

IB Grading Rubric

Design

Levels/ marks	Aspect 1	Aspect 2	Aspect 3
	Defining the problem and selecting variables	Controlling variables	Developing a method for collection of data
Complete 2	Formulates a focused problem/research question and identifies the relevant variables.	Designs a method for the effective control of the variables.	Develops a method that allows for the collection of sufficient relevant data.
Partial 1	Formulates a problem/research question that is incomplete or identifies only some relevant variables.	Designs a method that makes some attempt to control the variables.	Develops a method that allows for the collection of insufficient relevant data.
Not at all 0	Does not identify a problem/research question and does not identify any relevant variables.	Designs a method that does not control the variables.	Develops a method that does not allow for any relevant data to be collected.

- Research Question:** Define the problem or research question using one or more statements. Eg. "What is the relationship between pressure and volume of a gas?"
- Hypothesis:** The hypothesis is your prediction about the behavior of the variables under investigation. It should be specific and quantitative. It must be related to the research question. Your hypothesis must have an explanation. You need to state your reason using theory for your hypothesis. The hypothesis does not need to be correct as you may disprove your hypothesis but it must be reasonable. Cite any references you use.
- Relevant variables:** List the main relevant variables with a brief statement explaining why they are relevant to this investigation. Distinguish between qualitative and quantitative variables. State which variables will be investigated (manipulated and responding) and which variables need to be controlled.
- Apparatus:** List major pieces of apparatus. List only those possessed by the science department or that which you can provide yourself. Describe the apparatus in detail.
 Eg thermometer, -10°C to 110°C range, 1 degree graduations
 25 mL graduated cylinder, 0.2 mL graduations
 Vernier Labpro
- Diagram:** One or more large, clearly-labelled diagrams are needed to show the arrangement of the apparatus, where measurements are made, etc.
- Method:** Design a method which collects sufficient and relevant data for the variables under investigation and which controls the other variables. Your method must answer the following questions:
 - How do I control the control variables?
 - Which of the 2 variables under investigation is the manipulated variable?
 - How do I vary the manipulated variable?
 - How do I measure the manipulated and dependent variables?
 - What range do my variables (data) need to cover? ie. sufficient data
 Describe your method as series of numbered instruction sets in the order you would do them in the investigation
 Eg 1. a.
 b.
 2.
 3. etc.
- Assumptions:** Your chosen method will likely be based on one or more assumptions. List each of these with a brief supporting statement.

Data collection and processing

Levels marks	Aspect 1	Aspect 2	Aspect 3
	Recording raw data	Processing raw data	Presenting processed data
Complete 2	Records appropriate quantitative and associated qualitative raw data, including units and uncertainties where relevant.	Processes the quantitative raw data correctly.	Presents processed data appropriately and, where relevant, includes errors and uncertainties.
Partial 1	Records appropriate quantitative and associated qualitative raw data, but with some mistakes or omissions.	Processes quantitative raw data, but with some mistakes and/or omissions.	Presents processed data appropriately, but with some mistakes and/or omissions.
Not at all 0	Does not record any appropriate quantitative raw data or raw data is incomprehensible.	No processing of quantitative raw data is carried out or major mistakes are made in processing.	Presents processed data inappropriately or incomprehensibly.

Example 1

Determination of the percentage of ethanoic acid in vinegar
Volume of NaOH used for titration 1: 20.0 mL
Volume of NaOH used for titration 2: 20.0 mL

Grade = n

No raw data → just calculated volumes not eligible for further points

Example 2

Volume of NaOH used for titration 1: 22.5 - 2.5 = 20.0
Volume of NaOH used for titration 2: 41.5 - 1 = 40.5

Grade = p

some raw data implied, no qualitative observations, no units or uncertainties, inconsistent significant digits

Example 3

Titration of Standard HCl against NaOH & NaOH against Vinegar		
Final Volume/cm ³	22.5	41.5
Initial Volume/cm ³	2.5	1
Volume of base required/cm ³	20.0	40.5

Grade = p

some raw data recorded, no qualitative observations, no uncertainties, inconsistent significant digits only one set of data collected, data not recorded accurately

Example 4

Titration of 5.00 cm ³ vinegar against the standardized NaOH			
	Trial 1	Trial 2	Trial 3
Final Volume/cm ³ (±0.05)	42.50	43.25	40.50
Initial Volume/cm ³ (±0.05)	1.00	2.55	0.00
Volume of base required/cm ³ (±0.10)	41.50	40.70	40.50
Colors of solutions: HCl, NaOH, and Phenolphthalein were all colorless. At the end point the first trial was dark pink but trials two and three were slightly pink and remained slightly pink for at least 30 seconds.			

Grade = c

appropriate raw data with units and uncertainties. Proper sig fig.

An appropriate investigation must involve both the processing of raw data and the presentation of processed data. Where relevant the student must take into account uncertainties and errors.

Calculations: Show an example of each type of calculation and show all steps clearly explaining the method if it is not obvious. Show the rest of the similar processed data in tables. Average the processed data, not the raw data. Use the averaged values to calculate errors.

Graphs: graphs must have titles, labeled axis with units, best fit line, and appropriate scales for the x and y axis.

Conclusion and evaluation

Levels marks	Aspect 1	Aspect 2	Aspect 3
	Concluding	Evaluating procedure(s)	Improving the investigation
Complete 2	States a conclusion, with justification, based on a reasonable interpretation of the data.	Evaluates weaknesses and limitations.	Suggests realistic improvements in respect of identified weaknesses and limitations.
Partial 1	States a conclusion based on a reasonable interpretation of the data.	Identifies some weaknesses and limitations, but the evaluation is weak or missing.	Suggests only superficial improvements.
Not at all 0	States no conclusion or the conclusion is based on an unreasonable interpretation of the data.	Identifies irrelevant weaknesses and limitations.	Suggests unrealistic improvements.

- Drawing a conclusion:** State a valid conclusion, based on the correct interpretation of the results, with explanation, and a comparison to literature results where appropriate. Be sure to explain how your conclusion follows from the experimental results. Calculate the percent error and compare it with the experimental uncertainty. For example, in determining the value of R, the ideal gas constant, the student obtains a value of $8.11 \pm 0.16 \text{ kPa}\cdot\text{mL}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$. The theoretical value is $8.314 \text{ kPa}\cdot\text{mL}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$. It would appear that that student got really good values but if one compares the percent error (2.45% from the accepted value) and the uncertainty ($\pm 2\%$) then something is amiss. The true value lies outside of the experimentally determined range 8.11 ± 0.16 (7.95 to 8.27). Random error cannot account for the true value lying outside the range of the experimental value. Either systematic errors are present or there must be more uncertainty/errors than acknowledged.
- Evaluate the procedure:** List possible sources of error and describe how each error would impact on the result under consideration. Focus on systematic errors.

Types of Experimental errors

Systematic Errors are due to identifiable causes and can, in principle, be eliminated. Errors of this type result in measurements that are consistently too high or consistently too low. In principle, you want to identify and eliminate systematic errors. Systematic errors fall into 4 categories:

- Instrumental:** For example, a poorly calibrated instrument such as a thermometer reads 102°C when immersed in boiling water and 2°C when immersed in ice water. Such a thermometer would give measurements that are consistently too high.
- Observational:** For example, parallax in reading a buret.
- Environmental:** For example: measuring the cooling rate of a solution placed near a lighted Bunsen burner would cause the cooling rate to be slower or a cooling rate of a solution would be faster if placed under the air conditioning vent.
- Theoretical:** Due to simplification, an experiment used to measure acceleration from an applied force will give lower than expected results if friction is not included in the experimental design.

Random Errors are positive and negative fluctuations that cause about half of the measurements to be too high and half to be too low. Sources of random errors cannot always be identified. Random errors can often be quantified using statistical analysis. If there are only random errors then the measured values will spread about the "true value" with some values too high and some too low. If there are systematic errors in addition to the random errors then the values will be spread about some other value instead of the "true value." Possible sources of random errors are:

- Observational:** For example, errors in judgement of an observer when reading the scale of a measuring device to the smallest division.
- Environmental:** For example, unpredictable fluctuations in line voltage, temperature or mechanical vibrations of the instrument.

- Improving the investigation:** Make suggestions to improve the investigations following the identification of weaknesses. Suggestions should be realistic, not involving unavailable equipment or materials. Suggestions should be specific, not vague such as "be more careful".

The proposed changes may

- Eliminate or reduce errors
- Improve the control of control variables
- Reduce approximations
- Provide other procedures for better measurements.

Often additional sampling can improve the results of an experiment.

Manipulative skills (assessed summatively)

Level /marks	Aspect 1	Aspect 2	Aspect 3
	Following instructions*	Carrying out techniques	Working safely
Complete 2	Follows instructions accurately, adapting to new circumstances (seeking assistance when required).	Competent and methodical in the use of a range of techniques and equipment.	Pays attention to safety issues.
Partial 1	Follows instructions but requires assistance.	Usually competent and methodical in the use of a range of techniques and equipment.	Usually pays attention to safety issues.
Not at all 0	Rarely follows instructions or requires constant supervision.	Rarely competent and methodical in the use of a range of techniques and equipment.	Rarely pays attention to safety issues.