

## Subject-specific guidance

### Overview

This section covers individual subjects' requirements for the extended essay (EE) in terms of:

- Choice of topic
- Treatment of topic
- Assessment:
  - Criterion A: focus and method
  - Criterion B: knowledge and understanding
  - Criterion C: critical thinking
  - Criterion D: presentation
  - Criterion E: engagement.

It assumes that teachers are already familiar with the EE generic guide and the EE teacher support material, in particular the process whereby students choose a subject area and topic, write their research question and select the research method(s) they will use to explore and answer it.

For a full summary, see the process diagram and the generic assessment criteria.

Or for a quick refresher, read [Extended essay: general requirements](#) .

## General requirements

The EE is an in-depth study of a focused topic. It gives students the opportunity to:

- engage in independent research with intellectual initiative, creativity and rigour
- develop research, thinking, self-management and communication skills
- reflect on what they have learned throughout the research and writing process.

All students must:

- provide a logical and coherent rationale for their choice of topic
- review what has already been written about the topic
- formulate a clear research question
- offer a concrete description of the methods they use to investigate the question
- generate reasoned interpretations and conclusions based on their reading and independent research in order to answer the question.

## Choice of topic

See also *Initial guidance on research and writing*

Students first need to identify the broad area of inquiry they are interested in.

Sources of ideas may include:

- work already undertaken as part of the course
- preliminary reading of academic journals and reputable scholarly e-resources, eg conference papers, essays, book chapters or journal articles. A school librarian can advise on this
- conversations with teachers, fellow students and librarians.

## Literature review

Students should try to read as much as they can of what has already been written about their topic. Time spent on a literature review early on in the research process will guide and improve their work. It will help them to:

- contextualize their research question and subsequent findings
- meet criterion B: demonstrating knowledge and understanding .

While conducting their literature review, students may find it useful to compile an annotated bibliography and to record their responses to what they read in their researcher's reflection space (RRS).

If using the internet, students are encouraged to use specialized academic search engines that will find resources appropriate for citation in the EE.

Students must be aware of their responsibilities to cite properly the resources they use and to check their work for plagiarism. Their citations should adhere to [the requirements of the IB](#) and be consistently applied.

## Research question

Students should identify a **working** research question early on but be prepared to change, eg if too little information is available to permit the intended investigation.

Students should be guided by the idea that what they are writing is important because:

- it seeks to fill a gap in understanding their chosen topic, or
- it offers a resolution to some controversial argument.

The research question should therefore be non-trivial and follow from the existing body of literature on the topic. It must be:

- specific, sharply focused and capable of being answered within a 4,000-word essay
- stated clearly in the introduction of the essay and on the title page
- related to the chosen topic.

Students need to avoid researching questions that are too narrow or too obvious as this will limit their ability to formulate reasoned arguments.

Their answer to the question must be analytical rather than descriptive.

## Title

The title is a formal requirement on the title page of the essay. If the title is missing, it will be considered on balance with the other formal requirements against criterion D. While there is no explicit penalty in criterion A, the title will help address the requirements as it expands on the student's intended focus. Without a title, students lose an opportunity to clarify their focus.

## Treatment of the topic

Once students have identified their topic and written their research question, they can decide how to research their answer. They may find it helpful to write a statement outlining their broad approach.

The definition of "research" and terms such as "primary data" and "secondary data" varies from subject to subject.

In some subjects, students must use both primary and secondary data. In others, students may, or even must, rely exclusively on secondary data.

However, all students must carry out secondary research in terms of a literature review for their topic.

## Two important reminders

1. Undertaking an extended essay is a challenge. Planning is crucial. Students need to start writing their papers early and discuss any emerging difficulties with their supervisor. As well as their supervisors, librarians are a great source of information, advice and support for students.
2. Students risk their diploma if found guilty of academic misconduct:

## The sciences

An overview of writing an extended essay in the sciences, see [The sciences: An introduction](#).

Environmental systems and societies guidance is in the interdisciplinary essays section.

# Chemistry: Subject-specific guidance

See also: EE generic guide and EE teacher support material

## Overview

An extended essay (EE) in chemistry provides students with an opportunity to investigate a specific aspect of a material of our environment. The essay must be characterized by a particular chemical emphasis within a more general set of research criteria.

Chemistry is the science that deals with the composition, characterization and transformation of substances. A chemistry EE should incorporate chemical principles and theory, and emphasize the study of matter and of the changes it undergoes.

The outcome of the research should be a coherent and structured piece of writing that effectively addresses a particular research question and arrives at a particular, and preferably personal, conclusion or response to the research question.

## Choice of topic

The topic must allow an approach that specifically involves chemistry. Where a topic might be approached from different viewpoints, the treatment of the material must be from a chemistry perspective. For example, an EE in an option area of the IB syllabus such as biochemistry will, if registered as a chemistry EE, be judged on its content within the scope of the biochemistry option of the syllabus.

The scope of the topic and the research associated with it should enable all the criteria to be addressed. The research question must be sharply focused and able to be treated effectively within the word limit.

## Suitability of topics

Broad or complex literature-based topics do not allow the student to discuss conflicting ideas and theories, nor to produce an in-depth personal analysis within the word limit. Students should therefore avoid these topics (eg investigations into health problems caused by water pollution, chemotherapy for cancer treatment or the use of spectroscopy in chemical analysis).



Some topics may be unsuitable for investigation because of safety issues. Experiments involving toxic or dangerous chemicals, carcinogenic substances or radioactive materials should be avoided unless adequate safety apparatus and qualified supervision are available and evaluation of the level of risk has been positively determined. Teachers are responsible for following national or local guidelines, which may differ from country to country.

Other topics may be unsuitable because the outcome is already well known and documented in standard textbooks.

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.

## Examples of topics

These examples are just for guidance. Students must ensure their choice of topic is focused (left-hand column) rather than broad (right-hand column).

Focused topics 	Broad topics 
Determination of chloride, nitrate and calcium ion concentration in sea water	Study of sea water
Spectrophotometric determination of vitamin B2 content in cow's milk	Study of milk
Investigating the possibility of substituting hydrazine for kerosene as a rocket fuel	Theoretical investigation of hydrazine
Extracting DNA from peas using two different primary alcohols	DNA in plants

Once they have chosen their topic, students must then further define and refine it for study by expressing it in the form of a research question.

## Treatment of the topic

An EE in chemistry may be based on:

- literature
- theoretical models
- experimental data.

Whichever approach is chosen, the student must ensure that they have access to sufficient data to research the topic effectively.

Students who choose to write a literature- or survey-based essay should ensure that it 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
- online sources
- textbooks.

The internet should never be the sole 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 used an existing method. If they use an existing method, they must give its source and state how they have adapted and improved upon it.

## Supervision

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.

The supervisor has the responsibility to ensure that students understand that the EE must not duplicate the research topic, data or the results of the internal assessment. A statement to that effect should be included in the supervisor's comment on the cover of the EE.

Generating and presenting data should not be an end in itself; students must analyse data using appropriate techniques, evaluate it and where appropriate compare it with appropriate models or literature values.

## Use of secondary data

Students can also use data collected elsewhere. For example, for a research question that requires calculation of enthalpy changes in reactions, students can obtain average bond enthalpies from databases and manipulate these in order to answer the question.

However, to achieve high marks, students must devise their own method to analyse the secondary data in a way that leads to a specific answer to their research question.

In any chemistry EE, students must 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. Throughout the essay, students should emphasize clearly their own personal contribution.

## Examples of topics, research questions and suggested approaches

Once students have identified their topic and written their research question, they can decide how to research their answer. They may find it helpful to write a statement outlining their broad approach. These examples are for guidance only.

Topic	<b>The effect of storage temperature on alkaline battery discharge time</b>
Research question	What is the effect of storage temperature on the operational lifespan of an alkaline battery?
Approach	Experimental: set of 3 batteries is subjected to 5°C, 20°C, 30°C, 40°C, 50°C for a specific period of time, after which the batteries are discharged. Voltage is measured before and after storage period.

Topic	<b>Investigation of changing reflux time on the yield of aspirin</b>
Research question	Does increasing reflux time increase the percent yield of aspirin for the reaction between acetic anhydride and salicylic acid?
Approach	Experimental: aspirin is produced from acetic anhydride and salicylic acid at varying reflux time intervals.

Topic	<b>Replacement of coal with natural gas for electric power generation</b>
Research question	What would be the reduction in CO <sub>2</sub> emission (measured as % change by mass) in Germany of replacing all coal-fired power plants with modern CH <sub>4</sub> power stations?
Approach	Data based: calculate the CO <sub>2</sub> emission per kWh using public domain data for the heat of combustion, composition and efficiency of coal and natural gas power plants.

Topic	<b>Periodic properties of super-heavy elements 113–118</b>
Research question	Can the physical and chemical properties of the undiscovered elements be predicted using the law of periodicity?
Approach	Literature based: examine the ionization potential, electron affinity and other periodic trends, predict if the super-heavy elements obey the periodic law.

### An important note on “double-dipping”

Students must ensure that their EE does not duplicate other work they are submitting for the Diploma Programme.

### The chemistry EE and internal assessment

An EE in chemistry is not an extension of the internal assessment (IA) task. Students must ensure that they understand the differences between the two.

- The IA is more likely to focus on the syllabus content, whereas the EE could explore aspects of chemistry not covered in the syllabus.



- The IA must include data collection and analysis (from hands-on experiments, databases, simulations or modelling) and cannot purely be a literature review.
- The EE must construct a theoretical framework for the underlying chemistry of the chosen topic, whereas the IA focuses on the application of the scientific method to a problem of interest and will only include some background information.
- The EE explicitly assesses the students' ability to analyse and evaluate scientific arguments.

**Supervisors play an important role in guiding students on these distinctions. Students risk their diploma if academic misconduct is detected.**

## Interpreting the EE assessment criteria

### Criterion A: Focus and method

(Strands: Topic, Research question, Methodology)

The EE in chemistry must have a clear chemical emphasis and should focus on the chemistry aspect of the investigation.

It should incorporate chemical principles and relate to the study of matter and its chemical changes.

The topic can come from:

- the core
- the AHL topics or
- one of the IB Chemistry options of the syllabus.

However, the emphasis should be on chemistry.

The research question must be formulated as an actual question, such as "Can the spectator ions influence the rate of oxidation-reduction reaction?"

To address the research question the student must research the existing literature on the topic and choose an appropriate methodology to pursue the investigation by:

- undertaking work in the laboratory or
- basing their research on existing data.

If practical work is undertaken, the rationale for choosing the procedure should be clearly explained.

If the investigation is undertaken in an external laboratory, students have to show clearly their understanding of the methods and materials, and their role in collecting the data.

### Criterion B: Knowledge and understanding

(Strands: Context, Subject-specific terminology and concepts)

Students are expected to show understanding of the relevant chemical principles and ideas and to apply them correctly.