IB Chemistry: Guide to a Successful Internal Assessment (IA)
Updated for: First Assessment May 2025

The IA requirements are the same for Chemistry, biology and physics. The IA is worth 20% of the final assessment.

The Internal Assessment write-up should be less than 3000 words. Word count does not include:

- Charts and diagrams
- Data tables
- Equations, formulas, and calculations
- Citations
- Bibliography
- Headers

Criterion: Communication

Marks for this criterion have been removed for the new curriculum FA May 2025. But it is still a consideration in the assessment.

Effective communication is not a criterion on its own; it is an essential part of all four criteria (International Bacalaureate Organisation , 99).

- Effective communication is explicit in the research design criterion. The student needs to communicate the methodology (the purpose and practice) and the context of their investigation.
- Effective communication is an aspect of the data analysis criterion, where the recording and processing of data should be clear, precise and accurate in relation to the research question.
- Effective communication is also implicit in the conclusion and evaluation criteria, where an answer to the research question must be justified and where evidence of an evaluation needs to be expressed.

1. **<u>Formatting</u>**
   - Include section subtitles and numbered headings for diagrams, tables and graphs.
   - Font size 10-12, normal margins, 1.5 or double-spaced.
   - Graphs, calculations and diagrams can be drawn by hand and scanned in, provided the images are clear.
   - Be mindful of significant figures and units.

2. **<u>Referencing</u>**
   - In-text (parenthetical) citations should be embedded in the text every time you:
     - Quote a source directly
     - Paraphrase someone else's ideas
     - Use a diagram or picture that is not yours
   - Full references should be stated at the end of your investigation. The in-text citation sources must be included in full in the references section.
   - References do not count towards the page count.

Format of the report

The IBO does not recommend or suggest any particular format. The only guideline is that the report should be clear, concise, focused and demonstrate relevant scientific skills (International Bacalaureate Organisation).

The following outline is a suggestion for your IA; however, you may adjust in any way you choose. You do not need a title page.

At the start of the report:
- **Investigation Title –** Identifies the topic of your investigation.
- **Diploma Candidate Number** –Do not place your name anywhere on this document.
- **Diploma Candidate Number for all group members.** – There is a maximum size of 3 for each group
- **Word count –** See exclusions above.

Body of the report
The format of the report Is up to you.
- You could break the report up into the 4 sections matching each of the Criteria, or
- Follow the format of a traditional Chemistry report, or
- Follow the format of a Chemistry Research paper. Or
- A format of your own design.

- **Research Design -** This is your introduction and method or procedure. This must be written clearly and concisely. See further details below.
- **Data Analysis –** See below.
- **Conclusion –** See below.
- **Evaluation –** See below.
- **Citation –** Bibliography- CISH prefers that you MLA Format. You may choose alternate formats.

Detailed Information and Grading Criteria

Assessment is always based on evidence from the student's report, and this evidence needs to be clearly communicated in scientific terms.

The following information provides detailed guidance for your IA. The bold categories represent the criteria that are being evaluated and the rubrics incorporated into this document are the grading rubrics used by IB to evaluate your IA. Before submitting your document, you should read all of the included rubrics and evaluate your IA against the rubric.

Criterion: Research Design (6 Marks, 25% of the total report)

This criterion assesses the extent to which the student effectively communicates the methodology (purpose and practice) used to address the research question.

This criterion assesses the extent to which the student establishes the scientific context for the work, states a clear and focused research question and uses concepts and techniques appropriate to the Diploma Program level.

Marks	Level Descriptor
0	• The report does not reach the standard described by the descriptors below.
1-2	• The research question is stated without context. • Methodological considerations associated with collecting data relevant to the research question are stated. • The description of the methodology for collecting or selecting data lacks the detail to allow for the investigation to be reproduced.
3-4	• The research question is outlined within a broad context. • Methodological considerations associated with collecting relevant and sufficient data to answer the research question are described. • The description of the methodology for collecting or selecting data allows for the investigation to be reproduced with few ambiguities or omissions.
5-6	• The research question is described within a specific and appropriate context. • Methodological considerations associated with collecting relevant and sufficient data to answer the research question are explained. • The description of the methodology for collecting or selecting data allows for the investigation to be reproduced.

1 Source: IB Chemistry Guide, FA May 2015

This is your introduction and method or procedure. This must be written with sufficient detail for the assessor to see that you have understood your investigation and have planned appropriately. It will include these requirements.

➢ **Research Question** – Clearly and concisely state your research question.

The investigation of the research question must involve the collection and analysis of **quantitative data** that should be supported by **qualitative observations** where appropriate.

- Research question must be unique for each student.
- Topics outside the syllabus can be explored.
- Avoid questions where the answer is known. E.g don't determine the enthalpy of combustion of Ethanol, but you can investigate how enthalpy changes in a homologous series of alcohols.
- Research question may not have a directly measured variable but have a derived (calculated) value. E.g. rate of a reaction you measure a change and calculate the rate from that.
- The student needs to explain the relationship of the dependent variable to the system being investigated.
- The context should be specific to the system used. The range chosen for the independent variable must be realistic.
- The use of correctly balanced chemical equations with their corresponding state symbols should be standard practice.

➢ **Introduction –** Set the context for your investigation by discussing background information you have found through your research, regarding what is already known about the topic of your investigation. You may describe alternate methods of gathering data that you discovered during your research and explain why you have chosen the method you will use.

➢ **Hypothesis or Prediction –** Predict what you think the outcome of your investigation will be.
Note that not all Chemistry Reports require a Hypothesis.
If you choose to have a hypothesis you do not require an alternate hypothesis or null hypothesis.
You should justify your prediction or hypothesis using scientific knowledge and language.

➢ **Procedure/Methodology**

- In sufficient detail, outline the steps of your procedure in chronological order. A competent chemist should be able to reproduce your experiment. At the same time, it must be concise.
- Your methods of controlling variables should be very apparent in your procedural steps. If the control of certain variables is not practically possible, some effort should be made to monitor or control the variable(s) in a limited way. It will be important to discuss your inability to control a variable in your evaluation.
- You must have 5 manipulations (variations) of your independent variable and you should run 3 trials for each manipulation.
- If you will be graphing your data, you must have at least 5 data points. If you are determining a specific value such as density you should have an initial trial and then as many repeated trials as necessary until consistent results are obtained (usually 5 or more trials).
- Include safety precautions and clean-up/disposal procedures. Research all chemicals and indicate all safety and disposal precautions. If there is danger of burning skin, indicate how to avoid this such as stating you should use beaker tongs to remove a hot beaker. At a minimum, indicate that goggles and an apron must be worn. Refer to relevant Material Data Safety Sheets (MSDS)
- Be very specific about the equipment used. Always name the piece of equipment to be used and indicate what size should be used as well. For example: use a 100.0 mL graduated cylinder to measure 75.0 mL of water.
- Once you're done, read through the lab and make sure you can visualize each step as you read it.
- Do not use the first person "I", "we", etc. when writing the steps of your procedure.

Criterion: Data Analysis (6 Marks, 25% of the total report)

This criterion assesses the extent to which the student's report provides evidence that the student has recorded, processed and presented the data in ways that are relevant to the research question.

Marks	Level Descriptor
0	• The report does not reach the standard described by the descriptors below.
1-2	• The recording and processing of the data is communicated but is neither clear nor precise. • The recording and processing of data shows limited evidence of the consideration of uncertainties. • Some processing of data relevant to addressing the research question is carried out but with major omissions, inaccuracies, or inconsistencies.
3-4	• The communication of the recording and processing of the data is either clear or precise. • The recording and processing of data shows evidence of a consideration of uncertainties but with some significant omissions or inaccuracies. • The processing of data relevant to addressing the research question is carried out but with some significant omissions, inaccuracies, or inconsistencies.
5-6	• The communication of the recording and processing of the data is both clear and precise. • The recording and processing of data shows evidence of an appropriate consideration of uncertainties. • The processing of data relevant to addressing the research question is carried out appropriately and accurately.

2 Source: IB Chemistry Guide: FA May 2025

In this section you will record all **qualitative** as well as **quantitative** data you collected during your experiment. Qualitative data could include things such as a description of an odour if present, changes in colour or solubility, gas production, heat released or absorbed, and so on.

While conducting the lab you should record all your observations, measurements, or any other data you collect. For any measurements, be sure to include uncertainties and units. Data should be organized in tables whenever possible. The following recommendations should be considered when creating data tables:

Recording Raw Data

· Data is collected independently.
· Data is primarily quantitative (numerical)
· Data must include qualitative observations. (This may provide inspiration in the conclusion and especially the evaluation later.)
· Raw data should be recorded in suitable format(s) as described below.

Table organization

· Must have a title.
· Column headings should include the name of the variable, its associated metric unit and measurement uncertainty if it is the same for all measures in the column or row. The estimated digit in recorded measurements should match the decimal position of the measuring tool's uncertainty.
· Column & row headers identical to graph axes labels (if table is source of graph data) · Uses specific terms (ie. NaCl instead of *salt*; volume instead of *amount*; length instead of *size*) · Do not split tables between pages.
· Cells contain only one value.
· Tables show grid lines.

Table numbers

· Uncertainty in column headings after units. Absolute uncertainties expressed to 1 sig fig. (i.e $\pm$0.01 not $\pm$0.015)
· Align decimals.
· All values in a column must end at the same decimal place.
· Mean/average contains one more digit than significant figures in values.

Table units

· Units in column headings, not in cells
· No parentheses
· Use SI units - according to IB
· Variable that is measured or recorded is clearly stated (e.g. in the column heading in a table).
· Units for every variable.
· Uncertainty of measurements – based on significant digits –in the column headings. · The same level of precision (number of decimal places) is used for all the items of a variable.

Data Processing

You will also carry out all processing of your data necessary to draw a conclusion to your research question.

- The work **for calculations must be shown.** Include one example for **ALL** calculations and **ALL** results in a clear and concise manner using headings to describe your calculations.
- Brief explanations should be used to create a flow in calculations. Be meticulous and label **EVERYTHING!** You must show the propagation of uncertainties here.
- Be sure to calculate a **percent uncertainty** and an **absolute uncertainty**. Also you must calculate a **% error** if there is an accepted value with which you may compare your results.
- If it is appropriate, display data in the form of a graph.

A second data table with a title should be created to show ALL calculated results.

Criterion: Conclusion (6 Marks, 25% of the total report)

This criterion assesses the extent to which the student successfully answers their research question with regard to their analysis and the accepted scientific context.

Marks	Level Descriptor
0	• The report does not reach the standard described by the descriptors below.
1-2	• A conclusion is stated that is relevant to the research question but is not supported by the analysis presented. • The conclusion makes superficial comparison to the accepted scientific context.
3-4	• A conclusion is described that is relevant to the research question but is not fully consistent with the analysis presented. • A conclusion is described that makes some relevant comparison to the accepted scientific context.
5-6	• A conclusion is justified that is relevant to the research question and fully consistent with the analysis presented. • A conclusion is justified through relevant comparison to the accepted scientific context.

3 Source: IB Chemistry Guide: FA May 2025

Describing and Justifying Your Conclusion

To be awarded a high mark in this section, you should aim to write a conclusion that is fully justified (explains how the data in the analysis section supports your conclusion).

- Trends in the data that you identified in the Data Analysis section should now be explained using your scientific knowledge. This should involve referring back to your research question and background research in the exploration section of the investigation. Does your data answer the research question?

- You must draw a conclusion that clearly relates to your research question. Indicate if your conclusion supports your original thinking on the topic. If it does not, a consideration of why it does not will lead into an evaluation of the limitations of the method and suggestions as to how the method and approach could be adjusted to generate data that could help draw a firmer conclusion. For example, data collected might have such great variability that no reasonable conclusion can be drawn.

- You must justify your conclusion by comparing your result to an accepted scientific context or value. If a percentage error was calculated, you should comment on that percentage error. Discuss the precision and accuracy of your measurements in terms of their limitations on your data and the role they played as a source of error. Commenting on your percent error and **comparing your percent error to your percent uncertainty** is required and will help support your discussion of precision and accuracy.
- Compare your percent error to your percent uncertainty (random error). Percent uncertainty indicates how far your experimental values are allowed to be from the accepted value due to the limitations of your measuring tools. If your percent error is greater than your percent uncertainty, this indicates that there are flaws in your methods (systematic error) that are causing your experimental calculations to be further away from the accepted value.
- Further justification of your conclusion is required through the discussion of whether systematic errors or random errors were encountered. The direction of systematic errors and their impact on your conclusion must be discussed. For example, let's say you are finding a density. If you have a graduated cylinder with a glass bubble occupying a portion of the measured volume, this would cause the measure of volume to always be greater than it should be. You would need to also discuss the impact this systematically higher volume has on density. Since the volume measure is higher than it should be, when mass is divided by volume to find density, this would result in a density that is lower than it actually is.

Systematic errors arise from a problem in the experimental set-up that results in the measured values always deviating from the accepted value in the same direction-that is, always higher or always lower. An example would be a mis calibrated thermometer that always measures temperature as 0.30 degrees higher that the true temperature. Another example would be a poorly insulated device that allows heat that should be absorbed by water in a container to escape to the surroundings. The temperature of the water would always be measured as lower than it should be due to the loss of that heat.

Random errors arise from the imprecision of measurements due to the limitations of measuring tools. These errors can lead to readings being above or below the accepted value. Random errors can be reduced with the use of more precise measuring equipment, or their effect can be minimized through repeating measurements so that the random errors cancel out.

Criterion: Evaluation (6 Marks, 25% of the total report)

This criterion assesses the extent to which the student's report provides evidence of evaluation of the investigation and the results regarding the research question and the accepted scientific context. The evaluation criterion is allocated six marks and focuses on describing and justifying a conclusion, identifying weaknesses in the procedure and suggesting improvements to the investigation.

Marks	Level Descriptor
0	• The report does not reach the standard described by the descriptors below.
1-2	• The report states generic methodological weaknesses or limitations. • Realistic improvements to the investigation are stated.
3-4	• The report describes specific methodological weaknesses or limitations. • Realistic improvements to the investigation that are relevant to the identified • weaknesses or limitations, are described.
5-6	• The report explains the relative impact of specific methodological weaknesses or limitations. • Realistic improvements to the investigation, that are relevant to the identified weaknesses or limitations, are explained.

4 Source: IB Chemistry Guide: FA May 2025

Identifying Weaknesses and Suggesting Improvements

- In this section, strengths and weaknesses or limitations in the procedure should be identified and explained. In addition, improvements to your investigation should be suggested. If you wish to score highly in this section, a simple list of possible procedural improvements will not suffice. Reflect upon how you could adapt the method to deal with significant factors such as range, sample size, or alternative reaction system so that your conclusion is more valid. This should include a discussion of the uncertainties that you calculated in the analysis section and how they might have affected the results of your investigation. In addition, experimental errors should be classified as random or systematic. The direction of error may be determined by comparing the % error with % uncertainty.
- When suggesting improvements to your procedure, you should refer back to the random or systematic errors identified in the conclusion and explain how they can be minimized or prevented. The precision of the apparatus used in your investigation should also be considered. For example, a volumetric pipette has a higher precision than a graduated cylinder and can help reduce random errors. Make suggestions as to how the effects of random uncertainties may be reduced and systematic errors eliminated. You should be aware that random errors (not systematic errors), are reduced by taking repeated measurements. Suggested improvements to your investigation should be related to the weaknesses or limitations in the procedure and the types of errors identified. You should avoid suggesting improvements that are superficial or unrealistic or non-feasible in the environment of a school context or course. Errors due to careless manipulation of apparatus or events of which there is no evidence should not be included. Don't just say use better measuring tools. If a better tool should be used, suggest a specific tool and give justification. Don't just say find a different method, research and with detail suggest an improvement to the current method. If more trials would improve the lab, indicate how many more and why that would be an improvement.
- Finally, possible extensions to your investigation should be discussed with reference to your research question and methodology. Here, you should discuss realistic extensions to your investigation that would further help answer the research question. For extension, discuss a new variable or factor that could be investigated that is tied to the topic of your current investigation.

Example Evaluation:

Following on from the example in the analysis section where the enthalpy change of neutralization was calculated, we will now calculate the percentage error and classify the types of errors in the investigation.

The ΔH for the reaction was calculated as - 44 ± 5 kJ mol^{-1}*.*

The literature value for the enthalpy change of neutralization is - 57 kJ mol^{-1}*. The percentage error can be calculated using the following equation:*

Percentage error = (experimental value – theoretical value) ÷ theoretical value × 100

Percentage error = (-44 - -57) ÷ -57 × 100 = - 23% (the negative sign means that the experimental value was lower than the literature value).

Comparing this with the percentage uncertainty, which was 12%, it can be seen that the percentage error is greater, meaning that the major types of error in the investigation were systematic errors. These will be discussed in more detail in the evaluation section.

In the conclusion, the main types of errors in the investigation were identified as systematic errors. These are caused by heat being lost to the surroundings as the reaction took place. As soon as the reactants were mixed, the temperature of the mixture started to increase, which was expected as neutralization is an exothermic process. However, some of the heat was lost to the surroundings as the polystyrene cup is not a perfect insulator. This would cause the increase in temperature to be lower, which would result in the calculated ΔH value for the reaction being less than the literature value. An improvement to the investigation would be to use a material for the cup that is a more effective insulator than polystyrene or perhaps using two cups together to reduce heat loss. In addition, a lid could also be added to the cups to reduce the heat loss from the top. There were also assumptions made when calculating the ΔH, mainly that the density and specific heat capacity of the solution were the same as that of water. Looking at the balanced equation for the reaction, the products are salt (NaCl) and water, not pure water. Therefore, the specific heat capacity and density of salt water could be used to get a more accurate result.

This investigation could be extended by conducting the experiment at varying ambient temperatures. Does the initial temperature of the surroundings have an impact on the change in enthalpy for the reaction? The reaction could be carried out by heating and cooling the room to different temperatures prior to the start of the reaction.

Works Cited

International Bacalaureate Organisation. *Chemistry Teacher support material First Assessment May 2025*. First Assessment May 2025. Geneva: IInternational Bacalaaureate Organisation, 2023. Booklet.