Chemistry General Senior Syllabus 2019 v1.3

Subject report 2020

February 2021

Queensland Government

Queensland Curriculum & Assessment Authority

For all Queensland schools

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Queensland Curriculum & Assessment Authority
PO Box 307 Spring Hill QLD 4004 Australia
154 Melbourne Street, South Brisbane

Phone: (07) 3864 0299
Email: office@qcaa.qld.edu.au
Website: www.qcaa.qld.edu.au

Contents

Introduction

The first summative year for the new Queensland Certificate of Education (QCE) system was unexpectedly challenging. The demands of delivering new assessment requirements and processes were amplified by disruptions to senior schooling arising from the COVID-19 pandemic. This meant the new system was forced to adapt before it had been introduced — the number of summative internal assessments was reduced from three to two in all General subjects. Schools and the QCAA worked together to implement the new assessment processes and the 2020 Year 12 cohort received accurate and reliable subject results.

Queensland's innovative new senior assessment system combines the flexibility and authenticity of school-based assessment, developed and marked by classroom teachers, with the rigour and consistency of external assessment set and marked by QCAA-trained assessment writers and markers. The system does not privilege one form of assessment over another, and both teachers and QCAA assessors share the role of making high-stakes judgments about the achievement of students. Our commitment to rigorous external quality assurance guarantees the reliability of both internal and external assessment outcomes.

Using evidence of student learning to make judgments on student achievement is just one purpose of assessment. In a sophisticated assessment system, it is also used by teachers to inform pedagogy and by students to monitor and reflect on their progress.

This post-cycle report on the summative assessment program is not simply being produced as a matter of record. It is intended that it will play an active role in future assessment cycles by providing observations and findings in a way that is meaningful and helpful to support the teaching and learning process, provide future students with guidance to support their preparations for summative assessment, and promote transparency and accountability in the broader education community. Reflection and research are necessary for the new system to achieve stability and to continue to evolve. The annual subject report is a key medium for making it accessible to schools and others.

Background

Purpose

The annual subject report is an analysis of the previous year's full summative assessment cycle. This includes endorsement of summative internal assessment instruments, confirmation of internal assessment marks and external assessment.

The report provides an overview of the key outcomes of one full teaching, learning and assessment cycle for each subject, including:

- information about the application of the syllabus objectives through the design and marking of internal and external assessments
- information about the patterns of student achievement in each subject for the assessment cycle.

It also provides advice to schools to promote continuous improvement, including:

- identification of effective practices in the design and marking of valid, accessible and reliable assessments
- identification of areas for improvement and recommendations to enhance the design and marking of valid, accessible and reliable assessment instruments
- provision of tangible examples of best practice where relevant, possible and appropriate.

Audience and use

This report should be read by school leaders, subject leaders and teachers to inform teaching and learning and assessment preparation. The report is to be used by schools and teachers to assist in assessment design practice, in making assessment decisions and in preparing students for external assessment.

The report is publicly available to promote transparency and accountability. Students, parents, community members and other education stakeholders can learn about the assessment practices and outcomes for General subjects (including alternative sequences and Senior External Examination subjects, where relevant) and General (Extension) subjects.

Report preparation

The report includes analyses of data and other information from the processes of endorsement, confirmation and external assessment, and advice from the chief confirmer, chief endorser and chief marker, developed in consultation with and support from QCAA subject matter experts.

Subject data summary

Subject enrolments

Number of schools offering the subject: 407.

Completion of units	Unit 1	Unit 2	Units 3 and 4
Number of students completed	8031	8124	8115

*Units 3 and 4 figure includes students who were not rated.

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory	Not rated
Unit 1	7827	197	7
Unit 2	7676	437	11

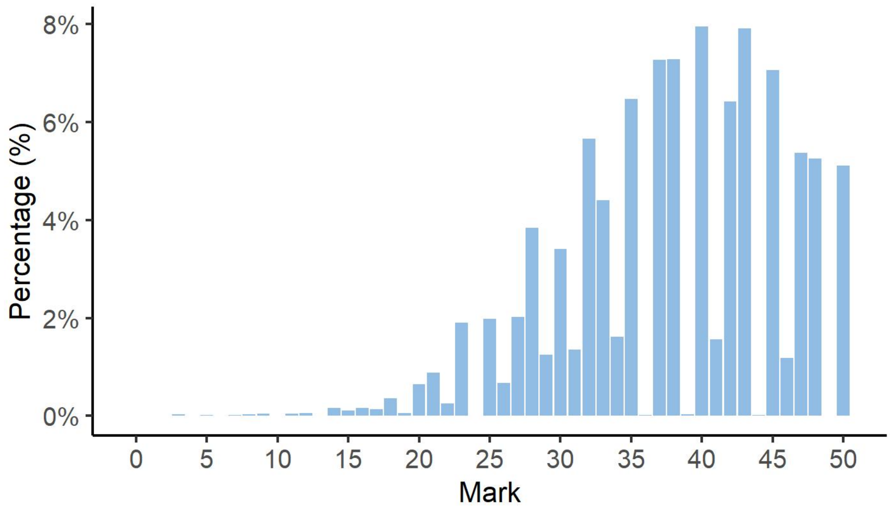
Units 3 and 4 internal assessment results

2020 COVID-19 adjustments

To support Queensland schools, teachers and students to manage learning and assessment during the evolving COVID-19 pandemic in 2020, the QCAA Board approved the removal of one internal assessment for students completing Units 3 and 4 in General and Applied subjects.

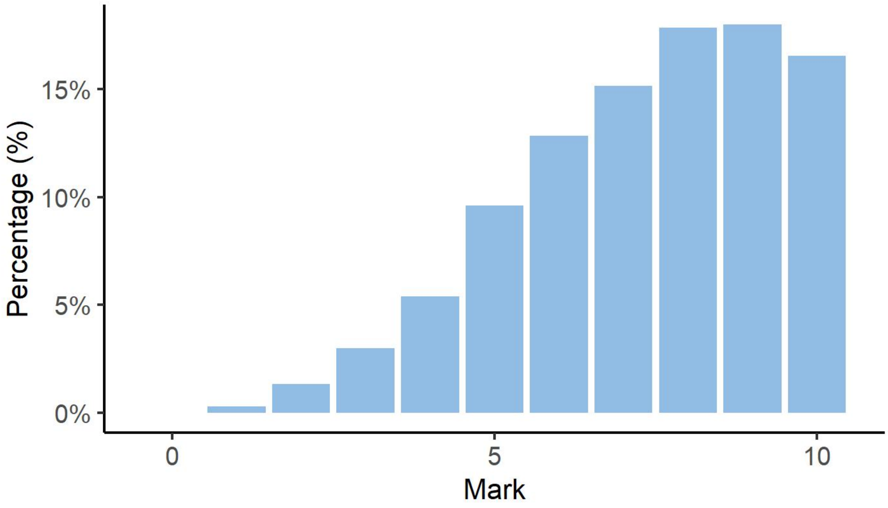
In General subjects, students completed two internal assessments and an external assessment. Schools made decisions based on QCAA advice and their school context. Therefore, across the state some instruments were completed by most schools, some completed by fewer schools and others completed by few or no schools. In the case of the latter, the data and information for these instruments has not been included.

Total results for internal assessment

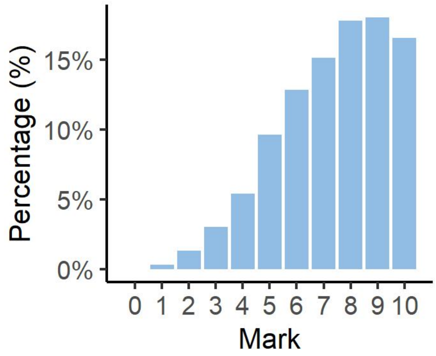


IA1 results

IA1 total

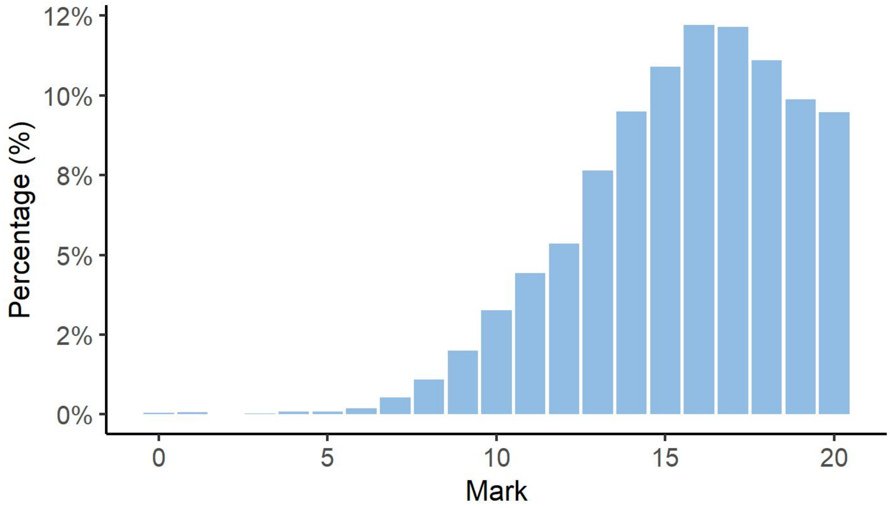


IA1 Criterion 1

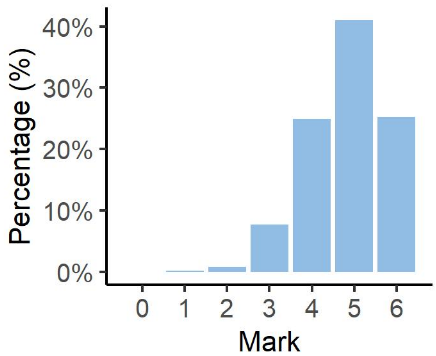


IA2 results

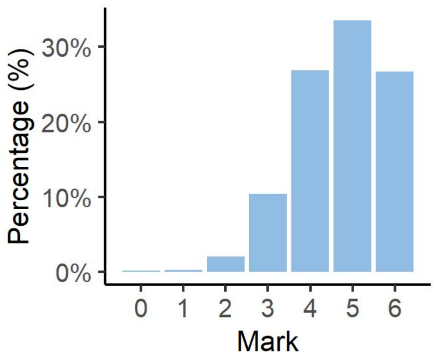
IA2 total



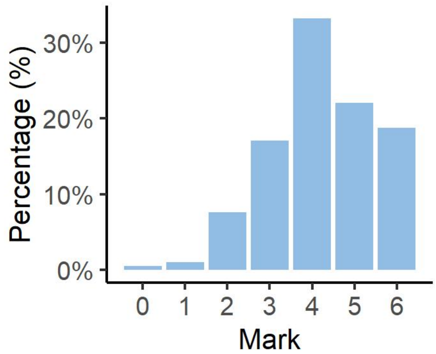
IA2 Criterion 1



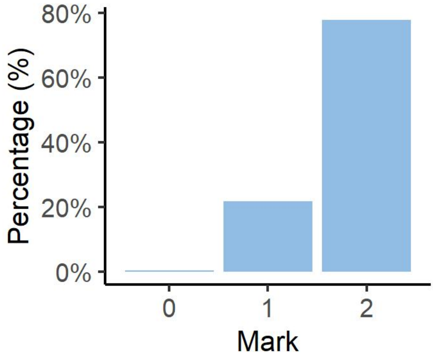
IA2 Criterion 2



IA2 Criterion 3

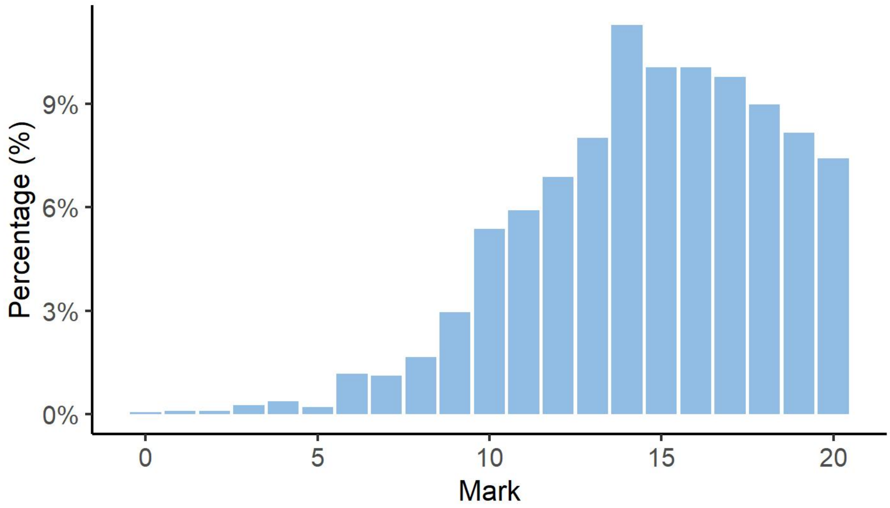


IA2 Criterion 4

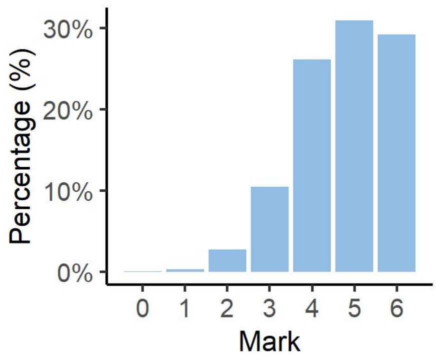


IA3 results

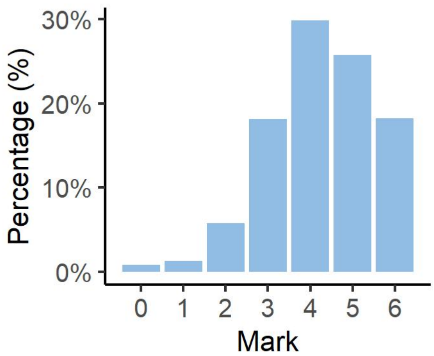
IA3 total



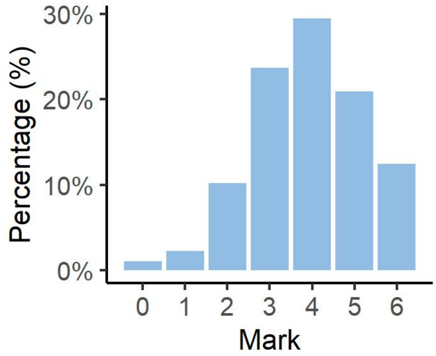
IA3 Criterion 1



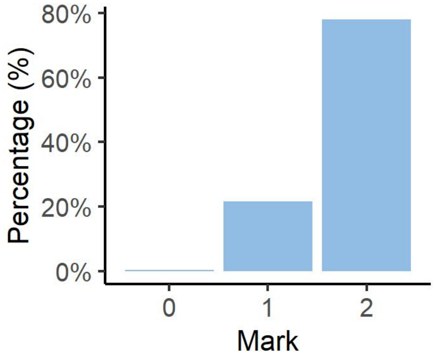
IA3 Criterion 2



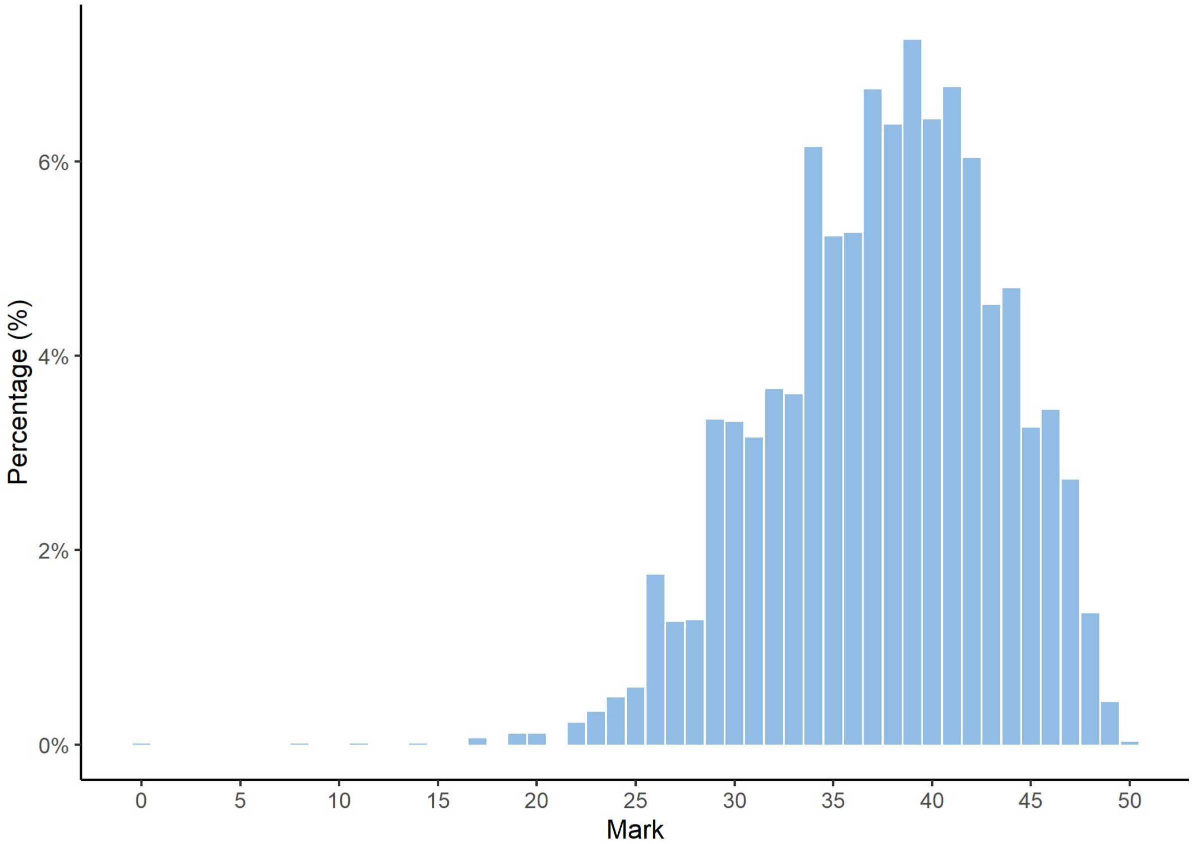
IA3 Criterion 3



IA3 Criterion 4



External assessment results



Final standards allocation

The number of students awarded each standard across the state are as follows.

Standard	A	B	C	D	E
Number of students	2349	3221	2408	88	0

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	100–84	83–70	69–46	45–17	16–0

Internal assessment

The following information and advice pertain 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 sections identifies the reasons why IA instruments were not endorsed at Application 1, by the priority for assessments. An IA may have been identified more than once for a priority for assessment, e.g. it may have demonstrated a misalignment to both subject matter and to the assessment objective. Refer to the quality assurance tools for detailed information about the assessment practices for each assessment instrument.

Total number of items endorsed in Application 1

Number of items submitted each event	IA1	IA2	IA3
Total number of instruments	413	413	413
Percentage endorsed in Application 1	26	86	78

Confirmation

Confirmation is the quality assurance process based on the attribute of reliability. Teachers make judgments about the evidence in students' responses using the instrument-specific marking guide (ISMG) to indicate the alignment of students' work with performance-level descriptors and determine a mark for each criterion. These are provisional criterion marks. The QCAA makes the final decision about student results through the confirmation processes. Data presented in the assessment decisions section identifies the level of agreement between provisional and final results.

Number of samples reviewed at initial, supplementary and extraordinary review

IA	Number of schools	Number of samples requested	Supplementary samples requested	Extraordinary review	School review	Percentage agreement with provisional
1	405	2167	0	0	0	99.91
2	266	1492	313	10	58	98.50
3	140	675	95	9	19	96.57

Internal assessment 1 (IA1)

Data test (10%)

The IA1 data test requires students to apply a range of cognitions to multiple provided items. Students respond to items using qualitative and/or quantitative data derived from practicals, activities or case studies on chemical equilibrium systems or oxidation and reduction. The task requires students to identify unknown scientific quantities or features; identify trends, patterns, relationships, limitations or uncertainty in datasets; and draw conclusions based on the analysis of data.

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 practices

Validity priority	Number of times priority was identified in decisions*
Alignment	212
Authentication	6
Authenticity	10
Item construction	78
Scope and scale	77

*Total number of submissions: 413. Each priority might contain up to four assessment practices.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that featured:

- items that showed clear alignment between the cognition in the question, the objective being assessed and the expected student response
- items that demonstrated clear alignment with the syllabus subject matter (i.e. chemical equilibrium systems and oxidation and reduction) and the cognitions being assessed
- items that adhered to the technical features of the assessment design, as specified by the syllabus. The stem of the questions provided students the opportunity to demonstrate thinking skills/cognitions, which form a part of the objective being assessed
- items that displayed appropriate scope and scale, allowing students to demonstrate the assessment objectives to the highest performance level specified in the ISMG and within the conditions of the syllabus
- a variety of authentic datasets and items that were clearly based on teaching and learning activities that students had experienced in Unit 3
- authentic contexts for students to respond to, given that teaching and learning has taken place in the classroom

- authentication strategies implemented in accordance with the *QCE and QCIA policy and procedures handbook*.

Practices to strengthen

It is recommended that assessment instruments:

- include a balance of items across the apply, analyse and interpret objectives as per the syllabus instrument mark allocation table
- avoid unnecessary repetition of cognitions, subject matter or calculations
- avoid assessing objective 1 — describe and explain; valid data test items only assess objectives 2, 3 and 4
- include only items that require students to use the given datasets
- avoid items where the answers are available in the Chemistry formula and data book or are given in other items within the instrument
- contain an appropriate amount of data within each dataset, allowing students to understand the dataset and respond to the item within 60 minutes
- use datasets that include diagrams, such as graphs, rather than asking students to sketch or draw these in their responses
- include an appropriate marking scheme that clearly matches each mark to a valued feature of the expected response.

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 practices

Accessibility priority	Number of times priority was identified in decisions*
Transparency	119
Language	109
Layout	70
Bias avoidance	56

*Total number of submissions: 413. Each priority might contain up to four assessment practices.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that featured:

- clear links between the items and the data required to answer the question
- language from the syllabus that was consistent between datasets and items
- consistent layout and language with clearly labelled and legible datasets, including legends, labelled axes, correct units and figure labels
- datasets and items with minimal distractors, and brief and succinct instructions that avoided unnecessary detail or complexity
- items that were constructed to avoid factors such as gender, social and/or cultural background

- a response space that matched the length of the expected response, e.g. one line for a single word response.

Practices to strengthen

It is recommended that assessment instruments:

- use language consistently between datasets and items, e.g. avoid referring to the same measurement using different terms — *average* concentration versus *mean* concentration
- avoid jargon, colloquial language and acronyms in the datasets
- are checked for typographical, spelling and grammatical errors within items and datasets
- construct instructions and items using clear and unambiguous language
- avoid including multiple instructions within the same item
- avoid constructing items using multiple cognitions and low mark distribution, which causes confusion around the marking of the item — distribution of marks should be across individual cognitions and in separate items
- maintain similar formatting, layout and visual design across the instrument to minimise distractors, e.g. equal white space between items, page breaks after or before an item, a box around each dataset
- use the print preview function prior to submission to check the layout and formatting, legibility of data tables and page breaks to ensure that datasets, figure labels and items are not separated 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 final results

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional
1	Data test	99.91	0.06	0.02

Effective practices

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

- marks were awarded for evidence of the cognitions associated with the objective of the endorsed item — this was done most accurately and consistently for objective 3 (analyse evidence) and objective 4 (interpret evidence)
- teachers annotated student responses to clearly match the marking scheme
- school-developed marking schemes clearly matched each mark to a valued feature of the expected response
- schools applied their marking schemes consistently across cohorts, e.g. schools made transparent and consistent decisions about how their mark schemes were applied to student responses.

Samples of effective practices

There are no student response excerpts because either the student/s did not provide permission or there were third-party copyright issues in the response/s.

Practices to strengthen

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

- schools check that mark totals and percentages have been determined correctly
- schools use the percentage cut-offs from the ISMG to determine the final mark out of 10
- schools update the original marking scheme (that was submitted at endorsement) to indicate how unexpected responses are marked
- schools implement internal quality assurance processes (e.g. cross marking) to ensure intra-marker and inter-marker reliability
- marks are awarded for responses that use data from the dataset, rather than simply demonstrating subject matter knowledge
- there is a clear alignment between the cognition in the question, the nature of the response and the objective being assessed
- schools check that the ISMG has been annotated to clearly show the mark awarded — individual descriptors in the ISMG do not need to be highlighted or annotated for IA1.

Internal assessment 2 (IA2)

Student experiment (20%)

The IA2 student experiment requires students to modify (i.e. refine, extend or redirect) an experiment to address their own hypothesis or question related to chemical equilibrium systems or oxidation and reduction. Students may use a practical performed in class as the basis for their methodology. They develop a research question, collect and process primary data, analyse and interpret evidence, and evaluate the reliability and validity of their experimental process.

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 practices

Validity priority	Number of times priority was identified in decisions*
Alignment	28
Authentication	18
Authenticity	0
Item construction	8
Scope and scale	4

*Total number of submissions: 413. Each priority might contain up to four assessment practices.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that featured:

- mandatory or suggested practicals from Unit 3 as experiments for students to use as the basis for their methodology and research question
- authentication strategies that included guidance for drafting, scaffolding and teacher feedback
- clear alignment of cognitions and language with the syllabus and the assessment objectives
- checkpoints to monitor student progress through the task, e.g. select modifications, complete risk assessment, collect and analyse data, submit draft, submit final response
- an indication of how students can work collaboratively and how the school will manage authentication of student work in these situations, e.g. the teacher will compare the responses of students who have worked together in groups
- clear scaffolding that modelled processes and directed students to address all components of the task without leading students to a pre-determined response
- a clear statement that feedback can only be provided on one draft
- realistic contexts for students to use as the basis for their methodology and research question
- appropriate scope and scale that allowed students to demonstrate the assessment objectives to the highest performance level specified within the syllabus.

Practices to strengthen

It is recommended that assessment instruments:

- include only experiments clearly related to Unit 3 subject matter for students to modify
- include all the task specifications in the task description
- include appropriate information in the scaffolding section, e.g. prompts about the requirements for the response
- include appropriate drafting and authentication strategies, e.g. collecting progressive samples of student work, interviews with students, using plagiarism-detection software
- clearly identify that the example provided in the scaffolding is not to be used in a student response.

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 practices

Accessibility priority	Number of times priority was identified in decisions*
Transparency	12
Language	5
Layout	1
Bias avoidance	0

*Total number of submissions: 413. Each priority might contain up to four assessment practices.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that featured:

- clear instructions that aligned to the specifications within the syllabus, the assessment objectives and the ISMG
- clear communication of task elements, using clear, succinct language and featuring accurate spelling, grammar and textual features
- communication that avoided jargon, specialist and/or colloquial language
- clear, appropriate headings
- checkpoints that provided an indication of the time available to students (e.g. Week 4) rather than specific dates.

Practices to strengthen

It is recommended that assessment instruments:

- include scaffolding that clearly directs students to address all aspects of the task, including the rationale
- are checked for typographical, spelling and grammatical errors
- maintain consistent formatting, layout and visual design across the instrument to minimise distractors
- avoid repetition of elements of the task in different sections.

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 final results

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional
1	Research and planning	98.10	1.79	0.11
2	Analysis of evidence	97.78	1.87	0.35
3	Interpretation and evaluation	98.32	1.44	0.24
4	Communication	99.81	0.05	0.14

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 clearly connected the research question to Unit 3 subject matter
  - modifications to the methodology were *justified* using concepts from Unit 3 and ensured that the experiment collected sufficient data to draw valid conclusions, e.g. at least five data points to establish a trend
  - a *specific* research question was explicit enough (e.g. the relationship between the dependent and independent variable was evident) to be answered within the required response length
  - a *relevant* research question was clearly linked to Unit 3 subject matter
  - a methodology that enabled the collection of *sufficient, relevant* data identified measurable variables (e.g. pH, concentration, temperature, time) rather than simply comparing products
- in the Interpretation and evaluation criterion
  - conclusions were *justified* by referring to the trends/patterns/relationships and uncertainty/limitations identified in the analysis of evidence
  - discussion of the reliability and validity of the experimental process was *justified* by referring to the uncertainty and limitations identified in the analysis of the evidence
  - suggested improvements and extensions to the experiment were *logically derived* from the uncertainty and limitations of evidence identified in the analysis.

The following is an excerpt from a response that illustrates the characteristics for the criterion at the performance level indicated. The sample may provide evidence of more than one criterion. The characteristics highlighted may not be the only time the characteristics have occurred throughout the response.

Analysis of evidence (5–6 marks)
Correct and relevant processing of data

Raw data is manipulated accurately to provide evidence that is applicable to the research question about Faraday's equation.

Analysis of evidence (5–6 marks)
Thorough and appropriate identification of the uncertainty and limitations of evidence

The uncertainty of the evidence has been quantified (i.e. error bars, *y*-intercept, correlation coefficient) so that a decision can be made about the application of the evidence to the research question.

PROCESSING OF DATA

The raw data was processed to determine each trial's change in mass, the average change in mass for each time, average currents and the absolute and percentage uncertainties (see table 3 and 4). Using Faraday's equation, theoretical masses were also calculated to determine the accuracy and thus, validity of the experimental results and process.

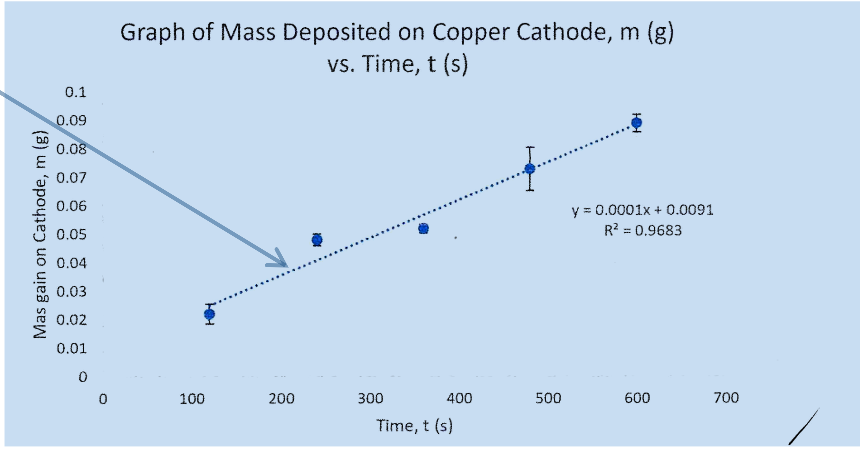


Figure 3 – Graph of Mass Deposition on Cathode, m (g) vs. Time, t (s)

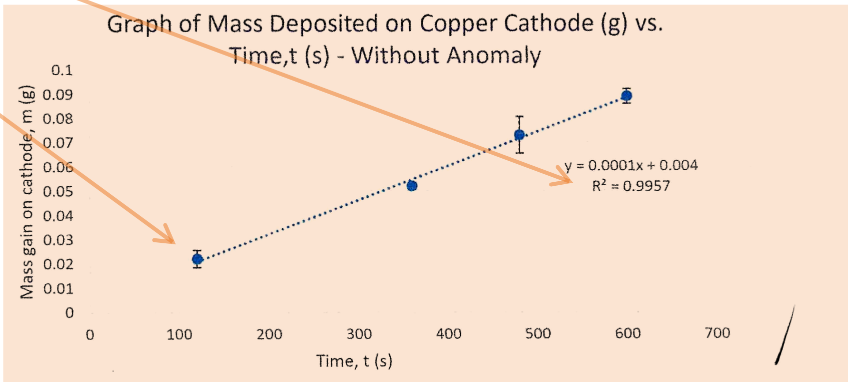


Figure 3 - Graph of Mass Deposition on Cathode, m (g) vs. Time, t (s) - Without anomaly

Analysis of evidence (5-6 marks) **Thorough identification of relevant trends, patterns or relationships** The response identifies a trend that is applicable to the research question. **Analysis of evidence (5-6 marks)** **Thorough and appropriate identification of the uncertainty and limitations of evidence** The *y*-intercept identifies limitations in the evidence associated with systematic errors. The correlation co-efficient (R^2) identifies limitations in the evidence associated with random errors.	TRENDS, PATTERNS AND RELATIONSHIPS It was expected that there would be a directly proportional relationship between the mass deposited and the duration of the current according to Faraday's equation where $m \propto t$. Figure 3 shows that as the duration of the current increased, the mass deposited on the cathode similarly increased. This resulted in a linear curve and suggests a directly proportional relationship between the two variables. The data shows that as the time increased by a factor of 1.25 from 480s to 600s, the mass deposition increased by a factor of 1.22 (approximately 1.25). This verifies the relationship as the variables increase by the same – or similar – factor. After analysing figure 3, the anomaly at time = 240 seconds was omitted to produce figure 4. In this graph, the line of best fit is better fitted to the four data points, the y-intercept of 0.004 is closer to the theoretical value of zero and the R^2 value is closer to one. Overall, this indicates that figure 4 – with no anomaly - is a better representation of the relationship. The absolute uncertainties in time (±0.2) were used as horizontal error bars and the absolute uncertainties in mass (see table 4) were used as vertical error bars. The visibility of the vertical error bars indicates that there is variance in the trendline suggesting that the experimental data is slightly unreliable.

Practices to strengthen

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

- in the Analysis of evidence criterion
  - a variety of analysis techniques should be used to identify trends, patterns and relationships, including
    - visual representations in tables and graphs
    - predictive analysis
    - removal of anomalies that would skew data points
  - a variety of analysis techniques should be used to identify uncertainty and limitations of evidence, including
    - an understanding of the uncertainty associated with using particular pieces of equipment, e.g. ± 0.05 mL when using a burette
    - comparing experimental values to theoretical values.

Additional advice

- Schools should use the ISMG from the syllabus without making any changes to wording or formatting.
- In the best-fit process for using ISMGs, when all the descriptors in a performance level have been demonstrated, the mark should be the higher of the two possible marks for that performance level.
- As part of the teaching and learning process, teachers should demonstrate the relevant data processing techniques that can be used to identify trends/patterns/relationships and uncertainty/limitations of data in practicals before students use these practicals as a basis their experiments.

- Teachers should use the strategies identified in the *QCE and QCIA policy and procedures handbook* to
  - manage response length to ensure that student responses meet the conditions of the syllabus
  - promote academic integrity to ensure that student responses clearly demonstrate their students' own achievement.

Internal assessment 3 (IA3)

Research investigation (20%)

The IA3 research investigation requires students to gather secondary evidence related to a research question in order to evaluate a claim about properties and structure of organic materials or chemical synthesis and design. Students develop a research question, collect and analyse secondary data, interpret evidence to form a justified conclusion, discuss the quality of the evidence and extrapolate the findings of the research to the claim.

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 practices

Validity priority	Number of times priority was identified in decisions*
Alignment	46
Authentication	28
Authenticity	0
Item construction	18
Scope and scale	2

*Total number of submissions: 413. Each priority might contain up to four assessment practices.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that featured:

- simple and direct claims that were clearly aligned to Unit 4 subject matter, e.g. the synthesis of biofuels from feedstock is viable
- claims that could generate multiple research questions, e.g. green chemistry is the way to a sustainable future
- claims that could be narrowed down into specific and relevant research questions, e.g. molecular manufacturing will revolutionise medicine
- claims that have sufficient data available for students to research, e.g. sustainable polymers are an effective replacement for synthetic polymers
- sufficient claims for the size of the cohort, allowing students to develop unique responses to the task
- authentication strategies that included guidance for drafting, scaffolding and teacher feedback
- checkpoints to monitor student progress through the task
- scaffolding that directed students to address all components of the task
- realistic contexts for students to use as the basis for their investigation and research question.

Practices to strengthen

It is recommended that assessment instruments:

- include all the task specifications in the task description
- contain claims that are clearly derived from Unit 4 subject matter
- use claims that are assertions without evidence. Science as a Human Endeavour (SHE) statements from the syllabus can be used as a starting place to develop claims; however, these statements are not necessarily suitable to be directly used as claims
- include appropriate drafting and authentication strategies, e.g. collecting progressive samples of student work, interviews with students, using plagiarism-detection software
- include appropriate information in the scaffolding section, e.g. it does not lead students towards a predetermined response by specifying the scientific concepts students are to investigate.

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 practices

Accessibility priority	Number of times priority was identified in decisions*
Transparency	4
Language	6
Layout	1
Bias avoidance	0

*Total number of submissions: 413. Each priority might contain up to four assessment practices.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that featured:

- claims written using clear, succinct language and featuring accurate spelling, grammar and textural features
- clear instructions that align to the specifications within the syllabus, the assessment objectives and the ISMG
- clear, appropriate headings
- checkpoints that provide an indication of the time available to students (e.g. Week 4) rather than specific dates
- instructions that avoid colloquial language and jargon.

Practices to strengthen

It is recommended that assessment instruments:

- are checked for typographical, spelling and grammatical errors
- maintain consistent formatting, layout and visual design across the instrument to minimise distractors
- avoid repetition of elements of the task in different sections.

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 final results

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional
1	Research and planning	96.17	3.46	0.38
2	Analysis and interpretation	95.30	4.32	0.38
3	Conclusion and evaluation	95.79	4.00	0.22
4	Communication	99.03	0.27	0.70

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 clearly connected the research question to Unit 4 subject matter
  - a *specific* research question was explicit enough to be answered within the required response length
  - selection of sufficient and relevant sources provided a variety of scientifically credible sources.
- in the Analysis and interpretation criterion, evidence was visually represented in tables and graphs to identify trends, patterns and relationships.

Samples of effective practices

The following is an excerpt from a response that illustrates the characteristics for the criterion at the performance level indicated. The sample may provide evidence of more than one criterion. The characteristics highlighted may not be the only time the characteristics have occurred throughout the response.

Research and planning (5–6 marks) **Considered rationale identifying clear development of the research question from the claim** Key terms in the claim have been clearly identified, defined and linked to research question. Unit 4 subject matter related to the claim has been clearly identified and applied to develop the research question. **Research and planning (5–6 marks)** **Specific and relevant research question** Research question is linked to Unit 4 subject matter. Measurable criteria are clearly identified.	**Claim:** Organochlorine compounds are by far the most superior insecticide. **Rationale:** An insecticide is a form of pesticide which repels and kills different species of insects (Insecticides, 2020). They are a necessity in vector control which involves the killing of insects that carry easily transmitted diseases. Mosquito control is a common vector control that uses insecticides to prevent the spread of malaria. Whilst most insecticides can be used for vector control, some are more superior than others which is determined by properties like mortality rates, knock-down time and residual effectiveness (Najera and Zaim, 2020). The more effective it is in each property, the more superior it is. Two of the better insecticides recommended by the World Health Organisation (WHO) for mosquito control are the organochlorine compound, Dichlorodiphenyltrichloroethane (DDT), and the pyrethroid, deltamethrin (Najera and Zaim, 2020). DDT is a synthetic, halogenated hydrocarbon which has one or more hydrogen atoms replaced with chlorine atoms. Due to the phenyl rings within DDT, it is very stable which reduces the polarity in the C-Cl bonds resulting in a very small net dipole. This makes it predominantly non-polar, thus, resistant to photolytic and hydrolysis degradation attributing to its long residual effect (Holmes, 2020). Additionally, they kill insects by opening sodium ion channels in the nerve cells, firing them spontaneously causing the insect to spasm and die (DDT: Secret Life of a Pesticide, 2020). Deltamethrin is also a synthetic compound structured on a naturally occuring pesticide, pyrethrins, which comes from a flower. It kills by acting on nerve membranes, delaying the activation gate of the sodium ion channel, interfering with nerve signals. This rapidly paralyses the nervous system resulting in a quick knock-down effect (Deltamethrin Technical Fact Sheet, 2020). By comparing both insecticides, the most superior one can be determined. As such, the developed research question is: For use in malaria control, is the organochlorine insecticide, DDT, more superior than the pyrethroid insecticide, deltamethrin, based on mortality rates, knock-down times and residual effectiveness? This review will use many research papers which investigate the insecticides mentioned and the properties which determine the superiority of an insecticide. These results will be reviewed and compared to determine if organochlorine insecticides are the most superior insecticide.

Practices to strengthen

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

- in the Analysis and interpretation criterion
  - identification of *sufficient and relevant* evidence should draw on qualitative and quantitative data from scientifically credible sources, e.g. peer-reviewed research papers
  - limitations of evidence were *thoroughly and appropriately* identified with respect to the research question
  - scientific arguments were *justified* using concepts from Unit 4 subject matter
- in the Conclusion and evaluation criterion
  - conclusions should be *justified* using the scientific arguments proposed in the analysis and interpretation of evidence rather than by simply providing a review of the data
  - an *insightful* discussion of the quality of the evidence should refer to the limitations identified in the analysis of data.

Additional advice

- Schools should use the ISMG from the syllabus without making any changes to wording or formatting.
- In the best-fit process for using ISMGs, when all the descriptors in a performance level have been demonstrated, the mark should be the higher of the two possible marks for that performance level.
- Teachers should develop resources and teaching/learning strategies that reflect the specific requirements of a research investigation (e.g. a rationale that develops the research question from a claim, extrapolation of findings of the research to the claim) rather than using approaches from previous syllabuses (e.g. extended response task) or other contexts (e.g. literature review).
- Teachers should use the strategies identified in the *QCE and QCIA policy and procedures handbook* to
  - manage response length to ensure that student responses meet the conditions of the syllabus
  - promote academic integrity to ensure that student responses clearly demonstrate their students' own achievement.

External assessment

Summative external assessment (EA) — Examination (50%)

Assessment design

Assessment specifications and conditions

Description

This examination included two papers. Each paper consisted of a number of different types of possible items:

- multiple choice
- short response items requiring single-word, sentence or paragraph responses
- calculating using algorithms
- interpreting graphs, tables or diagrams
- responding to unseen data and/or stimulus.

Conditions

Paper 1

- Time: 90 minutes plus 10 minutes perusal.
- Other:
  - QCAA-approved graphics calculator permitted
  - seen Chemistry formula and data book provided.

Paper 2

- Time: 90 minutes plus 10 minutes perusal.
- Other:
  - QCAA-approved graphics calculator permitted
  - seen Chemistry formula and data book provided.

The assessment instrument consisted of two papers. Questions were derived from the context of Unit 3 and 4. This assessment was used to determine student achievement in the following assessment objectives:

1. describe and explain chemical equilibrium systems, oxidation and reduction, properties and structure of organic materials, and chemical synthesis and design
2. apply understanding of chemical equilibrium systems, oxidation and reduction, properties and structure of organic materials, and chemical synthesis and design
3. analyse evidence about chemical equilibrium systems, oxidation and reduction, properties and structure of organic materials, and chemical synthesis and design to identify trends, patterns, relationships, limitations or uncertainty

4. interpret evidence about chemical equilibrium systems, oxidation and reduction, properties and structure of organic materials, and chemical synthesis and design to draw conclusions based on analysis.

Paper 1 Section 1 was 20 multiple choice questions (20 marks).

Paper 1 Section 2 was 7 short response questions (40 marks).

Paper 2 Section 1 was 5 short response questions (60 marks).

Assessment decisions

Overall, students responded well to the following assessment aspects:

- apply understanding to
  - identify the products of electrolysis
  - recognise the monomer of carbohydrates
  - substitute known values into formula given in the formula and data book to determine or calculate pK_a, K_w, atom economy values
  - products of redox reactions
  - identify redox reactions
  - determine standard reduction potential, E^o, for half-equations
  - use K_c values to determine the relative concentration of reactants and products
  - describe the production of ethanol by fermentation
  - identify organic molecules as unsaturated
  - use IUPAC rules to name organic molecules
  - identify Brønsted-Lowry acid in equations
- analyse data to
  - explain shifts in equilibrium as exothermic or endothermic
  - identify when reactions reach equilibrium and how changes in pressure affect equilibrium (concentration–time graphs)
  - calculate K_w
  - determine the species oxidised and oxidising agents
  - write equilibrium expressions (K_c)
- interpret evidence to
  - predict shifts in equilibrium using Le Châtelier’s principle.

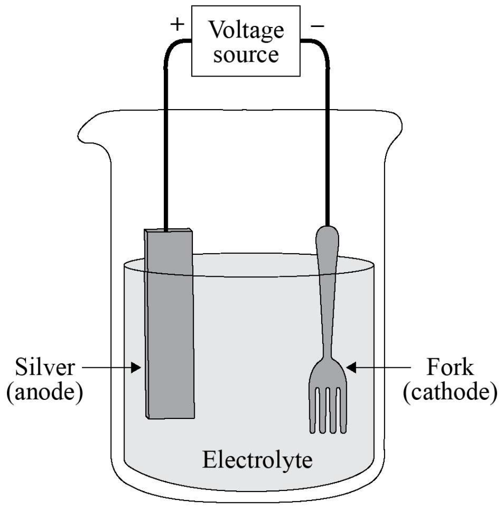
Effective practices

The following samples were selected to illustrate highly effective student responses in some of the assessment objectives of the syllabus.

Multiple choice item response

Assessment objective: Objective 1 — Describe and explain

This question required students to describe, using a diagram, the essential components of an electrochemical cell, including whether the reaction is spontaneous or non-spontaneous, the anode is positive or negative and the flow of electrons in the external circuit.



Which of the following is true for the electrochemical cell?

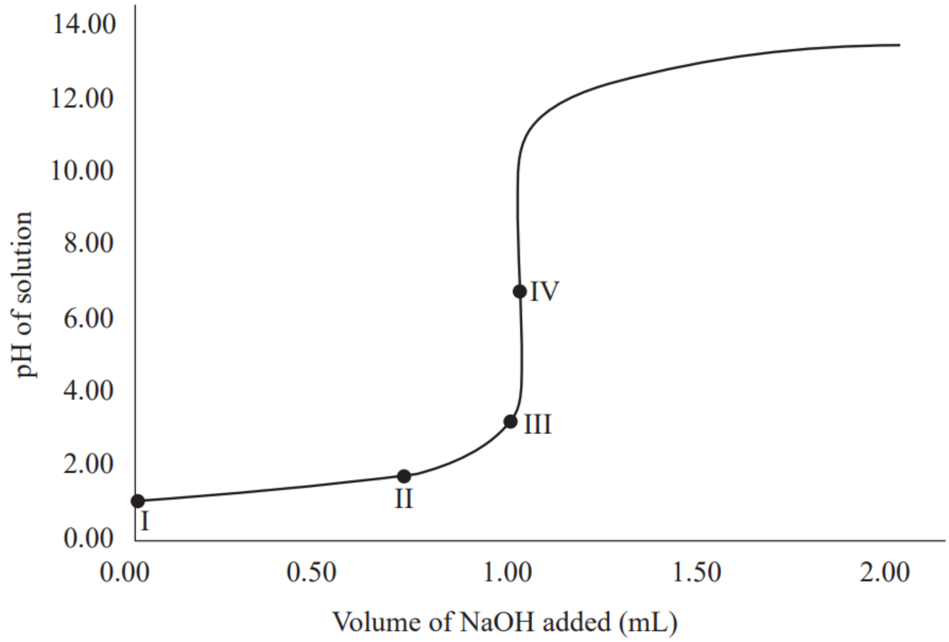
	Reaction	Anode	Flow of electrons
(A)	spontaneous	oxidation	From the negative terminal of the power pack, through the wire to the negative electrode.
(B)	spontaneous	positive electrode	From the positive terminal of the power pack, through the wire and the electrolyte to the negative electrode.
(C)	non-spontaneous	negative electrode	From the negative terminal of the power pack, through the wire and the electrolyte to the positive terminal.
(D)	non-spontaneous	oxidation	From the negative terminal of the power pack, through the wire to the negative electrode.

Option	Validity statements
A	This option is incorrect as the reaction is not spontaneous.
B	This option is incorrect because the reaction is not spontaneous and electrons flow from the negative terminal while ions move through the electrolyte.
C	This option is incorrect because the anode is positive and ions move through the electrolyte.
D	Key

Assessment objective: Objective 2 — Apply understanding

This question required students to identify important features of titration curves involving strong and weak acids and bases, including the intercept with pH axis, the equivalence point, the buffer region and points where pK_a = pH.

QUESTION 13



Identify the equivalence point on the titration curve.

(A) I

(B) II

(C) III

(D) IV

Option	Validity statements
A	This option refers to point I, which is the intercept with the pH axis.
B	This option refers to point II, which is the buffer region of the curve.
C	This option refers to point III, which is the inflection point at end of the buffer region.
D	Key

Short response

Assessment objective: Objective 1 — Describe and explain

Item: Paper 1, Q22 c)

Student sample of an effective response

Effective student responses:

- identified that phenol red changes colour from yellow to red when pH = pK_a
- indicated that when pH < pK_a, equilibrium favours the molecular form (HIn), and the solution is yellow. When pH > pK_a, equilibrium favours the ionic form (In^-), and the solution is red
- indicated that pH colour range is due to the molecular form and ionic form (conjugate acid-base pairs) being different colours.

Describe and explain (3 marks)	c) Explain the relationship between the pH range of phenol red and its pK_a value. *[3 marks]* When the colour of phenol red changes from yellow to red, at that point pH = pKa, this is because the concentration of the yellow phenol red equals the concentration of the red conjugate base ion so at this point: Ka = [H+] => pKa = pH. Additionally, the range of colour change for phenol red tends to be around pKa ± 1. This is due to the above fact that when the ~~pKa~~ pKa equals the pH the solution ~~starts to~~ changes colour. So, as the solution approaches that pH, the concentration of yellow molecules and red ions are becoming more equal and ~~approaching the~~ the concentration of [H+] is approaching the Ka, before becoming more than it once the solution is red. Therefore, due to these changes, this gives a pH range of pKa ± 1.

This response demonstrates that an item that uses the cognitive verb ‘explain’ requires a different response to an item that uses ‘describe’. Students often incorrectly described how an indicator was used in an acid-base titration rather than explaining the relationship between the pH range of an acid-base indicator and its pK_a value.

Assessment objective: Objective 2 — Apply understanding

Item: Paper 2 Question 1 c) i)

Student sample of an effective response

Effective student responses:

- determined that the E^{o} for HCl equals –0.34 V and the E^{o} for HNO_3 equals +0.46 V
- determined that the reaction between Cu and HCl is not spontaneous and therefore Cu will not dissolve
- indicated that the reaction between Cu and HNO_3 is spontaneous and therefore Cu will dissolve.

Apply understanding (3 marks)	c) Apply your understanding of standard reduction potentials to explain why: i) copper can dissolve in concentrated nitric acid, but does not dissolve in concentrated hydrochloric acid. *[3 marks]* The oxidation of copper (when it dissolves) is -0.34 V. Nitric acid (NO_3^-) as a ~~reducing~~ oxidising agent has a E^{o} value of $+0.80$V, this means it is a strong oxidizing agent, which can dissolve copper. Whereas ~~HCl~~ hydrochloric acid (Cl^-) has an E^{o} value of -1.36V which is lower than copper's -0.34V so it ~~cannot~~ doesnot oxidise copper and dissolve it.

This response demonstrates that an item that uses the cognitive verb 'apply' requires a different response to an item that uses the verb 'describe'. Students often incorrectly restated the question by describing the information provided rather than applying their knowledge of reduction potentials to support their response.

Assessment objective: Objective 2 — Apply understanding

Item: Paper 2, Question 5 d)

Student sample of an effective response

Effective student responses:

- indicated assumption to support $[CH_3CH_2NH_2] \approx 2.0$
- indicated $[C_2H_5NH_3^+] = [OH^-]$
- showed substitution correctly performed
- determined $[OH^-] = 3.35 \times 10^{-2}$
- determined pOH = 1.4754
- determined pH = 12.5.

Apply understanding (6 marks)	d) Calculate the pH of a 2.0 M solution of compound A. State any assumptions. Show your working. ($K_b = 5.6 \times 10^{-4}$) *[6 marks]* Assume conc. of $C_2H_5NH_3^+$ is equal to conc. of OH^- $Kb = \frac{[BH^+][OH^-]}{[B]}$ $5.6 \times 10^{-4} = \frac{x^2}{2-x}$ assume AX for 2-x is negligible $2 \times 5.6 \times 10^{-4} = x^2$ $1.12 \times 10^{-3} = x^2$ $\therefore x = 0.0334664M = [OH^-]$ $pOH = -\log_{10}[OH^-]$ $= -\log_{10}(0.0334664)$ $= 1.4754$ $pH = 14 - pOH$ $= 14 - 1.4754$ $= 12.52$ pH = 12.5 (to one decimal place)

This sample has been included to demonstrate a multi-step calculation. Assumptions stated are related to the calculations or the values used to determine the response, rather than generic statements or definitions related to acid and bases.

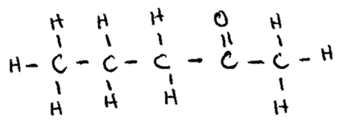
Assessment objective: Objective 4 — Interpret evidence

Item: Paper 1, Question 26

Student sample of an effective response

Effective student responses:

- identified IR peak at 1700–1750 corresponds to a C=O bond in aldehyde or ketone
- indicated that X is a ketone
- identified mass fragment at
  - 43 m/z as $CH_3CH_2CH_2^+$ and $COCH_3^+$ or
  - 71 m/z as $CH_3CH_2CH_2CO^+$
- used mass spectrum data to show that the molecular formula for X is $C_5H_{10}O$
- provided correct structural formula for pentan-2-one.

Interpret evidence (5 marks)	Analyse the spectra to deduce the structural formula of X. Explain your reasoning. M^+ ion peak ~~has~~ is 86. Mass of $C_5H_{10}O$ = 86, => molecule has molecular formula $C_5H_{10}O$ From IR: Has a peak at ≈ 3000 cm^{-1}, indicates C–H bonds. Has a peak at ≈ ~~27~~ 1725 cm^{-1}, indicates alcohol, ester, ketone or carboxylic acid, or aldehyde. Has to be alcohol ~~or~~, aldehyde or ketone as only one oxygen. Has to be ketone or aldehyde as no O–H stretching on IR spectrum. For MS: 43 m/z peak indicates $[C_3H_7]^+$ peak. 71 − 43 = 28 m/z then indicates $[C=O]^+$ and 86 − 71 = 15 m/z indicates a $[CH_3]^+$ ion. So, structural formula has to be:  (pentan-2-one)

This sample has been included to demonstrate that the cognitive verb:

- ‘analyse’ requires responses that explicitly refer to the dataset that has been provided
- ‘interpret’ requires responses that make meaning of features of the dataset using concepts from the syllabus subject matter.

Practices to strengthen

It is recommended that when preparing students for external assessment, teachers consider:

- the cognitive verb and the nature of the required response. When questions required students to explain, they often provided a generic response, restated the question or described the data provided in the question rather than drawing on their understanding of the subject matter to explain their reasoning. Students should take care to read and respond to the cognitive verb rather than provide general information which, although correct, does not answer the question
- problem-solving activities that require students to perform multistep calculations. Students were able to perform simple calculations but were often unable to substitute values into the appropriate equations provided in the Chemistry formula and data book

- When correct substitutions were performed, students were often unable to use their calculators correctly to calculate the correct response.
- For calculations that require working, students should ensure that all the key steps used to determine their response are clearly shown. The marks awarded for the question provide an indication of the number of steps required.
- Generally, response boxes were well used to indicate the final response.

- problem-solving activities that require students to critically analyse and interpret evidence to provide justified reasoning to support their response. Rather than simply describing or restating the evidence provided in the question, students should selectively use evidence from the dataset to address the cognitive verb and support their reasoning
  - When analysing data to provide an explanation, students should take care not to simply restate or describe the data provided in the question as their response.
  - When analysing data to deduce or make predictions, students should take care not to simply describe all the evidence derived from the data as their response. Rather, they should use evidence from the data selectively to support their reasoning.
- learning opportunities that allow students to apply their understanding to an appropriate depth across the breadth of the subject matter. Areas of weakness included
  - the acid-base nature of indicators
  - the relationship between standard reduction potentials and redox reactions
  - balancing half-equations in acid conditions
  - performing multistep calculations
  - reaction pathways.

Senior External Examination

The following information relates to the Chemistry Senior External Examination, a standalone examination offered to eligible Year 12 students and adult learners. This commentary should be read in conjunction with the external assessment section of the preceding comments for the General subject.

There were insufficient student enrolments in this subject to provide useful analytics.

Effective practices

Overall, students responded well to the following assessment aspects:

- identifying and justifying improvements to an investigation
- identifying trends in data.

Practices to strengthen

It is recommended that when preparing for the Senior External Examination 1 (SEE1) consideration be given to:

- the development of syllabus objectives as identified in Section 1.2.1 of the syllabus. For example,
  - using algebraic, visual and graphical representations of scientific relationships and data to determine unknown scientific quantities, e.g. processing data from mandatory practicals
  - using *mathematical processes* to identify trends, patterns, relationships, limitations and uncertainty in data
  - planning and carrying out experimental and/or research activities in order to obtain evidence for the purpose of reaching a conclusion
  - critically reflecting on evidence and making judgments about its application to a research question.