basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

QUALITATIVE ANALYSIS OF LEARNER RESPONSES
AND
EVALUATION OF THE QUESTION PAPERS (PER PAPER)
NATIONAL SENIOR CERTIFICATE 2025
WESTERN CAPE EDUCATION DEPARTMENT

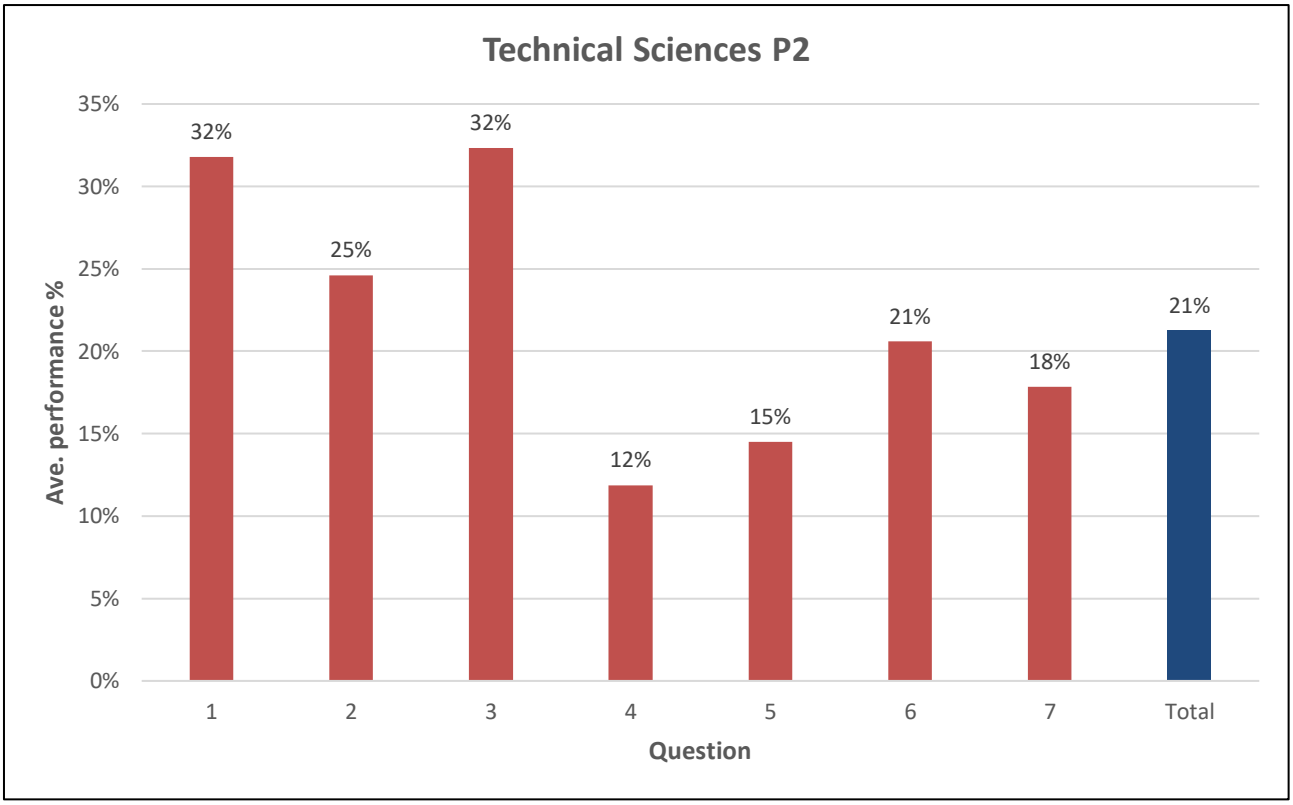
SUBJECT	**TECHNICAL SCIENCES**		
QUESTION PAPER	**1**	**2**	**3**
DURATION OF PAPER	**1.5 HOURS**		
INTERNAL MODERATOR	**MR JULIO R. VOGES (0711231446)**		
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DATES OF MARKING	**FROM: 29 NOVEMBER 2025**	**TO: 10 DECEMBER 2025**	
HEAD OF EXAMINATION	**MS L.M BREDENKAMP**		

REPORT 2: QUALITATIVE ANALYSIS OF LEARNER RESPONSES

SECTION 1: ***(GENERAL OVERVIEW OF LEARNER PERFORMANCE IN THE QUESTION PAPER AS A WHOLE)***

The following data have been obtained during the process of marking a sample of 100 scripts of candidates who were seated at different examination centres within the Western Cape:

Graph & table (below): Western Cape per-question and sub-question analysis of 100 sample scripts.

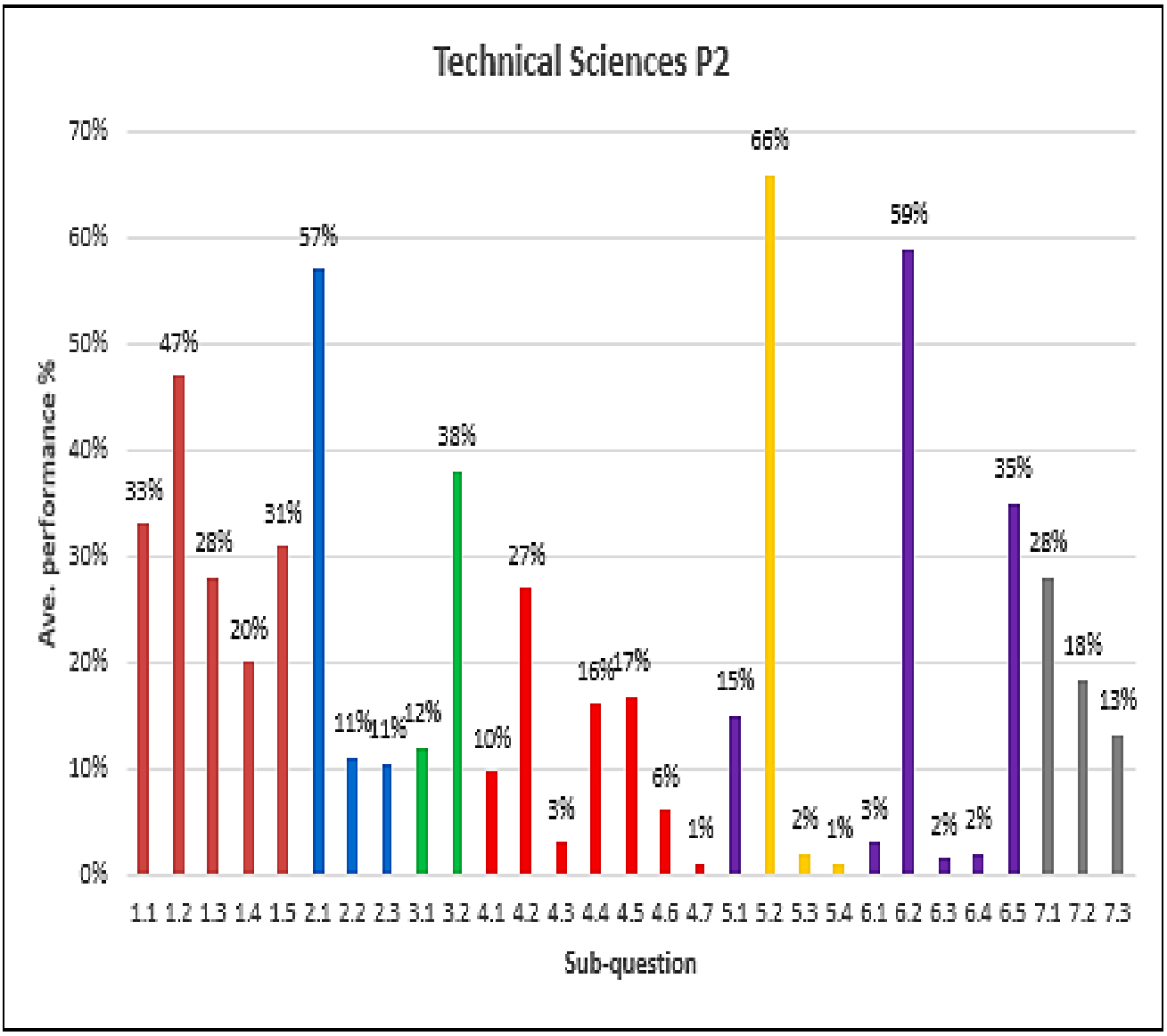


Question	Topic	Ave. performance %
1	Multiple choices	32%
2	Organic chemistry: Nomenclature	25%
3	Organic chemistry: Physical properties	32%
4	Organic chemistry: Organic reactions	12%
5	Matter and Materials: Semiconductors (p-n junction)	15%
6	Electrochemical cells: Electrolytic cell And Alternate energies	21%
7	Electrochemical cells: Galvanic/ Voltaic cell	18%
Total		**21%**

- Despite the noticeable effort made by the examiner panel to secure a well-balanced paper in terms of catering for all cognitive demands within its prescribed weightings, candidate performance was still not desirable, as summarised below:
  - Only 10 candidates met the pass requirements of minimum 30% for the paper.
  - None of the candidates showed a level of high performance *(i.e., 60% and above)*, and the rest performed as follow: 7 candidates obtained moderate achievements between 40% and 59%; and the other 3 candidates scored a very low mark of between 30% and 39%. Unfortunately, the remaining 90 candidates whose scripts have been used for Rasch diagnostic purposes performed within the

low achievement range of 29% and below.

- Findings pertaining to the performance per-question and sub-questions *(as displayed in the table below)* will be extensively discussed in the sections that follow.

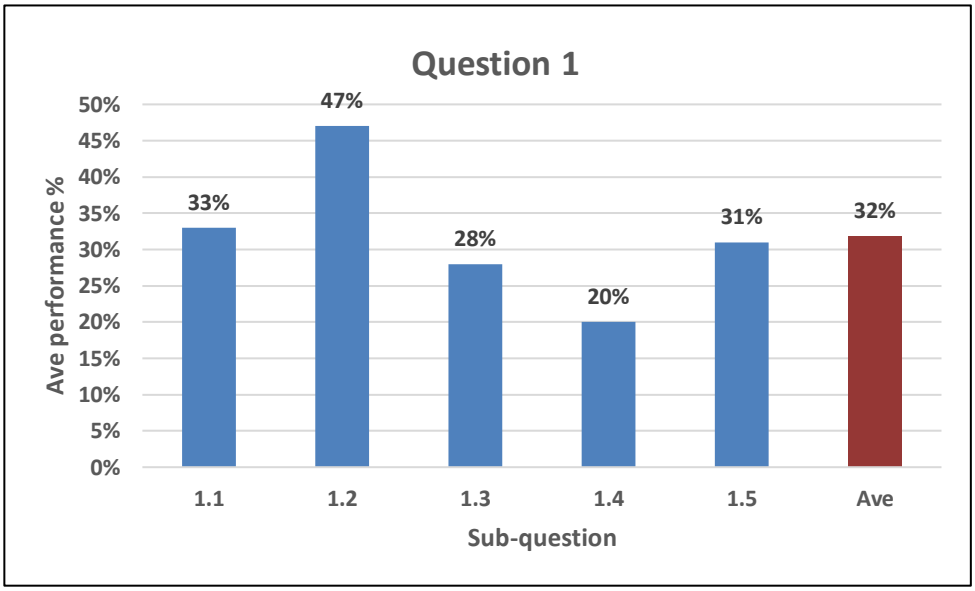


SECTION 2: ***COMMENT ON CANDIDATES' PERFORMANCE IN INDIVIDUAL QUESTIONS***

(It is expected that a comment will be provided for each question)

QUESTION 1

(a) General comment on the performance of learners in the specific question. Was the question well answered or poorly answered?



Summary of candidate performance in question 1:

Sub-question	Topic	Ave. performance %
1.1	Identifying the reaction type used to prepare propane from propene	33%
1.2	Listing compounds according to decreasing boiling points	47%
1.3	Identifying a saturated hydrocarbon from condensed structural formulae	28%
1.4	Elements used for doping	20%
1.5	Statements concerned with electrochemistry	31%

Performance for Question 1 was moderate, with an overall Rasch performance average of 32%. Although this is slightly higher than the averages of many other questions in the paper, the performance remains below the proficiency threshold, indicating that foundational organic chemistry, physical properties, semiconductors, and electrochemical principles are not fully mastered.

Performance varied across sub-questions:

- Best performance: Q1.2 (47%)
- Poorest performance: Q1.4 (20%)
- The rest of the questions fell between 28 – 33%

These results indicate that learners cope better with familiar recognition-based questions (e.g., boiling points) but show significant conceptual weaknesses in reaction types, saturated hydrocarbons, doping of semiconductors, and electrochemical principles.
Thus, the question can be considered moderately but not satisfactorily answered.

(b) Why was the question answered poorly? Also provide specific examples, indicate common errors committed by learners in this question, and any misconceptions.

Candidates still leave multiple-choice questions unattended, although by simply choosing one of the options having a 25% chance of scoring 2 marks per sub-question. Other challenges related to each of the five multiple choice questions in the paper include the following:

1. Reaction type used to convert propene to propane (33%)
Many learners were unable to identify **hydrogenation** as the reaction type.

Common errors

- Choosing **oxidation** or **halogenation**, showing confusion between reaction families.
- Selecting **hydrolysis**, indicating misunderstanding of addition reactions.
- Not recognising that **alkenes → alkanes** require adding hydrogen (H_2).

Misconception
Learners do not fully grasp that **hydrogenation saturates a molecule**, converting C=C to C–C.

2. Boiling point trends (47%) – best performance
This was the most accessible question, though still below 50%.

Common errors

- Incorrectly ranking alcohols vs acids due to misunderstanding hydrogen bonding.
- Believing longer chains *always* have lower boiling points.
- Confusing the effect of branching vs functional groups.

Misconception
Learners do not consistently apply **intermolecular force strength** (H-bonding > dipole–dipole > dispersion) when comparing boiling points.

3. Identifying a saturated hydrocarbon (28%)
Less than one-third of learners correctly identified the option containing only single bonds.

Common errors

- Selecting a molecule with a double bond (C=C) due to misreading condensed structural formulas.
- Associating "more H atoms" with being saturated.
- Not recognising that saturated hydrocarbons = **alkanes** only.

Misconception
Learners confuse **structural formula reading** with "guessing" based on appearance.

4. Doping materials for semiconductors (20%) – poorest performance
This is an area of chronic weakness across Technical Sciences nationally.

Common errors

- Incorrectly choosing At, N, S instead of correct trivalent (B) or pentavalent (As) dopants.
- Misinterpreting the periodic table valencies.
- Thinking any non-metal can act as a dopant.
- Confusing trivalent/pentavalent dopants with oxidation states rather than valence electrons.

Misconception

Learners have a weak grasp of:

- p-type vs n-type semiconductors
- The role of trivalent vs pentavalent dopants
- How crystal lattice structure changes when doped

This mirrors the conceptual weaknesses seen in **Question 5 (Diodes)**.

5. Evaluating statements about galvanic/electrolytic cells (31%)

Learners struggled with multi-statement logic.

Common errors

- Thinking the anode is always positive (incorrect for galvanic cells).
- Believing oxidation happens at the negative electrode in all cells.
- Not recognising electroplating as an **electrolytic** process.

Misconception

Learners memorise electrode behaviours without understanding the difference between **spontaneous (galvanic)** and **non-spontaneous (electrolytic)** systems.

(c) Provide suggestions for improvement in relation to Teaching and Learning.

1. Reinforce reaction patterns using visual reaction maps

Create summary sheets showing:

- Hydrogenation = addition of H_2
- Halogenation = addition of X_2
- Hydrolysis = addition of water
- Oxidation = increase in oxygen / decrease in hydrogen

This supports Q1.1.

2. Teach boiling point trends using comparative tables and molecular models

Focus on:

- Functional group strength (H-bonding > dipole-dipole > dispersion)
- Chain length vs branching
- Real-world examples (ethanol vs propanol vs pentanol)

This improves Q1.2.

3. Strengthen structural formula literacy

Learners should practise:

- Identifying double and triple bonds
- Distinguishing alkanes, alkenes, and alkynes
- Building models of hydrocarbon structures

This supports Q1.3 and conceptual fluency in organic chemistry.

4. Provide explicit instruction on semiconductor doping

Use:

- Colour-coded periodic table (Group 13 = trivalent; Group 15 = pentavalent)
- Visual models showing "holes" vs "extra electrons"
- Examples: B-doped silicon = p-type; As-doped silicon = n-type

Clearer conceptual teaching will improve Q1.4.

5. Use electrochemical acronyms in classroom practice

Introduce and revise the following repeatedly:

- **OILRIG**: Oxidation Is Loss, Reduction Is Gain
- **ANOX**: ANOde = OXidation
- **REDCAT**: REDuction = CAThode
- **PANIC**: Positive Anode, Negative Is Cathode *(for electrolytic cells)*

These drastically improve performance on Q1.5.

6. Incorporate multi-statement reasoning practice

Teachers should use:

- True/false grids
- Statement evaluation ("Which combination is correct?")
- Justification exercises

This prepares learners for questions like Q1.5.

(d) Describe any other specific observations relating to responses of learners and comments that are useful to teachers, subject advisors, teacher development etc.

1. Foundational chemistry knowledge is fragmented

Learners show partial recall of facts but weak conceptual integration.
This pattern appears across Questions 1–6.

2. Structural formula interpretation needs far more emphasis

Many errors stem from difficulty reading molecular formulas, especially in organic chemistry.

3. Semiconductor content requires significant teacher development

Low performance in Q1.4 aligns with very low performance in Question 5.
This suggests:

- Teachers may lack depth of knowledge
- The topic is often rushed
- Learners have minimal exposure to real-world semiconductor applications

Subject advisors should prioritise workshops on doping and p–n junction behaviour.

4. Learners confuse galvanic vs electrolytic cells consistently

This suggests a need for:

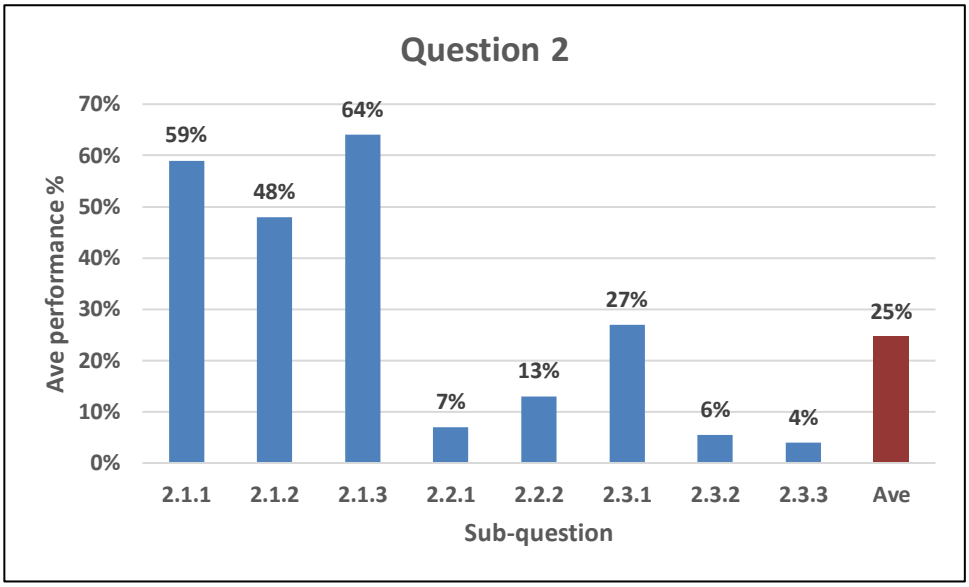
- Stronger conceptual teaching
- Comparative tables
- Hands-on modelling of electron and ion flow

5. Multi-step reasoning questions require explicit training

Learners struggle when applying several concepts simultaneously, as seen in Q1.5.

QUESTION 2

(a) General comment on the performance of learners in the specific question. Was the question well answered or poorly answered?



Summary of candidate performance in question 2:

Sub-question	Topic	Ave. performance %
2.1.1	Identifying a saturated hydrocarbon	59%
2.1.2	Identifying an isomer of but-2-ene	48%
2.1.3	Identifying an alkyne	64%
2.2.1.	Writing the name of a functional group	7%
2.2.2	Writing the IUPAC name of a given compound	13%
2.3.1	Naming the homologous series of a compound	27%
2.3.2	Drawing of a structural formula	6%
2.3.3	Writing of a general formula	4%

Question 2 was poorly answered, with an average score of 25% across a sample of 100 candidates.

While learners performed reasonably well on basic identification questions in Section 2.1 (59%, 48%, 64%), performance dropped sharply in the application-based components of the question. Sub-questions requiring naming, writing structural formulae, identifying functional groups, or recalling general formulae (2.2 and 2.3) scored between 4% and 13%, indicating substantial conceptual gaps.

This pattern shows that learners have surface-level familiarity with visual organic structures (e.g., identifying alkanes/alkenes/alkynes) but experience major difficulty when deeper chemical reasoning, interpretation, or systematic rules are required.

(b) Why was the question answered poorly? Also provide specific examples, indicate common

errors committed by learners in this question, and any misconceptions.
The extremely low performance in Q2.2.1 (7%) indicates that many learners could not identify the ketone functional group. Common errors / misconceptions: • Frequently naming the group as a carboxyl group instead of a carbonyl/ketone. • Confusing the functional group because of unfamiliarity with structural representations. • Associating any oxygen-containing group with "carboxyl" due to rote learning rather than conceptual understanding. Q2.2.2 recorded only 13%, showing lack of mastery of naming conventions. Common errors: • Incorrect use of hyphens and commas (e.g., writing "2 brom 2 methyl propane" or "2-brom,2methylpropane"). • Leaving out position numbers for substituents. • Incorrectly identifying the prefix (substituent) and suffix (functional group). • Misidentifying the longest carbon chain. • These errors reflect poor procedural knowledge and limited practice with multi-step naming tasks. Performance on Q2.3 was exceptionally low: • 2.3.1 (27%) – homologous series • 2.3.2 (6%) – structural formula • 2.3.3 (4%) – general formula Common errors: Learners did not know the structure of an ester, often drawing: • Combinations of alkyl groups • Carboxylic acids instead of esters • Random attachments of oxygen atoms • Learners showed no understanding of the two-part nature of esters: o Alkyl group (from alcohol) o Acyl group (from carboxylic acid) Misconceptions: • Believing the molecular formula of ethyl butanoate is the same as the general formula. • Confusing the functional group −COO− with the carboxyl group −COOH. • Treating ester naming as identical to alkane/alkene naming rules. • These misconceptions suggest a lack of foundational teaching on esterification and homologous series. These errors portray a limited ability from candidates to move from names ↔ structures ↔ formulae. This suggests a weak representational fluency, a key skill in organic chemistry. Learners struggled to: • Convert the IUPAC name into a structural formula. • Infer a general formula from a homologous series.

- Interpret structures into correct chemical names.

(c) Provide suggestions for improvement in relation to Teaching and Learning.

1. Strengthen functional group literacy

Teachers should:

- Use visual grouping charts to differentiate carbonyl, carboxyl, ester, alcohol, and halogen functional groups.
- Provide multiple structural representations: condensed, expanded, and skeletal.
- Use comparison tables to highlight key structural differences.

2. Explicit teaching of IUPAC naming rules

Include structured lessons on:

- Longest chain identification
- Numbering rules
- Prefixes (substituents) and suffixes (functional groups)
- Proper punctuation (hyphens for numbers-to-letters, commas for numbers)
- Step-by-step scaffolded practice moving from structure → name and name → structure.

3. Improve conceptual understanding of ester formation

Teaching recommendations:

- Demonstrate esterification using simulations, models, or real-life examples (odours, flavourings).
- Teach the breakdown:
    - Alcohol → alkyl group
    - Carboxylic acid → acyl group
- Provide repeated exercises where learners must build esters from given alcohols and acids.

4. Develop representational fluency

Learners should practise converting:

- Name → structural formula
- Structural formula → general formula
- Condensed → expanded → skeletal forms

Use progressively graded exercises, moving from simple to complex structures.

5. Use error analysis as a teaching tool

Provide learners with incorrect examples (like the common errors above) and ask them to correct the mistakes. This builds metacognitive awareness and addresses misconceptions actively.

(d) Describe any other specific observations relating to responses of learners and comments that are useful to teachers, subject advisors, teacher development etc.

1. Learners rely on rote memorization rather than conceptual understanding

High scores in basic identification (2.1) but extremely low scores in applied tasks (2.2 and 2.3) show that learners can recall facts but cannot use them meaningfully.

2. Structural organic chemistry is a critical weakness

Teachers need support in teaching:

- Drawing structures correctly
- Understanding functional groups
- Teaching homologous series beyond alkanes/alkenes/alkynes

This suggests the need for CAPS-aligned teacher development workshops in organic chemistry pedagogy.

3. Terminology and notation require explicit reinforcement

Misuse of hyphens, commas, and numbering indicates that learners do not understand the significance of chemical notation.

Teachers should emphasize:

- Accuracy
- Convention
- Communication of chemical meaning

4. Assessment tasks may not provide enough scaffolded progression

Learners appear unfamiliar with tasks that require multi-step reasoning.

Teachers may need:

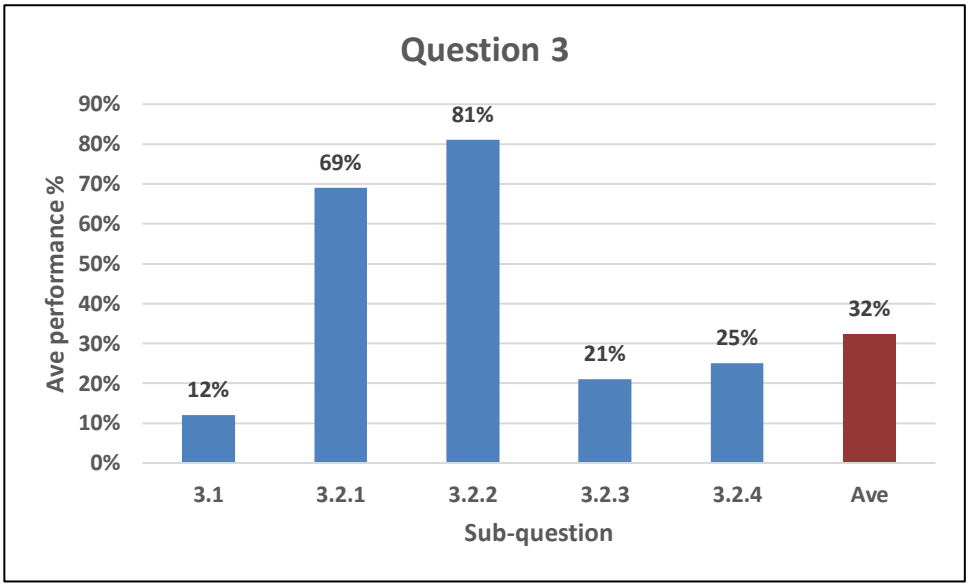
- More structured practice activities
- Clear modelling of thought processes
- Consolidation exercises before moving to complex organic reactions and naming

***5.* There is a possible language barrier in describing functional groups and structural features**

Some errors suggest that learners may not fully grasp the terminology (e.g., "carbonyl", "alkyl"). Glossaries, bilingual terminology charts, and concrete visual aids may assist.

QUESTION 3

(a) General comment on the performance of learners in the specific question. Was the question well answered or poorly answered?



Summary of candidate performance in question 3:

Sub-question	Topic	Ave. performance %
3.1	Defining the term vapour pressure	12%
3.2.1	Effect of increasing temperature on vapour pressure	69%
3.2.2	Identifying the compound with a given boiling point	81%
3.2.3	Providing a reason for the previous response	21%
3.2.4	Identifying the compound with the longest chain length and providing an explanation	25%

Question 3 was poorly answered, with an average score of 32% across the sample.
Performance varied significantly across sub-questions:

- Learners performed well in questions requiring direct reading from the graph (3.2.1: 69%; 3.2.2: 81%).
- Learners performed very poorly in questions requiring conceptual understanding, explanation, or the ability to apply theoretical principles (3.1: 12%; 3.2.3: 21%; 3.2.4: 25%).

This pattern shows that while learners can interpret surface-level graphical information, they struggle with the underlying scientific principles linking temperature, vapour pressure, boiling point, chain length, and intermolecular forces.

Thus, the question was poorly answered overall, primarily due to conceptual weaknesses rather than difficulty with graphs or numerical interpretation.

(b) Why was the question answered poorly? Also provide specific examples, indicate common errors committed by learners in this question, and any misconceptions.

1. Poor understanding of vapour pressure definition (Q3.1 – 12%)
Learners struggled to provide a scientifically correct definition.

Common errors:

- Omitting the word "pressure", leading to incomplete or meaningless definitions.
- Writing "the point at which a liquid evaporates" — confusing vapour pressure with boiling point.
- Omitting the requirement of a closed system, or incorrectly substituting closed with "isolated system".
- Failing to reference dynamic equilibrium between liquid and vapour.

Misconception:
Learners believe vapour pressure is an event (a point) rather than a physical quantity (a pressure exerted by vapour).

2. Good graph-reading but weak conceptual justification (Q3.2.1–Q3.2.3)
3.2.1 and 3.2.2 were well answered because they involved reading the trend or locating the boiling point on the graph.

However, when asked to explain why the boiling point of compound A is at 68 °C (Q3.2.3 – 21%), learners could not link their answer to the principle that a liquid boils when its vapour pressure equals the atmospheric pressure (101.3 kPa).

Common errors:

- Giving no scientific reasoning ("Because it is where the line meets the graph").
- Stating "because that is the temperature when it boils" — circular reasoning.
- Failing to mention vapour pressure at all.
- Saying "temperature is high enough" without referencing the atmospheric pressure requirement.

Misconception:
Learners think boiling occurs at a specific temperature irrespective of atmospheric pressure, or simply when the graph shows an intersection, without understanding the concept behind it.

3. Major difficulty linking chain length, vapour pressure and intermolecular forces (Q3.2.4 – 25%)
When determining which compound has the longest carbon chain, learners had to apply the relationship:

Longer chain → stronger London forces → lower vapour pressure at a given temperature

Based on the following responses and the low performance average, it is evident that candidates struggled significantly.

Common errors:

- Reversing the relationship (e.g., thinking higher vapour pressure = longer chain).

- Choosing the line with the highest vapour pressure instead of the lowest.
- Not mentioning intermolecular forces at all.
- Failing to connect chain length with strength of London dispersion forces.
- Incorrect use of degrees of comparison, for example referring to a "stronger intermolecular force" to compare compounds A, B and C instead of C having the "strongest intermolecular force"

Misconceptions:

- Vapour pressure is incorrectly believed to increase with chain length.
- All organic molecules are thought to have "similar" intermolecular forces, so chain length is not considered.
- Learners confuse vapour pressure with boiling point or volatility.

(c) Provide suggestions for improvement in relation to Teaching and Learning.

1. Emphasize correct scientific terminology and definitions

Teachers should explicitly teach:

- Vapour pressure with conceptual understanding
- Dynamic equilibrium within a vapour
- Difference between a closed and isolated system
- Boiling point is the condition where vapour pressure = atmospheric pressure

Strategies:

- Use vocabulary checklists
- Practice writing definitions
- Use annotated diagrams to reinforce the key components of each concept

2. Use visual models and simulations to teach vapour pressure

Learners often fail to visualise what is happening at a particle level.

Suggested tools:

- Simulations of evaporation and condensation
- Diagrams showing dynamic equilibrium
- Graphs showing vapour pressure at different temperatures

This helps learners understand why vapour pressure increases with temperature.

3. Reinforce the conceptual link: Temperature → Kinetic energy → Vapour pressure → Boiling point

Use stepwise reasoning and repeated worked examples.

4. Teach intermolecular forces using comparative examples

Provide structured comparisons to show how chain length affects:

- Strength of London dispersion forces
- Vapour pressure
- Boiling point
- Volatility

Use practical analogies (e.g., "longer molecules stick together more strongly like long

spaghetti strands").

5. Integrate graph interpretation with conceptual explanation
Learners must be taught to not only identify values on a graph but also explain the scientific meaning behind those values.

Use questioning such as:

- "What does this point on the graph represent physically?"
- "Why does this line lie lower/higher than that one?"

6. Use error analysis in classroom practice
Provide learners with incorrect definitions and explanations similar to those seen in this assessment.
Ask them to:

- Identify the error
- Correct it
- Explain the correct concept

This builds metacognition and conceptual clarity.

(d) Describe any other specific observations relating to responses of learners and comments that are useful to teachers, subject advisors, teacher development etc.

1. Learners rely heavily on graph-reading skills but lack theoretical understanding
This suggests teaching may be too focused on procedural skills rather than conceptual mastery.

2. Foundational gaps from earlier grades
Weakness in kinetic molecular theory and intermolecular forces from prior grades is evident (in Grade 10 and 11).

3. Many learners do not differentiate between related but distinct concepts
Examples:

- Vapour pressure vs atmospheric pressure
- Boiling point vs vapour pressure
- Closed system vs isolated system
- Chain length vs molecular size vs molecular mass

This indicates a need for explicit conceptual differentiation in teaching.

4. Teachers may need support in teaching particle-level explanations
Physical chemistry topics often require teacher upskilling in:

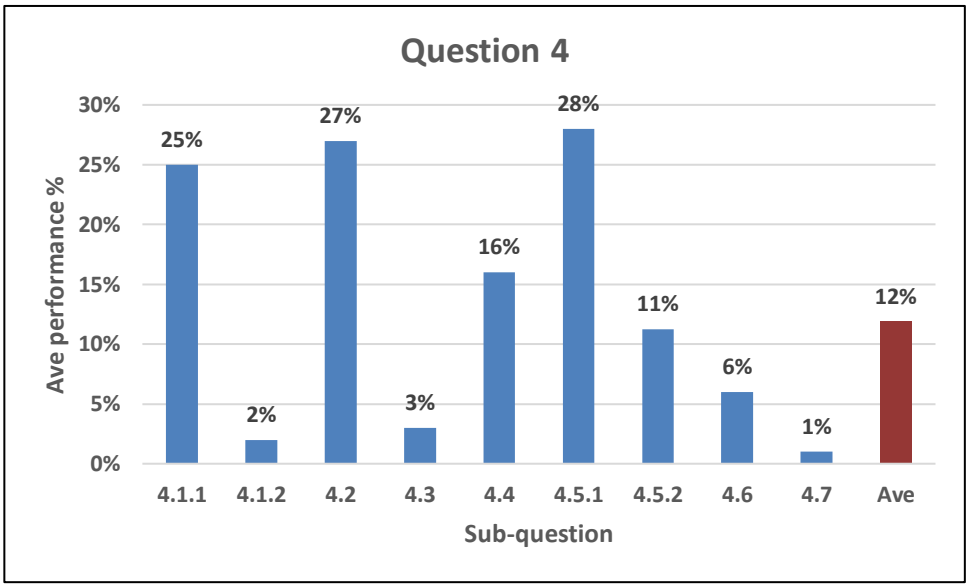
- Using models
- Explaining invisible processes
- Connecting micro-level behavior to macro-level observations

5. The topic is abstract and benefits from concrete visualization
Subject advisors can support by providing:

- Physical models
- Concept animations
- Structured worksheets
- Sample reasoning frameworks for learners

QUESTION 4

(a) General comment on the performance of learners in the specific question. Was the question well answered or poorly answered?



Summary of candidate performance in question 4:

Sub-question	Topic	Ave. performance %
4.1.1	Naming a reaction	25%
4.1.2	Stating two reaction conditions	2%
4.2	Identifying a reaction type	27%
4.3	Writing of a chemical formula	3%
4.4	Naming a reaction	16%
4.5.1	Identifying functional isomers	28%
4.5.2	Explaining the previous response and drawing structural formulae to support it	11%
4.6	Defining the term polymer	6%
4.7	Drawing the structural formula of a monomer	1%

Question 4 was very poorly answered, with an overall Rasch performance average of 12% across all questions.

Although some sub-questions such as 4.1.1 (25%), 4.2 (27%), and 4.5.1 (28%) showed slightly better performance, the majority of the question components revealed severe gaps in learners' understanding of:

- Organic reaction types
- Reaction conditions
- Structural interpretation/ representations
- Organic mechanisms
- Isomerism
- Polymers and monomers

Sub-questions requiring recall of precise definitions, application of reaction knowledge, or

accurate structural representation—particularly 4.1.2 (2%), 4.3 (3%), 4.5.2 (11%), 4.6 (6%), and 4.7 (1%)—were especially poorly answered.

Overall, the data indicates that the question was poorly answered across the sample and reveals widespread conceptual weaknesses in core organic chemistry concepts.

(b) Why was the question answered poorly? Also provide specific examples, indicate common errors committed by learners in this question, and any misconceptions.

1. Reaction identification errors (4.1.1 – 25%, 4.2 – 27%, 4.4 – 16%)
Many candidates were unable to correctly name the reaction types in 4.1.1, 4.2, and 4.4.

Common errors:

- Confusing addition, elimination, and substitution reactions.
- Frequently writing oxidation or combustion—even when no oxygen is added or removed.
- Misinterpreting halogenation and hydrolysis due to poor understanding of reactants.

Confusion caused by unclear understanding of organic functional groups and reaction patterns, contributed to clear conceptual gaps amongst candidates.

Note: The accommodation accepting either the reaction name or type mitigated the performance drop slightly; otherwise, scores would have been even lower.

2. Reaction conditions (4.1.2 – 2%)
The lowest performing conceptual question, showing almost no understanding of required conditions for addition (hydration) reaction.

Common errors:

- Giving conditions for the wrong reaction (e.g., UV light, catalysts for hydrogenation, fermentation conditions).
- Omitting either concentrated acid catalyst or heating, or writing irrelevant conditions.

Misconception:
Learners think any organic reaction simply requires "heat" or "UV light," with no connection between reaction type and required energy/catalyst. Thus the Rasch data (2%) strongly confirms systemic conceptual gaps.

3. Inorganic reactant identification (4.3 – 3%)
Learners could not identify $Cl_2(g)$ as the reagent for halogenation.

Common errors:

- Writing HCl, Cl, or incorrect ions like Cl^-.
- Choosing reagents associated with addition rather than substitution.

Misconception:
Students incorrectly assume "chlorine" means HCl or any chlorine-containing substance.

4. Functional isomers (4.5.1 – 28%) and structural explanation (4.5.2 – 11%)

- Q 4.5.1: Learners partially recognised propanal and propanone as functional isomers, showing basic recall.
- Q 4.5.2: Most could not explain why.

Common errors:

- Confusing general formula (CnH2nO) with molecular formula (C_3H_6O).
- Incorrect structural drawings:
- Wrong placement of oxygen
- Missing double bonds
- Incorrect carbon valencies

Descriptions such as "same types of atoms" rather than "same molecular formula."

Misconception:
Learners believe that as long as molecules "look similar," they are isomers — without understanding functional group differences. The drop from 28% → 11% clearly demonstrates poor structural representation skills.

5. Polymer definition (4.6 – 6%)
Learners gave incomplete or vague definitions.

Common errors:

- Omission of "large molecule" or "repeating units."
- Not mentioning "covalently bonded."
- Describing polymers as "plastic" or "recyclable material."

Misconception:
Learners confuse polymer material properties with polymer chemical definition.

6. Monomer identification from polymer structure (4.7 – 1%)
The lowest scoring question in the entire set.

Common errors:

- Writing the polymer repeating unit instead of the monomer.
- Failing to restore the C=C double bond required in addition polymerisation.
- Adding extra atoms or incorrect bonding patterns.

Misconception:
Learners do not understand that addition polymers originate from alkene monomers, so they cannot reverse the polymer back to the monomer.

(c) Provide suggestions for improvement in relation to Teaching and Learning.

Teaching and learning could be remedied with the following:

- Teach reaction types using structured visual frameworks or provide learners with concise summaries.
- Reinforce reaction conditions through differentiated assessment techniques, such as short daily quizzes, flashcards, reaction-condition matching activities, concept maps linking reaction → conditions → products

- Strengthen representational fluency and clearly distinguish between general formula, molecular formula, and structural formula
- Classroom techniques such as the building of compounds using the ball-and-stick model, peer-to-peer correction activities for the drawing of compounds
- Clarify isomerism through modelling and comparison
- Make use of tables to compare: 1) structural functional and positional isomers; 2) Aldehydes vs ketones; 3) Correct vs incorrect molecular formulae
- Have learners build isomers using model kits or digital tools.

(d) Describe any other specific observations relating to responses of learners and comments that are useful to teachers, subject advisors, teacher development etc.

1. Learners are relying on memorised patterns rather than conceptual understanding
This is evident in:
- Incorrect reaction names
- Misidentification of oxidation/combustion
- Guesswork in polymer questions
- Substitution of incorrect formulae

2. Structural representation remains a critical weakness
Errors in valencies, functional groups, and formula writing indicate inadequate practice.

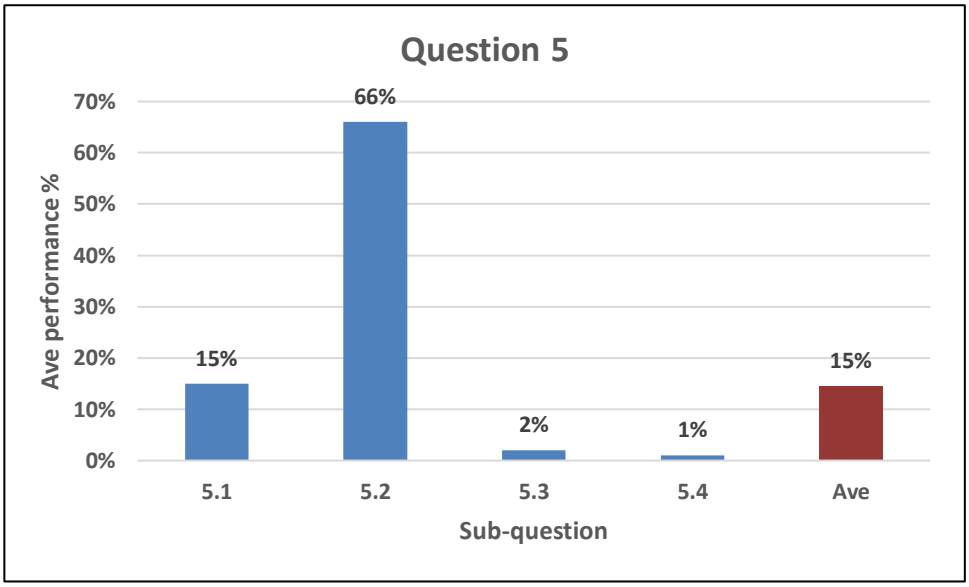
3. Teachers may require additional training in organic pedagogy
Particularly:
- Mechanistic explanation (bond-breaking and bond-forming)
- Representing organic transformations
- Linking functional groups with reaction behaviour

4. Students show poor differentiation between key organic concepts
Examples:
- Reaction type vs reaction name
- Molecular formula vs general formula
- Monomer vs polymer
- Reactant vs catalyst

5. The extremely low scores (1%–6%) highlight the need for systemic intervention
This likely requires:
- Curriculum pacing adjustments
- Additional scaffolding in earlier grades
- Clear models and worked examples
- Teacher training workshops

QUESTION 5

(a) General comment on the performance of learners in the specific question. Was the question well answered or poorly answered?



Summary of candidate performance in question 5:

Sub-question	Topic	Ave. performance %
5.1	Labelling the part (anode) in the diagram	15%
5.2	Identifying the type of p-n junction diode	66%
5.3	Providing a reason for the previous response	2%
5.4	Stating the characteristics of the p-n junction diode	1%

Question 5 was poorly answered, with a very low overall Rasch performance average of 15%, making it the second-lowest performing question in the paper.

While 66% of candidates could identify the type of biasing in Question 5.2, the performance on the remaining sub-questions fell sharply:

This severe drop indicates that candidates could recognise the biasing configuration but lacked the underlying conceptual understanding to justify or explain it.

It must also be acknowledged that p–n junction diodes are often taught hastily in many schools, frequently near the end of the term, and in some cases educators themselves do not have the depth of conceptual knowledge required to teach semiconductor physics effectively. This contextual factor contributes significantly to the weak learner performance across explanation- and reasoning-based basic questions.

(b) Why was the question answered poorly? Also provide specific examples, indicate common errors committed by learners in this question, and any misconceptions.

1. Poor recall of diode structure (5.1 – 15%)

Despite being a simple Level 1 recall task, only 15% could correctly identify the anode.

Common errors:

- Mixing up anode and cathode.
- Assuming the anode is always on the side connected to the positive terminal.
- Incorrectly labelling based on guesswork rather than understanding the symbol.

Underlying cause:

Learners may not be receiving thorough teaching of symbol literacy, and educators sometimes lack confidence in explaining how diode symbols map onto physical semiconductor structures.

2. Identification without conceptual understanding (5.2 – 66%; 5.3 – 2%)

Although most learners recognized the diode as being forward-biased, very few (only 2%) could justify why, with very few being able to mention the orientation of the terminals in relation to the anaode and cathode or depletion-layer effects.

Underlying misconception:

Learners memorise patterns ("positive to p-type = forward- biased") but do not understand:

- Direction of current flow for the any specific biasing
- depletion-layer widening/ narrowing,
- Low/ high potential drop

Contextual factor:

Because semiconductor physics is abstract, educators without strong conceptual grounding may rely on rule-based teaching instead of explaining the physical mechanism. This leads to high recognition but low explanation performance.

3. Characteristics of reverse bias not known (5.4 – 1%)

Learners could not state even one correct characteristic (e.g., narrowed depletion layer, negligible current that flows in one direction or low potential drop) or provided responses specific to reverse-biased.

This reflects conceptual collapse — learners confuse the behaviour of p–n junctions entirely.

Contributing teaching challenge:

Many schools rush this section at the end of the term or before exams, leaving insufficient time to teach the underlying physics of charge-carrier behaviour, a topic which educators themselves may find difficult.

(c) Provide suggestions for improvement in relation to Teaching and Learning.

1. Strengthen educator content knowledge

- Provide teacher workshops on p–n junction physics, depletion layers, doping, and charge carriers.
- Improve teacher understanding to ensure accurate, confident instruction.

2. Use visual and interactive teaching tools

- Incorporate simulations, colour-coded diagrams, animations, and physical models.
- Move beyond chalk-and-talk to make abstract semiconductor concepts concrete.

3. Teach structured, concept-based explanations

- Use consistent stepwise reasoning for forward and reverse bias.
- Help learners form a stable cognitive framework for explaining diode behaviour.

4. Improve symbol and diagram literacy

- Teach correct identification of anode/cathode and diode orientation.
- Rotate diagrams to prevent memorisation based on position.

5. Introduce conceptual scaffolding earlier in the year

- Teach doping, charge carriers, electric fields, and semiconductor basics before biasing.
- Prevent rushed, shallow instruction later in the term.

6. Prioritise explanation-based practice

- Use activities that require learners to explain *why*, not just identify *what*.
- Include comparative tables, short explanations, and error-analysis exercises.

(d) Describe any other specific observations relating to responses of learners and comments that are useful to teachers, subject advisors, teacher development etc.

1. Recognition skills do not translate into understanding

Rasch shows:

- 66% could identify reverse bias
- only 2% could explain it
- only 1% could describe its characteristics

This discrepancy is a warning sign that rote memorisation dominates learning

2. Conceptual gaps reflect systemic teaching challenges

Given that many educators:

- are not specialists in semiconductor physics,
- receive limited pre-service training in electronics, and
- often rush this section, learners inherit shallow or fragmented understanding.

3. Many learners lack prior conceptual foundations

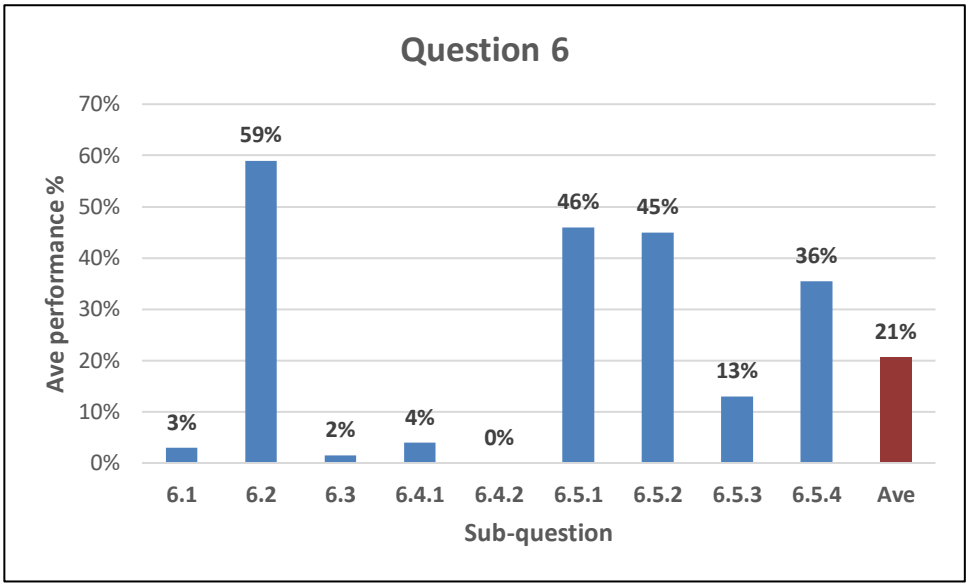
Misunderstandings suggest limited grasp of:

- electron flow
- electric potential
- the behaviour of charge carriers
- series circuits

These are Grade 10–11 foundations that must be strengthened for Grade 12 semiconductor work.

QUESTION 6

(a) General comment on the performance of learners in the specific question. Was the question well answered or poorly answered?



Summary of candidate performance in question 6:

Sub-question	Topic	Ave. performance %
6.1	Defining the term electrolyte	3%
6.2	Identifying the anode in the electrolytic cell	59%
6.3	Writing the half-reaction that occurs at a given electrode	2%
6.4.1	Writing the chemical formula of a substance forming at a given electrode	4%
6.4.2	Naming the oxidising agent in the reaction	0%
6.5.1	Giving an advantage of alternative energy	46%
6.5.2	Identifying the energy source linked to a photovoltaic cell	45%
6.5.3	Writing the energy conversion taking place in the cell referred to in the previous question	13%
6.5.4	Describing biodiesel	36%

Overall, Question 6 was poorly answered, with an average Rasch score of 21%. Performance varied significantly across sub-questions:

- Very low performance on electrolysis concepts:
  - 6.1 (3%) — defining electrolyte
  - 6.3 (2%) — writing half-reactions
  - 6.4.1 (4%) — product at the cathode
  - 6.4.2 (0%) — identifying the oxidising agent

- Moderate performance on identifying the anode and alternative energy recognition:
  - 6.2 (59%)

- 6.5.1 (45%), 6.5.2 (46%), 6.5.4 (36%)

- Very low performance again on explaining energy conversion:
  - 6.5.3 (13%)

The data shows a clear pattern: learners cope better with recognition tasks, but perform extremely poorly on tasks requiring definitions, chemical reasoning, ion/electron understanding, or process explanation.

(b) Why was the question answered poorly? Also provide specific examples, indicate common errors committed by learners in this question, and any misconceptions.

1. Poor definition of electrolyte (6.1 → 3%)
Although this was a recall-level question, most learners failed to include essential components of the definition.

Common errors:
- Stating "a substance that conducts electricity" (missing *dissolved/molten* state).
- Mentioning "conducts electricity" but omitting **ions** or **movement of ions**.
- Writing "liquid that conducts electricity" (incorrect).

Misconception:
Learners confuse **electrolyte** with **electrolytic solution**, and do not understand that **ions** and **mobility** are the key ideas.

2. Identifying the anode (6.2 → 59%)
Learners performed relatively well, probably through memorised patterns.
However, this was not supported by deeper understanding, as seen in 6.3 and 6.4.

Evidence of shallow understanding:
Many learners cannot explain *why* M is the anode, nor describe oxidation correctly.

3. Severe difficulty with half-reactions (6.3 → 2%)
Almost all candidates struggled to write the oxidation half-reaction at the anode.

Common incorrect responses:
- Reversing the reaction (reduction instead of oxidation).
- Writing full equations instead of half-reactions.
- Writing unbalanced equations.
- Choosing the wrong species (e.g., copper instead of chloride).

Misconceptions:
- Learners do not know that **oxidation is loss of electrons** (OILRIG).
- They do not apply **ANOX**: oxidation occurs at the anode.
- They confuse electron flow and ion movement.

4. Difficulty identifying products and redox agents (6.4.1 → 4%, 6.4.2 → 0%)
Performance here was extremely poor.

Typical errors:

- Writing **Cu^{2+}** instead of **Cu(s)** as the product.
- Thinking Cl_2 forms at the cathode.
- Writing "chloride" or "copper chloride" instead of copper metal.

Most critically, **0%** of learners correctly identified **Cu^{2+}** as the oxidising agent.

Misconceptions:

- Learners think the oxidising agent is "the thing that burns" or "the product at the anode".
- They do not apply **REDCAT** (Reduction at the cathode).
- They do not understand that the oxidising agent is the species that **gains electrons**.

5. Challenges with energy conversion (6.5.3 → 13%)

Even though this is a Life Sciences–style concept, learners still struggled.

Common incorrect responses:

- Stating only "light energy"
- Saying "solar energy" instead of "electrical energy"
- Giving only one part of the conversion

Correct conversion:

Light energy → electrical energy

Misconception:

Learners do not understand that solar panels *convert* energy, not "produce" or "generate" it.

(c) Provide suggestions for improvement in relation to Teaching and Learning.

1. Explicit teaching using electrochemistry acronyms

Teachers should consistently reinforce:

- **OILRIG** = Oxidation Is Loss (of electrons), Reduction Is Gain
- **ANOX** = ANOde is where OXidation occurs
- **REDCAT** = REDuction occurs at the CAT hode
- **PANIC** = Positive Anode, Negative Is Cathode *(for electrolytic cells)*

These provide easy retrieval cues for learners under exam conditions.

2. Build strong conceptual models using diagrams and particle-level explanations

Learners need to *visualise*:

- Cu^{2+} moving to the cathode
- Cl^- moving to the anode
- electrons flowing in the external circuit
- gas forming at the anode

Use:

- Colour-coded ion diagrams
- Movement arrows
- Teacher-led modelling using beads/balls
- PhET-like simulations

3. Practice half-reactions step-by-step

Teachers should scaffold half-reactions by teaching learners to:

1. Identify the reacting ion
2. Determine whether oxidation or reduction occurs
3. Add/lose electrons accordingly
4. Balance charges
5. Include state symbols

Frequent practice builds confidence.

4. Improve redox agent identification

Learners must understand:

The oxidising agent is the species that gains electrons (is reduced).

Use:

- Before/after electron diagrams
- Dual coding (tables + diagrams)
- Repeated examples including Cu^{2+}, Zn^{2+}, Cl_2, MnO_4^-, etc.

5. Strengthen conceptual understanding of electrolytes

Re-teach the definition using:

- Examples (NaCl(aq), $CuCl_2$(aq))
- Non-examples (sugar solution)
- Emphasis on "mobile ions"

6. Provide writing practice for chemical equations and conversions

To address errors in 6.5.3, use tasks that require learners to write:

- "X energy → Y energy"
- Explanations of what converts and why

(d) Describe any other specific observations relating to responses of learners and comments that are useful to teachers, subject advisors, teacher development etc.

1. Electrolysis is a systemic conceptual weakness

Extremely low scores (3%, 2%, 4%, 0%) show that learners lack foundational electrochemical understanding rather than simply making mistakes.

2. Teachers may lack confidence or depth in teaching electrochemistry

As noted across many schools, this section:

- is often rushed,
- receives limited class time, and
- may be taught procedurally rather than conceptually.

Subject advisors should consider:

- Professional development on electrolysis, half-reactions, and redox
- Content-deepening workshops
- Simplified teaching aids for ion movement and electrode processes

3. Learners struggle with symbolic and representational chemistry

Weaknesses include:

- Writing equations
- Using subscripts

- Identifying ions
- Understanding oxidation states
- Linking diagrams to chemical processes

4. Explanatory reasoning is consistently weak

6.5.3 (13%) shows that even simple process explanations (energy conversions) cause difficulty.

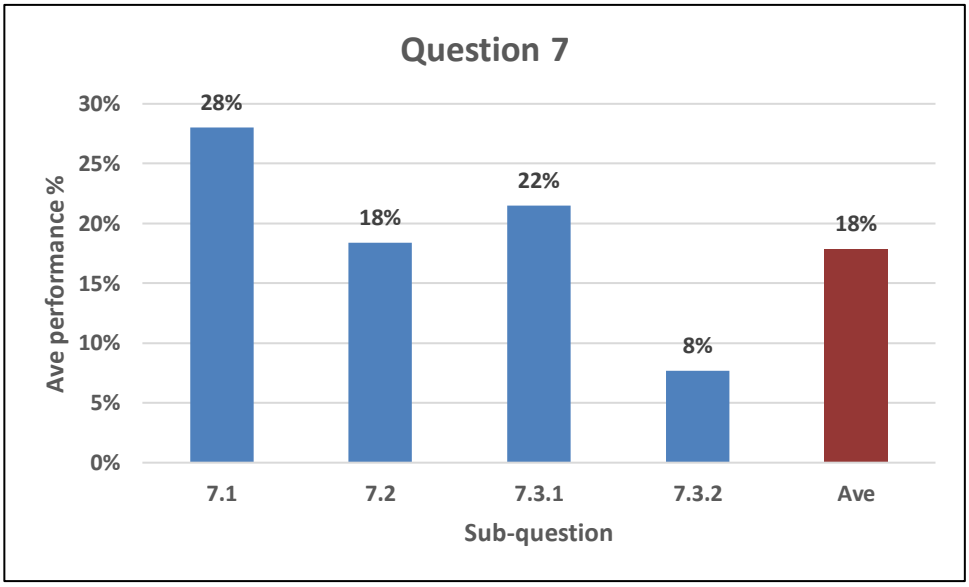
Learners need more exposure to "why" questions, not only recognition or identification tasks.

5. Learners show poor integration of electrochemistry concepts

Correct identification (6.2) does not translate into correct application (6.3, 6.4), showing **fragmented knowledge** rather than conceptual understanding.

QUESTION 7

(a) General comment on the performance of learners in the specific question. Was the question well answered or poorly answered?



Summary of candidate performance in question 7:

Sub-question	Topic	Ave. performance %
7.1	Defining the term reduction	28%
7.2	Using a calculation to identify an electrode	18%
7.3.1	Writing the half-reaction of a given half-cell	22%
7.3.2	Writing a cell notation	8%

Question 7 was poorly answered, with an average performance of only 18% across the 100 learners. Although sub-question 7.1 showed comparatively better performance at 28%, the rest of the items—particularly 7.3.2 at 8%—were significantly low. The data indicates that most learners struggled with the underlying concepts of electrochemistry, including electron transfer, interpreting standard reduction potentials, EMF calculations, and writing cell notation.

Taken together, these results show that learners have limited conceptual understanding of galvanic cells and struggle to apply electrochemical principles to structured questions.

(b) Why was the question answered poorly? Also provide specific examples, indicate common errors committed by learners in this question, and any misconceptions.

Learners commonly interchanged the words electrons and electrodes.
Example: Instead of saying "reduction is the gain of electrons", many wrote "reduction is the gain of electrodes".

Q.7.2.1
Confusion between physical components of a cell (electrodes) and sub-atomic particles involved in electron transfer (electrons).

Incorrect transcription of the EMF equation from the formula sheet.

Learners were unable to manipulate the formula to isolate and calculate and therefore could not correctly identify the unknown half-cell.

In addition, many did not link the negative polarity of half-cell B to the fact that it must be the anode, showing conceptual confusion. Learners do not understand that the anode is where oxidation occurs and where electrons are released—hence connected to the negative terminal in a galvanic cell.

Q.7.3.1
Learners could not correctly retrieve the relevant half-reaction from the standard reduction potential table.
Incorrect electron count, reversed equations, and wrong charges were common.

Many could not distinguish oxidation from reduction half-reactions and did not understand how to read reduction tables properly.

Q.7.3.2
Candidates failed to carry information from 7.2.1, particularly the identification of the anode and cathode. Many reversed the anode and cathode in cell notation or wrote non-standard formats.

Misconception:
Learners do not understand the structure
Anode | Anode ions || Cathode ions | Cathode

This suggests poor transfer of knowledge across linked sub-questions.

(c) Provide suggestions for improvement in relation to Teaching and Learning.

1. Strengthen foundational conceptual understanding
Re-teach oxidation and reduction using visual diagrams, electron flow models, and analogies.

Emphasise that electrons and electrodes are not the same, reinforcing vocabulary.

2. Guided practice with formula manipulation

- Provide structured exercises on how to rearrange equations, especially
- Teach learners to interpret the polarity (+/–) of electrodes correctly.

3. Explicit instruction on how to read standard reduction potential tables

- Show learners how to extract half-reactions from the table correctly.
- Include exercises that require reversing equations for oxidation when necessary.

4. Scaffold multi-step problems

Teach learners to logically carry information from one sub-question to the next, especially between 7.2.1 and 7.3.2.

Use flow diagrams linking anode/cathode → half-reactions → cell notation.

5. Provide repeated practice with cell notation

Reinforce the pattern:
Oxidation on the left, reduction on the right

Use whiteboard drills or card-sorting activities to strengthen fluency.

(d) Describe any other specific observations relating to responses of learners and comments that are useful to teachers, subject advisors, teacher development etc.

Vocabulary confusion (electrons vs electrodes) indicates that many learners cannot distinguish between microscopic and macroscopic concepts in electrochemistry. Terminology should be repeatedly emphasized with clear definitions and diagrams.

The extremely low score in cell notation (8%) suggests that learners do not see the relationship between different parts of the galvanic cell. Teachers should integrate these concepts rather than teaching them separately.

Many learners appear to rely on rote memorization instead of understanding. Their difficulty in rearranging formulae and connecting sub-questions suggests a lack of deeper conceptual grasp.

The data also indicates that procedural fluency is lacking. Even when learners know the correct concepts, they struggle with applying them systematically (e.g., using tables, equations, and notations correctly).

For teacher development:

- Workshops could focus on conceptual pedagogy for electrochemistry, including modelling electron flow, linking theory to real devices (batteries), and structured use of reduction tables.
- Teachers may benefit from training in diagnosing learner misconceptions and using formative assessments to address them early.