Thesis guide for chemistry

For Bachelor’s Thesis and Master's Thesis writing in Chemistry
at the Faculty of Science, University of Helsinki

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Contents

Abbreviations

KEK or BP Chem	Kemian kandiohjelma/Bachelor's Programme in Chemistry
BP BSc	Bachelor's Programme in Science
KEM or MP CHEMS	Master's Programme in Chemistry and Molecular Sciences
MATRES	Master's Programme in Materials Research
MP ATM	Master's Programme in Atmospheric Sciences
MP TCM	Master's Programme in Theoretical and Computational Methods

Purpose of the Document

This guide describes in detail the stages of completing a chemistry thesis in the Bachelor's and Master's degrees in the field of chemistry at the University of Helsinki. You should become familiar with the contents of this guide well before starting your thesis project. The presentation methods and writing instructions presented here are similar to those employed in reporting in chemistry in general, so the instructions are already useful in the earlier stages of your studies. In addition, knowing the stages of the thesis process in advance makes it easier to set your own goals and draw up a thesis action plan.

We encourage you to get to know chemistry researchers and their research areas during the formative years of your study. The process leading to completing your thesis begins with finding a supervisor and agreeing upon a research topic. A Bachelor's thesis is a literature review, but the subject of the thesis is often connected to laboratory or computational work performed by the student as part of the Bachelor's Research Practice work. A Master's thesis always includes a practical research component.

Several editions of this dissertation guide have been published over the years. Various changes and refinements have now been made. For example, attention has been paid to the accessibility of documents. For this reason, the University of Helsinki has introduced a template (Word document). The template ensures that all theses to be published meet accessibility criteria. The given format also simplifies the process for the author. There is currently no such model template available for the LaTex document preparation system. However, the LaTeX system can be used if you wish. Your supervisor can help you find a suitable template.

The guide gives instructions for preparing both a Bachelor's and Master's thesis in the field of chemistry in the education programs of the Faculty of Mathematics and Natural Sciences. A Bachelor of Science degree in the field of chemistry can be completed in the Bachelor's Program in Chemistry (KEK) and in the international Bachelor's Program in Science (BP BSc, taught entirely in English). The Master of Science degree in the field of chemistry can be completed in the Master's program in Chemistry and Molecular Sciences (CHEMO), the Master's program in Materials Science (MATRES), the Master's program in Atmospheric Sciences (MP ATM), or the

Master's program in Theoretical and Computational Methods (MP TCM). Check the study program-specific practical details for your own program at the following link: https://studies.helsinki.fi/instructions/article/thesis-and-maturity-test-masters-degree?degree_programme_code=MH50_007

1 Introduction

A thesis represents the traditional final stage of studies, providing the student with an opportunity to apply the knowledge and skills gained during previous studies in the context of an extensive research project. The thesis shows ability for scientific thinking, control of scientific methods, familiarity with the subject of the thesis, and science communication.

The scope and status of theses in degrees as well as the requirements of the maturity test and the related demonstration of proficiency in the native language (Finnish or Swedish) are specified in the Government Decree on University Degrees (794/2004) (https://www.finlex.fi/fi/laki/alkup/2004/20040794).

Each student completing a thesis is assigned a thesis supervisor. The research topic and the supervisory arrangements (supervisors/immediate supervisors) are agreed with the supervisor at the start of the thesis research period. Even though the thesis writing is an individual effort, the research project is usually completed as part of a research group. Therefore, there is usually plenty of additional support and guidance available for practical issues from laboratory team members. The research often consists of experimental laboratory work, but possible topics also include theoretical and computational chemistry. In a Master's thesis, the research work and the writing of the thesis form a unified whole. Bachelor's thesis is a literature review, but the subject area of the thesis is often associated with the B.Sc. research project, which is most often carried out in one of the research groups of the Department of Chemistry.

More information on research at the Department of Chemistry and thesis topics can be obtained from professors and other researchers as well as from the Department's website (https://www.helsinki.fi/en/faculty-of-science/faculty/chemistry).

Short presentations of the research groups offering places for thesis work are given on the Studies site https://studies.helsinki.fi/instructions/article/degree-programme-specific-traineeship-instructions .

The following sections 1.1 and 1.2 list the steps of the thesis projects for B.Sc. and M.Sc. degrees, respectively.

1.1 Process steps: Bachelor's thesis

1. Agreeing on the topic (section 2.2).
   You should inquire about possible research topics from the relevant professors and/or researchers in the Department. As for research conducted outside the Department of Chemistry, you must agree on a topic in advance with the responsible professor of the Master's Programme and then prepare a written research proposal. After the topic has been decided, you can prepare a written agreement that states the topic, supervisors, and the schedule of the project. For finding the possible projects at the Department, you may consult: https://studies.helsinki.fi/instructions/article/degree-programme-specific-traineeship-instructions

2. Scheduling of the project and expected workload (section 2.1).
   The research or work practice (9 cr) associated with Bachelor Programme (BP Chem) study lasts for approximately six weeks. The Bachelor's Thesis is a literature review with a scope of 6 credits, corresponding to a counted workload of four weeks. The two study units can be on the same topic, or they may be independent of each other. Please note that adherence to the planned and agreed schedule is considered as part of the assessment criteria. You must complete your project in accordance with the supervisor's instructions. From the beginning, record everything carefully in your laboratory diary.
   In the Bachelor' Programme in Science, the Research Project in Chemistry is an elective study unit, but highly recommendable, on the chemistry study track. The scope of this is 10 cr, but otherwise the work and thesis writing process follows the same guidelines as in the BP Chem.

3. Thesis Seminar
   The chemistry bachelor's degree includes a thesis seminar (4 ECTS), where you practice using databases and written material, writing, and giving an oral presentation. A personal tutor is available to help you in the seminar process.
   In the Bachelor' Programme in Science, there is a separate seminar programme that includes all study tracks in the programme. As part of that programme, you are expected to write and give a presentation on your thesis topic, or on a chemistry topic separately agreed with the leader of the seminar programme.

4. Maturity test. (section 3.3).
   When the thesis is completed, or is at least nearly completed, a maturity test must be taken. In BP Chem the maturity test in executed always as a supervised written exam (a short essay). More instructions can be found at https://studies.helsinki.fi/instructions/article/bachelors-theses-and-maturity-tests. If you have either Finnish or Swedish as your mother tongue, you must take the maturity test in that language, as this involves an official domestic language certificate. Other students may take the test in English.

5. Submitting a Bachelor's thesis for examination (chapters 3 and 4).
   A Bachelor's thesis is approved by a professor, a university lecturer or another Ph.D. level teacher working for the Department of Chemistry.

   The accepted (i.e., graded) Bachelor's Thesis is archived at the Department of Chemistry.

1.2 Process Steps: Master's Thesis and Research Project

1. Agreeing on the topic (section 2.2).
   You should inquire about possible research topics from the professors, research group leaders or researchers. As for research conducted outside the Department of Chemistry, you must agree on it in advance with your professor and prepare a written research proposal. After the topic has been decided, a written agreement can be prepared stating the topic, supervisors and the schedule of the project that is send to the director of the master program. To find the possible projects at the Department, you may consult:
   https://studies.helsinki.fi/instructions/article/degree-programme-specific-traineeship-instructions

2. Scheduling of the project and expected workload (section 2.1).
   The scope of the Master's thesis at the University of Helsinki is 30 credits (ECTS). In chemistry, about half of the time is reserved for the research work, with the rest reserved for final data work up and writing. Within the MP Chemistry and Molecular Sciences and MP Materials Research, however, the practical research part is extended by adding the study unit Research Project to the thesis topic. The scope of the Research Project is 15 cr. (However, in the MP Advanced Spectroscopy in Chemistry it is 10 cr). Accordingly, all components then cover 45 cr, of which approximately 2/3 is reserved for research work, and 1/3 for final data work-up and writing. The thesis to be examined must include both a literature review and a research part, and this is assessed as one submission. Within the CHEM and MATRES programmes, the research part requires approximately 4-5 months of full day work equivalents, and the combined thesis project as a whole (45 cr) corresponds to ca. 6-7 months of full day work (the work week is counted as 40 hours). Keeping the planned and agreed schedule is noted as an assessment criterion. All the work is carried out according to the orders and guidance of the supervisor from which a detailed laboratory notebook is kept.

3. Writing process (sections 2.2-2.4).
   A Master's Thesis is a substantial document encompassing many parts beyond the literature review. You must analyze the results of your own research and report them in a scientifically appropriate format. This requires a lot of work and familiarization with the wider research literature. However, the principles of scientific writing are the same as already learned during the BSc studies.

4. Maturity test (section 3.3.).
   When the thesis is complete, or at least nearly complete, a maturity test must be taken. This means assessment of a written text, where a student shows their ability in scientific reporting and their familiarity with the topic of the thesis. In practice, the manuscript and/or the abstract of the thesis is checked by one of the examiners, who approves the test after the required corrections have been done.
   For those having Finnish or Swedish as the mother tongue: if the official language test was completed already within the BSc thesis, the MSc maturity test involves only the knowledge of the topic of thesis. If the language test was not approved in an earlier degree, it must be done in connection to the MSc thesis.

5. Submitting a Master's thesis for evaluation (chapters 3 and 4).
   When the thesis is complete and in a final form that has been accepted by the supervisor, it will be stored in an electronic form (pdf) in the Digital Repository of the University of Helsinki (HELDA, e-Thesis). Before the permission to submit the master's thesis is granted, its content is verified using a plagiarism recognition system.

A Master's thesis is evaluated by two examiners. One of the examiners must be a professor in the Department of Chemistry and the other approved by the Master’s programme steering group. Based on the examiners report the Dean will accept and grade the thesis.

2 Completing a thesis in practice

2.1 Contents and scope of the work

2.1.1 Bachelor's Thesis and Research practice

In the Bachelor's Programme in Chemistry, a mandatory research or discipline practice unit "Kandiharjoittelu" of 9 cr is included, whereas in the Bachelor's Programme in Science (chemistry track), an elective study unit "Research Project in Chemistry" (10 cr) is offered. These are both completed in a same manner, by working within a research group at the Department of Chemistry or in a company or research institute where a research project with suitable chemistry related work can be completed. The extent of the work should be about 6 weeks, including writing of the associated research report or a report of the work practice. The research project can also be completed abroad as part of a student exchange programme. For work planned outside of the Department, you must agree in advance with the Director of the degree programme or a professor in an appropriate field of chemistry. The credits are registered when your report has been submitted and approved. You will be given detailed instructions for writing the report from your supervisor. The grading scale is pass-fail.

Bachelor's thesis (6 ECTS) is an individually written literature review based on scientific literature. Its suitable length is about 20 pages, maximum is about 30 pages. The thesis can be prepared either on the same subject area as the Research Project, or on a completely different topic. The bachelor's thesis is evaluated on the common scale (0-5). If the Research Project topic is close to the thesis, the Research Project report can be included in the thesis as an attachment. The report is assessed as part of the Research project on a scale pass-fail.

2.1.2 Master's Thesis and Research project

The Master's Thesis includes research work and literature review. The scope of the MSc Thesis at University of Helsinki is 30 cr, but in CHEMO and MP MATRES the practical research part is extended by adding the study unit "Research project" (15 cr. in MP ASC study track the scope is 10 cr, see below). Accordingly, in these programmes the scope of the whole work is 45 cr, of which about 2/3 consists of your

own experimental or computational research, and the rest (15 cr) is reserved for final data work-up and writing. The exact time division may vary according to the nature of the research. Commonly, the extent of the research work is 4-5 months, whereas the whole project is accounted formally for 6-7 months of full-day work (counted according to 40 h work weeks).

Practical research is completed as regular, full-time work. It also includes some processing of the results. The Research project (15 credits) can be registered and graded as passed/failed, when the report for the whole research has been submitted. In any case, the report is taken as part of the Thesis, and at that stage, it is still possible to improve the report. Especially, processing the conclusions may require some time and review of the literature. The whole package including the writing and literature review, research report as part of the thesis, and practical work is graded on the common scale 0-5.

Students in the Advanced Spectroscopy in Chemistry –study track must do a 10 cr research project, which is included in their thesis, but the project will also be graded on the scale 0-5.

2.1.3 Laboratory notebook and research report

You must immediately record every stage of the process in the form of comprehensive and clear entries in a bound laboratory notebook so that it contains unambiguous descriptions of all stages and observations. The laboratory notebook is an important document, which you must update carefully. You must not revise or delete entries afterwards or remove pages from the diary. If you revise or correct earlier results, you must record the revisions and corrections as new entries. There are some slightly different concepts and forms of laboratory notebooks in the Department's research fields and groups. Even electronic laboratory notebooks may be in use. Your supervisor will give the detailed instructions. After you have completed the project, you must submit the notebook to your supervisor.

The research report includes an introduction to the topic, the aims (these should be presented already in the beginning of the thesis) and methods of research, a description of all project stages, a presentation of the results and a discussion of the results. The discussion must entail a comparison between your observations and the

data given in the research literature, as well as your own conclusions. The order in which you prepare these sections varies with the topic. The description of the research methods must be so detailed that a chemist familiar with the methodology can repeat all the stages of the project exactly in the same way. You should report even those experiments that did not give the desired result, since even these may give some help for interpretations and planning of the following work. Naturally, the same writing guidelines and reference rules apply to both the report and the other sections of the thesis (section 2.3.3). Chapter 4 gives more information about the criteria employed in grading.

2.2 Literature review: selecting material and source criticism.

In the Bachelor's Thesis seminar, you may practice using data bases and handling of literature materials in connection to your own thesis work. Furthermore, construction of the thesis is planned and, and oral presentation of the research results is practiced.

Your thesis is based on original scientific research articles. Textbooks and review articles constitute basic background material, which helps in familiarizing with the topic. It is, however, good to note the most important related review articles even in the text and reference list. You should keep a diary that contains your information search plan, search terms, important researchers and other things considered useful whilst conducting a literature search.

The university library offers for your use a wide collection of data bases, scientific journals, and books conveniently in electronic form. As a helpful shortcut to the most important resources offered by the library is found at https://libraryguides.helsinki.fi/chemistry .

If you plan to use material published online, you must copy the material for yourself, and write down the date of access and other necessary reference information. This is because websites may change or even disappear when they are updated. Keep in mind that you must be critical when using documents published on private websites! Whilst articles in scientific journals have been peer-reviewed and revised, there is no such guarantee for the reliability or bias of individual web resources.

You should write your thesis assuming that the interested reader is a well-educated chemist. Thus, there is no need to explain general textbook information in detail. You should focus on what is essential and eliminate what is unessential. By compiling material in tables, you can make your thesis more compact and decrease the number of pages. Remember to add reference numbers to all results in tables too!

2.3 Writing process

It is challenging to write scientific text that flows naturally, but you can improve your skills through practice. Writing a detailed, substantive thesis includes iterative revision of your writing over time. This is often done under the supervision of those you work with. However, do not be overly critical of your writing during the early stages. Get into the habit of getting your thoughts down. Once you have a full draft of a substantial section of text, you can come back to it at a later stage to refine it. Some practical writing tips are collected in Table 1.

Table 1. Practical tips for a smooth writing process.

Topic	What should I consider
Start thinking about the big picture quickly	Prepare a rough draft of your thesis quickly so that your supervisor can comment on your work well. You can also improve the whole thing thoroughly later.
Searching for data	Learn to use databases and literature search well. These are skills you will need constantly!
Trust your supervisor	It's better to ask for advice early than to waste time doing the job many times!

Large language models based on artificial intelligence, such as Chat GPT, Google Bard and DeepL, are increasingly used for information retrieval and formulation of the text. If you use such language models, do it very carefully and remember that the responsibility for the final formatting and all content rests with you, the author. More instructions for using language models in studying can be found at https://studies.helsinki.fi/instructions/article/using-ai-support-learning. If a language model is used in the preparation of the thesis, the student must indicate, in

writing, which model has been used and in what way. Presenting content produced with artificial intelligence as your own text is considered as plagiarism.

The language model must not be named as a source reference, because the artificial intelligence extracts all its material from previously published materials. However, it cannot reliably provide references. Preparing a dissertation requires special expertise, i.e., evaluating and combining data in a way that artificial intelligence is not capable of. The language model may not be used when preparing the thesis summary. When writing the maturity test, the use of a language model is not allowed.

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2.3.1 Language of the thesis

The students in the Bachelor's Programme in Chemistry that have either Finnish or Swedish as their mother language must write their Bachelor's Thesis in the mother language. In this case the thesis can be written in English but only if the director of the Bachelor's programme gives permission based on a justified proposal. If you are studying for the bilingual degree (Finnish and Swedish), you may write the thesis in the so-called second language. In that case the maturity test must be taken separately in the mother language. If your mother tongue is not Finnish or Swedish, you may write the thesis alternatively in English.

In the Bachelor's Programme in Science the thesis is written in English.

The Master's Thesis can be written in English, Finnish, or Swedish, as you agree with your supervisor. Students in the Advanced Spectroscopy in Chemistry –study track write their theses in English.

2.3.2 Language and Style

In order to engage the reader's attention, it is of utmost importance that you polish the language, style and layout of your thesis carefully. Use good standard language and a formal style. You must follow the conventions and the general documentation style of your field. Your writing should be straightforward, clear, and based on your own words. Avoid repetition, extraneous sentences, and unusual expressions.

The nomenclature and the vocabulary of your thesis must be logical and follow the general conventions of the field. A chemistry thesis usually follows the recommendations of the IUPAC. State units of measurement in accordance with the SI system (International System of Units). Some exceptions are permissible as some units of different origin have remained in common use, e.g., the electron volt (eV) that is used for energy in micro systems. Seek advice from your supervisor if you are unsure. Always explain abbreviations and trade names when using them for the first time. Abbreviations and symbols should be given in a list which follows the table of contents at the start of the thesis. You should be careful when considering use of abbreviations so as not to affect the readability of the text.

You can find the Finnish Chemical Societies' English-Finnish glossary of terms used in chemistry at https://kemianseurat.fi/julkaisut/sanastot-ja-nimistot/. The department of chemistry has its own glossary of terms: https://labra.kemia.helsinki.fi/sanasto/FSEchem.html (English-Finnish-Swedish). However, new terms come into use constantly. Usually they appear first in English, and not all have an established Finnish or Swedish translation. If needed, you should check with your supervisor that you are using the term properly and that the possible translation is correct.

2.3.3 Using sources: references, quotation and plagiarism

When presenting information in your thesis, you must refer to the original source of the information. Get access to the original publications to avoid referring to sources with which you have not familiarised yourself (i.e., don't rely on the interpretation of others). Your text must always indicate which results and conclusions are derived from other sources and which are your own.

Keep in mind that it is forbidden to present information obtained from articles, theses, and books as your own. If you are going to use already published figures or tables as such (e.g., in your literature review), you must ask proper permission for doing so from the publisher and indicate that such permission has been granted by the holder of the right in conjunction with the figure or table in question. Using information without proper documentation of sources will affect your grade negatively whilst direct copying (plagiarism) may lead to the rejection of the thesis. All master's theses written at the University of Helsinki are verified using a

plagiarism recognition system before they are approved. The consequences of plagiarism are specified in Section 45 of the Regulations on Degrees and the Protection of Students' Rights at the University of Helsinki https://flamma.helsinki.fi/documents/d/yliopisto/tutkinto_oikeusturvajohtosaanto_englanti_muutettu-14122022-2-pdf

The most important consideration when using sources is consistency and clarity. References provide detailed information on the used or cited source, which enables the reader to locate the right article or book, if necessary. It is recommendable from the beginning save all the necessary references as fully as possible using a reference management tool. At the University of Helsinki, students can use the programs Endnote and Zotero, and the library also provides training for the users (https://libraryguides.helsinki.fi/viitteidenhallinta/uh_en).

With the programs you can print a bibliography in the format either required by different journals or defined by the user. It is of course possible to use also other suitable bibliographic databases, and e.g., LaTeX users may favour such. The recommended reference model, adapted from the Royal Society of Chemistry, is presented in section 2.4.8. Finally, remember to check the formatting and validity of the references before submitting your thesis. Many mistakes are often found in this section during grading, and this can impact your marks.

General principles of using references:

- Include all references given in the text in the bibliography.
- The bibliography contains only those references that appear in the text.
- You must always state clearly which results and conclusions are your own and which ones derive from research literature.

2.3.4 Examples of the format of references

Number the references in the order in which they appear in the text. State the number of the reference immediately after the referenced information in superscript. The same number always corresponds to the same article even if you refer to it repeatedly. Usually, the reference is included in the first sentence in which the information appears. If there is a punctuation mark at the end of the reference (a

comma, full stop or semicolon), place the number after it. In the bibliography, which is placed at the end of the thesis, references (see chapter 2.4.8) are in numerical order and appear only once even if the text contains several references to the same article.

Examples of the format of reference numbers in the text:

- In the field of analytical chemistry, phospholipid bilayers have been utilised in, among other things, the capillary electrophoresis of steroids.[4]

- ALD (atomic layer deposition) is a chemical gas phase method that applies the starting materials to the substrate one after another.[89–93]

- Michalke and Schramel[94] quantified selenium and platinum in their research, Magnusson and his working group[95,96] quantified selenium and arsenic compounds, and Tangen and his working group[99–101] quantified the organic compounds of lead.

- Asahi et al.[116] have produced TiO2 alloyed with nitrogen as both powder and thin film.

- There is not often a need to name the authors of the article. If you for some reason you wish to do this, for an article with two authors give both names (e.g., Michalke and Schramel[94] quantified…), but if there are more than two authors, indicate the name of the first author, followed by the Latin *et al.* (Asahi et al.[116] have produced…).

2.4 Layout and structure

It is important that the format of the thesis is consistent and clear. The language and the layout of a thesis submitted for assessment must be polished. You can look at previously approved theses for guidance but evaluate them critically and think how you could improve them.

2.4.1 Page layout

The thesis template of the University of Helsinki is recommended to be used: https://studies.helsinki.fi/instructions/article/thesis-and-maturity-test-masters-and-licentiates-programmes. The layout in the template is set to meet the requirements for accessibility. It also contains the title page and abstract page forms. The template is available in MS Word form (docx). However, every thesis must fulfil the accessibility criteria, even though another word processing programme was used. The criteria are given in detail in the template.

2.4.2 Structure of the thesis

The main sections of a Master's thesis can be ordered as follows:

1. title page
6. abstract
7. table of contents
8. list of abbreviations and symbols
9. introduction (the goals of the research are presented here)
10. literature review (with division into paragraphs and headings in accordance with the content)
11. experimental section (with an introduction, the presentation and discussion of the results as well as the description of the experimental methods)
12. conclusion
13. bibliography
14. appendices

The structure of the thesis can be modified as needed, but the sections 1, 2, 3, 5, 6, 7 and 9 should be included in every thesis. The same core structure should be followed in Bachelor's theses for sections 1-6 and 8-10. If the Bachelor's Research Practice topic is closely related to the Bachelor's thesis, the research report can be included in the thesis as an appendix.

2.4.3 Title page

Title page format is included in the Template.

2.4.4 Abstract

The Abstract is written on the form that is also included in the thesis template. The Abstract is placed in the thesis next to the title page without a page number. The abstract form is also available separately from https://studies.helsinki.fi/instructions/article/thesis-and-maturity-test-masters-and-licentiates-programmes .

The purpose of the abstract is to describe the key content of your thesis and thus help the reader to decide whether the thesis is interesting enough to read. The abstract is also a means of sharing information about research conducted at the University, which means that it must be prepared carefully. The supervisor checks the abstract before it is attached to the thesis.

The Master's thesis abstract must at least cover the topic, subject, aim(s), and methodology of research as well as the key results and the conclusions drawn from the thesis results. In the Bachelor's thesis the abstract must present the topic of the literature review, the main findings of the thesis and any conclusions. When writing your abstract, use complete sentences and no subheadings. It must not include references or quotations, nor should it contain information or claims not included in the thesis itself.

The abstract in the Master's Theses must state that the thesis is archived in the Digital Repository of the University of Helsinki /E-thesis. The Bachelor's theses are archived at the Department of Chemistry.

2.4.5 Headings and the table of contents

Use clearly numbered main and subheadings in your chapters. Your headings should begin from the left margin. The Template includes the style of the titles (Title 1, Title 2, Title 3). The purpose of headings is to make reading easier, which means that they must state the key content of the chapter. Avoid using too many levels and writing paragraphs that are too short. You can indicate the subheadings' order of importance through numbering and font (styles). Do not use abbreviations in headings. Prepare the table of contents in accordance with the headings and use the same font as the text.

2.4.6 Figures, tables and formulas

In figures and tables, you can present a wide collection of data in a compact manner. The layout for figures and tables are given in the instructions of the Template in sections 3.4-3.6.

Number figures and tables using Arabic numerals and refer to them in the text before they appear. Also add an explanatory caption to them. Place the caption below figures but on top of tables. The font or line spacing of a caption text can be slightly smaller than that of the main text. The caption must explain the physical quantities or phenomena you are describing, the manner of obtaining the results as well as other key points about the significance of the presented information (e.g., errors). You must also include the necessary references if you are referring to results published in research literature. You can add explanatory details as footnotes under the table. You can orient the table horizontally (landscape orientation) if it does not fit the page properly vertically (portrait orientation). Always place tables whose size is less than a page on one page. If the table is so large that you cannot fit it on one page, continue it on the next page and add the following note to it: “Table [number of the table] continues.” Also remember to add the table headings (column headings) to a table continuing on to the next page. The text in figures and tables must be in the same language as the main text. It is a good idea to use figures and summary tables because they allow you to illustrate the issues discussed in the main text and to show plenty of information in a compact form. When including Figures and Tables it is important to refer to them in the text so that the reader knows why this information is being included.

Number in-text equations and formulas in sequence, as in the following equation 1.

$$V = \frac{4}{3}\pi r^3 \qquad (1)$$

The symbols of entities and functions are written in *italics* and units in normal font. Refer to the structural formulas of compounds using bold numbers and number them in the text in the order of their appearance. Individual structural formulas are not referred as figures. You can transfer the graphs, formulas, and equations of your thesis directly from drawing or graphics software. For example, you can use Origin and ChemDraw with an academic license. Figures must use the same settings

throughout the whole thesis. This can be simplified by using different publisher settings in the program. For example, in ChemDraw it is possible to choose settings used by e.g., Royal Society of Chemistry –journals: Object → Apply Object Settings from [RSC (2 Column) Document].

In some cases, it is justified to copy a published image as it is. However, the copied image must bring to the thesis relevant added value and essential information, which is commented on in the text. If you copy a previously published image, permission from the holder of the publication rights must be requested, and the permission must be mentioned in connection with the copied image. In most cases, instructions for applying for permission are given on the publication's publisher's website, and it is usually easy to get a permit for use in a thesis.

2.4.7 Conclusion

Placed at the end of the Master's thesis, the conclusion presents the key results and your view on what their significance is and how research on the topic or its applications could be developed further. Note that you should not repeat the Abstract here; the meaning of this chapter is quite different. Make sure that the reader always knows which results and conclusions are your own and which you derive from the research literature. The Bachelor's thesis may end with a chapter briefly stating the main findings of the literature review and the conclusions drawn from them.

2.4.8 Preparing a list of references

Place the list of references after the conclusion. Each source of information may appear in the list just once even if you refer to it several times in the text. Arrange the references in numerical order and prepare the reference information in strict accordance with the guidelines. You can also print them in the appropriate format using reference management software.

A reference entry must include at least the following information so that the original publication can be located:

- journal articles: authors (first name, initials, and surname); the name of the journal using the abbreviations listed in the Chemical Abstracts Service database (http://cassi.cas.org/), the year of publication, the number of the

volume, the number of the issue (if necessary), and the page number of the article (the first page or the first and the last page) or the article number (DOI);

- books: author(s) or the authors of the chapter in question and the editors of the whole book, title, edition, publisher, the place of publication, the year of publication, the number of pages.

- electronic sources: author(s), title, document type, publication information, the date of access.

References must be complete and not include et al., *ibid.*, *idem* or similar abbreviations. However, the names of journals must be abbreviated using the Chemical Abstracts Service database.

The following examples have been formatted in accordance with the Royal Society of Chemistry model (https://edu.rsc.org/resources/how-to-reference-using-the-rsc-style/1664.article). The referencing model for RSC-journals: A. Name, B. Name and C. Name, Journal, year, volume, page.

Examples of references

1. T. E. Tomov, R. Tsukanov, M. Liber, R. Masoud, N. Plavner and E. Nir, *J. Am. Chem. Soc.*, 2013, **135**, 11935.
2. H. Itatani, H. Yoshimoto, T. Ibata, J. Toyoda, M. Sawada, M. Wada, T. Hamaguchi and S. Higashizaki, *Chem. Ind. (London)*, 1971, 674.
3. T. J. Hebden, R. R. Schrock, M. K. Takase and P. Müller, *Chem. Commun.*, 2012, DOI: 10.1039/C2CC17634C.
4. M. Weis and F. H. Frimmel, *Fresenius Z. Anal. Chem.*, 1989, **335**, 927.
5. C. Maccà, *Fresenius J. Anal. Chem.*, 1990, **336**, 29.
6. M. Modell, U.S. Pat., 4 543 190, 1985.
7. K. Kesencl, A. Denizli and E. Piskin, *Turk. J. Eng. Environ. Sci.*, 1997, **21**, 343; *Chem. Abstr.*, 1998, **128**, 168303.
8. G. D. Christian, *Analytical Chemistry*, John Wiley & Sons, USA, 5. ed., 1994, p. 556.
9. Reference 8, p. 559.

10. T. Aaltonen, Atomic Layer Deposition of Noble Metal Thin Films, dissertation, University of Helsinki, 2005. http://helda.helsinki.fi/bitstream/handle/10138/21099/atomicla.pdf?sequence=1
11. J. D. Olechno and J. A. Nolan, in Capillary Electrophoresis in Analytical Biotechnology, ed. by P. G. Righetti, CRC Press, USA, 1996, ch. 3, p. 61.
12. Bioenergy on the website Genomic Science Program, U.S. Department of Energy, 2023. http://genomicscience.energy.gov/biofuels/index.shtml, 20.1.2023.

Explanations for the above examples

1. Italicise the abbreviation of the journal's name. Do not italicise the year even when it indicates the number of the volume. Here the number of the volume appears in bold. If the page numbering starts at the beginning in each number, you must also indicate the issue of the journal.

2. If the abbreviation of the journal includes the place of publication, put it in brackets. State all authors of the article.

3. If the page number is not available, the DOI number should be given.

4. and 5. Even if the name of the journal has changed, give the name in use at the time of the publication of the article.

6. A reference to a patent.

7. If you have not been able to use the original article for some reason, or if it has been written in a language that the reader is probably unfamiliar with, you can refer to the information using, for instance, a journal of abstracts. In such a case, you must include the journal of abstracts (e.g. Chemical Abstracts) in the reference. Do not refer directly to a source that you have not read yourself!

8. A reference to a book.

9. Reference to different pages in a book mentioned earlier. You can also mention this in the text, in which case there is no need for a different reference number.

It is also possible to refer to a certain chapter in a book if you refer several times to it.

10. A reference to a doctoral dissertation. The referenced dissertation has also been archived digitally.

11. A reference to a work with multiple authors and compiled by editors in which different chapters have different authors, for instance.

12. An article on a website. Note the importance of the date of accessing the material.

2.5 Length of the thesis

The length of the thesis (number of pages) as such is not a criterion used in its assessment, but the length is looked at in relation to the contents of the Thesis, and the scope and expected workload in credits. A suitable length for a Bachelor's thesis (6 cr) is about 20 pages + list of references and possible appendices. A Bachelor's thesis should not exceed 30 pages. The length of a Master's thesis depends on the nature and amount of the available material. For example, presenting experimental results from different sub-disciplines can require different amounts of space. However, the length of a Master's thesis in chemistry does not exceed 80 pages. A well-made thesis of 40-50 pages can completely fulfil the requirements of an excellent thesis. Without the 15 cr research project, the length will be shorter. If necessary, documentation of results can be presented as appendices at the end of the thesis.

3 Submitting the thesis for examination

3.1 Submitting the Bachelor's Thesis for examination

When your bachelor's thesis is ready and polished, you can submit it to your supervisor for examination. You must agree on the examination in advance and remember to give the examiner enough time (at least one to two weeks). The supervisor will check the text and give necessary correction suggestions (also check the Maturity test, chapter 3.3.1). Before the assessment, the thesis is verified using the University's plagiarism recognition system. The bachelor's thesis is approved by a professor, a university lecturer or another Ph.D. level teacher working for the Department of Chemistry.

3.2 Submitting the Master's Thesis for examination

When your Master's thesis is ready and polished, the supervisor will check the text and give necessary correction suggestions (also check the Maturity test, chapter 3.3). You must agree on the examination in advance and remember to give both examiners enough time (be prepared to at least two or three weeks). Detailed guidelines for the examination stage of the master's thesis can be found on Instructions for Students (https://guide.student.helsinki.fi/en/article/thesis-and-maturity-test-masters-degree?degree_programme_code=MH50_007).

Before the assessment, the thesis is verified using the University's plagiarism recognition system. Only after all the required corrections are done, and the supervisor has given permission, the thesis will be uploaded to the Digital Repository of University of Helsinki, HELDA, https://ethesis.helsinki.fi (see also section 3.4 Publicity of the thesis).

The examiners prepare a grading proposal for the Dean of the Faculty who is officially responsible for approving the master's theses and confirms the grades. Before sending the grade proposal, there is a feedback discussion informing you of the grading and its grounds. You must sign the grading proposal in which you state that you have received and understood the examiners' grade proposal. If you are dissatisfied with the grading of your thesis, you may appeal. You must submit the appeal in writing no later than 14 days after receiving the notification of the approval decision, excluding the day of notification. Instructions on appealing can be found in

Instructions for Students: https://guide.student.helsinki.fi/en/article/legal-protection-students.

3.3 Maturity test

Both the first and second cycles of higher education involve taking a maturity test. It is a written test specified in the Government Decree on University Degrees that demonstrates your familiarity with the topic of the thesis and, while appropriate, your proficiency in Finnish or Swedish. The demonstration of language skills focuses on the native language and thus only applies to Finnish-speaking and Swedish-speaking students. Students whose native language is other than Finnish or Swedish can take the maturity test in another language (in English). In the latter case, the maturity test does not constitute an official demonstration of language skills.

3.3.1 Bachelor of Science

If your native language is Finnish or Swedish, you write your bachelor's thesis and the maturity test in your native language. When the student's native language is not Finnish or Swedish, the thesis and the maturity test can also be written in English. The maturity test is always carried out as a separate, supervised written exam (short essay). For more detailed instructions, see https://studies.helsinki.fi/instructions/article/bachelors-theses-and-maturity-tests.

3.3.2 Master of Science

If you have demonstrated the required proficiency in the native language in conjunction with the bachelor's thesis, the maturity test for the master's degree only demonstrates your familiarity with the field of the thesis. The maturity test is completed as a supervised exam (short essay). . More details on the Master's degree maturity test are available at https://studies.helsinki.fi/instructions/article/thesis-and-maturity-test-masters-and-licentiates-programmes.

3.4 Publicity of the thesis

Theses in university education degrees become public after they have been approved. Because of this, the thesis must not contain confidential material. Master's theses are available as pdf-files in the Digital Repository of the University of Helsinki (HELDA,

E-Thesis). The approved theses are always available at the Kumpula Campus Library computers, but they can even be published online. As the author of the thesis, you have the copyright to your own text, but the results you are reporting are often based on cooperation. You must consult your supervisor and, if necessary, your colleagues involved in the research project before concluding the publication agreement.

The thesis author is responsible that all references are correct and that all necessary rights and permissions have been acquired to use copyrighted material.

4 Assessment criteria and grading

Bachelor's and Master's Theses are assessed using a general numerical scale from 0 to 5. Research or work practice study units in bachelor's degrees and the research project in master's degree (KEM412, 15 cr) are graded as pass/fail. However, the Research project in the Advanced Spectroscopy in Chemistry –study track (KEM422, 10 cr) is graded as 0-5.

The general grading principles below have been prepared as applied to Master's theses, but the same principles can be applied to Bachelor's theses, as long as the different level requirements have been considered.

For the assessment, a written statement is prepared. The statement must be consistent with the proposed grading and clearly point out the merits of the thesis, and also the possible errors and deficiencies.

According to the guidelines followed in the University, three broad areas in the thesis are evaluated:

1. Assignment and content of the thesis.
2. Structure of the thesis and quality of presentation.
3. Work processes.

In the evaluation of the Master's theses in chemistry, emphasis is on the following factors:

1. Assignment and content of the thesis:
   - How the topic of the thesis is presented and how the research goals are justified.
   - How the research question is formulated and focused.
   - Choice of reference material, its suitability and depth.
   - Presentation of results and how they address the goals of the research.
   - Quality of research methodology and results.
   - Evaluation of the validity and significance of the results.

2. Structure of the thesis and quality of presentation:
   - Coherence and focus in the structure of the thesis

- Scientific style of presentation, correctness of the language, and overall readability of the text.
- Use of references.
- Use of equations, tables, and figures and their quality.

3. Work process:
   - Independent and creative thinking during the thesis work.
   - Skills in practical research work and ability to conduct results and data systematically.
   - Ability to collaborate with the supervisor and other members of the research team.
   - How well the planned schedule was implemented.

Each part is evaluated on a scale of 0-5. Instructions on how to apply the assessment criteria are presented below in Table 2. The criterion for acceptance is that within each category a minimum of 1 is achieved. The grade 5 (excellent) is given when the criteria are fulfilled in an excellent manner in all three areas of evaluation. The weighting of the areas may not always be the same, and the final grade of the thesis will not necessarily be the average of the three points.

The criteria used for the evaluation of Bachelor's theses are similar to those used for Master's theses, but as the Bachelor's thesis is a pure literature review, the research methods and results are not evaluated. A more detailed guideline for the evaluation of a Bachelor thesis is described in Table 3.

The following list gives the general guidelines for assessing the thesis at the University of Helsinki:

5 (Excellent): The thesis is of an exceptionally high quality and demonstrates the author's academic maturity, critical thinking skills, and thorough familiarity with the topic. The thesis covers all essential issues in a logical order and constitutes a coherent and consistent whole. The thesis meets excellently the requirements set for Master's theses in all the areas assessed.

4 (Very Good):	The thesis is of a very high quality and demonstrates the author's maturity, critical thinking, and familiarity with the topic. The thesis covers all essential issues in a logical order and constitutes a clear and consistent whole. The thesis meets very well the requirements set for Master's theses in almost all the areas assessed.
3 (Good):	The thesis is of a high quality, covers all essential issues in a logical order, and constitutes a consistent whole. The thesis meets well the requirements set for Master's theses in most of the areas assessed.
2 (Satisfactory):	The thesis constitutes an understandable and sufficiently logical whole. The thesis has some deficiencies, but meets the requirements set for Master's theses in several areas assessed.
1 (Passable):	The thesis covers some essential issues in a somewhat logical order and is passable. The thesis has many deficiencies but meets passably the requirements set for Master's theses in several areas assessed.
0 (Fail):	The thesis is fragmented and illogical and does not constitute a whole. The requirements set for the various areas assessed are not acceptably met.

Table 2. Instructions how to apply the evaluation criteria for chemistry Master's theses

Criteria for the grades 2 and 4 are not described separately. Grade 2 means that the merits are clearly above grade 1, but they do not meet all the criteria of grade 3. Similarly, grade 4 is give, when the merits exceed level 3, but they do not in all areas of evaluation reach the excellent level of grade 5.

	0	**1**	**2**	**3**	**4**	**5**
1) Assignment and content	Essential elements are missing (e.g. introduction or conclusions). The reference material is absent, or it has not been used in an appropriate way. Research topic is vague or severely misunderstood.	Research topic is narrowly described and the linking of the research goals with the wider background is insufficient. The references used are limited and the overall dependence of the text on the references is not obvious. The work shows limited or incorrect understanding of the thesis topic.		The topic of the thesis and the research goals are presented robustly. Research methods and materials are sufficient and correctly used. Presentation of results is acceptable. Conclusions and outlook show that the student is familiar with the research topic.		The topic of the thesis, research goals and questions and research methods are well presented. Research methods are valid. The reference material is sufficient and well chosen. Presentation of results is excellent. The validity and significance of the results is evaluated. Conclusions and outlook show insight and coherent view on the topic of the thesis.
2) Structure and quality of presentation	Thesis lacks structure. The text has not been written according to the standards of scientific writing. Citations to references are lacking. The overall style does not conform at all to standard of scientific writing. The figures and equations are irrelevant or poorly connected to the text.	Significant structural deficiencies. The use of the standards of scientific writing and citation technique are deficient. The thesis is too long or too short or the requirements on the overall style are not met. The figures and tables in the thesis are of poor quality, lacking or do not support the text. The equations are unclear, unnecessary or wrong, or the symbols are not explained. The thesis lacks preciseness, it contains scientific mistakes or lots of grammatical errors.		The structure of the thesis is good. The thesis conforms largely to the standards of scientific writing. The length is acceptable and the requirements on the overall style are mostly met. The figures and tables in the thesis are informative and support the written text. The equations are mostly in balance with the written text. The text is mostly clear and grammatically precise.		The structure of the thesis is excellent. The thesis conforms to the standards of scientific writing. The length is suitable, and the overall style is excellent. The figures and tables in the thesis are prepared well, are informative and support the written text. The equations are sufficient and well balanced with the written text, and all used symbols and acronyms are explained. Language and appearance are exemplary.
3) Work processes	Independence and capabilities to collaborate with the supervisor are difficult to assess or nonexistent. The thesis takes exceptionally long time to finish	Independence is largely missing, and the thesis proceeds mainly by the decisions and advice of the supervisor. The student lacks understanding of the methodology applied in the thesis. The thesis falls significantly behind the planned schedule.		Some independent thinking during the thesis work. Skilled application of practical research methods. Student interacts with the supervisor but requires often external input for making minor decisions. Work proceeds mostly according to the planned schedule.		Creativity and independence in practical research work, application of the methods, and analysis and inspection of the results. Skilled collaboration and/or interaction with the supervisor and other team members (if relevant) during the thesis work. Planned schedule is met.

Table 3. Instructions how to apply the evaluation criteria for chemistry Bachelor's theses.

Criteria for the grades 2 and 4 are not described separately. Grade 2 means that the merits are clearly above grade 1, but they do not meet all the criteria of grade 3. Similarly, grade 4 is give, when the merits exceed level 3, but they do not in all areas of evaluation reach the excellent level of grade 5.

	0	1	2	3	4	5
1) Assignment and content	There are many fundamental errors or misunderstandings in the text. There are crucial gaps in the source material, or it has been widely misused. The treatment of the research topic is vague, or the topic is misunderstood.	The research topic is described in a brief manner. There is little linkage with the larger picture. The references used cover only part of the subject matter or are weakly related to the topic under discussion. The thesis provides an overview of the subject but shows significant shortcomings in the understanding of the subject and the context. There are factual errors in the text, but they are not so extensive as to undermine the whole thesis.		The topic of the thesis is presented in a coherent way. The topic is linked in a natural way to larger issues. Sufficient use is made of references (usually at least 15-20) and they relate naturally to the subject matter. The conclusions and the way of thinking show that the student is well acquainted with the subject under study. There may be some minor factual errors and/or inaccuracies in the text.		The subject of the thesis is presented very well and coherently. The treatment of the topic is linked to the larger picture in a commendable way. The range of sources is adequate and particularly well chosen. The conclusions and the way of thinking show insight and a deeper than usual understanding of the subject and the discipline. There may be only minor inaccuracies in the text.
2) Structure and quality of presentation	The thesis lacks structure. The text is not written in accordance with scientific writing practices. The use of references is inadequate. The overall style does not follow scientific writing conventions at all. Diagrams, graphs, tables and equations are clearly unrelated to the text and/or are very poorly formulated. The language of the thesis is poor.	The thesis constitutes a minimum set of requirements, but it has significant structural deficiencies. There is poor compliance with scientific writing and citation practices. Diagrams, graphs, equations and tables are mainly of poor quality, unclear or do not support the text. The symbols used are not all properly explained. There may be a large number of typing errors in the text, but the overall language is satisfactory.		The structure of the thesis is good. The thesis largely follows the principles of good scientific writing, and the references are correct. The language in the thesis is fairly good. Diagrams, graphs, equations and tables are informative, clearly presented and support the text. The text is clear, and the expression is largely unambiguous and precise. Some parts of the thesis may be slightly less well-structured than others.		The structure of the thesis is excellent. The thesis follows scientific writing practices in an impeccable manner. The language is almost flawless, and the overall presentation is exceptionally clear and engaging. Diagrams, graphs, equations and tables are well thought out, elegant, informative and supportive of the text. All symbols and abbreviations are explained.
3) Work processes	Working independently produces very poor results. The ability to cooperate with the supervisor is non-existent.	The student is not able to move forward with the writing process on their own initiative, the work only progresses with strong guidance. The student may have difficulties in understanding the subject matter and the complexity of the thesis. The thesis takes considerably longer to complete than planned.		Student is able to independently carry out the agreed writing steps. Interaction with the supervisor works and the student makes use of the supervisor's feedback. There are no significant deviations from the planned timetable.		The writing process has been carried out largely independently. The student's cooperation with the supervisor is effective and productive. The work is completed within the planned timeframe.

Literature

There are plenty of different thesis guides and other literature to support your thesis project.

- Kielijelppi, Helsingin yliopiston kielikeskus, https://blogs.helsinki.fi/kielijelppi/
- Språkhjälpen av Språkcentrum vid Helsingfors universitet, https://blogs.helsinki.fi/kielijelppi/sv
- Gradutakuu – Erilainen graduopas, https://gradutakuu.fi/ .
- J. T. Hakala, Tulevan maisterin niksikirja, Gaudeamus, 2017. FIN EISBN: 9789523455047
- S. Kniivilä, S. Lindblom-Ylänne ja A. Mäntynen, Tiede ja teksti: tehoa ja taitoa tutkielman kirjoittamiseen, Gaudeamus, 2017. ISBN: 9789524954419
- K. Iisa, H. Oittinen ja A. Piehl, Kielenhuollon käsikirja, 7. laajennettu ja päivitetty painos, Suomen yrityskirjat, 2012. FIN EISBN: 9789526601335
- H. Vilkka, Akateemisen lukemisen ja kirjoittamisen opas, PS-Kustannus, 2020. ISBN: 9789524519564 (nidottu), ISBN: 9789523700420 (e-kirja)
- M. Davis, K. Davis ja M. Dunagan, Scientific Papers and Presentations, 3rd ed., Academic Press, San Diego, CA, 2012. ISBN: 9780123847270
- A. H. Hofmann, Scientific writing and communication: papers, proposals, and presentations, 5th ed., Oxford University Press, New York, 2022. ISBN-13: 978-0197613795
- Englantilais-suomalai(s-englantilai)nen kemian perussanasto/ English-Finnish(-English) Basic Dictionary in Chemistry, Finnish Chemical Societies, 2014, https://kemianseurat.fi/julkaisut/sanastot-ja-nimistot/
- A small glossary of terminology in chemistry (English-Finnish-Swedish) Department of Chemistry, University of Helsinki, 2015. https://labra.kemia.helsinki.fi/sanasto/FSEchem.html
- https://termipankki.fi/tepa/fi/
- https://termipankki.fi/tepa/sv/
- https://termipankki.fi/tepa/en/

Appendix. Useful web links for the thesis project.

• Researchers and research groups of the Department of Chemistry:
https://www.helsinki.fi/en/faculty-of-science/faculty/chemistry
https://studies.helsinki.fi/instructions/article/degree-programme-specific-traineeship-instructions

Completing the thesis and matriculation test: choose your own education program on the page: https://studies.helsinki.fi/instructions/article/thesis-and-maturity-test-masters-and-licentiates-programmes

On this site you will also find, for example, the following links:

- Dissertation supervision agreement
- Evaluation forms
- Thesis template

- The Abstract form as a separate file: University's abstract document (a word document)
- HELDA: https://ethesis.helsinki.fi
- Students' rights and review procedures: https://studies.helsinki.fi/instructions/article/protection-students-rights-and-review-procedures

- Writing Help

Chemistry discipline guide (Helsinki University Library):
https://libraryguides.helsinki.fi/chemistry

Vocabulary: https://kemianseurat.fi/julkaisut/sanastot-ja-nimistot/
A small glossary of terminology in chemistry (English-Finnish-Swedish):
https://labra.kemia.helsinki.fi/sanasto/FSEchem.html

Reference management guide: https://libraryguides.helsinki.fi/viitteidenhallinta
Chemical Abstracts: https://cassi.cas.org/
Royal Society of Chemistry – writing and reference instructions:
https://edu.rsc.org/resources/how-to-reference-using-the-rsc-style/1664.article