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| **IB Physics Internal Assessment**  **Comments on Student Script “E”**  Research Design, Data Analysis, Conclusion, Evaluation | SafariScreenSnapz001.tif |

**“Investigating the effect the concentration of salt in water has on evaporation”**

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| **Research**  **Design 0 – 6** | **Data**  **Analysis 0 – 6** | **Conclusion**  **0 – 6** | **Evaluation**  **0 – 6** | **Total**  **0 – 24** |
| **2** | **3** | **2** | **1** | **8** |

#### Research design assesses the extent to which the student effectively communicates the methodology (purpose and practice) used to address the research question

**Research Design Assessment** best fit at level 2. The only reason the teacher might award a higher mark is because the investigation is simple and straight forward (and we read into it what needs to be done).

**Research Design 1st Descriptor**

The answer to the research question is “yes”. The hypothesis is already known to be true; the addition of salt in pure water decreases the rate of evaporation. This is because of the decrease in the saturation vapor pressure of the salt solution. This means fewer water molecules can escape (the highest speed molecules) from the surface. Therefore, the higher the concentration, the lower the evaporation rate. The salt ions occupy space on the water surface, and this reduces the H2O present on the liquid-air boundary. Again, we know the rate is related to surface area (so adding salt reduces the pure water surface area). The research question is defined and clear, but the context is limited at best. The only context given by the student is the statement *“Liquids with an increased concentration form bonds with the salt affecting evaporation. The sodium and chloride ions are attracted to water molecules when salt dissolves in water. The internal energy of the water molecules will be reduced by the bonds, which are formed.”* This may be true, but the issue of surface evaporation is not fully explained by the student. Much of the first two paragraphs are paraphrased from the online article (not quoted but listed in the bibliography). We can say that the first thread of RD us outlined.

**Research Design 2nd Descriptor**

The methodology and procedures are spelled out (except for the lack of explanation to uncertainties, and just a bald statement of time and mass uncertainties). We do not need a photograph of an electronic balance with spatula. A longer time interval would be preferable. There are only three data points, including zero time. Any idea of how rate might change with time? More data points might have been interesting. Was the controlled variable of temperature constant overnight, day to day? The student rejects the 72-hour datum as it does not fit their assumed analysis of a linear line. Is this justified or is it cherry-picking? There are no repeated measurements, which could have been done simultaneously (although this is addressed in the evaluation). Two or three identical beakers could have been used side by side with identical solution. Controlled variables were described for the most part. The concept of concentration is not addressed in a scientific way, usually a relative proportion of solute and solvent present in the solution (molarity, molality, mass percentage, parts per some number, etc.). This oversight does not affect the investigation. The description here does not reach the level of an explanation. The second threat of RD is in mark band 1-2.

**Research Design 3rd Descriptor**

For the most part, we could repeat the student’s investigation but only with obvious additional procedures. Details are missing. The third threat of RD is in mark band 1-2.

#### Data analysis assesses the extent to which the student’s report provides evidence that the student has recorded, processed and presented the data in ways that are relevant to the research question.

**Data Analysis Assessment** is a best fit at a low level 3 (mark band 1-2 would be too severe).

**Data Analysis 1st Descriptor**

The raw and processed data tables are neat but not precise; there are a few mistakes, some inconsistencies in significant figures, and the lack of useful uncertainties. There is no data in Table 1 for zero salt (water alone) and yet the missing data is graphed. At closer inspection, it seems that the column for “Mass 1(g)” is really zero salt, and “Mass 2(g)” is really 1 g of salt, and so on.

**Data Analysis 2nd Descriptor**

The report shows limited evidence for the appreciation of experimental uncertainties. The mass and times uncertainties are simply stated, with no explanation or understanding. The graph’s uncertainty bars for mass are wrong, probably made up. Using the student’s value of 0.01 g the bars would not be noticeable given the scale of the graph. The uncertainty bars on the time scale seem appropriate but how in the world did the student come up with ±0.67 hours? (Perhaps this is the time it took to set up the five samples, the time—40 minutes—between producing the first beaker and the last beaker?) Or perhaps the student used a sundial? It was not a good decision to plot only three data points, and then impose a linear line (where theory suggests otherwise).

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| **Data Analysis 3rd Descriptor**  Given the RQ, why not display the results in a graph of evaporation rate and salt concentration?  The student’s graph reveals inconsistencies, such as not including the 5 g data, and the graphing of only 48 hours instead of the full 72 hours. |  |

The student explains this 72-hour omission by telling us that doing so would not allow a linear best fit line. The analysis contains significant (but not major) inaccuracies. No quantitative use of the gradients in was made, only an order (correctly addressing the research question). Again, more data points would have been interesting, either to accept a linear rate or to appreciate subtle changes. We will not know. As mentioned below under Conclusion, an appreciation of the trend of evaporation for all the concentrations would have helped support a quantitative hypothesis and conclusion.

#### Conclusion assesses the extent to which the student successfully answers their research question with regard to their analysis and the accepted scientific context.

**Conclusion Assessment** is not easy here because the analysis was done in a relevant way, and that the accepted phenomenon was already known. The conclusion was qualitative only, and an obvious fact. The student did not “prove” the hypothesis but confirmed the known fact that salt reduced the evaporation rate of water. The best fit assessment is at level 2. More understanding is required for a higher mark.

**Conclusion 1st Descriptor**

The textbook that the student used mentions that the evaporiation rate relates to surface area and the temperature (and we also know that air pressure, air density, relative humidity, and wind affect are factors). As a liquid evaporates, the temperature is reduced. The RMS speed of molecules is reduced, the liquid cools. This means that the rate of vaporization changes, decreases, but the rate cannot be constant (not a linear graph) because the liquid cools. Only because the student forces a linear fit on a very limited range of data do they think that the rate is constant. Proper uncertainty bars were not used. Nonetheless, if the student’s goal is qualitative only, that adding salt reduces evaporation, then they are correct. But more depth of understanding is expected at the IB level. Theory tells us that the gradient decreases with time (temperature change due to evaporation), but the student assumes a constant gradient, (assuming constant temperature) missing important physical concepts. (*d*m/*d*t becomes Δm/Δt). And yet given the limited range, the results are consistent with known physics. The student’s first conclusion (page 4) about time to break bonds was not justified (nor was this issue investigated). The second conclusion was demonstrated. A better conclusion would have been something like “The salt ions occupy space on the surface of the water, thus reducing the water surface area (the liquid-air boundary) thus reducing the number of molecules escaping, and thus reducing the evaporation rate.” Assessed under Data Analysis or Conclusion, the student could have used their data from Table 2 and produced another graph releveling an inverse linear function for all the samples. The best fit line (correlations –0.998) would have a constant rate of –0.034 grams per hour per gram. This would allow a clear and scientifically sound conclusion.

**Conclusion 2nd Descriptor**

The hypothesis was that *“Increasing the concentration of salt in water will reduce the rate of evaporation due to the salt creating new bonds with water, which will take more time to break for evaporation to occur.”* This as a conclusion is not justified (the student just repeats the hypothesis). The student suggests that *“The bonds created between ions in the salt and water take a longer time to break, leading for it to it taking longer to evaporation a solution with a greater salt concentration in the form of vapor”* supports the results. Only in a qualitative way can we say that the student has compared their result to within an accepted scientific context. More is expected at the IB level. The cause of reduced evaporation was not proved. The student realized that they ‘needed’ to omit the 72-hour data as well as the 5 g salt mass datum for their forced linear fit to work. This should have rung bells in the student’s understanding.

#### Evaluation assesses the extent to which the student’s report provides evidence of evaluation of the investigation methodology and has suggested improvements.

**Evaluation Assessment** is in the 1-2 mark band; because comments tend to be general and superficial, level 1 is the best fit.

**Evaluation 1st Descriptor**

The investigation did illustrate changing evaporation amounts with salt solution, but this alone is not a part of an evaluation. Although performing this investigation has added to the student’s scientific knowledge (as we all hoped it would) this too is not part of an evaluation. We all would agree that *“To make the investigation more precise preliminary experiments were conducted to minimize human error and clearly identify the correct steps needed required to collect the results”* but this again is not a part of an appropriate evaluation. The mention of a constant temperature was important, but this comes under research design criterion. The student made no effort to monitor or control the temperature. Theory also says the with evaporation the temperature reduces. (The *rms* speed reduces as the fastest molecules escape.) Some random errors were mentioned, but nothing specifically relating to the descriptor requirement (to the data and analysis). The section on “Representativeness” was an original and insightful point, a good NOS thought. This is a thought given which is relevant evaluation. The student knows that they did not use all the data, and if they had they might discover a non-linear function. The student was blinded by the linear straight-line approach to analysis.

**Evaluation 2nd Descriptor**

Improvements need to be based on recognized weakness or limitations. Stating ***“****To improve the investigation more accurate apparatuses with less error could be used instead”* addresses nothing here. The timing error did not appreciate that the actual time is not crucial but rather the precision of time would be helpful. For instance, 23 hours 42 minutes and 6 seconds could just as easily be used when graphing and finding the gradient. You just look at your watch. Other comments, such as on random errors are not focused nor meaningful in any relevant way. However, the student also suggests that multiple trials or repeated measurements (as the examiner commented on in Research Design comments) would be used to find a more accurate value. This limitation and its improvement were appropriate. Finally, the time required to set up the five samples is seen as the uncertainty in the time. This was addressed and somewhat relevant.

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07 August 2024