2022 HSC Science Extension Marking Guidelines

Section I

Question 1

Criteria	Marks
• Demonstrates a comprehensive understanding of content analysis • Provides a thorough explanation of how content analysis of the image can provide qualitative and quantitative data about land use	5
• Demonstrates a thorough understanding of content analysis • Provides an explanation of how content analysis of the image can provide qualitative and quantitative data about land use	4
• Demonstrates a sound understanding of content analysis • Provides an explanation of how to obtain qualitative and/or quantitative data from the image provided	3
• Demonstrates some understanding of qualitative and/or quantitative data • Outlines feature(s) of content analysis • Links answer to image provided	2
• Demonstrates an understanding of qualitative and/or quantitative data and/or content analysis	1

Sample answer:

Content analysis can be used to identify patterns or categories in this image. Identification of concepts such as urban areas, or the presence of different crops or the presence of trees and water channels can generate qualitative data. Scales of shading could be used to code for different vegetation and crop types.

Many aspects of the data set, including associations between land use types or between trees and proximity to waterways or urban settlement, can be described. A researcher should identify consistent, recognisable features that define the category and apply rules that determine parameters for each category. Categories should be relevant to the researcher's hypothesis.

Categories, once identified, can be quantified. A researcher might divide the image into a number of sections representing equal ground areas and identify features within each section to determine the frequency with which an identified category occurs. This frequency can result in quantitative data that can be compared using statistical analysis. In addition, the relationship between various categories can be quantified such as when a crop type is closely associated with a waterway.

Question 2

Criteria	Marks
• Describes how TWO assumptions made of the data can be verified to confirm that the use of the Student's t-test was appropriate	3
• Describes how ONE assumption made of the data can be verified to confirm that the use of the Student's t-test was appropriate OR • Identifies TWO assumptions of the data required for the Student's t-test to be appropriate	2
• Identifies ONE assumption of the data required for the Student's t-test to be appropriate OR • Demonstrates on understanding of how the Student's t-test is used	1

Sample answer:

For the use of a Student's t-test to be appropriate a number of assumptions are made, including:

- the data are normally distributed
- the variances of the two means are equal.

The normality of each distribution can be verified by plotting the data to show a bell-shaped curve. To show the variances of the two means are equal, an F-test can be used. The F-test value must be greater than the F-critical value at a chosen significance level eg $p<0.05$.

Question 3

Criteria	Marks
• Demonstrates a comprehensive understanding of how scientific advances occur • Makes an informed judgement about the extent to which the statement is correct • Supports the answer with relevant examples	5
• Demonstrates a thorough understanding of how scientific advances occur • Makes a judgement about the extent to which the statement is correct • Supports the answer with examples	4
• Demonstrates a developed understanding of how scientific advances occur • Demonstrates a sound understanding of the extent to which the statement is correct • Includes example(s)	3
• Demonstrates a sound understanding of how scientific advances occur	2
• Demonstrates some understanding of scientific advancement	1

Sample answer:

Many significant scientific advances have occurred as a result of accidental discoveries or the collection of data that do not fit the existing theories. Examples include Röntgen's discovery of X-rays or Fleming's observation of the anti-bacterial properties of moulds, both of which could be described as accidental and both of which led to large changes in understanding. Both were the result of anomalous data obtained while the researcher was undertaking routine experiments that could be described as 'normal' science. Although 'normal' science does not look for paradigm shifts, if it is performed carefully enough, it allows for precise measurements wherein anomalies may be detected.

Anomalous data provide the stimulus for new directions for research but do not represent a paradigm shift in themselves. A period of 'normal' science must follow to test new findings. Röntgen himself undertook weeks of planned experiments to test his new ideas. In the case of Fleming's observation, Florey and co-workers did the painstaking 'normal' science to develop the idea and produce penicillin. Even if it does not encompass big leaps in understanding, 'normal' science can still advance scientific knowledge in an incremental fashion. While it is doing this, it also provides the means for recognising and testing those big leaps when they occur.

Answers could include:

'Normal' science can also be viewed as a necessary restraint on the proposal of radical new ideas – it will initially view anomalous data as outliers until evidence is overwhelmingly in favour of a paradigm shift. Only after extensive testing, a new paradigm may be established.

Question 4

Criteria	Marks
• Demonstrates an extensive understanding of how legislation on the use of research animals influences scientific inquiry • Justifies an informed judgement with reference to Source 1 and Source 2	7
• Demonstrates a thorough understanding of how legislation on the use of research animals influences scientific inquiry • Justifies a judgement with reference to Source 1 and Source 2	6
• Demonstrates a developed understanding of how legislation on the use of research animals influences scientific inquiry • Justifies a judgement with reference to Source 1 and/or Source 2	4–5
• Demonstrates a sound understanding of how legislation on the use of research animals influences scientific inquiry • Refers to Source 1 and/or Source 2	2–3
• Demonstrates an understanding of relevant legislation and/or the use of research animals	1

Sample answer:

Legislation to control the use of animals in research has had an effect on scientific research methods by limiting access to animals in large numbers or by strictly controlling procedures, possibly suppressing some avenues of research. However, the timeline shows that major medical advances have continued to occur after the legislation, but it is unknown if some advances have not occurred.

Encouragement of non-animal techniques such as computer simulations and cell cultures has resulted in significant medical advances with reduced use of animals. These methods often rely on technological advances such as computers which were not available 50 years ago. Had the legislation been introduced earlier last century, some discoveries may have been postponed or suppressed.

While some experiments on animals are involved in all advances on the timeline, numbers of animals used may have been reduced by the legislation. From Source 2, the number of research animals has decreased relative to the 1970s, but it was declining prior to the introduction of legislation. Also, numbers have increased again after 2000 suggesting that the legislation has not continued to reduce the use of animals and the numbers are independent of the legislation.

On the other hand, the types of animals used in research have changed. The use of genetically modified animals, particularly mice, has increased in the last 20 years. This may reflect changing directions of research, or it may reflect a leniency towards the use of mice in the legislation. The continued decline in experiments using ‘normal’ animals suggests that some research that might have been conducted prior to legislation has been suppressed.

Although advances in medical research continue, animal ethics legislation has the capacity to redirect research efforts and possibly suppress some research.

Section II, Part A

Question 5 (a)

Criteria	Marks
• Provides a thorough comparison of satellite measurements with ground-based measurements • Draws an informed conclusion based on the comparison	3
• Provides a sound comparison of satellite measurements with ground-based measurements • Draws a conclusion based on the comparison	2
• Provides a comparison of satellite measurements with ground-based measurements	1

Sample answer:

Comparison of data from the satellite with two ground-based methods creates a gradient of close to 1 (1.02) suggesting the methods give the same results. The scatter of points is narrow with a correlation coefficient of 0.84 suggesting the association of measurements by satellite and ground-based methods is high. In addition, the two ground-based methods have different ranges of measurements on the scale, with extensive overlap. The satellite measurements match over the whole range of measurements from both ground-based methods. For these reasons, scientists can be highly confident that the remote sensing data is equivalent to ground-based methods of measurement.

Question 5 (b)

Criteria	Marks
• Demonstrates an extensive understanding of how data can be used to establish causation • Draws an informed conclusion based on the information provided	5
• Demonstrates a thorough understanding of how data can be used to establish causation	4
• Demonstrates a sound understanding of how data can be used to establish correlation or causation	3
• Demonstrates a sound understanding of how data can be used to establish a relationship between variables	2
• Demonstrates an understanding of how to establish a relationship(s) between variables	1

Sample answer:

Because the satellite can measure the ability of plants to absorb CO_2 (FPC) with many measurements per day, collecting FPC data at the same time as CO_2 data and plotting the trend in each would be sufficient to establish a correlation between photosynthesis and CO_2 levels. However, correlation of the variables does not imply causation.

To show causation, a rise in CO_2 must occur after photosynthesis drops. Close matching of CO_2 and FPC data may reveal this but will depend on how closely both measurements can be matched to one location. The video shows large movements in the CO_2 levels in the atmosphere with winds and weather patterns which may cancel the local regional effects despite claims that the satellite matches data to regional areas with precision.

In addition, to show causation the relationship identified between the two variables must not be explained by any third variable. More data would need to be collected to eliminate other variables. For example, changing emissions from power stations to provide heat over winter may increase atmospheric CO_2 independently from photosynthesis. Without more data, causation cannot be established.

Question 6

Criteria	Marks
• Demonstrates a comprehensive understanding of the suitability of the model to predict trends in atmospheric temperature • Makes an informed judgement based on Source 1 and Source 2	7
• Demonstrates a thorough understanding of the suitability of the model to predict trends in atmospheric temperature • Makes a judgement regarding the model's suitability • Supports answer with information from Source 1 and Source 2	6
• Demonstrates a developed understanding of the suitability of the model to predict trends in atmospheric temperature • Draws a relevant conclusion • Refers to Source 1 and/or Source 2	4–5
• Demonstrates a sound understanding of modelling and data • Refer to source(s) to support answer	2–3
• Demonstrates an understanding of modelling and/or data	1

Sample answer:

As the oceans (water in tank) warm, less CO_2 dissolves (Source 1), meaning there is more CO_2 in the atmosphere increasing global atmospheric temperature. The rising atmospheric CO_2 concentration is modelled by increasing the thickness of the insulation layer on top of the tank. However, the insulating layer does not adequately model the increase in CO_2 concentration in the air or absorbed by the water in the model.

Water stores more heat energy than air for the same rise in temperature (Source 2) suggesting that the increase in global atmospheric temperature is less than it would be without the oceans. The water in the tank is a suitable feature of the model as it will absorb some of the heat energy from the air. However, the small volume of water limits its capacity to model the contribution of the oceans. If the ocean surface temperature is warmer than the air (for example at night), some of the heat stored there will be returned to the atmosphere, increasing the air temperature by an amount 4x the reduction of temperature in the water. This temperature reversal is unlikely to occur in this small model.

The complex interaction between the oceans and atmosphere is not suitably represented by this model. For example, the model does not account for stratification of temperatures in the ocean as the stirrer will ensure uniform temperature within the insulated tank.

The student model suitably reflects some aspects of this complex problem and will predict a trend in atmospheric temperature. Due to the limitations of this model, it cannot be used to accurately predict the size of this trend on a global scale.

Section II, Part B

Question 7

Criteria	Marks
• Demonstrates extensive knowledge and understanding of the process of scientific research • Provides a comprehensive analysis of the research project including the hypothesis, methodology, data collection, analysis and presentation, validity of conclusions • 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 analysis of the research project including aspects of the hypothesis, methodology, data collection, analysis and presentation, validity of conclusions • Communicates ideas and information using scientific language • Presents a logical response	10–12
• Demonstrates developed knowledge and understanding of the process of scientific research • Provides a sound analysis of some aspects of the project • Presents a structured response using scientific language	7–9
• Demonstrates sound knowledge and understanding of the process of scientific research • Includes reference to the project to support the answer • Uses some scientific language	4–6
• Demonstrates an understanding of scientific research • Makes reference to the project	1–3

Sample answer:

The hypothesis investigated in this report is that weeds along creek banks are toxic to the naturally occurring aquatic fauna. To test this, the student put five animals of three different species into petri dishes with some ground leaves from two weeds and measured their survival time. The independent variable was the species of plant added to the dish and the dependent variable the number of animals surviving. Limitations of this experiment include the small numbers of animals tested from only three species. If one animal dies for an unrelated reason, the test population is reduced by 20%. However, the student did repeat the experiment with five more animals but these results are not provided. Another limitation is that the small volume of water in each petri dish (25 mL) means that the ground leaves can contribute to a strong concentration of possible toxins, but because the relative concentrations of leaf toxins are unknown, the relative toxicities cannot be established. Without measurement of the concentration of toxins, the results cannot be applied with any certainty to natural streams where toxins may be more dilute and washed away by natural stream flows.

The student carried out control experiments where one dish was left with no plant material added. Conclusions should only be drawn from experiments where all animals survived in control conditions. Because most of the mayfly nymphs in Figure 2 died at about the same

time in all dishes, including the controls, no conclusions should be drawn with respect to mayfly nymphs. Black wattle was used as another control as it was a native plant that was thought to be non-toxic. However, it clearly had an effect on Mud Eyes. Therefore, the student's second conclusion, that native Australian plants are not toxic to invertebrates, is not true for all species of invertebrate. As only one native plant was tested, the second conclusion is unlikely to be true for all native plant species.

The time over which results were recorded was adequate to show an effect of the weeds and the graphs are clearly presented. There is no table of results or statistical analysis showing significant differences between treatments, without which it is difficult to conclude how effective each treatment was compared with the controls. Also, more repetitions of the experiment would enhance confidence in the data.

Because the results are unclear for mayfly nymphs due to lack of survival in the control dish, results for only two species, both from the same order of invertebrates (Odonata), are available. Although the two weeds appeared to have been toxic to damselfly nymphs, it is not certain that Mud Eyes were affected by Camphor laurel, 80% surviving for the first 50 hours when all the animals in the control dish were alive. The data is too limited to reach the first general conclusion that the two weeds are toxic to invertebrates and the student may have missed a more important conclusion that there was a differential toxic effect of the three plants on the invertebrates tested. If results from the repeat of the experiment were similar, this conclusion would be strengthened.

The design of the experiment including controls was such that the hypothesis could be tested, but more data from repeated experiments, on more invertebrate species would improve the validity. Until more species are tested, and until concentrations of toxins in natural waterways are determined, it is premature to reach the third conclusion that weeds along a waterway influence the distribution and abundance of invertebrates.

2022 HSC Science Extension Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	5	M3: Patterns and Trends	SE-1, SE-5
2	3	M3: Statistics in Scientific Research	SE-4
3	5	M1: The Development of Modern Science	SE-2
4	7	M1: Influences on Current Scientific Thinking	SE-1, SE-2, SE-6

Section II, Part A

Question	Marks	Content	Syllabus outcomes
5 (a)	3	M2: Methodology and Data Collection M3: Patterns and Trends	SE-5
5 (b)	5	M3: Statistics in Scientific Research	SE-4, SE-6
6	7	M2: Methodology and Data Collection M3: Data Modelling	SE-1, SE-4, SE-5

Section II, Part B

Question	Marks	Content	Syllabus outcomes
7	15	M4: Reporting Findings	SE-1, SE-3, SE-5, SE-7