

## Internal Assessment process for teacher training

### Transcript

Determination of the Michaelis–Menten kinetic parameters,  $K_m$  and  $V_{max}$ , for catalase in the catalytic decomposition of hydrogen peroxide.

**CHEMISTRY EXAMINER:** Now let's start by looking at some individual investigations for biology, chemistry and physics.

**CHEMISTRY EXAMINER:** The first criteria, Personal engagement, has been given a mark of 1 by the teacher.

In this chemistry internal assessment sample, I felt that in this lab there is a good level of engagement in the background information (for example, tying in delta G), data collection, data processing and analysis. To me, this demonstrates initiative and interest. I think the teacher's point in awarding a mark of 1 is that there is a lack of direct justification of the study, but the level of engagement justifies the top award. The candidate shows good initiative, for example, when using the camera, and a mark of 2 is more appropriate than a mark of 1.

**PHYSICS EXAMINER:** This internal assessment might be a standard investigation, but the detail and what appears to be the competence of the candidate should earn them 2 marks for personal engagement. They clearly "own" this investigation, unless this is a copy (but with genuine data) of some well-known university lab.

If all the work was standard, then personal engagement is worth 1 mark, but here I would accept personal engagement at 2 marks.

**BIOLOGY EXAMINER:** Yes, I can see where you are coming from. In biology, I would score this as 1 to 2 marks for initiative, zero to 1 marks for personal engagement and 2 marks for personal input. So, you can see we are not coming at it quite from the same angle. In biology, it helps us to encourage students to take a risk and embark on something different.

**CHEMISTRY EXAMINER:** It is interesting to hear this, as the lab is a biochemistry lab. To chemists, the candidate has taken some risk, as this is a lab outside the realms of what a chemist may call a standard investigation.

**BIOLOGY EXAMINER:** In that case, and referring to the criteria, I could easily support 2 marks. Of course, this is not the only aspect of personal engagement the teacher should look out for; there are the aspects of initiative and personal input that count too.

**CHEMISTRY EXAMINER:** For Personal engagement the examiners gave a mark of 2.

**CHEMISTRY EXAMINER:** Moving on to Exploration, the teacher gave a mark of 6.

The topic is identified and the research question is well focused.

I felt that the measured dependent variable stated was not clear and was inaccurate to the study, so I gave 5 marks for the first part of the criterion. Background is good and puts it in the 5-to-6 mark band. It is extensive and concisely written, so a 6 is justified. There are plenty of variables identified and enough relevant data planned. It is not perfect though: the temperature, pH and pressure are not controlled adequately, so I would give 5 marks.

Safety, the environment and ethics are detailed but the specified safety classifications of hydrogen peroxide are not addressed fully, so I can only go with 5 marks, making a total of 5.

**BIOLOGY EXAMINER:** Okay, for this, I completely agree. I just saw that 0% substrate was missing from the method and there was no mention of eye protection, which, with hydrogen peroxide being used, I felt was essential.

**PHYSICS EXAMINER:** The experiment really seems thought out with all the details considered. Variables are considered and controlled variables are amazingly detailed. Are the method and procedures standard or did the candidate apply chemistry skills here? My feeling is this investigation is too ambitious for an internal assessment, but it seems to have worked out well. I would accept exploration at 6 marks.

**CHEMISTRY EXAMINER:** OK, so two 5s and a 6. Are we in agreement with 5 marks?

**PHYSICS EXAMINER:** I can understand why the teacher gave a 6, but I also see from your interpretation of the criteria why that is a little generous. We need to mark to a common standard.

**CHEMISTRY EXAMINER:** Something all three of us agree on, across all three sciences, is that in selecting a topic for investigation, there must be a dialogue between the candidate and the supervising teacher. This dialogue needs to establish that the investigation is feasible, is likely to generate useful data, is safe, ethical and environmentally sound. There is no sense in accepting an idea from a candidate that has a strong chance of resulting in failure. Examiners are expected to raise an exception to investigations that present significant safety risks, are ethically unacceptable, or will have a negative impact on the environment, which gives us an examiners' Exploration mark of 5.

**CHEMISTRY EXAMINER:** So the next criterion to look at is Analysis. Here, the teacher gave a mark of 5. I felt in this criterion there was extensive quantitative data measured to the correct precision and it was recorded with some qualitative observations, albeit general in nature. I did spot the temperature was not recorded. There are plenty of repeats and the frequency of the independent variable was sufficient for the research question, so I would give 6 marks.

The data processing is appropriate, although the average rate is found over the first 0.5 seconds. This is acceptable but a tangent may have been better. The Michaelis constant,  $K_m$ , and rate at which the enzyme catalyzed the reaction,  $V_{max}$ , are found using the Lineweaver-Burk plot, but the candidate did not give the units. It is still in the 5-to-6 mark band.

Uncertainties are propagated, although there are some minor errors, for example, a change in mass and also in significant figures. Standard deviation and the lines of best fit are appropriate, even though error bars are not shown. It is still in the 5-to-6 mark band. I am supportive of the data processing, but standard deviation and error bars are not fully discussed; however, the significance of R squared is addressed, so I would give 5 marks. For me, this puts it on the 5-to-6 mark boundary, but omissions and errors in this case should be assessed under communication criterion issues rather than analysis, so for me it is a 6.

**PHYSICS EXAMINER:** OK, assuming the method and data are appropriate, analysis seems thorough and detailed. Without error bars, graph 3.6 is not necessarily justified as a straight-line. The candidate addresses

the intercept and appreciates the systematic shift. This seems to be meaningful. There is excellent detail with controlled variables. I wonder if the mass versus time graphs should have had more data points in the first second or so. Perhaps the use of data logging with shorter sampling intervals would improve this crucial range. No error bars on graphs is a big deal in physics. However, if the candidate uses statistical approaches, then this is okay. Error bars reflect experimental variation while standard deviation reflects a formal or mathematical property between the best-fit line and the data points. The two approaches are significantly different. The work of the candidate is in the top mark band, but here I cannot distinguish a 5 or 6.

**BIOLOGY EXAMINER:** So, you found the determination of the gradient acceptable. I discussed something similar with a chemistry colleague a few years ago, who felt that averaging gradients rather than averaging the measurements should be carried out. The candidate has only used two data points for the gradient; I agree with you that a data logger would have been much better.

**CHEMISTRY EXAMINER:** That's quite rigorous from a chemist's point of view. If I pushed you both, would you agree with a 6?

**PHYSICS EXAMINER:** Yes, I would.

**BIOLOGY EXAMINER:** I think we need to accept that one size doesn't fit all, and there are differences in emphasis and approach between the three subjects. For example, we are perfectly aware that in Biology that we don't approach uncertainties and significant figures in the same way as in chemistry and physics. Using overlapping error bars as a test of significance is not acceptable in biology, but then again, we would not expect propagation of error. So, I can support your mark here on the basis that it isn't the same subject and you have different demands. Teachers will need to make their students aware of these differences in the different science courses.

**CHEMISTRY EXAMINER:** So overall, the examiners agree on a mark of 6.

The fourth criterion to look at is in Evaluation, and here the teachers gave a mark of 5.

The conclusion is described clearly and has some justification using the data, so I will give 5 marks here. There is some broad enzyme kinetics discussion, but it is limited at the molecular-level explanation. There are no relevant literature values specific to catalase, so I will give 3 to 4 marks here. The strengths are not explicitly addressed, but many procedural and some methodological limitations are stated. The issues with the reliability and range of hydrogen peroxide concentrations are appropriate, although the temperature should have been controlled initially. I will give 4 to 5 marks here. The improvements discussed are realistic and directly relevant, and the extension is well considered, so 5 marks overall is appropriate.

**BIOLOGY EXAMINER:** I agree with your interpretation of the report in the context of the criteria, so for me a 5 is appropriate here.

**PHYSICS EXAMINER:** For such a detailed investigation, I was surprised by the limited evaluation. Using the R squared value in physics is not a sound approach, as a number of functions between physically related quantities should yield a value of 0.9 or more. But I recognize this is different in chemistry. With the page-long list of limitations and sources of error, the candidate has tried to address all the relevant descriptor indicators under evaluation. I am wavering between a 4 and a 5.

**CHEMISTRY EXAMINER:** Can we go with a 5 to support the teacher's marking?

**BIOLOGY EXAMINER:** Agreed. For the use of the coefficient of determination, in other words, the R squared value, the way the candidate is using it is acceptable for biology. Here, it is being used to express how good the proposed trend lines fits the scatter of the plots. In biology, it is a statement of uncertainty in the data. What we have found in biology samples is that there is a tendency for candidates to use it synonymously with a correlation coefficient, which is very approximate. Unlike in physics, in biological situations, we do not find R squared systematically giving high values; the scatter of points is often very great. If a candidate forced the trend line into following the points just to obtain a high R squared value, that would be as unacceptable as in other sciences.

**PHYSICS EXAMINER:** Yes, agreed.

**BIOLOGY EXAMINER:** Evaluation is, perhaps, the most difficult criterion for the candidate. It requires a judgment on the results of the investigation *and* critical thinking. It is often observed that the conclusion and evaluation are treated rather superficially by candidates. Sometimes, this may be due to weak training in critical-thinking skills, but other factors may come into play. Internal assessment often occurs at a time when students are devoting time to other tasks, for example, internal assessment for other subjects, completion of extended essay, university applications, and so on. The teachers should watch out for student overload and try to adapt the workload accordingly. For a good example of an investigation that starts well but struggles to maintain consistency, it is worth looking at the biology sample.

**CHEMISTRY EXAMINER:** I also think that sometimes candidates require encouragement to fully address the evaluation, as this is the criterion in which they underperform the most.

**BIOLOGY EXAMINER:** Yes, that's right. As an examiner, I have noticed that a large number of schools appear to leave the individual investigation right to the end of the course. I have heard teachers say that they prefer to do this because students have more experience at the end. I think this is a false argument. One can begin to build the individual investigation as the course progresses and use it as part of the learning experience. Besides, leaving the investigation to the end means that there are no safety nets if anything unexpected should happen.

**CHEMISTRY EXAMINER:** This means that for the Evaluation, the examiners gave a mark of 5.

The last criterion we'll look at is Communication. The teacher's mark for this criterion is 4. The report is well structured and relevant to the research question. The use of terminology shows a good level of understanding. While it is nicely concise at times, some details are lacking, particularly in the procedure and analysis. The report is clear but there are major issues, namely the units of the Michaelis constant and the maximum velocity, the research question is ignored throughout, the error bars are omitted even though they are stated in the report and the presentation of the graphs is inaccurate. There are problems with significant figures in the final absolute uncertainty. While the report has more positive attributes, these major omissions mean a mark of 3 is more appropriate.

**PHYSICS EXAMINER:** The style of this report seems clear, focused and very precise. This reads like an academic journal article. Four decimal places for an uncertainty, for example, 5.336 plus or minus 0.1087 is incorrect. Communication is 3 or a low 4. I would go with 3 marks in agreement with your comments about important omissions.

**BIOLOGY EXAMINER:** Yes. There are no retrieval dates for the online sources, but I am fine with a 3. Academic integrity is very important to the International Baccalaureate, so citing sources correctly must be encouraged by the teacher. Teachers need to look out for signs of plagiarism in their students' work. If they suspect malpractice, then an interview with the student can be a way to clarify the authenticity of the work. Colleagues can also help check for academic integrity when the work is internally standardized.

**CHEMISTRY EXAMINER:** For Communication, the examiners gave a mark of 3.

The teacher's total mark was 21. The examiners' total mark was also 21.

We did disagree slightly with the teacher in the application of some of the criteria.

**BIOLOGY EXAMINER:** Yes, being a non-subject-specialist, the teachers' annotations were really helpful in helping to crystallize where the marks had been awarded.

**PHYSICS EXAMINER:** What was really important for all three of us was to agree on the same final mark which most closely matched the criteria.

**CHEMISTRY EXAMINER:** Well, thanks for your time. I think that was a useful experience for us all?

**BIOLOGY EXAMINER:** Yes. That was great.

**PHYSICS EXAMINER:** My pleasure. Thank you.

**ENDS**

