External Assessment subject report

Chemistry

October 2016

Queensland Government

Queensland Curriculum & Assessment Authority

160697

For all Queensland schools

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Introduction

Queensland is working towards a new system of senior assessment and tertiary entrance that will include:

- a model that uses school-based assessment and common external assessment
- processes that strengthen the quality and comparability of school-based assessment
- a move away from the Overall Position (OP) rank to an Australian Tertiary Admission Rank (ATAR).

In Semester 1 2016, the Queensland Curriculum and Assessment Authority (QCAA) trialled external formative assessments in five subjects to:

- provide an opportunity for schools to become familiar with the use of subject-based external assessments
- test our processes for delivering external assessments.

These assessments were:

- aligned to existing syllabuses
- an alternative to a task already being undertaken at participating schools
- developed in consultation with subject experts from schools, subject associations and universities
- administered under secure conditions and graded externally.

The trial involved:

- approximately 19 000 students from 249 schools
- five Year 11 subjects:
  - Chemistry
  - English
  - Geography
  - Mathematics B
  - Modern History.

In addition, more than 400 teachers took part in the online marking operation.

This report provides information on the *External Assessment Trial: Chemistry* assessment specifications, the sample responses and the performance characteristics of students.

The trial was conducted using the current syllabus, with Year 11 students and in a formative context. Commentaries and sample responses should be viewed in this context.

Electronic versions of the assessment are available online.

Claude Jones
Director, Assessment and Reporting Division

Overall commentary

The *External Assessment Trial: Chemistry* was a *supervised assessment* developed by the Queensland Curriculum and Assessment Authority (QCAA) and conducted under supervised conditions. The assessment was completed by 2344 students across 74 participating schools on Thursday 2 June 2016.

The *supervised assessment* was devised from identified subject matter from the Chemistry Senior Syllabus 2007 (amended 2014) and consisted of 21 items grouped into 12 questions. Expected responses to items were classified according to the standards they demonstrated. Some items produced evidence of a particular standard in a single criterion while others allowed students to demonstrate achievement across a range of standards and objectives in more than one criterion. A mark distribution table was provided with the supervised assessment. This table indicated the highest standard that could be demonstrated for each criterion that the question assessed. This also appeared in a notation beside each question.

- Questions 1–8 assessed *Knowledge and conceptual understanding*.
- Questions 10 and 11 provided opportunities in *Investigative processes*.
- Question 12 provided opportunities in *Evaluating and concluding*.
- Question 9 provided opportunities in both *Knowledge and conceptual understanding* and *Evaluating and concluding*.

Figures 1 to 6 indicate student performance overall, and according to gender. In terms of student performance, students generally demonstrated their strongest performance in *Knowledge and conceptual understanding*.

Note that the statistics in this report may be subject to rounding, resulting in totals not equal to 100 per cent.

Figure 1: Knowledge and conceptual understanding

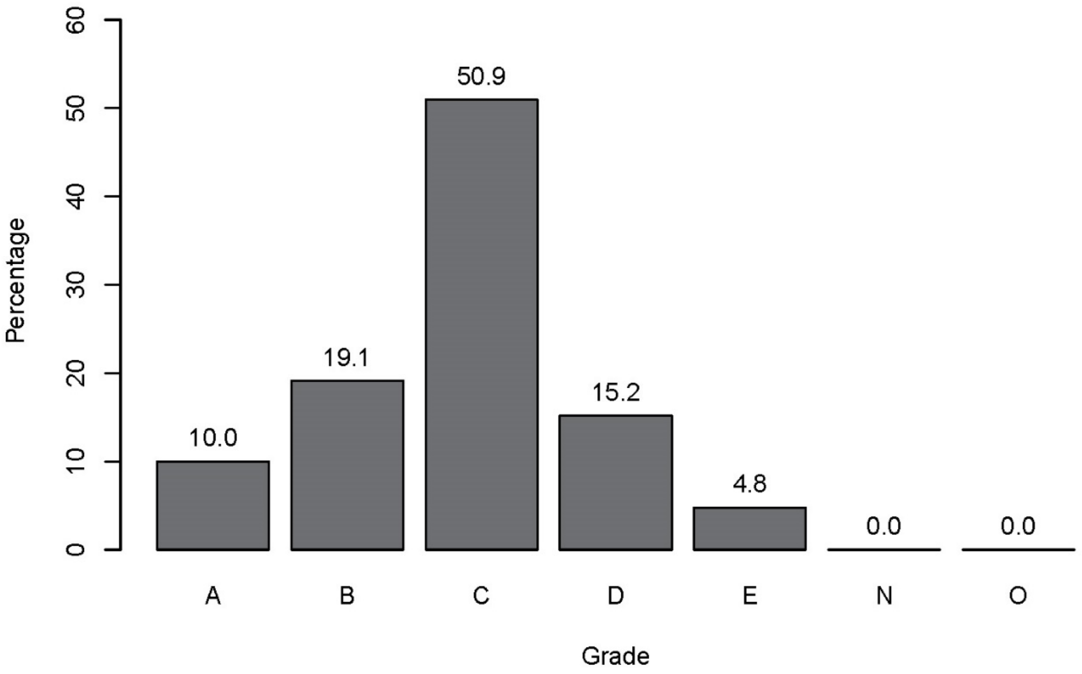


Figure 2: Knowledge and conceptual understanding by gender

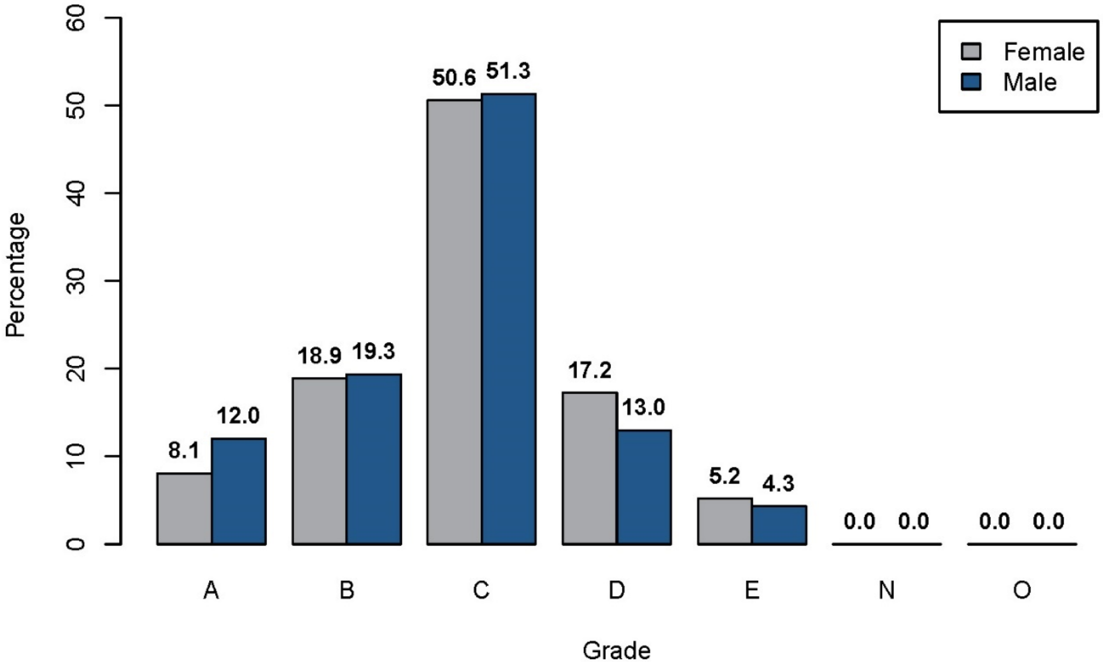


Figure 3: Investigative processes

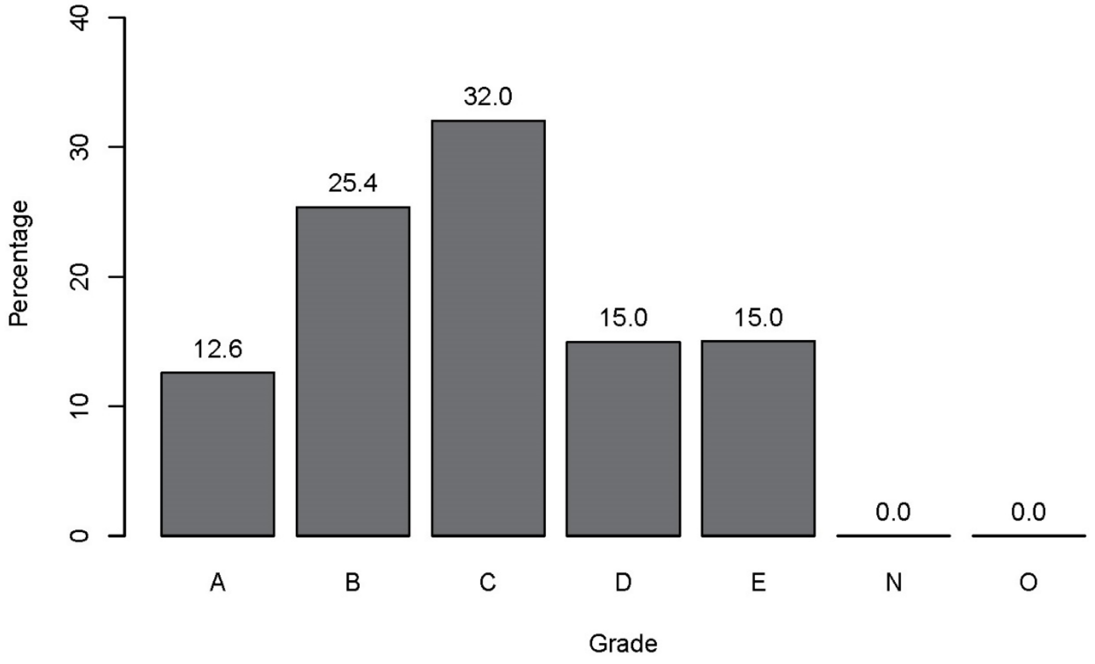


Figure 4: Investigative processes by gender

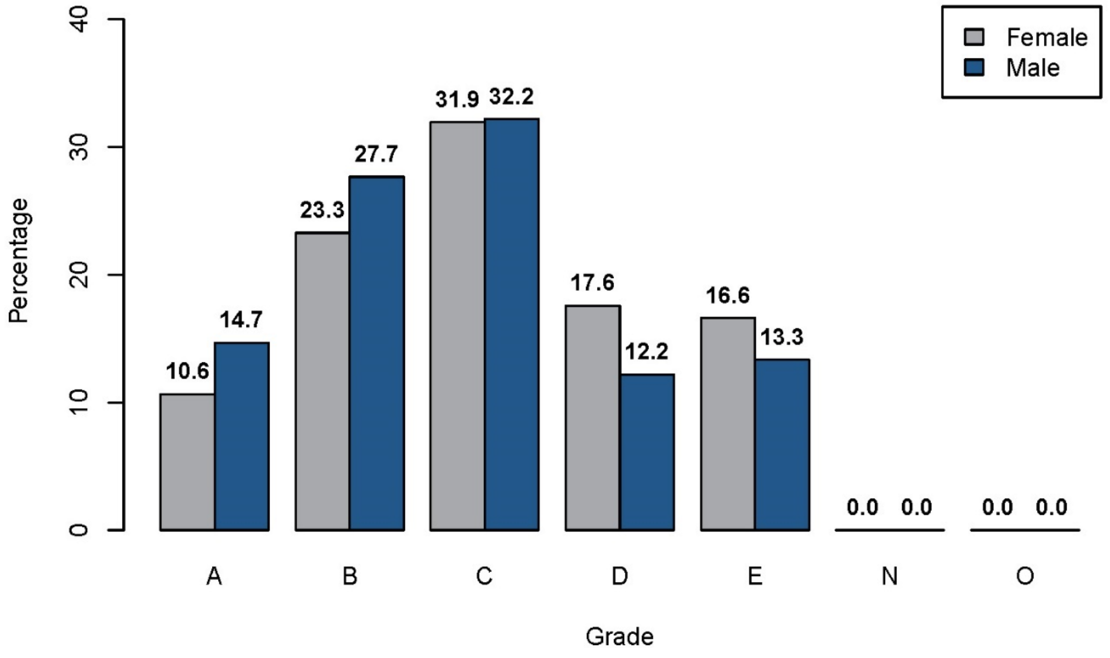


Figure 5: Evaluating and concluding

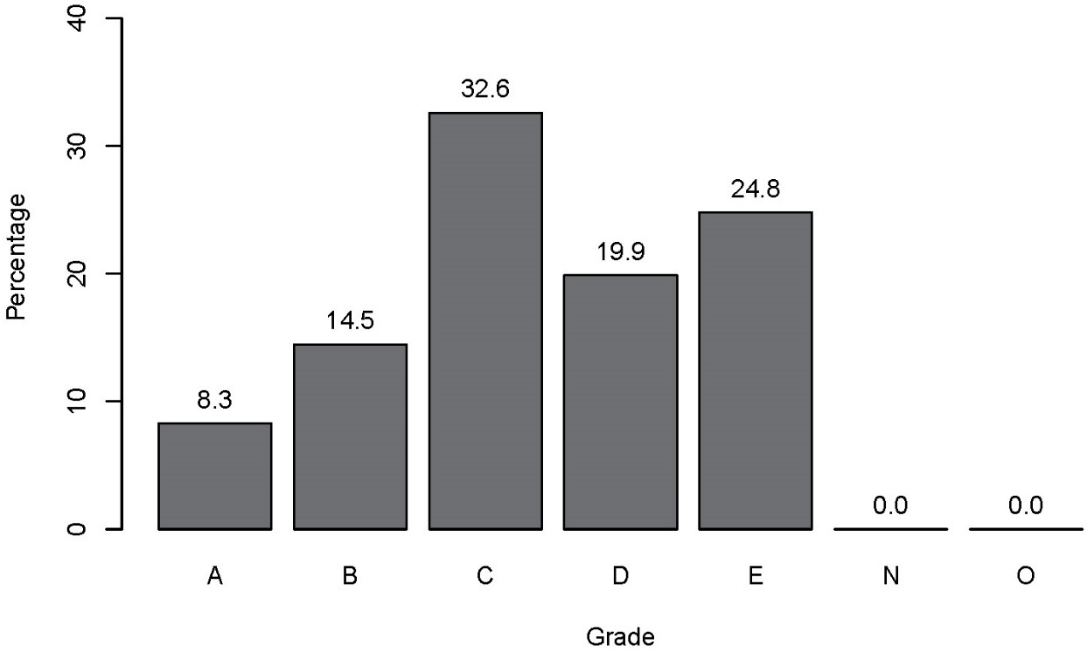
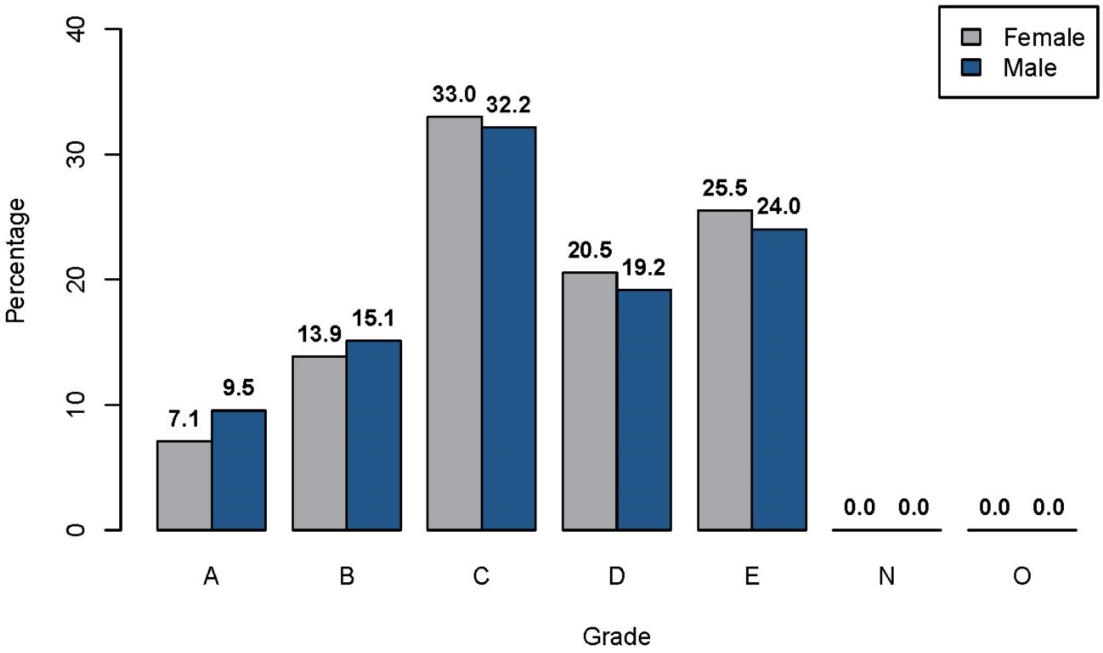


Figure 6: Evaluating and concluding by gender



Sample responses and commentaries

The following section provides commentary on student responses to the 12 questions on the *supervised assessment*. It highlights the strengths in particular questions and discusses aspects where students had less success and need to improve. A sample response is provided which models an appropriate response for each question. They have not been corrected for grammar, spelling or accuracy. Responses provided are sample responses only, and are not necessarily exemplary responses.

Question 1

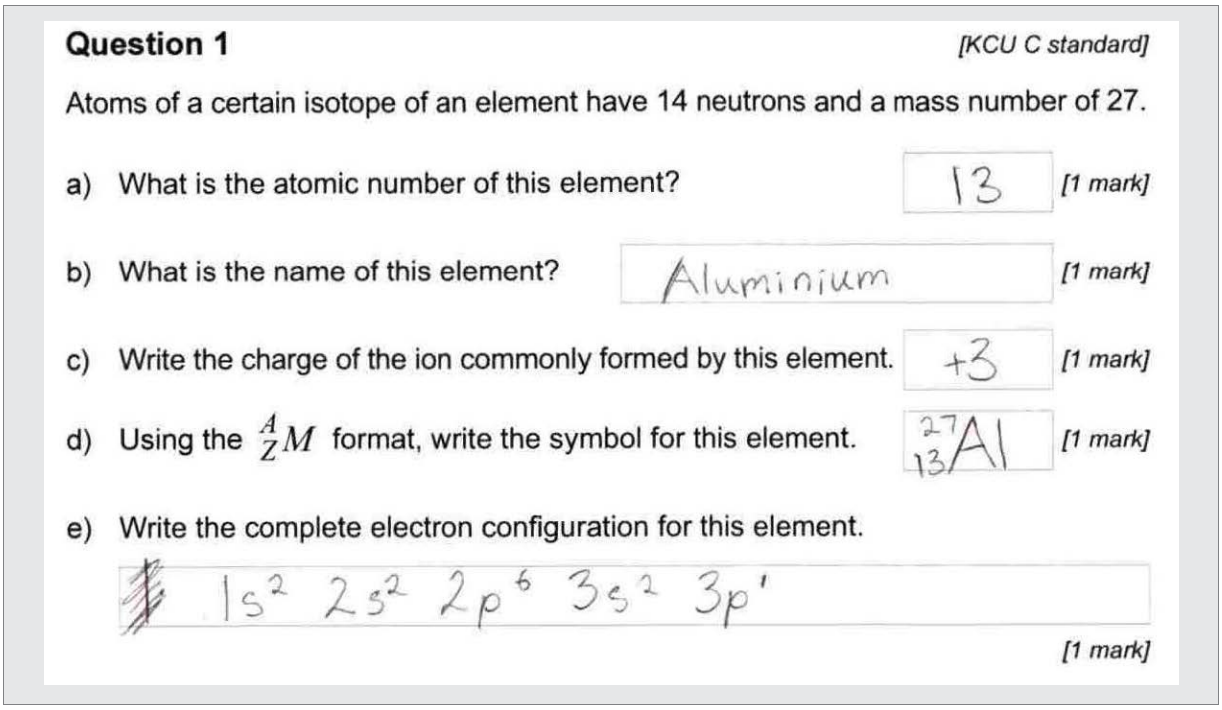
Question 1 provided opportunities for students to demonstrate application of concepts and algorithms related to atomic number, mass number, ionic charge and electron configuration. Marks were awarded for:

- using an appropriate algorithm to determine the number of protons and hence the atomic number of the element
- identifying the element based on the atomic number
- determining the charge based on the element
- writing the appropriate symbol for the element and including the corresponding mass number in place of A and the corresponding atomic number in place of Z
- using the correct format to write the electron configuration for the element identified.

More than 90% of students were able to determine the atomic number and the identity of the element. Most students were also able to determine the charge and write the symbol and electronic configuration correctly.

Common errors were interchanging the mass number for the atomic number and consequently identifying the element as cobalt, or applying the misconception that the number of neutrons determines the identity of the element and identifying the element as silicon.

Sample response



Question 1 *[KCU C standard]*

Atoms of a certain isotope of an element have 14 neutrons and a mass number of 27.

a) What is the atomic number of this element? 13 *[1 mark]*

b) What is the name of this element? Aluminium *[1 mark]*

c) Write the charge of the ion commonly formed by this element. +3 *[1 mark]*

d) Using the $^{A}_{Z}M$ format, write the symbol for this element. $^{27}_{13}Al$ *[1 mark]*

e) Write the complete electron configuration for this element.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

[1 mark]

Question 2

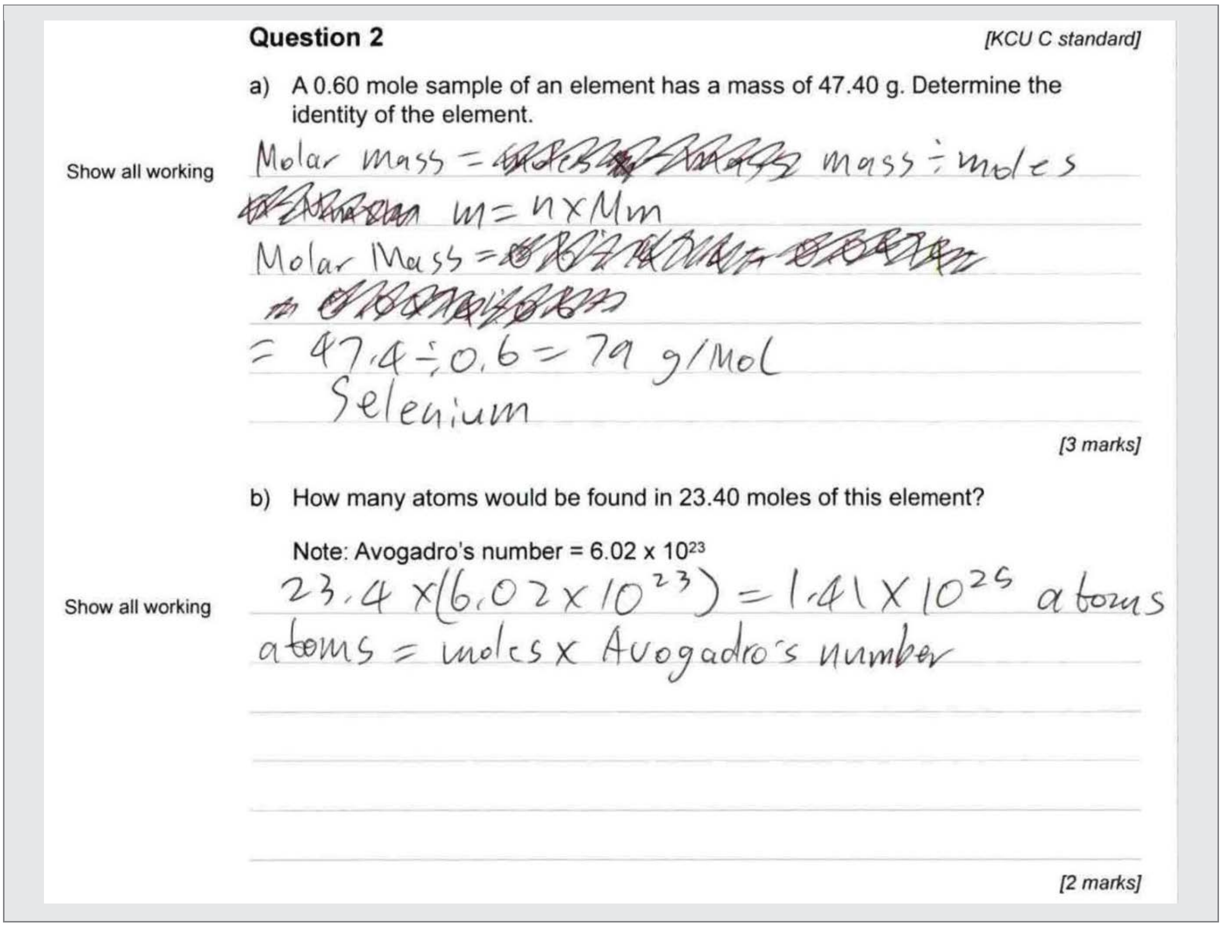
Question 2 required students to apply concepts and algorithms related to the concept of the mole and Avogadro's number. Marks were awarded for:

- using appropriate algorithms
- calculating answers correctly from these algorithms
- identifying the element based on the molar mass calculated in part a of the question.

More than 70% of students were able to calculate the molar mass and correctly identify the element. More than half were also able to calculate the number of atoms using Avogadro's number.

Common errors were applying an incorrect algorithm, or applying the correct algorithm incorrectly. Some students calculated the correct molar mass but identified the element incorrectly from the periodic table. Other students incorrectly substituted a value from one part of the problem into another.

Sample response



Question 2 *[KCU C standard]*

a) A 0.60 mole sample of an element has a mass of 47.40 g. Determine the identity of the element.

Show all working

Molar mass = mass ÷ moles

m = n × Mm

Molar Mass =

= 47.4 ÷ 0.6 = 79 g/Mol

Selenium

[3 marks]

b) How many atoms would be found in 23.40 moles of this element?

Note: Avogadro's number = 6.02×10^{23}

Show all working

$23.4 \times (6.02 \times 10^{23}) = 1.41 \times 10^{25}$ atoms

atoms = moles x Avogadro's number

[2 marks]

Question 3

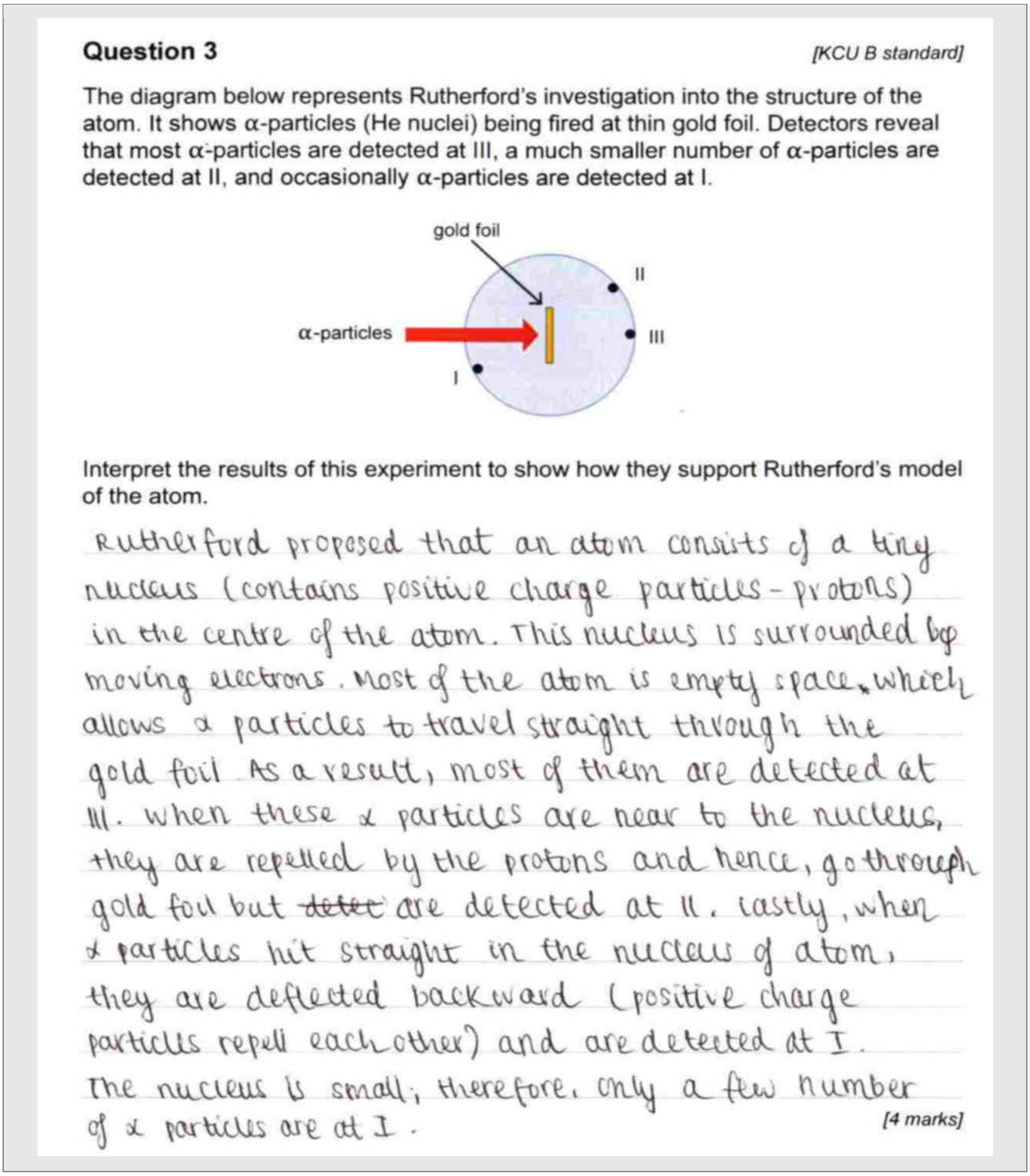
Question 3 required students to reproduce and interpret complex concepts, theory and principles related to atomic theory and Rutherford's model of the atom. Marks were awarded for:

- identifying that the alpha particle is positively charged
- inferring that, since α-particles are detected at I, the nucleus of the atom is small
- inferring that, since α-particles are detected at II, the nucleus is positively charged
- inferring that, since most of the α-particles are detected at III, most of the atom is empty space.

The most commonly achieved mark was for linking the observation that most of the α-particles pass directly through the atom with the idea that most of the atom is empty space.

A common error was to describe the diagram of Rutherford's gold foil experiment rather than interpreting the diagram as evidence to support Rutherford's model of the atom. Some students described Rutherford's model of the atom but did not relate it to the evidence provided.

Sample response



Question 3 *[KCU B standard]*

The diagram below represents Rutherford's investigation into the structure of the atom. It shows α-particles (He nuclei) being fired at thin gold foil. Detectors reveal that most α-particles are detected at III, a much smaller number of α-particles are detected at II, and occasionally α-particles are detected at I.

Interpret the results of this experiment to show how they support Rutherford's model of the atom.

Rutherford proposed that an atom consists of a tiny nucleus (contains positive charge particles - protons) in the centre of the atom. This nucleus is surrounded by moving electrons. Most of the atom is empty space, which allows α particles to travel straight through the gold foil. As a result, most of them are detected at III. when these α particles are near to the nucleus, they are repelled by the protons and hence, go through gold foil but ~~detet~~ are detected at II. lastly, when α particles hit straight in the nucleus of atom, they are deflected backward (positive charge particles repell each other) and are detected at I. The nucleus is small, therefore, only a few number of α particles are at I.

[4 marks]

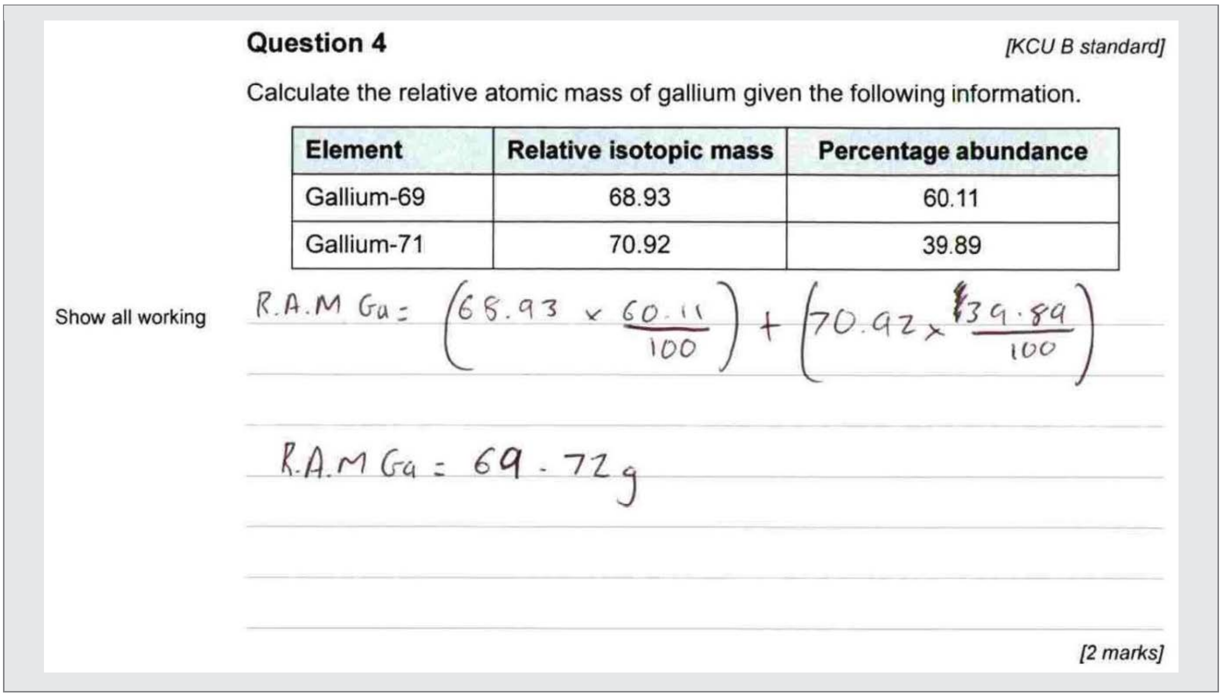
Question 4

Question 4 required students to interpret complex concepts and apply algorithms to find solutions in a complex situation related to isotopes, relative atomic mass and percentage abundance. Marks were awarded for:

- selecting an appropriate algorithm
- correctly calculating the relative atomic mass based on the algorithm used.

Almost two thirds of students received both marks on this question. Common errors were interchanging the mass number and the relative isotopic mass, or applying the incorrect algorithm.

Sample response



Question 4 *[KCU B standard]*

Calculate the relative atomic mass of gallium given the following information.

Element	Relative isotopic mass	Percentage abundance
Gallium-69	68.93	60.11
Gallium-71	70.92	39.89

Show all working

R.A.M Ga = $\left(68.93 \times \frac{60.11}{100}\right) + \left(70.92 \times \frac{39.89}{100}\right)$

R.A.M Ga = 69.72g

[2 marks]

Question 5

Question 5 required students to link and apply concepts, algorithms and schema to find solutions in complex situations related to moles, mole ratios, balancing chemical equations and writing ionic formula. Marks were awarded for:

- writing a correctly balanced chemical equation
- identifying the states of the reactants and products using appropriate notation
- naming the product based on the chemical equation written
- using an appropriate algorithm to determine the molar mass of magnesium hydroxide produced based on the balanced chemical equation written in 5a
- applying the mole ratio from the balanced chemical equation in 5a
- determining the mass of magnesium hydroxide based on the algorithms used.

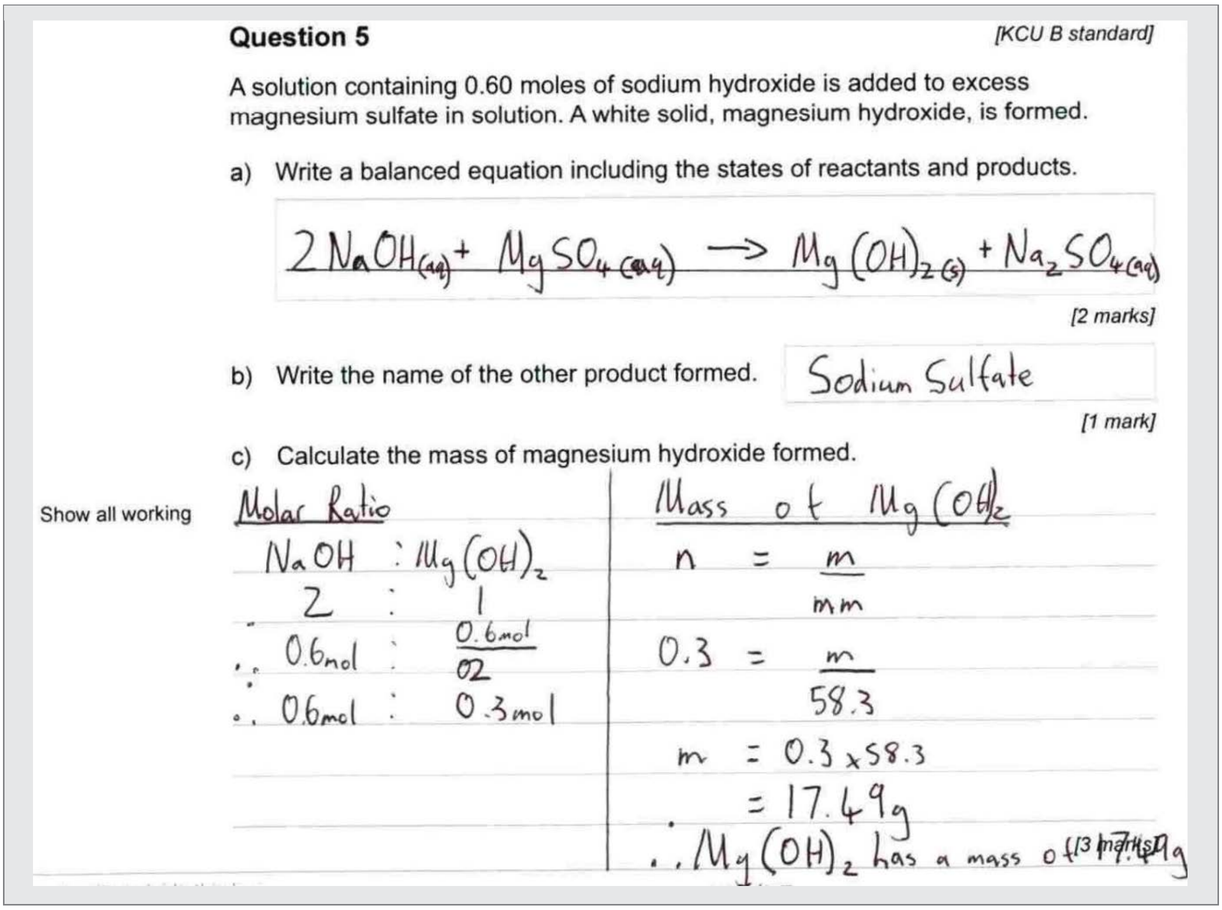
More than three quarters of students were able to name the second product of the reaction. More than half were also able to correctly calculate the mass of the magnesium hydroxide formed.

A common error for Question 5a was writing incorrect ionic formula for the compounds. This often resulted in students being unable to balance the chemical equation. Students often failed to include the states of the reactants and products in their answer.

A common error for Question 5b was writing the ionic formula for the product rather than naming the product. Most students were able to answer Question 5b correctly, indicating that they understood the mechanism of a double displacement reaction.

Common errors for Question 5c were applying the incorrect algorithm to calculate mass, or using the appropriate algorithm incorrectly. Some students who used the correct algorithm in Question 5c were unable to apply the mole ratio from Question 5a to determine an appropriate answer.

Sample response



Question 5 *[KCU B standard]*

A solution containing 0.60 moles of sodium hydroxide is added to excess magnesium sulfate in solution. A white solid, magnesium hydroxide, is formed.

a) Write a balanced equation including the states of reactants and products.

$2NaOH_{(aq)} + MgSO_{4(aq)} \rightarrow Mg(OH)_{2(s)} + Na_2SO_{4(aq)}$

[2 marks]

b) Write the name of the other product formed. Sodium Sulfate

[1 mark]

c) Calculate the mass of magnesium hydroxide formed.

Show all working

Molar Ratio

$NaOH : Mg(OH)_2$

$2 : 1$

$\therefore 0.6mol : \frac{0.6mol}{02}$

$\therefore 0.6mol : 0.3mol$

Mass of $Mg(OH)_2$

$n = \frac{m}{mm}$

$0.3 = \frac{m}{58.3}$

$m = 0.3 \times 58.3$

$= 17.49g$

$\therefore Mg(OH)_2$ has a mass of 17.49g

[3 marks]

Question 6

Question 6 required students to apply, compare and explain concepts and algorithms to find solutions in complex situations related to isotopes, atomic mass, atomic number and atomic structure. Marks were awarded for:

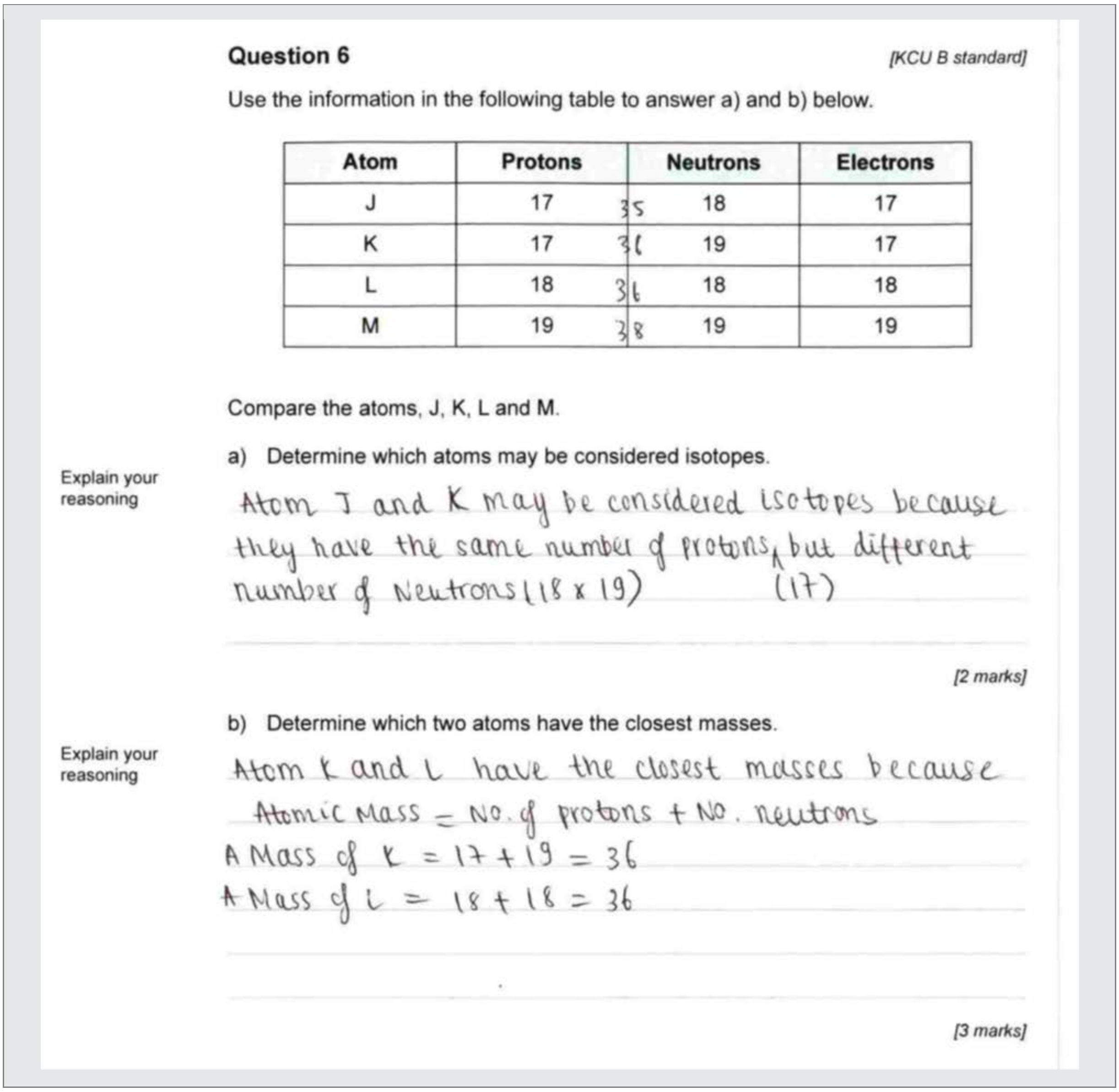
- identifying the isotopes
- using appropriate reasoning to support the atoms chosen as isotopes
- identifying the atoms with the closest masses
- using appropriate reasoning to support the atoms chosen as having the closest masses
- using an appropriate algorithm to determine the approximate atomic masses.

The majority of students were able to identify the isotopes and the atoms with the closest masses, giving a reason based on the number of protons and neutrons in each nucleus.

Common errors for Question 6a were the incorrect application of the definition of an isotope, or not using the data given in the table to determine the answer.

Common errors for Question 6b were applying the incorrect algorithm to calculate atomic mass, or using the appropriate algorithm incorrectly.

Sample response



Question 6 *[KCU B standard]*

Use the information in the following table to answer a) and b) below.

Atom	Protons	Neutrons	Electrons
J	17	35 18	17
K	17	36 19	17
L	18	36 18	18
M	19	38 19	19

Compare the atoms, J, K, L and M.

a) Determine which atoms may be considered isotopes.

Explain your reasoning

Atom J and K may be considered isotopes because they have the same number of protons (17) but different number of Neutrons (18 x 19)

[2 marks]

b) Determine which two atoms have the closest masses.

Explain your reasoning

Atom K and L have the closest masses because

Atomic Mass = No. of protons + No. neutrons

A Mass of K = 17 + 19 = 36

A Mass of L = 18 + 18 = 36

[3 marks]

Question 7

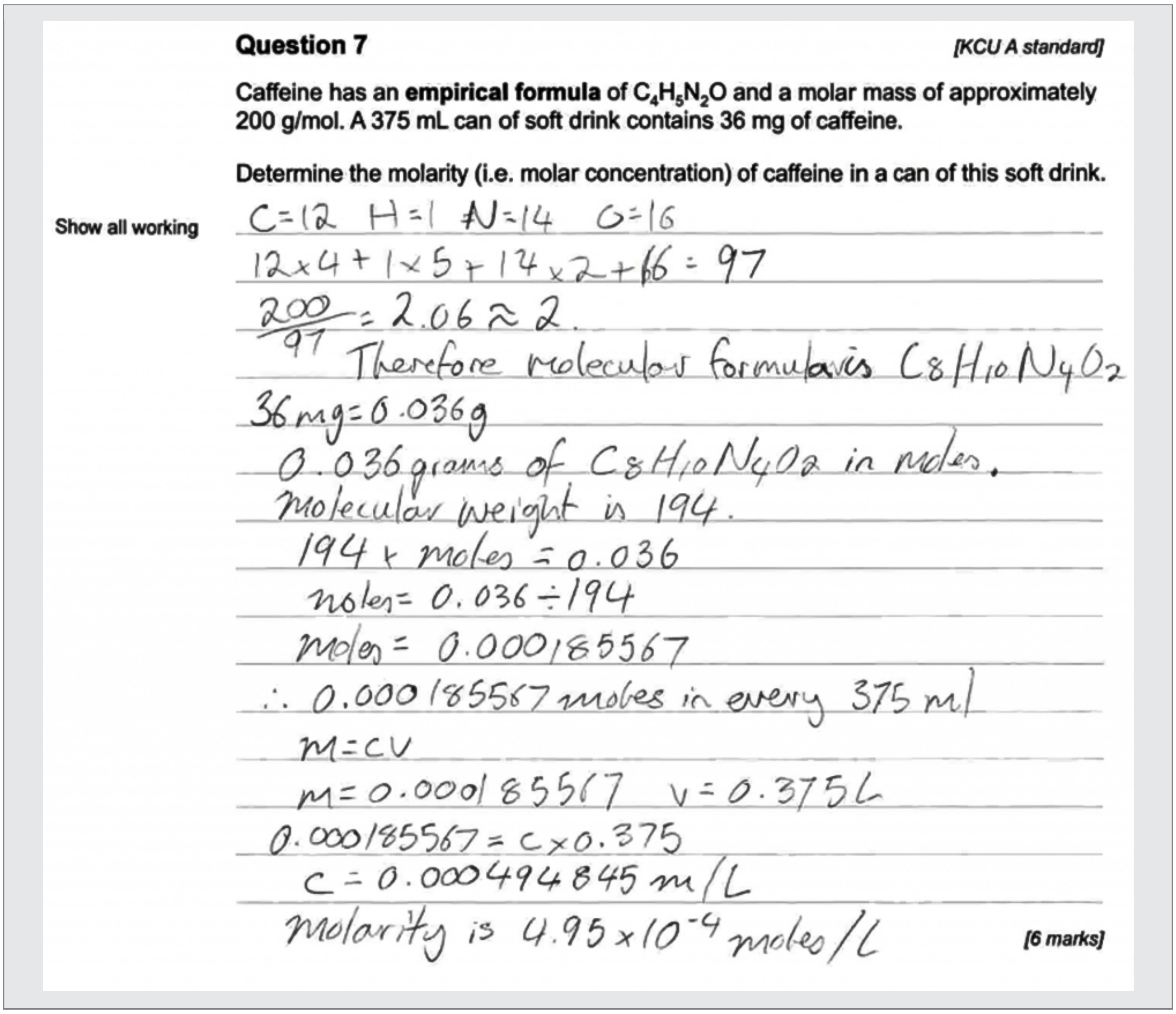
Question 7 required students to link and apply concepts and algorithms to find solutions in a complex and challenging situation related to empirical formulas, empirical formula mass, molar mass and molarity. Marks were awarded for:

- using an appropriate algorithm to determine the empirical formula mass
- using an appropriate algorithm to determine the molar mass based on the empirical formula mass calculated
- converting the mass of caffeine from milligrams to grams
- using an appropriate algorithm to determine the number of moles of caffeine based on molar mass determined and mass of caffeine
- converting the volume from millilitres to litres
- determining the molarity of caffeine.

Over 69% of students were able to correctly determine the molar mass from the empirical formula mass, and many used this to correctly determine the number of moles of caffeine in the can of soft drink.

A common error was to use the empirical formula mass as the molar mass. Some students were not able to correctly convert the units (i.e. mg to g and mL to L).

Sample response



Question 7 ***[KCU A standard]***

Caffeine has an **empirical formula** of $C_4H_5N_2O$ and a molar mass of approximately 200 g/mol. A 375 mL can of soft drink contains 36 mg of caffeine.

Determine the molarity (i.e. molar concentration) of caffeine in a can of this soft drink.

Show all working

$C=12 \quad H=1 \quad N=14 \quad O=16$

$12\times4+1\times5+14\times2+16=97$

$\frac{200}{97}=2.06\approx2.$

Therefore molecular formula is $C_8H_{10}N_4O_2$

36mg=0.036g

0.036 grams of $C_8H_{10}N_4O_2$ in moles.

molecular weight is 194.

194 × moles = 0.036

moles = 0.036 ÷ 194

moles = 0.000185567

∴ 0.000185567 moles in every 375 ml

$m=cv$

$m=0.000185567 \quad v=0.375L$

$0.000185567=c\times0.375$

$c=0.000494845$ m/L

Molarity is 4.95×10^{-4} moles/L

[6 marks]

Question 8

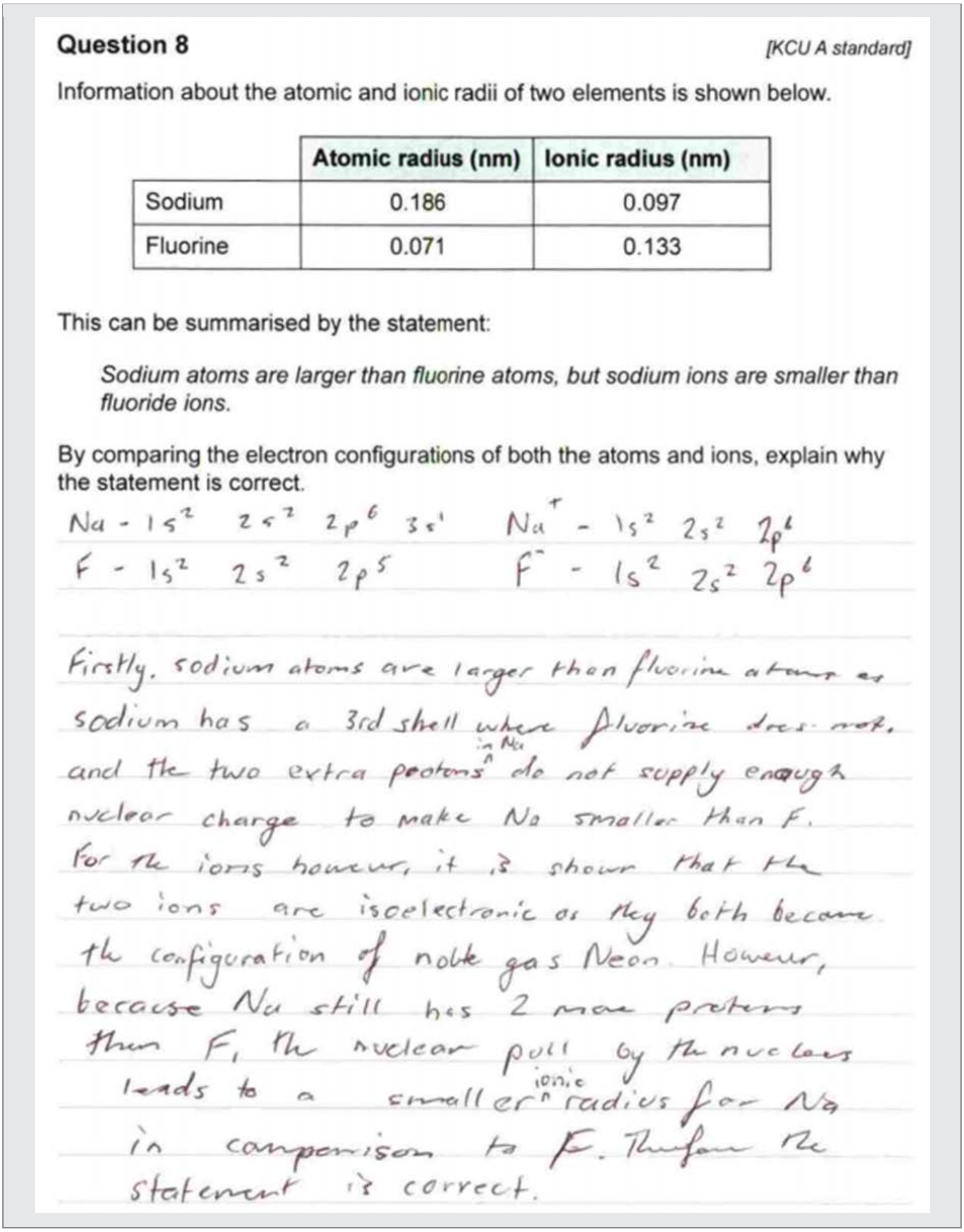
Question 8 required students to reproduce and interpret complex concepts and phenomena, apply theories to find solutions and compare and explain complex concepts and phenomena related to electron configuration, atomic radius and ionic radius. Marks were awarded for:

- correctly stating the electron configurations for the atoms
- identifying that a sodium atom has one more electron shell than a fluorine atom
- linking the number of electron shells to the atomic radii of the atoms, i.e. sodium is larger than fluorine
- identifying that sodium ions and fluoride ions have the same electron configuration
- identifying that sodium ions have more protons than fluoride ions
- appropriately linking the number of protons to the size of the attraction between valence electrons and the nucleus
- concluding that a sodium ion will have a smaller ionic radius than a fluoride.

The steps that students most commonly completed correctly were stating the electron configurations of the species and the number of shells and comparing the radii of the sodium and fluorine atoms.

A common error was that students compared the radii of the atoms with each other and compared the ions with each other, but did not compare the sodium atom with the sodium ion or the fluorine atom with the fluoride ion. Many students did not connect the concept of increased nuclear charge with greater electrostatic attraction and therefore relate this to atomic and ionic radii.

Sample response



Question 8

[KCU A standard]

Information about the atomic and ionic radii of two elements is shown below.

	Atomic radius (nm)	Ionic radius (nm)
Sodium	0.186	0.097
Fluorine	0.071	0.133

This can be summarised by the statement:

> *Sodium atoms are larger than fluorine atoms, but sodium ions are smaller than fluoride ions.*

By comparing the electron configurations of both the atoms and ions, explain why the statement is correct.

Na - $1s^2\ 2s^2\ 2p^6\ 3s^1$ Na^+ - $1s^2\ 2s^2\ 2p^6$

F - $1s^2\ 2s^2\ 2p^5$ F^- - $1s^2\ 2s^2\ 2p^6$

Firstly, sodium atoms are larger than fluorine atoms as sodium has a 3rd shell where fluorine does not, and the two extra protons in Na do not supply enough nuclear charge to make Na smaller than F. For the ions however, it is shown that the two ions are isoelectronic as they both become the configuration of noble gas Neon. However, because Na still has 2 more protons than F, the nuclear pull by the nucleus leads to a smaller ionic radius for Na in comparison to F. Therefore the statement is correct.

Question 9

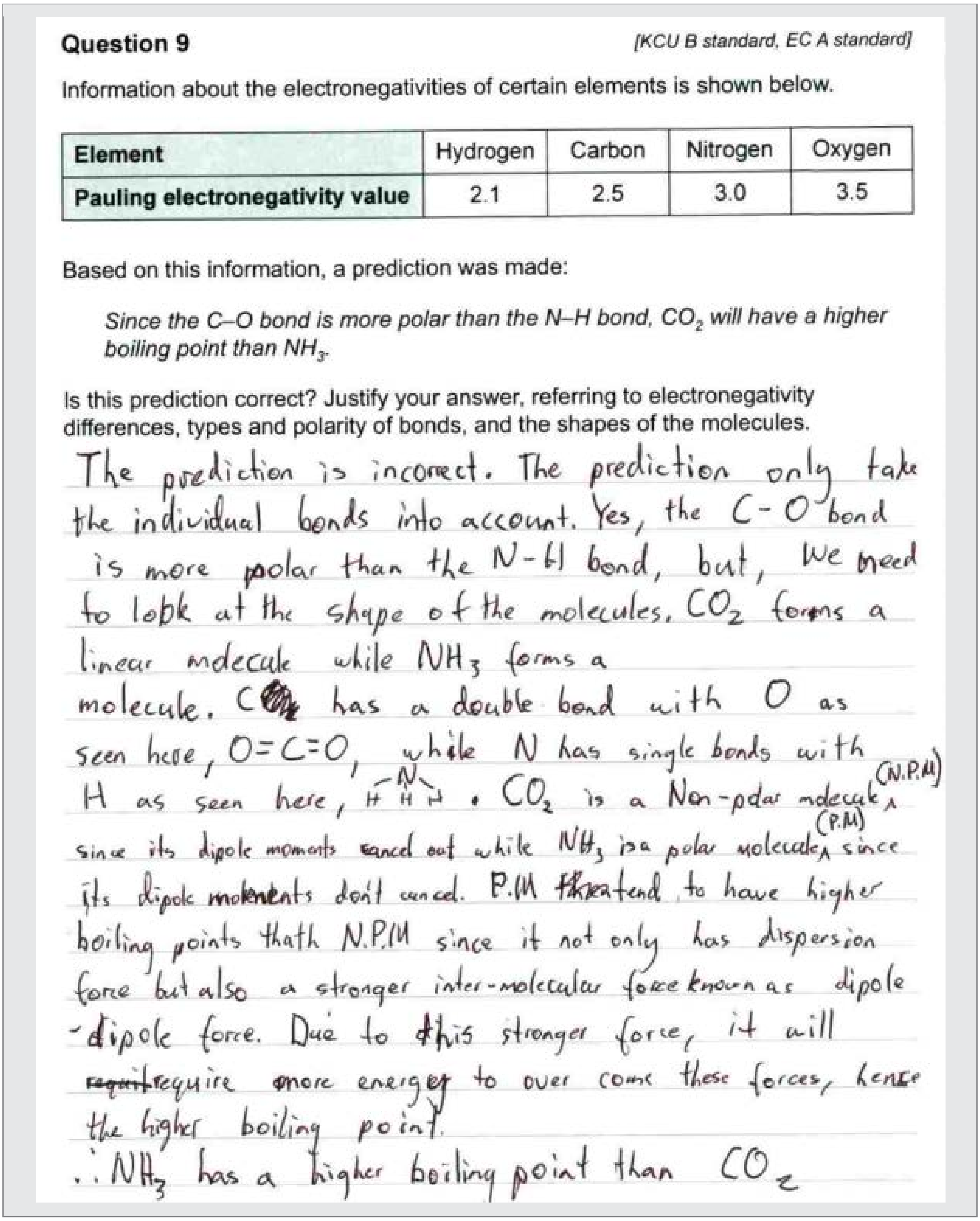
Question 9 required students to reproduce and interpret complex concepts and phenomena, apply algorithms and theories to find solutions and analyse and evaluate complex interrelationships related to intramolecular bonds, electronegativity, bond polarity, shapes of molecules, intermolecular bonds and physical properties. Marks were awarded for:

- using an appropriate algorithm to determine the electronegativity differences for the intramolecular covalent bonds
- identifying the linear shape of CO_2
- identifying the pyramidal shape of NH_3
- identifying that stronger intermolecular forces result in a higher boiling point
- identifying that, due to the differences in electronegativity of their atoms, the intramolecular bonds in CO_2 and NH_3 are both polar
- determining that the C–O bond is more polar than the N–H bond because it has a greater electronegativity difference
- identifying that the CO molecule is non-polar because its dipole moments cancel out
- classifying the bonds between CO_2 molecules as Van der Waal’s or London dispersion or instantaneous dipole-dipole forces
- identifying that the NH_3 molecule is polar because its dipole moments do not cancel out
- classifying the bonds between NH_3 molecules as hydrogen bonds
- identifying that the bonding between CO_2 molecules is weaker than bonding between NH_3 molecules
- concluding that the boiling point of CO_2 is lower than the boiling point of NH_3 and therefore the stated prediction is incorrect.

The aspects of this question that students handled best were identification of the shapes of carbon dioxide and ammonia and recognising that polar bonds are formed when the atoms in the bond have significantly different electronegativities.

Commonly, students neglected to calculate the electronegativity differences in the intramolecular bonds. Students also often confused the terms *intermolecular* and *intramolecular* and hence stated that the difference in boiling point was due to a difference in the number or strength of the bonds **within** the molecules as opposed to the bonds **between** the molecules.

Sample response



Question 9 *[KCU B standard, EC A standard]*

Information about the electronegativities of certain elements is shown below.

Element	Hydrogen	Carbon	Nitrogen	Oxygen
Pauling electronegativity value	2.1	2.5	3.0	3.5

Based on this information, a prediction was made:

> *Since the C–O bond is more polar than the N–H bond, CO_2 will have a higher boiling point than NH_3.*

Is this prediction correct? Justify your answer, referring to electronegativity differences, types and polarity of bonds, and the shapes of the molecules.

The prediction is incorrect. The prediction only take the individual bonds into account. Yes, the C-O bond is more polar than the N-H bond, but, We need to lobk at the shape of the molecules. CO_2 forms a linear molecule while NH_3 forms a molecule. C[illegible] has a double bond with O as seen here, O=C=O, while N has single bonds with H as seen here, $\overset{N}{H\ H\ H}$. CO_2 is a Non-polar molecule (N.P.M) since its dipole moments cancel out while NH_3 is a polar molecule (P.M) since its dipole moments don't cancel. P.M tend to have higher boiling points thath N.P.M since it not only has dispersion force but also a stronger inter-molecular force known as dipole-dipole force. Due to this stronger force, it will ~~requi~~require more energey to over come these forces, hence the higher boiling point.

∴ NH_3 has a higher boiling point than CO_2

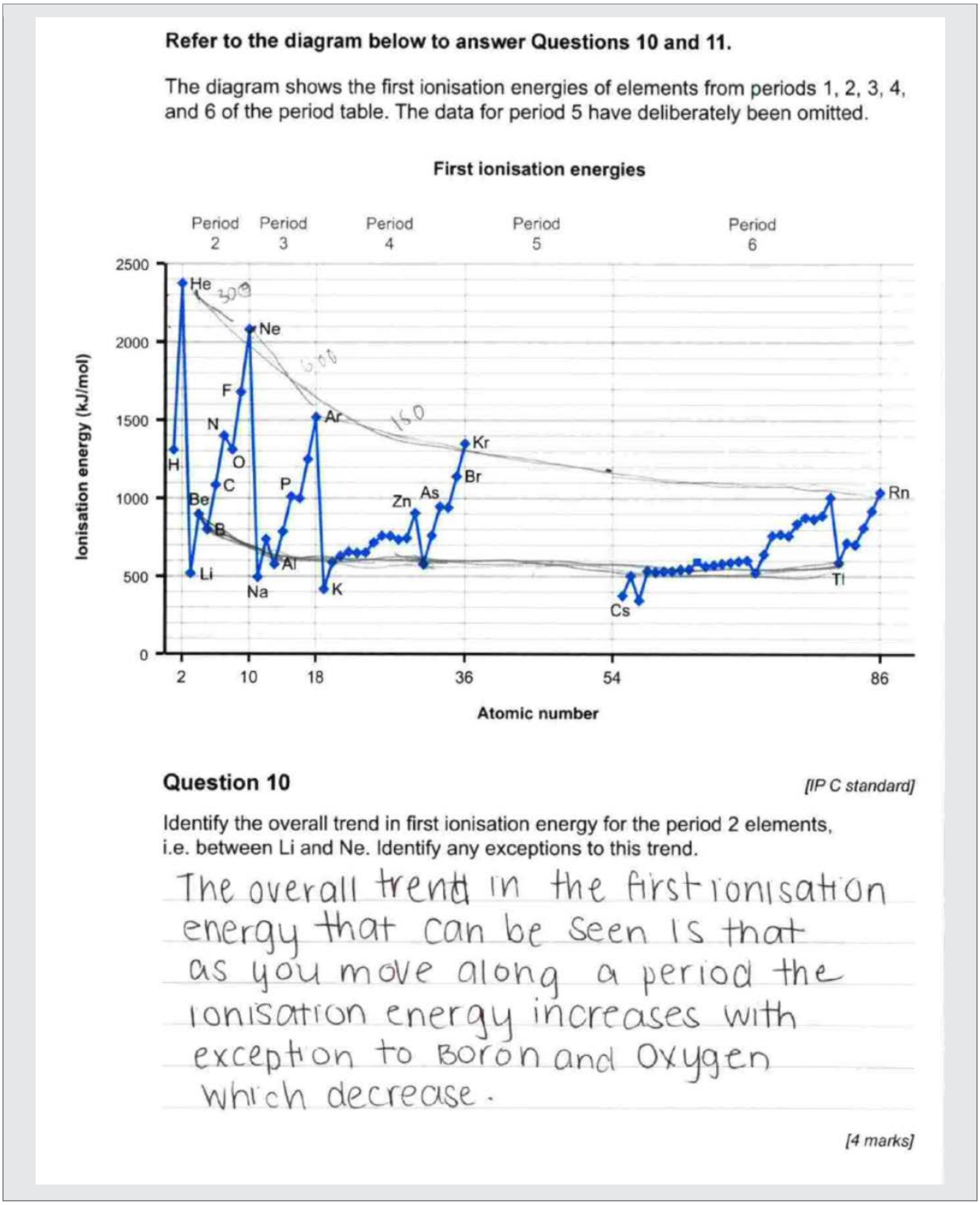
Question 10

Question 10 required students to analyse secondary data to identify trends related to first ionisation energy and periodic trends. Marks were awarded for:

- identifying that the first ionisation energy increases as atomic number increases
- identifying boron and oxygen as exceptions to this trend.

More than three quarters of students were able to identify the increasing trend for ionisation energy. Common errors were failing to relate this to the periodic trend of the period 2 elements, and not identifying exceptions to this periodic trend.

Sample response



Refer to the diagram below to answer Questions 10 and 11.

The diagram shows the first ionisation energies of elements from periods 1, 2, 3, 4, and 6 of the period table. The data for period 5 have deliberately been omitted.

Question 10 *[IP C standard]*

Identify the overall trend in first ionisation energy for the period 2 elements, i.e. between Li and Ne. Identify any exceptions to this trend.

The overall trend in the first ionisation energy that can be seen is that as you move along a period the ionisation energy increases with exception to Boron and Oxygen which decrease.

[4 marks]

Question 11

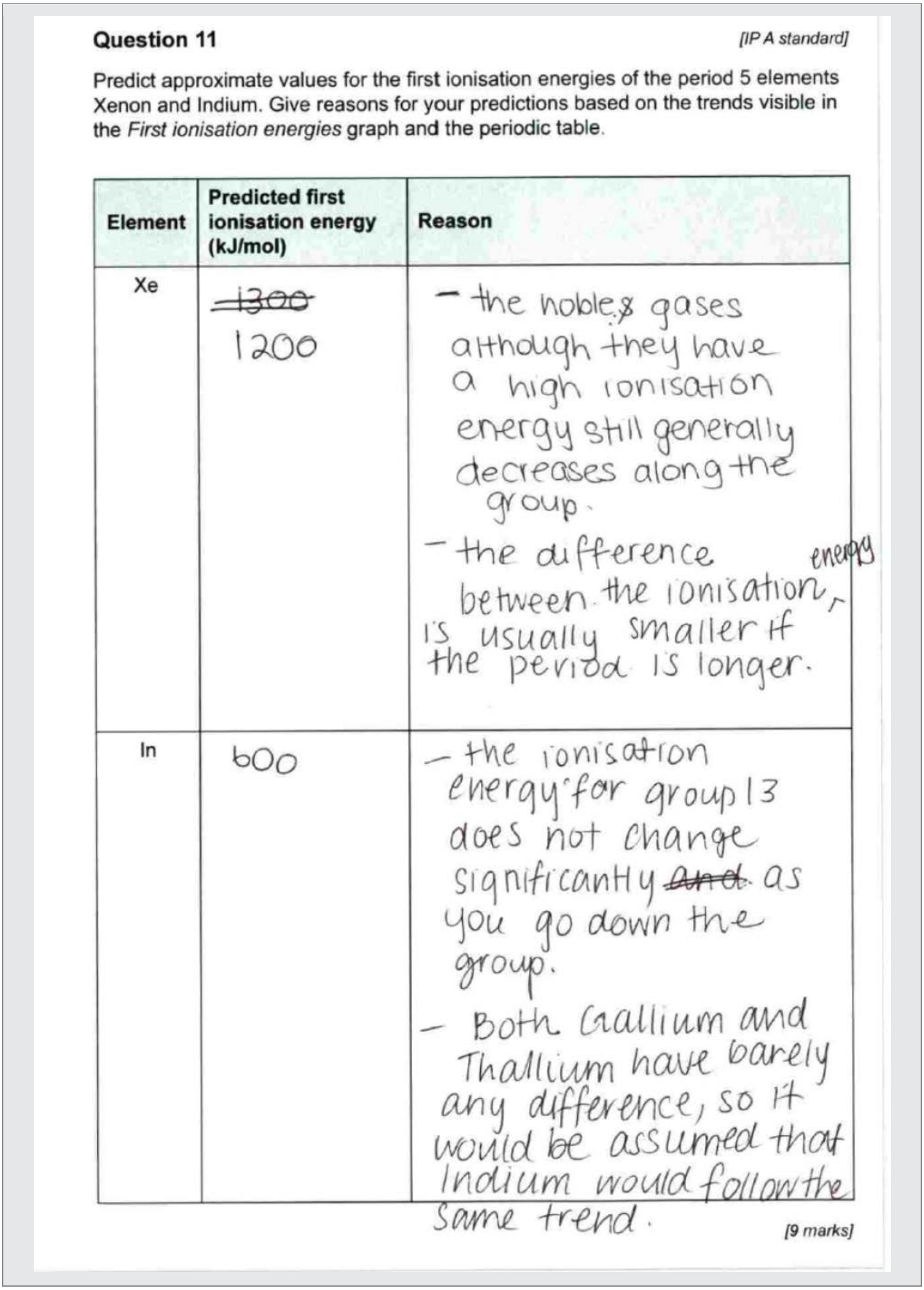
Question 11 required students to systematically analyse secondary data to identify relationships between trends in atomic number, electron configuration and first ionisation energy. Marks were awarded for:

- stating a first ionisation energy for xenon in the range 1100–1200 kJ/mol
- identifying that xenon is a noble gas
- identifying that the first ionisation energy decreases down the group of noble gases
- determining that the first ionisation energy for xenon lies between the first ionisation energy for krypton (~1350 kJ/mol) and radon (~1050 kJ/mol)
- identifying that the decreasing trend in first ionisation energy for noble gases is non-linear
- stating a first ionisation energy for indium in the range 550–600 kJ/mol
- identifying that indium is located in group 13 of the in periodic table
- identifying that the first ionisation energy of gallium (~550 kJ/mol) is similar to tellurium (~600 kJ/mol)
- identifying that the first ionisation for indium is similar to that of gallium and tellurium.

More than half the students were able to identify that xenon is a noble gas and that the first ionisation energies of the noble gases decrease as their atomic numbers increase.

A common error was providing insufficient reasoning to support predictions. Many students did not identify the non-linear trend for the first ionisation energies for the noble gases or the relationship between atomic number, electron configuration and first ionisation energies.

Sample response



Question 11 *[IP A standard]*

Predict approximate values for the first ionisation energies of the period 5 elements Xenon and Indium. Give reasons for your predictions based on the trends visible in the *First ionisation energies* graph and the periodic table.

Element	Predicted first ionisation energy (kJ/mol)	Reason
Xe	~~1300~~ 1200	- the noble~~s~~ gases although they have a high ionisation energy still generally decreases along the group. - the difference between the ionisation energy is usually smaller if the period is longer.
In	600	- the ionisation energy for group 13 does not change significantly ~~and~~ as you go down the group. - Both Gallium and Thallium have barely any difference, so it would be assumed that Indium would follow the same trend.

[9 marks]

Question 12

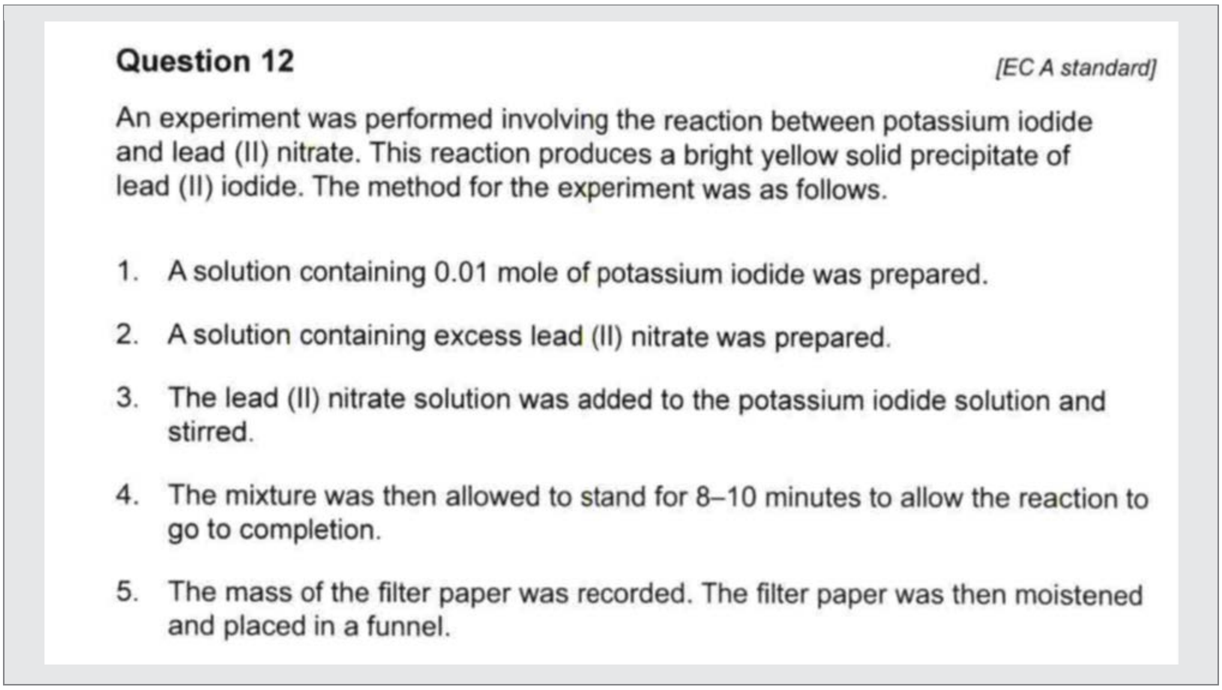
Question 12 required students to explore scenarios and possible outcomes related to theoretical yield, experimental design and sources of experimental error. Marks were awarded for:

- identifying a source of error that would increase yield, such as:
  - the filter paper was still wet
  - more than 0.01 moles of potassium iodide were reacted because the solution was too concentrated or the volume was too large
- identifying two sources of error that would decrease yield, such as:
  - the reaction did not go to completion
  - some of the product was lost because it passed through the filter paper or was not washed out of the reacting flask
  - less than 0.01 moles of potassium iodide were reacted because the solution was too weak or the volume was too small
  - the lead nitrate solution was not in excess
- providing valid justifications for how the sources of error would affect the yield.

Most students were able to identify one source of experimental error that could increase the yield and one source of experimental error that could decrease the yield.

Common errors included identifying a source of experimental error that could lead to an increase or a decrease in yield without providing supporting justification. Some students identified a source of experimental error that would increase the yield in Question 12a and then described the same source of error again as the justification in Question 12b.

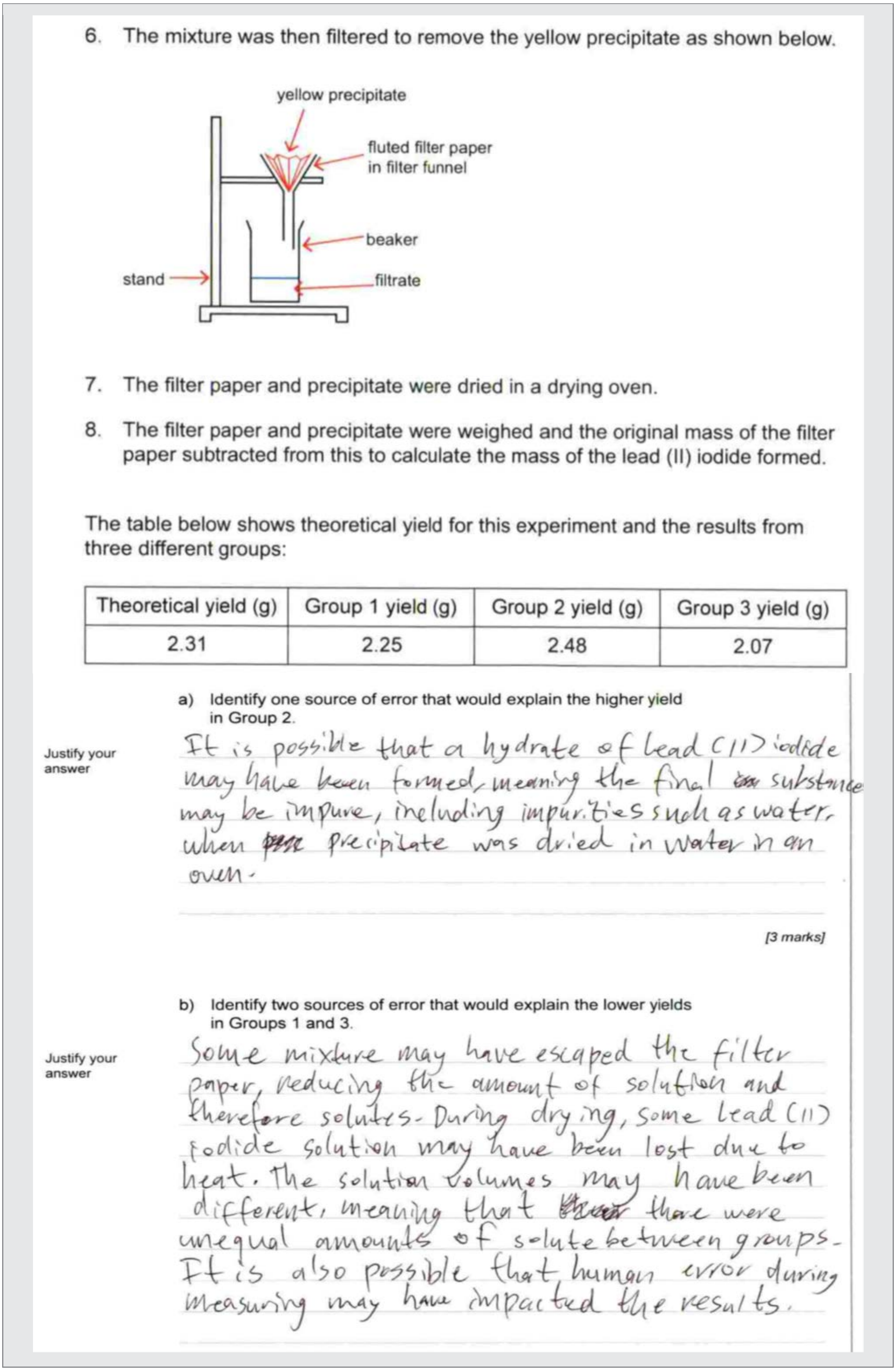
Sample response



Question 12 *[EC A standard]*

An experiment was performed involving the reaction between potassium iodide and lead (II) nitrate. This reaction produces a bright yellow solid precipitate of lead (II) iodide. The method for the experiment was as follows.

1. A solution containing 0.01 mole of potassium iodide was prepared.
2. A solution containing excess lead (II) nitrate was prepared.
3. The lead (II) nitrate solution was added to the potassium iodide solution and stirred.
4. The mixture was then allowed to stand for 8–10 minutes to allow the reaction to go to completion.
5. The mass of the filter paper was recorded. The filter paper was then moistened and placed in a funnel.



6. The mixture was then filtered to remove the yellow precipitate as shown below.

7. The filter paper and precipitate were dried in a drying oven.

8. The filter paper and precipitate were weighed and the original mass of the filter paper subtracted from this to calculate the mass of the lead (II) iodide formed.

The table below shows theoretical yield for this experiment and the results from three different groups:

Theoretical yield (g)	Group 1 yield (g)	Group 2 yield (g)	Group 3 yield (g)
2.31	2.25	2.48	2.07

a) Identify one source of error that would explain the higher yield in Group 2.

Justify your answer

It is possible that a hydrate of lead (II) iodide may have been formed, meaning the final substance may be impure, including impurities such as water, when precipitate was dried in water in an oven.

[3 marks]

b) Identify two sources of error that would explain the lower yields in Groups 1 and 3.

Justify your answer

Some mixture may have escaped the filter paper, reducing the amount of solution and therefore solutes. During drying, some lead (II) iodide solution may have been lost due to heat. The solution volumes may have been different, meaning that there were unequal amounts of solute between groups. It is also possible that human error during measuring may have impacted the results.

Recommendations and guidance

Teachers should ensure that students are able to:

- use the marks allocated and the space provided as a guide to the length of the response required
- recall formulas and definitions and know how to apply them correctly
- set out calculations showing all appropriate steps since marks can be awarded for the correct process even when the numerical values are incorrect
- use appropriate SI units when performing calculations
- read the questions carefully and check that they have answered the question in their response. General responses should be avoided
- write balanced chemical equations
- use correct chemical terminology in their responses.

Appendix 1: Instrument-specific standards matrix

	A	B	C	D	E
	The student work has the following characteristics:				
Knowledge and conceptual understanding (KCU)		• reproduction and interpretation of complex or challenging concepts, theories and principles	• reproduction of concepts, theories and principles	• reproduction of simple ideas and concepts	• reproduction of isolated facts
	• comparison and explanation of complex concepts, processes and phenomena	• comparison and explanation of concepts, processes and phenomena	• explanation of simple processes and phenomena	• description of simple processes and phenomena	• recognition of isolated simple phenomena
	• linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex and challenging situations	• linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex or challenging situations	• application of algorithms, principles, theories and schema to find solutions in simple situations	• application of algorithms, principles, theories and schema	• application of simple given algorithms
Investigative processes (IP)	• systematic analysis of primary and secondary data to identify relationships between patterns, trends, errors and anomalies	• analysis of primary and secondary data to identify patterns, trends, errors and anomalies	• analysis of primary and secondary data to identify obvious patterns, trends, errors and anomalies	• identification of obvious patterns and errors	• recording of data
Evaluating and concluding (EC)	• analysis and evaluation of complex scientific interrelationships	• analysis of complex scientific interrelationships	• description of scientific interrelationships	• identification of simple scientific interrelationships	• identification of obvious scientific interrelationships
	• exploration of scenarios and possible outcomes with justification of conclusions/recommendations	• explanation of scenarios and possible outcomes with discussion of conclusions/recommendations	• description of scenarios and possible outcomes with statements of conclusion/recommendation	• identification of scenarios or possible outcomes	• statements about outcomes

Appendix 2: Glossary of terms

Term	Definition
analyse	break up a whole into its parts; examine in detail to determine the nature of; look more deeply into and detect the relationships between parts[1]
apply	use or employ in a particular situation[2]
calculate	ascertain/determine from given facts, figures or information[2]
compare	display recognition of similarities and differences and recognise the significance of these similarities and differences of[1]
complete	to bring to an end; finish; fulfil[3]
consider	to contemplate mentally; meditate or reflect on[3]
describe	give an account of in speech or writing; convey an idea or impression of; characterise; represent pictorially; depict; trace the form or outline of[1]
determine	come to a resolution or decide[1]
discuss	identify issues and provide points for and/or against[2]
draw	to sketch in lines or words; delineate; depict[3]
evaluate	establish the value, quality, importance, merit, relevance or appropriateness of information, data or arguments based on logic as opposed to subjective preference[1]
explain	make clear or understandable; show knowledge in detail[1]
explore	inquire into or discuss (a subject) in detail; examine or evaluate (an option or possibility)[1]
find (solutions)	to come up with solutions[2]
identify	recognise, name or select[1]
interpret	give meaning to information presented in various forms, e.g. words, symbols, pictures, graphs[1]
justify	provide sound reasons based on logic or theory to support response; prove or show statements are just or reasonable; convince[1]
label	add title, labels or brief explanation(s) to a diagram or graph[4]
link	join; unite[3]
provide	to furnish or supply[3]
recognise	to identify from knowledge of appearance or character[3]
refer	to direct the attention or thoughts of[3]
reproduce	produce again[3]
respond	to react to a person or text (ac terms senior)
rule	to mark with lines, especially parallel straight lines, with the aid of a ruler or the like[3]
show	give steps in a derivation or calculation[4]

Term	Definition
solve	obtain the answer(s) using algebraic and/or numerical and/or graphical methods[4]
state	to declare definitely or specifically[3]

Sources:

[1] Queensland Curriculum and Assessment Authority

[2] Board of Studies, Teaching and Educational Standards New South Wales (BOSTES), *A Glossary of Key Words*, www.boardofstudies.nsw.edu.au/syllabus_hsc/glossary_keywords.html

[3] Macquarie Dictionary online, Macquarie Dictionary Sixth Edition, www.macquariedictionary.com.au

[4] International Baccalaureate, www.ibo.org

[5] Australian Curriculum, *List of verbs used in validated achievement standards, www.australiancurriculum.edu.au*