



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES

EXAMINATION GUIDELINES

GRADE 11

2015

These guidelines consist of 33 pages.

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1. INTRODUCTION

The Curriculum and Assessment Policy Statement (CAPS) for Physical Sciences outlines the nature and purpose of the subject Physical Sciences. This guides the philosophy underlying the teaching and assessment of the subject in Grade 11.

The purpose of these Examination Guidelines is to:

- Provide clarity on the depth and scope of the content to be assessed in the common/national Grade 11 examination in Physical Sciences.
- Assist teachers to adequately prepare learners for the examinations.

This document deals with the final Grade 11 examinations. It does not deal in any depth with the School-Based Assessment (SBA).

These Examination Guidelines should be read in conjunction with:

- *The National Curriculum Statement (NCS) Curriculum and Assessment Policy Statement (CAPS): Physical Sciences*
- *The National Protocol of Assessment: An addendum to the policy document, the National Senior Certificate: A qualification at Level 4 on the National Qualifications Framework (NQF), regarding the National Protocol for Assessment (Grades R–12)*
- The national policy pertaining to the programme and promotion requirements of the National Curriculum Statement, Grades R–12

2. ASSESSMENT IN GRADE 11**2.1 Format of question papers**

Paper	Types of questions	Duration	Total	Date	Marking
1	Physics 10 multiple-choice questions – 20 marks Structured questions – 130 marks	3 hours	150	October/November	Internal
2	Chemistry 10 multiple-choice questions – 20 marks Structured questions – 130 marks	3 hours	150	October/November	Internal

2.2 Numbering and sequence of questions

QUESTION 1: Multiple-choice questions

Subquestions numbered 1.1 to 1.10 (2 marks each)

Questions will be set across all cognitive levels and arranged from lower to higher cognitive levels.

QUESTION 2 onwards:

Longer questions that will assess skills and knowledge across cognitive levels. Numbering starts with QUESTION 2 and will be continuous. Subquestions will be numbered by two digits, e.g. 2.1, 2.2. Numbering is restricted to a maximum of three digits, e.g. 2.1.1, 2.1.2.

2.3 Information sheets

The separate information sheets for Paper 1 and Paper 2 are included in this document.

2.4 Weighting of cognitive levels

Papers 1 and 2 will include questions across all four cognitive levels. The distribution of cognitive levels in Physics and Chemistry papers is given below.

Cognitive level	Description	Paper 1 (Physics)	Paper 2 (Chemistry)
1	Remembering/ Recall	15%	15%
2	Understanding/ Comprehension	35%	40%
3	Applying and analysing	40%	35%
4	Evaluating and creating (synthesis)	10%	10%

2.5 Weighting of prescribed content

Paper 1: Physics Focus							
Content	Marks	Total	Duration	Weighting of cognitive levels			
Mechanics	68	150 marks	3 hours	15	35	40	10
Waves, sound and light	32						
Electricity and magnetism	50						

Paper 2: Chemistry Focus							
Content	Marks	Total	Duration	Weighting of cognitive levels			
Chemical change	80	150 marks	3 hours	15	40	35	10
Chemical systems	10						
Matter and materials	60						

2.6 Skills in Physical Sciences

- Identify and question phenomena:
 - Formulate an investigative question.
 - List all possible variables.
 - Formulate a testable hypothesis.
- Design/Plan of an investigation:
 - Identify variables (dependent, independent and controlled variables).
 - List appropriate apparatus.
 - Plan the sequence of steps which should include, amongst others:
 - The need for more than one trial to minimise experimental errors.
 - Identify safety precautions that need to be taken.
 - Identify conditions that ensure a fair test.
 - Set an appropriate control.

- **Graphs:**
 - Draw accurate graphs from given data/information.
 - Interpret graphs.
 - Draw sketch graphs from given information.
- **Results:**
 - Identify patterns/relationships in data.
 - Interpret results.
- **Conclusions:**
 - Draw conclusions from given information, e.g. tables, graphs.
 - Evaluate the validity of conclusions.
- **Calculations:**
 - Solve problems using two or more different calculations (multistep calculations).
- **Descriptions:**
 - Explain/Describe/Argue the validity of a statement/event using scientific principles.

2.7 Prior knowledge from Grade 10

All skills and application of knowledge learnt in Grade 10 are applicable to assessment in Grade 11. Skills and knowledge from Grades 10 that may be assessed in Grade 11 include the following:

- The scientific method
- The periodic table
- Writing of formulae and balanced equations
- The kinetic molecular theory
- Chemical bonding
- The mole concept and stoichiometric calculations
- Equations of motion
- Vectors and scalars

3. ELABORATION OF THE CONTENT FOR GRADE 11 (CAPS)

The final examination in Physical Sciences will cover the topics outlined below.

3.1 Paper 1: Physics

Vectors in two dimensions

(This section must be read in conjunction with the CAPS, p. 61.)

Resultant of vectors

- Define a resultant as the vector sum of two or more vectors, i.e. a single vector having the same effect as two or more vectors together.
- Determine the resultant of vectors (maximum four) on a Cartesian plane, using the component method, i.e. find the vertical and horizontal components of each vector and then add co-linear vertical components and co-linear horizontal components to obtain the resultant vertical vector (R_y) and resultant horizontal vector (R_x).
- Sketch the resultant vertical vector (R_y) and the resultant horizontal vector (R_x) on a Cartesian plane.
- Calculate the magnitude of the resultant using the theorem of Pythagoras.
- Determine the direction of the resultant using simple trigonometric ratios.
- Determine the resultant (R) of two vectors graphically using either the tail-to-head or tail-to-tail method (parallelogram method) as well as by calculation (component method) for a maximum of four vectors in both 1-dimension and 2-dimensions.
- Explain the meaning of a closed vector diagram.

Resolution of a vector into its horizontal and vertical components

- Use $R_x = R\cos\theta$ for the resultant x component if θ is the angle between R and the x-axis.
- Use $R_y = R\sin\theta$ for the resultant y component if θ is the angle between R and the x-axis.

Newton's laws and application of Newton's laws

(This section must be read in conjunction with the CAPS, p. 62–66.)

Different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables)

- Define normal force, N , as the force or the component of a force which a surface exerts on an object in contact with it, and which is perpendicular to the surface.
NOTE: The normal force acts perpendicular to the surface irrespective of whether the plane is horizontal or inclined. For horizontal planes the only forces perpendicular to the plane should be the weight, w , and the normal force, N . All other forces should be parallel to the plane. For inclined planes the only forces perpendicular to the plane is the component of weight, $w\cos\theta$, and the normal, N . All other forces should be parallel to the plane.
- Define frictional force, f , as the force that opposes the motion of an object and which acts parallel to the surface.
Know that a frictional force:
 - Is proportional to the normal force
 - Is independent of the area of the surfaces that are in contact with each other
- Define the static frictional force, f_s , as the force that opposes the tendency of motion of a stationary object relative to a surface. The static frictional force can have a range of values from zero up to a maximum value, $\mu_s N$. If a force, F , applied to an object parallel to the surface, does not cause the object to move, F is equal in magnitude to the static frictional force.

- State that the static frictional force is a maximum, f_s^{\max} , just before the object starts to move across the surface. The maximum static frictional force, f_s^{\max} , is equal to the magnitude of the maximum horizontal force that can be applied to the object without it starting to move across the surface.
- Solve problems using $f_s^{\max} = \mu_s N$ where f_s^{\max} is the maximum static frictional force and μ_s is the coefficient of static friction. If the applied force exceeds f_s^{\max} , a net force accelerates the object.
- Define the kinetic frictional force, f_k , as the force that opposes the motion of a moving object relative to a surface. The kinetic frictional force on an object is constant for a given surface and equals $\mu_k N$.
- Solve problems using $f_k = \mu_k N$, where f_k is the kinetic frictional force and μ_k the coefficient of kinetic friction.

Force diagrams, free-body diagrams

- Draw force diagrams. In a force diagram the force is represented by an arrow. The direction of the arrow indicates the direction of the force and the length of the arrow indicates the magnitude of the force.
- Draw free-body diagrams. Such a diagram shows the relative magnitudes and directions of forces acting on an object that has been isolated from its surroundings. The object is drawn as a dot and all the forces acting on it are drawn as arrows pointing away from the dot. The length of the arrows is proportional to the magnitude of the respective forces.
- Resolve a two-dimensional force, e.g. the weight of an object on an inclined plane, into its parallel ($F_{//}$) and perpendicular (F_{\perp}) components.
- Determine the resultant/net force of two or more forces.

Newton's first, second and third laws of motion

- State Newton's first law of motion: A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.
- Define inertia as the resistance of an object to any change in its state of motion. The mass of an object is a quantitative measure of its inertia.
- Discuss why it is important to wear seatbelts using Newton's first law of motion.
- State Newton's second law of motion: When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force and inversely proportional to the mass of the object.

In symbols: $a \propto F_{\text{net}}$, constant m and $a \propto \frac{1}{m}$, constant F_{net} , and therefore $F_{\text{net}} = ma$

- Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating.
- Apply Newton's second law of motion, and therefore, to a variety of equilibrium and non-equilibrium problems including:
 - A single object:
 - Moving in a horizontal plane with or without friction
 - Moving on an inclined plane with or without friction
 - Moving in the vertical plane (lifts, rockets, etc.)
 - Two-body systems (joined by a light inextensible string):
 - Both on a flat horizontal plane with or without friction
 - One in a horizontal plane with or without friction, and a second hanging vertically from a string over a frictionless pulley
 - Both on an inclined plane with or without friction
 - Both hanging vertically from a string over a frictionless pulley

NOTE: When an object accelerates, the equation $F_{\text{net}} = ma$ must be applied separately in the x and y directions. If there is more than one object, a free-body diagram must be drawn for each object and Newton's second law must be applied to each object separately.

- State Newton's third law of motion: When object A exerts a force on object B, object B SIMULTANEOUSLY exerts an oppositely directed force of equal magnitude on object A. (The forces are therefore an interaction between two bodies.)
- Identify Newton III force pairs (action-reaction pairs) and list the properties of the force pairs (action-reaction pairs). When identifying the forces it must be clearly stated which body exerts a force on which body, and what kind of force it is, e.g. the earth exerts a downward gravitational force on the object, and the object exerts an upward gravitational force of equal magnitude on the earth.

Newton's Law of Universal Gravitation

- State Newton's law of universal gravitation: Each particle in the universe attracts every other particle with a gravitational force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.
- Solve problems using $F = \frac{Gm_1m_2}{r^2}$.
- Calculate acceleration due to gravity on the Earth using $g = \frac{GM}{r_E^2}$, and on another planet using $g = \frac{GM_p}{r_p^2}$ where M_p is the mass of the planet and r_p is the radius of the planet.
- Describe weight as the gravitational force, in newton (N), exerted by the Earth on an object. Describe mass as the amount of matter in a body measured in kilogram (kg).
- Calculate weight using the expression $w = mg$.
- Calculate the weight of an object on other planets with different values of gravitational acceleration.
- Explain weightlessness as the sensation experienced when all contact forces are removed, i.e. no external objects touch one's body. For example, when in free fall, the only force acting on your body is the force of gravity that is a non-contact force. Since the force of gravity cannot be felt without any other opposing forces, you would have no sensation of it and you would feel weightless when in free fall.

Geometrical optics

(This section must be read in conjunction with the CAPS, p. 76–77.)

Refraction

- Know that the speed of light is being constant when passing through a given medium and having a maximum value of $c = 3 \times 10^8 \text{ m}\cdot\text{s}^{-1}$ in a vacuum.
- Define refraction of light as the change in direction of a light ray due to a change in speed when light travels from one medium into the other of different optical density.
- Define optical density as a measure of the refracting power of a medium. The higher the optical density, the more the light will be refracted or slowed down as it moves through the medium.
- Define the refractive index (n) of a material as the ratio of the speed of light in vacuum (c) to the speed of light in a material (v).
- Solve problems using $n = \frac{c}{v}$.

- Relate optical density to the refractive index of the material. Materials with a high refractive index will also have a high optical density.
- Define the terms normal, angle of incidence and angle of refraction, and identify them on a ray diagram.
Normal: The line, which is perpendicular to the plane of the surface.
Angle of incidence: The angle between the normal to a surface and the incident light ray.
- Angle of refraction: The angle between the normal to a surface and the refracted light ray.
- Draw ray diagrams to show the path of a light ray moving from one medium into another.
- State Snell's Law: The ratio of the sine of the angle of incidence in one medium to the sine of the angle of refraction in the other medium is constant.
$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1} \quad \text{OR} \quad n_1 \sin \theta_1 = n_2 \sin \theta_2 \quad \text{OR} \quad \frac{\sin \theta_i}{\sin \theta_r} = \frac{n_r}{n_i} \quad \text{OR} \quad n_i \sin \theta_i = n_r \sin \theta_r$$
- Solve problems using the above equations for Snell's law.
- Determine the refractive index of an optical medium by using $n = \frac{\sin \theta_1}{\sin \theta_2}$ for a ray of light traveling from vacuum (or air) to the medium.

Critical angles and total internal reflection

- State the law of reflection: When light is reflected the angle of incidence is always equal to the angle of reflection.
Angle of incidence: The angle between the normal to a reflecting surface and the incident light ray.
Angle of reflection: The angle between the normal to a reflecting surface and the reflected light ray.
- Define the critical angle as the angle of incidence in the optically denser medium for which the angle of refraction in the optically less dense medium is 90° .
- List conditions required for total internal reflection, i.e. when the refracted ray does not emerge from the medium, but is reflected back into the medium:
 - Light must travel from an optically denser medium (higher refractive index) to an optically less dense medium (lower refractive index).
 - The angle of incidence in the optically denser medium must be greater than the critical angle.
- Use Snell's law to calculate the critical angle at the surface between two optically different media.
- Explain the use of optical fibres in endoscopes and telecommunications.

2D and 3D wave fronts

(This section must be read in conjunction with the CAPS, p. 78.)

Diffraction

- Define a wave front as an imaginary line joining points on a wave that are in phase.
- State Huygens' principle: Every point of a wave front serves as a point source of spherical, secondary waves that move forward with the same speed as the wave.
- Define diffraction as the ability of a wave to spread out in wave fronts as the wave passes through a small aperture or around a sharp edge.
- Sketch the diffraction pattern for a single slit.
- Relate the degree of diffraction to the wavelength (λ) and width of slit (w):
degree of diffraction $\propto \frac{\lambda}{w}$
- State that diffraction demonstrates the wave nature of light.

Electrostatics

(This section must be read in conjunction with the CAPS, p. 84–85.)

Coulomb's law

- State Coulomb's law: The magnitude of the electrostatic force exerted by two point charges (Q_1 and Q_2) on each other is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them.
- Solve problems using the equation $F = \frac{kQ_1Q_2}{r^2}$ for charges in one dimension (1D) – restrict to three charges.
- Solve problems using the equation $F = \frac{kQ_1Q_2}{r^2}$ for charges in two dimensions (2D) – for three charges in a right-angled formation (limit to charges at the 'vertices of a right-angled triangle').

Electric field

- Describe an electric field as a region in space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.
- Draw electric field patterns for the following configurations:
 - A single point charge
 - Two point charges (one negative, one positive OR both positive OR both negative)
 - A charged sphere

NOTE: Restrict to situations in which the charges are identical in magnitude.

- Define the electric field strength at a point: The electric field strength at a point is the electrostatic force experienced per unit positive charge placed at that point.

In symbols: $E = \frac{F}{Q}$

- Solve problems using the equation $E = \frac{F}{Q}$.
- Calculate the electric field strength at a point due to a number of point charges, using the equation $E = \frac{kQ}{r^2}$ to determine the contribution to the field due to each charge. Restrict to three charges in a straight line.

Electric circuits

(This section must be read in conjunction with the CAPS, p. 88–89.)

Ohm's law

- State Ohm's law in words: The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.
- Interpret data/graphs on the relationship between current, potential difference and resistance at constant temperature.
- State the difference between ohmic and non-ohmic conductors and give an example of each.
- Solve problems using $R = \frac{V}{I}$ for circuits containing resistors that are connected in series and/or in parallel (maximum four resistors).

Power, energy

- Define power as the rate at which work is done or energy is transferred.
- Solve problems using $P = \frac{W}{\Delta t}$.
- Recall that $W = VQ$, and therefore, by substituting $V = IR$ in the equation, $W = VI\Delta t$, $W = I^2R\Delta t$ and $W = \frac{V^2}{R}\Delta t$ are obtained.
- Deduce, by substituting $P = \frac{W}{\Delta t}$ into above equations, the following equations: $P = VI$, $P = I^2R$ and $P = \frac{V^2}{R}$.
- Solve problems using $P = VI$, $P = I^2R$ and $P = \frac{V^2}{R}$.
- Solve circuit problems involving the concepts of power and electrical energy.
- Deduce that the kilowatt-hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour. Know that 1 kWh is an amount of electrical energy, also known as one unit of electricity.
- Calculate the cost of electricity usage given the power specifications of the appliances used, the duration and the cost of 1 kWh.

Electromagnetism

(This section must be read in conjunction with the CAPS, p. 86–88.)

Magnetic field associated with current-carrying conductors

- Use the right hand rule to determine the magnetic field (B) associated with a:
 - Straight current-carrying conductor
 - Current-carrying loop (single turn)
 - Solenoid
- Draw the magnetic field pattern around a:
 - Straight current-carrying wire
 - Current-carrying loop (single turn)
 - Solenoid

Faraday's law

- State Faraday's law of electromagnetic induction: The magnitude of the induced emf across the ends of a conductor is directly proportional to the rate of change in the magnetic flux linkage with the conductor.
- Use the right-hand rule to determine the direction of the current induced in a solenoid when a pole of a bar magnet moves into and out of the solenoid.
- Solve problems using $\Phi = BA\cos\theta$.
- Predict the direction of the induced current in a coil.
- Solve problems using $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$.

3.2 Paper 2: Chemistry

Atomic combinations: molecular structure

(This section must be read in conjunction with the CAPS, p. 67–71.)

A chemical bond

- Define a chemical bond as a mutual attraction between two atoms resulting from the simultaneous attraction between their nuclei and the outer electrons. (**NOTE:** The energy of the combined atoms is lower than that of the individual atoms resulting in higher stability.)
- Draw Lewis dot diagrams of elements.
A Lewis dot diagram is a structural formula in which valence electrons are represented by dots or crosses. It is also known as an electron dot formula, a Lewis formula, or an electron diagram.
- Determine the number of valence electrons in an atom of an element.
Valence electrons or outer electrons are the electrons in the highest energy level of an atom in which there are electrons.
- Explain, in terms of electrostatic forces between protons and electrons, and in terms of energy considerations, why:
 - Two H atoms form an H₂ molecule
 - He does not form He₂Interpret the graph of potential energy versus the distance between nuclei for two approaching hydrogen atoms.
- Define a covalent bond as the sharing of electrons between two atoms to form a molecule.
Molecule: A group of two or more atoms covalently bonded and that function as a unit.
- Draw Lewis diagrams, given the formula and using electron configurations, for simple molecules, e.g. H₂, F₂, H₂O, NH₃, HF, OF₂, HOCℓ and molecules with multiple bonds, e.g. N₂, O₂ and HCN.
- Describe rules for bond formation:
 - Different atoms, each with an unpaired valence electron, can share these electrons to form a chemical bond, e.g. two H atoms form a H₂ molecule by sharing an electron pair.
 - Different atoms with paired valence electrons, called lone pairs, cannot share these four electrons and cannot form a chemical bond, e.g. no bond forms between two He atoms.
 - Different atoms, with unpaired valence electrons, can share these electrons and form a chemical bond for each electron pair shared. The two atoms can form multiple bonds between them. If two pairs of electrons are shared, a double bond is formed, e.g. between two O atoms to form O₂.
 - Atoms with an empty valence shell can share a lone pair of electrons from another atom to form a coordinate covalent or dative covalent bond, e.g. in NH₄⁺ the lone pair of nitrogen is shared with H⁺ and in H₃O⁺ the lone pair of oxygen is shared with H⁺.
- Define a bonding pair as a pair of electrons that is shared between two atoms in a covalent bond.
Define a lone pair as a pair of electrons in the valence shell of an atom that is not shared with another atom.
- Describe the formation of the dative covalent (or coordinate covalent) bond by means of electron diagrams using NH₄⁺ and H₃O⁺ as examples.

Molecular shape: Valence shell electron pair repulsion (VSEPR) theory

- State the major principles used in the VSEPR:
 - Molecular shape is determined by the repulsions between electron pairs present in the valence shell of the central atom.
 - The number of electron pairs around the central atom can be determined by writing the Lewis structure for the molecule.
 - The shape of the molecule depends on the number of bonding electron groups (or atoms bonded to the central atom) and the number of lone pairs on the central atom.
 - A is used to represent the central atom and X is used to represent terminal atoms.
 - There are five ideal shapes found when there are NO lone pairs on the central atom, ONLY bond pairs.
- Use the VSEPR theory to classify given molecules as one of the five ideal molecular shapes by finding the number of atoms bonded to the central atom in molecules where there are NO lone pairs on the central atom. If this number equals:
 - Two, the molecular shape is linear – AX_2
Examples: CO_2 , $BeCl_2$, C_2H_2
 - Three, the molecular shape is trigonal planar – AX_3
Example: BF_3
 - Four, the molecular shape is tetrahedral – AX_4
Example: CH_4 , CCl_4
 - Five, the molecular shape is trigonal bipyramidal – AX_5
Example: PCl_5
 - Six, the molecular shape is octahedral – AX_6
Example: SF_6
- Use the VSEPR theory to determine the shapes of molecules with lone pairs on the central atom (H_2O , NH_3 , SO_2) and that CANNOT have one of the ideal shapes.

Electronegativity of atoms to explain the polarity of bonds

- Define electronegativity as a measure of the tendency of an atom in a molecule to attract bonding electrons.
- Describe a non-polar covalent bond as a bond in which the electron density is shared equally between the two atoms. An example is the bond between two H atoms.
- Describe a polar covalent bond as a bond in which the electron density is shared unequally between the two atoms. An example is the bond between an H atom and a Cl atom.
- Show polarity of bonds using partial charges, e.g. $\delta^+ H - Cl \delta^-$
- Compare the polarity of chemical bonds using a table of electronegativities:
 - With an electronegativity difference $\Delta EN > 2,1$ electron transfer will take place and the bond will be ionic.
 - With an electronegativity difference $\Delta EN > 1$ the bond will be polar covalent.
 - With an electronegativity difference $\Delta EN < 1$ the bond will be very weakly polar covalent.
 - With an electronegativity difference $\Delta EN = 0$ the bond will be nonpolar. covalent
- Explain that the character of a bond varies from purely covalent (when $\Delta EN = 0$) to almost purely ionic (when $\Delta EN > 3$). The above differences in electronegativity is only a guideline, many bonds have both ionic and covalent character.
- Use difference in electronegativity and molecular shape to explain that polar bonds do not always lead to polar molecules.

Bond energy and bond length

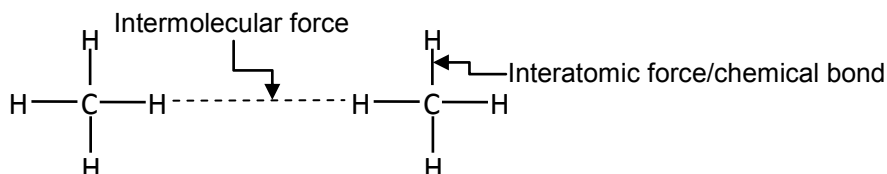
- Define bond energy of a compound as the energy needed to break one mole of its molecules into separate atoms.
- Define bond length as the average distance between the nuclei of two bonded atoms.
- Explain the relationship between bond energy and bond length, i.e. bonds with a shorter bond length require more energy to break than bonds with a longer bond length.
- Explain the relationship between the strength of a chemical bond between two atoms and the:
 - Length of the bond between them
If the force of attraction between two atoms is strong, the nuclei come very close together resulting in a short bond length.
 - Size of the bonded atoms
The bond length between larger atoms is longer than the bond length between smaller atoms.
 - Number of bonds (single, double, triple) between the atoms
Bond strength increases as the number of bonds between atoms increases, i.e. triple bonds are stronger than double bonds, which are stronger than single bonds.

Intermolecular forces

(This section must be read in conjunction with the CAPS, p. 71–75.)

Intermolecular forces and interatomic forces (chemical bonds)

- Name and explain the different intermolecular forces (Van der Waals forces):
 - (i) Mutually induced dipole forces or London forces: Forces between non-polar molecules
 - (ii) Dipole-dipole forces: Forces between two polar molecules
 - (iii) Dipole-induced dipole forces: Forces between polar and non-polar molecules
 - (iv) Hydrogen bonding: Forces between molecules in which hydrogen is covalently bonded to nitrogen, oxygen or fluorine – a special case of dipole-dipole forces
 - (v) Ion-dipole forces: Forces between ions and polar molecules
- Describe the difference between intermolecular forces and interatomic forces (intramolecular forces) using a diagram of a group of small molecules; and in words.
Example:



- State the relationship between intermolecular forces and molecular mass. For non-polar molecules the strength of induced dipole forces increases with molecular size.
- Explain the effect of intermolecular forces on boiling point, melting point, vapour pressure and solubility.

Boiling point: The temperature at which the vapour pressure of a substance equals atmospheric pressure. The stronger the intermolecular forces, the higher the boiling point.

Melting point: The temperature at which the solid and liquid phases of a substance are at equilibrium. The stronger the intermolecular forces, the higher the melting point.

Vapour pressure: The pressure exerted by a vapour at equilibrium with its liquid in a closed system. The stronger the intermolecular forces, the lower the vapour pressure.

Solubility: The property of a solid, liquid, or gaseous chemical substance (solute) to dissolve in a solid, liquid, or gaseous solvent to form a homogeneous solution.

Ideal gases and thermal properties

(This section must be read in conjunction with the CAPS, p. 79–81.)

Motion of particles; Kinetic theory of gases

- Describe the motion of individual gas molecules:
 - Molecules are in constant motion and collide with each other and the walls of the container.
 - There are forces of attraction between molecules.
 - Molecules in a gas move at different speeds.
- Describe an ideal gas as a gas:
 - That has identical particles of zero volume
 - With no intermolecular forces between particles
 - In which all collisions of the molecules with themselves or the walls of the container, are perfectly elastic
- Explain that real gases deviate from ideal gas behaviour at high pressures and low temperatures.
- State the conditions under which a real gas approaches ideal gas behaviour.

Ideal gas law

- State Boyle's law: The pressure of an enclosed gas is inversely proportional to the volume it occupies at constant temperature.
In symbols: $p \propto \frac{1}{V}$, therefore $p_1V_1 = p_2V_2$, $T = \text{constant}$
- State Charles' law: The volume of an enclosed gas is directly proportional to its kelvin temperature provided the pressure is kept constant.
In symbols: $V \propto T$, therefore $\frac{V_1}{T_1} = \frac{V_2}{T_2}$, $p = \text{constant}$
- State that the pressure of a gas is directly proportional to its temperature in kelvin at constant volume (Gay Lussac). In symbols: $p \propto T$, therefore $\frac{p_1}{T_1} = \frac{p_2}{T_2}$, $V = \text{constant}$
- For each of the above three relationships:
 - Interpret a table of results or a graph
 - Draw a graph from given results
 - Solve problems using a relevant equation
 - Use kinetic theory to explain the gas laws
- Use the general gas equation, $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$, to solve problems.
- Use the ideal gas equation, $pV = nRT$, to solve problems.
- Convert temperatures in Celsius to kelvin for use in ideal and general gas equations.

Temperature and heating, pressure

- Explain the temperature of a gas in terms of the average kinetic energy of the molecules of the gas.
- Explain the pressure exerted by a gas in terms of the collision of the molecules with the walls of the container.

Representing Chemical Change

(This section must be read in conjunction with the CAPS, p. 37.)

Balanced chemical equations

- Write and balance chemical equations. Use formulae for reactants and products and indicate the phases in brackets, i.e. (s), (l), (g) and (aq).
- Interpret balanced reaction equations in terms of:
 - Conservation of atoms
 - Conservation of mass (use relative atomic masses)

Quantitative aspects of chemical change

(This section must be read in conjunction with the CAPS, p. 50–52 and 82–83.)

The mole concept

- Describe the mole as the SI unit for amount of substance.
- Define one mole as the amount of substance having the same number of particles as there are atoms in 12 g carbon-12.
- Describe Avogadro's number, N_A , as the number of particles (atoms, molecules, formula-units) present in one mole ($N_A = 6,023 \times 10^{23}$ particles·mol⁻¹).
- Define molar mass as the mass of one mole of a substance measured in g·mol⁻¹.
- Calculate the molar mass of a substance given its formula.

Molar volume of gases

- State Avogadro's Law, i.e. one mole of any gas occupies the same volume at the same temperature and pressure.
- At STP: 1 mole of any gas occupies 22,4 dm³ at 0 °C (273 K) and 1 atmosphere (101,3 kPa). Thus the molar gas volume, V_M , at STP = 22,4 dm³·mol⁻¹.

Volume relationships in gaseous reactions

- Interpret balanced equations in terms of volume relationships for gases, i.e. under the same conditions of temperature and pressure, equal amounts (in mole) of all gases occupy the same volume.

Concentration of solutions

- Define concentration as the amount of solute per litre of solution.
- Calculate concentration in mol·ℓ⁻¹ (or mol·dm⁻³) using $c = \frac{n}{V}$.

More complex stoichiometric calculations

- Determine the empirical formula and molecular formula of compounds.
- Determine the percentage yield of a chemical reaction.
- Determine percentage purity or percentage composition, e.g. the percentage CaCO₃ in an impure sample of seashells.
- Perform stoichiometric calculations based on balanced equations that may include limiting reagents.

Energy and chemical change

(This section must be read in conjunction with the CAPS, p. 90–91.)

Energy changes in reactions related to bond energy changes

- Define heat of reaction (ΔH) as the energy absorbed or released per mole in a chemical reaction.
 $\Delta H = H_{\text{products}} - H_{\text{reactants}}$, where H_{products} and $H_{\text{reactants}}$ are the heat (energy) of the products and reactants respectively.
- Define exothermic reactions as reactions that release energy.
- Define endothermic reactions as reactions that absorb energy.
- Classify, with reason, reactions as exothermic or endothermic.

Exothermic and endothermic reactions

- State that $\Delta H > 0$ for endothermic reactions, i.e. reactions in which energy is absorbed.
- State that $\Delta H < 0$ for exothermic reactions, i.e. reactions in which energy is released.

Activation energy

- Define activation energy as the minimum energy needed for a reaction to take place.
- Define an activated complex as the unstable transition state from reactants to products.
- Draw or interpret fully labelled sketch graphs (potential energy versus course of reaction graphs) of catalysed and uncatalysed endothermic and exothermic reactions.

Types of reaction

(This section must be read in conjunction with the CAPS, p. 91–94.)

Acid-base reactions

- Define acids and bases according to Arrhenius and Lowry-Brønsted:
Arrhenius theory: An acid is a substance that produces hydrogen ions (H^+)/hydronium ions (H_3O^+) when it dissolves in water. A base is a substance that produces hydroxide ions (OH^-) when it dissolves in water.
Lowry-Brønsted theory: An acid is a proton/ H^+ ion donor. A base is a proton/ H^+ ion acceptor.
- Identify conjugate acid-base pairs for given compounds. When the acid, HA, loses a proton, its conjugate base, A^- , is formed. When the base, A^- , accepts a proton, its conjugate acid, HA, is formed. These two are a conjugate acid-base pair.
- Describe a substance that can act as either acid or base, as amphiprotic or as an ampholyte. Water is a good example of an ampholyte. Write equations to show how an amphiprotic substance can act as acid or base.
- Write names and formulae of common acids: hydrochloric acid, nitric acid, sulphuric acid and ethanoic acid (acetic acid).
- Write names and formulae of common bases: ammonia, sodium carbonate (washing soda), sodium hydrogen carbonate, sodium hydroxide (caustic soda) and potassium hydroxide.
- Write reaction equations for the dissolution of acids and bases in water.
Examples: $\text{HCl}(\text{g}) + \text{H}_2\text{O}(\ell) \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
 $\text{NH}_3(\text{g}) + \text{H}_2\text{O}(\ell) \rightarrow \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$
 $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\ell) \rightarrow 2\text{H}_3\text{O}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

- Write the overall equations for reactions of acids with metal hydroxides, metal oxides and metal carbonates:
 $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$
 $\text{HCl}(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{KCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$
 $\text{HNO}_3(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaNO}_3(\text{aq}) + \text{H}_2\text{O}(\ell)$
 $\text{HNO}_3(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{KNO}_3(\text{aq}) + \text{H}_2\text{O}(\ell)$
 $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\ell)$
 $\text{H}_2\text{SO}_4(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{K}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\ell)$
 $\text{CH}_3\text{COOH}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{CH}_3\text{COONa}(\text{aq}) + \text{H}_2\text{O}(\ell)$
 $2\text{HCl}(\text{aq}) + \text{CaO}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\ell)$
 $2\text{HCl}(\text{aq}) + \text{MgO}(\text{aq}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2\text{O}(\ell)$
 $2\text{HCl}(\text{aq}) + \text{MgO}(\text{aq}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2\text{O}(\ell)$
 $2\text{HCl}(\text{aq}) + \text{CuO}(\text{aq}) \rightarrow \text{CuCl}_2(\text{aq}) + \text{H}_2\text{O}(\ell)$
 $2\text{HCl}(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\ell) + \text{CO}_2(\text{g})$
 $2\text{HCl}(\text{aq}) + \text{CaCO}_3(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\ell) + \text{CO}_2(\text{g})$
- Describe an acid-base indicator as a weak acid, or a weak base, which colour changes as the H^+ ion concentration or the OH^- ion concentration in a solution changes. Know the colours of litmus, methyl orange, phenolphthalein and bromothymol blue in acids and in bases.
- Identify the acid and the base needed to prepare a given salt and write an equation for the reaction.
- Write down neutralisation reactions of common laboratory acids and bases.

Oxidation numbers of atoms in molecules

- Explain the meaning of oxidation number.
- Assign oxidation numbers to atoms in various ions and molecules, e.g. H_2O , CH_4 , CO_2 , H_2O_2 and HOCl , by using oxidation number guidelines or rules.

Redox reactions

- Describe a redox (oxidation-reduction) reaction as involving an electron transfer.
- Describe a redox (oxidation-reduction) reaction as always involving changes in oxidation numbers.
- Identify a redox reaction and apply the correct terminology to describe all the processes:
Oxidation: A loss of electrons./An increase in oxidation number.
Reduction: A gain of electrons./A decrease in oxidation number.
Reducing agent: A substance that is oxidised/that loses electrons/whose oxidation number increases.
Oxidising agent: A substance that is reduced/that gains electrons/whose oxidation number decreases.
- Balance redox reactions by using half-reactions from the Table of Standard Reduction Potentials (Tables 4A and 4B).

Exploiting the lithosphere or Earth's crust:

(This section must be read in conjunction with the CAPS, p. 138–140.)

Mining and processing of minerals

- Apply knowledge of chemistry, learnt in previous sections, to given reactions of the extraction processes of gold and iron.

Gold mining and processing

- State that South African gold is mined from deep level underground mines.
- State that the ore undergoes a series of crushing and milling steps to reduce its size for further processing.
- Describe the leaching of gold from the slurry by a dilute sodium cyanide (NaCN) or potassium cyanide (KCN) solution:
$$4\text{Au} + 8\text{NaCN} + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{NaAu}(\text{CN})_2 + 4\text{NaOH}$$

The solution containing the gold complex ion can now be filtered from the unwanted rock.
- Describe the addition of zinc powder to precipitate the gold:
$$\text{Zn} + 2\text{NaAu}(\text{CN})_2 \rightarrow 2\text{Au} + \text{Zn}(\text{CN})_2 + 2\text{NaCN}$$

Solid gold can now be filtered from the solution.
- Classify the above reactions as redox reactions, giving reasons.
- Identify the oxidation, reduction, oxidising agent and reducing agent in the above reactions.

Iron mining and processing

- Open pit mining is used to excavate iron ore that is close to the surface.
- The ore undergoes a series of crushing steps to reduce the particle size.
- After washing, screening and separation, the iron ore, containing 65% iron, goes into a blast furnace with coke (C), limestone (CaCO_3) and hot air.
- The following reactions takes place in the blast furnace:
 - Coke (carbon) is oxidised to carbon monoxide:
$$2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$$
 - CO reacts with iron ore to form iron:
$$3\text{CO} + \text{Fe}_2\text{O}_3 \rightarrow 2\text{Fe} + 3\text{CO}_2$$
 - Limestone is added to remove impurities from the molten iron to form slag:
$$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$$

$$\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3 \text{ (slag)}$$
 - Molten slag floats on top of the molten iron. The blast furnace produces pig iron that is sent to steel manufacturers.
- Classify the above reactions as redox reactions where applicable, giving reasons.
- Identify the oxidation, reduction, oxidising agent and reducing agent in the above reactions where applicable.

4. GENERAL INFORMATION

4.1 Quantities, symbols and units

The most common quantities, symbols and SI units used in introductory Physics are listed below. **A quantity should not be confused with the units in which it is measured.**

Quantity	Preferred symbol	Alternative symbol	Unit name	Unit symbol
mass	m		kilogram	kg
position	x, y		metre	m
displacement	$\Delta x, \Delta y$	s	metre	m
velocity	v_x, v_y	u, v	metre per second	$m \cdot s^{-1}$
initial velocity	v_i	u	metre per second	$m \cdot s^{-1}$
final velocity	v_f	v	metre per second	$m \cdot s^{-1}$
acceleration	a		metre per second per second	$m \cdot s^{-2}$
acceleration due to gravity	g		metre per second per second	$m \cdot s^{-2}$
time (instant)	t		second	s
time interval	Δt		second	s
energy	E		joule	J
kinetic energy	K	E_k	joule	J
potential energy	U	E_p	joule	J
work	W		joule	J
power	P		watt	W
force	F		newton	N
weight	w	F_g	newton	N
normal force	N	F_N	newton	N
tension	T	F_T	newton	N
friction force	f	F_f	newton	N
coefficient of friction	μ, μ_s, μ_k		(none)	
wavelength	λ		metre	m
frequency	f	ν	hertz or per second	Hz or s^{-1}
period	T		second	s
speed of light	c		metre per second	$m \cdot s^{-1}$
refractive index	n		(none)	
charge	Q, q		coulomb	C
electric field	E		newton per coulomb or volt per metre	$N \cdot C^{-1}$ or $V \cdot m^{-1}$
electric potential at point P	V_P		volt	V
potential difference	$\Delta V, V$		volt	V
emf	E	ϵ	volt	V
current	I, i		ampere	A
resistance	R		ohm	Ω
magnetic field	B		tesla	T
magnetic flux	Φ		tesla·metre ² or weber	$T \cdot m^2$ or Wb

Conventions (e.g. signs, symbols, terminology and nomenclature)

The syllabus and question papers will conform to generally accepted international practices.

NOTE:

1. For marking purposes, alternative symbols will also be accepted.
2. Separate compound units with a multiplication dot, not a full stop, for example $\text{m}\cdot\text{s}^{-1}$.
For marking purposes, $\text{m}\cdot\text{s}^{-1}$ will also be accepted.
3. Use the equal sign only when it is mathematically correct, for example:
Incorrect: $1 \text{ cm} = 1 \text{ m}$ (on a scale drawing)
Correct: $1 \text{ cm} = 10^{-2} \text{ m}$ 1 cm represents 1 m (on a scale drawing)

4.2 Information sheets – Paper 1 (Physics)**TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIESTE KONSTANTES**

NAME/NAAM	SYMBOL/SIMBOOL	VALUE/WAARDE
Acceleration due to gravity <i>Swaartekragversnelling</i>	g	9,8 m·s ⁻²
Gravitational constant <i>Swaartekragkonstante</i>	G	6,67 x 10 ⁻¹¹ N·m ² ·kg ⁻²
Radius of Earth <i>Straal van Aarde</i>	R _E	6,38 x 10 ⁶ m
Coulomb's constant <i>Coulomb se konstante</i>	k	9,0 x 10 ⁹ N·m ² ·C ⁻²
Speed of light in a vacuum <i>Spoed van lig in 'n vakuum</i>	c	3,0 x 10 ⁸ m·s ⁻¹
Charge on electron <i>Lading op elektron</i>	e	-1,6 x 10 ⁻¹⁹ C
Electron mass <i>Elektronmassa</i>	m _e	9,11 x 10 ⁻³¹ kg
Mass of the Earth <i>Massa van die Aarde</i>	M	5,98 x 10 ²⁴ kg

TABLE 2: FORMULAE/TABEL 2: FORMULES**MOTION/BEWEGING**

$v_f = v_i + a \Delta t$	$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$v_f^2 = v_i^2 + 2a \Delta x$	$\Delta x = \left(\frac{v_f + v_i}{2} \right) \Delta t$

FORCE/KRAG

$F_{\text{net}} = ma$	$w = mg$
$F = \frac{Gm_1m_2}{r^2}$	$\mu_s = \frac{f_{s(\text{max})}}{N}$
$\mu_k = \frac{f_k}{N}$	

WAVES, SOUND AND LIGHT/GOLWE, KLANK EN LIG

$v = f \lambda$	$T = \frac{1}{f}$
$n_i \sin \theta_i = n_r \sin \theta_r$	$n = \frac{c}{v}$

ELECTROSTATICS/ELEKTROSTATIKA

$F = \frac{kQ_1Q_2}{r^2}$ (k = 9,0 x 10 ⁹ N·m ² ·C ⁻²)	$E = \frac{F}{Q}$
$E = \frac{kQ}{r^2}$ (k = 9,0 x 10 ⁹ N·m ² ·C ⁻²)	$V = \frac{W}{Q}$

ELECTROMAGNETISM/ELEKTROMAGNETISME

$\varepsilon = -N \frac{\Delta \Phi}{\Delta t}$	$\Phi = BA \cos \theta$
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CURRENT ELECTRICITY/STROOMELEKTRISITEIT

$I = \frac{Q}{\Delta t}$	$R = \frac{V}{I}$
$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \dots$	$R = r_1 + r_2 + r_3 + \dots$
$W = Vq$	$P = \frac{W}{\Delta t}$
$W = VI \Delta t$	$P = VI$
$W = I^2 R \Delta t$	$P = I^2 R$
$W = \frac{V^2 \Delta t}{R}$	$P = \frac{V^2}{R}$

4.3 Information sheets – Paper 2 (Chemistry)**TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIESE KONSTANTES**

NAME/NAAM	SYMBOL/SIMBOOL	VALUE/WAARDE
Avogadro's constant <i>Avogadro-konstante</i>	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$
Molar gas constant <i>Molêre gaskonstante</i>	R	$8,31 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$
Standard pressure <i>Standaarddruk</i>	p^θ	$1,013 \times 10^5 \text{ Pa}$
Molar gas volume at STP <i>Molêre gasvolume by STD</i>	V_m	$22,4 \text{ dm}^3\cdot\text{mol}^{-1}$
Standard temperature <i>Standaardtemperatuur</i>	T^θ	273 K

TABLE 2: FORMULAE/TABEL 2: FORMULES

$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$	$pV = nRT$
$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$n = \frac{V}{V_m}$	$c = \frac{n}{V}$ OR/OF $c = \frac{m}{MV}$

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARDREDUKSIEPOTENSIALE

Half-reactions		E^{\ominus} (V)
$F_2(g) + 2e^-$	$\rightleftharpoons 2F^-$	+ 2,87
$Co^{3+} + e^-$	$\rightleftharpoons Co^{2+}$	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons 2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons Mn^{2+} + 4H_2O$	+ 1,51
$Cl_2(g) + 2e^-$	$\rightleftharpoons 2Cl^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons 2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons 2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	$\rightleftharpoons Pt$	+ 1,20
$Br_2(l) + 2e^-$	$\rightleftharpoons 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons Hg(l)$	+ 0,85
$Ag^+ + e^-$	$\rightleftharpoons Ag$	+ 0,80
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	$\rightleftharpoons Fe^{2+}$	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons H_2O_2$	+ 0,68
$I_2 + 2e^-$	$\rightleftharpoons 2I^-$	+ 0,54
$Cu^+ + e^-$	$\rightleftharpoons Cu$	+ 0,52
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons 4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	$\rightleftharpoons Cu$	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	$\rightleftharpoons Cu^+$	+ 0,16
$Sn^{4+} + 2e^-$	$\rightleftharpoons Sn^{2+}$	+ 0,15
$S + 2H^+ + 2e^-$	$\rightleftharpoons H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	$\rightleftharpoons H_2(g)$	0,00
$Fe^{3+} + 3e^-$	$\rightleftharpoons Fe$	- 0,06
$Pb^{2+} + 2e^-$	$\rightleftharpoons Pb$	- 0,13
$Sn^{2+} + 2e^-$	$\rightleftharpoons Sn$	- 0,14
$Ni^{2+} + 2e^-$	$\rightleftharpoons Ni$	- 0,27
$Co^{2+} + 2e^-$	$\rightleftharpoons Co$	- 0,28
$Cd^{2+} + 2e^-$	$\rightleftharpoons Cd$	- 0,40
$Cr^{3+} + e^-$	$\rightleftharpoons Cr^{2+}$	- 0,41
$Fe^{2+} + 2e^-$	$\rightleftharpoons Fe$	- 0,44
$Cr^{3+} + 3e^-$	$\rightleftharpoons Cr$	- 0,74
$Zn^{2+} + 2e^-$	$\rightleftharpoons Zn$	- 0,76
$2H_2O + 2e^-$	$\rightleftharpoons H_2(g) + 2OH^-$	- 0,83
$Cr^{2+} + 2e^-$	$\rightleftharpoons Cr$	- 0,91
$Mn^{2+} + 2e^-$	$\rightleftharpoons Mn$	- 1,18
$Al^{3+} + 3e^-$	$\rightleftharpoons Al$	- 1,66
$Mg^{2+} + 2e^-$	$\rightleftharpoons Mg$	- 2,36
$Na^+ + e^-$	$\rightleftharpoons Na$	- 2,71
$Ca^{2+} + 2e^-$	$\rightleftharpoons Ca$	- 2,87
$Sr^{2+} + 2e^-$	$\rightleftharpoons Sr$	- 2,89
$Ba^{2+} + 2e^-$	$\rightleftharpoons Ba$	- 2,90
$Cs^+ + e^-$	$\rightleftharpoons Cs$	- 2,92
$K^+ + e^-$	$\rightleftharpoons K$	- 2,93
$Li^+ + e^-$	$\rightleftharpoons Li$	- 3,05

Increasing oxidising ability/Toenemende oksiderende vermoë

Increasing reducing ability/Toenemende reduserende vermoë

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARDREDUKSIEPOTENSIALE

Half-reactions		E° (V)
$\text{Li}^+ + \text{e}^-$	$\rightleftharpoons \text{Li}$	- 3,05
$\text{K}^+ + \text{e}^-$	$\rightleftharpoons \text{K}$	- 2,93
$\text{Cs}^+ + \text{e}^-$	$\rightleftharpoons \text{Cs}$	- 2,92
$\text{Ba}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Ba}$	- 2,90
$\text{Sr}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Sr}$	- 2,89
$\text{Ca}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Ca}$	- 2,87
$\text{Na}^+ + \text{e}^-$	$\rightleftharpoons \text{Na}$	- 2,71
$\text{Mg}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Mg}$	- 2,36
$\text{Al}^{3+} + 3\text{e}^-$	$\rightleftharpoons \text{Al}$	- 1,66
$\text{Mn}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Mn}$	- 1,18
$\text{Cr}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Cr}$	- 0,91
$2\text{H}_2\text{O} + 2\text{e}^-$	$\rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^-$	- 0,83
$\text{Zn}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Zn}$	- 0,76
$\text{Cr}^{3+} + 3\text{e}^-$	$\rightleftharpoons \text{Cr}$	- 0,74
$\text{Fe}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Fe}$	- 0,44
$\text{Cr}^{3+} + \text{e}^-$	$\rightleftharpoons \text{Cr}^{2+}$	- 0,41
$\text{Cd}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Cd}$	- 0,40
$\text{Co}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Co}$	- 0,28
$\text{Ni}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Ni}$	- 0,27
$\text{Sn}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Sn}$	- 0,14
$\text{Pb}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Pb}$	- 0,13
$\text{Fe}^{3+} + 3\text{e}^-$	$\rightleftharpoons \text{Fe}$	- 0,06
$2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons \text{H}_2(\text{g})$	0,00
$\text{S} + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons \text{H}_2\text{S}(\text{g})$	+ 0,14
$\text{Sn}^{4+} + 2\text{e}^-$	$\rightleftharpoons \text{Sn}^{2+}$	+ 0,15
$\text{Cu}^{2+} + \text{e}^-$	$\rightleftharpoons \text{Cu}^+$	+ 0,16
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+ 0,17
$\text{Cu}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Cu}$	+ 0,34
$2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-$	$\rightleftharpoons 4\text{OH}^-$	+ 0,40
$\text{SO}_2 + 4\text{H}^+ + 4\text{e}^-$	$\rightleftharpoons \text{S} + 2\text{H}_2\text{O}$	+ 0,45
$\text{Cu}^+ + \text{e}^-$	$\rightleftharpoons \text{Cu}$	+ 0,52
$\text{I}_2 + 2\text{e}^-$	$\rightleftharpoons 2\text{I}^-$	+ 0,54
$\text{O}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons \text{H}_2\text{O}_2$	+ 0,68
$\text{Fe}^{3+} + \text{e}^-$	$\rightleftharpoons \text{Fe}^{2+}$	+ 0,77
$\text{NO}_3^- + 2\text{H}^+ + \text{e}^-$	$\rightleftharpoons \text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+ 0,80
$\text{Ag}^+ + \text{e}^-$	$\rightleftharpoons \text{Ag}$	+ 0,80
$\text{Hg}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Hg}(\ell)$	+ 0,85
$\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^-$	$\rightleftharpoons \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+ 0,96
$\text{Br}_2(\ell) + 2\text{e}^-$	$\rightleftharpoons 2\text{Br}^-$	+ 1,07
$\text{Pt}^{2+} + 2\text{e}^-$	$\rightleftharpoons \text{Pt}$	+ 1,20
$\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$	+ 1,23
$\text{O}_2(\text{g}) + 4\text{H}^+ + 4\text{e}^-$	$\rightleftharpoons 2\text{H}_2\text{O}$	+ 1,23
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^-$	$\rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+ 1,33
$\text{Cl}_2(\text{g}) + 2\text{e}^-$	$\rightleftharpoons 2\text{Cl}^-$	+ 1,36
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$	$\rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+ 1,51
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons 2\text{H}_2\text{O}$	+ 1,77
$\text{Co}^{3+} + \text{e}^-$	$\rightleftharpoons \text{Co}^{2+}$	+ 1,81
$\text{F}_2(\text{g}) + 2\text{e}^-$	$\rightleftharpoons 2\text{F}^-$	+ 2,87

Increasing oxidising ability/Toenemende oksiderende vermoë

Increasing reducing ability/Toenemende reduserende vermoë

5. MARKING GUIDELINES: PAPER 1

5.1 Calculations

- 5.1.1** Marks will be awarded for: correct formula, correct substitution, correct answer with unit.
- 5.1.2** No marks will be awarded if an **incorrect or inappropriate formula is used**, even though there may be relevant symbols and applicable substitutions.
- 5.1.3** When an error is made during **substitution into a correct formula**, a mark will be awarded for the correct formula and for the correct substitutions, but **no further marks** will be given.
- 5.1.4** If **no formula** is given, but **all substitutions are correct**, the candidate will **forfeit one mark**.
- 5.1.5** **No penalisation if zero substitutions are omitted** in calculations where **correct formula/principle is given correctly**.
- 5.1.6** Mathematical manipulations and change of subject of appropriate formulae carry no marks, but if a candidate starts off with the correct formula and then changes the subject of the formula incorrectly, marks will be awarded for the formula and the correct substitutions. The mark for the incorrect numerical answer is forfeited.
- 5.1.7** Marks are only awarded for a formula if a **calculation has been attempted**, i.e. substitutions have been made or a numerical answer given.
- 5.1.8** Marks can only be allocated for substitutions when values are substituted into formulae and not when listed before a calculation starts.
- 5.1.9** Final answers to all calculations, when not specified in the question, must be rounded off to a minimum of TWO decimal places.
- 5.1.10** If a final answer to a calculation is correct, full marks will not automatically be awarded. Markers will always ensure that the correct/appropriate formula is used and that workings, including substitutions, are correct.
- 5.1.11** Questions in which a series of calculations have to be made (e.g. a circuit-diagram question) do not necessarily always have to follow the same order. **FULL MARKS** will be awarded, provided it is a valid solution to the problem. However, any calculation that will not bring the candidate closer to the answer than the original data, will not count any marks.

5.2 Units

- 5.2.1** Candidates will only be penalised once for the repeated use of an incorrect unit **within a question**.
- 5.2.2** Units are only required in the final answer to a calculation.
- 5.2.3** Marks are only awarded for an answer, and not for a unit per se. Candidates will therefore forfeit the mark allocated for the answer in each of the following situations:
- Correct answer + wrong unit
 - Wrong answer + correct unit
 - Correct answer + no unit
- 5.2.4** SI units must be used, except in certain cases, e.g. $V \cdot m^{-1}$ instead of $N \cdot C^{-1}$, and $cm \cdot s^{-1}$ or $km \cdot h^{-1}$ instead of $m \cdot s^{-1}$ where the question warrants this.

5.3 General

- 5.3.1 If one answer or calculation is required, but two are given by the candidate, only the first one will be marked, irrespective of which one is correct. If two answers are required, only the first two will be marked, etc.
- 5.3.2 For marking purposes, alternative symbols (s, u, t, etc.) will also be accepted.
- 5.3.3 Separate compound units with a multiplication dot, not a full stop, e.g. $\text{m}\cdot\text{s}^{-1}$. For marking purposes, $\text{m}\cdot\text{s}^{-1}$ and m/s will also be accepted.

5.4 Positive marking

Positive marking regarding calculations will be followed in the following cases:

- 5.4.1 Subquestion to subquestion: When a certain variable is incorrectly calculated in one subquestion (e.g. 3.1) and needs to be substituted into another subquestion (3.2 or 3.3), full marks are to be awarded for the subsequent subquestions.
- 5.4.2 A multistep question in a subquestion: If the candidate has to calculate, for example, current in the first step and gets it wrong due to a substitution error, the mark for the substitution and the final answer will be forfeited.

5.5 Negative marking

Normally an incorrect answer cannot be correctly motivated if based on a conceptual mistake. If the candidate is therefore required to motivate in QUESTION 3.2 the answer given to QUESTION 3.1, and QUESTION 3.1 is incorrect, no marks can be awarded for QUESTION 3.2. However, if the answer for, for example, QUESTION 3.1 is based on a calculation, the motivation for the incorrect answer in QUESTION 3.2 should be considered.

6. MARKING GUIDELINES: PAPER 2

6.1 Calculations

- 6.1.1 **Marks will be awarded for:** correct formula, correct substitution, correct answer with unit.
- 6.1.2 **No marks** will be awarded if an **incorrect or inappropriate formula is used**, even though there may be relevant symbols and applicable substitutions.
- 6.1.3 When an error is made during **substitution into a correct formula**, a mark will be awarded for the correct formula and for the correct substitutions, but **no further marks** will be given.
- 6.1.4 If **no formula** is given, but **all substitutions are correct**, the candidate will **forfeit one mark**.

Example: No K_c expression, correct substitution:

$$K_c = \frac{(2)^2}{(2)(1)^3} \checkmark = 2 \checkmark \quad \left(\frac{2}{3}\right)$$

- 6.1.5** Marks are only awarded for a formula if a **calculation has been attempted**, i.e. substitutions have been made or a numerical answer has been given.
- 6.1.6** Marks can only be allocated for substitutions when values are substituted into formulae and not when listed before a calculation starts.
- 6.1.7** The final answer to all calculations, when not specified in the question, must be rounded off to a minimum of TWO decimal places.
- 6.1.8** If a final answer to a calculation is correct, full marks will not automatically be awarded. Markers will always ensure that the correct/appropriate formula is used and that workings, including substitutions, are correct.
- 6.1.9** Mathematical manipulations and change of subject of appropriate formulae carry no marks, but if a candidate starts off with the correct formula and then changes the subject of the formula incorrectly, marks will be awarded for the formula and the correct substitutions. The mark for the incorrect numerical answer is forfeited.

Example:

CORRECT	ANSWER (1)	POSSIBLE	ANSWER (2)	POSSIBLE
$n = \frac{m}{M} \checkmark$ $0,01 \checkmark = \frac{m}{52} \checkmark$ $m = 0,52 \text{ g} \checkmark$	$n = \frac{m}{M} \checkmark$ $0,01 \checkmark = \frac{52}{m} \times$ $m = 5\,200 \text{ g} \times$	$m = \frac{n}{M} \times$ $= \frac{0,01}{52}$ $= 0,002 \text{ g}$	$n = \frac{m}{M} \checkmark$ $m = \frac{M}{n} \times$ $\frac{52}{0,01} \checkmark$ $= 5\,200 \text{ g} \times$	$n = \frac{m}{M} \checkmark$ $= 0,52 \text{ g} \checkmark$
(4)	(2)	(0)	(3)	(2)

6.2 Units

- 6.2.1** Candidates will only be penalised once for the repeated use of an incorrect unit **within a question**.
- 6.2.2** Units are only required in the final answer to a calculation.
- 6.2.3** Marks are only awarded for an answer and not for a unit per se. Candidates will therefore forfeit the mark allocated for the answer in each of the following situations:
- Correct answer + wrong unit
 - Wrong answer + correct unit
 - Correct answer + no unit
- 6.2.4** Separate compound units with a multiplication dot, not a full stop, for example $\text{mol} \cdot \text{dm}^{-3}$. Accept $\text{mol} \cdot \text{dm}^{-3}$ (or mol/dm^3) for marking purposes.

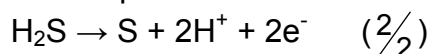
6.3 General

6.3.1 If one answer or calculation is required, but two are given by the candidate, only the first one will be marked, irrespective of which one is correct. If two answers are required, only the first two will be marked, etc.

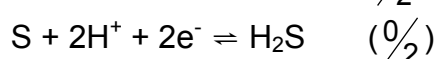
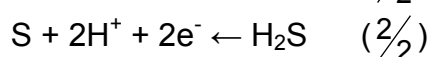
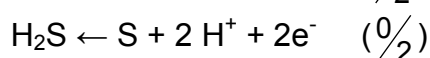
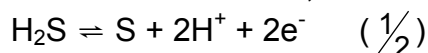
6.3.2 When a chemical **FORMULA** is asked, and the **NAME** is given as answer, the candidate forfeits the marks. The same rule applies when the **NAME** is asked and the **FORMULA** is given.

6.3.3 When redox half-reactions are to be written, the correct arrow should be used.

If the equation



is the correct answer, the marks must be given as follows:



6.3.4 When candidates are required to give an explanation involving the relative strength of oxidising and reducing agents, the following is not accepted:

- Stating the position of a substance on Table 4 only (e.g. Cu is above Mg).
- Using relative reactivity only (e.g. Mg is more reactive than Cu).
- The correct answer would be for instance: Mg is a stronger reducing agent than Cu, and therefore Mg will be able to reduce Cu^{2+} ions to Cu. The answer can also be given in terms of the relative strength as electron acceptors and donors.

6.3.5 One mark is forfeited when the charge of an ion is omitted per equation (not for the charge on an electron).

6.3.6 The error-carrying principle does not apply to chemical equations or half-reactions. For example, if a learner writes the wrong oxidation/reduction half-reaction in the subquestion and carries the answer to another subquestion (balancing of equations or calculation of $E_{\text{cell}}^{\ominus}$), then the learner will not be credited for this substitution.

6.3.7 In the structural formula of an organic molecule all hydrogen atoms must be shown. Marks will be deducted if hydrogen atoms are omitted.

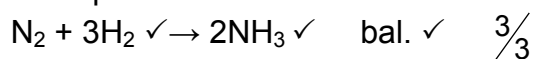
6.3.8 When a structural formula is required, marks will be deducted if the learner writes the condensed formula.

6.3.9 When a IUPAC name is asked and the candidate omits the hyphen(s) (e.g. instead of pent-1-ene or 1-pentene the candidate writes pent 1 ene or 1 pentene), marks will be forfeited.

6.3.10 When a chemical reaction is asked, marks are awarded for correct reactants, correct products and correct balancing.

If only a reactant(s) followed by an arrow, or only a product(s) preceded by an arrow, is/are written, marks may be awarded for the reactant(s) or product(s). If only a reactant(s) or only a product(s) is/are written, without an arrow, no marks are awarded for the reactant(s) or product(s).

Examples:



6.4 Positive marking

Positive marking regarding calculations will be followed in the following cases:

6.4.1 Subquestion to subquestion: When a certain variable is calculated in one subquestion (e.g. QUESTION 3.1) and needs to be substituted in another (QUESTION 3.2 or QUESTION 3.3), e.g. if the answer for QUESTION 3.1 is incorrect and is substituted correctly in QUESTION 3.2 or QUESTION 3.3, **full marks** are to be awarded for the subsequent subquestions.

6.4.2 A multistep question in a subquestion: If the candidate has to calculate, for example, current in the first step and gets it wrong due to a substitution error, the mark for the substitution and the final answer will be forfeited.

6.5 Negative marking

Normally an incorrect answer cannot be correctly motivated if based on a conceptual mistake. If the candidate is therefore required to motivate in QUESTION 3.2 the answer given to QUESTION 3.1, and QUESTION 3.1 is incorrect, no marks can be awarded for QUESTION 3.2. However, if the answer for, for example, QUESTION 3.1 is based on a calculation, the motivation for the incorrect answer in QUESTION 3.2 could be considered.

7. CONCLUSION

This Examination Guidelines document is meant to articulate the assessment aspirations espoused in the CAPS document. It is therefore not a substitute for the CAPS document, which educators should teach to.

Qualitative curriculum coverage as enunciated in the CAPS cannot be over-emphasised.