



# **IB Chemistry**

## **Extended essay guidelines**



## **Nature of the extended essay**

The extended essay is an in-depth study of a focused topic chosen from the list of approved Diploma Programme subjects—normally one of the student's six chosen subjects for the IB diploma. It is intended to promote high-level research and writing skills, intellectual discovery and creativity. It provides students with an opportunity to engage in personal research in a topic of their own choice, under the guidance of a supervisor (a teacher in the school). This

leads to a major piece of formally presented, structured writing, in which ideas and findings are communicated in a reasoned and coherent manner, appropriate to the subject chosen. It is recommended that completion of the written essay is followed by a short, concluding interview, or *viva voce*, with the supervisor. The extended essay is assessed against common criteria, interpreted in ways appropriate to each subject.

The extended essay is:

- compulsory for all Diploma Programme students
- externally assessed and, in combination with the grade for theory of knowledge, contributes up to three points to the total score for the IB diploma
- a piece of independent research/investigation on a topic chosen by the student in cooperation with a supervisor in the school
- chosen from the list of approved Diploma Programme subjects, published in the Handbook of procedures for the Diploma Programme
- presented as a formal piece of scholarship containing no more than 4,000 words
- the result of approximately 40 hours of work by the student
- concluded with a short interview, or *viva voce*, with the supervising teacher (recommended).

In the Diploma Programme, the extended essay is the prime example of a piece of work where the student has the opportunity to show knowledge, understanding and enthusiasm about a topic of his or her choice. In those countries where it is the norm for interviews to be required prior to acceptance for employment or for a place at university, the extended essay has often proved to be a valuable stimulus for discussion.

## **Aims**

The aims of the extended essay are to provide students with the opportunity to:

- pursue independent research on a focused topic
- develop research and communication skills
- develop the skills of creative and critical thinking
- engage in a systematic process of research appropriate to the subject
- experience the excitement of intellectual discovery.

## **Assessment objectives**

In working on the extended essay, students are expected to:

1. plan and pursue a research project with intellectual initiative and insight
2. formulate a precise research question
3. gather and interpret material from sources appropriate to the research question
4. structure a reasoned argument in response to the research question on the basis of the material gathered
5. present their extended essay in a format appropriate to the subject, acknowledging sources in one of the established academic ways
6. use the terminology and language appropriate to the subject with skill and understanding
7. apply analytical and evaluative skills appropriate to the subject, with an understanding of the implications and the context of their research.

## **Responsibilities of the supervisor**

It is required that the supervisor:

- provides the student with advice and guidance in the skills of undertaking research
- encourages and supports the student throughout the research and writing of the extended essay
- discusses the choice of topic with the student and, in particular, helps to formulate a well-focused research question
- ensures that the chosen research question satisfies appropriate legal and ethical standards with regard to health and safety, confidentiality, human rights, animal welfare and environmental issues
- is familiar with the regulations governing the extended essay and the assessment criteria, and gives copies of these to the student
- monitors the progress of the extended essay to offer guidance and to ensure that the essay is the student's own work (this may include presenting a section of the essay for supervisor comment)
- reads and comments on one completed draft only of the extended essay (but does not edit the draft)
- reads the final version to confirm its authenticity
- submits a predicted grade for the student's extended essay to IB
- completes the supervisor's report (if the extended essay cover is not signed by both the student and the supervisor, the essay will not be accepted for assessment and may be returned to the school)

- provides an explanation in the report in cases where the number of hours spent with the student in discussing the extended essay is zero; in particular, it is necessary to describe how it has been possible to guarantee the authenticity of the essay in such circumstances
- writes a report and presents it to the school's Diploma Programme coordinator if malpractice, such as plagiarism, is suspected in the final draft.

### **Responsibilities of the student**

It is required that students:

- choose a topic that fits into one of the subjects on the approved extended essay list
- observe the regulations relating to the extended essay
- meet deadlines
- acknowledge all sources of information and ideas in an approved academic manner.

It is strongly recommended that students:

- start work early
- think very carefully about the research question for their essay
- plan how, when and where they will find material for their essay
- plan a schedule for both researching and writing the essay, including extra time for delays and unforeseen problems
- record sources as their research progresses (rather than trying to reconstruct a list at the end)
- have a clear structure for the essay itself before beginning to write
- check and proofread the final version carefully
- make sure that all basic requirements are met (for example, all students should get full marks for the abstract).

## **Advice to students from examiners**

Recommended: things to do

- read the assessment criteria
- read previous essays to identify strengths and possible pitfalls
- spend time working out the research question (imagine the finished essay)
- work out a structure for the essay.

During the research process, and while writing the essay, students should:

- start work early and stick to deadlines
- maintain a good working relationship with their supervisor
- construct an argument that relates to the research question
- use the library and consult librarians for advice
- record sources as they go along (rather than trying to reconstruct a list at the end)
- choose a new topic and a research question that can be answered if there is a problem with the original topic
- use the appropriate language for the subject
- let their interest and enthusiasm show.

After completing the essay, students should:

- write the abstract
- check and proofread the final version carefully.

## **Recommended: things to avoid**

Examiners' reports also mention these things to be avoided at all costs.

- Students should not work with a research question that is too broad or too vague, too narrow, too difficult or inappropriate. A good research question is one that asks something worth asking and that is answerable within 40 hours/4,000 words. It should be clear what would count as evidence in relation to the question, and it must be possible to acquire such evidence in the course of the investigation. If a student does not know what evidence is needed, or cannot collect such evidence, it will not be possible to answer the research question.

In addition, students should not:

- forget to analyse the research question
- ignore the assessment criteria

- collect material that is irrelevant to the research question
- use the internet uncritically
- plagiarize
- merely describe or report (evidence must be used to support the argument)
- repeat the introduction in the conclusion
- cite sources that are not used.

One further piece of advice is as follows: the more background a student has in the subject, the better the chance he or she has of writing a good extended essay. Choosing to write the extended essay in a subject that is not being studied as part of the Diploma Programme often leads to lower marks.

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## Researching and writing the extended essay

### ***The research process***

When researching the extended essay, students should do the following.

1. Choose the approved Diploma Programme subject for the extended essay.
  - Read the assessment criteria and the relevant subject guidance.
2. Choose a topic.
3. Formulate a well-focused research question.
4. Plan the investigation and writing process.
  - Identify how and where they will gather material.
  - Identify which system of academic referencing they will use, appropriate to the subject of the essay.
  - Set deadlines for themselves that will allow them to meet the school's requirements.
5. Plan a structure (outline headings) for the essay. This may change as the investigation develops but it is useful to have a sense of direction.
6. Undertake some preparatory reading.
  - If students discover that it will not be possible to obtain the evidence needed in the time available, the research question should be changed. This should be done sooner rather than later: students should not lose time waiting and hoping that something will turn up. Students should go back to stage 3, 2 or 1, and choose a new research question that can be answered.

7. Carry out the investigation.

- The material gathered should be assembled in a logical order, linked to the structure of the essay. Only then will students know whether they have enough evidence for each stage of the argument so that they can proceed to the next.
- Students should be prepared for things to go wrong. Sometimes they may discover something later in the investigation that undermines what they thought had been established earlier on. If that happens, the investigation plan needs to be revised.

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## **Writing the extended essay**

The structure of the essay is very important. This is what helps students to organize the argument, making best use of the evidence gathered. The required elements of the final work to be submitted are listed here. More details about each element are given in the “Formal presentation of the extended essay” section. Please note that the order in which they are presented here is not necessarily the order in which they should be written.

- Title page
- Abstract
- Contents page
- Introduction
- Body (development/methods/results)
- Conclusion
- References and bibliography
- Appendices

Students should use the chosen system of academic referencing as soon as they start writing. That way, they are less likely to forget to include a citation. It is also easier than trying to add references at a later stage. Most modern word processors are helpful with this.

Some students draft the introduction first. If students do that, they must be prepared to revise it once the essay is complete.

The main task is writing the body of the essay, which should be presented in the form of a reasoned argument. The form of this varies with the subject of the essay but, as the argument develops, it should be clear to the reader what relevant evidence has been discovered, where/how it has been discovered and how it supports the argument. In most subjects, sub-headings within the main body of the essay will help the reader to understand the argument (and will also help the student to keep on track).

Once the main body of the essay is complete, it is possible to finalize the introduction (which tells the reader what to expect) and the conclusion (which says what has been achieved, including notes of any limitations and any questions that have not been resolved).

Any information that is important to the argument should not be included in appendices or footnotes/endnotes.

The examiner is not bound to read notes or appendices, so an essay that is not complete in itself will lose marks.

The remaining stages in writing the essay take time but are not difficult. Students need to check that they have cited sources for all material that is not their own, and that the citations are complete and consistent with the chosen referencing system. The bibliography should list only the sources used in the essay. The whole essay needs to be proofread carefully (computer spelling and grammar checkers are useful but will not do everything). Pages must be numbered and the contents page must be completed. The abstract is normally written last.

### **Formal presentation of the extended essay**

The extended essay should be written in a clear, correct and formal academic style, appropriate to the subject from which the topic is drawn. The use of word processors is encouraged.

### ***The length of the extended essay***

The upper limit is 4,000 words for all extended essays. This upper limit includes the introduction, the body, the conclusion and any quotations, but **does not include**:

- the abstract
- acknowledgments
- the contents page
- maps, charts, diagrams, annotated illustrations and tables
- equations, formulas and calculations
- citations/references (whether parenthetical or numbered)
- footnotes or endnotes
- the bibliography
- appendices.

Essays containing more than 4,000 words are subject to penalties and examiners are not required to read material in excess of the word limit.

### ***Title***

The title should provide a clear indication of the focus of the essay. It should be precise and not necessarily phrased in the form of a question.

### ***Abstract***

An abstract not exceeding 300 words must be included with the essay submitted. It does not serve as an introduction, but presents an overview of the extended essay, and should, therefore, be **written last**.

The inclusion of an abstract is intended to encourage students to examine closely the development of an argument within the extended essay and the pertinence of any conclusions that are reached. It is also designed to allow readers to understand quickly the contents of the extended essay.

The minimum requirements for the abstract are for it to state clearly:

- the research question being investigated
- the scope of the investigation
- the conclusion(s) of the extended essay.



The abstract should be typed or word processed on one side of a sheet of paper, and placed immediately after the title page.

### ***Contents page***

A contents page must be provided at the beginning of the extended essay and all pages should be numbered. An index is not required.

### ***Illustrations***

Presentation and overall neatness are important, and it is essential that illustrative material, if included, is well set out and used effectively. Graphs, diagrams, tables and maps are effective only if they are clearly labelled and can be interpreted with ease. All such material that is incorporated into the extended essay must be directly related to the text and acknowledged where appropriate. The use of photographs and other images is acceptable only if they are captioned and/or annotated and are used to illustrate a specific point made in the extended essay.

### ***Bibliographies, references and citations***

An extended essay must reflect intellectual honesty in research practices and provide the reader with the exact sources of quotations, ideas and points of view through accurate bibliographies and referencing. Producing accurate citations, referencing and a bibliography is a skill that students should be seeking to perfect. Documenting the research in this way is vital: it allows readers to evaluate the evidence for themselves and it shows the student's understanding of the importance of the sources used.

Failure to comply with this requirement will be viewed as plagiarism and will, therefore, be treated as a case of malpractice.

### ***What is a bibliography?***

A bibliography is an alphabetical list of every source used to research and write the essay. Sources that are not cited in the body of the essay, but were important in informing the approach taken, should be cited in the introduction or in an acknowledgment. The bibliography should list only those sources cited.

The MLA documentation style should be applied in both the final draft of the essay and in the initial research stages of taking notes. This is good practice, not only for producing a high-quality final product, but also for reducing the opportunities and temptation to plagiarize.

More information about the MLA referencing system can be found here:

<http://owl.english.purdue.edu/owl/resource/747/01/>

### ***What is a reference?***

A reference is a way of indicating to the reader, in an orderly form, where information has been obtained. A reference provides all the information needed to find the source material. References must be cited because they acknowledge the sources used, and enable the reader to consult the work and verify the data that has been presented.

References must be given whenever someone else's work is quoted or summarized. References can come from many different sources, including books, magazines, journals, newspapers, emails, internet sites and interviews.

Internet references should include the title of the extract used as well as the website address, the date it was accessed and, if possible, the author. Caution should be exercised with information on websites that do not give references or that cannot be cross-checked against other sources. The more important a particular point is to the essay, the more the quality of its source needs to be evaluated.

Any references to interviews should state the name of the interviewer, the name of the interviewee, the date and the place of the interview.

### ***What is a citation?***

A citation is a shorthand method of making a reference in the body of an essay, which is then linked to the full reference at the end of the essay. A citation provides the reader with accurate references so that he or she can locate the source easily. How sources are cited varies with the particular documentation style that has been chosen.

Page numbers should normally be given when referencing printed material: in some styles this will be in the citation, in others in the full reference. Once again, it is important to emphasize that there must be consistency of method when citing sources.

### **Appendices, footnotes and endnotes**

Appendices, footnotes and endnotes are not an essential section of the extended essay and examiners are not required to read them, so care should be taken to include all information of direct relevance to the analysis and argument in the main body of the essay. An essay that attempts to evade the word limit by including important material in notes or appendices risks losing marks under several criteria.

Unless considered essential, complete lists of raw data should not be included in the extended essay.

Students should not constantly refer to material presented in an appendix as this may disrupt the continuity of the essay.

### **The *viva voce* (concluding interview)**

The *viva voce* is a short interview between the student and the supervisor, and is a recommended conclusion to the extended essay process. Students who do not attend the *viva voce* may be disadvantaged.

The *viva voce* serves the following purposes.

- A check on plagiarism and malpractice in general
- An opportunity to reflect on successes and difficulties in the research process
- An opportunity to reflect on what has been learned
- An aid to the supervisor's report

The *viva voce* should last between 10 and 15 minutes. This is included in the recommended amount of time the supervisor should spend with the student. The following are examples of questions that can be asked, which should be adapted to the particular essay and student.

- "I am not clear what you mean on page XXX. You quote Y: could you explain a little more about what this tells us?"

- “On page \*\*\* you cite Z. I couldn’t find this reference (for example, website). Could you tell me more about it?”
- “What have been the high and low points of the research and writing processes?”
- “What were the most interesting aspects of the process? Did you discover anything that surprised you?”
- “What have you learned through writing this essay? Is there any advice you would want to pass on to someone just starting out on an extended essay?”
- “Is there anything else that you would particularly like me to mention in my report?”

In conducting the viva voce and writing the report, supervisors should bear in mind the following.

- Examiners want to know that students understand any material (which must be properly referenced) that they have included in their essays. This is particularly important in subjects like mathematics. If the way the material is used in context in the essay does not clearly establish this, the supervisor can check the student’s understanding in the viva voce and report on it.
- Minor slips in citation and referencing may lose the odd mark. If there appear to be major shortcomings, the supervisor should investigate thoroughly. No essay should be authenticated if the supervisor believes it contains plagiarism.
- In assessing criterion K (holistic judgment), examiners will take into account any information given in the report about unusual intellectual inventiveness or persistence in the face of unexpected difficulties.
- The report should not attempt to do the examiner’s job. It should refer to things, largely process-related, that may not be obvious in the essay itself.
- Unless there are particular problems, the viva voce should end positively. Completion of a major piece of work such as the extended essay is something for students to feel good about.

## Assessment criteria

All extended essays are externally assessed by examiners appointed by the IB, and are marked on a scale from 0 to 36. This maximum score is made up of the total criterion levels available for each essay. The total score obtained on the scale 0 to 36 is used to determine in which of the following bands the extended essay is placed.

This band, in conjunction with the band for theory of knowledge, determines the number of diploma points awarded for these two requirements. See the following “Award of diploma points” section for further details.

The band descriptors are:

- A** Work of an excellent standard
- B** Work of a good standard
- C** Work of a satisfactory standard
- D** Work of a mediocre standard
- E** Work of an elementary standard.

### Award of diploma points

The extended essay contributes to the overall diploma score through the award of points in conjunction with theory of knowledge. A maximum of three points are awarded according to a student’s combined performance in both the extended essay and theory of knowledge.

Both the extended essay and theory of knowledge are measured against published assessment criteria. According to the quality of the work, and based on the application of these assessment criteria, a student’s performance in each of the extended essay and theory of knowledge will fall into one of the five bands described previously.

The total number of points awarded is determined by the combination of the performance levels achieved by the student in both the extended essay and theory of knowledge according to the following matrix.

		Theory of knowledge					
		Excellent <b>A</b>	Good <b>B</b>	Satisfactory <b>C</b>	Mediocre <b>D</b>	Elementary <b>E</b>	Not submitted
Extended essay	Excellent <b>A</b>	3	3	2	2	1 + Failing condition*	N
	Good <b>B</b>	3	2	1	1	Failing condition*	N
	Satisfactory <b>C</b>	2	1	1	0	Failing condition*	N
	Mediocre <b>D</b>	2	1	0	0	Failing condition*	N
	Elementary <b>E</b>	1 + Failing condition*	Failing condition*	Failing condition*	Failing condition*	Failing condition*	N
	Not submitted	N	N	N	N	N	N

A student who, for example, writes a good extended essay and whose performance in theory of knowledge is judged to be satisfactory will be awarded 1 point, while a student who writes a mediocre extended essay and whose performance in theory of knowledge is judged to be excellent will be awarded 2 points.

A student who fails to submit an extended essay will be awarded N for the extended essay, will score no points, and will not be awarded a diploma.

Performance in both the extended essay and theory of knowledge of an elementary standard is a failing condition for the award of the diploma.

\* From 2010 onwards, 28 points overall will be required to be eligible for the diploma if a student attains an "E" grade in either the extended essay or theory of knowledge. As previously, a grade "A" in one of the requirements earns an extra point even if the other is a grade "E". Attaining a grade "E" in both the extended essay and theory of knowledge continues to represent an automatic failure.

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### Criterion A: research question

This criterion assesses the extent to which the purpose of the essay is specified. In many subjects, the aim of the essay will normally be expressed as a question and, therefore, this criterion is called the “research question”. However, certain disciplines may permit or encourage different ways of formulating the research task.

Achievement level	Descriptor
0	The research question is not stated in either the introduction or on the title page or does not lend itself to a systematic investigation in an extended essay in the subject in which it is <b>registered</b> .
1	The research question is stated in either the introduction or on the title page but is not clearly <b>expressed or is too broad in scope to be treated effectively within the word limit</b> .
2	The research question is clearly stated in either the introduction or on the title page and is <b>sharply focused, making effective treatment possible within the word limit</b> .

### Criterion B: introduction

This criterion assesses the extent to which the introduction makes clear how the research question relates to existing knowledge on the topic and explains how the topic chosen is significant and worthy of investigation.

Achievement level	Descriptor
0	Little or no attempt is made to set the research question into context. There is <b>little or no attempt to explain the significance of the topic</b> .
1	Some attempt is made to set the research question into context. There is <b>some attempt to explain the significance of the topic and why it is worthy of investigation</b> .
2	The context of the research question is clearly demonstrated. The introduction <b>clearly explains the significance of the topic and why it is worthy of investigation</b> .

### Criterion C: investigation

This criterion assesses the extent to which the investigation is planned and an appropriate range of sources has been consulted, or data has been gathered, that is relevant to the research question. Where the research question does not lend itself to a systematic investigation in the subject in which the essay is registered, the maximum level that can be awarded for this criterion is 2.

Achievement level	Descriptor
0	There is little or no evidence that sources have been consulted or data gathered, and little or no <b>evidence of planning in the investigation.</b>
1	A range of inappropriate sources has been consulted, or inappropriate data has been gathered, <b>and there is little evidence that the investigation has been planned.</b>
2	A limited range of appropriate sources has been consulted, or data has been gathered, and some relevant material has been selected. <b>There is evidence of some planning in the investigation.</b>
3	A sufficient range of appropriate sources has been consulted, or data has been gathered, and relevant material has been selected. <b>The investigation has been satisfactorily planned.</b>
4	An imaginative range of appropriate sources has been consulted, or data has been gathered, and relevant material has been carefully selected. <b>The investigation has been well planned.</b>

### Criterion D: knowledge and understanding of the topic studied

Where the research question does not lend itself to a systematic investigation in the subject in which the essay is registered, the maximum level that can be awarded for this criterion is 2. "Academic context", as used in this guide, can be defined as the current state of the field of study under investigation. However, this is to be understood in relation to what can reasonably be expected of a pre-university student. For example, to obtain a level 4, it would be sufficient to relate the investigation to the principal lines of inquiry in the relevant field; detailed, comprehensive knowledge is not required.

Achievement level	Descriptor
0	<b>The essay demonstrates no real knowledge or understanding of the topic studied.</b>
1	The essay demonstrates some knowledge but little understanding of the topic studied. <b>The essay shows little awareness of an academic context for the investigation.</b>
2	The essay demonstrates an adequate knowledge and some understanding of the topic studied. <b>The essay shows some awareness of an academic context for the investigation.</b>
3	The essay demonstrates a good knowledge and understanding of the topic studied. <b>Where appropriate, the essay successfully outlines an academic context for the investigation.</b>
4	The essay demonstrates a very good knowledge and understanding of the topic studied. <b>Where appropriate, the essay clearly and precisely locates the investigation in an academic context.</b>

### Criterion E: reasoned argument

This criterion assesses the extent to which the essay uses the material collected to present ideas in a logical and coherent manner, and develops a reasoned argument in relation to the research question. Where the research question does not lend itself to a systematic investigation in the subject in which the essay is registered, the maximum level that can be awarded for this criterion is 2.

Achievement level	Descriptor
0	<b>There is no attempt to develop a reasoned argument in relation to the research question.</b>
1	There is a <b>limited or superficial attempt</b> to present ideas in a logical and coherent manner, and <b>to develop a reasoned argument in relation to the research question.</b>
2	There is <b>some attempt</b> to present ideas in a logical and coherent manner, and to develop a <b>reasoned argument in relation to the research question, but this is only partially successful.</b>
3	Ideas are presented in a logical and coherent manner, and a reasoned argument is developed <b>in relation to the research question, but with some weaknesses.</b>
4	Ideas are presented clearly and in a logical and coherent manner. The essay succeeds in <b>developing a reasoned and convincing argument in relation to the research question.</b>

### Criterion F: application of analytical and evaluative skills appropriate to the subject

Achievement level	Descriptor
0	<b>The essay shows no application of appropriate analytical and evaluative skills.</b>
1	<b>The essay shows little application of appropriate analytical and evaluative skills.</b>
2	The essay shows some application of appropriate analytical and evaluative skills, which may be <b>only partially effective.</b>
3	<b>The essay shows sound application of appropriate analytical and evaluative skills.</b>
4	The essay shows <b>effective and sophisticated application</b> of appropriate <b>analytical and evaluative skills.</b>



### Criterion G: use of language appropriate to the subject

Achievement level	Descriptor
0	The language used is inaccurate and unclear. There is no effective use of terminology <b>appropriate to the subject</b> .
1	The language used sometimes communicates clearly but does not do so consistently. The use of terminology <b>appropriate to the subject is only partly accurate</b> .
2	The language used for the most part communicates clearly. The use of terminology <b>appropriate to the subject is usually accurate</b> .
3	The language used communicates clearly. The use of terminology appropriate to the subject is <b>accurate, although there may be occasional lapses</b> .
4	The language used communicates clearly and precisely. Terminology appropriate to the <b>subject is used accurately, with skill and understanding</b> .

### Criterion H: conclusion

This criterion assesses the extent to which the essay incorporates a conclusion that is relevant to the research question and is consistent with the evidence presented in the essay.

Achievement level	Descriptor
0	<b>Little or no attempt is made to provide a conclusion that is relevant to the research question.</b>
1	A conclusion is attempted that is relevant to the research question but may not be entirely <b>consistent with the evidence presented in the essay</b> .
2	An effective conclusion is clearly stated; it is relevant to the research question and consistent with the evidence presented in the essay. It should include unresolved questions where <b>appropriate to the subject concerned</b> .

### Criterion I: formal presentation

This criterion assesses the extent to which the layout, organization, appearance and formal elements of the essay consistently follow a standard format. The formal elements are: title page, table of contents, page numbers, illustrative material, quotations, documentation (including references, citations and bibliography) and appendices (if used).

Achievement level	Descriptor
0	The formal presentation is unacceptable, or the essay exceeds 4,000 words.
1	The formal presentation is poor.
2	The formal presentation is satisfactory.
3	The formal presentation is good.
4	The formal presentation is excellent.

**Criterion J: abstract**

The requirements for the abstract are for it to state clearly the research question that was investigated, how the investigation was undertaken and the conclusion(s) of the essay.

Achievement level	Descriptor
0	The abstract exceeds 300 words or one or more of the required elements of an abstract (listed above) is missing.
1	The abstract contains the elements listed above but they are not all clearly stated.
2	The abstract clearly states all the elements listed above.

**Criterion K: holistic judgment**

The purpose of this criterion is to assess the qualities that distinguish an essay from the average, such as intellectual initiative, depth of understanding and insight. While these qualities will be clearly present in the best work, less successful essays may also show some evidence of them and should be rewarded under this criterion.

Achievement level	Descriptor
0	The essay shows no evidence of such qualities.
1	The essay shows little evidence of such qualities.
2	The essay shows some evidence of such qualities.
3	The essay shows clear evidence of such qualities.
4	The essay shows considerable evidence of such qualities.

**Academic honesty**

The student is ultimately responsible for ensuring that his or her extended essay is authentic, with the work or ideas of others fully and correctly acknowledged. Additionally, it is the responsibility of a supervisor to confirm that, for each student he or she has supervised, to the best of his or her knowledge, the version of the extended essay submitted for assessment is the authentic work of the student.

Both plagiarism and collusion are forms of malpractice that incur a penalty. The same piece of work, or two versions of the same work, cannot be submitted to meet the requirements of both the extended essay and another assessment component of a subject contributing to the diploma or an additional certificate.

## The extended essay in Chemistry

### Overview

An extended essay in chemistry provides students with an opportunity to investigate a particular aspect of the materials of our environment. Such extended essays must be characterized by a particular chemical emphasis within a more general set of research criteria. The outcome of the research should be a coherent and structured piece of writing that effectively addresses a particular issue or research question and arrives at a particular, and preferably personal, conclusion.

### Choice of topic

It is important that the extended essay has a clear chemical emphasis and is not more closely related to another subject. Chemistry is the science that deals with the composition, characterization and transformation of substances. A chemistry extended essay should, therefore, incorporate chemical principles and theory, and emphasize the essential nature of chemistry, relating to the study of matter and of the changes it undergoes.

Although the same assessment criteria apply to all extended essays, for an extended essay submitted in chemistry the topic chosen must allow an approach that distinctly involves chemistry. Where a topic might be approached from different viewpoints, the treatment of the material must be approached from a chemistry perspective. For example, an extended essay in an interdisciplinary area such as biochemistry will, if registered as a chemistry extended essay, be judged on its chemical content, not its biological content.

The scope of the topic and the research associated with it should enable all the criteria to be addressed. A good topic is one where the single research question is sharply focused and can be treated effectively within the word limit. Perhaps the most important factor is the depth of treatment that can be given to the topic by the student.

Broad or complex survey topics (for example, investigations into health problems caused by water pollution, chemotherapy for cancer treatment or the use of spectroscopy in chemical analysis) will not permit the student to discuss conflicting ideas and theories, nor to produce an in-depth personal analysis within the word limit.

Some topics may be unsuitable for investigation because of safety issues. For example, experiments involving toxic or dangerous chemicals, carcinogenic substances or radioactive materials should be avoided unless adequate safety apparatus and qualified supervision are available.

Other topics may be unsuitable because the outcome is already well known and documented in standard textbooks, **and** the student may not be able to show any personal input. An example might be a study of the reactions of the alkali metals with water as this is already covered by the syllabus. However, some care does need to be exercised in deciding whether a topic is suitable or not; for example, previously, the study of the allotropes of carbon might have been thought to be trivial but this would not be the case today.

The following examples of titles for chemistry extended essays are intended as guidance only. The pairings illustrate that focused topics (indicated by the first title) should be encouraged rather than broad topics (indicated by the second title).

- “The ratio of the gases evolved at the positive electrode during the electrolysis of common salt solution” **is better than** “Electrolysis of solutions”.
- “Spectrophotometric determination of trace amounts of lead in drinking water” **is better than** “Water analysis”.
- “The effects of sugar-free chewing gum on the pH of saliva in the mouth after a meal” **is better than** “Acid–base chemistry”.
- “How can the natural oxidant rutin be extracted and purified from the seed of the Chinese Scholartree?” **is better than** “Extraction of natural products from plants”.

Moreover, it may help if the student further defines and refines the topic chosen for study in the form of a research question or statement.

<b>Title</b>	<b>The ratio of the gases evolved at the positive electrode during the electrolysis of common salt solution</b>
Research question	Is there a relationship between the concentration of aqueous sodium chloride solution and the ratio of the amounts of oxygen and chlorine gas that are evolved at the positive electrode during electrolysis?
<b>Title</b>	<b>The caffeine content of a cup of tea</b>
Research question	Does the time it takes to brew a cup of tea using a specific commercial brand of tea leaves significantly alter the amount of caffeine that is dissolved in the drink?
<b>Title</b>	<b>Analysis of strawberry jellies by paper chromatography</b>
Research question	The use of paper chromatography to determine whether strawberry jellies obtained from 24 different countries in 5 different continents all contain the same red dyes.

### **Treatment of the topic**

An extended essay in chemistry may be based on literature, theoretical models or experimental data. Whichever category or combination of categories is chosen, the student should ensure that sufficient data is available for evaluation and that the topic can be researched accurately using locally available resources.

Students who choose to write an extended essay based on literature and/or surveys should ensure that their extended essay clearly shows its chemical basis. Essays written at the level of a newspaper or news magazine article are unlikely to achieve a high mark.

Since chemistry is an experimental science, students are strongly encouraged to undertake experimental work as part of their research, although this is not compulsory. In order to place their research into the appropriate context, students should research the area of the investigation before commencing any experimental work. Where possible,

they should consult original research using scientific journals, personal communications and the internet. Textbooks should never be the only source of information.

All essays involving experimental work undertaken by the student should include a clear and concise description of the experimental work. Students should indicate clearly whether they have personally designed the experiment, or give the source of an existing experiment method that they have used and state how they have adapted and improved upon it. All essays must be supervised by a school supervisor. Many of the best essays are written by students investigating relatively simple phenomena using apparatus and materials that can be found in most school laboratories, and this approach is to be encouraged. If the practical work is carried out in an industrial or university laboratory, the essay should be accompanied by a letter from the external supervisor outlining the nature of the supervision and the level of guidance provided. The school supervisor must be satisfied that the work described in the essay is genuine and essentially that of the student.

Data collected from an experiment designed by the student is of little value unless it is analysed using appropriate scientific techniques, evaluated and perhaps compared with appropriate models.

It is possible to produce an extended essay in chemistry in which the student has used data collected elsewhere as the primary source. In such cases, the element of personal analysis and evaluation is extremely important.

In any chemistry extended essay, students should be able to demonstrate that they understand the theory underlying any experimental work and state any assumptions made. They should show an understanding of the results obtained and be able to interpret them with reference to the research question posed. They should be critical of inadequate experimental design, the limitations of the experimental method and any systematic errors. Students should be encouraged to consider unresolved questions in their research, and to suggest new questions and areas for further investigation in their conclusion. Throughout the whole of the essay, students should emphasize clearly their own personal contribution.

## **Interpreting the assessment criteria**

### **Criterion A: research question**

Many research questions can be formulated as an actual question or questions. A typical example is: "What gas is evolved when zinc is added to copper (II) sulfate solution and what factors affect its formation?". However, in chemistry extended essays it is perfectly reasonable to formulate the research question as a statement or as a hypothesis rather than an actual question. "An analysis of the amount of aluminium in three different brands of underarm deodorant by visible spectroscopy" and "The kinetics of oxidation of iodide ions with hydrogen peroxide in acidic solutions" are two such examples where a statement rather than a question is appropriate. Whichever way it is formulated, it should be identified clearly as the research question and set out prominently in the introduction.

### **Criterion B: introduction**

The purpose of the introduction is to set the research question into context, that is, to relate the research question to existing knowledge in chemistry. It is usually appropriate to include also the underlying chemical theory required to understand how the research question has arisen. Some research questions require some background knowledge that is not related to chemistry—for example, "Do the fossils found in different strata of rocks at

a particular location contain different amounts of sulfur?” . For the essay to make sense, it would be important to state the ages of the rocks and give some geological background. In such cases, only the essential non-chemistry information should be provided in the introduction, as the essay will be marked on its chemical content. If it is necessary to include more non-chemistry (for example, geological) information, then the appropriate place for it is the appendix.

### **Criterion C: investigation**

The way in which the investigation is undertaken will depend very much on whether or not the essay contains experimental work performed by the student. For non-experimental essays, students should endeavour to show clearly how the data has been selected. They should distinguish between primary sources (original scientific publications, personal communications, interviews) and secondary sources (textbooks, newspaper articles, reviews), and show awareness of how reliable these sources are. For experimental work, sufficient information should be provided so that the work could be repeated if necessary by an independent worker. Students should make it clear which experiments they have designed themselves and which they have altered, adapted or improved from existing methods.

### **Criterion D: knowledge and understanding of the topic studied**

Students should show that they understand fully the underlying chemistry behind the context of their research question and their subsequent investigation. They are not expected to explain basic chemistry forming part of the Diploma Programme chemistry course, but they are expected to show that they fully understand the relevant principles and ideas and can apply them correctly. They should also demonstrate that they understand the theory behind any techniques or apparatus used.

### **Criterion E: reasoned argument**

Students should be aware of the need to give their essays the backbone of a developing argument. A good argument in chemistry will almost certainly include consideration and comparison of different approaches and methods directly relevant to the research question. Straightforward descriptive or narrative accounts that lack analysis do not usually advance an argument and should be avoided.

### **Criterion F: application of analytical and evaluative skills appropriate to the subject**

A thorough understanding of the reliability of all data used to support the argument should be shown. Inadequate experimental design or any systematic errors should be exposed. The magnitude of uncertainties in physical data should be evaluated and discussed. Approximations in models should be accounted for and all assumptions examined thoroughly. Where possible, the quality of sources accessed or data generated should be verified by secondary sources or by direct calculations.

### **Criterion G: use of language appropriate to the subject**

Correct chemical terminology and nomenclature should be used consistently and effectively throughout the extended essay. Relevant chemical formulas (including structural formulas), balanced equations (including state symbols) and mechanisms should be included. The correct units for physical quantities must always be given and the proper use of significant figures is expected.

**Criterion H: conclusion**

The conclusion must be consistent with the argument presented and should not merely repeat material in the introduction or introduce new or extraneous points to the argument. In chemistry, it is almost always pertinent to consider unresolved questions and to suggest areas for further investigation.

**Criterion I: formal presentation**

This criterion relates to the extent to which the essay conforms to academic standards about the way in which research papers should be presented. The presentation of essays that omit a bibliography or that do not give references is deemed unacceptable (level 0). Essays that omit one of the required elements—title page, table of contents, page numbers—are deemed no better than satisfactory (maximum level 2), while essays that omit two of them are deemed poor at best (maximum level 1).

The essay must not exceed 4,000 words of narrative. Graphs, figures, calculations, diagrams, formulas and equations are not included in the word count. For experiments where numerical results are calculated from data obtained by changing one of the variables, it is generally good practice to show one example of the calculation. The remainder can be displayed in tabular or graphical form.

**Criterion J: abstract**

The abstract is judged on the clarity with which it presents an overview of the research and the essay, not on the quality of the research question itself, nor on the quality of the argument or the conclusions.

**Criterion K: holistic judgment**

Qualities that are rewarded under this criterion include the following.

- Intellectual initiative: Ways of demonstrating this in chemistry essays include the choice of topic and research question, and the use of novel or innovative approaches to address the research question.
- Insight and depth of understanding: These are most likely to be demonstrated as a consequence of detailed research and thorough reflection, and by a well-informed and reasoned argument that consistently and effectively addresses the research question.
- Originality and creativity: These will be apparent by clear evidence of a personal approach backed up by solid research and reasoning.

**The information in this document is taken from:**

The International Baccalaureate Organization ® *Extended Essay Guide (First examinations 2013)*