2024 HSC Science Extension Marking Guidelines

Section I

Question 1

Criteria	Marks
• Demonstrates a comprehensive understanding of the use of a literature search to gather relevant scientific literature • Provides a comprehensive assessment of the appropriateness of the student's initial search criteria for the investigation	5
• Demonstrates a thorough understanding of the use of a literature search to gather relevant scientific literature • Provides a thorough assessment of the appropriateness of the student's initial search criteria for the investigation	4
• Demonstrates a sound understanding of the use of a literature search to gather relevant scientific literature • Provides an assessment of the appropriateness of the student's initial search criteria for the investigation	3
• Demonstrates some understanding of the use of a literature search to gather scientific literature • Describes the appropriateness of the student's initial search criteria	2
• Demonstrates an understanding of the use of a literature search	1

Sample answer:

The search terms are appropriate as they are specific and related to the research question and gather relevant literature to increase the efficiency in gaining knowledge in this field. The student's use of 'AND' between search terms gathers studies that correctly identify linked search terms, such as 'Cepheid variable star' and 'nearby galaxies' along with the correct use of 'OR' when terms are similar or distinct. This would improve the relevance of the search results.

The attempt to focus on one author is inappropriate as an initial search criterion as it may present results that bias the student's perspective or limits the scope of their understanding from literature to a single researcher's view. This, along with a publication date search

window from 2021–2024, may prevent the student from accessing key literature related to the research topic and omit relevant research.

The publication period does however allow the student to access recent findings on Cepheid variable stars and emerging ideas in that field worthy of pursuing. This is not consistent with the exclusion of conference proceedings, which generally focus on contemporary findings. This omission of this criterion may be appropriate to ensure the literature search results are published and likely to be peer-reviewed.

Answers could include:

- Language inclusivity
- Open access and paid access
- All fields selected.

Question 2 (a)

Criteria	Marks
• Determines that the hypothesis is falsifiable • Details the conditions required • Provides a justification relevant to the stimulus	3
• Demonstrates sound understanding of the condition(s) required for a hypothesis to be falsifiable	2
• Demonstrates some understanding of falsifiability	1

Sample answer:

This hypothesis is falsifiable as it is testable and can be proven incorrect. It can be tested through quantitative observations of the removal of petrol by each treatment to determine if copper nanoparticle treatment removes a greater percentage of petrol than bacterial or chemical treatment.

Answers could include:

A falsifiable hypothesis is explanatory and/or predictive.

Question 2 (b)

Criteria	Marks
• Demonstrates a comprehensive understanding of how data can be used as evidence when supporting a conclusion • Makes an informed judgement based on thorough analysis of the stimulus and each source	5
• Demonstrates a thorough understanding of how data can be used as evidence when supporting a conclusion • Makes an informed judgement based on thorough analysis of each source	4
• Demonstrates a sound understanding of how data can be used as evidence when supporting a conclusion • Makes a judgement based on analysis of each source	3
• Demonstrates some understanding of how data can be used as evidence when supporting a conclusion • Interprets some data from a source	2
• Demonstrates some understanding of how data can be used as evidence when supporting a conclusion	1

Sample answer:

Source 1 partially supports the conclusion in that the copper nanoparticle treatment removed the greatest mean percentage of petrol at week 40 relative to the other treatments. Conversely, the lack of overlap between the copper nanoparticle treatment and bacterial treatment standard deviations 80% of the time indicates that the true value for percentage petrol removed at each 4-week interval does not fall within the same data range and would therefore be different. In Source 2, the statistically significant difference ($p = 0.015 < 0.05$) between the means of the copper nanoparticle treatment and bacterial treatment at week 40 further supports this. The overlapping standard deviations and lack of statistical significance ($p = 0.05$) between the copper nanoparticle and chemical treatments suggest that copper nanoparticle treatment may not remove a greater percentage of petrol than chemical treatment. Thus, reinforcing that the conclusion is only partially supported by the data. This judgement is based on test statistics conducted on sample sizes too small for normality to be achieved ($n_{chemical\ treatment} = 15$), which may have prevented a statistically significant result in support for the conclusion.

Source 1 shows that the conclusion drawn from this experiment is highly dependent on the time frame in which it is carried out. Using standard deviations, the conclusion is only accurate between copper nanoparticle and bacterial treatments from weeks 28–40 and between copper nanoparticle and chemical treatment in week 36. Had analysis of the data been conducted any week prior to week 28, the conclusion would be completely unsupported.

Answers could include:

- Discussion of R^2 values
- Links between conclusion and scientific hypothesis
- Methodology used to collect data
- Appropriateness of graphical representation.

Question 3

Criteria	Marks
• Demonstrates a comprehensive evaluation of the extent to which ethical behaviours can influence scientific research • Provides an informed judgement with reference to the stimulus	7
• Demonstrates a thorough evaluation of the extent to which ethical behaviours can influence scientific research • Provides a judgement with reference to the stimulus	6
• Demonstrates a developed understanding of the extent to which ethical behaviours can influence scientific research • Provides a judgement with reference to the stimulus	4–5
• Demonstrates a sound understanding of the extent to which ethical behaviours can influence scientific research • Refers to the stimulus	2–3
• Demonstrates an understanding of an ethical behaviour that can influence scientific research	1

Sample answer:

During the first meeting, the signing of the agreement and assignment of the same two researchers demonstrated the application of the ethical behaviour of confidentiality. Upholding confidentiality allows the privacy and anonymity of the Aboriginal Peoples to be maintained. Shared respect and trust being built between collaborators can lead to greater scope for future collaborative research, which would be reliant on the cooperation of key stakeholders such as the Aboriginal community. Scientific research will be reliant on all groups agreeing on sharing of information to the broader community.

Transparency as an ethical behaviour is evident in the initial meetings with the Aboriginal community and research team where a shared vision and mutual expectations about how the information will be shared back to the community was established. However, it could also be argued that since the agreement was signed during the initial meeting, this did not allow all parties to engage with and discuss the conditions of the agreement, which is not transparent. If it was not clear in the signed agreement that the partnership between the Aboriginal community and research team was about the one experiment (extent of research), the research team could be deceptive in leveraging the Aboriginal community for future research on reflectivity. Whilst ethically problematic, this could increase the scientific research around minerals and pigments as well as their application in society or research. If parameters around handling, use and testing of minerals that are culturally significant are not discussed when mutual agreement is reached, this could also be considered deceptive.

Answers could include:

- To do more good than harm
- To act with fairness/impartiality.

Section II, Part A

Question 4 (a)

Criteria	Marks
• Provides a thorough distinction between data and evidence in scientific research • Provides relevant links to the stimulus	3
• Distinguishes between data and evidence in scientific research • Provides some links to the stimulus	2
• Demonstrates a sound understanding of data and/or evidence	1

Sample answer:

Data is raw information based on observations, whereas evidence is appropriately selected data used to support or refute an argument, claim or hypothesis. In the stimulus, the researcher observes a number of different male peacock spider behaviour and has classified these into categories. This data becomes evidence when they seek to identify this behaviour as part of a courtship ritual or attempt to establish a sequence of behaviour that lead to a particular outcome relevant to an hypothesis.

Question 4 (b)

Criteria	Marks
• Demonstrates a comprehensive understanding of how to conduct qualitative analysis • Demonstrates a thorough qualitative analysis of the stimulus using inductive reasoning to support generalised conclusions	5
• Demonstrates a thorough understanding of how to conduct qualitative analysis • Demonstrates a qualitative analysis of the stimulus using inductive reasoning to support generalised conclusions	4
• Demonstrates a sound understanding of how to conduct qualitative analysis • Describes how qualitative analysis using inductive reasoning can support generalised conclusions	3
• Demonstrates some understanding of how to conduct qualitative data analysis • Outlines feature(s) of qualitative analysis • Links answer to stimulus provided	2
• Demonstrates an understanding of qualitative analysis	1

Sample answer:

The use of inductive reasoning allows the researchers to make observations without a specific hypothesis in mind. As a result, the ecologists would begin by familiarising themselves with the videoed behaviour and developing transcripts. They would then analyse the data to develop themes or to convert the qualitative data into quantitative data.

All associated data can be sorted into groups. Themes, such as ‘fan dance’, ‘colour interplay with light’, ‘abdominal bobbing’, ‘fan flapping’ and ‘rumble-rumps’, can be grouped into the theme ‘displays that result in female repositioning’. Themes should be reviewed and revised to ensure that each theme has enough data to support it and is distinct from other themes. Similar themes should be merged and those without enough data removed. An ecologist could consider a second theme of ‘vibratory signals’ which is distinct from the first. The ecologists would compare and homogenise themes which may group shared themes under new themes, such as ‘fan dance’, ‘pre-mount display’, ‘body orientation’ themes fitting a ‘displacing motion’ theme.

From here, the team begins to consider how the themes can come together in a report that address aims of the investigation. The themes regarding ‘female repositioning’ and ‘displacing motion’ can be used to support the observations that males used a combination of vibratory signals, body decorations and motion displays when courting females as the behaviour led to greater courtship success or female selection. These themes can then be applied to establish a general theory of mating practices in peacock spiders.

Question 4 (c)

Criteria	Marks
• Demonstrates a comprehensive understanding of the use of qualitative and quantitative data as evidence in scientific research • Provides a comprehensive evaluation of the statement with reference to the stimulus	7
• Demonstrates a thorough understanding of the use of qualitative and quantitative data as evidence in scientific research • Provides a thorough evaluation of the statement with reference to the stimulus	6
• Demonstrates a sound understanding of the use of qualitative and quantitative data as evidence in scientific research • Provides a sound evaluation of the statement with reference to the stimulus	4–5
• Demonstrates a sound understanding of the use of qualitative and quantitative data as evidence in scientific research • Provides argument(s) to support the statement	2–3
• Demonstrates an understanding of the use of qualitative and quantitative data as evidence in scientific research	1

Sample answer:

The data in this investigation, such as voice recordings and visual observations, can be used to determine the nature of interactions between male and female peacock spiders. Data drawn from qualitative analysis can be more responsive to the information being collected as research questions can be formed and altered at any stage of the data collection process. This may introduce observer bias based on the preconceived expectations of the researcher, however this flexibility may also provide opportunity to explore unexpected directions. Qualitative data can be more valuable in providing evidence to support conclusions made relative to quantitative data which is inflexible and typically requires data to be collected to fit a preconceived hypothesis or research question.

Quantitative data may be perceived as holding greater value in scientific research due to the confidence numerical data provides in drawing conclusions with the aid of statistical analyses to support or reject hypotheses. The objectivity in the analysis of quantitative data provides greater value in reducing biases, although these may still be present when decided critical values to apply to a data set which can shift conclusions on statistical hypotheses.

Whilst both data types are prone to biases and manipulation that skew or limit their value as evidence in drawing accurate conclusions from scientific research, they both provide value as evidence for conclusions. This value can increase when used in conjunction with one another. For instance, the inclusion of quantitative data, such as frequency counts on certain courtship behaviour or proximity measures of behaviour to a female's location, alongside the reported behavioural observations can provide further insight into an hypothesis being tested.

Section II, Part B

Question 5

Criteria	Marks
• Demonstrates extensive knowledge and understanding of the process of scientific research • Provides a comprehensive assessment of the scientific research proposal • Communicates ideas and information using appropriate scientific language • Presents a logical and coherent response	13–15
• Demonstrates thorough knowledge and understanding of the process of scientific research • Provides a thorough assessment of the scientific research proposal • Communicates ideas and information using scientific language • Presents a logical response	10–12
• Demonstrates developed knowledge and understanding of the development of a scientific research proposal • Provides a sound assessment of the scientific research proposal • Presents a structured response using scientific language	7–9
• Demonstrates sound knowledge and understanding of the development of a scientific research proposal • Includes reference to the scientific research proposal to support the answer • Uses some scientific language	4–6
• Demonstrates an understanding of the development of a scientific research proposal	1–3

Sample answer:

The research question is too ambiguous to understand the intended research. There is a lack of specificity of the variables. The term ‘nutritional quality’ is broad as it may refer to other nutritional properties such as sugar content and protein profile rather than the number of antioxidants. Also, ‘level of exposure’ is more appropriately the frequency of radio waves bees are exposed to as exposure duration is controlled across treatments. This may lead to a research project that is unable to draw relevant conclusions. Conversely, the aim and hypothesis are more appropriately constructed, specifying that the number of antioxidants present is the measure of nutritional quality. The disconnect between the research question and aim/hypothesis reduces the overall quality of the proposal.

Rationale is a crucial aspect of a research proposal as it identifies the need for the research to occur. The rationale appropriately establishes antioxidant number as an appropriate measure of the nutritional quality of honey. This rationale effectively demonstrates a gap in existing research and the need for this project to be completed. Proposals with well-developed rationales that explore gaps in research are more likely to be approved as they may be more likely to advance scientific understanding.

The method has some well-considered aspects as it includes the radio wave frequencies that the bees will be exposed to and for how long. However, details on how the antioxidant

content will be measured have not been provided. The quality of the proposal may come into question as the methods used, such as antioxidant analysis, may not be based on widely accepted techniques. The aim and hypothesis mention radio wave frequency ranges; however, the method categorises frequency as 2.4 GHz and 5.8 GHz in line with Wi-Fi routers. This method would not provide continuous data to address the aim and hypothesis. This lack of consistency may reduce the likelihood of the proposal being approved.

Removing the bees from the wild and placing them into controlled conditions may elicit a stress response introducing a confounding variable that may affect the number of antioxidants produced by the bees. Moreover, if the bees were collected from multiple hives and locations, prior radio wave exposure level and radio wave exposure frequency would not be controlled across the establishing colonies in this project. As a result, the effects of radio wave frequencies may be further compounded in this study as no consistent baseline of exposure is established. These will reduce confidence in the conclusions therefore reducing the quality of the proposal.

The inclusion of a timeline shows that the proposal has considered the time constraints associated with developing the student research project to ensure feasibility. The period designated for the experiment to be conducted accommodates the time required for the bees to produce honey. As a result, the timeline established is suitable. However, allocating one month for analysis and planning a gap between the end of the experiment and the start of analysis is not ideal. These steps should occur concurrently to allow the researcher to check the quality of the data as it is being collected and the appropriateness of the method and statistical tests.

The proposed analytical techniques are suitable for the hypothesis. The use of an F-test prior to conducting a Student's t-test follows appropriate statistical assumptions including consideration of normality and an appropriate sample size for each treatment (n=60). In developing a proposal, it is important to select the most suitable statistical tests which align with the data collected and is relevant to the hypothesis. This will allow for the determination of statistical significance and improves the quality of the proposal.

Answers could include:

- Ethics
- Inclusion of literature
- Methods
- Use of two frequencies
- Design of the greenhouses
- Design of the colonies
- Accessibility of equipment and space for project
- Timeline
- Difficulty and cost of collection of bees and set-up
- Collaboration with other scientists.

2024 HSC Science Extension Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	5	M2: Developing the Question and Hypothesis	SE-1, SE-3, SE-6
2 (a)	3	M1: The Development of Modern Science	SE-2
2 (b)	5	M1: Influences on Current Scientific Thinking M3: Patterns and Trends M3: Decisions from Data and Evidence	SE-1, SE-4, SE-5, SE-6
3	7	M1: Influences on Current Scientific Thinking	SE-2, SE-5

Section II Part A

Question	Marks	Content	Syllabus outcomes
4 (a)	3	M3: Patterns and Trends	SE-5
4 (b)	5	M1: The Development of Modern Science M2: Methodology and Data Collection M3: Patterns and Trends	SE-1, SE-4, SE-7
4 (c)	7	M2: Methodology and Data Collection M2: Processing Data for Analysis M3: Statistics in Scientific Research	SE-1, SE-4, SE-7

Section II Part B

Question	Marks	Content	Syllabus outcomes
5	15	M2: Scientific Research Proposal M2: Methodology and Data Collection M4: Reporting Findings	SE-1, SE-2, SE-3, SE-7