Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**Candidate performance against each criterion 2017 IB Review** Period: \_\_\_\_

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| **Article** | **Notes** |
| **Exploration** Of the six-point criteria (Exploration, Analysis and Evaluation) it was Exploration that proved the most successful for students with Higher Level candidates on average securing midway between 3 and 4 points while Standard Level students averaged 3 points. In many cases a suitable topic was identified and a relevant research question was described to a better extent than in May 2016. Many research questions fell into the category of determining how a measurable independent variable effected an identified dependent variable and these generated reports that were easily assessable with the IA criteria. Weaker research questions were those simple brand analyses of food, cleaning or pharmaceutical products. Any trends identified would be explainable in terms of business principles (manufacturers decide the composition rather than being the outcome of solely scientific principles). There are possible fruitful avenues available by studying commercial products but these really only open up if a student can link some component of the product composition (which they can experimentally determine or read from the packaging) to a chemical or physical property of the product. The quality of the background information was mixed and possibly weaker than in May 2016. Frequently it was of general character rather than addressing the specifics of the chosen research question or methodology. The top level descriptor requires the background information to be entirely appropriate and relevant so teachers should advise students to keep it focused. A common failing was that students failed to include balanced chemical equations for the key reactions associated with their investigation. In terms of taking into consideration the significant factors that may influence the relevance, reliability and sufficiency of the collected data the responses of the candidates were similar to last year in that it was extremely varied. A good number of students clearly controlled relevant variables, selected a suitable number of values of independent variable and repeats in order to establish reliability and sufficiency. However an equal number of students didn’t carry out repeats and most significantly failed to correctly identify or control key variables with the result that their data did not properly answer their research question. For example many investigations focusing on food tended to ignore relevant variables such as variety of food, moisture content and storage conditions. Another weakness was that quite a few candidates omitted reporting capacities for volume measuring instruments or used inappropriately imprecise glassware such as beakers and measuring cylinders instead of volumetric flasks and graduated pipettes. The correct choice affects uncertainty and should be carefully considered during design. Also while many students considered rightly the calibration of instruments such as pH-meters, others ignored this relevant step thereby decreasing the reliability of collected data. Even more so than last year students showed at least some awareness of safety, ethical or environmental issues relevant to their methodology. In many cases this was confined to a quite basic measures such as gloves and safety glasses but an increased number of candidates did consider safe and environmentally appropriate disposal of reagents. |  |
| **Analysis** The overall achievement for Analysis was close to that for Exploration although the marks were distributed widely across the range. Most students recorded sufficient data related to the independent and dependent variables so that they could subsequently carry out sufficiently meaningful process and interpretation. Qualitative observations were often recorded although it was not uncommon to find photographs replacing, rather than supporting, written qualitative data. The interpretation of these photographs was frequently not easy and this practice should not be encouraged. Fewer students though recorded the wider data that can provide valuable context for the evaluation of the procedure such as measurements of controlled variables, for example the temperature of the reaction mixture, as opposed to room temperature, in studies of reaction rates or the current in electrolysis investigations where all too often students simply assume current is directly proportional to the voltage setting on a power pack without actually measuring for themselves. In common with other sessions a significant number of candidates reported solely processed data such as added volume of a titrant or averages instead of raw data and thereby limited their achievement. We saw that a common approach to processing was simply to average the dependent variable data and then plot a graph against the independent variable to see the nature of the relationship. Very often this was done well enough to award good credit. Other common data processing approaches were quantitative determinations based on titrations (plenty of redox titrations featured which stretched the students) and calorimetry calculations. Last year it was noted that teachers needed to check calculations through carefully since moderators were uncovering serious processing errors that led to significant downward mark adjustments. This session the situation seemed much improved. Although students are still prone to processing errors these were more often identified by teachers. Some common areas of weakness surfaced. Calculations in acid-base chemistry were often erroneous with the relationship between pH and pKa poorly understood and some students assumed pH values were additive. In rate of reaction investigations a significant number of students didn’t actually calculate a rate at all and contented themselves with comparative comments on reaction time and there were many reports where students presented inappropriate bar charts rather than properly constructed graphs. On other occasions graphs were presented but students opted for establishing average rate instead of using tangent at initial times which rather diminished the purpose of constructing the graph. There was a variety of evidence presented towards the consideration of the impact of measurement uncertainty on the analysis. These included:• Sensible protocols on propagation of errors through numerical calculations such as outlined in Topic 11.1 of the Chemistry Guide or the TSM or standard deviations on a sufficiently large data set or square rooting sum of the squares, etc. • Well-constructed best fit graph lines • Error bars on graphs (this was much more common this year than in the past). • Maximum or minimum slopes. • Appropriate consideration of outlier data.* Consideration of equation of a graph line and the R2 value

• Consistent significant figures and decimal places. • Comparison of data from different data sources (secondary data examples) to evaluate reproducibility. • Evidence of investigation of research into the uncertainties associated with database data.No investigation needed to include all these features to achieve full credit and most students were able to reach at least the middle band descriptor in this regard. Some weaknesses that arose were: a significant number of students who made no attempt to propagate uncertainties through calculations, a number of candidates presented lines of best fit on graphs involving discrete independent variables which is of course not valid, frequently error bars were inconsistent with the record uncertainties while there are still quite a number of students who present numerical results to an excessive number of significant figures. More pleasingly compared to last year there appeared to be a reduction in the number of inappropriate statistical treatments such as T-tests on a minimum of data and the use of Excel seemed improved with less polynomial graph lines appearing like water slides and roller coasters! Most students were able to interpret their processed data so that subsequently a conclusion to the research question could be deduced although in a significant number of cases the interpretations were often merely prose descriptions of the data and in other cases there was no interpretation at all. When interpreting a graph a common mistake was to describe linear negative slopes as inversely proportional and any deviation from linearity in a positive slope was termed exponential. Less students this year simply presented a complicated Excel graph line equation without any appreciation of what it may be indicating as an underlying trend. It is worth noting that some students achieved poorly across Analysis since their designed methodology was too limited and only a small amount of data was collected and the consequent processing and consideration of uncertainties was unchallenging. The IA framework places the responsibility on the student and part of the independent learning task is for students to be aware of the criteria up front and for us to challenge them at an early stage of the process as to whether they think their proposed investigation gives them chance to fully satisfy the criteria and counsel them accordingly.  |  |
| **Evaluation** Evaluation this continues to be the most challenging criterion and the students’ attainment was significantly behind those for Exploration and Analysis by about half a point on average. This is probably not surprising since it is a demanding reflective criterion requiring higher order thinking skills while the writing of the relevant report section comes at the end of the process when possibly fatigue has set in and often the submission deadline is looming large. The first part of the criterion was fulfilled fairly well with most students able to draw a conclusion that was consistent with the data to an extent that met the 3-4 band descriptor or above.The second part of the criterion was not well fulfilled by a large number of candidates as students failed to correctly describe or justify their conclusion through relevant comparison to the accepted scientific context. For this part of the descriptor students could possibly be making the comparison of their experimentally determine quantities to readily available literature values and/or referring to whether any trends and relationships identified were in line with accepted theory possibly by referring back to their original background information. It was disappointing how few students achieved this successfully. The descriptors regarding limitations and improvements also were not well fulfilled by many students. Strengths were rarely addressed and limitations were usually procedural and few. Very few investigations addressed systematic and random errors in details while many referred to them but failed to identify them in their specific investigation. Suggestions for improvements usually included more repetitions even at times when the number of trials had been acceptable. Specific improvements that were also related to previously identified limitations were less common. Moderators did see a bit more meaningful emphasis on extensions being given this year which addressed a weakness from the last May session.  |  |
| **Communication** As in the May 2016 session the Communication criterion was in most cases quite well fulfilled and averaged midway between 2 and 3 marks. Understandably this criterion, along with Personal Engagement, saw a minimal differential between Higher and Standard Level candidates. Most reports were clearly presented with an appropriate structure and many students gained credit for coherently presenting the information on focus and outcomes. Common weaknesses were for insufficient detail to be included in the description of the methodology and for students to not present at least one worked example calculation so the reader could understand how the data was processed. Many reports were mostly concise and nearly all of them did meet the 12 page limit which did prove sufficient for even the most sophisticated investigations. Less students than last year included lengthy appendices in order to circumvent the page limit ruling which was good since examiners do not have to read the appendices so vital marks could have been lost. Most of the reports were relevant although the one common area of weakness was the inclusion of general background information that wasn’t focused on the Research Question. With regard to the use of terminology and conventions many students proved inconsistent in their use of labelling graph axes, units, decimal places and significant figures although in most cases understanding was not greatly hampered. The using of citations and references was overall very good.Recommendations for the teaching of future candidates • Students should develop investigations that seek to answer research questions whose answer is not self-evident to them known beforehand. • Encourage students to include any relevant balanced chemical equations in their introductory material so it is clear as to the reactions and processes involved in their investigation. • Encourage students to reflect on data while collecting it so they have the chance to modify methodology if the data are proving insufficient, unreliable or erroneous. • It is good practice for students to give a safety and environmental evaluation for any investigation involving hands on practical work even if it is to show that safety and ecofriendly disposal have been evaluated but no special precaution is then required. • Encourage students to describe briefly in a paragraph the process of developing their methodology. This narrative will help explain the amount of data collected and give insight into the decision making of the student that in part evidences Personal Engagement. • Ensure students record all relevant associated data and not just the independent and dependent variable data. • When evaluating methodology encourage a consideration of underlying factors affecting the validity of the method such as range, sample size, use of an alternative reaction system to study the same phenomenon, etc. • Encourage students to interpret results quantitatively wherever possible. This will also provide a sound foundation for high quality conclusions. • Students should consider suggestions for improvements that are related to previously identified limitations and that should be realistic and specific to their investigation. • Methodologies should be written in sufficient detail so that the reader could in principle repeat the investigation and also so that an idea of the associated uncertainties can be gained. • Where relevant to the analysis students should present at least one worked example calculation so the reader could understand how the data was processed. • Discourage the inclusion of appendices.  |  |
| **Further comments** When assessing the students work teachers should: • Carefully check methodology for any missing key variables that would invalidate the conclusions being drawn. • Carefully check calculations for errors that would affect the conclusions being drawn. • Apply the model of best fit marking of the criteria evenly and not prioritizing some descriptors over others when awarding marks. |  |
| **Personal Engagement:** The candidates were awarded either one or two marks with fairly equal frequency with a zero award being very rare. There were less cases than in the May 2016 session of the students’ efforts to justify their choice of topic spilling over into overlong and contrived narratives relating to their early childhood experiences. The commonest limitation to achievement was where students failed to show genuine curiosity by presenting a very undemanding research question where the outcome too self-evident, such as determining how the mass of alcohol combusted affects the heat energy evolved or whether time current passes affects the mass change of an electrode during electrolysis. Where students presented a research question that reflected a question that they genuinely appeared interested in answering and couldn’t already be expected to know the answer then credit was easily given. The second part of the descriptor regarding personal input and initiative is evidenced across the whole report and here the outcome was again variable. A good number of students did show plenty of personal input and initiative in the designing and implementation or presentation of the investigation but it was not uncommon for students to simply repeat a commonplace school investigation with a procedure that had not been adapted or extended in any way. Another indication that students were not fully engaged was when there were clear limitations in the initial methodology that could have been quickly and easily addressed during the process but the student made no attempt to do so. Successful students evidenced input by applying a known technique to an interesting real world situation and then by fully using their time to carry out trials at plenty of values of independent variable as well as including repeats rather than confining themselves to the simple few trials specified in the old internal assessment framework.  |  |