

CHEMISTRY

Overall grade boundaries

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

The range and suitability of the work submitted

With over twelve hundred candidates submitting their extended essay in chemistry this session there was a wide range of essay titles. As in previous years common titles included the analysis of vitamin C or caffeine in various natural products, investigations involving aspirin, the effectiveness of sunscreens, the oxidation of wine and a comparison of biodiesel with diesel or gasoline as an alternative to fossil fuels. Some more innovative essays this year included the use of a microwave oven to bring about chemical reactions and the use of ultrasound to elucidate organic reaction mechanisms. Most titles chosen had the potential to produce a suitable research question however many of the research questions stated were either too broad or not clearly enough expressed to be treated effectively within the word limit. Many essays seemed to lack imagination with research questions that were effectively just data collection, for example finding the level of vitamin C in a number of orange juice samples, rather than having any real research question such as "the effect of X on Y". A few students are still choosing unsuitable areas of investigation such as 'how healthy' a particular drink or food is or 'how chemical warfare has shaped our nation as a superpower'. Some students seemed to be carrying out summer research at tertiary institutes working on topics that they almost certainly did not devise themselves and which they did not fully understand. The best essays were the ones where the candidates used their own initiative by developing new methods or apparatus which was clearly under their own control and where there was a genuine interest in the work being covered.

Clearly a sharply focused research question is the key to writing a good essay. However even with a good research question many candidates did not then produce a suitable essay. Too often, students (with perhaps the encouragement of their supervisors) wrote what were essentially laboratory reports rather than essays. Sometimes it seemed as if they were addressing the internal assessment criteria rather than the extended essay criteria. Headings such as Design (or even 'Planning A'), Data Collection, Data Processing etc. were commonly present. What was often missing was the context of the research question, including well documented background information, and a reasoned argument. Many students spent much time analysing the uncertainty of the equipment used without questioning underlying chemical assumptions or realising that an experiment that has only been performed once is not scientific.

Candidate performance against each criterion

A: research question

In most cases the research question was clearly stated in the introduction, although it was not always sufficiently focused. In a few cases the research question was assumed to be the same as the title of the essay as no specific reference to it was made in the introduction.

B: introduction

This new criterion should have been a help to those writing chemistry extended essays as it directed them towards explaining the context of the research question. Good students handled this well and were able to explain clearly the significance of the topic and why it was worthy of investigation. However many of the weaker students seemed to have little idea of how to put the research question into context. It was not unusual to find an introduction with no cited references or genuine background information.

C: investigation

Students who are carrying out their own practical work still need 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 have settled on a particular approach. Too often students just quoted a traditional laboratory method for their own investigation without discussing any alternatives or ways in which they had adapted the method to address their own situation. Students who gathered all their data from elsewhere needed to show that an imaginative range of resources had been consulted – too often this was lacking with the essay being little more than a précis of a single resource.

D: knowledge and understanding of the topic studied

If there was a widespread weakness, it was to omit an explanation of the theory behind techniques and to a lesser extent not to make it clear that the chemistry behind the research question was understood. It was not unusual to find candidates simply giving an equation or formula for calculating the result from their chosen method without showing its derivation.

E: reasoned argument

This is the criterion that clearly distinguishes the excellent extended essay from the rest. Those students that scored highly produced a convincing argument in relation to the research question. These students set out their ideas clearly and logically and analysed the strengths and weaknesses of their claims. Students who wrote mainly descriptive or narrative essays scored poorly on this criterion.

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

There was considerable variation in performance on this criterion. The best looked at the underlying assumptions behind their method and tried to determine the source of real weaknesses and uncertainties. Too many students worked out percentage uncertainties as they have been taught for the internal assessment without looking critically at the source of their information. For example, if three significantly different titration results are given as raw data for exactly the same experiment then the source of the problem is more likely to be the student's weakness at manipulative skills rather than the uncertainties associated with the burette or pipette. Perhaps even worse is that some students based their whole scientific argument on a single result. There were several cases where wrong equations or formulas were taken from Internet sites with no attempt made to analyse whether or not the information was correct chemistry.

G: use of language appropriate to the subject

The language of chemistry is complex and some students demonstrated a very good grasp of it. For example, they used IUPAC or common names consistently throughout the essay rather than changing them according to which references they were using. They included the correct units and correct number of significant figures when necessary and labelled the axes on graphs correctly. They used correct structures for organic compounds and ensured that all equations were balanced and accurate. Weaker students did not comply with some or many of these points.

H: conclusion

There was considerable variation in performance on this criterion. 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

Most students were able to score at least two of the four marks for this criterion merely by checking that the required elements, such as including a table of contents and numbering the pages, were present. Very few students exceeded the 4000 word limit. The weak areas tended to be not following a standard format for correct referencing, using poor or inappropriate diagrams or digital images and using the appendix for material that should be in the body of the essay in order to keep the word count below 4000. Although they were not penalised, students should be made aware of the fact that the abstract is not part of the extended essay itself and should not appear in the table of contents.

J: abstract

In the *Extended essay guide* it is strongly recommended that supervisors give advice to students on writing an abstract. Some benefited from this advice and wrote clear and succinct abstracts. Many however seemed to have little idea of how to write an abstract and missed out some or all of the key elements. A common error was for students to include a research question in the abstract which was different to the one stated in the introduction. Some students scored zero for writing more than 300 words.

K: holistic judgment

Unless the essay was almost totally descriptive students tended to score at least two of the four marks for this criteria provided they showed some personal involvement and understanding. The evidence written by the supervisor on the cover sheet was taken into account here. For the first time the best supervisor's reports included some information about the candidate's responses in the *viva voce*. Examiners found this very helpful as an aid to assessing qualities such as depth of understanding and insight.

Recommendations for the supervision of future candidates

- Schools must ensure that all teachers acting as supervisors are adequately trained.
- 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 format.
- Encourage students to be innovative and 'take a risk'.
- Encourage students to use 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.