CHAPTER 2

TECHNICAL SCIENCES

The following report should be read in conjunction with the Technical Sciences question papers of the NSC November 2018 examinations.

2.1 PERFORMANCE TRENDS (2018)

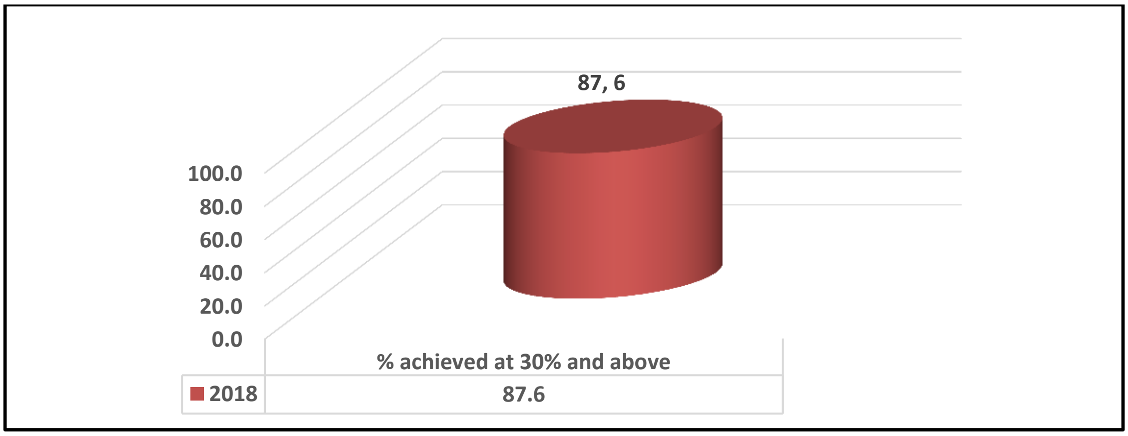
In 2018, 10 503 candidates sat for the Technical Sciences examination. The performance of the candidates in 2018 at the 30% level was 87,6% and at the 40% level it was 50,8%.

Table 2.1.1(a) Overall Achievement Rates in Technical Sciences

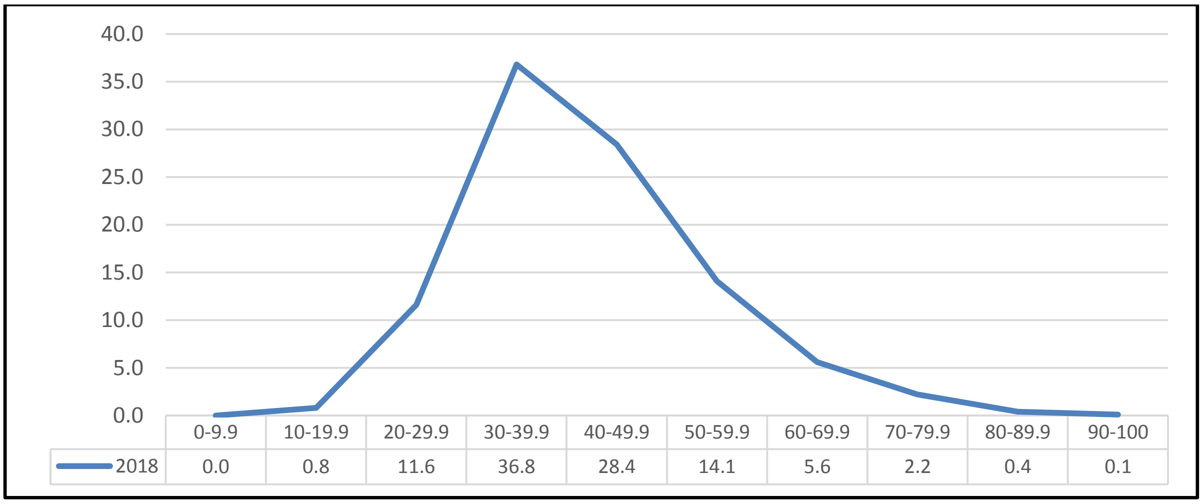
Year	No. Wrote	No. achieved at 30% and above	% achieved at 30% and above	No. achieved at 40% and above	% achieved at 40% and above
2018	10 503	9 204	87,6%	5 335	50,8%

The performance of candidates in Technical Sciences in 2018 was good and can be attributed to the inclusion of the PAT. There is still room for improvement in the performance of the candidates if the challenges surrounding practical work, problem-solving skills, mathematical skills, conceptual understanding and integration of topics are addressed.

Graph 2.1.1(b) Overall Achievement Rates in Technical Sciences (Percentage)



Graph 2.1.1(c) Performance Distribution Curves in Technical Sciences (Percentage)



2.2 OVERVIEW OF LEARNER PERFORMANCE IN PAPER 1

General Comments

(a) The multiple-choice items in Q1 and the questions on elasticity, viscosity and hydraulics and electrodynamics in Q5 and Q9 were generally well answered.

(b) Questions 3, 4 and 8 were poorly answered. Learners struggled with Q3 (momentum, impulse and the principle of conservation of linear momentum). Q4 dealt with work and energy. Learners confused energy principles with momentum. Q8 which was based on electrostatics, posed a problem because the content was a continuation from previous grades.

(c) Newton's laws, assessed in Q2, were fairly answered, but learners could not apply their knowledge. Q7 was based on electric circuits and was fairly answered.

(d) Questions pertaining to pure recall of content were very poorly answered. Teachers are advised to use informal assessment tasks to reinforce basic concepts and principles by using, for example, short speed tests (±10 minutes). This can be used in content relating to definitions and laws listed in the *CAPS* and the examination guidelines.

(e) Learners are struggling with drawing and labelling free-body diagrams. The drawing of free-body diagrams is central to solving problems involving forces acting on objects and teachers should therefore ensure that learners are able to draw force and free-body diagrams and assess them in formal and informal activities. Emphasis must be placed on magnitude, direction and the labelling of forces.

(f) Some learners have difficulty with understanding and using formulae and scientific notation. Learners should be taught to identify and use the correct formula from the data-sheet and substitute values correctly. It is also important to correct calculator skills and write down the answer with correct units. Emphasise the correct direction where relevant, by revisiting vector addition taught in previous grades.

(g) Application of mathematical principles is a challenge for many learners. Learners should be given a variety of problem-solving activities that involve mathematical skills pertaining to fractions, manipulating the subject of the formula and graphs in formal and informal activities.

(h) Learners must be able to interpret and answer questions based on a variety of action verbs. Refer to the examination guidelines (Blooms' taxonomy).

(i) Correct definitions and laws should be enforced during daily teaching and learning. Teachers should include at least multiple choice items, definitions and laws as well as structured questions on the various topics in formal and informal activities on a regular basis. This is to enhance a deeper understanding of Science concepts and content knowledge as well as to take remedial action.

(j) Enhance teaching and learning by means of teaching aids such as models, pictures, drawings, diagrams, videos, simulations as well as experiments and demonstrations. Learners must also be able to analyse information and answer questions based on diagrams and graphs.

(k) Learners must be given enough activities to practise correct conversion of units. Rounding off must be done as instructed.

(l) Learners must be exposed to the correct use and understanding of subscripts, e.g. Fnet, Wnet, fk.

2.3 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 1

QUESTION 1: MULTIPLE CHOICE

Common Errors and Misconceptions

(a) In Q1.2, many candidates failed to understand that the object moved at a constant velocity because the net force and acceleration were zero.

(b) In Q1.3, candidates failed to understand the relationship between mass and inertia.

(c) In Q1.4, candidates failed to understand the relationship between contact time, change in momentum and net force in the given scenario on air bags.

(d) In Q1.5, the candidates misunderstood the concept of elastic and inelastic collision.

(e) In Q1.8, candidates failed to recognise that the dielectric material is air and is represented by K=1. The substitution in the formula was therefore misunderstood, and candidates failed to understand that the formula $C = \kappa \frac{\varepsilon_o A}{d}$, can be written as $C = \frac{\varepsilon_o A}{d}$.

(f) In Q1.9, some candidates failed to link the question to the definition of stress.

Suggestions for Improvement

(a) Teach learners to identify the applied force(s), calculate the net force and select the correct formula. Learners must understand that when acceleration is zero, velocity is constant and should be able to apply their knowledge of net and applied forces. Components of forces must be taught. It is also important to understand and practise a variety of vector additions in different situations.

(b) The relationship between mass and inertia must be taught. Teachers must teach these concepts well and state the definitions correctly.

(c) The impulse-formula must be known to understand the relationship between contact time, change in momentum and net force in a scenario. Learners must know that $F_{net.}\,\Delta t$ is impulse.

(d) Teach learners to understand the concept of elastic and inelastic collision and their relationship to the conservation of total linear momentum and that of total kinetic energy in a system.

(e) Use different types of dielectric materials in calculations, and explain the concept of permittivity of free space, to enhance the understanding of the formula, $C = \kappa \frac{\varepsilon_o A}{d}$.

(f) Give weekly informal tests on a variety of definitions and concepts.

(g) Learners should also be exposed to as many multiple-choice questions as possible, where they must be taught the skill to answer multiple-choice questions. They must be given an opportunity to explain their choice (of the correct option) and this exercise must be used to clarify any misconception. Guess-work should be discouraged.

(h) Encourage the use of the formula sheet.

QUESTION 2: NEWTON'S LAWS OF MOTION

Common Errors and Misconceptions

(a) In Q2.1.1, candidates omitted key words such as 'single force that has same effect as two or more forces acting together' in their definition of net force. Some candidates wrote 'a net force is a sum of friction and gravitational force', instead of 'a vector sum of all forces acting on an object'. They did not understand the concept of vector sum.

(b) In Q2.1.2, candidates did not realise that they were supposed to calculate the net force and not just a force. Many of them did not indicate the correct direction. Many candidates used an incorrect or incomplete formula. F_{net} was not used to obtain the vector sum of the forces of Jerry, Sipho and the friction. In some instances only $F = F_{jerry} + F_{Sipho}$ was used.

(c) Many learners used T (tension) when calculating the force or used simultaneous equations to calculate the acceleration, which was then substituted back into the equation to calculate some force. Some candidates used the unit of J (joule) instead of newton (N).

(d) Some learners cannot state Newton's second law in words. Some learners stated Newton's second law in terms of the rate of change of momentum of the object in the direction of the net force.

(e) Candidates had trouble with calculations where more than one force is acting on an object, particularly if one of these forces is acting at an angle. They fail to resolve F_{Jerry} into its components. Candidates failed to do correct vector addition.

(f) In Q2.1.2 & 2.1.5 the sign convention in terms of the direction proved to be a challenge. Some candidates omitted the direction and units in their final answer. Some used incorrect units, e.g. $m.s^{-1}$ instead of $m.s^{-2}$.

(g) In Q2.2, candidates could not identify and state the law relevant to a given scenario. Some stated the law instead of using it to explain the given scenario. They could not explain what happened to the passenger. The common responses of candidates included statements such as 'the passenger remains at rest', or 'exerts an unbalanced force on the dash board' or 'the passenger exerts a velocity on the car and the car is moving object B whereas object B exerts the same amount of velocity back to A which will injure the passenger'.

Suggestions for Improvement

(a) Definitions, stating laws and principles, calculations involving more than one force acting on an object and forces acting at an angle, as well as application of laws and principles to a given scenario must be emphasized and integrated into informal assessment tasks to prepare for formal task and enhance learner understanding.

(b) Learners must be exposed to questions involving the various scenarios relating to the application of Newton's laws. If there is more than one object involved, they must be taught to identify which one of the objects exerts a force on which other one and the effect of the exerted force.

(c) Learners must be able to identify the formula applicable to a given situation. They must be able to identify all the forces acting and to calculate the net force using vector addition.

(d) Emphasise the correct use of SI units and conversions as well manipulation of mathematical formula.

(e) Teachers must encourage the use of free body or force diagrams to solve problems.

QUESTION 3: MOMENTUM

Common Errors and Misconceptions

(a) In Q3.1.3, candidates calculated momentum instead of the change in momentum. Those who calculated the change in momentum swapped the value for v_i and v_f.

(b) In Q3.1.4, candidates struggled to identify the correct formula, instead of using the formula $\sum p_i = \sum p_f$, they used $\Delta p = m \Delta p$ or p = mv.

(c) Candidates confused elastic and inelastic collision with elasticity (perfect elasticity and plasticity) in Q3.2. They explained elastic collision in terms of elasticity. Some omitted the word 'total' or 'sum of' from the phrase 'total kinetic energy' and 'total linear' from 'total momentum'. They just wrote kinetic energy is (not) conserved or momentum is conserved. They used calculations to explain elastic and inelastic collisions.

(d) In Q3.3.1, candidates defined impulse as the rate of change in momentum, instead of the change in momentum.

(e) Candidates used p = mv instead of $F_{net}. \Delta t = \Delta p$ to calculate impulse in Q3.3.2. Some substituted incorrect values and calculated F_{net} instead of impulse.

(f) In Q3.3.3, some candidates used the formula F_{net} = ma and F_g = mg instead of $F_{net}\Delta t = \Delta p$ to calculate the force experienced by the wicketkeeper's hands.

(g) In Q 3.3.5, candidates struggled to identify the relationship between F_{net} and Δt. Some mentioned that the change in momentum stays the same and explained the decrease in time in relation to the force. They failed to mention that the net force increases.

Suggestions for Improvement

(a) Quality time must be spent on teaching momentum, change in momentum and impulse ($F_{net.}\Delta t$). The principle of conservation of linear momentum must be well taught.

(b) Learners must be given more activities with calculations involving the principle of conservation of linear momentum and impulse, including application in transport, safety and sports.

(c) Learners must also be given experience involving elastic and inelastic collisions. The teacher must clarify the difference between elastic collision and elasticity, emphasizing the phrases' total kinetic energy' and 'total linear momentum'.

(d) Teachers must teach learners the correct sign conventions regarding direction.

(e) Teachers must teach learners the skill of analysing the information to identify the correct formulae, do correction substitution and calculator skills. Learners must practise to write the correct answer with correct units and direction (magnitude and direction).

(f) Teachers must clarify learners' misconception that the initial velocity will always be smaller than the final velocity.

(g) Learners must be taught the difference between Newton's second law (F_{net} = ma), momentum and impulse ($F_{net}\Delta t = \Delta p$) and practise application and calculations of these concepts.

QUESTION 4: WORK, ENERGY AND POWER

Common Errors and Misconceptions

(a) In, Q4.1.1, some of the candidates confused the definition of work done with the principle of conservation of mechanical energy. Those who defined work done, omitted key words such as 'product' or 'applied'.

(b) In Q4.1.2, most candidates could not identify the forces that are working on the object. They could not resolve the applied force in its horizontal component. Some candidates omitted $\cos 180^o$ or $\cos 0^o$ in the formula and did not indicate the direction of the frictional force or the component of the applied force. They did not use the formula for net work, but only calculated work done. Incorrect units were also used, e.g. N or W instead of J.

(c) Ccandidates omitted the word 'total' or 'in an isolated system' and just wrote that mechanical energy is conserved in Q4.2.1.

(d) In Q4.2.2, candidates used formulae or calculations to distinguish between kinetic and potential energy instead of explaining in words.

(e) Candidates failed to apply the principle of conservation of mechanical energy in Q4.2.4.

(f) In Q4.2.5, candidates substituted h = 1,6 instead of 1,2 because they failed to interpret the question correctly. They could not deduce the height of the brick at the point where it was caught.

Suggestions for Improvement

(a) Expose candidates to a variety of contexts for problem-solving activities, involving work done (including net work) and conservation of mechanical energy, focusing on one or more skills at a time, such as interpreting the context and identifying relevant formulae.

(b) Learners must know the definitions as stated in the *CAPS* and the examination guidelines. Teachers must emphasise the use of correct scientific language, for example the use of words such as 'isolated' system and 'total linear momentum' in the principle of conservation of linear momentum.

(c) Learners must be given extensive exposure to calculations involving work done by forces on an object (drawing free body and force diagrams), work done by individual forces and the work done by the net force, as well the net work done. Resolution of forces into components must be emphasised. Formulae/Equations must also be used to enhance an explanation of the relationship between different variables. Ensure that learners know what each symbol represents in each equation.

(d) Teachers must emphasise the correct use of the angle ($\text{Cos}\ \theta$, $\text{Cos}\ 0^0$, $\text{Cos}180^0$) between the displacement and forces acting on the object.

QUESTION 5: ELASTICITY, HYDRAULICS

Common Errors and Misconceptions

(a) Some candidates could not define 'strain' in Q5.1.1. They confused the definition of strain with that of 'stress' and omitted key words such as 'ratio' and 'change in length'.

(b) In Q5.1.2, some candidates failed to understand that 'change (Δ)' in length is the difference between the original and new dimensions and included a unit.

(c) Some candidates could not define the term 'perfect elasticity' in Q5.1.3. Some omitted key words such as 'regains its original shape and size completely' and 'when the deforming force is removed.' They failed to give correct examples of a perfect elastic body and gave the names of elastic objects, e.g. balloons, plastic bags and rubber.

(d) In the final answer to Q5.1.4, some candidates placed the comma in the wrong position. They lacked an understanding of the conversion of units and of scientific notation. They confused the unit of pressure (Pa) with the unit of force (N).

(e) In Q5.2, some candidates explained how Hooke's law was applied in technology instead of stating the law, e.g. 'A field in applied science and engineering dealing with mechanical properties of liquids'.

(f) Most learners failed in Q5.3 to identify that the distance between the pistons do not influence the force in the hydraulic system.

Suggestions for Improvement

(a) Learners must master Hooke's law, definitions of stress, strain, elastic body, perfect and elastic body. They must be given regular speed tests to assess the learner's ability to recall definitions and laws.

(b) Learners need more practice in analysing diagrams.

(c) Conversions of units and values must be practiced and assessed on regular basis.

(d) Learners must know that Δ (change) means 'final – initial'.

(e) Teach learners explanation and examples of perfect elastic body and hydraulic systems.

(f) Give learners many practice exercises on calculations involving stress, strain, Hooke's law and hydraulics systems. Place emphasis on the correct units, conversion of units and scientific notation.

QUESTION 6: CAPACITORS AND SEMICONDUCTORS

Common Errors and Misconceptions

(a) In Q6.1, several candidates struggled to state the definition correctly. They defined a capacitor as 'a device for storing electric current' while others defined it as 'a device for storing energy or electricity'.

(b) In Q6.2, candidates confused the factors affecting the induced emf with those affecting the capacitance of the capacitor. Others wrote only 'area' or 'size' instead of 'total surface area of the plates' or 'distance' instead of 'distance between the plates' or 'dielectric' instead of 'type of dielectric material'.

(c) Candidates struggled with correct conversion of units and scientific notation in Q6.3.

Suggestions for Improvement

(a) Learners must be able to define capacitance, capacitor, dielectric material, doping, and intrinsic conductors.

(b) Factors affecting capacitance must be written in full and not just using key words.

(c) Learners must know the correct formulae and meaning of each symbol and how they relate to each other.

(d) Activities must be given to learners to practise the types of calculations involving capacitance, including correct conversion of units.

QUESTION 7: ELECTRIC CIRCUITS

Common Errors and Misconceptions

(a) In Q7.1.1, some candidates failed to invert $\frac{1}{R_p}$ to $R_{parallel}$ and some did not distinguish between the series and parallel resistors.

(b) Some candidates did not use the three cells for the emf of the battery in Q 7.1.2. They only used one cell of 2V.

(c) In Q7.2, candidates did not understand the relationship between the current and resistance.

Suggestions for Improvement

(a) Exercises must be used to expose learners to different circuit diagrams to enhance the understanding of diagrams of various electric circuits. Learners must know how to simplify circuit diagrams.

(b) Emphasize that several cells make a battery.

(c) Use correct scientific terminology.

(d) Revise content of electricity and electric circuits from precious grades (10 and 11).

(e) Mathematical skills such as the addition and inversion of fractions must be given attention.

(f) Teach learners to identify resistors that are connected in series and in parallel as well as identify and substitute into the correct formula.

QUESTION 8: ELECTROSTATICS

Common Errors and Misconceptions

(a) In Q8.1.1, some candidates confused magnetic field around a current carrying conductor with magnetic fields between or surrounding bar magnets. Some drew a circular field but failed to show the correct direction of the field. They misinterpreted the meaning of the cross and the dot in the diagram.

(b) In Q8.1.2, some candidates could not identify if the interaction between the two magnetic fields in Q8.1.1 was attraction or repulsion.

(c) Some candidates stated Faraday's law incompletely in Q8.2.1. They wrote: 'when the magnetic flux linked with the coil changes, an emf is induced in the coil.' or 'the magnitude of the induced emf is directly proportional to the rate of change of magnetic flux.'

(d) In Q8.2.2, some candidates omitted the negative sign from the formula. Others swapped values for Φ_1 and Φ_2 when substituting into the equation $\varepsilon = -N\frac{\Delta\phi}{\Delta t}$.

(e) Some candidates confused the factors affecting the induced emf with those affecting the capacitance of a capacitor in Q8.2.3. Instead of writing the 'speed at which the magnet or coil are moved relative to each other' some wrote 'time interval' instead of 'rate of change in magnetic flux'. In some cases candidates wrote only 'strength' instead of 'strength of magnetic field' or 'turn/coil' instead of 'number of turns on a coil'.

Suggestions for Improvement

(a) Teachers must revisit Grade 11 electrostatics and emphasis must be placed on various rules e.g. the right-hand rule to identify the direction of the magnetic field surrounding a current carrying conductor. Make use of sign conventions the dot (**•**) and the cross (**x)** in teaching magnetic fields surrounding current carrying conductors.

(b) Teach learners the difference in magnetic fields between bar magnets and current carrying conductors.

(c) Teach learners to state factors in complete sentences, e.g. write 'number of the turns of the coil' and not just 'turns'. Teach them to indicate that the factor is 'the speed at which the magnet and coil is moved relative to each other' and not just 'speed or change of the magnetic flux', and write 'strength of the magnetic field' instead of the 'size of the magnetic field'.

QUESTION 9: ELECTRODYNAMICS

Common Errors and Misconceptions

(a) In Q9.1, most candidates could identify the correct formula but calculated the V_p instead of V_s.

(b) In Q9.2.1, some candidates could not use the given information in the drawing of the generator where slip rings were clearly indicated to identify the AC generator.

(c) Most candidates could not give the function of the slip ring in Q9.2.2. They generalised the function and the incorrect responses included the following 'the slip-rings measures the speed of the rotation of the conductor' or 'the slip-rings maintain stability' or 'the slip-rings allow current to reach the coil' instead of 'slip rings maintain electrical contact between the load and the rotating coil in an AC generator'.

Suggestions for Improvement

(a) Emphasise the structure and function of a transformer before attempting any calculations. Make use of pictures, models and videos to help learners understand transformers better. Teach learners that the input voltage is the primary voltage and the output voltage is the secondary voltage.

(b) Teach learners the components of generators and motors as well as the function of each component. Tabulate the differences between generators and motors.

(c) Teach learners the terminology associated with motors and generators, e.g. slip-rings, commutator, brushes, etc. Make use of examples of actual motors and generators, models, drawings, pictures and simulations.

2.3 DIAGNOSTIC QUESTION ANALYSIS OF PAPER 2

General Comments

(a) Questions on definitions were poorly answered. Teachers are advised to teach and assess definitions as stated in the *CAPS* and examination guidelines.
(d) Candidates could not apply scientific reasoning to explain certain phenomena.
(b) Naming of organic compounds in Q2, organic reactions in Q4, electrolytic cell in Q5 and refraction of light in Q8 were poorly answered.
(c) Most candidates struggled with the interpretation and understanding of the flow diagram in Q4.
(d) Most candidates struggled with the interpretation of diagrams and pictures.
(e) Candidates struggled with conversion of units.

2.4 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 2

QUESTION 1: MULTIPLE CHOICE

Common Errors and Misconceptions

(a) In Q1.5, candidates could not identify the reaction taking place at the anode or the cathode.
(b) Candidates confused an electrolytic cell with a galvanic cell in Q1.6.
(c) Many candidates failed to differentiate between the dependent and the independent variables in Q1.8.
(d) In Q1.10, candidates struggled to use basic mathematical relationships such as ratios.

Suggestions for Improvement

(a) Learners must be able to identify the reaction taking place at a specific electrode in an electrochemical cell.
(b) The difference between galvanic and electrolytic cells must be taught. Teachers must make use of diagrams and theory, referring to the reactions occurring at the electrodes (anode and the cathode).
(c) Teachers must ensure that learners can identify variables. Give learners assessment activities on a regular basis as well as a variety of questions in the formal and informal activities relating to experiments.
(d) Basic mathematical skills should be integrated in teaching and learning.

QUESTION 2: NAMING OF ORGANIC MOLECULES AND STRUCTURAL FORMULAE

Common Errors and Misconceptions

(a) The definition of the term 'functional group' was confused with that of a 'functional isomer'.
(b) Candidates drew the structural formula of the functional group or they gave the name of the homologous series instead of naming the functional group in Q2.2.1 and Q2.2.2.
(c) Candidates confused homologous series and functional group. Instead of writing down the homologous series 'ketone' they gave the functional group 'carbonyl' in Q2.3.1.
(d) When naming organic compound F in Q 2.3.2, candidates omitted a hyphen.
(e) Candidates struggled to identify and draw structural isomers in Q2.3.4 and Q 2.3.6.

Suggestions for Improvement

(a) Greater emphasis should be placed on the learning of the definitions as stated in the *CAPS* and the examination guidelines and should be assessed in informal and formal activities.
(b) Differentiate using examples, the functional group, functional group name and homologous series. Learners must be taught to read the information in the question and follow instructions.
(c) Teach learners the difference between homologous series and functional groups of different organic compounds.

(d) The rules of IUPAC naming of organic compounds must be emphasized, e.g. the number, comma and hyphen should be placed correctly.

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

QUESTION 3: PHYSICAL PROPERTIES OF ORGANIC COMPOUNDS

Common Errors and Misconceptions

(a) In Q3.1, candidates struggled to define the term 'homologous series' and confused the term 'molecular formula' with 'general formula'.

(b) Candidates could not identify the strongest type of intermolecular force that acts between molecules of alcohols in Q3.2.2.

(c) Candidate's responses were generic instead of being based on chain length, strength of the type of intermolecular force and energy. They stated that more energy is needed to get the substance to boil in Q3.2.4.

(d) Candidates could not explain the relationship between boiling point and vapour pressure in Q3.2.6.

(e) Learners could not identify the types of intermolecular forces and compare the strength of the forces in ethane and ethanol in Q3.4.

(f) Candidates referred to the breaking of the bonds instead of overcoming the intermolecular forces.

Suggestions for Improvement

(a) Learners should be taught definitions, including all necessary key words. They must be able to differentiate between the concepts 'molecular formula' and 'general formula'. Informal tests should be used to assess definitions regularly.

(b) The strength and the type of intermolecular forces acting on different organic compounds should be clearly explained.

(c) Candidates need to be guided on how to use chain length, strength of the intermolecular forces and energy to explain trends in physical properties of organic compounds. Teachers need to use a variety of questions which requires explanations in informal and formal activities.

(d) The relationship between boiling point and vapour pressure should be explained. Substances with high boiling points have low vapour pressures and vice versa.

(e) The type of intermolecular forces, strength of the intermolecular forces and the energy involved must be used to explain the trends of physical properties of organic compounds.

(f) Emphasize that energy is needed to overcome the intermolecular forces and NOT to break the bonds.

QUESTION 4: REACTIONS OF ORGANIC COMPOUNDS

Common Errors and Misconceptions

(a) In Q4.1.1 to Q4.1.3, candidates could not differentiate between the different types of addition reactions.

(b) Candidates could not write and balance the reaction for oxidation/combustion of alkanes in Q4.2.

(c) In Q4.3, candidates struggled to name compound **X** because they could not interpret the flow diagram.

(d) Candidates struggled to differentiate between different types of reactions in Q4.4.1.

(e) In Q4.4.2, candidates were unable to state the reaction conditions for the substitution reaction and confused them with standard conditions under which the galvanic cell operates.

(f) In Q4.5.1, candidates struggled to define the term 'plastic', instead they explained it in terms of their everyday knowledge. They left out key words such as: 'synthetic' and 'organic'.

Suggestions for Improvement

(a) During teaching emphasis should be on differentiating between the different types of reactions (combustion/Oxidation, substitution reactions and the different types of addition reactions) as well as their reaction conditions.

(b) Writing of equations for the oxidation/combustion reaction of hydrocarbons and skills of balancing the equations should be practiced.

(c) Make use of a variety of flow diagrams and teach IUPAC naming of organic compounds. Emphasis should be on differentiating between the different types of reactions and their reaction conditions as well as an interpretation of the flow diagram.

(d) The difference between standard conditions for a galvanic cell and reaction conditions for organic molecules reactions should be explained.

(e) Teach the difference between a definition and an explanation.

QUESTION 5: ELECTROLYTIC CELL

Common Errors and Misconceptions

(a) Candidates struggled to define the term electrolysis in Q5.1.

(b) In Q5.3, candidates confused the energy conversion for a galvanic and an electrolytic cell.

(c) In Q5.4.1 to Q5.4.2, candidates could not explain the observation at the anode and the cathode during the electrolysis of $CuCl_2$. Instead of mentioning the observation, they wrote half reactions.

(d) Candidates could not identify the reducing agent in Q5.6.

(e) In Q5.7.1 to Q5.7.2, candidates were unable to write the half reactions occurring at the anode and the cathode. They wrote half reactions for the Zn-Cu cell instead of the electrolytic cell of $CuCl_2$, used double arrows for half reactions and left out charges on ions.

(f) In Q5.8, instead of choosing between the cations and anions as instructed in the question, candidates wrote positive and negative ions.

Suggestions for Improvement

(a) Energy conversion for a galvanic and an electrolytic cell should be explained.

(b) When doing practical work, candidates should be guided in the skills they need to acquire, such as observations, measuring, interpreting, comparing, and drawing conclusions. Include questions relating to practical work in formal and informal activities.

(c) Learners should be taught to identify the reducing and oxidising agent in electrochemical reactions, as well as relate them to oxidation and reduction reactions.

(d) Learners should be taught to use the standard reduction potential table to write oxidation half reactions, reduction half reactions and the net reaction.

(e) Teach learners to read the questions and follow instructions.

QUESTION 6: GALVANIC CELL

Common Errors and Misconceptions

(a) In Q6.1, candidates could not define the term, galvanic cell.

(b) Candidates did not understand that the reading on the voltmeter in an incomplete galvanic cell was zero. They wrote the reading they obtained from the PAT experimental results done at schools, or they calculated the emf of the cell.

(c) In Q6.6.1, candidates did not know in which direction electrons flow in the external circuit.

(d) It was evident in Q6.6.2, that candidates could not give the standard conditions under which the cell operates. They wrote 'temperature' and 'concentration' without mentioning the values and included standard pressure and wrote incorrect units for concentration.

(e) Q6.6.3 candidates struggled to write the net reaction of the cell. They wrote the half reactions incorrect, included a double arrow and swopped the charges on the ions of copper and zinc. They wrote down the half reactions and not the net reaction.

Examples of errors were:

i. $Cu^{2+} + Zn^{2+} \rightarrow Cu + Zn$

ii. $Zn^{2+} + Cu \rightarrow Cu^{2+} + Zn$

(f) Candidates could not differentiate between net cell reaction and the cell notation. Some swopped the anode and the cathode when writing the cell notation in Q6.6.4.

Examples of the errors made were:

i. Cu(s)/$Zn^{2+(}$aq)//Cu^{2+}(aq)Zn(s)

ii. Zn^{2+} (aq)/Zn(s)//Cu(s)/$Cu^{2+(}$aq)

(g) In Q6.7.1 and Q6.7.2, candidates could not differentiate between environmental advantages, uses and forms of energy. Some stated advantages of using solar energy which were not related to the environment.

Suggestions for Improvement

(a) Perform experiments and teach learners how to observe, write down observations and interpret diagrams.

(b) The direction of the flow of electrons in the external circuit and the direction of specific ions in the salt bridge should be clearly explained.

(c) When giving standard conditions under which a galvanic cell operates, the values must also be stated. Explain when to include standard pressure.

(d) Ensure that candidates understand how to use the table of standard reduction potentials to write half reactions, net cell reaction and can identify and compare the strength of the reducing and the oxidizing agents.

(e) Learners should be taught to differentiate between the net cell reaction and the cell notation and include questions on these concepts in both formal and informal activities.

(f) The environmental advantages and disadvantages of using the alternative energies should be taught and assessed.

QUESTION 7: REFLECTION OF LIGHT

Common Errors and Misconceptions

(a) In Q7.1, candidates could not state the law of reflection or stated only one part of the law. Some confused the concepts of 'reflection' and 'refraction'.

(b) Candidates could not explain how the angle of incidence and the angle of reflection were related in Q7.3.2.

(c) Candidates could not explain that total internal reflection occurs when light travels from an optically denser medium to an optically less dense medium in Q7.4.2. They failed to interpret the diagram, did not understand the conditions needed for total internal reflection and could not provide a scientific explanation for the phenomena.

(d) In Q7.4.3, candidates could not mention the uses of total internal reflecting prisms.

(e) In Q7.5.1 to Q7.5.3, properties of real and virtual images were challenging for candidates.

Suggestions for Improvement

(a) Teachers must ensure that learners can differentiate between refraction and reflection and state the correct definitions thereof.

(b) Teach and use practical activities to demonstrate what happens when light moves through different media or is reflected in mirrors and prisms. Scientific reasoning should be emphasised when answering questions such as differentiating between reflection and refraction.

(c) Explain total internal reflection and teach the conditions for total internal reflection. Use experiments to explain how the change in the angle of incidence influences the angle of reflection and the relationship between the incident ray and the reflected ray.

(d) Familiarise learners with practical applications of reflection and refraction.

(e) Ensure that candidates know the properties of real and virtual images.

QUESTION 8: REFRACTION OF LIGHT

Common Errors and Misconceptions

(a) Candidates failed to identify the property of light in Q8.1.1. They confused refraction and reflection and they referred to the phenomena as reflection instead of refraction.
(b) Candidates could not explain the observation when light undergoes refraction.
(c) In Q8.2.2, candidates did not know that there was no deviation of the light ray through the optical centre of the lens.
(d) In Q8.3.1, most candidates could not draw the ray diagram through a lens, and hence they did not know where the object should be placed to get a real and inverted image on the opposite side of the lens as the object in Q8.3.2.
(e) Candidates could not define a virtual image in Q8.3.3.
(f) Candidates could not identify the correct lens in Q8.4.1, and hence they could not identify the eyesight problem to be corrected by that lens in Q8.4.2.
(g) In Q8.4.3, candidates could not state the properties of the image formed through a concave lens.

Suggestions for Improvement

(a) Properties of light should be emphasised, e.g. reflection and refraction of light.
(b) Refraction should be taught and assessed during class and homework. Make use of various teaching aids such as videos, models and demonstrations during experiments with lenses and light boxes. Teach learners to observe and explain observations scientifically. Practical activities should be used to reinforce concepts.
(c) Teachers must ensure that they thoroughly teach and assess the drawing of ray diagrams for convex and concave lenses. Include the applicable terminology such as focal point, focal length and principal axis as well as list the properties of images formed by these lenses at various positions from the optical centre of the lenses.
(d) Teach learners the difference between a virtual and a real image.
(e) Applications of lenses should be taught.

QUESTION 9: ELECTROMAGNETIC WAVES

Common Errors and Misconceptions

(a) In Q9.1, candidates struggled to define electromagnetic waves.

(b) Candidates could not give and explain the uses of ultraviolet and infrared light in Q9.2 and Q9.3.

(c) In Q9.4, learners used a wrong value for Planck's constant, failed to convert nm to m and wrote the final answer without units or with incorrect units.

Suggestions for Improvement

(a) Teachers should discuss everyday uses of electromagnetic radiation when teaching this topic.

(b) Teachers must expose learners to a variety of calculations involving energy of a photon and ensure that conversion of units is done correctly. Emphasise that the final answer should have correct units.