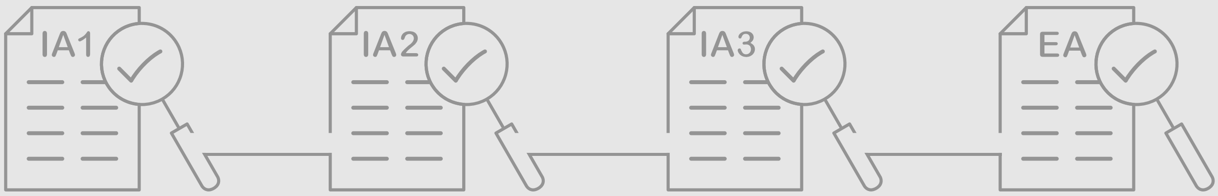
Chemistry subject report

2024 cohort

January 2025



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Contents

Introduction

The annual subject reports seek to identify strengths and opportunities for improvement of internal and external assessment processes for all Queensland schools. The 2024 subject report is the culmination of the partnership between schools and the QCAA. It addresses school-based assessment design and judgments, and student responses to external assessment for General and General (Extension) subjects. In acknowledging effective practices and areas for refinement, it offers schools timely and evidence-based guidance to further develop student learning and assessment experiences for 2025.

The report also includes information about:

- how schools have applied syllabus objectives in the design and marking of internal assessments
- how syllabus objectives have been applied in the marking of external assessments
- patterns of student achievement.

The report promotes continuous improvement by:

- identifying effective practices in the design and marking of valid, accessible and reliable assessments
- recommending where and how to enhance the design and marking of valid, accessible and reliable assessment instruments
- providing examples that demonstrate best practice.

Schools are encouraged to reflect on the effective practices identified for each assessment, consider the recommendations to strengthen assessment design and explore the authentic student work samples provided.

Audience and use

This report should be read by school leaders, subject leaders, and teachers to:

- inform teaching and learning and assessment preparation
- assist in assessment design practice
- assist in making assessment decisions
- help prepare students for internal and external assessment.

The report is publicly available to promote transparency and accountability. Students, parents, community members and other education stakeholders can use it to learn about the assessment practices and outcomes for senior subjects.

Subject highlights

419
schools offered Chemistry

77%
agreement with provisional marks for IA3

22%
improvement in endorsed IA1 at Application 1

Subject data summary

Subject completion

The following data includes students who completed the General subject.

Note: All data is correct as at January 2025. Where percentages are provided, these are rounded to two decimal places and, therefore, may not add up to 100%.

Number of schools that offered Chemistry: 419.

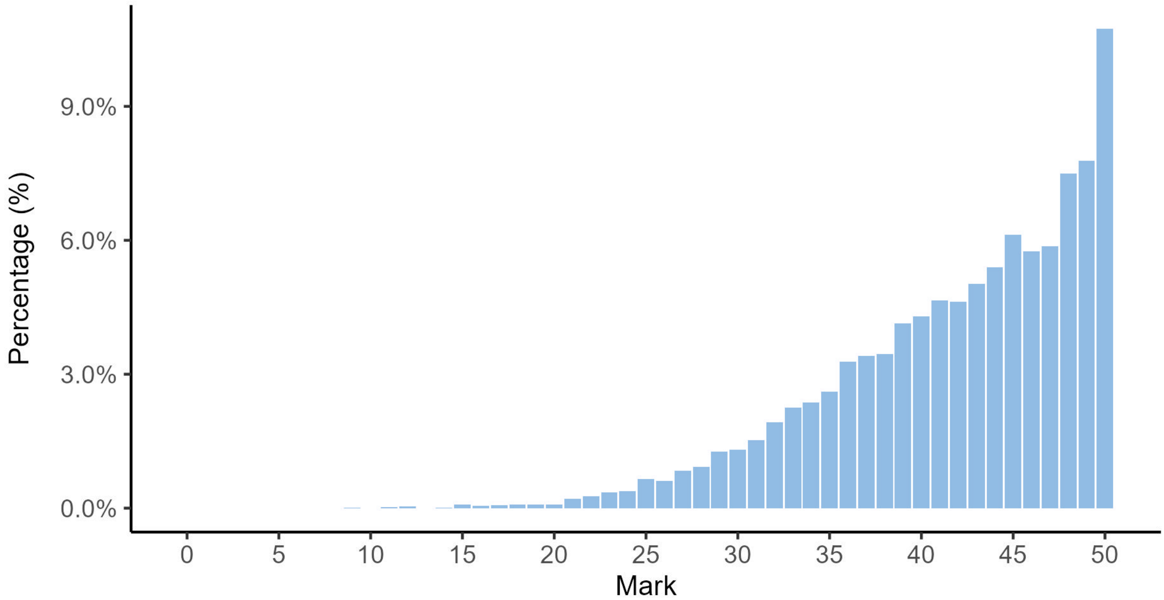
Completion of units	Unit 1	Unit 2	Units 3 and 4
Number of students completed	10,507	9,749	8,748

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory
Unit 1	9,933	574
Unit 2	9,099	650

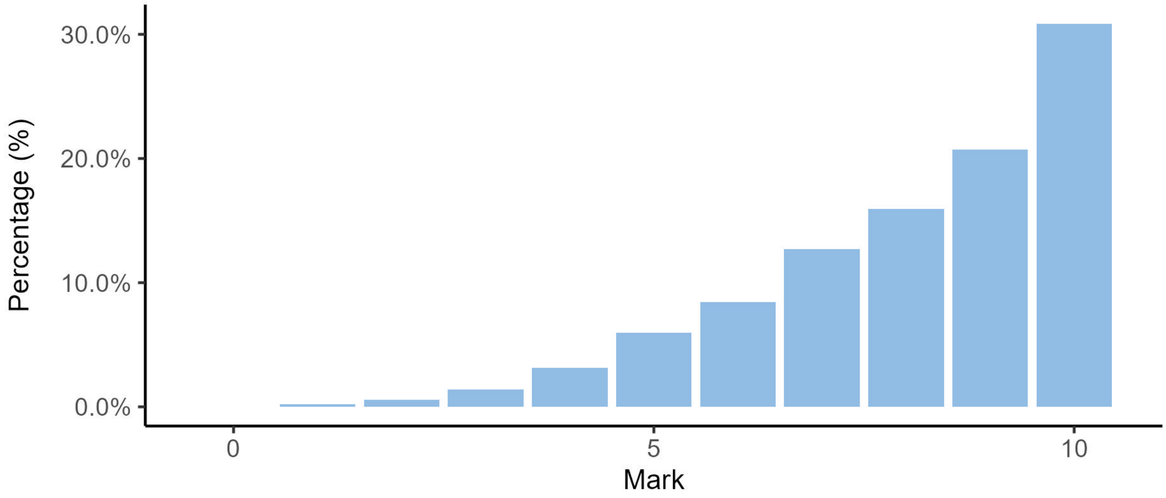
Units 3 and 4 internal assessment (IA) results

Total marks for IA

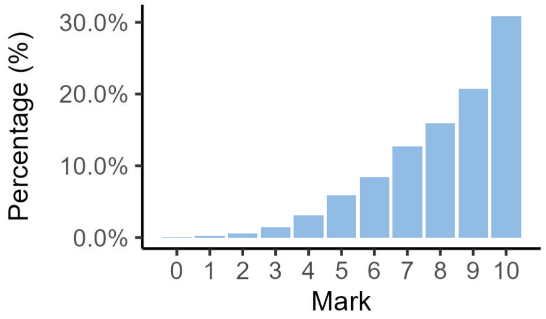


IA1 marks

IA1 total

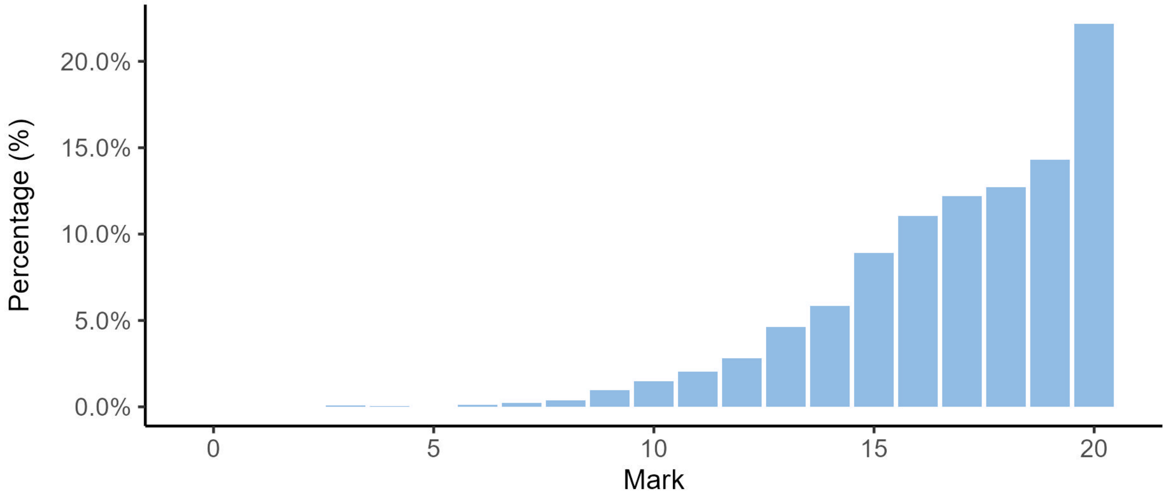


IA1 Criterion: Data test

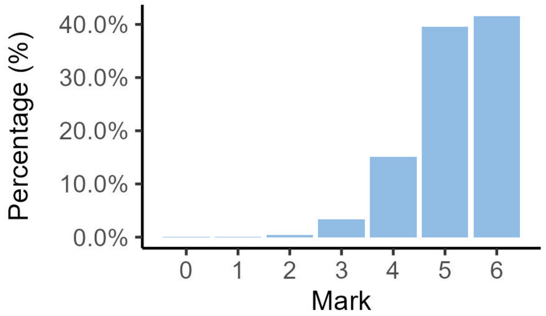


IA2 marks

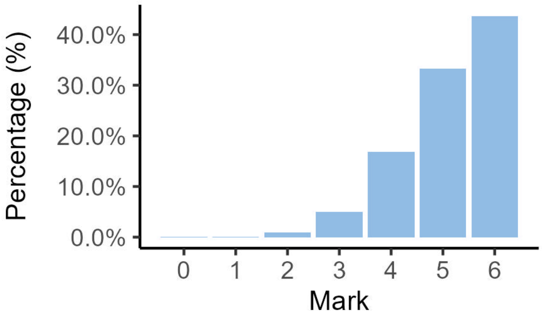
IA2 total



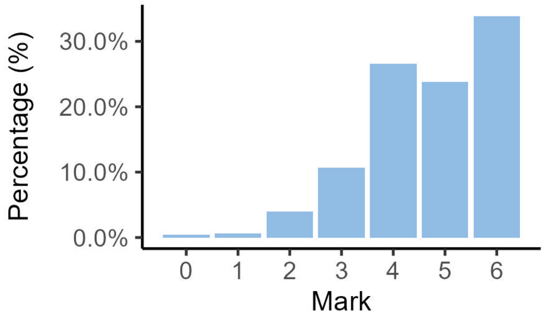
IA2 Criterion: Research and planning



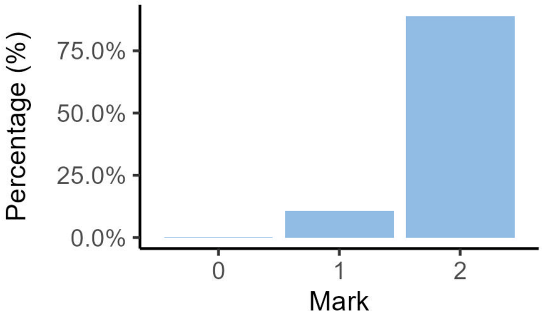
IA2 Criterion: Analysis of evidence



IA2 Criterion: Interpretation and evaluation

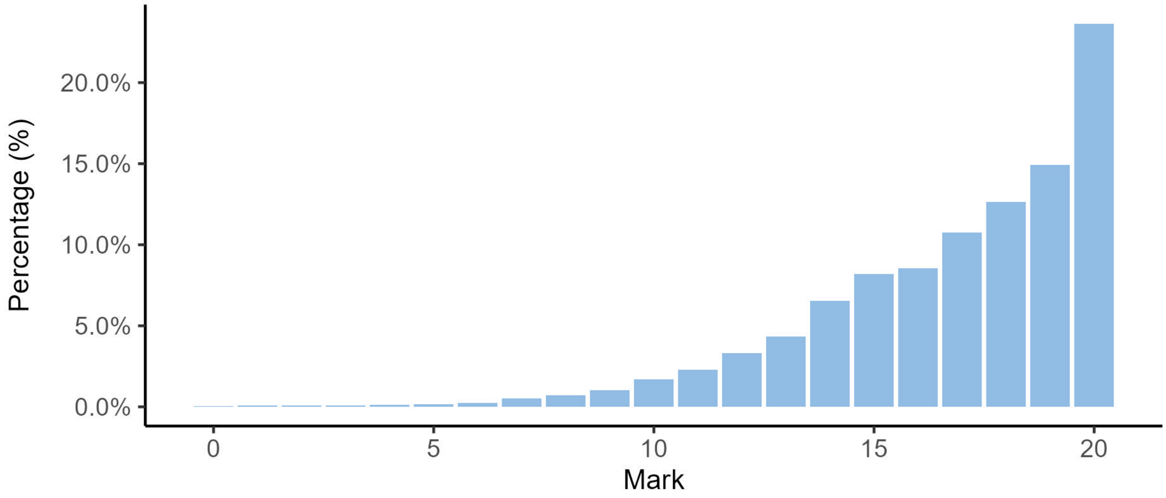


IA2 Criterion: Communication

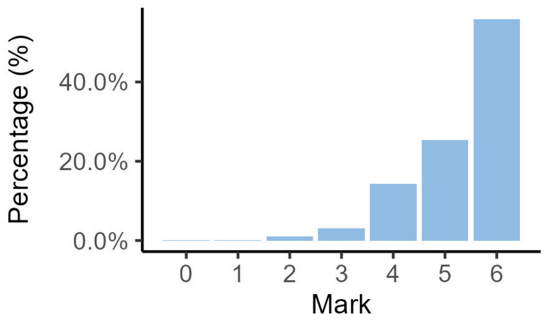


IA3 marks

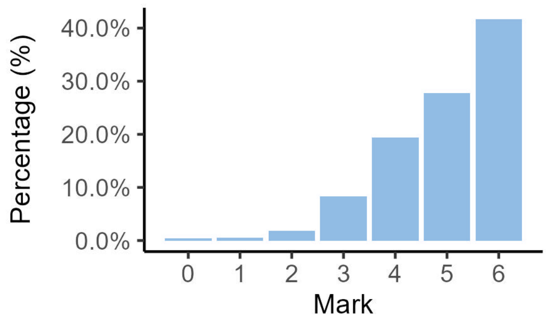
IA3 total



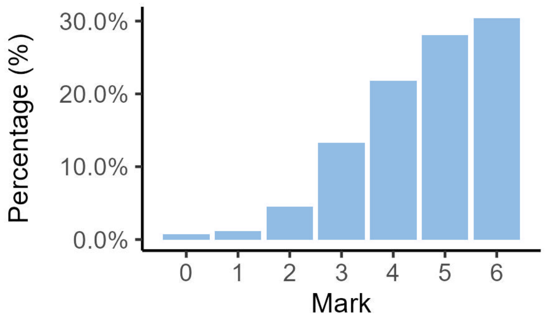
IA3 Criterion: Research and planning



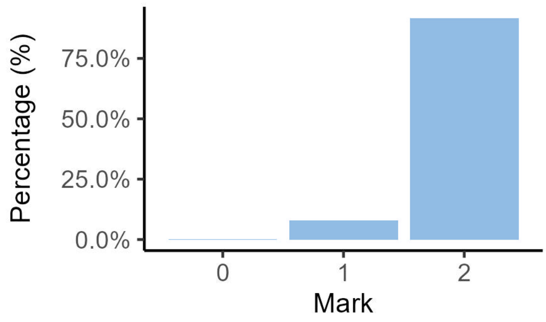
IA3 Criterion: Analysis and interpretation



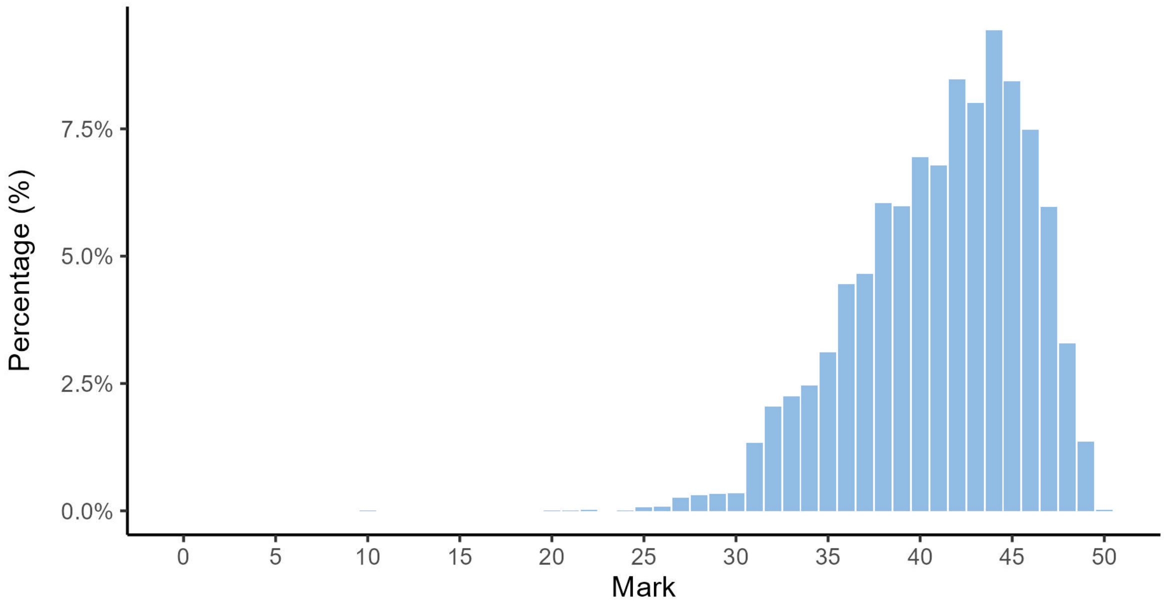
IA3 Criterion: Conclusion and evaluation



IA3 Criterion: Communication

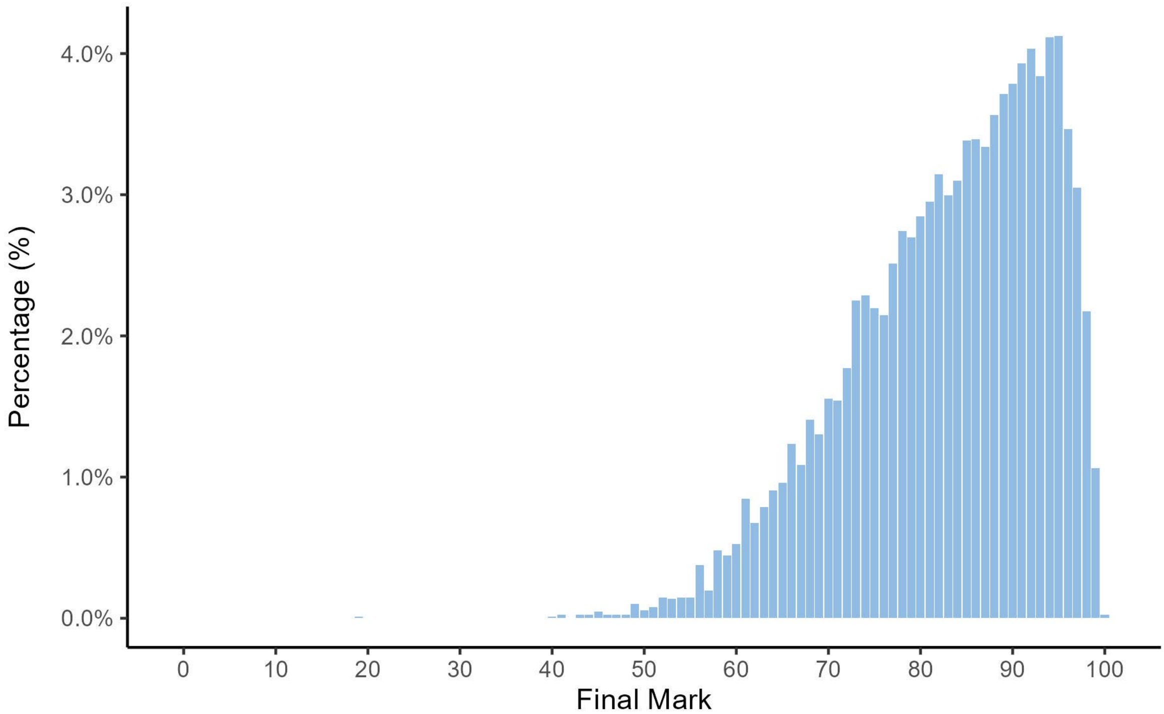


External assessment (EA) marks



Final subject results

Final marks for IA and EA



Grade boundaries

The grade boundaries are determined using a process to compare results on a numeric scale to the reporting standards.

Standard	A	B	C	D	E
Marks achieved	100–87	86–72	71–50	49–20	19–0

Distribution of standards

The number of students who achieved each standard across the state is as follows.

Standard	A	B	C	D	E
Number of students	3,869	3,536	1,316	26	1

Internal assessment

The following information and advice relate to the assessment design and assessment decisions for each IA in Units 3 and 4. These instruments have undergone quality assurance processes informed by the attributes of quality assessment (validity, accessibility and reliability).

Endorsement

Endorsement is the quality assurance process based on the attributes of validity and accessibility. These attributes are categorised further as priorities for assessment, and each priority can be further broken down into assessment practices.

Data presented in the Assessment design section identifies the reasons why IA instruments were not endorsed at Application 1, by the priority for assessment. An IA may have been identified more than once for a priority for assessment, e.g. it may have demonstrated a misalignment to both the subject matter and the assessment objective/s.

Refer to *QCE and QCIA policy and procedures handbook v6.0*, Section 9.5.

Percentage of instruments endorsed in Application 1

Instruments submitted	IA1	IA2	IA3
Total number of instruments	418	418	417
Percentage endorsed in Application 1	61	92	41

Confirmation

Confirmation is the quality assurance process based on the attribute of reliability. The QCAA uses provisional criterion marks determined by teachers to identify the samples of student responses that schools are required to submit for confirmation.

Confirmation samples are representative of the school's decisions about the quality of student work in relation to the instrument-specific marking guide (ISMG), and are used to make decisions about the cohort's results.

Refer to *QCE and QCIA policy and procedures handbook v6.0*, Section 9.6.

The following table includes the percentage agreement between the provisional marks and confirmed marks by assessment instrument. The Assessment decisions section of this report for each assessment instrument identifies the agreement trends between provisional and confirmed marks by criterion.

Number of samples reviewed and percentage agreement

IA	Number of schools	Number of samples requested	Number of additional samples requested	Percentage agreement with provisional marks
1	414	2,967	0	100.00
2	413	2,951	54	71.74
3	413	2,936	37	77.00

Internal assessment 1 (IA1)

Data test (10%)

This assessment focuses on the application of a range of cognitions to multiple provided items.

Student responses must be completed individually, under supervised conditions, and in a set timeframe.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment

Validity priority	Number of times priority was identified in decisions
Alignment	100
Authentication	0
Authenticity	4
Item construction	38
Scope and scale	20

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- provided two to four datasets that
  - were clearly related to Unit 3 subject matter
  - used minimal explanatory text, were free of distractors and contained clear images
  - contained discernible data that could be analysed, rather than labelled diagrams of galvanic cells or lists of reduction potential values
- contained a series of short response questions that
  - were of appropriate scope and scale that allowed objectives to be assessed using a variety of cognitive verbs rather than repetitively using a single cognitive verb to assess an objective
  - required students to use evidence provided in the dataset, and provided no new information in the questions
  - clearly linked the expected student response in the marking guide to the number of marks awarded
  - used appropriate cognitive verbs to cue the question to the nature of the expected response (Syllabus section 4.5.1 and glossary).

Practices to strengthen

It is recommended that assessment instruments:

- avoid the use of part marks as this can affect the scale and transparency of the item, i.e. students may be misled when planning their response
- align questions to the intended objective in the Mark allocations table (Syllabus section 4.5.1), i.e. questions requiring students to
  - determine unknown scientific quantities or features align to Objective 2 (Apply understanding)
  - identify trends, patterns, relationships, limitations or uncertainty in datasets align to Objective 3 (Analyse evidence)
  - draw conclusions based on the analysis of datasets align to Objective 4 (Interpret evidence).

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment

Accessibility priority	Number of times priority was identified in decisions
Bias avoidance	23
Language	29
Layout	16
Transparency	23

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- used consistent labelling and language between datasets, preambles and the items, e.g. instruments had clearly labelled graphs on an accurate, clear grid background
- were free from spelling, grammar and punctuation errors
- contained succinct questions and cognitive verbs that clearly cued the expected responses identified in the marking scheme, e.g. by ensuring the cognitive verb matched the nature of the response.

Practices to strengthen

It is recommended that assessment instruments:

- structure questions clearly so students are directed to use the data presented when generating their responses, e.g. provide only necessary text that
  - does not distract or confuse students about the expected response
  - does not include additional information
  - limits the amount of theory and background information in the context of the question
- model correct scientific conventions when writing chemical formulas and equations, e.g. NH_3 instead of NH3

- are quality assured for spelling, grammar and consistent textual features within questions and datasets, e.g. A table labelled as ‘Table 1’ in a dataset should not be referred to as ‘Figure 1’ in the question.

Additional advice

- Schools should ensure that
  - comparable assessments allow students to demonstrate the same cognitions and skills required for the endorsed instrument and provide a separate marking scheme as required
  - the data test includes questions that require analysis of the dataset and that cannot be correctly answered by describing or explaining a scientific concept.
  - they use the **Print preview** function of the Endorsement application (app) to ensure data is formatted correctly and that graphs and/or images in the datasets are appropriately placed and not split across pages.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and confirmed marks

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
1	Data test	100	0	0	0

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- student responses were clearly annotated to indicate
  - how marks allocated aligned with the marking scheme, with multi-mark questions clearly showing the breakdown of marks allocated for the question rather than a total mark (*QCE and QCIA policy and procedures handbook v6.0*, Section 9.6.1)
  - where evidence matched the marking scheme (e.g. using underlining, ticks and crosses) with annotations placed next to the evidence rather than being placed in margins or next to evidence not supported by the marking scheme
- marking schemes were correct and showed the full breakdown of mark allocations including half marks, when used, and consistently applied across questions to support consistent and accurate marker decision-making
- percentage cut-offs were used appropriately to determine marks.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- marks are correctly totalled, percentages are accurately determined, and cut-offs from the ISMG are correctly applied to determine provisional marks, e.g. 13/20 is 65%, which is >60%, therefore a mark of 7 should be awarded
- marking guides are updated at confirmation to ensure errors are corrected and alternative student responses are captured for quality assurance processes
- the marking scheme is accurate, and the application of the marking scheme and the determination of the percentage cut-offs are internally moderated to ensure inconsistencies and errors are corrected before they are submitted for confirmation.

Samples

The following excerpts demonstrate internal moderation and the full breakdown of mark allocations awarded to a question.

Excerpt 1 illustrates consistent and accurate marker decision-making to ensure marking schemes are correct.

Excerpt 2 illustrates the use of annotations on an internally moderated student response to ensure consistent and accurate application of the marking scheme.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

According to LCP, a system will oppose the stress of increased temp by favouring the endothermic reaction. Kc indicates extent of forward reaction or equilibrium constant, and as it decreases from 0.084 to 0.033, this indicates that the reverse reaction is being favoured. Thus, the forward reaction must be exothermic.

Excerpt 2

The ~~react~~ forward reaction is exothermic and reverse is endothermic. Due to temperature increasing the Kc is decreasing, ~~therefore~~ it means that the reactants are being favoured because as they increase in concentration the Kc value will get smaller as shown in Table 1.

Additional advice

- Schools should ensure that comparable assessment instruments
  - allow students to use the same knowledge and skills required for the endorsed instrument
  - include a separate marking scheme
  - are developed in the Endorsement app, as required.

Internal assessment 2 (IA2)

Student experiment (20%)

This assessment requires students to research a question or hypothesis through collection, analysis and synthesis of primary data. A student experiment uses investigative practices to assess a range of cognitions in a particular context. Investigative practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment

Validity priority	Number of times priority was identified in decisions
Alignment	18
Authentication	3
Authenticity	2
Item construction	7
Scope and scale	0

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- provided appropriate checkpoints and scaffolding consistent with the advice in the *QCE and QCIA policy and procedures handbook v6.0*, Section 8
- included all task requirements as part of the task description (Syllabus section 4.5.2)
- identified the required task specifications within the task description, particularly those aspects that were to be completed as individuals or as a group

Practices to strengthen

It is recommended that assessment instruments:

- include practicals that are related to the topics of Unit 3, (i.e. Topic 1: Chemical equilibrium systems and Topic 2: Oxidation and reduction), e.g. single displacement reactions in aqueous solution
- direct students to address all aspects of the task listed in the syllabus specifications (Syllabus section 4.5.2).

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment

Accessibility priority	Number of times priority was identified in decisions
Bias avoidance	0
Language	3
Layout	0
Transparency	2

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- used internal quality assurance processes to ensure the task was free from errors in spelling, grammar or other textual features, e.g. using 'rational' instead of 'rationale'
- listed checkpoints that provide directions for students to complete the task
- modelled appropriate chemical formulation for species symbols throughout the task, e.g. CO_2 instead of CO2.

Practices to strengthen

There were no significant issues identified for improvement.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and confirmed marks

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
1	Research and planning	83.29	15.98	0.48	0.24
2	Analysis of evidence	85.23	13.56	0.48	0.73
3	Interpretation and evaluation	84.99	14.53	0.24	0.24
4	Communication	99.03	0.24	0.73	0.00

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- for the Analysis of evidence criterion
  - *sufficient* and *relevant* raw data was systematically and effectively analysed using correct and relevant processes, e.g. calculation of percentage uncertainty or linearisation of data including correlation coefficients (r^2)
  - uncertainty and limitations were thoroughly identified through analysis of the evidence from the experimental data rather than discussing problems relating to methodology and appropriately related to the correct and relevant processing of data.
- for the Interpretation and evaluation criterion
  - discussions of validity and reliability were *justified* by referring to data, systematic and random errors in datasets and, where appropriate, accepted values for constants to consider how specific aspects of the experimental design or data collection process impacted, or improved, the extent to which the experiment measured what was intended, (i.e. validity) or the likelihood that another experimenter would obtain the same results, (i.e. reliability)
  - improvements and extensions to an experiment were *logically derived* from analysis of experimental evidence by referring to a thorough identification of uncertainty and limitations of the evidence
  - *justified* conclusions referred to the trends, patterns or relationships identified in the analysis of evidence to indicate how the evidence matched with the theoretical concepts identified in the rationale.
- in the Communication criterion
  - findings, arguments and conclusions were *fluently* and *concisely* conveyed through precise and accurate use of
    - discipline-specific language
    - symbols, units and prefixes
    - indicators of measurement uncertainty, e.g. error bars and uncertainties
    - tables, graphs and diagrams
  - *appropriate* use of genre conventions was demonstrated by adherence to accepted rules of spelling and punctuation and the expectations of particular generic forms, e.g.
    - for a scientific report — clearly identified headings and captions, an appropriately formal tone
    - for a poster presentation — appropriately sized font and visual elements, use of clear spoken/signed language
    - for a multimodal conference presentation — clear slides with appropriate amounts of text, visual and oral components present different information, use of clear spoken/signed language
  - *appropriate* referencing conventions acknowledged sources through the consistent use of an accepted referencing methodology, e.g. APA or Harvard.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- for the Research and planning criterion
  - a *specific* research question explicitly states the relationship between an independent and dependent variable with relevant controlled variables included, where appropriate, to inform the rationale and lead to a justified conclusion
  - *justified* modifications to the methodology clearly state how each modification will improve the reliability and/or validity of the evidence
  - the impacts of risks associated with the investigation and their subsequent management are *considered* in the methodology.

Samples

The following excerpts demonstrate a considered rationale, a specific and relevant research question, justified modifications to the methodology; and the considered management of risks.

Excerpt 1 clearly develops a specific and relevant research question from a considered rationale, justifies modifications to the methodology to state how each modification will improve the reliability and/or validity of the evidence, and considers the management of risks associated with the modified experiment.

Excerpt 2 uses a table format to indicate how each modification will improve the reliability and/or validity of the evidence and how the impacts of risks associated with the investigation and their subsequent management in the methodology are condisered.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

Rationale

2 Appropriate Genre Conventions

Soda water is carbonated through the infusion of pressurized carbon dioxide gas (CO_2). This solution is stored in a closed system ensuring the beverage retains its effervescence by preventing the escape of CO_2 in the form of gas bubbles. Thus, there is a constant interchangeable process between CO_2 present in soda waters aqueous solution and the CO_2 gas bubbles rising into the air remaining at the top of the bottle. This interchangeable process is also evident when the remaining CO_2 aqueous solution and H_2O react to form carbonic acid also present in the carbonated drink. These processes can be explained by two equilibrium equations as follows;

1) $CO_{2(g)} \leftrightarrow CO_{2(aq)}$

2) $CO_{2(aq)} + H_2O_{(l)} \leftrightarrow H_2CO_{3(aq)}$

Therefore, in order to calculate the concentration of carbonic acid (H_2CO_3) present in a 300mL bottled soda water, a mandatory experiment consisting of 3 trials was undertaken. It was completed through an acid-base titration with 50ml of a 0.1M potassium hydroxide (KOH) solution. Thus, potassium hydroxide reacted with carbonic acid solution producing H_2O and potassium carbonate, the equation for this reaction is as follows;

$$H_2CO_{3(aq)} + 2KOH_{(aq)} \rightarrow K_2CO_{3(aq)} + 2H_2O_{(l)}$$

However, in the mandatory experiment, Trials were conducted with each sample of soda water varying in standing time within a 30-minute period. Hence, the effect of standing time was not investigated over a large enough timeframe to observe its impact on the concentration of carbonic acid. Therefore, the experiment was redirected to measure the effect of standing time on the concentration of carbonic acid over 91 hours to provide clear trends into the equilibrium's ability to control external disturbances.

When considering the equilibriums present in a bottle of soda water, any changes can be explained by the Le Chatelier principle (LCP). Introduced in 1884 by French Chemist Henry Louis Le Chatelier's *(Lette, 1998)*, the LCP states that any external change imposed on a system at equilibrium will induce a response within the system, causing it to shift its position to counteract the disturbance and restore a new equilibrium. Variables that impact systems at equilibrium are temperature, pressure/volume, and concentration.

When soda water is opened the initial volume of the closed bottle is enlarged, the pressure is reduced and equilibrium 1 is disturbed. The initial pressure released in the form of CO_2 gas causes the equilibrium to moderate this disturbance by shifting to the left causing less production of $CO_{2(aq)}$. Thus, due to this reduction of $CO_{2(aq)}$, equilibrium 2 shifts to the left to compensate for this change and carbonic acid ($H_2CO_{3(aq)}$) is unable to retain its standard concentration. This process, concerning the systems attempt to re-standardize the pressure, causes the 'flattening' of aerated drinks. Thus, the hypothesis proposes that a prolonged standing time of the opened soda water bottle results in a decline in the concentration of $H_2CO_{3(aq)}$ due to the gradual release of CO_2 gas. According to 'The Chemistry of Pop, 2019', as the standing time of soda water increases the concentration of carbonic decreases resembling an exponential relationship *(The Chemistry of Pop | Let's Talk Science, n.d.)*.

Hence the research question for this experiment is;

Does increasing the standing time in uneven increments (0h, 25h, 48h, 67h, 91h) of a 300mL opened soda water bottle decrease the concentration of Carbonic Acid (H_2CO_3), given that the temperature of soda water remains constant at 5°C?

5-6 Specific and Relevant Research Question

Justified Modifications to the Methodology

In the mandatory practical, 0.1M potassium hydroxide (KOH) was titrated with 20mL soda water to calculate the concentration of carbonic acid (H_2CO_3) present in soda water at room temperature. 20mL of soda water was pipetted using 4 drops of indicator phenolphthalein to determine the end point of the titration. This experiment had 3 Trials.

Redirection

The mandatory experiment *(Lourdes Hill College, 2024)* was redirected to measure the effect of standing time (over a range of 0-91 hours) on the concentration of carbonic acid at a constant refrigerated temperature of 5°C (±0.5°C). This standing time range allows a new trend between standing time and concentration to be observed.

5-6 Justified Modifications

Extensions

The experiment was extended by:

Conducting 5 Trials at each standing time, totaling 25 Trials to be conducted overall. This extensive number of Trials ensures a more precise means to be calculated with a lower possibility of potential outliers within the data.

Extending the standing time from 0-30 minutes to a broader range of durations (0h, 25h, 48h, 67h, 91h) allows for the relationship between the concentration of carbonic acid and standing time to be analyzed over a large time frame to obtain a more accurate trendline.

5-6 Justified Modifications

1 Competent Use of Scientific Language

Risk Assessment

Hazard – common Risk	Management Strategy
Glassware 50mL glass burette ±0.05mL 150mL conical flask - Glass may crack or break if mishandled causing sharp glass fragments that may cut skin. - Flask chips around edge causing cuts to the skin.	Inspect and discard any chipped or cracked flasks, no matter how small the damage. Sweep up any broken glass with brush and dustpan – do not use fingers.
Electricity and Water Magnetic Stirrer (250RPM) - May cause electric shock if power cord damages cohere with spilled liquid.	Ensure all electrical sources do not make contact with water or any water spillage. If water is spilled move all surrounding objects out of the way and clean the spill.
Chemicals Potassium Hydroxide KOH (0.1M) - Is highly corrosive to skins, eyes and tissues. Direct contact can cause severe burns. Phenolphthalein - Highly flammable liquid and vapor	Wear safety protection - safety glasses, gloves, apron, when handling any harmful chemicals. If any solution touches the skin or eyes, wash immediately with water using sink or eyewash station.
- Limited hazards when dissolved in solvent (H_2CO_3), in pure form presents risks of irritation or reaction if contact is made with the skin or eyes.	

5-6 Considered Management of Risks

Table 1 – Hazard Risk assessment

Excerpt 2

Modifications

	Modification	Justification
Refinement	Conducting three trials of each concentration.	This will improve precision and ensure that the results are reliable because random error will be reduced and calculations of the mean, absolute uncertainty, percentage uncertainty, percentage error and absolute error can be deduced. Thus, improving the data to determine trends and patterns between the independent and dependent variables as the original experiment limited the ability to draw conclusions.
	Allowing 10 seconds before recording the voltage	This will improve precision as the voltages recorded for the original experiment were inconsistent leading to low reliability with the results. Thus, refining the time, will determine precise and reliable results.
Extension	Increasing the concentration of $ZnSO_4$ for 0.1M, 0.2M, 0.3M, 0.4M,0.5M, 0.6M, 0.7M	This will allow the thorough identification of patterns and trends between the electrolyte solutions and will determine whether the concentration of $ZnSO_4$ (cathode) will increase the voltage.

Risks

Hazard	Risk	Precaution
$MgSO_4$ and $ZnSO_4$ electrolytes solutions	• Toxic to environment	• Do not pour down the drain. • Alert supervisor and await instructions when disposing the solutions. There are no ethical concerns in this experiment.
	• Irritation to skin and eyes if contact occurs. • Toxic if consumed.	• Wear PPE • Rinse thoroughly with water. • Alert supervisor. • Do not consume. • Wash hands immediately after experiment.
Metal Electrodes	• Sharp • Cause cuts	• Wear PPE • Cautiously handle. • Alert supervisor and await instructions
Glass beakers	• Breakages • Spillages of electrolyte solutions	

Additional advice

- Schools should ensure
  - they use appropriate strategies to promote academic integrity and manage response length in student responses (*QCE and QCIA policy and procedures handbook v6.0*, Sections 8.1.1 and 8.2.6)
  - accuracy and consistency in judgments when determining provisional marks for each criterion by applying the best-fit approach (see Syllabuses app > QCAA Portal > *Using ISMGs for General Science syllabuses*). After determining the performance level that best fits the evidence matched to characteristics for a criterion within an ISMG, for a two-mark range performance level, the higher mark should only be awarded if there is evidence of all the characteristics in the performance-level descriptor (or better)
  - ISMGs are clearly annotated to indicate the characteristics evident in the student response and the mark awarded for each criterion (*QCE and QCIA policies and procedures handbook v6.0,* Section 9.6.1).

Internal assessment 3 (IA3)

Research investigation (20%)

This assessment requires students to evaluate a claim. They will do this by researching, analysing and interpreting secondary evidence from scientific texts to form the basis for a justified conclusion about the claim. A research investigation uses research practices to assess a range of cognitions in a particular context. Research practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment

Validity priority	Number of times priority was identified in decisions
Alignment	232
Authentication	15
Authenticity	3
Item construction	22
Scope and scale	7

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- focused on the topics identified in the task conditions, which matched the subject matter addressed in the claims
- directed students to address all aspects of the task, as outlined in the syllabus specifications (Syllabus section 5.5.1).

Practices to strengthen

It is recommended that assessment instruments:

- list claims that are linked to Unit 4 subject matter and allow students to generate multiple research questions, e.g. Synthetic polymers are chemically superior.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment

Accessibility priority	Number of times priority was identified in decisions
Bias avoidance	1
Language	7
Layout	0
Transparency	1

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- were free from formatting, spelling and/or other language errors
- scheduled only one complete or near-complete draft for feedback in the checkpoints (*QCE and QCIA policy and procedures handbook v6.0*, Section 8.2.5).

Practices to strengthen

There were no significant issues identified for improvement.

Additional advice

- Schools should avoid including checkpoints or due dates that specify a date or week of term, e.g. Use 'Week 2', not 'Term 3, Week 2, Lesson 2'.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and confirmed marks

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
1	Research and planning	89.10	9.69	1.21	0.00
2	Analysis and interpretation	90.31	8.47	0.73	0.48
3	Conclusion and evaluation	85.47	14.04	0.48	0.00
4	Communication	99.27	0.24	0.48	0.00

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- in the Research and planning criterion
  - a *considered* rationale demonstrated an application of Unit 4 subject matter to the development of the research question from the claim

  - *relevant* sources were identified from a variety of scientifically credible outlets and not limited to peer-reviewed journal articles
- in the Analysis and interpretation criterion
  - an *appropriate* selection of evidence was identified and *thoroughly* applied to support relevant trends, patterns and relationships
  - a *thorough* and *appropriate* identification of limitations of evidence identified issues such as weak points in the data and methodological limitations with respect to the research question
  - *justified* scientific arguments linked to Unit 4 chemical concepts and supported this with data from the sources
  - a *thorough* and *appropriate* identification of limitations of evidence focused on aspects of the evidence that would affect its ability to address the claim.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- in the Conclusion and evaluation criterion
  - *justified* conclusions discuss how the trends, patterns and relationships identified in the analysis of evidence link back to the research question
  - *insightful* discussion of quality of evidence examines specific features and limitations of the evidence (rather than a discussion of the credibility of the source) when connecting to the research question and claim
  - *considered* and *relevant* improvements and extensions focus on ways the research investigation could be refined or extended to obtain more valid evidence applicable to the claim.

Samples

The following excerpts demonstrate sufficient and relevant evidence to support relevant trends, patterns and relationships; the thorough and appropriate identification of the limitation of the evidence, insightful discussion of the quality of evidence, considered and relevant improvements; and justified conclusions.

Excerpt applies sufficient and relevant evidence to support relevant trends, patterns and relationships, and thoroughly identifies appropriate limitations of the evidence supported by justified scientific arguments.

Excerpt 2 insightfully discusses the quality of evidence by examining specific features of the evidence that connect the research question to the claim, considers relevant improvements and extensions that could obtain more valid and/or reliable evidence to address the claim, and justified conclusions by linking analysis of the evidence presented back to the research question.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

2 ANALYSIS AND INTERPRETATION:

Evidence 1 - Tensile Strength:

Both studies (Rebouillat & Steffenino (2006) and Brown et al. (2011)) aimed to investigate the "mechanical properties" of each fibre each measuring tensile strength respectively via the use of a universal pulling machine and a tensile tester.

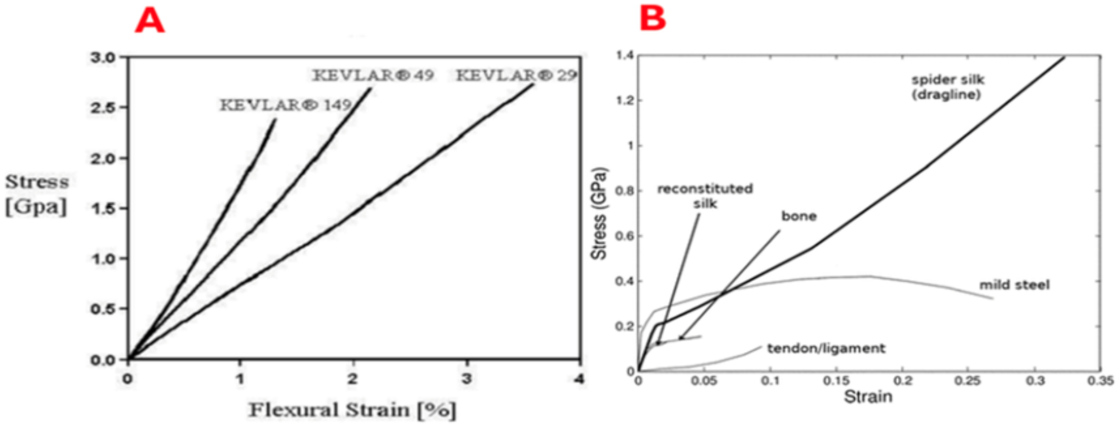


FIGURE 1: (A) stress and strain (GPa/Flexural Strain) curve for Kevlar variants (29,49,149) (B) stress and strain (GPa/Flexural Strain) curve for Spider silk and additional silks.

ANALYSIS AND INTERPRETATION:

From the data in Figure 1A, it is evident that all Kevlar variants exhibit a lower stress-to-strain ratio characterized by a linear, directly proportional relationship. Kevlar 29 shows a flexural strain of 3.5% at 2.7 GPa, Kevlar 49 at 2.1% at 2.7 GPa, and Kevlar 149 at 1.2% at 2.5 GPa, underscoring their substantial resistance to deformation under high stress and showcasing high tensile strength. The steep gradient of each curves further reinforces Kevlar's minimal strain under increased stress levels. In comparison, Figure 2A shows that spider silk can only withstand 1.4 GPa of pressure with a flexural strain of 30%, indicating lower tensile strength but higher elasticity. This suggests that, although spider silk is more elastic, Kevlar's higher tensile strength enhances the safety of bulletproof vests.

A study by Ștefania Ursache et al. (2023) support these findings, explaining that Kevlar derives its exceptional strength from its molecular structure and the chemical properties of its aramid fibres. Kevlar consists of tightly packed parallel polymer chains formed by polymerizing PPD and TCl, resulting in long, rigid chains where each benzene ring is bonded to amide groups that form hydrogen bonds with neighbouring chains. These bonds and the planar, rigid structure of the benzene rings distribute tensile stress evenly across the fibres. Additionally, Kevlar's high crystallinity further prevents the chains from moving under stress, significantly enhancing its tensile strength.

LIMITATIONS:

The spider silk utilized in figure 1B to measure tensile strength was not specified. This potential disparity in the comparison groups can skew results and impact the reliability of the conclusions drawn from the data, as different spider species produce silk with varying strengths. Furthermore, the amount of strands/ size of the fibre used was not present in each evidence. This could cause a limitation of reliability as there could be a chance that one study utilised significantly higher amounts of fibre. The Data was also collected from different sources with each source using a different type of measuring technique which reduces the generalizability of results as different testing conditions can potentially result in varying results.

Attributions for Figure 1 sources

Steffenino, B., & Rebouillat, S. (2006). High Performance Fibres And The Mechanical Attributes Of Cut Resistant Structures Made Therewith. Www.witpress.com.

Brown, Cameron & Rosei, Federico & Traversa, Enrico & Licoccia, Silvia. (2011). Spider silk as a load bearing biomaterial: tailoring mechanical properties via structural modifications. Nanoscale. 3. 870-6. 10.1039/c0nr00752h.

Excerpt 2

3 CONCLUSION AND EVALUATION:

3.1 Quality of Evidence and review of literature sources:

- **Evidence 1 – Tensile strength:** Rebouillat & Steffenino (2006), Brown et al. (2011)
- **Evidence 2 – compression strength:** Ko et al. (2001)
- **Evidence 3 – Thermal Resistance:** DuPont (2019) , Aparicio-Rojas et al. (2020)

All studies for each evidence is deemed credible due to each paper being a publish research article or journal by qualified experts, However, Dupont (2019) is a technical guide created by the company's founder, which could introduce bias as a marketing tool. Additionally, some evidence, such as from Ko et al. (2001) and Rebouillat & Steffenino (2006), may be outdated as it spans back more than 15 years therefore further investigations with more recent evidence may be required. The number of trials for all experiments has not been confirmed, which may affect the validity of the results as without a clear indication of the number of repetitions, it is challenging to assess the consistency and accuracy of the findings. These suggests that further review of sources may be required for a more accurate and comprehensive review.

The investigation's scope is also limited to assessing the raw resistance in each measurement sector, which may not fully represent real-life applications where multiple factors interact simultaneously. However, this does not invalidate the extensive research and data obtained. Each measured factor represents the main components required for a comprehensive assessment, and the evidence strongly supports the claim and research question.

3.2 Suggested Improvements and Extensions:

Although the current data is accurate, additional factors such as strength-to-weight ratio, abrasion resistance, and ballistic protection should be considered to truly determine if synthetic fibres enhance the safety of bulletproof vests. The effect of Kevlar was measured under controlled conditions, limiting the reliability of the results for real-life applications. Testing in a rigorous training environment with actual gunfire would provide a more accurate representation of performance, addressing the lack of realistic application testing noted in all evidences.

Using data from standardized testing setups can reduce disparities and inconsistencies observed in evidence 1 and 3 regarding testing setups, number of trials and material use, offering a more comprehensive review of Kevlar's performance compared to spider silk. Furthermore, including data on different fibre slayers can further enhance understanding, as bulletproof vests typically use multiple layers of various materials for optimal protection.

Additionally, considering more Kevlar variations when measuring compression stress can address limitations noted in evidence 2. Using more than the three standard Kevlar variants (29, 49, 149) would provide a broader understanding overall, as each variant has unique modifications that can enhance specific attributes. This approach allows for a more comprehensive analysis of Kevlar's physical properties.

Furthermore, comparing Kevlar with various other organic and synthetic fibres can broaden the understanding of its protective capabilities, highlighting its effectiveness relative to other materials allowing for a more comprehensive analysis of the claim.

3.3 Conclusion:

The analysis of the provided data demonstrates that synthetic polymers, particularly Kevlar, significantly outperform spider silk in tensile strength, compression strength, and thermal resistance, thereby addressing the research question effectively. This is evident as the findings indicate that Kevlar variants (29, 49, 149) exhibit lower stress/strain ratios, enduring maximum strains/deformations of 1.4-3.5% at stress levels of 2.5-2.7 GPa before breakage. In contrast, spider silk only withstands up to 1.4 GPa with a strain of 30% before breaking. Furthermore, Kevlar endures a maximum compression stress of 72 MPa with a resulting compression strain of 18% ΔUD, whereas spider silk withstands a maximum compression stress of 41 MPa with a 33% strain before failure. Additionally, the thermal resistance of Kevlar variants (29, 49, 149) can withstand temperatures up to 600°C, while spider silk can only endure temperatures up to 400°C.

Although reliable, the data is subject to certain limitations, as all tests were conducted in controlled lab conditions limiting the scope on its effectiveness in a realistic environment where more variables are present. Additionally only 3 measurement sectors were considered limiting the overall understanding of Kevlar's properties. Therefore to mitigate this factors such as strength-to-weight ratio, abrasion resistance, and ballistic resistance should be considered and testing with different fibre layers and in real ballistic applications can also enhance the reliability of these findings .

In conclusion, the initial claim that "synthetic polymers will shape our future" is validated, as synthetic polymers like Kevlar offer superior protection compared to spider silk and have the potential to save lives. However, for a more comprehensive analysis, additional factors and considerations should be taken into account.

Additional advice

- Schools should ensure
  - they use appropriate strategies to promote academic integrity and manage response length in student responses (*QCE and QCIA policy and procedures handbook v6.0*, Sections 8.1.1 and 8.2.6)
  - accuracy and consistency in judgments when determining provisional marks for each criterion by applying the best-fit approach (see Syllabuses app > QCAA Portal > *Using ISMGs for General Science syllabuses*). After determining the performance level that best fits the evidence matched to characteristics for a criterion within an ISMG, for a two-mark range performance level, the higher mark should only be awarded if there is evidence of all the characteristics in the performance-level descriptor (or better).
  - ISMGs are clearly annotated to indicate the characteristics evident in the student response and the mark awarded for each criterion (*QCE and QCIA policies and procedures handbook v6.0*, Section 9.6.1).

External assessment

External assessment (EA) is developed and marked by the QCAA. The external assessment for a subject is common to all schools and administered under the same conditions, at the same time, on the same day.

Examination (50%)

Assessment design

The assessment instrument was designed using the specifications, conditions and assessment objectives described in the summative external assessment section of the syllabus.
The examination consisted of two papers:

- Paper 1, Section 1 consisted of multiple choice questions (20 marks)
- Paper 1, Section 2 consisted of short response questions (38 marks)
- Paper 2, Section 1 consisted of short response questions (52 marks)

Assessment decisions

Assessment decisions are made by markers by matching student responses to the external assessment marking guide (EAMG). The external assessment papers and the EAMG are published in the year after they are administered.

Multiple choice question responses

There were 20 multiple choice questions in Paper 1.

Percentage of student responses to each option

Note:

- The correct answer is **bold** and in a blue shaded table cell.
- Some students may not have responded to every question.

Question	A	B	C	D
1	**70.99**	14.83	8.19	5.70
2	9.93	**64.47**	19.34	6.02
3	5.94	14.14	**71.40**	8.29
4	**82.66**	7.82	6.67	2.60
5	22.11	9.85	**59.92**	7.89
6	20.22	3.35	27.89	**48.31**
7	**77.20**	1.95	6.13	14.54
8	**87.74**	4.07	5.44	2.55
9	2.18	18.18	**32.19**	47.04
10	4.52	**69.23**	20.84	5.15
11	2.54	6.29	12.45	**78.43**

Question	A	B	C	D
12	**79.64**	5.08	12.83	2.19
13	10.03	**68.36**	9.21	12.15
14	4.80	**53.16**	18.93	22.55
15	10.42	14.97	**67.45**	6.83
16	**50.85**	16.68	15.61	16.47
17	38.39	23.39	9.72	**28.13**
18	8.36	11.07	31.14	**49.00**
19	16.73	5.44	**71.55**	5.96
20	5.16	**56.82**	18.75	18.91

Effective practices

Overall, students responded well to:

- Objective 1 (Describe and explain) items that required them to
  - describe condensation reactions, peptide bonds and the structure of organic molecules using diagrams
  - explain reversible arrows in equilibrium equations, chromate–dichromate equilibrium at an atomic level and saturated organic compounds
- Objective 2 (Apply understanding) items that required them to
  - calculate atom economy, pH and the concentration of acids and strong bases using appropriate working
  - apply oxidation numbers to determine half-equations and standard reduction potentials to determine reducing agents
  - identify the features of titration curves, the conjugate base of an indicator and the limitations associated with standard reduction potentials
  - identify organic functional groups, geometric isomers, and primary, secondary and tertiary organic molecules
- Objective 3 (Analyse evidence) items that required them to
  - analyse experimental data to identify optimal reaction conditions and reactants for biodiesel production
  - analyse experimental data to explain the acid dissociation and conductivity in aqueous solutions
  - analyse experimental data to explain the effect of temperature on the pH of water
- Objective 4 (Interpret evidence) items that required them to
  - compare the relative strengths of acid based on pH and K_a data
  - distinguish between the concentration and strength for acids and bases
  - deduce the position of equilibrium for reversible reactions
  - deduce reaction pathways, including reagents, conditions and chemical equations, given the starting materials and the products.

Practices to strengthen

When preparing students for external assessment, it is recommended that teachers consider:

- the cognitive verb and the nature of the response required to address the question, e.g. when responding to questions that use the cognitive verb ‘explain’, students should ensure they give a detailed account of the scenario by providing additional relevant information
- teaching and learning opportunities for students to practise strategies for responding to examination questions, e.g. when responding to questions students should
  - read the question carefully and provide a response that clearly addresses the question
  - consider the number of marks awarded and the response space provided. Responses should be logically set out, clearly address all aspects of the question and consider the number of marks awarded to ensure the response demonstrates the required depth and breadth of understanding
  - use the data in the stimulus and appropriate information and equations from the Chemistry *Formula and data book* to address the question
- teaching and learning opportunities for students to develop understanding of subject matter through practical work, e.g. mandatory practicals provide an opportunity for students to develop knowledge and understanding of subject matter in context
- teaching and learning opportunities for students to practise drawing structural formulas and correctly apply the International Union of Pure and Applied Chemistry (IUPAC) nomenclature system to name organic compounds.

Samples

Short response

Paper 1, Question 23b)

The following excerpts are from Question 23b) in Paper 1. It required students to explain why KHP(aq) is used as a standard solution rather than NaOH(aq).

Effective student responses:

- explained that the concentration of KHP does not change, therefore an accurate concentration of KHP can be determined.

These excerpts have been included to demonstrate alternative responses that addressed the question. Students often incorrectly explained that KHP was used as the standard solution because it was a weak acid and, therefore, could neutralise NaOH, which was a strong base.

Excerpt 1 illustrates a concise response that aligns with the mark awarded for the question and the response space provided.

Excerpt 2 illustrates an acceptable alternative response that addresses the question by recognising that a higher molar mass minimises errors and reduces percentage uncertainty when making up a solution of a particular concentration.

Excerpt 1

Because it is more stable than NaOH

Excerpt 2

KHP has a higher molar mass than NaOH (71.08g/mol vs 40.0g/mol respectively). This high molar mass and thus molarity makes it more suitable as a standard solution.

Paper 1, Question 24

The following excerpt is from Question 24 in Paper 1. It required students to explain the effect of increasing temperature on the pH of water by considering the enthalpy of the forward reaction of the self-ionisation of water.

Effective student responses:

- identified that pK_w decreased as temperature increased
- explained that increasing temperature shifts the equilibrium toward products and that increasing temperature decreased pH
- determined that the forward reaction is endothermic.

This excerpt has been included:

- to demonstrate the use of data in the stimulus and equations in the Chemistry *Formula and data book* to address the question
- to demonstrate
  - the use of data provided in the stimulus to address the question. Students often stated responses that contradicted the graph provided, which indicated that as temperature increased, pK_w decreased
  - understanding of the difference between pK_w, K_w, pH and $[H^+]$ and the inverse relationship between pKw and K_w, and pH and $[H^+]$. Students often incorrectly explained that, as [H+] increased, pH increased
  - the understanding that K_w represents the self-ionisation of water and familiarity with equations provided in the Chemistry *Formula and data book*. Students often incorrectly identified $H^+(aq)$ and $OH^-(aq)$ as reactants of water self-ionisation rather than products.

As temperature is increased, the pK_w of water decreased, ∴ The K_w of the self ionisation of water is increasing when heat is added. Hence the self ionisation of water must be endothermic as an increase in heat favours the endothermic reaction. pH of the water will then increase as temp. increases as the $[H^+]$ ions in the solution will increase (thus increasing pH) as reaction shifts to the endothermic side

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq) \; +\Delta H$$

Paper 1, Question 26a) and Question 26b)

The following excerpt is from Question 26)a and Question 26b) in Paper 1. It required students to identify a reducing agent, explain reasoning and determine a reduction half-equation.

Effective student responses:

- identified that the iodine ion (I^-) in KI is the reducing agent
- explained that I^- is oxidised by losing electrons
- determined that $IO_3^-(aq)$ and $H^+(aq)$ were reactants and I_2 + H_2O were products, then used electrons to balance the reduction half-equation.

These excerpts have been included:

- to demonstrate the use of oxidation numbers to determine the
  - species oxidised and acting as a reducing agent
  - reduction half-equation when the balanced redox equation is provided
- to demonstrate
  - the application of oxidation and reduction theory to identify and explain reducing agent, oxidising agent and spectator ions in redox equations. Students often incorrectly identified K or KI as the reducing agent or incorrectly explained that I^- in KI was reduced because its oxidation number increased
  - the understanding that reduction is the gain of electrons and therefore reduction half-equation indicate the species reduced and the number of electrons gained. Students often incorrectly identified that electrons are lost in reduction or neglected to use electrons to balance the reduction half-equation.

Excerpt 1 demonstrates a response that identifies the reducing agent and applies oxidation numbers to provide reasoning. Additional information which extended the response beyond the response space was not required to be awarded the 2 marks.

Excerpt 2 illustrates an alternative acceptable response used to determine the reduction half-equation from the balanced redox reaction.

Excerpt 1

KI (I^-) is the reducing agent. The oxidation number of iodine increases from -1 to 0, indicating it is oxidising, so will provide electrons to another species (ie. act as a reducing agent)

Excerpt 2

KIO_3 (aq) becomes K^+ (spectator) and IO_3^-

$2IO_3^-(aq) \rightarrow I_2(s)$ ← balancing under acidic conditions.

$2IO_3^-(aq) \rightarrow I_2(s) + 6H_2O(l)$

$2IO_3^-(aq) + 12H^+(aq) \rightarrow I_2(s) + 6H_2O(l)$

$2IO_3^-(aq) + 12H^+(aq) + 10e^- \rightarrow I_2(s) + 6H_2O(l)$

Paper 1, Question 28c)

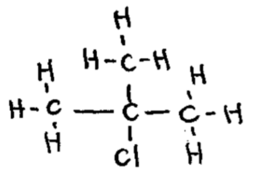
The following excerpt is from Question 28c) in Paper 1. It required students to determine the structural formula of an isomer of C_4H_9Cl that is a tertiary haloalkane and apply IUPAC rules to name the isomer.

Effective student responses:

- determined the structural formula of an isomer of C_4H_9Cl that is a tertiary haloalkane
- applied IUPAC rules to name an isomer.

This excerpt has been included:

- to demonstrate the structural formula of a tertiary haloalkane
- to demonstrate the application of IUPAC nomenclature to name an organic compound
- to demonstrate
  - use of the appropriate type of formula when responding to organic compound questions. Students often incorrectly wrote a condensed molecular formula or empirical formula rather than drawing a structural formula. When drawing a structural formula, students should take care to include all relevant bonds and all hydrogen atoms
  - the listing of side groups in alphabetical order with dashes and commas used correctly when naming an organic compound. Students often incorrectly placed the methyl group before the chloro group when naming and used a comma where a dash was required.



IUPAC name: 2-chloro-2-methyl propane

Paper 2, Question 2c)

The following excerpt is from Question 2c) in Paper 2. It required students to explain the relationship between the pH colour range for phenol red and its pK_a value.

Effective student responses:

- identified that colour change occurs when the [HIn] = [In^-] and that the pH range of colour change is pK_a ±1
- explained that when [HIn] = [In^-], the K_a of phenol red equals [H^+], and, therefore, pH equals the pK_a and that the pH range of colour change occurs either side of pK_a because colour change is detected when the [HIn] : [In^-] changes.

This excerpt has been included:

- to demonstrate a logical approach that clearly sets out how the response addresses all aspects of the question and aligns to the number of marks awarded
- to demonstrate a response to the cognitive verb *explain* by
  - describing the relationship between the [HIn], [In^-], pH, pK_a and colour change of an indicator. Students often defined HIn, In^-, pH and/or pK_a rather than describing the relationship that exists between these components
  - describing in more detail how the pH of the solution affects the relationship between the [HIn] and [In^-] and the range of the colour change of the indicator. Students often simply stated the colour range equals pK_a ±1 rather than providing additional information to give an account of how the interaction of [HIn], [In^-], pH, and pK_a explains the range of the colour change.

① pK_a of phenol red = 7.9, pH range = 6.8 – 8.4

② When pH of solution < pKa, too much H^+ means equilibrium lies left, favouring HIn form, so solution is yellow. ✓

③ When pH of solution > pKa, not enough H^+ means equilibrium lies right, favouring In^- form, so solution is red. ✓

④ When pH = pKa, [HIn] = $[In^-]$ because $K_a = [H^+]$, so solution is orange ✓

⑤ Indicators act similarly to buffers, where resistance to changes in pH can be seen by colour changes

Paper 2, Question 4a) and Question 4b)

The following excerpt is from Question 4a) and Question 4b) in Paper 2. It required students to explain the role of enzymes in converting amylose and amylopectin in starch to glucose and describe the structure of amylose and amylopectin by completing a table which identified specific features common to both.

Effective student responses:

- identified that enzymes break glycosidic bonds in starch to form glucose
- explained that enzymes convert starch to glucose via hydrolysis
- described that
  - the monomer for amylose and amylopectin is α-glucose
  - amylose contains 1,4-glycosidic bonds and amylopectin contains 1,4 and 1,6-glycosidic bonds
  - amylose has a straight chain structure, and that amylopectin has a branched chain structure
  - amylose is helical in shape and that amylopectin forms spheres.

This excerpt has been included:

- to demonstrate alternative wording that was accepted when describing the features of amylose and amylopectin
- to demonstrate a clear response that addresses the question
- to demonstrate that students should
  - give an account of the characteristics (features) when responding to the cognitive verb *describe*. Students often incorrectly described the features of α-glucose and ß-glucose or α -helix and ß-pleated sheets for secondary proteins rather than recognising that amylose and amylopectin are polysaccharides

- provide a unique response that clearly aligns with each aspect of the question being addressed. Students often repeated the same response when responding to a different aspect of the question, often resulting in no marks being awarded for one or more features.

Excerpt 1 illustrates a succinct explanation of the role of enzymes in converting amylose and amylopectin in starch to glucose.

Excerpt 2 illustrates alternative wording that was accepted to describe the structure of amylose and amylopectin.

Excerpt 1

Enzymes catalyse the hydrolysis of glycosidic bonds to convert ~~a~~ starch to glucose monomers and increases rate of reaction.

Excerpt 2

	Amylose	Amylopectin
Monomer	~~α-glycos~~. α-glucose	α-glucose
Glycosidic linkage	C_1 and C_4	C_1 and C_4, C_1 and C_6
Chain structure	linear and unbranched	non ~~linear~~ linear and branched
Shape	helix /helical	granules (and can also be spiral)

Paper 2, Question 5

The following excerpt is from Question 5 in Paper 2. It required students to describe the movement of electrons in a galvanic cell.

Effective student responses:

- identified that the magnesium electrode was oxidised and that electrons are consumed at Q(s) to reduce Q^{2+}(aq)
- described the movement of electrons through the wire from the Mg(s) electrode to the metal Q electrode.

This excerpt has been included:

- to demonstrate the alignment between the number of marks and the number of aspects required in the response
- to demonstrate a response to the cognitive verb *describe* by
  - identifying that Mg(s) is oxidised to produce electrons and that Q^{2+}(aq) is reduced to use electrons. Students often provided generic statements (e.g. oxidation occurs at the anode and reduction occurs at the cathode) without providing any evidence that Mg(s) was the anode and Q(s) was the cathode
  - giving an account of the movement of electrons from the Mg(s) electrode where they are produced, through the wire (external circuit) to the Q(s) electrode where they are consumed. Students often incorrectly identified that electrons moved through the electrolyte solutions and salt bridge rather than the wire.

① Mg (s) oxidises : Mg (s) → Mg^{2+} (aq) + $2e^-$. e^- travelling in external circuit from Mg (s) anode to metal Q cathode after Mg(s) loses them

② A Q cathode, it bonds with Q^{2+} in solution as such: Q^{2+} (aq) + $2e^-$ → Q (s), so Q^{2+} is reduced by gaining e^-

③ Movement of e^- creates cell potential of 2.55V, thanks to redox reactions

Additional advice

- Teachers should review
  - opportunities for students to practise drafting responses to external examination questions that are clear, well considered, and succinct enough to fit within the allocated space
  - teaching and learning sequences to ensure they help students to understand the connections between the subject matter across syllabus topics and units.