Advanced Higher Coursework Assessment Task

Advanced Higher Chemistry

Project

Assessment task

This document provides information for teachers and lecturers about the coursework component of this course in terms of the skills, knowledge and understanding that are assessed. It **must** be read in conjunction with the course specification.

Valid from session 2020–21 and until further notice.

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Contents

Introduction

This document contains instructions for teachers and lecturers, marking instructions and instructions for candidates for the Advanced Higher Chemistry project. You must read it in conjunction with the course specification.

The project is worth 25 marks (scaled to 40). This is 25% of the overall marks for the course assessment.

This is one of two course assessment components. The other component is a question paper.

Instructions for teachers and lecturers

General information

This information applies to the project for Advanced Higher Chemistry.

The project assesses the application of skills of scientific inquiry and related chemistry knowledge and understanding.

The project gives candidates an opportunity to demonstrate the following skills, knowledge and understanding:

- extending and applying knowledge of chemistry to new situations, interpreting and analysing information to solve more complex problems
- planning, designing and safely carrying out chemical experiments/investigations, including risk assessments to make a discovery, demonstrate a known fact, illustrate particular effects or test a hypothesis
- recording systematic detailed observations and collecting data
- selecting information from a variety of sources
- presenting detailed information appropriately in a variety of forms
- processing and analysing chemical information and data (using calculations, significant figures and units, where appropriate)
- making reasoned predictions and generalisations from a range of evidence and/or information
- drawing valid conclusions and giving explanations supported by evidence and/or justification
- critically evaluating experimental procedures by identifying sources of uncertainty and suggesting and implementing improvements
- drawing on knowledge and understanding of chemistry to make accurate statements, describe complex information, provide detailed explanations and integrate knowledge
- communicating chemical findings and information fully and effectively
- analysing and evaluating scientific publications and media reports

The project offers challenge by requiring candidates to apply skills, knowledge and understanding in a context that is one or more of the following:

- unfamiliar
- familiar but investigated in greater depth
- integrating a number of familiar contexts

Candidates research and report on a topic that allows them to apply skills and knowledge in chemistry at a level appropriate to Advanced Higher.

The topic must be chosen with guidance from teachers and/or lecturers.

The project has two stages:

- research
- report

In the research stage, candidates must plan and carry out their experiment, and collect and analyse their data. Candidates must also gather information from the internet, books or journals to support their understanding of the chemistry underlying their project.

Candidates must produce a report on their research.

Candidates should keep a lab book recording their work, which forms the basis of their report. This lab book should include details of their planning, research, experiments, and recorded data.

The lab book is not required for course assessment and is not submitted to SQA.

Conditions of assessment

Setting, conducting and marking the project

Setting

The project is set:

- by centres within SQA guidelines
- at a time appropriate to the candidate's needs
- within teaching and learning and includes experimental work at a level appropriate to Advanced Higher

Conducting

The project is conducted:

- under some supervision and control
- in time to meet a submission date set by SQA
- independently by the candidate

Marking

The project report is submitted to SQA for external marking.

All marking is quality assured by SQA.

Assessment conditions

Controlled assessment is designed to:

- prevent third parties from providing inappropriate levels of guidance and input
- mitigate concerns about plagiarism and improve the reliability and validity of SQA awards
- allow centres a reasonable degree of freedom and control
- allow candidates to produce an original piece of work

Both stages of the project are conducted under some supervision and control.

This means that:

- candidates do not need to be directly supervised at all times
- the use of resources, including the internet, is not tightly prescribed
- the work an individual candidate submits for assessment is their own
- teachers and lecturers can provide reasonable assistance

The term 'reasonable assistance' is used to try to balance the need for support with the need to avoid giving too much assistance. However, teachers or lecturers should not adopt a directive role or provide specific advice on how to re-phrase, improve responses or provide model answers. Teachers and lecturers must be careful that the integrity of the assessment is not compromised.

The project may involve candidates undertaking a large amount of autonomous work without close supervision. Although candidates may complete part of the work outwith the learning and teaching setting, teachers or lecturers must put in place processes for monitoring progress and ensuring that the work is the candidate's own and that plagiarism has not taken place. For example:

- having regular progress meetings with candidates
- conducting spot-check interviews with candidates
- regularly reviewing candidates' lab books
- completing checklists to record candidates' progress

Teachers and lecturers must exercise professional responsibility to ensure that the report submitted is the candidate's own work.

Instructions

This assessment is carried out over a period of time. Candidates should start at an appropriate point in the course.

The instructions for candidates outline the requirements for the project. Teachers and lecturers must give these to candidates at the outset. Teachers and lecturers must ensure candidates understand the requirements of the task.

Teachers and lecturers should encourage candidates to use a lab book to record their planning, research, experimental measurements, and analysis. It is important that the teacher or lecturer checks each candidate's lab book regularly to monitor progress and give advice.

Teachers and lecturers must not, at any stage, provide candidates with a template or model answers.

Research stage

The research stage is conducted under some supervision and control. See 'Conditions of assessment' section.

Choosing the topic

At the start of the research stage, the teacher or lecturer must agree the choice of topic with the candidate to ensure that it:

- is appropriate for Advanced Higher Chemistry
- has associated experimental work that can generate data suitable to allow analysis at a level appropriate to Advanced Higher Chemistry
- allows the candidate the opportunity to access all of the available marks

Teachers and lecturers should discourage candidates from embarking on over-ambitious plans. Well-executed simple projects that are understood by candidates are more likely to gain higher marks than projects that are overly complex, which often do not allow candidates to draw valid conclusions.

Candidates from the same centre should investigate different topics. The only exception to this is where a centre is presenting a large number of candidates (more than 10). In this instance, the centre must minimise the number of candidates carrying out the same investigation. If two candidates are carrying out the same investigation, they should have different aims and/or be using different experimental methods, and the teacher or lecturer must ensure that they work independently of each other.

Once candidates have agreed the topic with their teacher or lecturer, they must formulate an aim.

Formulating the aim

To ensure the candidate's aim is achievable, the teacher or lecturer must provide advice on its suitability, taking into account:

- health and safety considerations
- the availability of resources

Teachers and lecturers must not provide candidates with an aim.

After the candidate has formulated an aim, they can progress to planning and carrying out their experimental work, recording their data, and gathering information from internet/literature sources to support their data and their understanding of the underlying chemistry.

Candidates may carry out research outwith the direct supervision of teachers or lecturers.

Experimental research

It is expected that candidates should spend approximately 10 to 15 hours on experimental work; however, candidates may choose to take longer.

Teachers and/or lecturers are responsible for ensuring that an appropriate risk assessment has been carried out, and that candidates have guidance on the safe and correct use of equipment.

Candidates must plan their own experimental work and this should include, where possible, selecting appropriate instructions for their procedures. If necessary, teachers and lecturers can supply instructions for the experimental procedures. However, these instructions must not include a session-by-session breakdown, or details of the number and range of values, or reference to repeats.

Teachers and/or lecturers must not provide candidates with experimental data.

Teachers and/or lecturers must not provide a blank or pre-populated table for experimental results.

Candidates must carry out the experimental work individually. Group work is not allowed.

Internet/literature research

As with experimental research, internet/literature research must be the work of the individual candidate.

Report stage

The report stage is conducted under some supervision and control. See 'Conditions of assessment' section.

Evidence to be gathered

The following candidate evidence is required for this assessment:

- a project report

The project report is submitted to SQA, within a given timeframe, for marking.

The same project report cannot be submitted for more than one subject.

Volume

The project report should be between 2500 and 4500 words in length, excluding the title page, contents page, tables of data, graphs, diagrams, calculations, references and acknowledgements.

Candidates must include their word count on the project report flyleaf.

If the word count exceeds the maximum by more than 10%, a penalty is applied.

Marking instructions

In line with SQA's normal practice, the following marking instructions for the Advanced Higher Chemistry project are addressed to the marker. They will also be helpful for those preparing candidates for course assessment.

Candidates' evidence is submitted to SQA for external marking.

General marking principles

Always apply these general principles. Use them in conjunction with the detailed marking instructions, which identify the key features required in candidates' responses.

Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

Detailed marking instructions

Read the whole report before assigning any marks.

Section	Max mark	Expected response and marking instructions
1 Abstract (1 mark)		
	1	**A brief abstract stating the overall aim and conclusion of the project** The abstract must: ♦ come before the underlying chemistry ♦ clearly state the aim of the project ♦ state the conclusion of the project, which must be consistent with what is given in the conclusion section later in the report and/or with the experimental results, and must relate to the aim ♦ be brief If the aim of the project is to determine the quantity of a substance, then the conclusion must include the values obtained. For example, if the aim is to determine the mass of vitamin C in a fruit juice, then values must be stated in the abstract. However, if the aim is to compare the quantities of vitamin C in two different fruit juices, then the actual values do not need to be given. It is enough to say that 'type X contains more vitamin C than type Y'. A table or list of all values would also constitute a comparison. You can still award the mark for an incorrect conclusion, if it is consistent with what is given in the conclusion section. Extra findings unrelated to the aim are not required. However if stated, they must be consistent with the conclusion and/or results.

Section	Max mark	Expected response and marking instructions
2 Underlying chemistry (3 marks)		
	3	**A description of the underlying chemistry relevant to the aim of the investigation** Mark this section holistically. Award marks for the quality of the underlying chemistry at a depth appropriate to at least Advanced Higher. The relevant chemistry may have been covered at National 5 or Higher but Advanced Higher Chemistry must be included. Underlying chemistry can be found anywhere in the project report but award the marks for it in this section. The candidate must demonstrate an understanding of relevant chemistry and use their own words, wherever possible. However, they can include complex diagrams and/or complicated structural formulae from the internet/literature source. ♦ Award 3 marks for a good understanding of relevant chemistry — the description does not need to be excellent or complete. **or** ♦ Award 2 marks for a reasonable understanding of relevant chemistry. **or** ♦ Award 1 mark for a limited understanding of relevant chemistry. **or** ♦ Award 0 marks for no understanding of relevant chemistry. Only award marks for underlying chemistry. Do not award marks for general information, for example historical or socio-economic information.

Section	Max mark	Expected response and marking instructions
3 Data collection and handling (9 marks)		
3 a	2	**Procedures are clearly described in the past tense and using the impersonal passive voice** Award 2 marks if all procedures: ♦ contain sufficient detail for another Advanced Higher Chemistry candidate to be able to repeat the procedures without reference to other sections of the report ♦ contain details, such as concentrations and volumes of solutions, masses of chemicals, temperatures and colour changes, if these are necessary to follow the procedure(s) ♦ are written in the past tense and using the impersonal passive voice — the incorrect tense can be used on one occasion only Only accept a bulleted or numbered list if statements are in sentences and are coherent — they must make sense if the numbers or bullet points are removed. Award 1 mark if: ♦ any one procedure contains sufficient detail for another Advanced Higher Chemistry candidate to be able to repeat the procedure **or** ♦ details of concentrations and volumes of solutions, temperatures and colour changes have been recorded elsewhere in the report, for example, in the results section Candidates can include labelled diagrams or photographs of assembled apparatus.

Section	Max mark	Expected response and marking instructions
3 Data collection and handling (9 marks)		
3 b	1	**Statement of appropriate safety measure(s) with justification(s)** Award 1 mark if the candidate: ♦ identifies and justifies all additional safety measures taken to minimise risk during their experimental work. For example, when spraying a developing agent on a chromatogram, an appropriate safety measure would be to spray the chromatogram inside a fume cupboard. An appropriate justification would be that the developing agent used was flammable and an irritant **or** ♦ has stated that no additional safety measures were required during the experimental work for the project Award this mark even if the candidate has not stated that safety glasses or goggles were worn, as these are not considered to be additional safety measures.
3 c	1	**Data collected using methods of appropriate complexity and demand** Award 1 mark if the candidate has recorded data obtained from one procedure and: ♦ a second procedure **or** ♦ a modification in light of experience (the candidate must state the original results before the modification) **or** ♦ a control experiment (an experiment used to validate a procedure) **or** ♦ the standardisation of any solution, if the accuracy of the concentration is crucial in the analysis

Section	Max mark	Expected response and marking instructions
3 Data collection and handling (9 marks)		
		Only award the mark if the experimental work was conducted by the candidate and not for results obtained on their behalf by a technician or other third party. **Example of a procedure** A procedure is an experimental process that generates a recorded set of results. For example, the candidate carries out the synthesis of paracetamol, records the raw data (first procedure) and determines the purity of the product using colorimetric analysis (second procedure). **Example of a modification in light of experience** A chromatogram run using a solvent mentioned in the literature is presented showing poor resolution of components. A second chromatogram is presented showing the effect of using an alternative solvent selected by the candidate. If a candidate has carried out an incorrect procedure, it is not regarded as a modification if they simply correct the error in the original execution. **Example of a control experiment** If a volumetric method is used to determine the vitamin C content of orange juice, a standard solution of vitamin C can be used in place of a juice sample to check the accuracy of the procedure. There must be evidence that the candidate has used the results from the control to validate the procedure. **Standardisation of a solution** There must be evidence that the candidate has carried out the standardisation and that the result has been used in the calculations that follow.

Section	Max mark	Expected response and marking instructions
3 Data collection and handling (9 marks)		
3 d	1	**Experimental results providing evidence that the procedures have been carried out in duplicate** Award 1 mark if all procedures are carried out in duplicate, with the exception of: ♦ procedures with time-consuming steps that do not allow for duplication during the time allowed for practical work and do not lend themselves to be performed in tandem with the initial experiment, for example, a complex synthesis, such as paracetamol from phenol ♦ calibration graphs ♦ control experiments ♦ blank determinations ♦ standardisations ♦ spectra If the candidate has conducted a procedure with time-consuming steps, award the mark if all other procedures (such as those used to characterise the product), have been duplicated. In the volumetric determination of the quantity of an analyte in a commercially available product, it is sufficient for two samples from the same package to be used. For example, when determining the mass of vitamin C in fruit juice, results from samples taken from the same carton are accepted as evidence of duplication.

Section	Max mark	Expected response and marking instructions
3 Data collection and handling (9 marks)		
3 e	1	**Details of the apparatus, techniques, methods, chemicals and any other substances used to achieve the required levels of precision and/or accuracy** Evidence that the candidate chose the correct apparatus and chemicals can be provided by any of the following: ♦ the procedure ♦ an apparatus list ♦ measurements recorded in the results section It must be clear from the procedure that the apparatus used for each measurement was appropriate for the required level of precision and/or accuracy, and so an apparatus list on its own may not be sufficient. For volumetric analysis: ♦ appropriate glassware should be used if the accuracy or measurement of volume would have a significant effect on results, for example pipettes, burettes, and volumetric flasks ♦ titres should generally exceed 5·0 cm^3

Section	Max mark	Expected response and marking instructions
3 Data collection and handling (9 marks)		
3 f	1	**All relevant raw data recorded** Raw data must be recorded for all procedures: ♦ For titrations, initial and final burette readings must be given. ♦ When weighing by difference or heating to constant mass, all balance readings must be recorded. ♦ For procedures that generate raw data in the form of graphs, for example spectra or graphs from data-loggers, these must be labelled clearly and correctly. ♦ When a product is synthesised, the appearance of the product must be described. ♦ For qualitative tests, observations such as colour changes, the formation of a precipitate or the evolution of a gas must be described. ♦ Accept photographs or diagrams of chromatograms and statements of results as raw data.

Section	Max mark	Expected response and marking instructions
3 Data collection and handling (9 marks)		
3 g	1	**Numerical data appropriately presented** When recording experimental measurements, the number of decimal places must be appropriate for the apparatus used. Burette readings can be recorded to one or two decimal places. When two decimal places are used, the final digit must be either '0' or '5'. Initial burette readings of 0 are acceptable. In all tables: ♦ data must have appropriate headings ♦ units must be indicated in headings or given after every data entry Appropriate units must be stated for all measurements and final calculated values. Units are not required throughout a calculation but if given must be correct.

<table>
<tr><th>Section</th><th>Max mark</th><th>Expected response and marking instructions</th></tr>
<tr><td colspan="3">3 Data collection and handling (9 marks)</td></tr>
<tr><td>3 h</td><td>1</td><td>Citations and references provided for three sources of internet/literature data using any relevant referencing system

The candidate must cite a minimum of three distinct sources within the body of the report and give these references at the end of the report. The system used for citing and referencing must be consistent for all three references.

Each citation must link to the corresponding reference.

References must be listed with sufficient information to allow them to be retrieved.

<table>
<tr><th>Source</th><th>Reference</th></tr>
<tr><td>Website</td><td>The full URL for the page(s) with date accessed is essential.

The URL ‘www.rsc.org’ (October 2013) is not acceptable, but ‘http://www.rsc.org/Merck-Index/monograph/mono1500000841, (October 2013)’ is an acceptable reference</td></tr>
<tr><td>Journal</td><td>Title, author(s), journal title, volume and page number</td></tr>
<tr><td>Book</td><td>Title, author(s), (page number) and either edition or ISBN number</td></tr>
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Section	Max mark	Expected response and marking instructions
4 Data analysis (5 marks)		
4 a	4	**Analysis of data at a level of demand commensurate with Advanced Higher Chemistry** Analysis to include, as appropriate: ♦ values calculated correctly using chemical relationships ♦ scatter, line or bar graphs ♦ chromatograms ♦ spectra Mark this section holistically. Award 4 marks for a good analysis of the experimental data at a level appropriate to Advanced Higher Chemistry. The analysis does not need to be excellent and may contain a small number of minor errors; however, the final values must be correct. Award marks, where appropriate, for: ♦ chemical calculations — carried out using correct chemical relationships with correct numerical values ♦ graph(s) — constructed in an appropriate format(s) with suitable scale(s), labels and units, accurately plotted data points and, if appropriate, line(s) of best fit ♦ chromatograms — interpreted with retention times or distances accurately recorded, and components within each chromatogram assigned ♦ spectra — interpreted with major peaks assigned, and wavenumbers and/or wavelengths for significant peaks extracted and recorded

Section	Max mark	Expected response and marking instructions
4 Data analysis (5 marks)		
		Award 3 marks for a reasonably good analysis of the experimental data at a level appropriate to Advanced Higher Chemistry, for example: ♦ non-concordant titre values may have been used **or** ♦ duplicate values may have been processed incorrectly **or** ♦ there are a number of errors in the arithmetic using correct chemical relationships **or** ♦ there are small errors in a graphical representation, such as: — a unit missing from an axis — minor gridlines missing that do not affect the checking of the accuracy of data point plotting — minor errors in plotting data points that do not impact on the positioning of the line of best fit Award 2 marks for a better than limited analysis of the experimental data at a level appropriate to Advanced Higher Chemistry. This could include: ♦ an analysis that includes errors in one of the calculations, graphs, chromatograms or spectra leading to an incorrect final result **or** ♦ an analysis that includes a number of errors throughout **or**

Section	Max mark	Expected response and marking instructions
4 Data analysis (5 marks)		
		♦ if photographs of chromatograms or spectra (or originals) are not provided to allow the accuracy of interpretation to be readily checked **or** ♦ if graphs are not of a size that allows the scaling and labelling of the axes and the accuracy of the plotted data points to be readily checked Award 1 mark for a limited analysis of the experimental data at a level appropriate to Advanced Higher Chemistry. This could include: ♦ using a correct chemical relationship **or** ♦ a simplistic treatment of the experimental data **Examples of analysis at a level appropriate to Advanced Higher** ♦ complex chemical calculation commensurate with the demands of Advanced Higher Chemistry, for example those needed to process back titration, kinetics and equilibrium data **or** ♦ calculations of more than one type, for example, a titration calculation and a percentage yield calculation **or** ♦ calculations from two different procedures, for example two different titration methods **or** ♦ processing large quantities of data using a calculation, for example if the candidate has a wide range of variables and these have been duplicated, generating a large quantity of data **or** ♦ chemical calculation and an appropriate analysis of a graph, chromatogram or spectrum

Section	Max mark	Expected response and marking instructions
4 Data analysis (5 marks)		
		Examples of chemical relationships Chemical calculations include those involving: ♦ the relationship between moles, concentration and volumes ♦ the relationship between moles and gram formula masses ♦ reacting masses or gas volumes based on balanced equations ♦ percentage yields or percentage extractions ♦ enthalpy ♦ entropy ♦ free energy ♦ relative or average rates for a chemical reaction ♦ a rate constant ♦ an equilibrium constant ♦ the relationship between the pH and hydrogen ion concentration ♦ the pH of solutions of a weak acid ♦ the pH of buffer solutions ♦ the ionic product of water ♦ R_f values ♦ the relationship between the speed of light, frequency, and wavelength ♦ calculations involving the relationship between energy and frequency

Section	Max mark	Expected response and marking instructions
4 Data analysis (5 marks)		
		Constructing scatter, line, or bar graphs Graphs must be based on candidates' own experimental data. Award marks for computer-generated graphs in the same way as hand-drawn graphs. Graphs must: ♦ be of a size and scale that allow the accuracy of the plotting of the data points to be checked ♦ be constructed in an appropriate format, where the axes have suitable scales, and suitable labels and units ♦ have all data points plotted accurately with line(s) of best fit, if appropriate It may not be possible to check the accuracy of plotting if the data points are excessively large, minor gridlines are omitted, or the candidate has not used graph paper. **Interpretation of chromatogram(s)** Candidates must provide photographs, diagrams or original chromatograms, to allow the accuracy of interpretation to be readily checked. ♦ Retention times or distances travelled are accurately measured from the chromatogram(s) and recorded with appropriate units. ♦ Components within each chromatogram(s) are assigned.

Section	Max mark	Expected response and marking instructions
4 Data analysis (5 marks)		
		Interpretation of spectrum (spectra) Candidates must provide spectra to allow accuracy of interpretation to be readily checked. ♦ Wavelengths and/or wavenumbers for significant peaks are extracted from the spectrum or spectra and recorded using appropriate units. ♦ Major peaks are assigned.
4 b	1	**Calculated values stated to an appropriate number of significant figures** The acceptable number of significant figures for a calculated value is determined by the experimental measurement recorded to the smallest number of significant figures. The final value of a calculation should be quoted to no more than one figure less, and no more than two figures more, than the number of significant figures in this experimental measurement. If the candidate has provided a number of values calculated from the same procedure, they should use a consistent number of significant figures or decimal places to record this set of values.

Section	Max mark	Expected response and marking instructions
5 Conclusion (1 mark)		
	1	**A valid conclusion that relates to the aim and is supported by all the data in the report** The conclusion should be a judgement or decision made based on the results obtained. Do not award the mark if no aim has been stated anywhere in the report. If a conclusion is written after each experiment, the candidate must also provide an overall conclusion in this section. The aim given in the abstract must be covered by the conclusion and must be valid for the experimental results obtained. This mark can still be awarded if a mistake is made in processing the results that makes them invalid and a correct conclusion is given based on these invalid results. Extra conclusions that do not relate to the original aim must be valid from the results.

6 Analysis (1 mark)		
	1	**A valid comparison of the experimental results with an internet/literature source(s) or a comparison of duplicate experimental results if no internet/literature source is available**

Section	Max mark	Expected response and marking instructions
7 Evaluation (4 marks)		
	4	**Evaluation of the investigation** Award 1 mark for each valid evaluative statement with justification, if appropriate, to a maximum of 4 marks. Evaluative statements can relate to experimental procedures, results or data from internet/literature sources. Award a maximum of 1 mark for an evaluation of data from internet/literature sources. If a quantitative treatment of uncertainties has been carried out: ♦ award 1 mark for a list of correct uncertainty values associated with the measurements ♦ award a second mark for correctly combining the uncertainties to calculate the relative error in the final value ♦ award a third mark for a correct calculation of the absolute error in the final value

8 Structure (1 mark)		
	1	**A clear and concise report with an informative title, contents page and page numbers** The project report structure should be easy to follow. Do not penalise occasional missing page numbers (for example on graphs).
Total	**25**	

Instructions for candidates

This assessment applies to the project for Advanced Higher Chemistry.

The project is worth 25 marks. This is 25% of the overall marks for the course assessment.

The project has two stages:

- research
- report

Your teacher or lecturer will let you know if there are any specific conditions for doing this assessment.

In this project, you have to investigate a topic in chemistry by doing research. You will work individually to gather data/information from your own experiments and from internet/literature research. This may involve you carrying out a significant part of the work without supervision.

Your research involves planning experiments and gathering data. You should plan to spend approximately 10 to 15 hours doing experimental work. You will also gather information from internet/literature sources to support your understanding of the underlying chemistry and to provide comparative experimental data, if appropriate.

From the start of your project, and during the time you spend on your project, you should keep a record of your work in a lab book.

You then produce a report on your project.

Your teacher or lecturer will not mark your report at any point. It is sent to SQA for marking.

Research stage

At the start of your project, you should set up a timescale with start dates and deadlines for each phase of your project. Practical work usually takes longer than you anticipate.

Phase	Start date	Tasks	Deadline dates	Completed
Research — planning		Read the 'Instructions for candidates'.		
		Choose your topic and discuss it with your teacher or lecturer.		
		Decide on the aim for your project.		
		Show your teacher or lecturer your lab book, with your aim included.		
		Research the underlying chemistry of your chosen topic.		
		Research potential experiments and show your teacher or lecturer a detailed plan of your experimental procedures.		
		Prepare a risk assessment for your procedures and have this checked by your teacher or lecturer.		
Research — experimental		Check and organise that the apparatus and chemicals will be available for you when you need them.		
		Complete the experimental work in the time allocated. Allow time to make modifications and carry out repeat experiments.		
		Analyse your experimental results, consider your conclusions and evaluate your experiments.		
Report		Complete a draft of your report.		
		Finalise your report.		

Keeping a lab book

It is important that you ask your teacher or lecturer to check your lab book regularly, and take their advice.

Your lab book should contain a complete record of the work you carry out during each lab session and should be dated.

It should include:

- the aim of your project
- notes of any discussions with your teacher or lecturer and any other scientists
- background research
- references
- details of procedures
- tables of results
- analysis of results
- modifications
- next steps
- findings and conclusions

It is important that you write your entries into your lab book in a way that you find easy to follow and understand when you use it to produce your report. Ongoing analysis of your results allows you to plan what to do next. This may be repeating what you have already done, making modifications or moving on.

Choosing your topic

- You need to choose an appropriate topic in chemistry to investigate.
- You must agree your topic with your teacher or lecturer.

Deciding your aim

- Once you have chosen your topic, you need to decide what the aim of your project is. Remember that you need to plan, carry out and collect data and/or observations from your experiments.
- Your teacher or lecturer will provide advice on the suitability of your aim.

Experimental research

- When planning your experiments, remember that they must allow you to make observations and take measurements that can generate numerical data. This data must allow you to carry out calculations involving chemical relationships.
- When carrying out your experiments, you must work on your own.
- Make sure you take a sufficient number of measurements over a wide enough range to meet the aim of your project.
- You must repeat your experiments.

Internet/literature research

- In your report, you will need to show that you understand the chemistry underlying your project. You can use information from websites, books and/or journals to help you write your description of the underlying chemistry. In your report, you will need to show your understanding by writing this description using your own words.
- You will also need to research comparative data from an internet/literature source.
- It is important that you record where you get your information. In your report, you will need to cite and reference at least three of your sources.

Report stage

Producing the report

The report must be all your own work.

Resources

You can access any resources you need to write your report. The information you record in your lab book should form the basis of your report.

Guidance on producing your report

Using headings may help to make your report clear.

Title page

This page must have:

- a title that clearly indicates the subject matter of your project
- your name and candidate number, and the name and number of your centre

You might start out with a working title and then consider revising the wording of the title as your project nears completion.

Contents page

This page must list the sections within the report along with their corresponding page numbers for the purposes of cross-referencing. It is essential that all pages throughout the report are numbered.

Abstract

Your abstract must:

- have a clear statement of the aim of your project
- state the overall conclusion of your project
- be brief
- come before the underlying chemistry

As the abstract summarises your project, it could be one of the last things you write.

Your conclusion must be consistent with the conclusion you give in the conclusion section and must relate to the aim. For example, if the aim of your project is to determine the actual mass of a substance, then the abstract must include the values obtained.

Underlying chemistry

You must include a description of the underlying chemistry that is relevant to your project.

You can use a variety of sources of information when researching your chosen topic.

You may choose to include:

- a description showing your understanding of the underlying chemistry of your topic
- a description showing your understanding of the underlying chemistry of the experimental procedures and techniques you use
- formulae or balanced equations
- an explanation of properties
- explanations of relationships or trends
- an explanation of the meaning of any chemical terms you use
- diagrams
- structural formulae
- chemical relationships

At least three references to sources of information you used must be cited in the text **and** listed at the end of the report. The information from the sources could have supported your understanding of the chemistry, helped you to plan your experiments or provided a source to allow you to analyse and evaluate your results.

Downloading directly from the internet or copying directly from books and/or journals may suggest to the marker that you have not understood the chemistry involved, and may be considered as plagiarism. You should always put things into your own words.

Procedures

You must write a detailed description of the procedures you carried out in your project.

Procedures must:

- be written in the past tense and using the impersonal passive voice
- be in sufficient detail to allow your experiments to be repeated
- contain details of the apparatus, techniques, methods, chemicals and any other substances used to achieve your results
- not be a list of instructions or a bulleted or numbered list
- include a risk assessment stating the appropriate safety measures used, with justification
- be at an appropriate level of demand for Advanced Higher Chemistry
- show duplication with results clearly displayed in the results section

Example of past tense and impersonal passive voice

'25·0 cm^3 of 0·105 mol l^{-1} sodium hydroxide solution was pipetted into a conical flask.'

Do not write:

- 'Pipette 25·0 cm^3 of 0·105 mol l^{-1} sodium hydroxide solution into a conical flask.'
- 'I pipetted 25·0 cm^3 of 0·105 mol l^{-1} sodium hydroxide solution into a conical flask.'

Example of the level of detail required

When you are describing procedures, it is important to show that you have used the correct equipment for each measurement to give the accuracy required. For example, in a quantitative dilution of a standard solution, you must show you have used a standard flask rather than a measuring cylinder.

When you are giving quantitative data, you must quote these values to the correct number of decimal places appropriate to the equipment used. For example, if you use a balance reading to two decimal places, then you must quote masses to two decimal places, for example, 5·00 g and not 5 g.

It may be appropriate to include labelled diagrams or photographs of assembled apparatus.

Example of risk assessment

You must always follow general safety rules, such as wearing safety glasses or goggles; therefore, it is not necessary to state this in your report.

You must identify any additional safety measures taken to minimise risk during your experimental work and **justify why**.

For example, when spraying a developing agent on a chromatogram, an appropriate control measure would be to spray the chromatogram inside a fume cupboard. An appropriate justification would be that the developing agent used was flammable and an irritant.

If you required no additional safety measures during the experimental work for your project, you must state this.

Example of an appropriate level of demand for Advanced Higher Chemistry

You must carry out one procedure, with at least one of the following:

- a second procedure
- a modification in light of experience (you must state the original results you obtained before you carried out the modification)
- a control experiment
- the standardisation of any solution, if the accuracy of the concentration is crucial in the analysis

A procedure is an experimental process that generates a recorded set of results.

It does not count as a modification if you carried out the procedure incorrectly to begin with and the modification involved you then carrying out the procedure the correct way. For example, measuring out a volume for titration using a measuring cylinder then changing to using a pipette, when you should have been using a pipette to begin with.

A control experiment is an experiment you use to validate a procedure and is carried out by repeating the experiment using a known substance. For example, in a project to determine the vitamin C content of fruit juice, an appropriate control would be to repeat the experiment with a known quantity of vitamin C.

Example of duplication

You should duplicate each experiment to improve the reliability of your results.

Repeating titrations to get concordant results is good experimental practice, but does not count as doing an experiment in duplicate. However, if you are carrying out titrations to determine a quantity of substance in an actual product, you should start with two separate samples so that you can carry out all the procedures and process the results in duplicate. For example, if you are determining the mass of vitamin C in fruit juice then you should use at least two samples from the same juice carton.

Results

In the results section, you must:

- provide all raw data
- present raw and processed data using tables, graphs, diagrams, chromatograms, spectra, calculations and units, as appropriate
- show sample calculations
- present data with appropriate significant figures

Raw data

Raw data are the readings you actually record in each experiment, for example:

- titrations — the raw data are the initial and final burette readings, and the titre volumes are processed data
- weighing by difference — the raw data are the initial and final balance readings and the difference between these values is processed data
- chromatograms — the raw data are the distances travelled by the spots and the calculated R_f values would be processed data

Raw data can also include melting point data, chromatograms or diagrams, or photographs of chromatograms.

Tables and graphs

Your tables must have appropriate headings and correct units.

You must support your graphs with tables of raw and/or processed data. A graph on its own is not sufficient — you must also present the data from which it has been derived.

When drawing a graph, you must ensure that:

- scales are chosen so that the plotted points are widely spread
- each axis is labelled with the name of the quantity and the correct unit
- data are plotted accurately
- a best-fit straight line or curve is drawn where appropriate

If you use software packages to present graphs, it is important that you adapt the axes to suit the data, so that you present the results in the most appropriate way. If you use a computer-generated equation of a line to process the results, then you must provide this equation.

Calculations

You must clearly structure your calculations, with at least one sample calculation for each type of calculation carried out.

If you repeat the same type of calculation for different raw data, you only need to set out one sample calculation in detail, but you must always include all the raw data.

If calculating gram formula masses of compounds, you should check the correct formula of the substance to see if it contains molecules of water of crystallisation. For example, anhydrous $CuSO_4$ has a different gram formula mass compared to $CuSO_4 \cdot 5H_2O$, so you must be aware of the correct formula of the compound you use.

Significant figures

You must take care with significant figures in presenting and processing data. In calculations, for example, it is appropriate that intermediate results carry a number of extra digits beyond the last significant one, but you must quote the raw data and final results to an appropriate number of significant figures.

The number of significant figures in the final calculated result depends on the apparatus used, and the accuracy and precision of the measurements taken. This is usually the same as the lowest number of significant figures in any measurement used to determine the final result. The number of significant figures is not the same as the number of figures after the decimal point. For example, the value 20·6 has three significant figures and so has $1{\cdot}40 \times 10^{-5}$ but 0·06 and 1×10^{-5} have only one significant figure.

Conclusion

Your conclusion must:

- be under a separate heading
- relate to the aim of your project
- only be based on the experimental results obtained, and be valid based on these results
- be a judgement or decision made based on the results obtained

If the aim of your investigation was to determine the actual mass of a substance, then the conclusion must include the values obtained. For example, if the aim of the investigation was to determine the saponification value of an oil or oils, then you must provide the saponification values you determine in your conclusion.

If you write a conclusion after each experiment, you must link these together under the 'Conclusion' heading near the end of your report.

Do not include any additional conclusions if you have no supporting results or evidence for them.

Analysis

You must include a valid comparison of your experimental data with data from an internet/literature source.

If no internet/literature values are available to compare, then you must compare your duplicate experimental data.

Evaluation

Your evaluation must be under a separate heading and after the conclusion. It should include, if appropriate:

- statements evaluating your results, with appropriate justifications relating to your experimental procedures
- a statement evaluating the data from your internet/literature source(s)
- quantitative treatment of uncertainties

You may want to include:

- suggestions for the main sources of error that may have affected your results and how these were (or could have been) reduced
- how close your results were to the known values and the significance of this
- how close the results of your control experiments were to the known values and the significance of this
- the precision of your procedures, and how close the results were in duplicate experiments

- any modifications you made (or could have made) to improve the procedures in your investigation and how these relate to your results
- suggestions for why any procedures you attempted did not work
- what effect the uncertainties you identified in the procedures and apparatus had on the final calculated results

If you write an evaluation after each experiment, you must link these together under the 'Evaluation' heading at the end of your report.

References

The purpose of referencing is to show clearly which ideas or words are not your own, to provide enough information for someone else to find the source of those ideas or words, and to present that information consistently.

You must cite and reference (using a relevant referencing system), at least three different sources of information that you used. Different pages from the same book counts as **one** reference only. If you refer to the same website several times, this also counts as **one** reference.

Citation

When you use another person's work in your project report, either by referring to their ideas, or by including a direct quotation, you must acknowledge this in the main text of your report. This acknowledgement is called a citation.

The method used to cite references must be consistent throughout your report.

Reference list

The reference list is placed at the end of the report. It provides full information about every citation and allows the reader to locate each source you use.

There are many acceptable referencing systems and you must use one of these **consistently** throughout your report.

Example of a relevant referencing system

You should use a simple referencing system, for example, the one used by the Royal Society of Chemistry:

- **Citations**
  Superscript numbers are used to acknowledge a reference in the main text of the report.

  'Melting point analysis can be used to confirm the identity of a substance.[1]'

  Note: reference numbers are cited in the correct numerical order through the text.

- **References**

  References are listed at the end of the report in numerical order, with the following information.

Source	Reference
Website	Name of resource, URL, (accessed date). Note: URL and date accessed are essential. **For example:** The Merck Index Online, http://www.rsc.org/Merck-Index/monograph/mono1500000841, (accessed October 2013).
Journal	A. Name, B. Name and C. Name, *Journal Title*, year, **volume**, page. **For example:** T. J. Hebden, R. R. Schrock, M. K. Takase and P. Müller, *Chem. Commun.*, 2012, **48**, 1851–1853.
Book	A. Name, B. Name and C. Name, *Book Title*, Publisher, Publisher Location, year. **For example:** S T Beckett, *Science of Chocolate*, Royal Society of Chemistry, Cambridge, 2000.

Summary

You can use this table to check you have covered all the sections in your report.

Section	Expected response	Mark allocation
Abstract	A brief abstract (summary) stating the overall aim and conclusion of the project	1
Underlying chemistry	A description of the underlying chemistry that: ♦ is relevant to the project ♦ demonstrates an understanding of the underlying chemistry relevant to the aim ♦ demonstrates an understanding of the underlying chemistry of the techniques and procedures used ♦ uses chemical terms/ideas accurately	3
Data collection and handling	Procedure(s) clearly described in the past tense and use the impersonal voice	2
	Statement of appropriate safety measure(s) with justification(s)	1
	Data collected using methods of appropriate complexity, including one procedure and at least one of the following: ♦ a second procedure ♦ a modification in light of experience ♦ a control experiment ♦ standardisation of any solution where the accuracy of the concentration is crucial in an analysis	1
	Experimental results providing evidence that the procedure(s) has (have) been carried out in duplicate	1
	A description of the correct use of the appropriate apparatus, chemicals and any other substances to achieve the required levels of precision and/or accuracy	1
	All relevant raw data is recorded	1
	Numerical data is appropriately presented	1
	Citations and references for three sources of internet/literature data, using any relevant referencing system	1

Section	Expected response	Mark allocation
Data analysis	Analysis of data of a level of demand commensurate with Advanced Higher Chemistry. Analysis to include, as appropriate: ♦ values calculated correctly using chemical relationships ♦ scatter, line or bar graphs ♦ chromatograms ♦ spectra	4
	Calculated values stated to an appropriate number of significant figures	1
Conclusion	A valid conclusion that relates to the aim and is supported by all the data in the report	1
Analysis	A valid comparison of the experimental data with data from the internet/literature source(s), or a comparison of duplicate experimental data if no internet/literature source is available	1
Evaluation	Evaluation of the investigation including, as appropriate: ♦ evaluation of data from the internet/literature ♦ evaluative statements supported by justification ♦ quantitative treatment of uncertainties	4
Structure	A clear and concise report with an informative title, contents page and page numbers	1
Total		**25**

Once complete, give your report to your teacher or lecturer to submit to SQA.

Administrative information

Published: June 2020 (version 2.0)

History of changes

Version	Description of change	Date
1.1	Table heading on pp 19–24 corrected to correspond with marks in 'Data analysis' section.	July 2019
1.2	The chemical formula on page 34 for anhydrous copper(II) sulfate has been amended	December 2019
2.0	Additional wording added to 'Underlying Chemistry' in the Marking Instructions on page 10. Additional wording added to 'Example of a control experiment' in the Marking Instructions on page 13. Addition of 'Blank determinations' to 'Data collection and handling' in the Marking Instructions of page 14. Removal of 'colour change…' from 'Data collection and handling' in the Marking Instructions of page 16. Additional wording added to 'Data collection and handling' in the Marking Instructions of page 17.	June 2020

Note: you are advised to check SQA's website to ensure you are using the most up-to-date version of this document.

Security and confidentiality

This document can be used by SQA approved centres for the assessment of National Courses and not for any other purpose.