# CHAPTER 3

## TECHNICAL SCIENCES

**The following report should be read in conjunction with the Technical Sciences question papers of the NSC November 2021 examinations.**

### 3.1 PERFORMANCE TRENDS (2018–2021)

In 2021, 14 642 candidates sat for the Technical Sciences examination, 2 987 more candidates than in 2020.

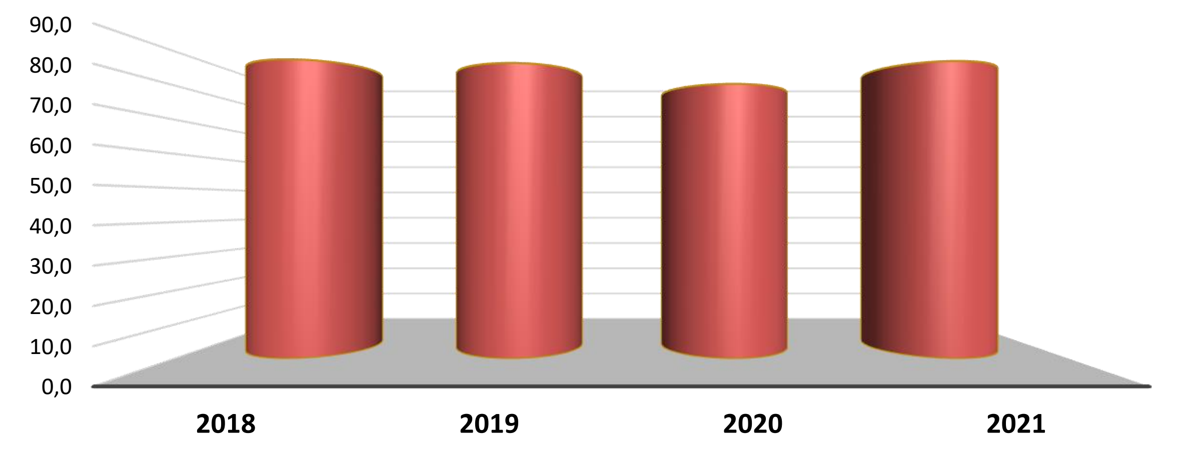
The performance of the candidates in 2021 shows a significant increase when compared to the performance in 2020. The pass percentage at 30% (Level 2) increased from 80,4% in 2020 to 87,1% in 2021.

It was very encouraging that 24,3% of candidates achieved over 50% this year in comparison with 18,2% of candidates doing so in 2020. The percentage of distinctions (80% and above) decreased marginally from 0,4% in 2020 to 0,3% in 2021.

**Table 3.1.1 Overall achievement rates in Technical Sciences**

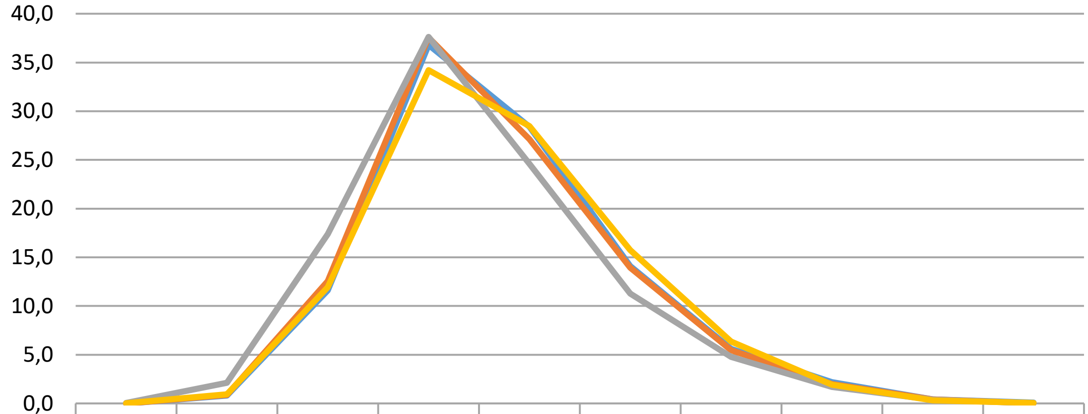
| Year | No. wrote | No. achieved at 30% and above | % achieved at 30% and above |
|---|---|---|---|
| **2018** | 10 503 | 9 204 | 87,6 |
| **2019** | 10 862 | 9 401 | 86,5 |
| **2020** | 11 655 | 9 375 | 80,4 |
| **2021** | 14 642 | 12 758 | 87,1 |

**Graph 3.1.1 Overall achievement rates in Technical Sciences (percentage)**




| | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|
| % achieved at 30% and above | 87,6 | 86,5 | 80,4 | 87,1 |

**Graph 3.1.2 Performance distribution curves in Technical Sciences (percentage)**




| | 0-9.9 | 10-19.9 | 20-29.9 | 30-39.9 | 40-49.9 | 50-59.9 | 60-69.9 | 70-79.9 | 80-89.9 | 90-100 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2018 | 0,0 | 0,8 | 11,6 | 36,8 | 28,4 | 14,1 | 5,6 | 2,2 | 0,4 | 0,1 |
| 2019 | 0,0 | 0,9 | 12,6 | 37,6 | 27,1 | 13,9 | 5,5 | 2,0 | 0,4 | 0,0 |
| 2020 | 0,1 | 2,1 | 17,4 | 37,6 | 24,6 | 11,3 | 4,8 | 1,7 | 0,4 | 0,0 |
| 2021 | 0,0 | 0,9 | 11,9 | 34,2 | 28,5 | 15,7 | 6,4 | 1,9 | 0,3 | 0,0 |

There is much room for improvement in the performance of the candidates as the challenges surrounding conceptual understanding, mathematical skills, integration of topics, problem-solving skills and practical work are being addressed.

## 3.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN PAPER 1

**General comments**

(a) The multiple-choice items in Q1 and the questions on Newton's First, Second and Third Laws of Motion (Q2), work, energy and power (Q4) were generally well answered.

(b) In general, Q3, Q6, Q7, Q8 and Q9 were poorly answered. Q3 examined momentum and impulse; Q6 focused on light; Q7 dealt with electromagnetic radiation; Q8 examined capacitors and capacitance and Q8 was on electric circuits.

(c) Recall questions are still posing a challenge to the candidates.

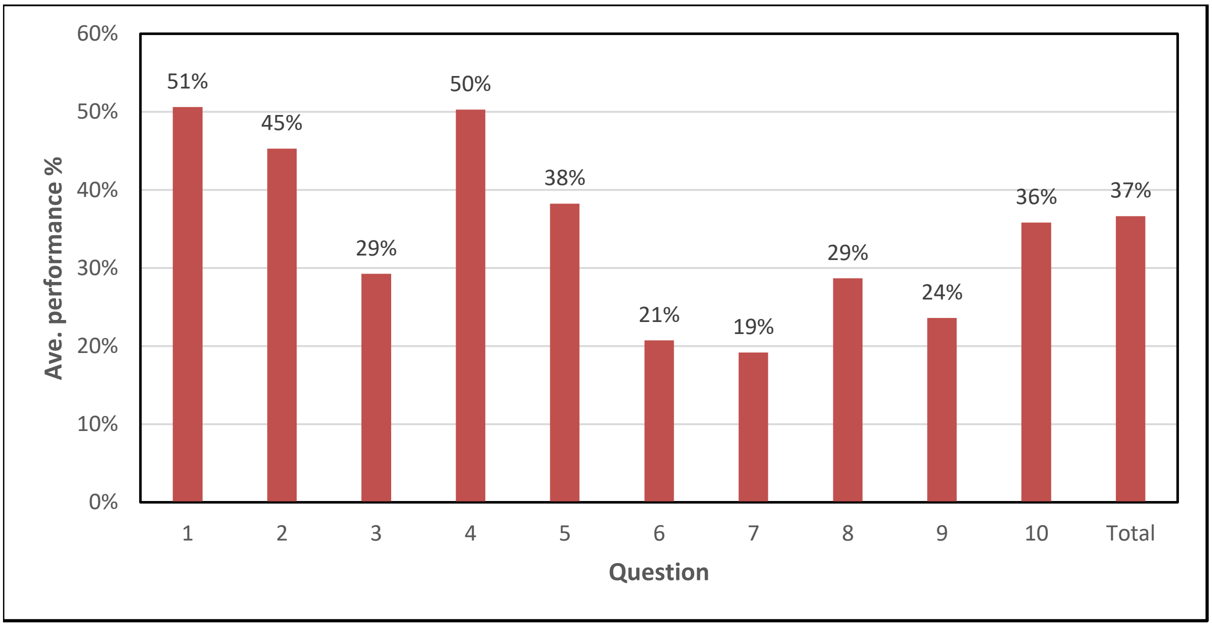
(d) Candidates showed a significant improvement in drawing and labelling free-body diagrams. However, some still struggled in this regard.

(e) Most candidates showed poor mathematical skills, such as understanding and using formulae and scientific notation as well as interpreting and representing direction in terms of a positive and negative sign.

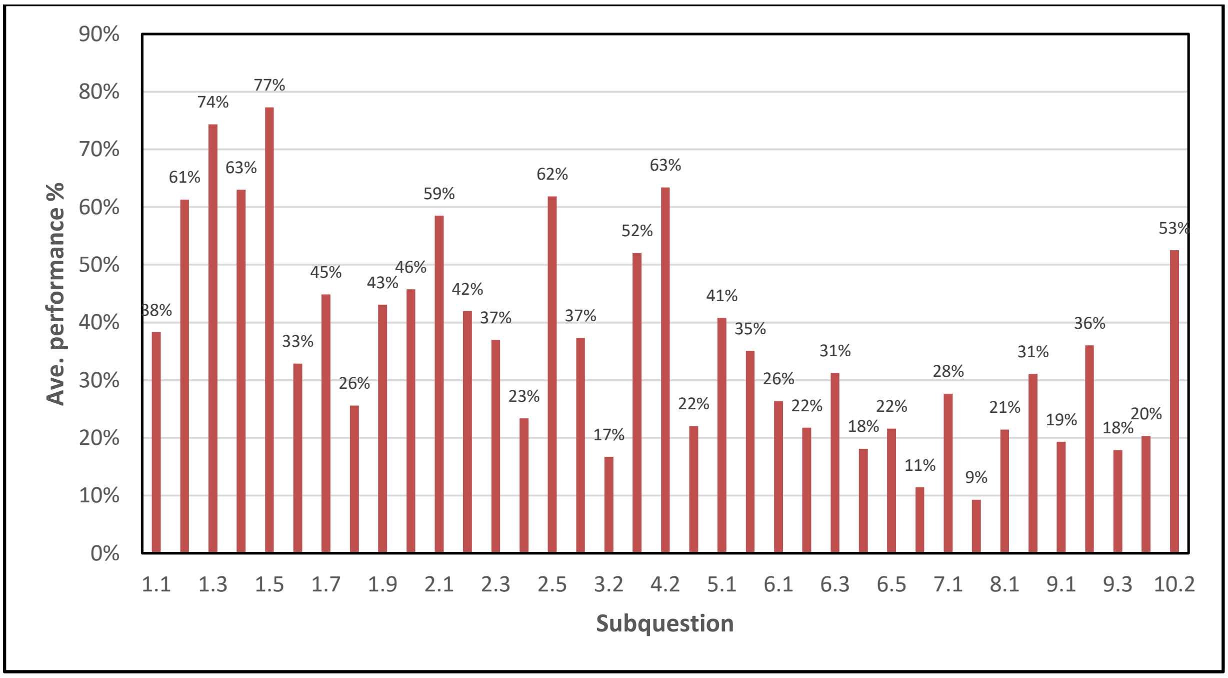
## 3.3 DIAGNOSTIC QUESTION ANALYSIS OF PAPER 1

The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

**Graph 3.3.1 Average performance per question in Paper 1**




**Graph 3.3.2 Average performance per subquestion in Paper 1**




## 3.4 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 1

### QUESTION 1: MULTIPLE-CHOICE QUESTIONS

**Common errors and misconceptions**

(a) In Q1.1 candidates assumed that the direction of motion is the same as the applied force. They failed to realise that the net force determines the direction of motion.

(b) Most candidates showed poor mathematical skills in Q1.6 as they could not use the formula, $P = \frac{F}{A}$, to determine the unit of pressure.

(c) In Q1.7 a significant number of candidates had difficulty in determining the path followed by light rays as they pass through a convex lens.

(d) In Q1.8 majority of candidates could not use the right-hand rule to determine the direction of the magnetic field when current goes out of the page.

(e) Candidates showed a poor understanding of the relationship between the resistance, current and brightness of the bulb for bulbs connected in series and parallel in Q1.9.

(f) In Q1.10 a significant number of candidates had no idea of what the different components of generators and motors are as well as energy conversion taking place in these machines.

**Suggestions for improvement**

(a) Learners must be the taught the skills to answer the MCQ rather than relying on guesswork. They must be able to state a reason for eliminating incorrect options in multiple-choice questions.

(b) Expose learners to multiple-choice-questions regularly through daily activities/informal tasks and short speed tests (±10 minutes).

(c) Learners must be taught the basics by ensuring that they know ALL the terminology (definitions, laws and principles) as stated in the *CAPS* and *Examination Guidelines*.

(d) Teachers must teach and expose learners to questions from different cognitive demand from basic calculation to drawing and interpretation of graphs as well as reasoning/justification.

(e) *Edukite* or *PhET*-simulations must be used to reinforce understanding of generators and motors. This can also be used to show the relationship between resistance, current and brightness of the bulbs in parallel and series circuits.

**QUESTION 2: NEWTON'S LAW OF MOTION**

**Common errors and misconceptions**

(a) In Q2.1 and Q2.5.1 candidates omitted keywords when stating Newton's laws. Omissions were as follows:
- In Q2.1 the keywords *rest, resultant (force)* and *uniform velocity* were omitted.
- The keywords *simultaneously*, *equal magnitude* and *opposite direction* were omitted in Q2.5.1.

(b) A notable number of candidates could not calculate the horizontal and vertical components of the force, 60 N applied at an angle of 30°, in Q2.2.1 and Q2.2.3. Common errors include:
- Confusing the horizontal and vertical component, by:
  - Calculating the vertical component instead of the horizontal component and vice versa
  - Using cos 30° instead of sin 30° for the vertical component and sin 30° instead of cos 30° for the horizontal component
- not writing the units in the final answer

(c) In Q2.2.2 a significant number of candidates had difficulty in calculating the normal force when there is a force acting on object at an angle. Some of the common errors were mainly the use of incorrect formulae:
- To calculate the normal force, using $N = mg$ instead $N = mg – F·sin\theta$
- To calculate the coefficient of kinetic friction using $f_s^{max} = \mu_s N$ instead of $f_k = \mu_k N$

(d) Most candidates committed the following errors in Q2.3:
- Wrote the formula $F_{net} = ma$ as $F = mg$ or $F = ma$
- Substituted 9.8 for acceleration, *a*
- Could not determine $F_{net}$ as they seemed to have no idea what horizontal force is acting on the object
- Failed to choose/indicate a positive and a negative direction
- Omitted the direction in the final answer and forfeited a mark for the final answer

(e) In Q2.4 candidates were unable to explain how the vertical component of the applied force affect the magnitude of the normal when the angle between the horizontal and applied force is increased.

(f) A significant number of candidates labelled applied force as tension as if a string or a rope was used to tow a caravan in Q2.5.2.

**Suggestions for improvement**

(a) Learners must be exposed to recall questions like defining concepts, stating laws and principles without omitting keywords.
- Classrooms and laboratories must have print-rich materials with lists of definitions, principles and laws on the walls/notice boards.
- Speed tests must be used to drill learners to recall definitions, laws and principles.

(b) Drawing of free-body diagrams and identification of forces acting on an object must be drilled as it is a useful skill for problem-solving.

(c) Teachers must emphasise the fact that the number of forces required correlates with mark allocation, e.g. Four forces are required if the mark allocation is 4.

(d) Learners must be cautioned to avoid common errors in a free-body diagram like:
- Omitting the dot
- Using a line instead of an arrow
- Using dotted/broken lines
- Drawing the number of forces that are not correlating with mark allocation

(e) Emphasise the fact that vectors have magnitude and direction, therefore:
- Learners must choose a negative and positive direction in calculations involving vector quantities.
- The final answer of calculations of vector quantities must have correct the value with units and direction.

(f) Teachers must expose learners to questions across different cognitive levels including:
- Routine and multi-step calculations
- Using laws, principles and equations to explain or justify answers
- Questions involving scientific reasoning

## QUESTION 3: IMPULSE AND CONSERVATION OF MOMENTUM

### Common errors and misconceptions

(a) In Q3.1.1 and Q3.1.4 candidates omitted keywords like *product* and *total*.

(b) Most candidates used the equation $\Delta p = mv_f - mv_i$ in Q3.1.2. Some candidates omitted the direction in the final answer.

(c) Some of the common errors that candidates committed in Q3.1.3 were:
- Using $p_{before} = p_{after}$ or $\sum Ek_i = \sum Ek_f$ instead of $\sum p_{before} = \sum p_{after}$
- Omitting the SI unit or direction in the final answer

(d) A significant number of candidates distinguished between elasticity and plasticity instead of elastic and inelastic collisions in Q3.1.4. Common mistakes include:
- Omitting the keyword *total* or symbol $\sum$
- Using calculations to show the difference between elastic and inelastic collision instead of stating the difference between the two

(e) In Q3.2.1 most candidates used the formula $F_{net} \cdot \Delta t = \Delta p$ instead of Newton's First Law or inertia to explain how the seatbelt reduces injuries during collision.

(f) Candidates had a challenge in realising that Impulse = $\Delta p$ in Q3.2.2. They did not realise that $\Delta p$ was given.

(g) In Q3.2.3 most candidates calculated $\Delta p$ instead of $F_{net}$. They also did not state whether the wall will withstand the impact of collision or not.

### Suggestions for improvement

(a) Learners must be taught how to define concepts and state principles without omitting keywords. Teachers must highlight keywords when teaching these concepts or principles.

(b) Teachers must emphasise the fact that momentum is a vector quantity, therefore, learners must always choose a negative and positive direction in calculations involving momentum.

(c) Teachers must expose learners to problems involving different practical applications of momentum and Newton's laws in road and motor vehicle safety.

(d) Learners must be familiar with the equations in the data sheet. They must:
- Be able to identify the relevant equation applicable to a specific problem
- Use equations to explain relationships between different variables

(e) Subject advisors must organise workshops to reinforce the teaching of momentum and impulse using practical examples.

(f) PEDs and district officials must develop and give schools appropriate teacher and learner support material to strengthen the teaching and learning of momentum and impulse.

## QUESTION 4: WORK AND ENERGY

### Common errors and misconceptions

(a) In Q4.1.1 most candidates omitted the words *product, applied force* or *displacement* when defining work done.

(b) A notable number of candidates omitted the SI units in the final answer in Q4.1.2. Other errors include:
- Omitting $\Delta$x in the formula for work done and substitution step
- Failing to recognise that F is applied at an angle and substituting 60 for F instead of using the horizontal component of F, i.e. 60×cos25°
- Stating the principle of conservation of linear momentum instead the principle of conservation of mechanical energy
- Others omitted keywords like *total* or *sum* and *isolated system*

(c) In Q4.3 a significant number of candidates did not realise that $E_p$ calculated in Q4.2.2 and $E_k$ calculated in Q4.2.2 were $E_p$ and $E_k$ at the top. They did not use these values to calculate $E_p$ at the bottom.

### Suggestions for improvement

(a) Teachers must emphasise the use of keywords when teaching principles and concepts.

(b) Learners must be exposed to the use of formula/data sheet in informal and formal activities.

(c) Teach learners to identify the forces that are doing work on an object.

(d) Teachers must emphasise the difference between *mechanical energy*, *kinetic energy*, *gravitational potential energy* as well as the *principle of conservation of mechanical energy and principle of conservation of linear momentum*.

## QUESTION 5: ELASTICITY, HYDRAULICS AND VISCOSITY

### Common errors and misconceptions

(a) In Q5.1.1 most candidates had difficulty in calculating the area. Some of the common mistakes included:
- Using A = $\ell \times b$ instead of A = $\pi r^2$ or A = $\frac{\pi d^2}{4}$
- Failing to convert mm to m
- Using the length of a diameter in the formula A = $\pi r^2$
- Using the incorrect formula to calculate stress, i.e., $P = \frac{F}{A}$. or $\varepsilon = \frac{\Delta \ell}{L}$ instead of $\sigma = \frac{F}{A}$
- Omitting the units in the final answer

(b) In Q5.1.2 the majority of candidates had a challenge to realise that $\Delta \ell$ was given, so they substituted 3 $-$ 0,0005 for $\Delta \ell$. Some of their common mistakes include:
- Using the incorrect formula to calculate stress, i.e. $\sigma = \frac{F}{A}$ instead of $\varepsilon = \frac{\Delta \ell}{L}$
- Including the SI unit in the final answer

(c) Candidates could not use the values calculated in Q5.1.1 and Q5.1.2 to calculate Young's modulus of the wire in Q5.1.3.

(d) In Q5.2.1 a significant number of candidates had no idea of what the pressure at a particular point is.

(e) A substantial number of candidates could not answer Q5.2.2. Some of the incorrect responses included:
- Using the incorrect formulae - $\rho = pgh$, $p = mv$, $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ and $\sigma = \frac{F}{A}$
- Giving the incorrect SI units in the final answer

(f) In Q5.2.3 most candidates calculated the area of the input piston instead of the area of the output pressure. They failed to recognise that the area of the input area was given in the leading statement.

**Suggestions for improvement**

(a) Learners must be taught mathematical skills required with emphasis on scientific notation, conversion of units and the meaning of prefixes like *nano, giga, mega, milli*, etc. in calculations.

(b) Teachers must give learners more practical problems where they can:
- Use mathematical skills learned in (a).
- Distinguish between stress, strain and pressure.
- Know the formula used to calculate each of these variables (i.e. pressure, stress and strain).

(c) Learners must be taught a skill to identify different variables including the unknown from the information on the question/leading statement or diagram. This will help them to select a correct formula to calculate the unknown.

**QUESTION 6: REFRACTION & TOTAL INTERNAL REFLECTION**

**Common errors and misconceptions**

(a) In Q6.1 candidates omitted keywords *bending* or from *one medium to another*. Others defined *reflection* instead of *refraction*.

(b) The phrases *angle of incidence* or *refracted ray* in Q6.2 were given as *critical angle* by most of the candidates.

(c) In 6.3 a notable number of candidates had difficulty in stating the magnitude of a critical angle. Some wrote 30° or 45° as an answer instead of 90°.

(d) A large number of candidates had no idea which ray undergoes total internal reflection in Q6.5. Some just wrote *R* instead of ray *QR*.

(e) In Q6.6 a significant number of candidates had difficulty in stating the conditions required for total internal reflection to occur. Most of the candidates stated the uses of total internal reflection.

**Suggestions for improvement**

(a) Learners must be taught definitions of all concepts as prescribed in the *CAPS* and the *Examination Guidelines* without omitting keywords in definitions.

(b) Teachers must teach the concepts *reflection, refraction, critical angle* and *total internal reflection* thoroughly.

(c) Practical activities and *PhET* simulations must be used to reinforce the understanding of the concepts in (b).

(d) PEDs and schools must procure light kits required to do practical work of this section or teachers may download open source *Edukite* or *PhET*-simulation software.

(e) PEDs and district officials must train teachers on the effective use of light kits and *Edukite* or *PhET*-simulations.

**QUESTION 7: ELECTROMAGNETIC RADIATION (WAVES/SPECTRUM)**

**Common errors and misconceptions**

(a) In Q7.1.1 a notable number of candidates omitted keywords like *white*, *break up* or *component colours*. Some of them used the phrase *different colours* instead of *component colours*.

(b) Most candidates could not identify the specific colours of the spectrum as required in Q7.1.2. A common incorrect response was *red* and *violet*.

(c) In Q7.1.3 a significant number of candidates had difficulty in stating the property of light responsible for dispersion.

(d) Candidates could not determine the relationship between a *wavelength* and *speed* of a wave in Q7.1.4.

(e) In Q7.2.1 a notable number of candidates had a challenge in defining a *wave*. A common error was *a repetitive movement*.

(f) Most candidates had difficulty recalling characteristics of electromagnetic waves in Q7.5. A significant number of candidates did not even attempt to answer this question.

**Suggestions for improvement**

(a) Emphasise learning of definitions as they appear in the *CAPS* and *Examination Guidelines*.

(b) Teachers must use light kits and *PhET*-simulations to reinforce the teaching and learning of *dispersion* and *electromagnetic waves/spectrum.*

(c) Learners must be taught to use acronyms and rhymes to recall different colours of the spectrum like *ROYGBIV* and electromagnetic waves like *RMIVUXG*.

(d) Teachers should give learners more activities involving the labelling of colours of the spectrum of visible light and electromagnetic waves.

## QUESTION 8: ELECTRIC CIRCUITS AND POWER

### Common errors and misconceptions

(a) In Q8.1 a significant number of candidates showed little understanding of a difference between *capacitor* and *capacitance*. Some common mistakes included:
- Omitting keywords like *amount*, *store* and *per unit volt*
- Using *energy* instead of *charge*

(b) In Q8.2 and Q8.3 candidates swopped the equations $C = \frac{Q}{V}$ and $C = \frac{\varepsilon_0 A}{d}$ around. Some had difficulty in using unit conversion as well the relationship between the scientific notation and prefixes, e.g. $10^9$ means *nano*.
Others wrote incorrect SI units in the final answer.

### Suggestions for improvement

(a) Teach learners all concepts, definitions, terminology, laws and principles as defined or stated in *CAPS* and the *Examination Guidelines*.

(b) Unit conversion, scientific notation and writing of an SI unit in the final answer must be revised thoroughly.

(c) Teachers must drill calculator skills.

(d) PEDs and district officials must organise regular Technical Sciences teacher development workshops.

## QUESTION 9: ELECTRIC CIRCUITS AND POWER

### Common errors and misconceptions

(a) In Q9.1 most candidates omitted keywords like *rate* or *electric energy*. The responses showed that they were defining *power* as defined in *mechanics* not *electric power* as required.

(b) In Q9.2 candidates struggled to identify the equation suitable to calculate resistance using the information provided on the leading statement. Some used the equations $R = \frac{V}{I}$ and $W = \frac{V^2 \Delta t}{R}$ for calculating resistance and were frustrated by having two unknown variables.

(c) A notable number of candidates used the parallel resistors equation to calculate effective/total resistance of resistors in series in Q9.3. Some did not realise that to calculate potential difference across the 5 Ω resistor, one needs to use the current flowing in the circuit.

### Suggestions for improvement

(a) Teachers must teach learners the basic concepts of resistors, i.e. how to calculate the total resistance of resistor in series and in parallel.

(b) Learners must be given informal activities to reinforce the fact that parallel resistors are current dividers and resistors in series are voltage dividers.

(c) Teachers must revise Ohm's laws taught in lower grades.

**QUESTION 10: GENERATORS AND TRANSFORMERS**

**Common errors and misconceptions**

(a) In Q10.1.1 most candidates had difficulty stating a phenomenon illustrated in the diagram.

(b) In Q10.1.2 candidates stated Faraday's law instead of using it to state a relationship between the extent of the deflection of a needle, rate of change and induced emf.

(d) A significant number of candidates could not give a reason why this transformer is a step-down transformer in Q10.2.1. They failed to refer to the *number of windings* and voltage in the primary and secondary coil.

(e) In Q10.2.2 most candidates substituted incorrectly or wrote down the formula for a transformer incorrectly instead of copying it directly from the formula sheet. Some had difficulty of making the *number of windings* in the primary coil a subject of the formula.

**Suggestions for improvement**

(a) Teachers must teach learners terminology as they appear in the *CAPS* and *Examination Guidelines*.

(b) *Edukite* or *PhET*-simulations must be used to enhance the understanding of the principle of electromagnetic induction as well as Faraday's law and Lenz' law.

(c) The difference between a *motor* and a *generator*, as well as the difference between an *AC* and a *DC* motor/generator must be explained thoroughly.

(d) Teachers must emphasise the writing of the correct formula, substitution and the need to have units in the final answer.

## 3.5 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 2

**General comments**

(a) Questions on definitions were poorly answered.

(b) Candidates struggled with Question 4 (Reactions of organic molecules), Question 5 (Electrolytic cell) and Question 6 (Galvanic cell).

(c) Writing half-reactions and net ionic cell reactions proved to be a challenge for candidates.

(d) The interpretation and the use of the Table of Standard Reduction Potentials posed a challenge to most of the candidates.

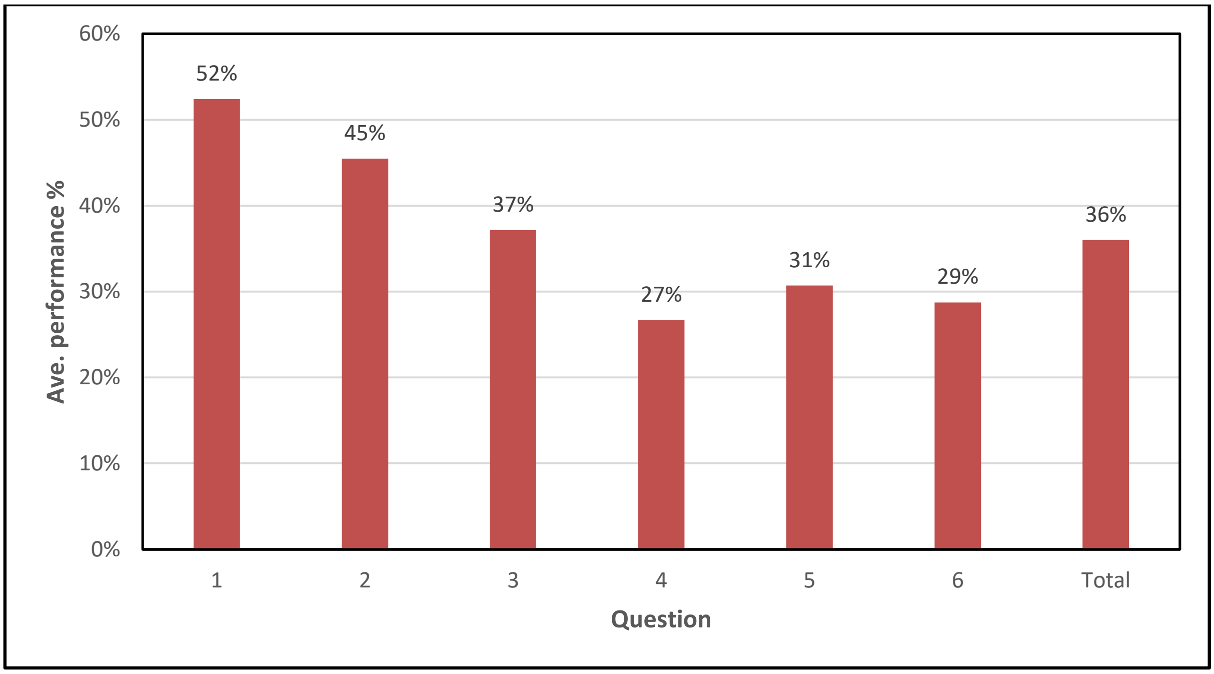
(e) The types of isomers proved to be a problem for candidates.

(f) Candidates' performances were poor in questions which required motivation using scientific reasoning.

## 3.6 DIAGNOSTIC QUESTION ANALYSIS OF PAPER 2

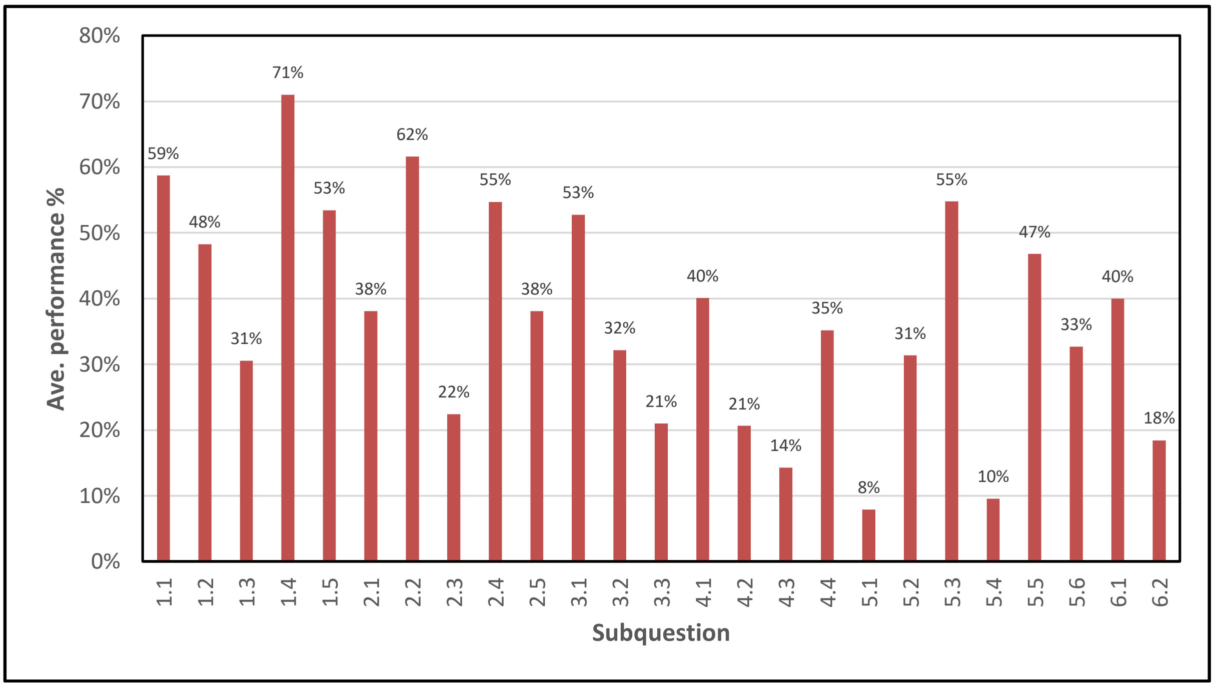
The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

**Graph 3.6.1 Average performance per question in Paper 2**




| Q | Topics | Q | Topics |
|---|---|---|---|
| 1 | Multiple-choice Questions | 4 | Reactions of Organic Compounds |
| 2 | Naming of Organic Molecules and Structures | 5 | Electrolytic Cell |
| 3 | Physical Properties of Organic Molecules | 6 | Galvanic Cell |

**Graph 3.6.2 Average performance per subquestion in Paper 2**



## 3.7 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 2

### QUESTION 1: MULTIPLE-CHOICE QUESTIONS

**Common errors and misconceptions**

(a) In Q1.1 candidates could not correctly identify the functional group, especially when there were similarities in the structure of the functional group, e.g. ketones and aldehydes.

(b) Candidates could not identify the compound with the lowest vapour pressure even though boiling points were given in Q1.2. They could not draw inference from the relationship between the boiling point and vapour pressure.

(c) In Q1.3 a significant number of candidates failed to recall the definition of oxidation in terms of electron transfer and oxidation numbers.

(d) Most candidates could not identify the electrode that gains and the one that loses mass between an anode and a cathode in a galvanic cell in Q1.5.

**Suggestions for improvement**

(a) Teachers should explain the difference between the different homologous series by using their functional groups.

(b) Teachers must thoroughly explain that when given a series of values for the boiling point or melting point, the highest negative value would be the lowest in terms of its magnitude on the numerical scale. These values should also be linked to and taught in accordance with physical properties.

(c) Teachers need to explain the relationship between the different physical properties of organic molecules, e.g. melting point, boiling point and vapour pressure.

(d) The difference between oxidation and reduction should be thoroughly explained in terms of electron transfer and oxidation numbers.

(e) Learners must be guided to eliminate the wrong answers through regular practice and assessment. Use the practice of scientific argumentation among learners to identify incorrect multiple-choice distractors.

### QUESTION 2: NAMING OF ORGANIC MOLECULES AND STRUCTURAL FORMULAE

**Common errors and misconceptions**

(a) In Q2.1 candidates omitted the word 'only' when defining *hydrocarbon*.
There was the incorrect use of words that changed the context of the definition, e.g. 'The carbon atom that is bonded to hydrogen atom only'.

(b) The most common mistakes committed in Q 2.2.1 when drawing the structural formula of 1-chlorobutane include the following:
- A bond indicated between C and ℓ for chlorine
- The omission of bonds or hydrogen atoms

- Using double bonds between the carbon atoms
- The chlorine atom often placed on the second carbon of the hydrocarbon compound instead of the first

(c) Common errors committed by candidates when drawing structural formula for butan-1-ol in Q2.2.2 are as follows:
- ‘ol’ was used instead of -O-H.
- When the correct functional group was used, it was not clear which of the atoms between O and H was bonded to the carbon atom.
- Had two bonds for hydrogen as -C-H-O instead of -C-O-H.
- Drawing a structural formula of a carboxylic acid rather than of an alcohol.

(d) In Q2.3 candidates could not identify and give the IUPAC name of the *ester* when the structural formula was given.

(e) Most candidates could not identify the *homologous series* of the given molecules from recognition of their *functional groups* in Q2.4.1 and Q2.4.2.

(f) In Q2.5.1 candidates used the phrase ‘*they are compounds having the same general formula but different structures*’ instead of defining *structural isomers* as *‘organic compounds having the same molecular formula but different structural formula’*.

(g) Candidates struggled to identify the type of structural isomers of compounds B (ester) and D (carboxylic acid) in Q2.5.2.

**Suggestions for improvement**

(a) Teachers must emphasise the inclusion of the key words when defining concepts. Short informal tests on definitions, stating laws and principles should be written. Greater emphasis should be placed on the learning of definitions listed in the *CAPS* and the *Examination Guidelines*.

(b) Teachers must emphasise the link between the functional group and homologous series of molecules. The structural differences between functional groups should be reinforced by using consolidation activities, with specific reference to the drawing of structural formulae.

(c) Drawing of structural formula of the functional groups and compounds in different homologous series should be assessed informally and formally. Learners should check whether each carbon atom has four bonds and that all hydrogen atoms are included.

(d) The bond between the Oxygen and Hydrogen should be indicated when drawing the structural formula of the alcohols.

(e) The IUPAC naming rules of organic compounds must be emphasised, i.e. a correct prefix must be given and a number, comma and hyphen should be placed correctly. Emphasise the fact that a hyphen is only used between a letter and a number in the IUPAC name and a comma is only placed between two numbers when having multiple locations of additional attachments to the parent chain.

(f) Learners must be assessed on different structural isomers, i.e. chain, functional and position in terms of defining, identifying and drawing them.

(g) The use of audio-visual aids when revising organic chemistry is encouraged.

## QUESTION 3: PHYSICAL PROPERTIES OF ORGANIC COMPOUNDS

### Common errors and misconceptions

(a) Candidates failed to correctly identify the type of intermolecular forces between alkane molecules in Q3.1.1. Some wrote Van der Waals forces instead of being specific by writing London forces.

(b) In Q 3.1.2 candidates could not identify a compound with stronger intermolecular forces between butane and methylpropane.

(c) In Q3.1.3 candidates failed to recognise and explain that branching or chain length is a factor that had an influence on the strength of the intermolecular forces when comparing butane and methylpropane. Some did not compare these compounds when responding to the question.

(d) Candidates struggled to give reasons why the comparison of the boiling points of butane and butan-1-ol is fair in Q3.2.1.

(e) Candidates failed to explain why butan-1-ol (alcohol) had a higher boiling point than butane (alkane) in Q3.2.3. They could not identify correct type of intermolecular forces and to compare the strength of the intermolecular forces of the alkanes and alcohols.

(f) Most candidates could not arrange the given compounds in order of decreasing vapour pressure through identification of the type and strength of their intermolecular forces in Q3.3.

### Suggestions for improvement

(a) Teachers must emphasise the importance of being specific about the type of intermolecular forces and the strength of intermolecular forces acting on organic compounds from different homologous series.

(b) All factors, e.g. chain length, branching, homologous series/type of functional group, type of intermolecular forces, etc., that influence the strength of the intermolecular forces should be explained thoroughly and when to use them.

(c) When explaining the impact of the physical properties of organic compounds, learners must be encouraged to give their explanation in point form addressing structure, relationship and energy rather than in a paragraph.

(d) Learners must be guided on how to use chain length, type of intermolecular forces, strength of the intermolecular forces and energy to explain trends in physical properties of organic compounds. Emphasis should be on the comparison between the given compounds.

(e) Teachers must train learners to pay attention to the mark allocation of a question, which will inform them regarding the extent to which the answer should be given.

(f) Learners must be able to identify the factor that determines the strength of the intermolecular forces of a specific question.

(g) Learners must mention compounds when comparing compounds and should be specific about the factors which are compared rather than being too general.

(h) Teachers must emphasise the relationship of physical properties and the impact they have on each other.

(i) Teachers must guide learners on how to articulate their responses in such a way that it encompasses all desired aspects about physical properties of organic compounds in informal (classwork and homework) and formal tasks.

## QUESTION 4: REACTIONS OF ORGANIC COMPOUNDS

### Common errors and misconceptions

(a) Candidates could not analyse the given reactions so that they could name them in Q4.1.1 and Q4.1.2.

(b) Candidates failed to name the catalyst needed for hydrogenation of propene in Q4.2.1.

(c) In Q4.2.2 candidates struggled to recall the reaction condition needed for the substitution reaction of an alcohol with hydrogen bromide. The common incorrect response was excess water instead of no water, and mild temperature instead of mild heat.

(d) In Q4.3.1 some candidates used molecular formulae instead of structural formulae for the reaction of propane with bromine to form 2-bromopropane. Those who managed to use structural formula made the following common mistakes:

- Wrong symbols used; Br instead of Br-Br and writing bromine as br or BR
- Omission of the arrow to separate reactants from the products
- Drew the structural formula of 1-bromopropane instead of 2-bromopropane
- $H_2O$ was not included as one of the products
- Drew the structural formula of the major product without the reactants and the arrow

(e) In Q4.3.2 candidates failed to recall the products for the combustion of alkanes.

(f) Candidates had difficulty in naming the process that is used to improve the conductivity of semiconductors in Q4.4.1.

(g) Candidates defined an intrinsic semiconductor as a conductor in its pure form, instead of a semiconductor in its pure form.

(h) In Q4.4.3 most candidates struggled to distinguish between an n-type semiconductor and a p-type semiconductor. The word 'carriers' was omitted. They stated that an n-type semiconductor is negative and the p-type semiconductor is positive.

### Suggestions for improvement

(a) Teachers must emphasise the different types of reactions which include combustion/oxidation, substitution and addition as well as their reaction conditions.

(b) Teachers must explain that saturated compounds will undergo substitution reaction while unsaturated compounds will undergo addition reaction.

(c) Emphasise the difference between molecular, structural and condensed structural formulae. The correct scientific symbols must be used when writing reactions.

(d) It should be clearly explained that products in any combustion reaction of the hydrocarbons will be $CO_2$ and $H_2O$. Use simulations and videos to explain combustion reactions for learners to gain a deeper understanding of the concept.

(e) The difference between doping as a process and the definition should be thoroughly explained.

(f) Interpretation and analysis of questions should be addressed so that learners respond to the questions accordingly.

(g) Teachers must emphasise definition of concepts.

(h) Teach the concepts of n-type and a p-type semiconductors using Lewis structures to show the formation of excess negative charge carriers and positive hole. It is advised that teachers use computational simulations when teaching *doping* in electronic properties of matter. This will allow learners to make a clear distinction between the n-type and p-type semiconductors and gain a deeper understanding of the concept.

| p-type | n-type |
|---|---|
| Doped with Group III/trivalent elements | Doped with group 5/pentavalent elements |
| Impurities added create vacancy of electrons(holes) | Impurities added provide extra electrons |
| Electrons are minority charge carriers and holes are the majority charge carriers | Electrons are majority charge carriers and holes are minority charge carriers |

**QUESTION 5: ELECTROLYTIC CELL**

**Common errors and misconceptions**

(a) Majority of the candidates could not give the name of the cations in Q5.1.1 and of anions in Q5.1.2 of the electrolyte even though the formula of these ions were given in the diagram. They wrote copper instead of copper (II) ions and chlorine ions instead of chloride ions. Some learners gave the symbol of the ions instead of the names.

(b) In Q5.2.1 and Q5.2.2 most candidates swopped the polarity of the *anode* and the *cathode*. Some candidates gave ions as representation of the electrodes instead of stating whether the electrode was the positive or negative.

(c) In Q5.3 some candidates defined oxidation as a substance that loses electrons or the loss of electrodes instead of referring to it as loss of electrons.

(d) Most candidates wrote the half-reaction of copper ($Cu^{2+} + 2e^- \rightarrow Cu$) instead of chlorine ($2C\ell^- \rightarrow C\ell_2 + 2e^-$) in Q5.4 for the reaction occurring at the positive electrode. Some used double arrows and omitted ions.

(e) Candidates confused the definition of *reducing agent* with that of *oxidation* in Q5.5. They defined reducing agent as loss of electrons or as a process that undergoes oxidation, instead of *'a substance that is oxidised or loses electrons'*.

(f) In Q5.6 candidates failed to follow instructions and drew a galvanic cell instead of an electrolytic cell. Common mistakes were as follows:

- Electrodes were not labelled as spoon and silver but labelled as anode and cathode or had incorrect labels.
- $CuC\ell_2$ or silver chloride was used as an electrolyte instead of silver nitrate or silver acetate.
- The spoon to be electroplated was connected to the positive terminal and the silver electrode at the negative terminal of the battery.

**Suggestions for improvement**

(a) The difference between cations and anions, and the names of the specific ions of any electrolyte should be clearly explained. For copper, specify whether it is copper (I) ions or copper (II) ions when giving the name of the ions.

(b) Ensure that there is a clear distinction between the anode and the cathode and explain how the electrodes are polarised in electrolytic cells.

(c) Definitions, with the emphasis on the key words, and the difference between *reducing agent*, *oxidising agent*, *oxidation* and *reduction* should be addressed.

(d) Learners should be taught to use the Table of Standard Reduction Potentials to write oxidation and reduction half-reactions, to identify the oxidising and reducing agents and to write the overall net cell reactions.

**QUESTION 6: GALVANIC CELL**

**Common errors and misconceptions**

(a) In Q6.1.1 some candidates identified the type of cell as an electrochemical cell instead of galvanic or voltaic cell.

(b) Candidates failed to use the Table of Standard Reduction Potential to write the net ionic reaction of the Zn-Cu cell in Q6.1.2. Some wrote it incorrectly as: $Zn^{2+} + Cu \rightarrow Zn + Cu^{2+}$ or wrote the cell notation, omitted ions and used double arrows.

(c) In Q 6.1.3 candidates:
- Struggled to calculate the emf the zinc-copper cell
- Used unconventional abbreviations or details concerning subscripts or superscripts have been omitted
- Had no units in the final answer
- Swopped the E° values of the cathode and the anode

(d) Most candidates found it difficult to identify the reaction which is spontaneous and to use the Table of Standard Reduction Potential to explain in Q6.2.1 and Q6.2.2.

**Suggestions for improvement**

(a) Teachers must differentiate between the two types of electrochemical cells which are the galvanic and the electrolytic cell.

(b) Teachers should ensure that learners understand how to use the Table of Standard Reduction Potentials to write half-reactions and the net cell reaction. The table should also be used to predict the spontaneity of a reaction by referring to the oxidising or reducing ability of the reactants.

(c) Learners should be able to identify and compare the strength of the reducing and the oxidising agents using the Table of Standard Reduction Potentials.

(d) Learners should be exposed to what is in the data sheet and how to use it. Teachers should ensure that learners can use the Table of Standard Reduction Potentials to get the correct values to be used in the calculation of the emf of the cell.

(e) Much emphasis should be placed on the importance of copying formulae correctly from the data sheet, together with ensuring that final values calculated are furnished with an appropriate unit.

(f) Learners should be reminded that, when using formulae, marks will only be credited for a formula if the values are correctly substituted into the formula.

(g) Practical work (experiment) of the galvanic cell should be infused in lessons.