How to Write an IB Lab Report

IB Sciences @ Ruamrudee IS ***(revised 30 October, 2011)***

General

The only way you can learn science is through the laboratory experience. So, in general, 30-40% of your class time will be spent doing something related to practical work. The laboratory work will consist of a variety of activities. Some will require an entire class block; some will take a few days to complete. For some experiments complete instructions will be given; for others you will have to plan part or all of the experiment yourself. Usually, you will be working in a group of 2-3 people. Occasionally you will be on your own!! For some experiments you will write complete reports. Other reports may involve only collection and analysis of data and writing of a brief conclusion. You will always be told what is expected of you for each experiment.

Laboratory Notes

Your lab notes are where the raw data are recorded at the time of the experiment. You must record your raw data/rough notes either on the yellow data sheets provided or in a lab notebook. Each person must have their own set of data/rough notes or lab notebook. This is an IB requirement, as well as our requirement. If using data sheets, the sheet will then be stapled to the back of your lab report, or kept by you if no lab report is required. This raw data *must be signed and dated by your teacher* at the end of the class period in which you did the lab. *If the data is not signed, you may have to redo the experiment!*

Reports of laboratory work

Your teacher will let you know if your report must be typed or if it can be hand written. When submitting electronically, *include your name in the title of the file!*

When you are writing in your lab report try to keep the thought in mind: 'could someone else understand what I am doing, observing, calculating, writing etc'. A scientist's report is the way that scientific discovery is communicated to the rest of the world. You must always consider that there will be an audience for your report (right now the audience is your teacher - and maybe the world wide web - but someday it might be the some government agency checking the validity of your results and techniques). Your lab report should also be written in the "Third Person". Don't say "I want to…" , or "I will be …".

As mentioned above, many lab activities will not involve producing complete reports – rather just specific parts i.e. Data Collection or Data Processing and Presentation. The graphic to the right shows you the components of a lab report. The next several pages include more specific information about the various elements of a complete report.

A Complete Lab Report Contains:

1. Name, Class, Date, Exp #, Title
2. Aim of Experiment
3. Safety Statement
4. Introduction (Design)
  a. Research Question
  b. Background
  c. Hypothesis
  d. Variables
  e. Method (Procedure)
5. Data Collecting & Processing
6. Conclusion & Evaluation

A Complete Lab Report will include:

1. **Your Full Name, Class, Date, Experiment #, and Title of the experiment** (*this is required for every experiment*).

2. **Aim of the experiment:** a short (one to two sentences) statement of the purpose of the experiment, *preferably written in your own words* (*this is required for every experiment*).

3. **Safety Precautions:** Record the necessary safety information and special hazards of all materials used in the experiment. Describe what you will do to make sure that these hazards do not become a problem to you (*this is required for every experiment*).

4. **Introduction [Design]** this section *should always begin* with a clearly stated:
   a. ***Research Question***. The Research Question should not just be a repeat of the general problem provided by the teacher. Rather, your Research Question should indicate what specific aspect of the general problem you will be investigating.

4. Introduction (cont.)

a. *Research Question*

> A *Focused* Research Question would look something like:
>
> "How does _________ affect ___________?"
> or
> "Is (are) ___________ as effective as _____________?"
>
> A *Poor* Research Question would be: "What factors affect the rates of reaction?"
>
> A *Focused* Research Question would be: "Are homogeneous catalysts as effective as heterogeneous catalysts in the decomposition of 6% hydrogen peroxide?"

b. *Background* is the *next step* to include. Specifically, this is the theory one should know to understand the experiment. The *Background* will also lead to, or justify a *prediction* of what you think will happen in the experiment.

c. This *prediction* is called the ***Hypothesis*** and is written as a *testable statement or question* directly related to the *Research Question* about what you think is going to happen when you measure one variable and you change another. The *hypothesis* statement is followed by a *brief explanation*.

> Hypothesis:
>
> Stated as a *Testable Question* followed by "…and this is due to __________."

d. Now, you need to s*pecifically mention* the **Variables** that you will *control.* That is, the variables that you will change and measure; *independent*, *dependent*, and *fixed* – i.e. the same ones from your hypothesis.

e. Method (Procedure) [Design 2 & 3] this section provides an outline of how you intend to carry out the experiment and *control the variables* you have identified. It may take some practice before you will be comfortable as to what details to include. The most important details are things like mass, volume, and concentrations of chemicals and solutions, the type of glassware and equipment used, and any safety precautions. These details not only provide relevant experimental information but also show *how you are keeping certain variables fixed, while changing others*. Where appropriate, it is important to outline why one approach is taken versus another.

Keep in mind to clearly mention what specific data will be recorded and how often the measurements will be replicated (generally at least 3-5 trials must be taken). Write the procedure so that you, or someone else with some science background, could perform the experiment. A flow chart or "bullet points" can be used to explain lengthy procedures. Avoid the use of I, we, us, etc. Write the reports in the "third person".

6. Data Collection [DC&P 1]: record all relevant *quantitative* and *qualitative data* and *observations* and the relevant *uncertainties*. Report any changes in procedure or unusual conditions. All numerical data, tables, and graphs should be *clearly identified and labeled*. You should record all observed data – not just calculated results. Here is an example of a well-prepared table taken from a student's report.

Table 1. Data collected during a precipitation reaction of soluble aqueous AX2 and BY to form insoluble AaYy and soluble BX. Different volumes of a 0.10 M solution of BY were added to 10.00 mL of 0.10 M solution of AX2. The yellow precipitate was collected by filtration, washed with ice-cold water and then dried. The mass of precipitate recovered on the filter paper was recorded. The highlighted results indicate our group's experiment.

Vol. of 0.10 M AX2 (mL) (± 0.01)	Vol. of 0.10 M BY (mL) (± 0.01)	Mass of pre-labeled filter paper (g) (± 0.01)	Mass of filter paper and collected ppt. (g) ± 0.01)
10.00	2.50	0.803	0.885
10.00	5.00	0.799	0.895
10.00	10.00	0.811	0.998
10.00	15.00	0.797	1.118
10.00	20.00	0.803	1.227
10.00	25.00	1.581	2.008
10.00	30.00	0.780	1.222

6. Data Collection (cont.):
Correct units and significant figures must be used for all data and the uncertainties must have consistent decimal points.

Now – a small word about *titles*. You will find out pretty quickly that I am pretty sticky about titles. I like your titles to be descriptive – they should concisely summarize what was done to obtain the data in your table or graph. Please spend some time trying to master the art of good title writing – it will make you happy because you will get a good grade and it will make me happy because I will be able to assign you a good grade!!!

7. Data Processing and Presentation [DC&P 2 & 3]: results are different than data. Results are what happens to the data after you do a calculation or plot a graph. They are what *'results'* after you *manipulate* the data. Your presentation of the results might be in the form of a table, a graph, or maybe a pie chart. Graphs generally should have the "best-fit" line in the form y = mx + b generated including the statistics for COR. How you present the results will depend on the experiment – these are part of the skills I want you to learn. That is, how to take a mumbo jumbo of data and after some calculations and rearrangements, present the outcome in a way that allows a clear interpretation of the experiment. *All tables, graphs etc should be clearly identified and labeled*.

Furthermore it is necessary to *show how you manipulated the data* i.e. what sort of calculations did you do. A brief explanation of what you are doing at each stage of the calculation is just as important as the calculation itself. Finally, where several similar calculations are needed, show *one* example and give the results of the others. If you are determining a known value, ie. the Universal Gas Constant "R", you must calculate the *% Error* comparing your value to the known value. Use this information to discuss the accuracy of your procedure and results in the Conclusion and Evaluation.

When the internal assessment criteria are applied to investigations, the issues of *errors and uncertainties* must be interpreted. You need to be able to make statements about the minimum uncertainty, based on the least significant figure in a measurement, and can also make statements about the manufacturer's claim of accuracy. You must be able to estimate uncertainties in compound measurements, and make educated guesses about uncertainties in the method of measurement. If uncertainties are small enough to be ignored, the candidate should note this fact. Higher level candidates should also be able to express uncertainties as fractions and as percentages. They should also be able to propagate uncertainties through a calculation. Please refer to the handout "*Errors and Uncertainties*" for some specific examples of the propagation of errors.

8. Conclusion and Evaluation: This is the section where you draw conclusions about the experiment as it relates to your aim and hypothesis. Any calculated results should be compared to values from the literature (*i.e.* accepted values from professional laboratories) where possible. This section should include:

- Conclusion based on your *Aim* or *Hypothesis.* **[C&E-1]**
  - States the quantitative or qualitative relationship
  - Correctly interprets the graph of the data
  - Includes relevant calculated values to support conclusion
  - Includes some elaboration based on the science being learned
  - Compares results to a reference value; includes the source of the reference value
- Evaluation/Discussion of *errors and limitations* to the experiment **[C&E-2]**
  - Must comment on the "quality" of the results, do they make sense?
  - Identifies anomalous results where appropriate
  - Prioritizes errors and suggests where they came from.
  - Utilizes the ideas of "systematic" and "random" errors in the discussion
  - Indicate what *effect* the error(s) would have on the results
  - Human errors should not be the main source of errors!
- Suggestions for *improvements* **[C&E-3]**
  - Identifies weaknesses in the experiment and suggests realistic suggestions for improvement
  - Improvements should help to improve the errors previously identified.

9. **Grading:** The easiest way to see how you will be graded is to refer to the IB grading rubric (a shortened version is shown below). For each lab, your teacher will simply determine how well your lab meets the criteria listed in the score form.

   When you turn in a lab to be graded, the *IB Grading Rubric* with your *full name*, *date of the lab* and *complete title of the lab must be* attached to the front of the lab report.

   Note that some labs will have all the criteria evaluated, whereas in others only a few of the criteria will be evaluated.

   The scores from all of your reports account for at least 25% of your semester grade (depending on your teacher). Your *laboratory notes,* either on the yellow data sheets or in a laboratory notebook, must be attached to each lab report. If no report is assigned, your *laboratory notes* must be kept in a safe place until then end of the course.

   Abbreviated IB Rubric:

Internal Assessment Criteria	Aspect	Evidence of standard			Mark
		None (0)	Partial (1)	Complete (2)	
Design: Defined focused problem/research question and identifies relevant variables (1); Developed realistic procedures for the control of variables to include appropriate apparatus, materials, and methods (2) for the collection of relevant data. (3)	(1)				
	(2)				
	(3)				
Data Collection & Processing: Observed and recorded raw data with precision (1) and presented them in an organized way (2) Transformed and manipulated raw data, and presented this processed data to provide effective communication including errors & uncertainty (3)	(1)				
	(2)				
	(3)				
Conclusion and Evaluation: Made a valid and supported conclusion of the results (1) and evaluated the procedure (2); suggested realistic improvements to the procedure (3)	(1)				
	(2)				
	(3)				