Chemistry subject report

2022 cohort

February 2023

Queensland Government

QCAA
Queensland Curriculum & Assessment Authority

230034

For all Queensland schools

ISBN

Electronic version: 978-1-74378-236-1

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Introduction

Throughout 2022, schools and the QCAA worked together to further consolidate the new Queensland Certificate of Education (QCE) system. The familiar challenges of flood disruption and pandemic restrictions were managed, and the system continued to mature regardless.

We have now accumulated three years of assessment information, and our growing experience of the new system is helping us to deliver more authentic learning experiences for students. An independent evaluation will commence in 2023 so that we can better understand how well the system is achieving its goals and, as required, make strategic improvements. The subject reports are a good example of what is available for the evaluators to use in their research.

This report analyses the summative assessment cycle for the past year — from endorsing internal assessment instruments to confirming internal assessment marks, and marking external assessment. It also gives readers 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, including those 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 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 General subjects (including alternative sequences (AS) and Senior External Examination (SEE) subjects, where relevant) and General (Extension) subjects.

Report preparation

The report includes analyses of data and other information from endorsement, confirmation and external assessment processes. It also includes 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 completion

The following data includes students who completed the General subject.

Note: All data is correct as at 31 January 2023. Where percentages are provided, these are rounded to two decimal places and, therefore, may not add up to 100%.

Number of schools that offered the subject: 416.

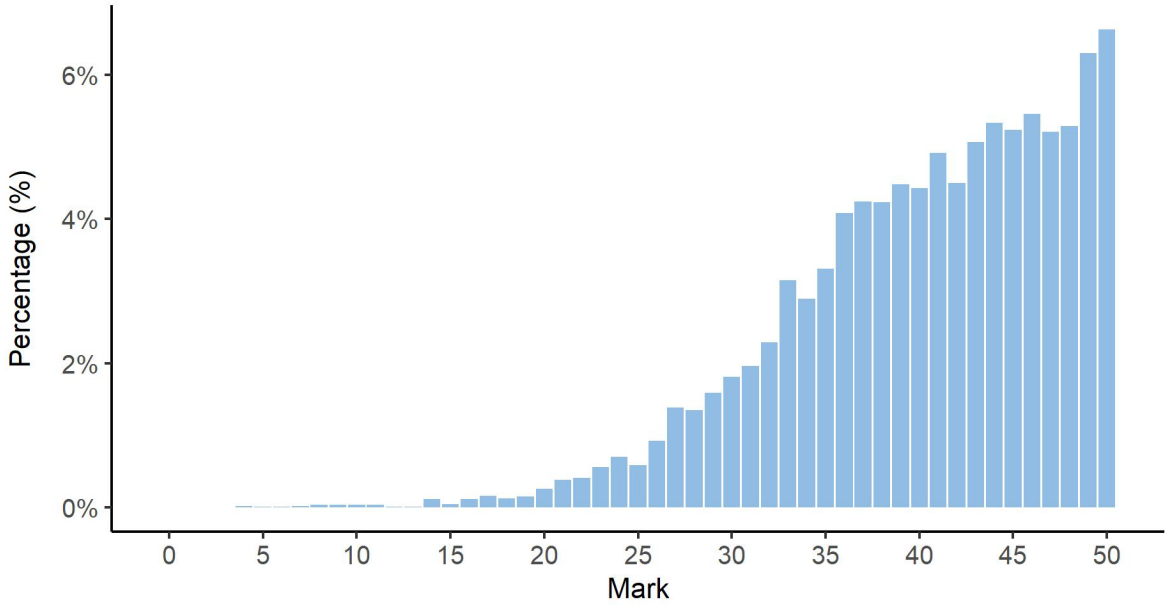
Completion of units	Unit 1	Unit 2	Units 3 and 4
Number of students completed	10 376	9597	8453

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory
Unit 1	9773	603
Unit 2	8876	721

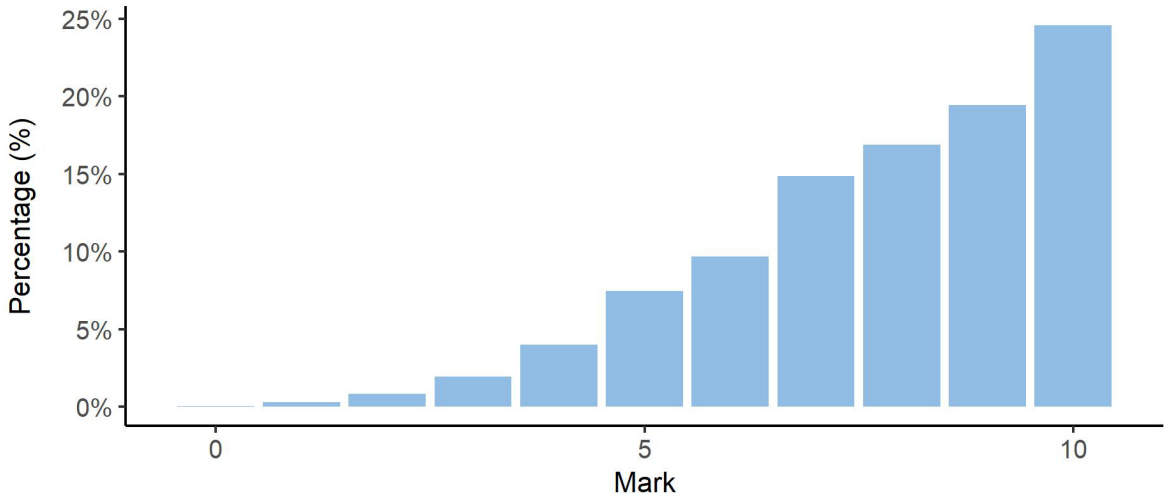
Units 3 and 4 internal assessment (IA) results

Total marks for IA

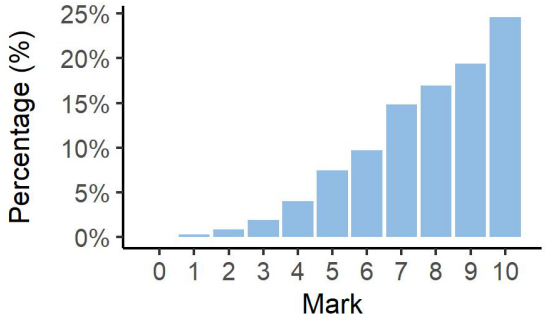


IA1 marks

IA1 total

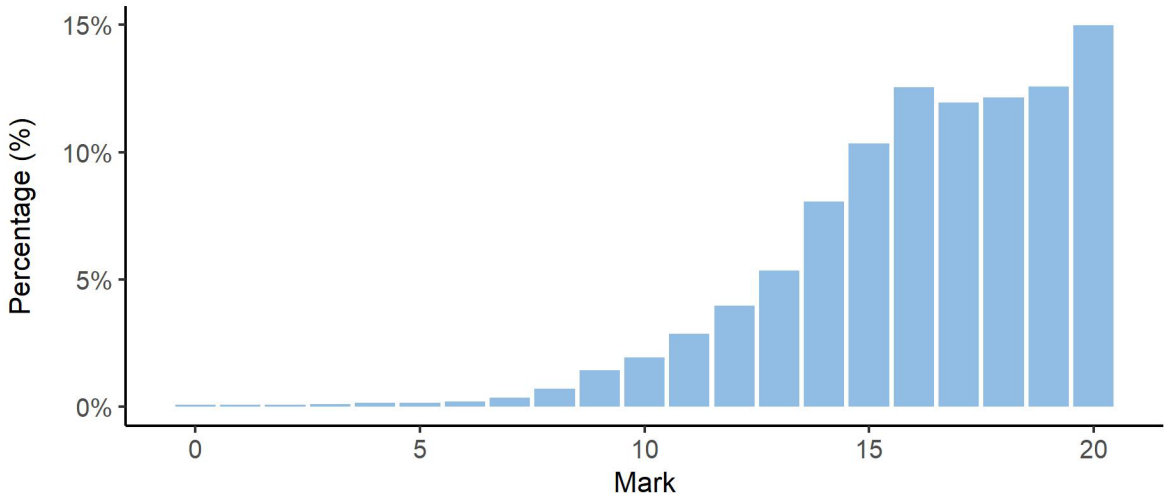


IA1 Criterion: Data test

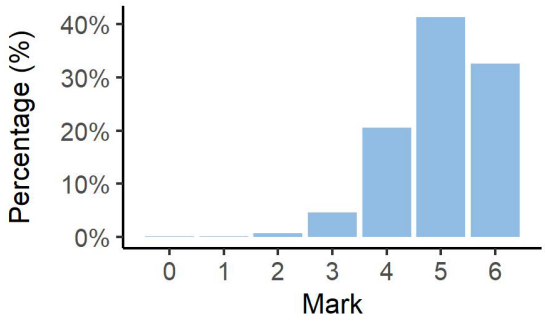


IA2 marks

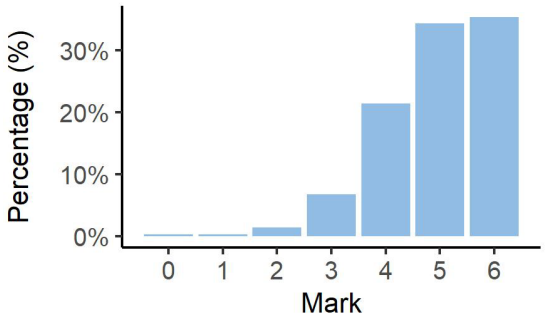
IA2 total



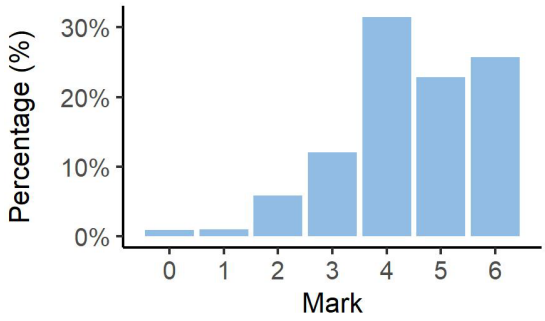
IA2 Criterion: Research and planning



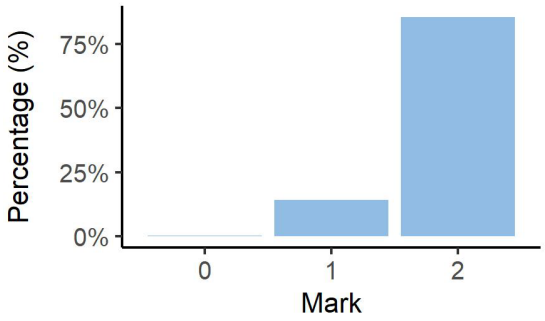
IA2 Criterion: Analysis of evidence



IA2 Criterion: Interpretation and evaluation

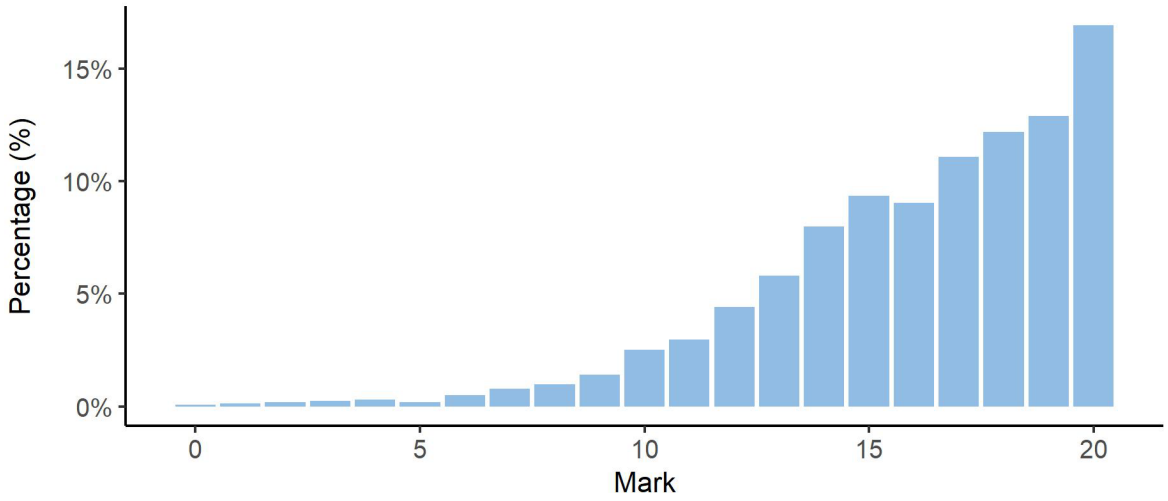


IA2 Criterion: Communication

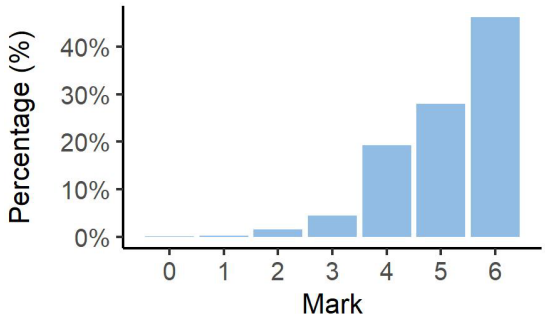


IA3 marks

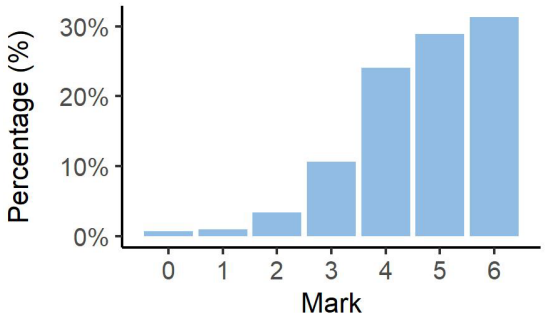
IA3 total



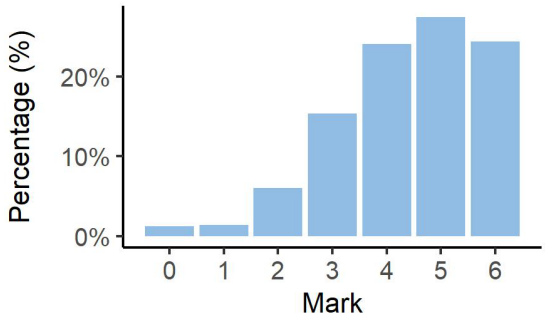
IA3 Criterion: Research and planning



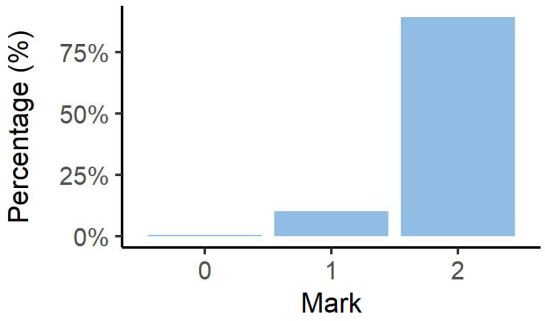
IA3 Criterion: Analysis and interpretation



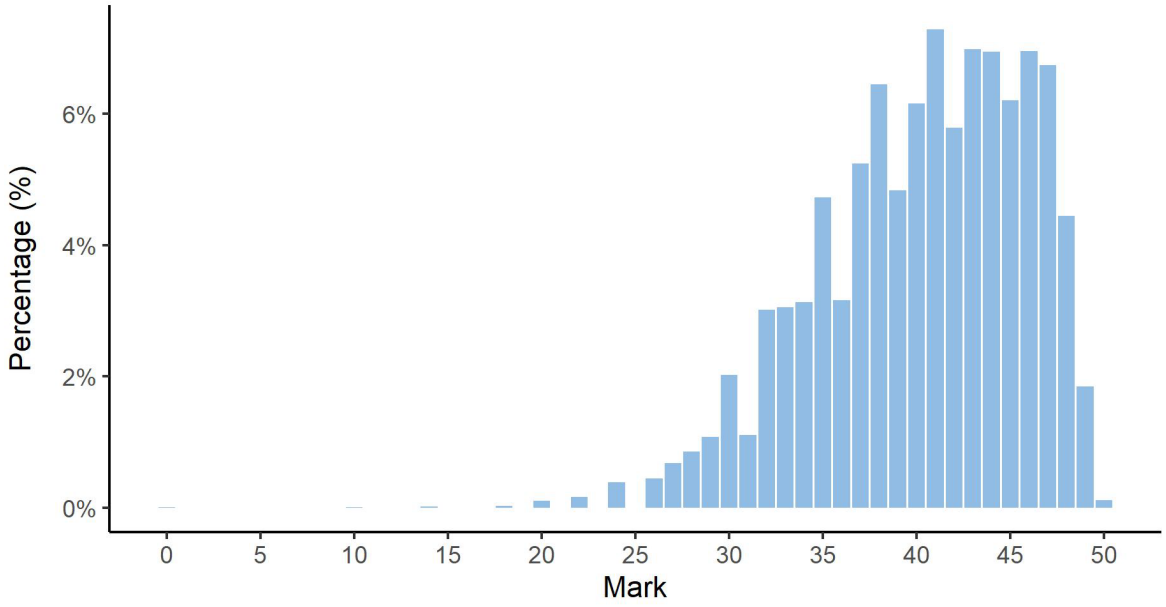
IA3 Criterion: Conclusion and evaluation



IA3 Criterion: Communication

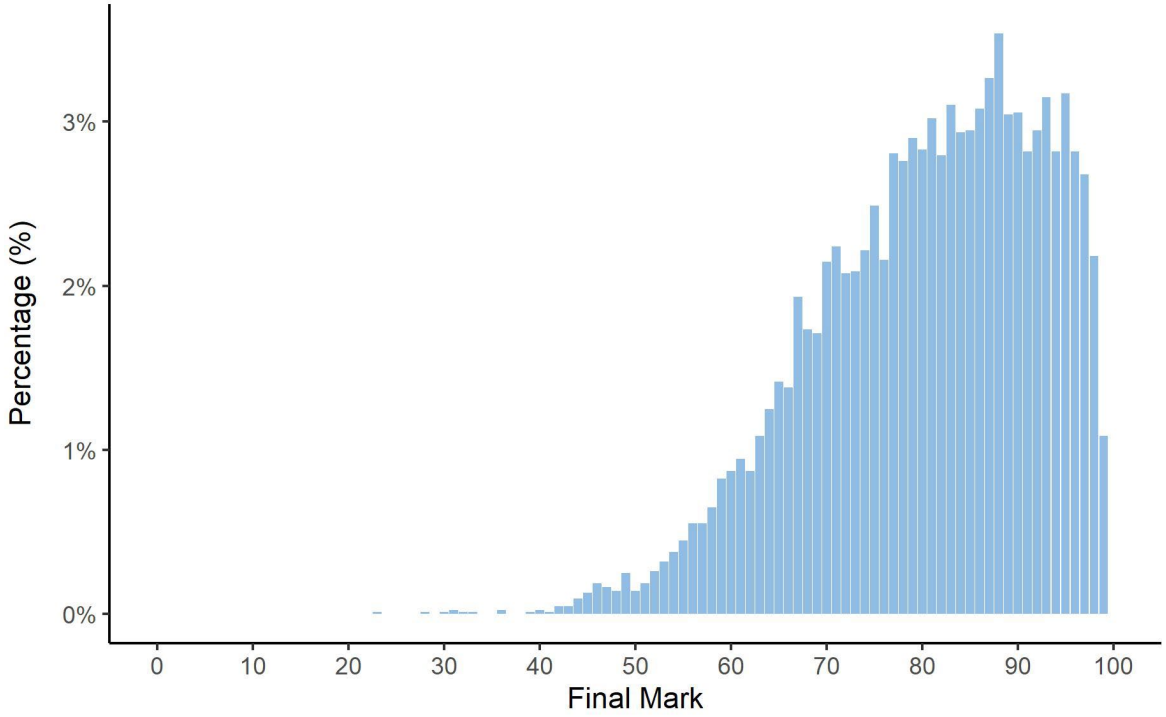


External assessment (EA) marks



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	100–86	85–71	70–50	49–19	18–0

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	3367	3325	1160	101	0

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 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 the subject matter and the assessment objective/s.

Refer to *QCE and QCIA policy and procedures handbook v4.0*, Section 9.5.

Percentage of instruments endorsed in Application 1

Number of instruments submitted	IA1	IA2	IA3
Total number of instruments	412	412	412
Percentage endorsed in Application 1	41%	84%	89%

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 v4.0*, 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	409	2566	0	99.27%
2	407	2573	245	75.43%
3	408	2555	271	77.7%

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	165
Authentication	0
Authenticity	8
Item construction	68
Scope and scale	36

*Each priority might contain up to four assessment practices.

Total number of submissions: 412.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- included datasets derived from a variety of practicals and activities clearly related to the Unit 3 topics: Chemical equilibrium systems and Oxidation and reduction
- followed the conventions of item construction for this assessment technique, e.g. did not include multiple choice items or items that require graph-plotting
- included items where each cognition was assessed only once per item, e.g. ‘Identify the equivalence point of Acid 2’
- followed a consistent approach to allotting marks to items, i.e. one mark per cognition.

Practices to strengthen

It is recommended that assessment instruments:

- include a marking scheme that clearly and succinctly matches each mark to a feature of the expected response, e.g. calculates the exact value (1 mark)

- ensure the mark allocation for each item matches the scale of the expected response, e.g. avoid the use of part marks or awarding insufficient marks for long, multi-step responses
- avoid items that assess assessment objective 1, i.e. describe and explain scientific concepts, theories, models and systems and their limitations.

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	32
Language	76
Layout	35
Transparency	53

*Each priority might contain up to four assessment practices.

Total number of submissions: 412.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- contained datasets and questions with minimal distractors, e.g. graphs with appropriate scales to respond to the item
- included only the relevant information that students needed to respond to the given items, i.e. datasets only include the data necessary to answer the questions
- contained clear instructions, e.g. ‘Each question is associated with the dataset that immediately precedes it’
- provided appropriate response spaces, e.g. one line for a single-word response.

Practices to strengthen

It is recommended that assessment instruments:

- are checked using the print preview or print function in the Endorsement application to ensure datasets and items are appropriately formatted, e.g. the dataset or questions do not carry over the page (see *Developing summative internal assessment instruments — Endorsement user guide*, pp. 20–25).

Additional advice

- Schools should review internal assessments to identify avoidable errors such as spelling, grammar and punctuation prior to submission. The QCAA quality assurance tool assists schools to review validity and accessibility of the instruments prior to the endorsement event.

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	99.27%	0%	0.24%	0.49%

Effective practices

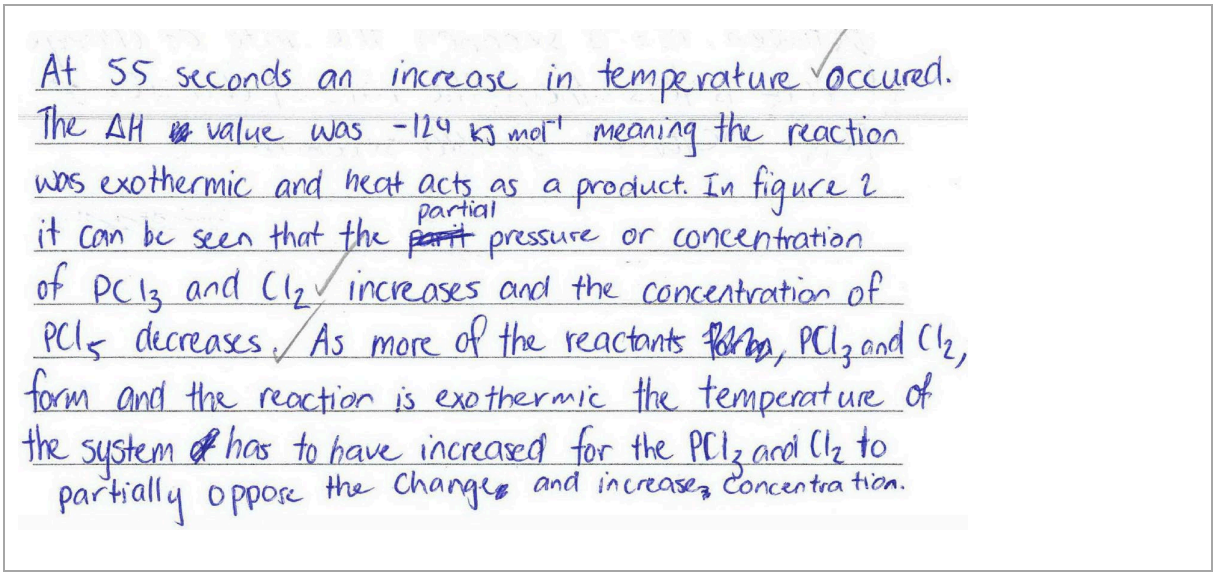
Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- the marking scheme was consistently and accurately applied across all samples for the cohort
- marking schemes were correct and showed the breakdown of mark allocations awarded for questions to support consistent and accurate judgments
- there was a consistent approach to mark value (i.e. one mark per cognition) and judgments refrained from using part-marks.

Samples of effective practices

The following excerpt demonstrates suitable annotations matching aspects of the ISMG on a student response to an objective 4 item that requires interpreting graphs of relative concentrations over time of reactants and products to infer the effects of Le Châtelier's principle on this reaction.

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



Practices to strengthen

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

- match the student mark to the correct percentage cut-offs on the ISMG (please refer to the Chemistry Making judgments webinar available on the Syllabuses application).

Additional advice

- Student responses need to be annotated clearly to indicate how the student was marked against the marking scheme (*QCE and QCIA policy and procedures handbook v4.0*, Section 9.6.1).

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	24
Authentication	6
Authenticity	3
Item construction	29
Scope and scale	0

*Each priority might contain up to four assessment practices.

Total number of submissions: 412.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- provided relevant practicals or activities that clearly related to the Unit 3 topics: Chemical equilibrium systems and Oxidation and reduction
- contained clear communication of the genre to be used, e.g. scientific report or multimodal presentation
- avoided leading students to a predetermined response by providing appropriate scaffolding to support development of the research question.

Practices to strengthen

It is recommended that assessment instruments:

- include a statement that precludes students from using the research question in the scaffolding if this question is based on a practical included in the instrument.

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	5
Layout	1
Transparency	6

*Each priority might contain up to four assessment practices.

Total number of submissions: 412.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- included clear instructions that reflect all the conditions and specifications of the syllabus.

Practices to strengthen

There were no significant issues identified for improvement.

Additional advice

In the authentication strategies, schools should:

- clearly outline strategies that are appropriate to their context
- clearly indicate that feedback will be provided on one draft only.

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	84.28%	14.00%	1.72%	0%
2	Analysis of evidence	86.98%	12.04%	0.98%	0%
3	Interpretation and evaluation	86.49%	12.53%	0.98%	0%
4	Communication	98.77%	0.25%	0.98%	0%

Effective practices

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

- in the Analysis of evidence criterion
  - *sufficient and relevant* raw data was systematically and effectively analysed using *correct and relevant* processes such as
    - calculation of indicators of uncertainty, e.g. percentage uncertainty
    - linearisation of data, e.g. correlation coefficient (r^2)
  - *thorough* identification of uncertainty and limitations involved scrutiny of the evidence rather than discussing problems relating to methodology
  - *appropriate* identification of uncertainty and limitations related to the *correct and relevant* processing of data
- in the Interpretation and evaluation criterion
  - conclusions were *justified* by referring to the trends, patterns or relationships and the uncertainty and limitations identified in the analysis of evidence to determine how the evidence matched with the theoretical concepts identified in the rationale
  - experimental processes were critically evaluated through *justified discussion* of the reliability and validity that referred 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.

Samples of effective practices

The following excerpts demonstrate thorough identification of uncertainties and limitations of evidence leading to a justified discussion of the reliability and validity of the experimental process.

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

Excerpt 1

- The voltages recorded for the concentration-controlled trials varied, thus, the average cell potentials are less reliable because the trials had imprecise results. The uncertainties for the mean (0.323%, 0.325%, and 0.278%) were caused by random and systematic error because theoretically, each trial should produce the same voltage. This reduces the validity of the results as they're not as hypothesised.
- The measured values for 2M, 2.5M, 3M zinc nitrate had 14.94%, 15.335% and 17.311% respectively, and this substantial variability affects the accuracy and decreases the validity of the experimental process as the measured values significantly vary from the theoretical values.
- The same copper-sulphate electrolyte, zinc electrode and copper electrode were used for all trials. This affects the reliability because the circuit closed so the flow of electrons started, thus the initial conditions for each trial are inconsistent, so the same results are unachievable. Eventually, the cathode will increase in size due to the added ions and the anode will decrease in size due to the lost electrons, having a greater impact on the precision of the results, and thus, the reliability.

Excerpt 2

Conclusion

The experimental results obtained are reliable because there is minimal variability in the results which is confirmed by the significantly small uncertainties for the mean (0.323%, 0.325%, and 0.278% for 2M, 2.5M, and 3M zinc nitrate). While in theory, the data should not have varied, the impact of systematic and random error was evident, therefore, the results are deemed somewhat valid. The experimental cell potential for 2M, 2.5M and 3M were 0.928V, 0.922V, and 0.898V. The theoretical voltages were 1.091V, 1.089V, and 1.086V with uncertainties of 14.94%, 15.335%, and 17.311% respectively. These large uncertainties reduce the experiment's accuracy, thus figures 1 and 2 present somewhat accurate results which, in combination with the discussed limitations, are deemed partially reliable. Due to the minimal effect of the systematic errors displayed in percentage errors and uncertainties, the data is deemed valid.

The results show that as the concentration of the electrolyte zinc nitrate increases from 2M to 2.5M to 3M, the voltage from the galvanic cell decreases. As the concentration of the products increases, the reverse reaction is favoured to reach equilibrium; however, the forward reaction is favoured overall. Because the system shifts closer to equilibrium, the voltage produced decreases. Due to the partial validity of the results, an overall trend can be determined; that increasing the concentration of the products increases the cell potential.

The results obtained demonstrate that altering the concentration of 50mL zinc nitrate (2M, 2.5M, 3M), while maintaining the concentration of 50mL copper sulphate (1M) in a zinc-copper galvanic cell, reduces the voltage generated. The research question has been answered with partially reliable data from the experiment.

Practices to strengthen

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

- in the Research and planning criterion
  - a *considered* rationale clearly connects the research question to subject matter from relevant topics in Unit 3

- a *specific and relevant* research question identifies the independent and dependent variable to be tested and is directly related to Unit 3
- *justified* modifications to the methodology discuss the improvements to validity or reliability of a familiar experiment.

Additional advice

- Teachers should provide students with opportunities to engage with a variety of analytical processes as part of their teaching and learning.
- Appendixes should only include supplementary material that will not be directly used as evidence when marking the response (*QCE and QCIA policy and procedures handbook v4.0*, Section 8.2.6). If raw data is included in an appendix, there must be evidence of collection of sufficient and relevant raw data in other areas of the response, e.g. methodology, sample calculations and data presentation.
- Marked ISMGs must clearly indicate the characteristics evident in the student response and the mark awarded for each criterion (*QCE and QCIA policies and procedures handbook v4.0*, Section 9.6.3).
- When applying best-fit judgments on an ISMG, the higher of the two possible marks for that performance level is awarded when all characteristics in the performance level are identified (refer to the Chemistry Making judgments webinar available via the Syllabuses application).
- Schools must use appropriate strategies to manage response length and promote academic integrity (*QCE and QCIA policy and procedures handbook v4.0*, Sections 8.1 and 8.4).

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	17
Authentication	7
Authenticity	3
Item construction	8
Scope and scale	3

*Each priority might contain up to four assessment practices.

Total number of submissions: 412.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- listed claims that provided the opportunity for the development of research questions that are within the scale of the task, i.e. able be completed in 10 hours of class time and a 2000-word response
- included claims closely related to the subject matter of Unit 4 topics: Properties and structure of organic materials and Chemical synthesis and design, e.g. 'Biodegradable plastics are beneficial to the environment' and 'Synthetic derivatives of naturally occurring drugs are more effective'.

Practices to strengthen

It is recommended that assessment instruments:

- avoid listing claims that significantly overlap with topics of Sciences subjects other than Chemistry or subject matter from outside Unit 4, e.g. 'Rusting metal parts dumped in rivers are harmful to the environment'
- include a statement that precludes students from using the research question in the scaffolding if this question is based on a claim included in the instrument.

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	6
Layout	0
Transparency	1

*Each priority might contain up to four assessment practices.

Total number of submissions: 412.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- included clear instructions that reflect all the conditions and specifications of the syllabus.

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	84.56%	14.46%	0.49%	0.49%
2	Analysis and interpretation	86.52%	12.25%	0.74%	0.49%
3	Conclusion and evaluation	85.29%	13.97%	0.25%	0.49%
4	Communication	98.77%	0.74%	0.25%	0.25%

Effective practices

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

- in the Analysis and interpretation criterion
  - *sufficient and relevant* evidence was directly related to the research question, based on subject matter from Unit 4 of the syllabus and drawn from more than one source
  - *thorough* identification of trends, patterns and relationships and *thorough and appropriate* identification of limitations were sufficient to ensure that credible findings of the research could be extrapolated to the claim
  - *thorough and appropriate* identification of limitations of evidence identified issues such as weak points of the data with respect to the research question, methodological limitations of the sources and whether justified scientific arguments are supported by data from the sources.
- in the Conclusion and evaluation criterion
  - conclusions were *justified* using the scientific arguments developed through the analysis and interpretation of evidence rather than restating trends, patterns or relationships
  - an *insightful discussion* of the quality of the evidence clearly connected the research question to the limitations identified in the analysis of the evidence
  - suggested improvements and extensions were based on the discussion of the quality of the evidence and had a direct bearing on the claim for them to be considered *logically derived*.

Samples of effective practices

The following excerpts demonstrate thorough and appropriate identification of the limitations of evidence and the extrapolation of credible findings of the research to the claim.

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

Excerpt 1

Due to population growth, polyethylene remains in high demand, causing increases in production and consumption rates (OECD 2022). However, millions of tonnes of polyethylene are landfilled or lost to the environment each year (UNEP n.d.). This is reflected in Graph 1, which examines the tons of polyethylene in landfill from 1960 to 2018 in the United States. The data, measured in US tons, was collected from reports by the American Chemistry Council, the National Association for PET Container Resources, and the Association of Plastic Recyclers, and published by the United States Environmental Protection Agency (EPA) (United States EPA 2021). The graph indicates that as time increased, so too did the tons of polyethylene landfilled, revealing a directly proportional relationship. Specifically, 390000 US tons of polyethylene was landfilled in 1960, which increased by a factor of 69.15 to 26970000 US tons in 2018. Therefore, the tons of polyethylene landfilled increased approximately at a rate of 458275.86 US tons per year, further reflecting the high linear correlation. Moreover, it is likely this relationship is causal, as plastic production must increase to sustain the growing population (OECD 2022). This then gives rise to increased landfill rates by increasing the opportunity for polyethylene to be lost to the environment. However, the inconsistent scaling of intervals on the x-axis presents limitations, as it prevents a trendline and R^2 value from being calculated. Consequently, the extent of the positive correlation cannot be mathematically determined.

Excerpt 2

Moreover, the Royer et al. study was peer reviewed and published in the Public Library of Science (PLOS). As the data was published in a medical journal and collected by authors respected in their fields, it is reliable. Similarly, the United States EPA cooperates with the United States federal government, and the information is also peer reviewed to ensure it is accurate (United State EPA 2022). However, the World Bank collected their emissions data from Climate Watch, which in turn sourced their statistics from four different databases (The World Bank 2020). Therefore, the accuracy of the data is limited and impacted by the reliability of these other results. As an evaluation has not been conducted on these other sources, bias may be present. Any errors in the data from these other sources would have been carried through this investigation, impacting the accuracy of the conclusions obtained.

The data is also limited by the small sample size. In particular, the Royer et al. study only collected measurements of methane concentration on four days. Whilst it is likely the trend may have remained consistent, extending the experiment by measuring methane emissions over 28 days, for example, would have provided additional information to consolidate the correlation observed. However, three samples of LDPE were exposed to the solar radiation, which allows for an accurate mean value to be calculated that is representative.

Ultimately, irrespective of the lack of information regarding methodology, publication and peer review in certain instances, the sources are credible and can therefore be used to establish an overall conclusion. Wholistically, the data suggests that the increasing tons of polyethylene in landfill is contributing to global methane emissions, thereby verifying the claim. However, the graphs fail to explicitly demonstrate the rate at which polyethylene in landfill impacts methane emissions. Therefore, a numerical value cannot be utilised to establish causation or the strength of the relationship; it can only be inferred based on the trends observed. Subsequently, further investigation is required.

Practices to strengthen

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

- in the Research and planning criterion
  - a *considered* rationale should clearly connect the research question to Unit 4 subject matter and demonstrate how the research question was developed from the claim

- a research question is *specific* if it allows a justified conclusion to the claim to be reached within the response length conditions of the syllabus, e.g. 'Can synthetic silk replace natural silk fibres when considering strength, flexibility and extensibility?'
- if a research question focuses more on subject matter from Units 1 and 2 than Unit 4, it should be judged as *inappropriate*
- *sufficient and relevant* sources are selected from a variety of scientifically credible sources and evident throughout the report.

Additional advice

- Teachers should guide students through the research investigation to support the development of a research question that allows successful completion of the task within the scope of Unit 4 (IA3 effective processes and practices resource).
- Marked ISMGs must clearly indicate the characteristics evident in the student response and the mark awarded for each criterion (*QCE and QCIA policies and procedures handbook v4.0*, Section 9.6.3).
- When applying best-fit judgments on an ISMG, the higher of the two possible marks for a performance level is awarded when all the characteristics in the performance level are identified (refer to the Chemistry Making judgments webinar available via the Syllabuses application).
- Schools must use appropriate strategies to manage response length and promote academic integrity (*QCE and QCIA policy and procedures handbook v4.0*, Sections 8.1 and 8.4).

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 (31 marks)
- Paper 2, Section 1 consisted of short response questions (49 marks).

The examination assessed subject matter from Units 3 and 4. Questions were derived from the context of Chemical equilibrium systems, Oxidation and reduction, Properties and structure of organic materials and Chemical synthesis and design.

The assessment required students to respond to multiple choice and short response questions.

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	**78.18**	3.74	6.73	11.15
2	3.35	4.8	8.72	**83.02**
3	19.2	**60.16**	14.48	5.88
4	5.78	**59.48**	6.62	27.95
5	9.27	15.2	44.53	**30.51**
6	**53.85**	13.03	25.26	7.6
7	8.72	4.84	10.33	**75.99**
8	20.77	44.68	12.38	**21.96**
9	**42.16**	14.14	7.88	35.61
10	21.12	**32.27**	37.4	8.83
11	22.9	28.27	16.56	**32.07**
12	14.02	18.57	11.04	**56.14**
13	19.8	24.59	**48.47**	6.57
14	31.11	24.03	**30.4**	14.05
15	**78.29**	9.78	2.74	8.89
16	9.46	11.46	**68.77**	10.17
17	14.05	12.07	**42.05**	31.36
18	3.02	2.51	**86.52**	7.79
19	**43.43**	17.88	15.89	22.42
20	**60.64**	18.89	13.01	7.21

Effective practices

Overall, students responded well to:

- short response items requiring them calculate a numerical value from one or two steps
- opportunities to describe and explain their understanding and application of familiar concepts
- questions related to analysis of evidence to identify features within a dataset.

Samples of effective practices

Short response

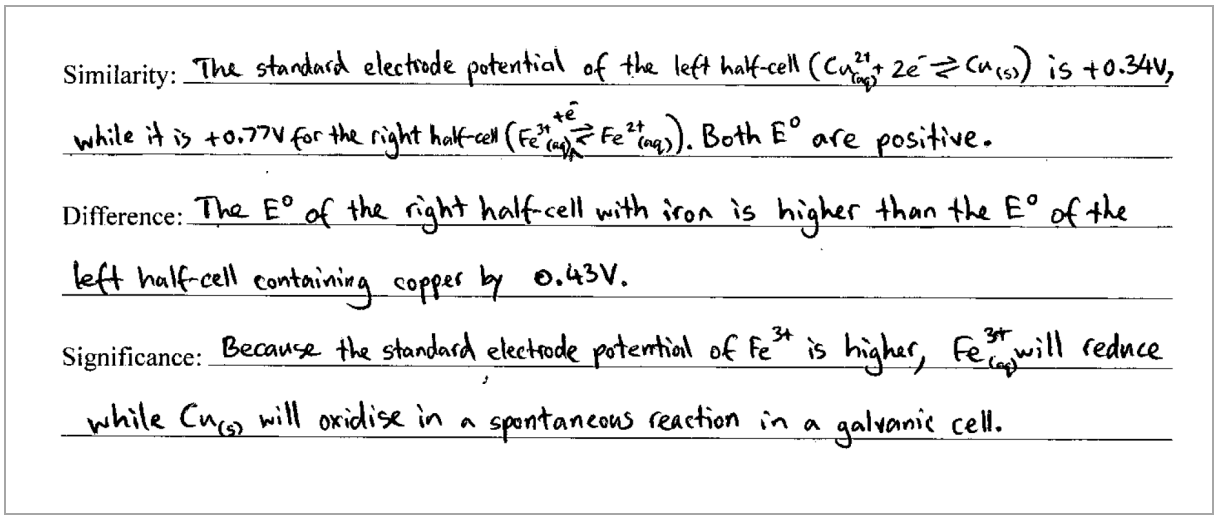
The following excerpt is from Question 24a from Paper 1. It required students to compare the standard electrode potential of two-half cells.

Effective student responses:

- identified a similarity
- identified a difference
- explained the significance of the difference.

This excerpt has been included:

- to demonstrate an explanation of the significance of the difference between the two half-cells.


Similarity: The standard electrode potential of the left half-cell ($Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$) is +0.34V, while it is +0.77V for the right half-cell ($Fe^{3+}_{(aq)} \overset{+e^-}{\rightleftharpoons} Fe^{2+}_{(aq)}$). Both E° are positive.

Difference: The E° of the right half-cell with iron is higher than the E° of the left half-cell containing copper by 0.43V.

Significance: Because the standard electrode potential of Fe^{3+} is higher, $Fe^{3+}_{(aq)}$ will reduce while $Cu_{(s)}$ will oxidise in a spontaneous reaction in a galvanic cell.

The following excerpt is from Question 27 from Paper 1. It required students to identify solutions by analysing experimental data.

Effective student responses:

- identified the five solutions
- used indicator data to identify acids and bases
- used conductivity data to identify the relative strength of bases
- used conductivity data to identify the relative strength of acids
- identified that the diprotic acid is more conductive than the monoprotic acid.

This excerpt has been included:

- to demonstrate the use of all of the experimental data provided to explain the relative strengths of acids and bases
- to demonstrate the analysis of evidence to identify the relationship between the relative conductivity of monoprotic and diprotic acids.

* Phenol red turns yellow in an acidic solution as if the pH is below its pK_a (7.9), then the ~~production~~ acid colour dominates. Thus, solutions A, C and D are expected to be acids. All solutions are at 0.1M so this does not affect conductivity. ~~Stronger~~ Acids that dissociate into H^+ ions the most will conduct electricity better because there are more freely moving charged particles in solution. HCl and H_2SO_4 are both strong acids, and so will dissociate more than CH_3CH_2COOH which is a weak acid. ~~Out of solutions A, C and D, solution C must be CH_3CH_2COOH.~~ However, H_2SO_4 will dissociate into more H^+ ions than HCl since H_2SO_4 is diprotic while HCl is monoprotic. This means $H_2SO_4 > HCl > CH_3CH_2COOH$ in order of most conductive to least conductive in solution. Out of the three acidic solutions (A, C, D), solution D is the most conductive with a reading of 6.7S/m, solution A is the second most conductive with a reading of 4.1S/m, and solution C is the least conductive with the lowest reading of 0.08S/m. (See next page)

Question 27 (continued)

Therefore, solution D is H_2SO_4, solution A is HCl, and solution C is CH_3CH_2COOH.

Solutions B and E are basic since phenol red turns red, indicating the base colour is favoured due to the increased number of hydroxide ions. Again, all solutions are at 0.1M, so this does not affect conductivity. NH_3 and KOH are the two bases. KOH is a strong base while NH_3 is a weak base. Hence it is expected that KOH will dissociate into more OH^- ions than NH_3, and thus KOH solution will conduct electricity better due to more freely moving charged particles. Solution E has a higher conductivity reading than solution B, at 4.9S/m compared to 0.14S/m. Therefore, solution E is KOH, and solution B is NH_3.

*A higher conductivity reading (in S/m) indicates that the solution conducts electricity better.

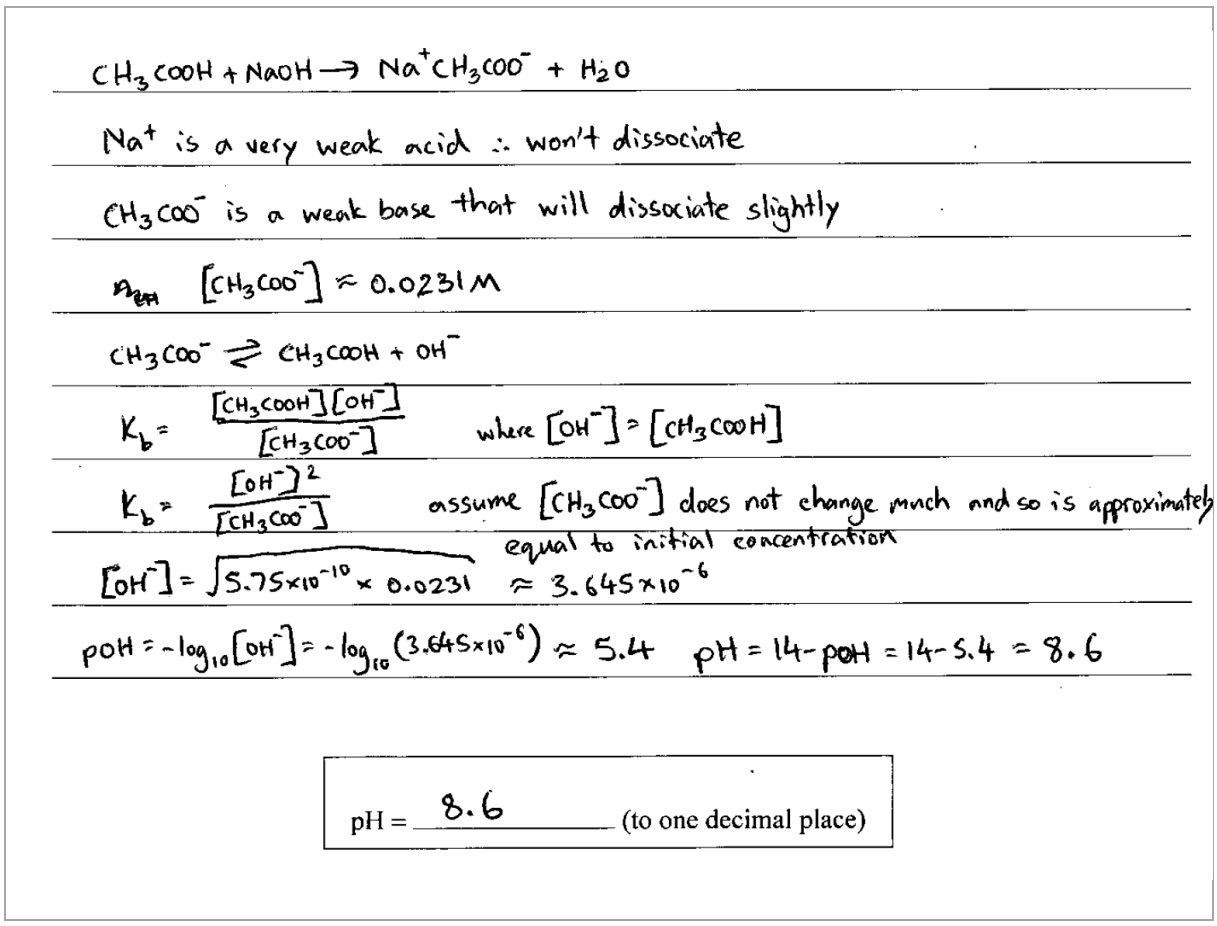
The following excerpt is from Question 3d from Paper 2. It required students to calculate the pH at the equivalence point.

Effective student responses:

- provided a correct substitution
- calculated the concentration of hydroxide ions
- determined the pOH
- calculated pH.

This excerpt has been included:

- to demonstrate understanding of equivalence point
- to demonstrate application of understanding in a multi-step calculation.



Practices to strengthen

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

- teaching students to consider the significance of the difference when identifying similarities and differences in questions that use the verb 'compare'
- encouraging students to explain their analysis of data to support reasoning
- providing students with opportunities to practise multiple choice and short response questions that require application of understanding across two or more steps.

Additional advice

- Schools should review their sequences of teaching and learning to ensure that they help students to understand the connections between syllabus topics and units.

Senior External Examination

The Chemistry Senior External Examination (SEE) is a standalone examination offered to eligible Year 12 students and adult learners. It contributes 100% to a student's final subject result.

Assessment design

The assessment was designed using the specifications, conditions and assessment objectives described in the summative external assessment section of the Chemistry Senior External Examination syllabus.

The SEE consisted of two assessments:

- SEE 1 contributed 50% of the marks
- SEE 2 contributed 50% of the marks.

Note: The SEE information should be read in conjunction with the rest of the subject report.

Number of students who completed the Chemistry Senior External Examination: 11.

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

Assessment decisions

Effective practices

Overall, students responded well to:

- opportunities to demonstrate their understanding of titration curves to identify an appropriate indicator
- questions that required analysis of equilibrium graphs and titration curves to identify general trends, patterns and relationships
- opportunities to interpret evidence by writing conclusions in response to a research question.

Practices to strengthen

It is recommended that when preparing students for the Senior External Examination, teachers consider:

- modelling the development of research questions that are specific and relevant to a claim
- encouraging students to refer to data when describing trends, patterns and relationships or when justifying conclusions
- providing opportunities for students to practise identifying the limitations of evidence.