

2023 HSC Science Extension Marking Guidelines

Section I

Question 1

Criteria	Marks
<ul style="list-style-type: none">• Demonstrates a comprehensive understanding of methods used to communicate the findings of scientific research• Provides a comprehensive assessment of the effectiveness of the given method of scientific communication with respect to purpose, audience and context	5
<ul style="list-style-type: none">• Demonstrates a thorough understanding of methods used to communicate the findings of scientific research• Provides a thorough assessment of the effectiveness of the given method of scientific communication	4
<ul style="list-style-type: none">• Demonstrates a sound understanding of methods used to communicate the findings of scientific research• Describes the effectiveness of the given method of scientific communication	3
<ul style="list-style-type: none">• Demonstrates some understanding of methods used to communicate the findings of scientific research• Outlines the effectiveness of the given method of scientific communication	2
<ul style="list-style-type: none">• Demonstrates an understanding of at least one method by which the findings of scientific research are communicated	1

Sample answer:

The use of signs to communicate scientific findings in a busy street can be effective if the purpose is to increase general public awareness of the findings. Other forms of scientific communication, such as peer-reviewed journals and research conferences, would not be effective for this purpose as the general public may not engage or have access to these. A benefit of signs is that they are succinct and in easy-to-access locations so most people who walk past will become informed of the finding. Sharing similar information in a social

media post may be more effective in reaching a larger audience as it could be more rapidly shared globally. However, AI algorithms may only target people already interested in the topics whereas the sign is seen by everyone walking past.

The use of the sign is ineffective in communicating detail and context of the research findings to a scientific audience. A scientist would not be able to consider the validity and limitations of the findings. Peer-reviewed journals such as referenced on the sign, and conference presentations would include far greater detail, including background research, methodology, tables of results and statistical analysis. The lack of this additional information on signs may result in the misinterpretation of findings.

Question 2 (a)

Criteria	Marks
<ul style="list-style-type: none"> • Demonstrates a thorough understanding of ways that data can be cleansed in Source 1 • Provides justifications relevant to the purpose of the investigation 	3
<ul style="list-style-type: none"> • Demonstrates sound understanding of ways that data can be cleansed in Source 1 	2
<ul style="list-style-type: none"> • Demonstrates some understanding of data cleansing 	1

Sample answer:

The student is investigating the relationship between temperature and the percentage of hydrogen stored, so columns D and E could be removed as these columns do not contain relevant variables.

Row 6 could also be removed as the adsorbents cannot be used at this temperature therefore including these could lead to incorrect conclusions.

Answers could include:

In this data, there are two incomplete rows (row 4 and 7) which should be deleted as it may lead to incorrect conclusions if included in statistical analysis.

Question 2 (b)

Criteria	Marks
<ul style="list-style-type: none"> Provides a comprehensive explanation of how scientific research is affected by the data sets being released publicly Demonstrates a thorough understanding of the positive and negative effects of the release of the raw and derived data sets 	5
<ul style="list-style-type: none"> Provides a thorough explanation of how scientific research is affected by the data sets being released publicly Demonstrates a thorough understanding of the effects of the release of the raw and derived data sets 	4
<ul style="list-style-type: none"> Demonstrates a sound understanding of how scientific research is affected by the data sets being released publicly Relates issues associated with raw or derived data sets being released publicly 	3
<ul style="list-style-type: none"> Demonstrates some understanding of how scientific research is affected by data being released publicly 	2
<ul style="list-style-type: none"> Identifies issues related to data being released publicly 	1

Sample answer:

Releasing the raw data set will allow other scientists who may not have access to funding and/or specific equipment to access this data. This can lead to more collaboration which may hasten advancement from research. The inclusion of more collaborators may result in original ideas and links across scientific fields, which could provide new directions for scientific research.

Since the raw data is publicly available, there may be limited opportunities to profit from the research so some researchers may be less interested in using the data. This could slow research in this area, inhibiting the development of new understanding. As this data is publicly available, scientists may be more likely to use this existing data rather than repeating the experiment. Therefore, incorrect conclusions may remain unidentified.

The processing applied to the derived data set makes the data accessible to a larger population, including students. This greater access may lead to more individuals analysing the data, resulting in a greater likelihood of novel research. However, as the processed data may exclude variables, it may be more prone to biased or incorrect conclusions. This could lead to misconceptions.

Question 3

Criteria	Marks
<ul style="list-style-type: none"> • Demonstrates a comprehensive understanding of the relationship between the criteria and the data provided • Makes a recommendation based on a thorough analysis of each source 	7
<ul style="list-style-type: none"> • Demonstrates a thorough understanding of the relationship between the criteria and the data provided • Makes a recommendation based on a thorough analysis of most sources 	6
<ul style="list-style-type: none"> • Demonstrates a developed understanding of the relationship between the criteria and the data provided • Interprets data from some sources to make a recommendation 	4–5
<ul style="list-style-type: none"> • Demonstrates a sound understanding of the relationship between the criteria and the data • Interprets some data from some source(s) 	2–3
<ul style="list-style-type: none"> • Demonstrates an understanding of some data 	1

Sample answer:

Site A does not meet the first criteria since wind speed is statistically significantly ($p < 0.01$) less than required. Site B is above requirement and is statistically significant. Site C does not show a statistically significant difference between 13 and 13.1 km/h ($p \geq 0.01$). Data at Site C was collected for a full year allowing full seasonal variation, however, this was a shorter period when compared to other sites reducing the confidence in the wind speed data for Site C.

Site B has approximately three hours above 20 km/h during peak period, and Site C has approximately 6 hours. Both sites meet the minimum criteria, however Site C has a longer time period with wind speed over 20 km/h while mean power consumption per household is greater than 600 kW.

Site B and C may produce more than 1000 kW power output per turbine. Since Site B has only 3000 m² per turbine, the model in Source 3 suggests expected output of approximately 1100 kW. This is more than required, however, given the accuracy and variability in the data of ± 300 kW, it may be less than the required output of 1000 kW. This indicates that approximately half of the sites produced less than 1000 kW. It cannot be concluded that the turbines at Site B will produce sufficient power. In comparison, Site C has 3500 m² per turbine and according to the model should produce approximately 1300 kW. Even at the lowest margin of error, this still meets the minimum requirement of 1000 kW.

Considering the criteria and each site’s fulfilment of these, Site C is the most suitable site for a new wind farm.

Section II, Part A

Question 4 (a)

Criteria	Marks
• Provides a thorough justification of whether Occam's razor can be applied to the stimulus	3
• Provides a justification of whether Occam's razor can be applied	2
• Demonstrates a sound understanding of Occam's razor	1

Sample answer:

Occam's razor is applied to select the simplest of multiple conclusions and can only be applied when these are equally possible.

Whilst Aristotle's conclusion is the simplest since it identifies only five elements, it is not as equally possible as Priestley's or Mendeleev's. Likewise, Priestley's conclusion is simpler than Mendeleev's, but is also shown not to be equally possible. This is because additional experiments showed that there were more than 63 elements and that some of the elements proposed by Aristotle (eg water) and Priestley (eg light) were misidentified.

Thus, Occam's razor is not appropriate to use to choose between these three conclusions because they are not equally possible.

Question 4 (b)

Criteria	Marks
<ul style="list-style-type: none"> • Demonstrates comprehensive understanding of empiricism and alternative ways of knowing • Provides a thorough explanation as to how empiricism and alternative ways of knowing have affected the development of scientific understanding • Supports the answer with information from the stimulus 	5
<ul style="list-style-type: none"> • Demonstrates thorough understanding of empiricism and alternative ways of knowing • Provides an explanation as to how empiricism and alternative ways of knowing have affected the development of scientific understanding • Supports answer with reference to the stimulus 	4
<ul style="list-style-type: none"> • Demonstrates a sound understanding of empiricism and/or alternative ways of knowing • Supports answer with reference to the stimulus 	3
<ul style="list-style-type: none"> • Demonstrates some understanding of empiricism or alternative ways of knowing 	2
<ul style="list-style-type: none"> • Demonstrates an understanding of the development of scientific understanding 	1

Sample answer:

Empiricism and alternative ways of knowing provide scientists with an appropriate set of processes to follow to develop scientific understanding. However, they may hinder the development of scientific understanding.

Empiricism focuses on the importance of observations, rather than intuition. Empirical evidence garners a greater acceptance of new ideas as evidence is often required to shift existing ideologies. For example, Priestley and other scientists could more accurately identify chemical elements due to their careful observations and experimentation which allowed them to disprove Aristotle’s philosophical standpoint that there were only five fundamental elements. This developed scientific understanding of elements.

Authority as an alternate way of knowing has not always led to improved scientific understanding. Aristotle’s authority as a leader in philosophy led to incorrect knowledge about the elements being retained for 2000 years. This may have hindered scientific understanding in this area as it may have prevented others from confirming or challenging his findings. However, authority figures can also be important as scientists can build upon others’ work without having to replicate the observations themselves. For example, Mendeleev did not replicate the experiments showing that all 63 elements existed when predicting the existence of undiscovered elements.

Answers could include:

Intuition and rationalism as alternative ways of knowing.

Question 5

Criteria	Marks
<ul style="list-style-type: none"> Provides a comprehensive discussion of the suitability of both pathways for developing a scientific research question Supports arguments with reference to the pathways and the student's own experience developing a scientific research question 	7
<ul style="list-style-type: none"> Provides a thorough discussion of the suitability of both pathways for developing a scientific research question Supports arguments with reference to the pathways and the student's own experience developing a scientific research question 	6
<ul style="list-style-type: none"> Provides a sound discussion of the suitability of pathway(s) for developing a scientific research question Supports arguments with reference to the pathway(s) and the student's own experience developing a scientific research question 	4–5
<ul style="list-style-type: none"> Provides a sound discussion of the suitability of one pathway for developing a scientific research question Supports arguments with reference to a pathway and/or the student's own experience developing a scientific research question 	2–3
<ul style="list-style-type: none"> Demonstrates an understanding of the processes involved in developing a scientific research question 	1

Sample answer:

Both pathways A and B are suitable pathways for developing a scientific research question, with different strengths.

In Pathway A, the initial literature search is important to identify suitable sources of information to inform the research. However, the value of a literature search relies on the skill of the researcher and does not involve an analysis of the research. Ongoing discussion of literature with a mentor can increase understanding for the researcher to develop a research question that is feasible. Relying on a mentor to provide a thorough understanding of the area of interest may lead to bias and gaps in knowledge. In developing potential research questions, I was guided by my teacher to ensure they were viable within the school environment. Since my teacher was not an expert in the field, I struggled to understand some of the literature which increased the time taken to develop and evaluate potential questions.

Pathway B starts with simple experimentation, which can be important in determining the viability and success of initial research questions or the relationships between variables. Repeated experimentation, especially that which is informed by literature, is helpful to identify a testable hypothesis and therefore ensure the viability of the final research question. However, this was not relevant in my pathway and may be resource and time intensive. Conducting a literature review is important to understand the latest developments in the area and/or existing gaps in the research to ensure the research question is adding value to scientific understanding. Whilst my research question was not based on prior observations made in experiments, it was informed by a thorough literature review, which allowed me to finalise the question and generate a testable hypothesis.

Answers could include:

- Induction and deduction
- Primary sourced and secondary sourced.

Section II, Part B

Question 6

Criteria	Marks
<ul style="list-style-type: none"> • Demonstrates extensive knowledge and understanding of the process of scientific research • Provides a comprehensive research plan that includes a falsifiable hypothesis, appropriate methodology, analysis of data and representation of results • Integrates information from the stimulus to support the plan • Communicates ideas and information using appropriate scientific language • Presents a logical and coherent response 	13–15
<ul style="list-style-type: none"> • Demonstrates thorough knowledge and understanding of the process of scientific research • Provides a well-developed research plan that includes most of the given features: a falsifiable hypothesis, appropriate methodology, analysis of data and representation of results • Refers to the stimulus as a basis for the plan • Communicates ideas and information using scientific language • Presents a logical response 	10–12
<ul style="list-style-type: none"> • Demonstrates developed knowledge and understanding of the process of scientific research • Provides some features of a research plan including a hypothesis and appropriate methodology • Refers to the stimulus as a basis for the plan • Presents a structured response using scientific language 	7–9
<ul style="list-style-type: none"> • Demonstrates sound knowledge and understanding of the process of scientific research • Provides some features of a research plan • Uses some scientific language 	4–6
<ul style="list-style-type: none"> • Demonstrates an understanding of scientific research • Provides a feature of a research plan 	1–3

Sample answer:

Hypothesis

The level of plastic pollution in the ocean affects dissolved oxygen concentration.

Methodology

Approximately six randomly selected locations in the Pacific Ocean will be chosen using a random coordinate (latitude and longitude) generator. A 1 km radius will be drawn from each location, avoiding transect overlap. Boats carrying nets will travel the length of each transect capturing any surface level plastic pollution. This will be quantified with manual counts using the naked eye and microscopes for microplastics. Simultaneously, manual transect surveys will also be done within a 20 m distance from the boat and recorded. From these results the

location with the highest plastic pollution counts and lowest counts will be selected as the high plastic pollution and low plastic pollution location for the study.

At each site, approximately 30 locations will be randomly selected along the 1 km transect. A boat will be used to visit each sampling site in each location and the dissolved oxygen probe attached to an electronic data logger will be submerged to a set depth and take readings. This will be recorded electronically in a results table and an average calculated for each of the 30 samples of dissolved oxygen concentration at each location for each plastic pollution level category.

Variable summary

Independent variable: Sampling location (area with high vs low plastic pollution counts)

Dependent variable: Dissolved oxygen concentration (ppm)

Analysis of data

As the measured data is numerical and has two means across two categorical independent variables 'high plastic pollution' and 'low plastic pollution' a student's t-test will be used to compare the mean for dissolved oxygen concentration for each plastic pollution category. This assumes the data is normally distributed as the sample size for dissolved oxygen concentration measures at each location is at least 30.

H_0 = there is no significant difference in the concentration of dissolved oxygen between areas of the ocean with high and low plastic pollution.

H_A = there is a significant difference in the concentration of dissolved oxygen between areas of the ocean with high and low plastic pollution.

To determine if the means are statistically significant a 95% confidence level ($\alpha = 0.05$) and a t-score and corresponding p value will be used. This will determine whether to reject or accept the null hypothesis. For example, the alternate hypothesis can be accepted if the p value, calculated from the t-test, is less than the alpha value.

Representation of results

A report will be provided that includes a table with the columns, plastic pollution level categories and dissolved oxygen concentration for each sampling event, culminating in an average dissolved oxygen concentration for each sample in each plastic pollution level category.

A column graph will be used to plot the plastic pollution level categories on the x-axis against the mean dissolved oxygen concentration on the y-axis. This will include error bars showing standard deviation around each mean.

Answers could include:

A range of hypotheses could be investigated, such as:

- the density of plastic pollution affects relative motion of plastics to ocean current flow rate
- the concentration of plastic pollution affects sea surface temperatures
- the presence of plastic pollution affects the chemical composition of ocean water
- the mass of plastic pollution increases up a food chain (bioaccumulation)
- the density of plastic pollution affects the properties (amplitude, frequency, wavelength and speed) of the ocean waves.

2023 HSC Science Extension Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	5	Module 4: Reporting Findings	SE-7
2 (a)	3	Module 3: Patterns and Trends Module 3: Statistics in Scientific Research	SE-4, SE-6
2 (b)	5	Module 2: Developing the Question and Hypothesis Module 2: Processing Data for Analysis	SE-6
3	7	Module 2: Methodology and Data Collection Module 3: Statistics in Scientific Research Module 3: Decisions from Data and Evidence Module 3: Data Modelling	SE-1, SE-4, SE-5

Section II Part A

Question	Marks	Content	Syllabus outcomes
4 (a)	3	Module 1: The Development of Modern Science	SE-2
4 (b)	5	Module 1: The Development of Modern Science	SE-2
5	7	Module 2: Developing the Question and Hypothesis Module 2: Scientific Research Proposal	SE-1, SE-3

Section II Part B

Question	Marks	Content	Syllabus outcomes
6	15	Module 2: Developing the Question and Hypothesis Module 2: Scientific Research Proposal Module 2: Methodology and Data Collection Module 3: Statistics in Scientific Research Module 4: Reporting Findings	SE-1, SE-3, SE-4, SE-5, SE-7