary appropriately, and in which spelling, punctuation and grammar are accurate.

Skill I: Implementing — Total 12

Mark Descriptor

The candidate:

Mark		Descriptor
1		
<u>2</u>	**2a**	demonstrates competence in simple practical procedures; adopts safe working practices some of the time.
	2b	records basic data; organises data in a simple manner.
3		
4		
<u>5</u>	**5a**	demonstrates competence in a wider range and/or in more complex practical procedures; adopts safe working practices most of the time; resolves problems with assistance; demonstrates a sense of purpose in the collection of data; demonstrates ability to work in an organised manner and collects most data carefully.
	5b	records a greater range of data, most of which is relevant to the aims of the investigation; organises data systematically; records some data precisely and with suitable units.
6		
7		
<u>8</u>	**8a**	demonstrates effective practice in all practical procedures; works safely throughout the investigation; resolves most problems without assistance; demonstrates a clear sense of purpose in the collection of data; works methodically and in an organised manner and collects almost all data carefully.
	8b	records an appropriate amount and range of data that are relevant to the aims of the investigation; records data that is generally of an appropriate quality; makes effective use of tables, where appropriate, most of which have appropriate labels and headings; records most data precisely and with suitable units.
9		
10		
<u>11</u>	**11a**	demonstrates well developed skills in all practical procedures; works safely throughout the investigation; resolves almost all problems without assistance; pays attention to fine detail in the collection of data, works methodically, carefully and in a very organised manner and collects all data carefully.
	11b	records an appropriate amount and range of data, including fine detail, and links the data coherently to the aims of the investigation; records data that are of high quality and any poor quality data are clearly identified and/or re-investigated; makes effective use of tables, where appropriate, all of which have appropriate labels and headings; records all data precisely and with suitable units.
12		demonstrates highly developed skills in all aspects of practical procedures; works safely throughout the investigation; pays particular attention to the fine detail in data collection; demonstrates a high degree of competence when handling equipment and materials and when recording data; is highly organised and resolves all problems without assistance.

Skill A: Analysing — Total 11

Mark Descriptor

The candidate:

Mark		Descriptor
1		
<u>2</u>	**2a**	carries out basic calculations and/or draws basic graphs.
	2b	describes the outcomes of the investigation in simple terms.
3		
4		
<u>5</u>	**5a**	carries out straight forward calculations correctly and/or draws simple graphs from collected data; makes some progress in more demanding calculations; explains some steps in calculations.
	5b	recognises simple patterns and trends in data where appropriate; describes the outcomes of the investigation in some detail; uses evidence from raw and /or processed data to draw simple conclusions that are consistent with underlying chemical ideas drawn from more than one area of the specification.
6		
7		
<u>8</u>	**8a**	carries out most expected calculations correctly and/or draws most expected graphs from collected and processed data; explains main steps in calculations; draws most graphs of suitable quality and format; includes calculations and/or graphs that help meet the aims of the investigation.
	8b	recognises more detailed patterns and trends in data where appropriate; describes the outcomes of the investigation, including most details; uses evidence from raw and /or processed data to draw fuller and/or more detailed conclusions that are consistent with underlying chemical ideas drawn from more than one module of the specification; produces a generally clear account, using specialist vocabulary appropriately most of the time, and in which spelling, punctuation and grammar are generally accurate.
9		
10		
<u>11</u>	**11a**	carries out all expected calculations correctly and/or draws all expected graphs from collected and processed data; explains all steps in calculations; draws all graphs of suitable quality and format; includes calculations and/or graphs that are coherent and logical and help meet the aims of the investigation.
	11b	recognises more complex patterns and trends in data where appropriate; describes the outcomes of the investigation fully and in detail; uses evidence from raw and /or processed data to draw comprehensive and detailed conclusions that are soundly based on underlying chemical ideas drawn from different parts of the AS and A2 specification; produces a clear account, using specialist vocabulary appropriately, and in which spelling, punctuation and grammar are accurate.

Skill E: Evaluating — Total 11

Mark Descriptor

The candidate:

Mark		Descriptor
1		
<u>2</u>	**2a**	comments in simple terms on some limitations of practical procedures.
	2b	comments in general terms on the uncertainty associated with measurements recorded during the investigation or on limitations associated with equipment used during the investigation.
3		
4		
<u>5</u>	**5a**	describes in reasonable detail some of the limitations of the practical procedures
	5b	comments on the uncertainty associated with the use of specific equipment and/or calculates the uncertainty associated with some specific measurements.
6		
7		
<u>8</u>	**8a**	describes, including most appropriate detail, most limitations of the practical procedures; describes in simple terms, where appropriate, how some practical procedures might be modified to improve the reliability of the data collected.
	8b	correctly calculates the uncertainty associated with specific examples of most types of measurements recorded during the investigation.
9		
10		
<u>11</u>	**11a**	fully describes limitations of the practical procedures; assesses the relative significance of the limitations of the practical procedures in terms of their effect on the overall outcomes of the investigation; suggests, where appropriate, suitable changes to practical procedures to improve the reliability of data collected.
	11b	correctly calculates the uncertainty associated with specific examples of all types of measurements recorded during the investigation; assesses the relative significance of uncertainties associated with measurements in terms of their effect on the overall outcomes of the investigation; suggests, where appropriate, suitable changes to equipment to improve the precision of data collected.

10 Exemplar Individual Investigations

A number of topics which can lead to interesting and challenging investigations and which provide opportunities for candidates to demonstrate their abilities in all skill areas are indicated below. This list is **not** intended to be a prescribed list of investigations but rather an indication of the type of approach that will allow candidates to access the full mark range in each skill area. Candidates and their teachers will wish to decide on their own investigations using this list as a guide.

NOTE ABOUT SYNOPTIC ASSESSMENT

In all A2 investigations, candidates are required to bring together chemical knowledge and understanding drawn from more than one area, module and part of the AS and A2 specifications. Evidence for this synoptic component of the assessment should be demonstrated in skill areas P (Planning) and A (Analysing evidence and drawing conclusions). This is illustrated in the first two examples below.

(1) An investigation into the kinetics of the decomposition of hydrogen peroxide

This investigation can be approached in a number of different ways. One candidate may choose to investigate a single aspect of the decomposition of hydrogen peroxide in great detail. Another candidate may choose to investigate several aspects in less detail. Each approach should allow the candidate access to the full mark range in the four skill areas, but emphasis should be placed on the quality, rather than the quantity, of candidates' work.

Candidates can investigate the catalysis of the decomposition of hydrogen peroxide by the enzyme catalase; candidates could change the concentration of both substrate and enzyme in order to determine the order of the reaction and hence the rate equation; candidates could carry out the decomposition at different temperatures in order to determine the activation enthalpy of the reaction; candidates could investigate the pH sensitivity of the enzyme-catalysed reaction; candidates could investigate the effect on rate of reaction of potential inhibitors such as metal ions or organic molecules such as alcohols; candidates could investigate the decomposition of hydrogen peroxide catalysed by metal oxides such as manganese(IV) oxide, lead(IV) oxide and iron oxides, changing the temperature so as to calculate an activation enthalpy that can be compared with that of the enzyme catalysed reactions.

(Synoptic coverage: enzymes – A2 Unit Engineering Proteins; catalysts – AS Unit Developing Fuels; amount of substance – AS Unit Elements of Life; concentrations – AS Unit From Minerals to Elements; rate of reaction – AS Unit Atmosphere; rate equation, rate constant, order of reaction – A2 Unit Engineering Proteins; enthalpy profile, activation enthalpy – AS Unit The Atmosphere; effect of temp on rate of reaction – A2 Unit Aspects of Agriculture; d-block elements – A2 Unit Steel Story; alcohols - AS Unit Developing Fuels; periodicity – AS Unit Elements of Life; catalytic effect of d-block elements – A2 Unit Steel Story).

(2) An investigation into the methods which may be used to determine the purity of a sample of aspirin

This investigation can be approached in a number of different ways. One candidate may choose to investigate a single method to determine the purity of a sample of aspirin in great detail. Another candidate may choose to investigate several methods in less detail. Each approach should allow the candidate access to the full mark range in the four skill areas, but emphasis should be placed on the quality, rather than the quantity, of candidates' work.

Candidates will need to be sure of the composition of the samples containing aspirin that they are going to analyse. This can be achieved by making up samples of pure aspirin, salicylic acid and an equi-molar mixture of the two compounds. They can then carry out some of the different methods of analysis suggested below on the three samples in order to determine the purity of the aspirin.

One suitable method of analysis is to use an acid base titration; a second approach is to hydrolyse the aspirin and to carry out a back titration; a third method is to carry out a pH titration using a pH probe, which could be connected to a data logging device; the mixtures may also be assayed colorimetrically using iron(III) chloride solution; candidates might then make their own sample of aspirin and find the purity of this; candidates could also re-crystallise their sample.

(**Synoptic coverage**: mole calculations - AS Unit Elements of Life; molecular formula of acids, phenol, esters, aspirin and salicylic acid – A2 Unit What's in a Medicine?; acids and bases – AS Unit From Minerals to Elements; concentrations of solutions – AS Unit From Minerals to Elements; hydrolysis of esters – A2 Unit Designer Polymers; pH – A2 Unit The Oceans, Ka – A2 Unit The Oceans; reaction of phenol with iron(III) solution – A2 Unit What's in a Medicine; colorimetric measurements – A2 Unit The Steel Story; making aspirin – A2 Unit What's in a Medicine; re-crystallisation – A2 Unit Designer Polymers).

(3) Analysis of river or stream water

Samples can be taken to allow the investigation of the effect on water quality of an 'event' such as a sewage outfall, run off from fields, factory discharge or mixing with another water course. Chemical aspects of the water samples such as pH, conductivity, hardness, concentration of nitrate and phosphate and 'permanganate value' could be investigated.

(4) An investigation into the kinetics of the reaction between iodide ions and peroxodisulphate ions

The rate of this reaction can be determined using a fixed amount of thiosulphate ions and starch indicator using the 'clock' technique. The effects on reaction rate of changing the concentration of reactants, or changing the temperature can be investigated leading to a determination of order of reaction and activation enthalpy. Alternatively, a candidate might focus on the catalytic effect of d-block ions and determine the relative effect of different ions, the effect of different concentrations of the same ion or the effect of a mixture of added ions.

Many other systems provide opportunities for kinetics studies. Where one of the components is coloured a colorimeter provides a useful way of monitoring the reaction. Suitable systems for investigation include the reactions between:

(i) the decomposition of hydrogen peroxide

(ii) bromate(V) ions and bromide ions

(iii) magnesium and acids

(iv) manganate(VII) ions and ethandioate ions

(v) manganate(VII) ions and hydrogen peroxide

(vi) iodine and propanone

(vii) organic halogen compounds and sodium hydroxide

(5) An investigation into other enzyme catalysed reactions

The kinetics of reactions involving enzymes such as lipase, urease and polyphenoloxidase can be studied using appropriate techniques. The effects on rate of reaction of changing substrate and enzyme concentration, pH, temperature and addition of potential enzyme inhibitors can be investigated.

(6) A comparison of the methods which may be used to determine the purity of a substance

A similar approach to that used to determine the purity of a sample of aspirin can be used to investigate the use of different methods to determine the concentration in solution of a metal ion such as copper(II). A range of volumetric techniques as well as colorimetric and gravimetric analysis could be used. The investigation could be extended to find the amount of copper in a brass screw or an old coin. .

An investigation could also be carried out into the methods available for the determination of vitamin C. After first using solutions of known concentration the investigation might be extended to look at the vitamin C content of a foodstuff or drink. Alternatively, a single analytical technique could be used to monitor how the concentration of vitamin C changes under different storage conditions.

(7) An investigation into the factors that affect the accuracy of the method used to determine the amount of manganese in a paper clip

Vogel's 'Quantitative Inorganic Analysis' includes a detailed method for the estimation of manganese together with information about ions that are said to affect the accuracy of the determination. The relative effects of modifying the method and of the presence of contaminating ions can be investigated by carrying out a series of determinations in which conditions are deliberately varied and others in which the sample is carefully contaminated with interfering ions.

This type of investigation can be applied to a number of other metal ions such as iron(III) and aluminium.

(8) An investigation of wine

Investigations into wine provide a number of different possibilities in which the focus might be the concentration of alcohol, weak acids or sulphur dioxide. Wine might be artificially aged by drawing air through it so that the impact of ageing on the wine composition may be investigated.

(9) Investigations into dyes and dyeing

Investigations into the fastness of different dyes with different fabrics provide opportunities to explore intermolecular attractions. The loss of dye from dyed fabrics into successive washes with water or other solutions may be monitored using a colorimeter. Investigations could be extended to look at the effect of different mordants or to look at dyes from plant materials.

(10) Investigating conductivity

Possible investigations include the effect of salts with common ions on the conductivity of solutions, the effect of temperature on conductivity and the use of conductivity in finding the solubility of a solute.

(11) Investigating the formulae of inorganic compounds

This type of investigation allows candidates to bring together a variety of titrimetric, gravimetric and other techniques to solve in a single investigation.

(12) Investigating fats and oils

It is possible to investigate the hydrolysis, oxidation, saponification and unsaturation of fats and oils. Some of these procedures are lengthy and care should be taken in planning the investigation to ensure that sufficient data will be obtained.

(13) Investigating ion exchange resins

Investigations using ion exchange columns provide opportunities to compare the exchange of different cations or anions or to use the technique to separate mixtures of ions.

(14) Investigating hardness of water

Possible investigations include comparing the effectiveness of different ways of reducing the permanent and/or temporary hardness of water using an EDTA titration.

11 Frequently asked questions (FAQs)

1. In AS, can a single coursework exercise be used to assess more than one skill?

   Yes, skills may be assessed separately or in combination. All four skills can be tested at any one time. However, it is the responsibility of candidates and their centres to ensure that it is clear where each skill is being covered. This should be achieved by the use of titles and sub-titles.

2. In AS, is it advisable to test more than one skill in any one exercise?

   This depends very much on the nature of the task and how it is set up. Candidates who have not planned and carried out an investigation (or at least seen it demonstrated) will find it difficult to evaluate the investigation. Skill ***E*** *may, therefore, be better assessed in a whole exercise. If all four skills are to be tested in one exercise, it is essential that it is clear to moderators, by means of titles, subtitles, teachers' comments, etc., which are being tested where.*

3. In A2, is there any size or word limit on coursework submissions?

   No, ***but*** *there is absolutely nothing to be gained by submitting particularly large volumes of work for assessment. Moderators will be looking at the quality of the work rather than the quantity and clear evidence that candidates have achieved a good match with the mark descriptors listed under each skill.*

4. Do Centres need to show evidence of marking on candidate's work?

   Yes. It is also particularly helpful if a brief comment is included at the end of each section of work, or on the candidates' cover sheet, explaining where specific descriptors have not been sufficiently met and why, therefore, a particular mark has been awarded.

5. In AS, do Centres need to submit copies or lists of the worksheets, exercises and resources given to students?

   Yes; Moderators need to know exactly what candidates were asked to do, and what help they received.

6. Do Centres need to submit mark schemes?

   In the Assessment of AS Experimental Skills, Centres may choose to use the detailed mark schemes included within this booklet. A copy of the mark scheme used should be included with the sample of work sent for moderation. However, Centres may choose to develop specific sets of detailed descriptors for use with other assessment activities. If such descriptors are used, they must be very closely based on the standard AS descriptors, they should be of similar style and demand as the exemplar descriptors included within this booklet and they ***must*** *be sent to the moderator with the sample of work. It should be noted that the moderator will mark using the general set of descriptors (given in the specification), to ensure that the standard of work is the same from centre to centre.*

   In the assessment of A2`individual investigations, Centres must use the general A2 mark descriptors and apply them in the context of each investigation.

   For Skill I, teachers should provide details of the aspects of the work that were scrutinised, in the form of check lists or written notes. At AS, it is likely that the teacher will have prepared a detailed check list in advance of the assessment and will look at precisely defined aspects of manipulation of equipment and materials. At A2, the teacher will need to note the candidates performance over the course of the whole investigation and in the context of the particular investigation undertaken by the candidate.

7. Some candidates find coursework very difficult. What advice can you offer which will increase candidates' prospects of achieving good marks?

It is clearly important that candidates are taught the skills and given opportunities to practice, before being assessed. Candidates may find it helpful if staff go through a worked exemplar showing how they themselves would tackle a particular topic, provided that candidates are not allowed to produce work on the same topic for submission. Candidates should be made aware of the descriptors used to assess their work, so that they can ensure that all aspects of the descriptors are addressed. Worksheets clearly give considerable assistance to candidates, but if they are too specific, the help which they give may prevent candidates making choices and so limit access to the highest marks, so they should be used carefully.

8. I am having trouble deciding whether my exercises properly address the demands of the skills listed in the specification. What advice is available?

A proposed task may be submitted to OCR and a response on its suitability will be provided. INSET courses are provided each year; details are sent to Centres, and a contact address for the Training and Customer Support section is given in Section 12.

9. I have a class of very able students. Does this mean they cannot all achieve full marks for their assessments?

No. As long as candidates' work meets all the mark descriptors, including the top band, there is no reason why full marks should not be awarded. There can be a big range of performances ***within*** *the top band. If you have one or two brilliant students, do not let this persuade you that those who are only 'very good' must be worth less than full marks. Conversely, if all your candidates are of more limited ability, do not be misled into giving the best of them full marks.*

10. At A2, can candidates use the Internet during their investigations?

Yes; there is some excellent material available and the highest mark descriptors for Skill ***P*** *require candidates to draw together material from several sources. All URLs should be listed (with any other sources) in a bibliography. It should be noted that unless this information is processed or modified in some way and* ***used*** *in the development of the strategy, it is unlikely to be worthy of credit.*

11. Will candidates improve their chances of achieving high marks by making extensive use of Information and Communication Technology in their reports?

Computer generated material is not in itself worth any more marks than hand-written work. However, if the use of ICT enables the mark descriptors for any of the skills to be more effectively addressed, then candidates could gain extra credit. It should be noted that some graph-plotting packages, if not used expertly, may not produce the most appropriate graphs.

12 Coursework forms

Coursework forms and instructions may be downloaded from the OCR website: www.ocr.org.uk. There are separate forms for AS 2852/02 and A2 2855.

12 OCR Contacts

Subject Officer for A Level Chemistry (syllabus-specific queries only)

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