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CHEMISTRY

This is a supplementary report following the May 2010 session and should be read in conjunction with the May 2009 extended essay report.

Overall grade boundaries

Grade:	E	D	C	B	A
Mark range:	0 - 7	8 - 15	16 - 22	23 - 28	29 - 36

General comments

The aims and objectives for a chemistry extended essay are set out in the guide. Essentially a student has to plan and pursue a piece of research in chemistry and communicate their findings in an accepted academic way. Clearly much of this is down to the skill, understanding and perseverance of the student but a significant amount does also depend on the quality of advice and guidance given by the supervisor. Last year (May 2009) was the first time that the essays had been written to follow the 2007 guidelines and marked according to the new criteria. This year (May 2010) there was a significant improvement in the quality of chemistry extended essays as students and supervisors seemed more conversant with the demands of the new criteria. However there is considerable cause for concern over the quality of supervision (possibly even the lack of supervision) that some students seem to be receiving. In some schools where the supervision was obviously done competently, all the students were able to achieve at least a satisfactory grade C with many achieving an A or B. However in other schools, where the ability of the students at chemistry seemed quite comparable, many of the students gained low marks through their inability to meet the criteria correctly. Failing to state the research question in the introduction and an inability to include the three basic components of the research question, how the investigation was undertaken and the conclusion in the abstract are just two examples of where poor supervision led to the loss of unnecessary marks. The guide sets out the responsibilities of the student, the school and the supervisor. It is not fair to place **all** the responsibility on the student. One of the recommendations for the school is that all supervisors receive proper training in the task of supervision. This can be achieved in house, at IB (or IB-approved) face-to-face workshops or through on-line workshops. Assigning an untrained supervisor to a student is likely to result in a much lower grade for the student.

The guide specifies clearly the type of help and guidance a supervisor is able to give. By reading through the first draft carefully and making suitable comments supervisors should be able to ensure that no students get zero marks for some of the more formulaic criteria such as Criteria B, I and J. Providing students with a suitable checklist for them to go through carefully before handing in their final version of the essay can also be extremely helpful. One other advantage of good training is that supervisors are able to make more realistic assessments of the essays when they give their predicted grades.

The range and suitability of the work submitted

As usual there was a wide range of titles. Many of the old favourites relating to some aspect of aspirin, vitamin C, caffeine and biodiesel were again much in evidence but there were some quite innovative essays this year. Some of these were novel twists on the traditional topics such as

> *Does the colour of the pepper (capsicum annuum) affect its vitamin C content?*

and

> *Anti-oxidant effects of ascorbic acid and citric acid – can a method be developed to distinguish their strengths which can be used for other anti-oxidizing compounds such as ASA?*

These types of essays are likely to score more highly on the holistic criterion than those that are simply of the type 'Is what it states on the label true?'

Other good essays titles made connections between less obvious variables such as

> *The correlation between the degree of unsaturation and the smoke point for fats and oils*

and

> *The kinetics of disappearing ink.*

Sadly there are still a sizeable proportion of essays performed in a university where the school supervisor has little control over how the work proceeds. Too often it is clear that the project has been chosen for the student and throughout the essay the student fails to demonstrate that he or she understands the underlying chemistry. The essay might look impressive superficially as the title is very erudite but often students score quite low marks as they do not fulfil the requirements of each criterion. Three of these types of essays where the same university was used in each case were:

> *Synergistic cancer therapy through targeted drug delivery and microwave ablation.*
>
> *Synthesising high quality artificial photonic crystals using sol-gel chemistry.*
>
> *Effect of light polarization on the optical properties of gold nanocrescents.*

Some candidates have a good title for their essay but are still failing to focus the research question to something that is manageable in 40 hours/4000 words of work. This is another area where the guidance of the supervisor is essential as one of the supervisor's tasks is to help them arrive at a suitably focused research question. This year for the first time a Grade E is potentially a failing condition for the Diploma and some of those that did obtain Grade E were writing essays with very little or no chemical content – again this suggest poor supervision.

For the past few years many students have been simply submitting an extended Design-type practical write-up for their extended essay which addresses the Internally Assessed criteria rather than the EE criteria. This was again in evidence in all the essays submitted from some schools but other schools do now seem to training their students in the proper requirements for an extended essay. Giving students examples of excellent chemistry essays (which can

be obtained from a variety of sources) so that they can see the type of approach required can be useful to combat this IA-type approach syndrome.

Candidate performance against each criterion

A: research question

The reasons why some students failed to score two marks for this criterion included:

- forgetting to include the research question in the introduction.
- not stating the research question clearly.
- stating multiple research questions.
- stating a research question that is too broad to be covered in 4000 words.
- stating a research question in a subject other than Chemistry.
- stating a research question which does not lend itself to a systematic investigation.

These can be summed up as 'failing to address the criteria fully'. Since all they need to do to score the two marks is:

- State the research question clearly in the introduction.
- Ensure the research question is sharply focused (making effective treatment possible within 4000 words).

With the correct guidance all students should be able to score the maximum marks for Criterion A and the role of the supervisor is crucial here. Once the research question has been formulated students should be trained to ask whether it is actually sharply focused or whether it could be narrowed down even further.

B: introduction

Students who scored highly for this criterion put their research question into context. That is, they showed the significance and worthiness of the topic. All introductions should contain material that is clearly referenced to show that the student has done meaningful background research. Too often students made sweeping statements with no concrete evidence to support them.

C: investigation

Students who planned and did their own practical work still needed to consider the work of others in their chosen field and discuss the merits or otherwise of the possible different methods that can be used and to explain why they settled on a particular approach. They needed to put their investigation into the context of work done by others. Many students ignored this and launched straight into their experimental method without discussing the source of their method or how they adapted it to address their particular research question.

Students who did not perform their own experiments needed to demonstrate that they had gained their data from an imaginative range of different sources, not just one or two.

D: knowledge and understanding of the topic studied

This is one of most difficult criteria to address well. Students do not need to repeat the theory of chemical topics that are on the syllabus but they do need to show that they thoroughly understand the chemistry underpinning them. One of the common weaknesses was to omit to explain the theory behind techniques that are unusual or off the main syllabus. It was quite common to find candidates simply giving an equation or formula for calculating the result from their chosen method without showing how it was derived. Good students gave the structural formulas of organic compounds they were referring too but also showed that they understood the significance of the functional groups contained within them.

E: reasoned argument

This continues to be the criterion that clearly distinguishes the excellent extended essay from the rest. To score highly for this criterion students must produce a convincing argument in relation to the research question. The students who did this set out their ideas clearly and logically and analysed the strengths and weaknesses of their claims. Many of the low scoring essays were simply descriptive or narrative with no real argument.

F: application of analytical and evaluative skills appropriate to the subject

This criterion too distinguished between those who thought and those who just applied and repeated what they had been trained to do for the Internal Assessment criteria. Students should realise that all subjects have this criteria. Historians and geographers do not use burettes and pipettes so how do they analyse and evaluate their data? Clearly some idea of the uncertainties associated with the measuring equipment is worth including but the real evaluation comes from questioning the validity of all the data used – not just the data generated by the student. Students need to be trained to look critically at the data and information they quote. There are several websites that were quite commonly referred to where the equations and chemistry information are simply wrong and yet students quoted them without ever questioning their validity. Even with their own experiments many students omitted to question the underlying assumptions or omitted to refer to side-reactions or other reasons why a reaction may not go to completion. Examiners understand that there may not have been enough time to repeat the work sufficiently to make it scientifically rigorous in the forty hours available but students needed to show they clearly understands the significance of this.

G: use of language appropriate to the subject

Many students did well on this criterion. Although IUPAC names should be used what matters here is consistency so using acetic acid rather than ethanoic acid throughout is fine but the two should not be interchanged within the same essay. Included in the language of chemistry

is scientific language so the correct use of units and significant figures and the correct labelling of graphs are also important.

H: conclusion

This should be a relatively easy criterion to score well as the conclusion does not depend on the quality of the argument that has gone before, it must simply be consistent with it. Many students were able to do this successfully. Common reasons for not scoring highly were: including new material not consistent with the evidence presented in the essay; failing to be consistent with the evidence presented and not including unresolved questions.

I: formal presentation

Some students lost marks unnecessarily for this criterion. A simple check-list would have alerted them to the fact they did not include a table of contents or that their pages were not numbered or that they had used an inconsistent way of listing the references in the bibliography. Very few students were penalised for writing more than 4000 words. A few even wrote on the front page that the total was more than 4000 according to the Microsoft Word count but once headings, tables and equations were removed the actual total came to less than 4000. There is no minimum but it was rare to find essays with less than about 3000 words that scored satisfactory or better.

J: abstract

The abstract provided one of the clearest signs for examiners of ascertaining how much supervision a candidate had received. The extended essay guide states that it is strongly recommended that supervisors give advice to students on writing an abstract. Some students obviously had no idea of how to write an abstract whereas others were almost models of perfection. Some students scored zero for writing more than 300 words. It is worth pointing out to students that the abstract is not part of the extended essay and should not appear in the table of contents.

K: holistic judgment

Examiners are looking to reward evidence of intellectual initiative, insight and depth of understanding and originality and creativity under this criterion. Most students were able to show some of these qualities and were able to score at least two of the four marks. The report written by the supervisor was often helpful here. One recent addition to some supervisor's reports which examiners have found very useful is some indication of the student's responses during the *viva voce*. This can be particularly useful when the work has been done outside the school environment and the candidate is able to show (or otherwise) during the oral that they do understand the underlying chemistry.

Recommendations for the supervision of future candidates

- Schools must ensure that all teachers acting as supervisors are adequately trained before they undertake the task of supervision.
- Supervisors must ensure that students are given advice and guidance throughout and that the chosen research question is suitable for a 40 hour/4000 word essay in chemistry.
- Ensure that students are fully conversant with what is expected of them and are familiar with the assessment criteria.
- Ensure that students have access to some past chemistry extended essays which have been graded excellent.
- Encourage students to carry out a risk assessment for any practical work they undertake.
- Check that the method(s) used by the student has (have) the potential to generate meaningful data.
- Explain the importance of developing an argument when writing the essay and avoiding a purely descriptive account.
- Encourage students to find two or more different approaches to solving their research question as the merits/drawbacks of these different approaches can lead to a good argument.
- Encourage students to think critically and not mindlessly follow the internal assessment criteria.
- Encourage students to be innovative and 'take a risk'.
- Encourage students to use a wide variety of other resources as well as Internet websites.
- Provide guidance on documenting sources, writing a bibliography and an abstract.
- Discourage students from working on sophisticated topics chosen by others where the student cannot demonstrate depth of understanding or personal initiative and involvement.
- Write helpful supervisor's comments on the cover sheet and include some reference to the *viva voce*.
- Ensure that the student has a check-list of all the points covered by the criteria to be completed to their own satisfaction before handing in the final version of the essay.