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SUBJECT	PHYSICAL SCIENCES PAST QUESTIONS PAPERS AND MEMOS PAPER 2 AND EXAMINATION GUIDELINE
GRADE	12
YEAR	2018-2023 (JUNE) NO NOVEMBER QUESTION PAPER AND MEMO FOR 2023
COMBINED BY	BAG OF HOPE ACADEMY
CONTACT	079 897 5624/ 081 882 2512/ 076 953 1123

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES

EXAMINATION GUIDELINES

GRADE 12

2021

These guidelines consist of 36 pages.

TABLE OF CONTENTS

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 12.

The purpose of these Examination Guidelines is to:

- Provide clarity on the depth and scope of the content to be assessed in the Grade 12 National Senior Certificate (NSC) Examination in Physical Sciences.
- Assist teachers to adequately prepare learners for the examinations.

This document deals with the final Grade 12 external 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 12

2.1 Format of question papers

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

2.2 Numbering and sequence of questions

QUESTION 1: Multiple-choice questions
Subquestions numbered 1.1 to 1.10 (2 marks each)
Questions may cover all cognitive levels and will be arranged according to topics.

QUESTION 2 onwards:
Longer questions assessing 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.

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2.4 Weighting of cognitive levels

Papers 1 and 2 will include questions across 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	65	150 marks	3 hours	15	35	40	10
Waves, sound and light	15						
Electricity and magnetism	55						
Matter and materials	15						

Paper 2: Chemistry Focus							
Content	**Marks**	**Total**	**Duration**	**Weighting of cognitive levels**			
Chemical change	92	150 marks	3 hours	15	40	35	10
Matter and materials	58						

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 Grades 10 and 11

All skills and application of knowledge learnt in Grades 10 and 11 are applicable to assessment in Grade 12. In addition to content from Grades 10 and 11 included under examinable content for Grade 12, skills and knowledge from Grades 10 and 11 that may be assessed in Grade 12 include the following:

- The use of equations of motion in solving problems dealing with momentum, vertical projectile motion, work, energy and power
- Sound waves and properties of sound
- Electromagnetism

NOTE: Although there will be no direct questions about these aspects, applications thereof can be assessed.

3. ELABORATION OF THE CONTENT

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

3.1 Paper 1: Physics

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 with which it is in contact, and which is perpendicular to the surface.
- Define *frictional force*, f, as the force that opposes the motion of an object and which acts parallel to the surface.
  Define *static frictional force*, f_s, as the force that opposes the tendency of motion of a stationary object relative to a surface.
  Define *kinetic frictional force*, f_k, as the force that opposes the motion of a moving object relative to a surface.
  Know that a frictional force:
  - Is proportional to the normal force
  - Is independent of the area of contact
  - Is independent of the velocity of motion
- 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.
  NOTE:
  - If a force, F, applied to a body parallel to the surface does not cause the object to move, F is equal in magnitude to the static frictional force.
  - The static frictional force is a maximum (f_s^{max}) just before the object starts to move across the surface.
  - If the applied force exceeds f_s^{max}, a resultant net force accelerates the object.
- 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.
- Draw free-body diagrams. (This is a diagram that shows the relative magnitudes and directions of forces acting on a body/particle that has been isolated from its surroundings.)
- Resolve two-dimensional forces (such as the weight of an object on an inclined plane) into its parallel (x) and perpendicular (y) components.
- Determine the resultant or 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.
- Discuss why it is important to wear seatbelts using Newton's first law of motion.
- State Newton's second law of motion: When a net force acts on an object, the object will accelerate in the direction of the force and the acceleration is directly proportional to the force and inversely proportional to the mass of the object.
- Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating.

- Apply Newton's laws to a variety of equilibrium and non-equilibrium problems including:
  - A single object:
    - Moving on a horizontal plane with or without friction
    - Moving on an inclined plane with and without friction
    - Moving in the vertical plane (lifts, rockets, etc.)
  - Two-body systems (joined by a light inextensible string) by applying Newton's laws of motion separately to EACH of the bodies:
    - Both on a flat horizontal plane with and without friction
    - One on a horizontal plane with and 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
- 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.
- Identify action-reaction pairs.
- List the properties of action-reaction pairs.

Newton's Law of Universal Gravitation
- State Newton's Law of Universal Gravitation: Each body in the universe attracts every other body with a 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 $F = \frac{Gm_1m_2}{r^2}$.
- Describe *weight* as the gravitational force the Earth exerts on any object on or near its surface.
- Calculate weight using the expression $w = mg$.
- Calculate the weight of an object on other planets with different values of gravitational acceleration.
- Distinguish between *mass* and *weight*.
- Explain *weightlessness*.

Momentum and Impulse
(This section must be read in conjunction with the CAPS, p. 99–101.)

Momentum
- Define *momentum* as the product of an object's mass and its velocity.
- Describe *linear momentum* as a vector quantity with the same direction as the velocity of the object.
- Calculate the momentum of a moving object using p = mv.
- Describe the vector nature of momentum and illustrate it with some simple examples.
- Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum for each of the cases above.

Newton's second law in terms of momentum
- State Newton's second law of motion in terms of momentum: The net (or resultant) force acting on an object is equal to the rate of change of momentum of the object in the direction of the net force.
- Express Newton's second law of motion in symbols: $F_{net} = \frac{\Delta p}{\Delta t}$
- Explain the relationship between net force and change in momentum for a variety of motions.
- Calculate the change in momentum when a resultant/net force acts on an object and its velocity:
  - Increases in the direction of motion, e.g. 2nd stage rocket engine fires
  - Decreases, e.g. brakes are applied
  - Reverses its direction of motion, e.g. a soccer ball kicked back in the direction it came from

Impulse
- Define *impulse* as the product of the resultant/net force acting on an object and the time the net force acts on the object.
- Use the impulse-momentum theorem, $F_{net}\Delta t = m\Delta v$, to calculate the resultant/net force exerted, the time for which the force is applied and the change in momentum for a variety of situations involving the motion of an object in one dimension.
- Explain how the concept of impulse applies to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds.

Conservation of momentum and elastic and inelastic collisions
- Explain what is meant by a *system* (in Physics).
- Explain (when working with systems) what is meant by *internal* and *external forces*.
- Explain what is meant by *an isolated system* (in Physics), i.e. a system on which the net external force is zero.
  (An isolated system excludes external forces that originate outside the colliding bodies, e.g. friction. Only internal forces, e.g. contact forces between the colliding objects, are considered.)
- State the principle of conservation of linear momentum: The total linear momentum of an isolated system remains constant (is conserved).
- Apply the conservation of momentum to the collision of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention.
- Distinguish between *elastic collisions* and *inelastic collisions* by calculation.

Vertical Projectile Motion in One Dimension (1D) (This section must be read in conjunction with the CAPS, p. 102–103.)

- Explain what is meant by a *projectile*, i.e. an object which has been given an initial velocity and then it moves under the influence of the gravitational force only.
- Define *free fall* as motion during which the only force acting on an object is the gravitational force.
- Use equations of motion to determine the position, velocity and displacement of a projectile at any given time.
- Sketch position versus time (x vs. t), velocity versus time (v vs. t) and acceleration versus time (a vs. t) graphs for:
  - A free-falling object
  - An object thrown vertically upwards
  - An object thrown vertically downwards
  - Bouncing objects (restricted to balls)
- For a given x vs. t, v vs. t or a vs. t graph, determine:
  - Position
  - Displacement
  - Velocity or acceleration at any time t
- For a given x vs. t, v vs. t or a vs. t graph, describe the motion of the object:
  - Bouncing
  - Thrown vertically upwards
  - Thrown vertically downward

Work, Energy and Power (This section must be read in conjunction with the CAPS, p. 117–120.)

Work

- Define the work done on an object by a constant force F as $F\Delta x\cos\theta$, where F is the magnitude of the force, Δx the magnitude of the displacement and θ the angle between the force and the displacement. (Work is done by a force – the use of the term 'work is done against a force', e.g. work done against friction, must be avoided.)
- Draw a force diagram and free-body diagrams.
- Calculate the net work done on an object.
- Distinguish between *positive net work done* and *negative net work done* on the system.

Work-energy theorem

- State the work-energy theorem: The work done on an object by a net force is equal to the change in the object's kinetic energy OR the work done on an object by a net force is equal to the change in the object's kinetic energy.
  In symbols: $W_{net} = \Delta K = K_f - K_i$
- Apply the work-energy theorem to objects on horizontal, vertical and inclined planes (for both frictionless and rough surfaces).

Conservation of energy with non-conservative forces present

- Define a *conservative force* as a force for which the work done in moving an object between two points is independent of the path taken. Examples are gravitational force, the elastic force in a spring and electrostatic forces (coulombic forces).
- Define a *non-conservative force* as a force for which the work done in moving an object between two points depends on the path taken. Examples are frictional force, air resistance, tension in a chord, etc.
- State the principle of conservation of mechanical energy: The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. **NOTE:** A system is isolated when the net external force (excluding the gravitational force) acting on the system is zero.
- Solve conservation of energy problems using the equation: $W_{nc} = \Delta E_k + \Delta E_p$
- Use the relationship above to show that in the absence of non-conservative forces, mechanical energy is conserved.

Power

- Define *power* as the rate at which work is done or energy is expended.

  In symbols: $P = \frac{W}{\Delta t}$
- Calculate the power involved when work is done.
- Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.
- Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed).

Doppler Effect (relative motion between source and observer)
(This section must be read in conjunction with the CAPS, p. 121–122.)

With sound and ultrasound

- State the Doppler effect as the change in frequency (or pitch) of the sound detected by a listener, because the sound source and the listener have different velocities relative to the medium of sound propagation.
- Explain (using appropriate illustrations) the change in pitch observed when a source moves toward or away from a listener.
- Solve problems using the equation $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ when EITHER the source OR the listener is moving.
- State applications of the Doppler effect.

With light – red shifts in the universe (evidence for the expanding universe)

- Explain red shifts.
- Use the Doppler effect to explain why we conclude that the universe is expanding.

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 one point charge (Q_1) on another point charge (Q_2) 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 of 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 lines 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 *electric field at a point*: The electric field 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 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 & 121.)

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.
- Determine the relationship between current, potential difference and resistance at constant temperature using a simple circuit.
- State the difference between ohmic conductors and non-ohmic conductors and give an example of each.
- Solve problems using $R = \frac{V}{I}$ for series and parallel circuits (maximum four resistors).

Power, energy

- Define *power* as the rate at which work is done.
- Solve problems using $P = \frac{W}{\Delta t}$.
- Solve problems using $P = VI$, $P = I^2R$ or $P = \frac{V^2}{R}$.
- 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.
- Calculate the cost of electricity usage given the power specifications of the appliances used, the duration and the cost of 1 kWh.

Internal resistance, series and parallel networks

- Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors excluding internal resistance).
- Define the term *emf* as the maximum energy provided by a battery per unit charge passing through it.
- Solve circuit problems using $\varepsilon = V_{load} + V_{internal\ resistance}$ or $\varepsilon = IR_{ext} + Ir$.
- Solve circuit problems, with internal resistance, involving series-parallel networks of resistors (maximum four resistors).

Electrodynamics
(This section must be read in conjunction with the CAPS, p. 130–131.)

Electrical machines (generators, motors)

- State the energy conversion in generators.
- Use the principle of electromagnetic induction to explain how a generator works.
- Explain the functions of the components of an AC and a DC generator.
- State examples of the uses of AC and DC generators.
- State the energy conversion in motors.
- Use the motor effect to explain how a motor works.
- Explain the functions of the components of a motor.
- State examples of the use of motors.

Alternating current

- State the advantages of alternating current over direct current.
- Sketch graphs of voltage versus time and current versus time for an AC circuit.
- Define the term *rms* for an alternating voltage/current.
  The rms potential difference is the AC potential difference which dissipates/produces the same amount of energy as an equivalent DC potential difference.
  The rms current is the alternating current which dissipates/produces the same amount of energy as an equivalent direct current (DC).
- Solve problems using $I_{rms} = \frac{I_{max}}{\sqrt{2}}$, $V_{rms} = \frac{V_{max}}{\sqrt{2}}$.
- Solve problems using $P_{ave} = I_{rms}V_{rms} = \frac{1}{2} I_{max}V_{max}$ (for a purely resistive circuit), $P_{ave} = I^2_{rms}R$ and $P_{ave} = \frac{V^2_{rms}}{R}$.

Optical Phenomena and Properties of Materials
(This section must be read in conjunction with the CAPS, p. 132–133.)

Photo-electric effect

- Describe the *photoelectric effect* as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.
- State the significance of the photoelectric effect.
- Define *threshold frequency*, f_o, as the minimum frequency of light needed to emit electrons from a certain metal surface.
- Define *work function*, W_o, as the minimum energy that an electron in the metal needs to be emitted from the metal surface.
- Perform calculations using the photoelectric equation:
  $E = W_o + E_{k(max)}$, where $E = hf$ and $W_o = hf_o$ and $E_{k(max)} = \frac{1}{2} mv^2_{max}$
- Explain the effect of intensity and frequency on the photoelectric effect.
- State that the photoelectric effect demonstrates the particle nature of light.

Emission and absorption spectra

- Explain the *formation of atomic spectra* by referring to energy transition.
- Explain the difference between *atomic absorption* and *emission spectra*.
  An atomic absorption spectrum is formed when certain frequencies of electromagnetic radiation passing through a substance is absorbed.
  For example, when light passes through a cold gas, atoms in the gas absorb characteristic frequencies of the light and the spectrum observed is a continuous spectrum with dark lines where characteristic frequencies of light were removed. The frequencies of the absorption lines are unique to the type of atoms in the gas.
  An atomic emission spectrum is formed when certain frequencies of electromagnetic radiation are emitted due to an atom making a transition from a higher energy state to a lower energy state.
  For example, atoms in a hot gas emit light at characteristic frequencies. The spectrum observed is a line spectrum with only a few coloured lines of frequencies unique to the type of atom that is producing the emission lines.

3.2 Paper 2: Chemistry

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

Balanced chemical equations
- Write and balance chemical equations.
- 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. 82.)

Molar volume of gases
- 1 mole of any gas occupies 22,4 dm^3 at 0 °C (273 K) and 1 atmosphere (101,3 kPa).

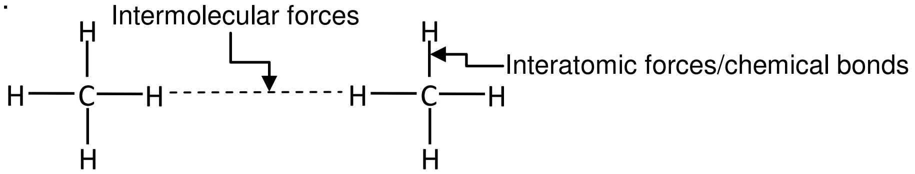
Volume relationships in gaseous reactions
- Interpret balanced equations in terms of volume relationships for gases, i.e. under the same conditions of temperature and pressure, equal number of moles of all gases occupy the same volume.

Concentration of solutions
- Calculate the molar concentration of a solution.

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 $CaCO_3$ in an impure sample of seashells.
- Perform stoichiometric calculations based on balanced equations.
- Perform stoichiometric calculations based on balanced equations that may include limiting reagents.

Intermolecular Forces
(This section must be read in conjunction with the CAPS, p. 71–73.)

Intermolecular and interatomic forces (chemical bonds)
- Name and explain the different intermolecular forces (Van der Waal's forces):
  (i) Dipole-dipole forces:
  Forces between two polar molecules
  (ii) Induced dipole forces or London forces:
  Forces between non-polar molecules
  (iii) Hydrogen bonding:
  Forces between molecules in which hydrogen is covalently bonded to nitrogen, oxygen or fluorine – a special case of dipole-dipole forces
- 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 size. For non-polar molecules, the strength of induced dipole forces increases with molecular size.

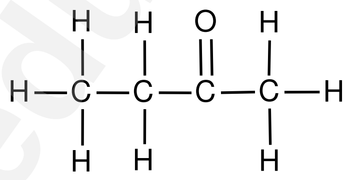
- Explain the effect of intermolecular forces on boiling point, melting point and vapour pressure.
  Boiling point:
  The temperature at which the vapour pressure of a substance equals atmospheric pressure. The stronger the intermolecular forces, the higher the boiling point.
  Melting point:
  The temperature 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.

Organic Molecules
(This section must be read in conjunction with the CAPS, p. 104–116.)

- Define organic molecules as molecules containing carbon atoms.

Organic molecular structures – functional groups, saturated and unsaturated structures, isomers

- Write down condensed structural formulae, structural formulae, molecular formulae and IUPAC names (up to 8 carbon atoms) for:
  - Alkanes (no ring structures)
  - Alkenes (no ring structures)
  - Alkynes
  - Halo-alkanes (primary, secondary and tertiary haloalkanes; no ring structures)
  - Alcohols (primary, secondary and tertiary alcohols)
  - Carboxylic acids
  - Esters
  - Aldehydes
  - Ketones
- Know the following definitions/terms:
  - Molecular formula: A chemical formula that indicates the element and numbers of each of the atoms in a molecule.
    Example: C_4H_8O
  - Structural formula: A structural formula of a compound shows which atoms are attached to which within the molecule. Atoms are represented by their chemical symbols and lines are used to represent ALL the bonds that hold the atoms together.
    Example:



  - Condensed structural formula: This notation shows the way in which atoms are bonded together in the molecule, but DOES NOT SHOW ALL bond lines.
    Example:
    $CH_3CH_2COCH_3$ OR $CH_3CH_2\overset{\overset{O}{||}}{C}CH_3$
  - Hydrocarbon: Organic compounds that consist of hydrogen and carbon only.
  - Homologous series: A series of organic compounds that can be described by the same general formula OR in which one member differs from the next with a CH_2 group

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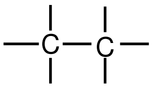
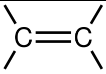
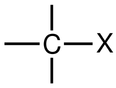
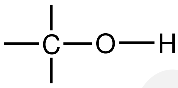
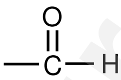
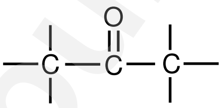
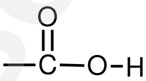
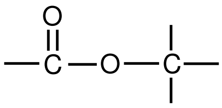
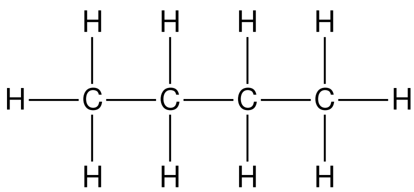
- Saturated compounds: Compounds in which there are no multiple bonds between C atoms in their hydrocarbon chains
- Unsaturated compounds: Compounds with one or more multiple bonds between C atoms in their hydrocarbon chains
- Functional group: A bond or an atom or a group of atoms that determine(s) the physical and chemical properties of a group of organic compounds

Homologous series	Structure of functional group	
	Structure	**Name/Description**
Alkanes		Only C-H and C-C single bonds
Alkenes		Carbon-carbon double bond
Alkynes		Carbon-carbon triple bond
Haloalkanes	 (X = F, Cℓ, Br, I)	Halogen atom bonded to a C atom in an alkane
Alcohols		Hydroxyl group bonded to a saturated C atom
Aldehydes		Formyl group
Ketones		Carbonyl group bonded to two C atoms
Carboxylic acids		Carboxyl group
Esters		-

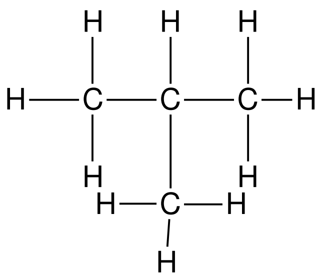
- Structural isomer: Organic molecules with the same molecular formula, but different structural formulae

• Identify compounds (up to 8 carbon atoms) that are saturated, unsaturated and are structural isomers.

• Restrict structural isomers to chain isomers, positional isomers and functional isomers.
  - Chain isomers: Same molecular formula, but different types of chains, e.g. butane and 2-methylpropane

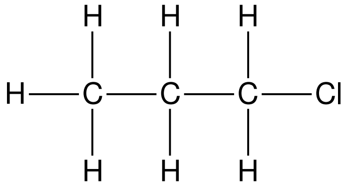


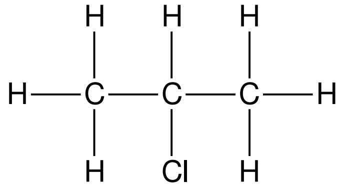
Butane

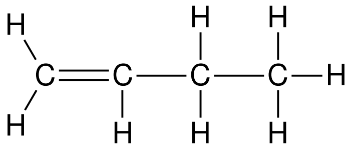


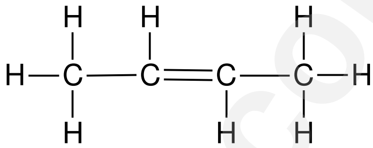
2-methylpropane

- ○ Positional isomers: Same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain, e.g. 1-chloropropane and 2-chloropropane or but-2-ene and but-1-ene

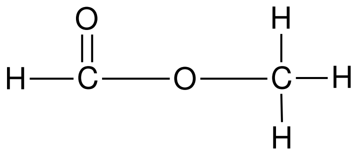

1-chloropropane

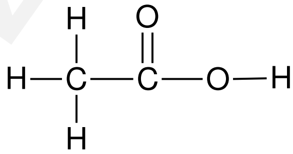

2-chloropropane


but-1-ene


but-2-ene

- ○ Functional isomers: Same molecular formula, but different functional groups, e.g. methyl methanoate and ethanoic acid


methyl methanoate


ethanoic acid

IUPAC naming and formulae for compounds in the homologous series above

- Write down the IUPAC name when given the structural formula or condensed structural formula.
- Write down the structural formula when given the IUPAC name or molecular formula.
- Compounds must be restricted to one functional group per compound (except haloalkanes).
- Haloalkanes restricted to two functional groups per compound.
- Alkyl substituents (methyl- and ethyl- only) restricted to a maximum of THREE on the parent chain.
- When naming haloalkanes:
  - ○ Halogen substituents do not get preference over alkyl groups.
  - ○ Numbering should start from the end nearest to the first substituent.
  - ○ When substituents, e.g. Br and Cℓ or Cℓ and methyl, have the same number when numbered from different ends of chain, preference is given to alphabetical order, e.g. bromo- over chloro-; chloro- over methyl-.
- When writing IUPAC names, substituents are written alphabetically namely bromo, chloro, ethyl, methyl. Ignore prefixes di and tri.

Structure and physical properties (boiling point, melting point, vapour pressure) relationships

- For a given example (from the above functional groups), explain the relationship between physical properties and:
  - ○ Strength of intermolecular forces (Van der Waal's forces), i.e. hydrogen bonds, dipole-dipole forces, induced dipole forces
  - ○ Type of functional groups
  - ○ Chain length
  - ○ Branched chains

Oxidation of alkanes
- State the use of alkanes as fuels.
- Write down an equation for the combustion of an alkane in excess oxygen.

Esterification
- Write down an equation, using structural formulae or condensed structural formulae, for the formation of an ester.
- Name the alcohol and carboxylic acid used and the ester formed.
- Write down reaction conditions for esterification.

Substitution, addition and elimination reactions
- Identify reactions as elimination, substitution or addition.
- Write down, using structural formulae or condensed structural formulae, equations and reaction conditions for the following addition reactions of alkenes:
  - Hydrohalogenation:
    The addition of a hydrogen halide to an alkene
  - Halogenation:
    The reaction of a halogen (Br_2, $C\ell_2$) with a compound
  - Hydration:
    The addition of water to a compound
  - Hydrogenation:
    The addition of hydrogen to an alkene
- Identify major and minor products in the above addition reactions.
- Write down, using structural formulae or condensed structural formulae, equations and reaction conditions for the following elimination reactions:
  - Dehydrohalogenation of haloalkanes:
    The elimination of hydrogen and a halogen from a haloalkane
  - Dehydration of alcohols:
    Elimination of water from an alcohol
  - Cracking of alkanes:
    The chemical process in which longer chain hydrocarbon molecules are broken down to shorter more useful molecules.
- Identify major and minor products in the above elimination reactions.
- Write down, using structural formulae or condensed structural formulae, equations and reaction conditions for the following substitution reactions:
  - Hydrolysis of haloalkanes
    Hydrolysis: The reaction of a compound with water
  - Reactions of HX (X = $C\ell$, Br) with alcohols to produce haloalkanes
  - Halogenation of alkanes
    The reaction of a halogen (Br_2, $C\ell_2$) with a compound
- Distinguish between *saturated* and *unsaturated hydrocarbons* using bromine water.

Energy and 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 in a chemical reaction.
- 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.

Rate and Extent of Reaction
(This section must be read in conjunction with the CAPS, p. 123–124.)

Rates of reaction and factors affecting rate

- Define reaction rate as the change in concentration of reactants or products per unit time.
- Calculate reaction rate from given data for reactants:

  Rate = $\frac{\Delta c}{\Delta t}$ (Unit: $mol{\cdot}dm^{-3}{\cdot}s^{-1}$)

  Calculate reaction rate from given data for products:

  Rate = $\frac{\Delta c}{\Delta t}$ (Unit: $mol{\cdot}dm^{-3}{\cdot}s^{-1}$)

  Questions may also include calculations of rate in terms of change in mass/volume/ moles per time.
- List the factors that affect the rate of chemical reactions, i.e. nature of reacting substances, surface area, concentration (pressure for gases), temperature and the presence of a catalyst.
- Explain in terms of the collision theory how the various factors affect the rate of chemical reactions. The collision theory is a model that explains reaction rate as the result of particles colliding with a certain minimum energy to form products.

Measuring rates of reaction

- Answer questions and interpret data (tables or graphs) on different experimental techniques for measuring the rate of a given reaction.

Mechanism of reaction and of catalysis

- Define the term catalyst as a substance that increases the rate of a chemical reaction without itself undergoing a permanent change.
- Explain that a catalyst increases the rate of a reaction by providing an alternative path of lower activation energy. It therefore decreases the net activation energy.
- Interpret Maxwell-Boltzmann curves (number of particles against kinetic energy) to explain the effect of a catalyst, temperature and concentration on reaction rate.

Chemical Equilibrium
(This section must be read in conjunction with the CAPS, p. 125–126.)

Chemical equilibrium and factors affecting equilibrium
- Explain what is meant by:
  - Open and closed systems: An open system continuously interacts with its environment, while a closed system is isolated from its surroundings.
  - A reversible reaction: A reaction is reversible when products can be converted back to reactants and vice versa.
  - Chemical equilibrium: It is a dynamic equilibrium when the rate of the forward reaction equals the rate of the reverse reaction.
- List the factors that influence the position of an equilibrium, i.e. pressure (gases only), concentration and temperature.

Equilibrium constant
- List the factors that influence the value of the equilibrium constant, K_c.
- Write down an expression for the equilibrium constant, having been given the equation for the reaction.
- Perform calculations based on K_c values.
- Explain the significance of high and low values of the equilibrium constant.

Application of equilibrium principles
- State Le Chatelier's principle: When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will oppose the disturbance.
- Use Le Chatelier's principle to explain changes in equilibria qualitatively.
- Interpret graphs of equilibrium, e.g. concentration/rate/number of moles/mass/ volume versus time.

Acids and Bases
(This section must be read in conjunction with the CAPS, p. 127–128.)

Acid-base reactions
- Define *acids* and *bases* according to Arrhenius and Lowry-Brønsted theories:
  Arrhenius theory: Acids produce hydrogen ions (H^+/H_3O^+/hydronium ions) in aqueous solution. Bases produce hydroxide ions (OH^-) in aqueous solution.
  Lowry-Brønsted theory: An acid is a proton (H^+ ion) donor. A base is a proton (H^+ ion) acceptor.

Relative strengths of acids and bases
- Distinguish between *strong acids/bases* and *weak acids/bases* with examples.
  Strong acids ionise completely in water to form a high concentration of H_3O^+ ions. Examples of strong acids are hydrochloric acid, sulphuric acid and nitric acid.
  Weak acids ionise incompletely in water to form a low concentration of H_3O^+ ions. Examples of weak acids are ethanoic acid and oxalic acid.
  Strong bases dissociate completely in water to form a high concentration of OH^- ions.
  Examples of strong bases are sodium hydroxide and potassium hydroxide.
  Weak bases dissociate/ionise incompletely in water to form a low concentration of OH^- ions.
  Examples of weak bases are ammonia, calcium carbonate, potassium carbonate, calcium carbonate and sodium hydrogen carbonate.
- Distinguish between *concentrated acids/bases* and *dilute acids/bases*.
  Concentrated acids/bases contain a large amount (number of moles) of acid/base in proportion to the volume of water.
  Dilute acids/bases contain a small amount (number of moles) of acid/base in proportion to the volume of water.

Acid-base reactions

- Write down the reaction equations of aqueous solutions of acids and bases.
  Examples: $HC\ell(g) + H_2O(\ell) \rightarrow H_3O^+(aq) + C\ell^-(aq)$ ($HC\ell$ is a monoprotic acid.)
  $NH_3(g) + H_2O(\ell) \rightarrow NH_4^+(aq) + OH^-(aq)$
  $H_2SO_4(aq) + 2H_2O(\ell) \rightarrow 2H_3O^+(aq) + SO_4^{2-}(aq)$ (H_2SO_4 is a diprotic acid.)
- Identify conjugate acid-base pairs for given compounds.
- Describe a substance that can act as either acid or base as ampholyte. Water is a good example of an ampholyte substance. Write equations to show how an ampholyte substance can act as acid or base.
- Write down neutralisation reactions of common laboratory acids and bases.
  Examples: $HC\ell(aq) + NaOH(aq)/KOH(aq) \rightarrow NaC\ell(aq)/KC\ell(aq) + H_2O(\ell)$
  $HC\ell(aq) + Na_2CO_3(aq) \rightarrow NaC\ell(aq) + H_2O(\ell) + CO_2(g)$
  $HNO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + H_2O(\ell)$
  $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(\ell)$
  $(COOH)_2(aq) + NaOH(aq) \rightarrow (COO)_2Na_2(aq) + H_2O(\ell)$
  $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(\ell)$
  NOTE: The above are examples of equations that learners will be expected to write from given information. However, any other neutralisation reaction can be given in the question paper to assess, e.g. stoichiometry.

Hydrolysis

- Define *hydrolysis* as the reaction of a salt with water.
- Determine the approximate pH (equal to, smaller than or larger than 7) of salts in salt hydrolysis.
  - Hydrolysis of the salt of a weak acid and a strong base results in an alkaline solution, i.e. the pH > 7. Examples of such salts are sodium ethanoate, sodium oxalate and sodium carbonate.
  - Hydrolysis of the salt of a strong acid and a weak base results in an acidic solution, i.e. the pH < 7. An example of such a salt is ammonium chloride.
  - The salt of a strong acid and a strong base does not undergo hydrolysis and the solution of the salt will be neutral, i.e. pH = 7.

Acid-base titrations

- Motivate the choice of a specific indicator in a titration. Choose from methyl orange, phenolphthalein and bromothymol blue.
- Define the *equivalence point of a titration* as the point at which the acid/base has completely reacted with the base/acid.
  Define the *endpoint of a titration* as the point where the indicator changes colour.
- Perform stoichiometric calculations based on titrations of a strong acid with a strong base, a strong acid with a weak base and a weak acid with a strong base. Calculations may include percentage purity.
- For a titration, e.g. the titration of oxalic acid with sodium hydroxide:
  - List the apparatus needed or identify the apparatus from a diagram.
  - Describe the procedure to prepare a standard oxalic acid solution.
  - Describe the procedure to conduct the titration.
  - Describe safety precautions.
  - Describe measures that need to be in place to ensure reliable results.
  - Interpret given results to determine the unknown concentration.

pH and the pH scale

- Explain the pH scale as a scale of numbers from 0 to 14 used to express the acidity or alkalinity of a solution.
- Calculate pH values of strong acids and strong bases using $pH = -\log[H_3O^+]$.
- Define K_w as the equilibrium constant for the ionisation of water or the ion product of water or the ionisation constant of water, i.e. $K_w = [H_3O^+][OH^-] = 1 \times 10^{14}$ by 298 K.

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- Explain the *auto-ionisation of water*, i.e. the reaction of water with itself to form H_3O^+ ions and OH^- ions.
- Interpret K_a values of acids to determine the relative strength of given acids. Interpret K_b values of bases to determine the relative strength of given bases.
- Compare strong and weak acids by looking at:
  - pH (monoprotic and diprotic acids)
  - Conductivity
  - Reaction rate

Electrochemical Reactions
(This section must be read in conjunction with the CAPS, p. 134–137.)

Galvanic cells

- Define the *galvanic cell* as a cell in which chemical energy is converted to electrical energy.
- Define *oxidation* and *reduction* in terms of electron (e^-) transfer:
  Oxidation is a loss of electrons. Reduction is a gain of electrons.
- Define *oxidation* and *reduction* in terms of oxidation numbers:
  Oxidation: an increase in oxidation number
  Reduction: a decrease in oxidation number
- Define an *oxidising agent* and a *reducing agent* in terms of oxidation and reduction:
  Oxidising agent: a substance that is reduced/gains electrons.
  Reducing agent: a substance that is oxidised/loses electrons.
- Define an *anode* and a *cathode* in terms of oxidation and reduction:
  Anode: the electrode where oxidation takes place
  Cathode: the electrode where reduction takes place
- Define an *electrolyte* as a substance of which the aqueous solution contains ions OR a substance that dissolves in water to give a solution that conducts electricity.

Relation of current and potential difference to rate and equilibrium

- State that the potential difference of a galvanic cell (V_{cell}) is related to the extent to which the spontaneous cell reaction has reached equilibrium.
- State and use the qualitative relationship between V_{cell} and the concentration of product ions and reactant ions for the spontaneous reaction, namely V_{cell} decreases as the concentration of product ions increases and the concentration of reactant ions decreases until equilibrium is reached at which the $V_{cell} = 0$ (the cell is 'flat'). (Qualitative only. Nernst equation is NOT required.)

Understanding of the processes and redox reactions taking place in galvanic cells

- Describe the movement of ions in the solutions.
- State the direction of electron flow in the external circuit.
- Write down the half-reactions that occur at the electrodes.
- State the function of the salt bridge.
- Use cell notation or diagrams to represent a galvanic cell.
  When writing cell notation, the following convention should be used:
  - The $H_2|H^+$ half-cell is treated just like any other half-cell.
  - Cell terminals (electrodes) are written on the outside of the cell notation.
  - Active electrodes:
    reducing agent | oxidised species || oxidising agent | reduced species
  - Inert electrodes (usually Pt or C):
    Pt | reducing agent | oxidised species || oxidising agent | reduced species | Pt
    Example: Pt | $C\ell^-$(aq) |$C\ell_2$(g) || F_2(g) | F^-(aq) | Pt
- Predict the half-cell in which oxidation will take place when two half-cells are connected.

- Predict the half-cell in which reduction will take place when connected to another half-cell.
- Write down the overall cell reaction by combining two half-reactions.
- Use the Table of Standard Reduction Potentials to calculate the emf of a standard galvanic cell.
- Use a positive value of the standard emf as an indication that the reaction is spontaneous under standard conditions.

Standard electrode potentials

- Write down the standard conditions under which standard electrode potentials are determined.
- Describe the standard hydrogen electrode and explain its role as the reference electrode.
- Explain how standard electrode potentials can be determined using the reference electrode and state the convention regarding positive and negative values.

Electrolytic cells

- Define the *electrolytic cell* as a cell in which electrical energy is converted into chemical energy
- Electrolysis: The chemical process in which electrical energy is converted to chemical energy OR the use of electrical energy to produce a chemical change

Understanding the processes and redox reactions taking place in electrolytic cells

- Describe the movement of ions in the solution.
- State the direction of electron flow in the external circuit.
- Write equations for the half-reactions taking place at the anode and cathode.
- Write down the overall cell reaction by combining two half-reactions.
- Describe, using half-reactions and the equation for the overall cell reaction as well as the layout of the particular cell using a schematic diagram, the following electrolytic processes:
  - The decomposition of copper(II) chloride
  - Electroplating, e.g. the electroplating of an iron spoon with silver/nickel
  - Refining of metals, e.g. copper
  - The electrolysis of a concentrated solution of sodium chloride

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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 unit 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
work function	W_0		joule	J
power	P		watt	W
momentum	p		kilogram metre per second	$kg\cdot m\cdot s^{-1}$
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)	
torque	τ		newton metre	$N\cdot m$
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)	
focal length	f		metre	m
object distance	s	u	metre	m
image distance	s'	v	metre	m
magnification	m		(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	ΔV, V		volt	V
emf	**E**	ε	volt	V
current	I, i		ampere	A
resistance	R		ohm	Ω
internal 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, e.g. $m \cdot s^{-1}$. For marking purposes, $m.s^{-1}$ will also be accepted.
3. Use the equal sign only when it is mathematically correct, e.g.

Incorrect:	1 cm = 1 m	(on a scale drawing)
Correct:	1 cm = 10^{-2} m	1 cm represents 1 m (on a scale drawing)

4.2 Information sheets – Paper 1 (Physics)

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	$9{,}8\ m\cdot s^{-2}$
Universal gravitational constant	G	$6{,}67 \times 10^{-11}\ N\cdot m^2\cdot kg^{-2}$
Speed of light in a vacuum	c	$3{,}0 \times 10^{8}\ m\cdot s^{-1}$
Planck's constant	h	$6{,}63 \times 10^{-34}\ J\cdot s$
Coulomb's constant	k	$9{,}0 \times 10^{9}\ N\cdot m^2\cdot C^{-2}$
Charge on electron	e	$-1{,}6 \times 10^{-19}\ C$
Electron mass	m_e	$9{,}11 \times 10^{-31}\ kg$
Mass of the Earth	M	$5{,}98 \times 10^{24}\ kg$
Radius of the Earth	R_E	$6{,}38 \times 10^{6}\ m$

TABLE 2: FORMULAE

MOTION

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

FORCE

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = \frac{Gm_1m_2}{d^2}$ OR $F = \frac{Gm_1m_2}{r^2}$	$g = \frac{GM}{d^2}$ OR $g = \frac{GM}{r^2}$

WORK, ENERGY AND POWER

$W = F\Delta x\cos\theta$	$U = mgh$ OR $E_P = mgh$
$K = \frac{1}{2}mv^2$ OR $E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta K$ OR $W_{net} = \Delta E_k$ $\Delta K = K_f - K_i$ OR $\Delta E_k = E_{kf} - E_{ki}$
$W_{nc} = \Delta K + \Delta U$ OR $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$	

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WAVES, SOUND AND LIGHT

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$	$E = hf$ OR $E = h\frac{c}{\lambda}$
$E = W_o + E_{k(max)}$ OR $E = W_o + K_{max}$ where $E = hf$ and $W_0 = hf_0$ and $E_{k(max)} = \frac{1}{2}mv^2_{max}$ OR $K_{max} = \frac{1}{2}mv^2_{max}$	

ELECTROSTATICS

$F = \frac{kQ_1Q_2}{r^2}$	$E = \frac{kQ}{r^2}$
$V = \frac{W}{q}$	$E = \frac{F}{q}$
$n = \frac{Q}{e}$ OR $n = \frac{Q}{q_e}$	

ELECTRIC CIRCUITS

$R = \frac{V}{I}$	emf (ε) = I(R + r)
$R_s = R_1 + R_2 + ...$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + ...$	$q = I\,\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2\Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$

ALTERNATING CURRENT

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}}$	$P_{ave} = V_{rms}I_{rms}$ $P_{ave} = I^2_{rms}R$ $P_{ave} = \frac{V^2_{rms}}{R}$

4.3 Information Sheets – Paper 2 (Chemistry)

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Standard pressure	p^θ	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP	V_m	$22{,}4\ dm^3\cdot mol^{-1}$
Standard temperature	T^θ	273 K
Charge on electron	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at 298 K	
$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ OR $E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ OR $E^\theta_{cell} = E^\theta_{oxidising agent} - E^\theta_{reducing agent}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

KEY

Atomic number: 29
Electronegativity: 1,9
Symbol: Cu
Approximate relative atomic mass: 63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

TABLE 4A: STANDARD REDUCTION POTENTIALS

Increasing strength of oxidising agents

Increasing strength of reducing agents

Half-reactions			E^θ (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
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 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
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 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
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**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
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	– 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

TABLE 4B: STANDARD REDUCTION POTENTIALS

Increasing strength of oxidising agents

Half-reactions			E^θ (V)
$Li^+ + e^-$	⇌	Li	− 3,05
$K^+ + e^-$	⇌	K	− 2,93
$Cs^+ + e^-$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

Increasing strength of reducing agents

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 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 where a series of calculations do not necessarily always have to follow the same order (as in circuit calculations) full marks will be awarded provided that it is a valid solution to the problem.
5.1.12 Any calculation that will not bring the candidate closer to the answer than the original solution, 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. $m{\cdot}s^{-1}$. For marking purposes, $m.s^{-1}$ 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:

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

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
$n=\frac{m}{M}$ ✓ $0{,}01$ ✓ $=\frac{m}{52}$ ✓ $m = 0{,}52$ g ✓ (4)	$n=\frac{m}{M}$ ✓ $0{,}01$ ✓ $=\frac{52}{m}$ ✗ $m = 5\ 200$ g ✗ (2)	$m=\frac{n}{M}$ ✗ $=\frac{0{,}01}{52}$ $= 0{,}002$ g (0)	$n=\frac{m}{M}$ ✓ $m=\frac{M}{n}$ ✗ $=\frac{52}{0{,}01}$ ✓ $= 5\ 200$ g ✗ (3)	$n=\frac{m}{M}$ ✓ $= 0{,}52$ g ✓ (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, e.g. $mol{\cdot}dm^{-3}$. Accept $mol.dm^{-3}$ (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

$H_2S \rightarrow S + 2H^+ + 2e^-$ $\quad (2/2)$

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

$H_2S \rightleftharpoons S + 2H^+ + 2e^-$ $\quad (1/2)$

$H_2S \leftarrow S + 2H^+ + 2e^-$ $\quad (0/2)$

$S + 2H^+ + 2e^- \leftarrow H_2S$ $\quad (2/2)$

$S + 2H^+ + 2e^- \rightleftharpoons H_2S$ $\quad (0/2)$

6.3.4 When candidates are required to give an explanation involving the relative strength of oxidising and reducing agents, do not accept the following:
- 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^{θ}_{cell}), 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 must be deducted if hydrogen atoms are omitted.

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

6.3.9 When a IUPAC name is asked and the candidate omits the hyphen (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:

$N_2 + 3H_2$ ✓→ $2NH_3$ ✓	bal. ✓	$^3/_3$
$N_2 + H_2$ →✓		$^1/_3$
→ NH_3 ✓		$^1/_3$
$N_2 + H_2$		$^0/_3$
NH_3		$^0/_3$

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 e.g. 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 teachers should teach to.

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

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2018

MARKS: 150

TIME: 3 hours

This question paper consists of 15 pages and 4 data sheets.

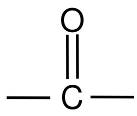
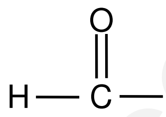
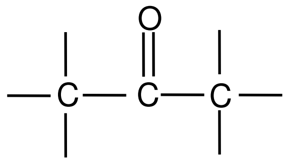
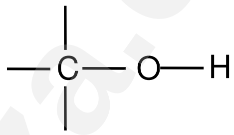
INSTRUCTIONS AND INFORMATION

1. Write your examination number and centre number in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of TEN questions. Answer ALL the questions in the ANSWER BOOK.
3. Start EACH question on a NEW page in the ANSWER BOOK.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. Show ALL formulae and substitutions in ALL calculations.
9. Round off your FINAL numerical answers to a minimum of TWO decimal places.
10. Give brief motivations, discussions, etc. where required.
11. You are advised to use the attached DATA SHEETS.
12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 D.

1.1 Which ONE of the following is the structural formula of the functional group of the KETONES?

A		**B**	
C		**D**	

(2)

1.2 Which ONE of the formulae below represents an ALKANE?

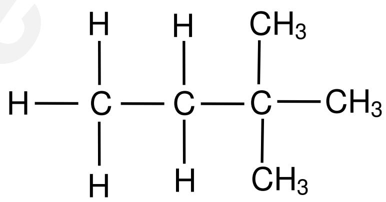
A C_2H_4

B C_5H_{10}

C $C_{14}H_{30}$

D C_8H_{14} (2)

1.3 Consider the organic compound below.



The IUPAC name of this compound is …

A 2,3-dimethyl butane.

B 3,3-dimethyl butane.

C 2,2-dimethyl butane.

D 1,1,1-trimethyl propane. (2)

1.4 Activation energy can best be described as the minimum energy required to …

A cause effective collisions.

B make reactant molecules collide.

C change the orientation of reactant molecules.

D increase the kinetic energy of reactant molecules. (2)

1.5 Which statement is CORRECT for a system in DYNAMIC EQUILIBRIUM?

A All reactants are used up.

B The forward reaction is equal to the reverse reaction.

C All substances in the reaction are of equal concentration.

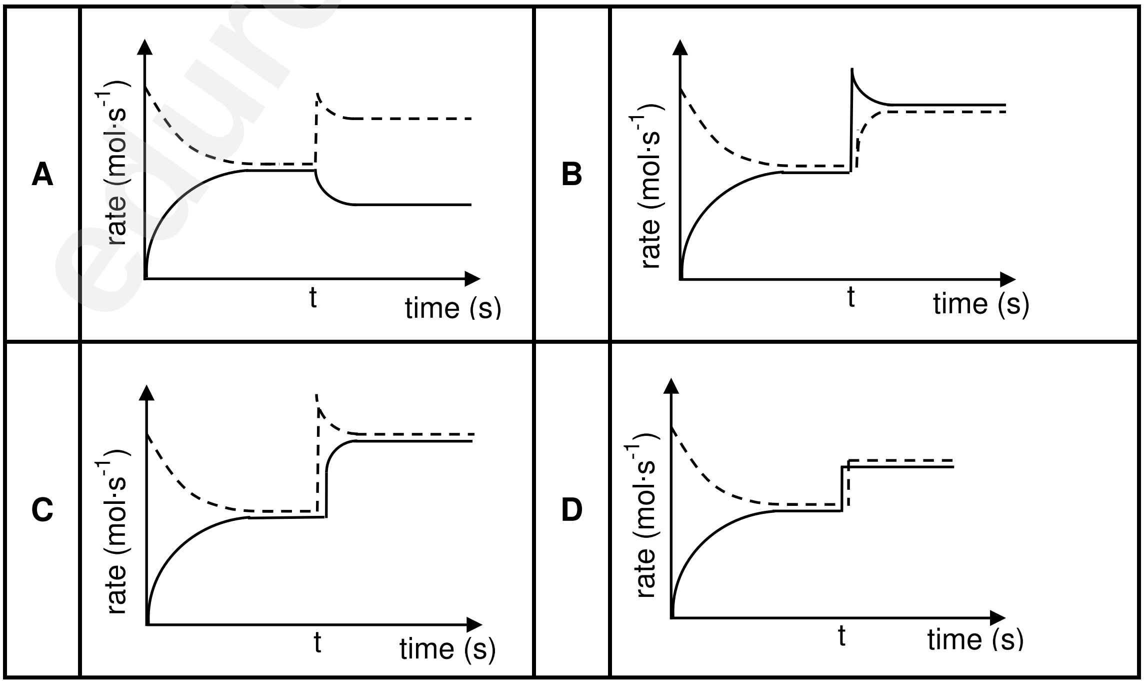
D The concentration of the reactants and products remain constant. (2)

1.6 Initially, a certain amount of P(g) was placed in an empty container. The hypothetical reaction reaches equilibrium in a closed container according to the following balanced equation:

$$P(g) \rightleftharpoons 2Q(g) \qquad \Delta H < 0$$

At time t, the temperature is increased.

Which graph below best illustrates the resulting changes in the rates of the forward and reverse reactions after the temperature is increased?



(2)

1.7 Reactions **I** and **II** below have equilibrium constants (K_c) greater than 1.

I: $H_3X + HCO_3^- \rightleftharpoons H_2X^- + H_2CO_3$ $K_c > 1$

II: $H_3O^+ + H_2X^- \rightleftharpoons H_2O + H_3X$ $K_c > 1$

Based on the reactions above, the ACIDS in order of INCREASING STRENGTH (weakest to strongest) are …

A H_3X, H_2X^-, H_3O^+

B H_2CO_3, H_3X, H_3O^+

C H_3X, H_2CO_3, H_3O^+

D H_3X, H_3O^+, H_2CO_3 (2)

1.8 Consider the cell notation for a galvanic cell below.

$$Ni(s) \mid Ni^{2+}(aq) \parallel H^+(aq) \mid H_2(g) \mid Pt(s)$$

Which ONE of the following half-reactions takes place at the ANODE of this cell?

A $2H^+(aq) + 2e^- \rightarrow H_2(g)$

B $H_2(g) \rightarrow 2H^+(aq) + 2e^-$

C $Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$

D $Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$ (2)

1.9 Which ONE of the following is applicable to an ELECTROLYTIC CELL?

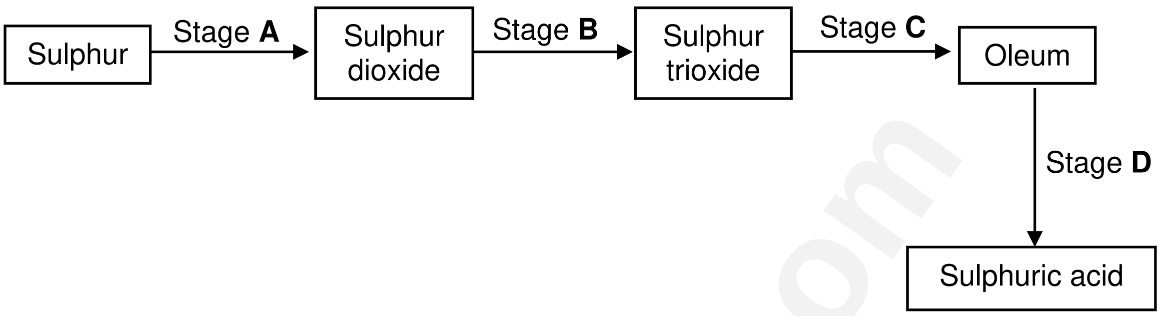
A Reduction takes place at the anode.

B Oxidation takes place at the cathode.

C It uses alternating current.

D A battery is used for the cell to function. (2)

1.10 The flow diagram below shows four stages (**A**, **B**, **C** and **D**) in the conversion of sulphur to sulphuric acid.



At which stage is a catalyst used?

A **A**

B **B**

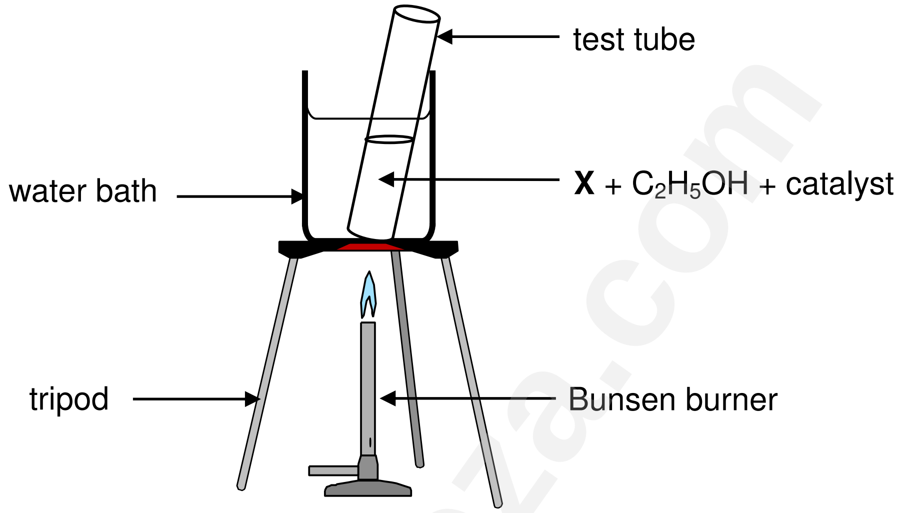
C **C**

D **D** (2)

[20]

QUESTION 2 (Start on a new page.)

A test tube containing a straight chain organic acid **X**, ethanol and a catalyst is heated in a water bath, as illustrated below.



Organic compound **Y** is produced according to the following equation:

$$X + C_2H_5OH \rightarrow Y + H_2O$$

2.1 Give a reason why the test tube is heated in a water bath instead of directly over the flame. (1)

2.2 Write down the:

2.2.1 Type of reaction that takes place here (1)

2.2.2 FORMULA of the catalyst needed (1)

2.2.3 Homologous series to which compound **Y** belongs (1)

The molecular mass of compound **Y** is 144 $g \cdot mol^{-1}$ and its empirical formula is C_4H_8O.

2.3 Determine the molecular formula of compound **Y**. (2)

2.4 Write down the IUPAC name of compound **Y**. (2)

2.5 Write down the structural formula of the organic acid **X**. (2)
[10]

QUESTION 3 (Start on a new page.)

The boiling points of different organic compounds are given below.

COMPOUND		BOILING POINT (°C)
A	HCOOH	101
B	CH_3COOH	118
C	CH_3CH_2COOH	141
D	$CH_3CH_2CH_2COOH$	164

3.1 Define *boiling point*. (2)

3.2 Write down the:

3.2.1 Name of the FUNCTIONAL GROUP of these compounds (1)

3.2.2 IUPAC name of compound **C** (1)

3.2.3 Structural formula of the FUNCTIONAL isomer of compound **B** (2)

3.3 Which ONE of the compounds, **A** or **B** or **C**, has the highest vapour pressure? Refer to the data in the table to give a reason for the answer. (2)

3.4 The boiling point of compound **B** is now compared with of compound **X**.

COMPOUND		BOILING POINT (°C)
B	CH_3COOH	118
X	$CH_3CH_2CH_2OH$	98

3.4.1 Besides the conditions used to determine boiling points, give a reason why this is a fair comparison. (1)

3.4.2 Is compound **X** a PRIMARY, SECONDARY or TERTIARY alcohol? Give a reason for the answer. (2)

3.4.3 Fully explain the difference between the boiling points by referring to the types of intermolecular forces present in each of these compounds. (4)

[15]

QUESTION 4 (Start on a new page.)

4.1 Three reactions of organic compounds from the same homologous series are shown below.

I:	Butane + Br_2 $\longrightarrow$ 2-bromobutane + **P**
II:	Pentane + excess oxygen $\xrightarrow{\text{heat}}$
III:	Hexane $\longrightarrow$ C_2H_4 + **Q**

4.1.1 Define a *homologous series*. (2)

4.1.2 Name the type of reaction represented by **I**. (1)

4.1.3 Write down the formula of the inorganic compound **P**. (1)

4.1.4 Give the structural formula of a POSITIONAL isomer of 2-bromobutane. (2)

4.1.5 Using molecular formulae, write down the balanced equation for reaction **II**. (3)

Reaction **III** is an example of a cracking reaction.

4.1.6 Define a *cracking reaction*. (2)

4.1.7 Give the structural formula of organic compound **Q**. (2)

4.2 Study the flow diagram below.

2-bromobutane $\xrightarrow{\text{Hydrolysis}}$ Compound **R** $\longrightarrow$ Alkene

4.2.1 Write down the IUPAC name of compound **R**. (2)

4.2.2 Compound **R** reacts in the presence of concentrated phosphoric acid to form an alkene.

Write down the structural formula of the MAJOR PRODUCT in this reaction. (2)
[17]

QUESTION 5 (Start on a new page.)

The reaction of zinc and EXCESS dilute hydrochloric acid is used to investigate factors that affect reaction rate. The balanced equation for the reaction is:

$$Zn(s) + 2HC\ell(aq) \longrightarrow ZnC\ell_2(aq) + H_2(g)$$

The reaction conditions used and the results obtained for each experiment are summarised in the table below.

The same mass of zinc is used in all the experiments. The zinc is completely covered in all reactions. The reaction time is the time it takes the reaction to be completed.

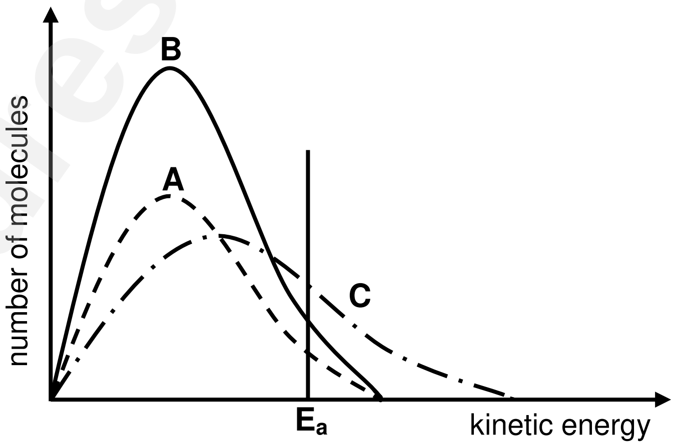
EXPERIMENT	CONCENTRATION OF HCℓ (mol·dm^{-3})	VOLUME OF HCℓ (cm^3)	STATE OF DIVISION OF Zn	TEMPERATURE OF HCℓ (°C)	REACTION TIME (min.)
1	2,0	200	powder	25	7
2	1,5	200	granules	25	14
3	5,0	200	powder	25	5
4	1,5	400	granules	25	**x**
5	2,0	200	powder	35	4

5.1 Experiment **1** and experiment **5** are compared. Write down the independent variable. (1)

5.2 Define *reaction rate*. (2)

5.3 Write down the value of **x** in experiment **4**. (2)

5.4 The Maxwell-Boltzmann energy distribution curves for particles in each of experiments **1**, **3** and **5** are shown below.



Identify the graph (**A** or **B** or **C**) that represents the following:

5.4.1 Experiment **3**
Give a reason for the answer. (2)

5.4.2 Experiment **5**
Give a reason for the answer. (2)

5.5 Experiment **6** is now conducted using a catalyst and the SAME reaction conditions as for Experiment **1**.

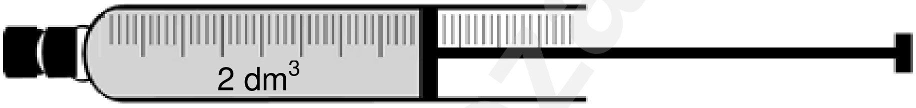
5.5.1 What is the function of the catalyst in this experiment? (1)

5.5.2 How will the heat of reaction in experiment **6** compare to that in experiment **1**? Choose from: GREATER THAN, EQUAL TO or LESS THAN. (1)

5.6 Calculate the average rate of the reaction (in $mol \cdot min^{-1}$) with respect to zinc for experiment **2** if 1,5 g of zinc is used. (4)
[15]

QUESTION 6 (Start on a new page.)

Dinitrogen tetraoxide, $N_2O_4(g)$, decomposes to nitrogen dioxide, $NO_2(g)$, in a sealed syringe of volume 2 dm^3.



The mixture reaches equilibrium at 325 °C according to the following balanced equation:

$$\underset{\text{colourless}}{N_2O_4(g)} \rightleftharpoons \underset{\text{brown}}{2NO_2(g)}$$

When equilibrium is reached, it is observed that the colour of the gas in the syringe is brown.

6.1 State Le Chatelier's principle. (2)

6.2 The syringe is now dipped into a beaker of ice water. After a while the brown colour disappears.

Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Explain the answer using Le Chatelier's principle. (3)

6.3 The volume of the syringe is now decreased while the temperature is kept constant.

How will EACH of the following be affected? Choose from: INCREASES, DECREASES or REMAINS THE SAME.

6.3.1 The number of moles of $N_2O_4(g)$ (1)

6.3.2 The value of the equilibrium constant (1)

6.3.3 The rate of the forward and reverse reactions (1)

6.4 Initially **X** moles of $N_2O_4(g)$ were placed in the syringe of volume 2 dm^3. When equilibrium was reached, it was found that 20% of the $N_2O_4(g)$ had decomposed.

If the equilibrium constant, K_c, for the reaction is 0,16 at 325 °C, calculate the value of **X**. (8)
[16]

QUESTION 7 (Start on a new page.)

7.1 Sulphuric acid is a strong acid present in acid rain. It ionises in two steps as follows:

I:	$H_2SO_4(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + HSO_4^-(aq)$
II:	$HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + SO_4^{2-}(aq)$

7.1.1 Define an *acid* in terms of the Lowry-Brønsted theory. (2)

7.1.2 Write down the FORMULA of the conjugate base of $H_3O^+(aq)$. (1)

7.1.3 Write down the FORMULA of the substance that acts as an ampholyte in the ionisation of sulphuric acid. (2)

7.2 Acid rain does not cause damage to lakes that have rocks containing limestone ($CaCO_3$). Hydrolysis of $CaCO_3$ results in the formation of ions, which neutralise the acid.

7.2.1 Define *hydrolysis* of a salt. (2)

7.2.2 Explain, with the aid of the relevant HYDROLYSIS reaction, how limestone can neutralise the acid. (3)

7.3 The water in a certain lake has a pH of 5.

7.3.1 Calculate the concentration of the hydronium ions in the water. (3)

The volume of water in the lake is 4×10^9 dm^3. Lime, CaO, is added to the water to neutralise the acid according to the following reaction:

$$CaO + 2H_3O^+ \rightleftharpoons Ca^{2+} + 3H_2O$$

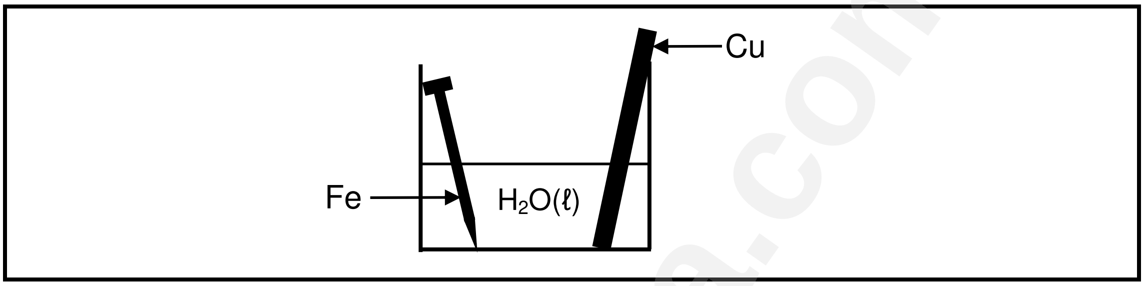
7.3.2 If the final amount of hydronium ions is $1{,}26 \times 10^3$ moles, calculate the mass of lime that was added to the lake. (7)
[20]

QUESTION 8 (Start on a new page.)

8.1 Corrosion is a redox reaction that takes place in the presence of oxygen and water. Rusting is the corrosion of iron leading to the formation of iron(III) ions.

8.1.1 Define *oxidation* in terms of electron transfer. (2)

A cleaned copper rod and a cleaned iron nail are placed in a beaker containing water at 25°C, as shown below.



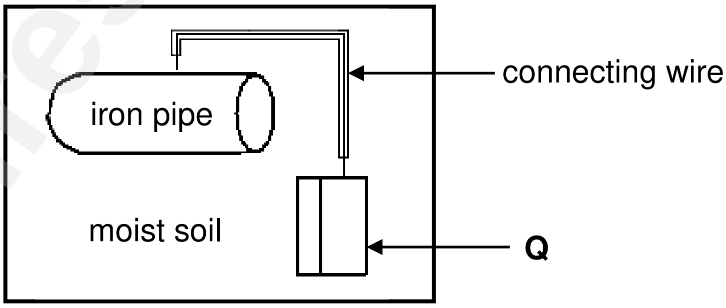
After a while it was observed that the iron nail was coated with rust. The copper rod showed no visible signs of corrosion.

8.1.2 Write down the half-reaction for the iron nail. (2)

8.1.3 Does iron act as REDUCING AGENT or OXIDISING AGENT in the beaker? (1)

8.1.4 Explain the above observation by referring to the Table of Standard Reduction Potentials. (3)

To prevent rusting of an underground iron pipe, the pipe is connected to a metal (**Q**) that corrodes easily.



8.1.5 You are given two metals, Zn and Cu, to use as metal **Q**. Which metal would more suitable? Give a reason. (2)

8.2 A galvanic cell is constructed using a Fe | Fe^{3+} half-cell and a Cu | Cu^{2+} half-cell.

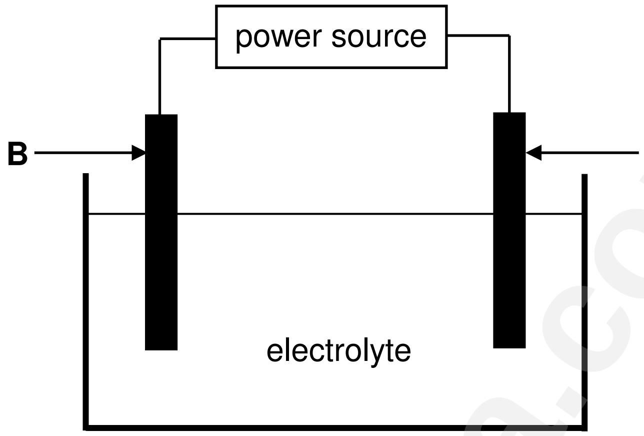
8.2.1 Write down the overall (net) cell reaction that takes place when the cell is functioning. (3)

8.2.2 Calculate the cell potential of this cell under standard conditions. (4)

[17]

QUESTION 9 (Start on a new page.)

The electrolytic cell below is set up to obtain pure copper from a piece of impure copper.



The impure copper contains other metals, such as platinum, iron, cobalt, silver and nickel.

The cell potential of the power source is adjusted so that only copper is deposited on electrode **B**.

9.1 Define an *electrolytic cell*. (2)

9.2 Write down the FORMULA of a suitable electrolyte for this cell. (1)

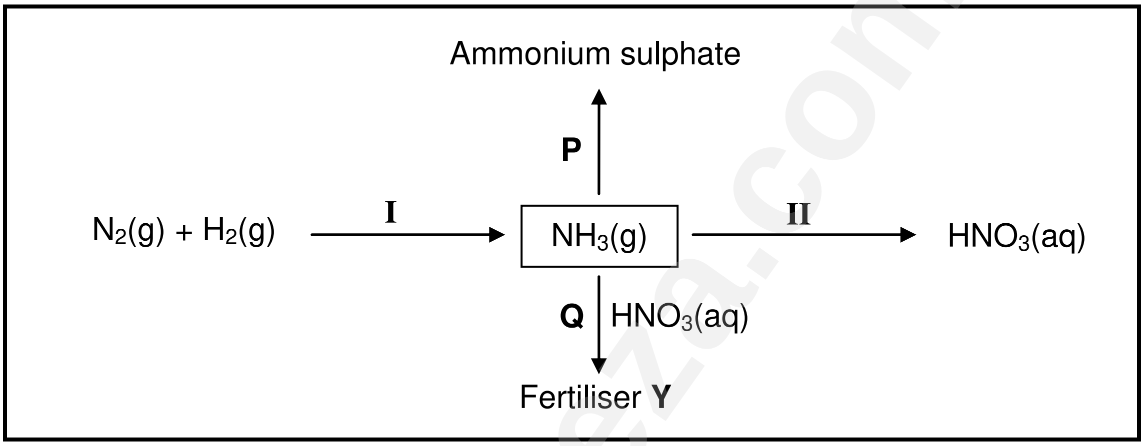
9.3 Which electrode (**A** or **B**) is the cathode?
Write down the relevant half-reaction taking place at this electrode. (3)

9.4 Sludge forms below one of the electrodes while the cell above is in operation. Which of the metals, PLATINUM, IRON, COBALT, SILVER or NICKEL, will be present in the sludge? (2)
[8]

QUESTION 10 (Start on a new page.)

In the flow diagram below, **I** and **II** represent industrial processes used in the fertiliser industry.

P and **Q** are chemical reactions that take place to produce ammonium sulphate and fertiliser **Y** respectively.



10.1 Write down the name of the industrial process:

10.1.1 **I** (1)

10.1.2 **II** (1)

10.2 Write down the NAME or FORMULA of:

10.2.1 Fertiliser **Y** (1)

10.2.2 The catalyst used in process **I** (1)

10.3 In reaction **P**, $NH_3(g)$ reacts with another substance. Write down a balanced equation for this reaction. (3)

10.4 The following substances are present in a bag of fertiliser:

- 20 kg ammonium nitrate (NH_4NO_3)
- 12 kg sodium phosphate (Na_3PO_4)
- 18 kg potassium chloride ($KC\ell$)

Calculate the NPK ratio of the fertiliser. (5)
[12]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1,013 \times 10^5$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22,4\ dm^3 \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1,6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6,02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising agent} - E^{\theta}_{reducing agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Atomic number / *Atoomgetal*	29
Electronegativity / *Elektronegatiwiteit*	1,9
Symbol / *Simbool*	Cu
Approximate relative atomic mass / *Benaderde relatiewe atoommassa*	63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Half-reactions/*Halfreaksies*			E^θ (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
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 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
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 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
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	− 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: STANDAARD-REDUKSIEPOTENSIALE

Increasing oxidising ability/*Toenemende oksiderende vermoë*

Increasing reducing ability/*Toenemende reduserende vermoë*

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	⇌	Li	− 3,05
$K^+ + e^-$	⇌	K	− 2,93
$Cs^+ + e^-$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE
NASIONALE SENIOR SERTIFIKAAT

GRADE/*GRAAD* 12

PHYSICAL SCIENCES: CHEMISTRY (P2)
FISIESE WETENSKAPPE: CHEMIE (V2)

NOVEMBER 2018

MARKING GUIDELINE/*NASIENRIGLYN*

MARKS/*PUNTE*: 150

These marking guidelines consist of 18 pages.
Hierdie nasienriglyne bestaan uit 18 bladsye.

QUESTION 1/*VRAAG 1*

1.1	C ✓✓	(2)
1.2	C ✓✓	(2)
1.3	C ✓✓	(2)
1.4	A ✓✓	(2)
1.5	D ✓✓	(2)
1.6	B ✓✓	(2)
1.7	B ✓✓	(2)
1.8	D ✓✓	(2)
1.9	D ✓✓	(2)
1.10	B ✓✓	(2)
		[20]

QUESTION 2/*VRAAG 2*

2.1 **ANY ONE/*ENIGE EEN*:**

- (Alcohol/ethanol) is flammable/catches fire easily. ✓
  (Alkohol/etanol) is vlambaar/slaan maklik aan die brand.
- To heat it evenly./*Om dit eweredig te verhit.*
- Water bath is used for low heat/low temperature./*Waterbad word gebruik vir lae hitte/lae temperatuur.*
- Alcohol/ethanol will evaporate too quickly./*(Alkohol/etanol) sal te vinnig verdamp.*

Accept/*Aanvaar*:
(Alcohol/ethanol) is volatile./*(Alkohol/etanol) is vlugtig.* (1)

2.2

2.2.1 Esterification/condensation ✓
Verestering/esterifikasie/kondensasie (1)

2.2.2 H_2SO_4 ✓ (1)

2.2.3 Esters ✓ (1)

2.3 $\frac{M(\text{ester})}{M(C_4H_8O)} = \frac{144}{72✓} = 2$

$\therefore$ 2 x $C_4H_8O = C_8H_{16}O_2$ ✓

Marking guidelines/*Nasienriglyne*
- If only answer given, award 2 marks on final answer./*Indien slegs antwoord gegee, ken 2 punte toe vir finale antwoord.*
- If 72 g·mol^{-1} calculated without substituting, no mark is awarded./*Indien 72 g·mol^{-1} bereken is sonder om te vervang word geen punt toegeken nie.*

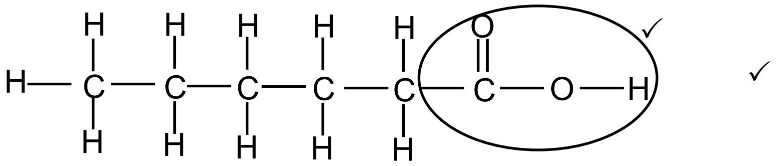
(2)

2.4 Ethyl ✓ hexanoate ✓
Etielheksanoaat

Note/*Aantekening*
Accept any other ethyl ESTER from QUESTION 2.3.
Aanvaar enige ander etiel ESTER vanaf VRAAG 2.3.

(2)

2.5 **POSITIVE MARKING FROM QUESTION 2.4.**
POSITIEWE NASIEN VANAF VRAAG 2.4.



Marking criteria/*Nasienriglyne*
• Whole structure correct/*Hele struktuur korrek:* $\frac{2}{2}$
• Only functional group correct/*Slegs funksionele groep korrek:* Max/*Maks.*: $\frac{1}{2}$
• Accept/*Aanvaar* -OH as condensed/*gekondenseerd.*
IF/*INDIEN*
• More than one functional group/wrong functional group/*Meer as een funksionele groep/foutiewe funksionele groep:* $\frac{0}{2}$
• If condensed structural formulae used/*Indien gekondenseerde struktuur-formules gebruik:* Max/*Maks.*: $\frac{1}{2}$

(2)
[10]

QUESTION 3/*VRAAG 3*

3.1

Marking guidelines/*Nasienriglyne*
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

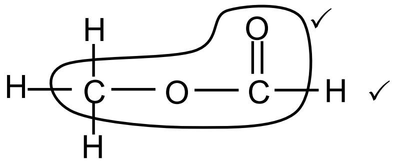
The temperature at which the vapour pressure of a substance equals atmospheric/external pressure.
Die temperatuur waar die dampdruk van 'n stof gelyk is aan atmosferiese/ eksterne druk. (2)

3.2
3.2.1 Carboxyl (group)/*karboksiel(groep)* ✓

Accept/*Aanvaar*
Carboxylic/*Karboksiel* (1)

3.2.2 Propanoic acid/*propanoësuur* ✓ (1)

3.2.3



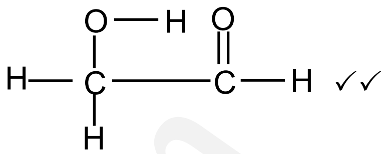
Marking criteria/*Nasienriglyne*

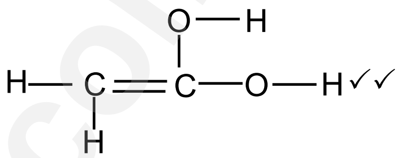
- Whole structure correct:
  Hele struktuur korrek: $^2/_2$
- Only functional group correct:
  Slegs funksionele groep korrek: Max/*Maks*: $^1/_2$

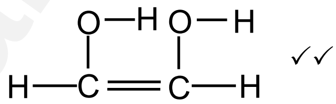
IF/*INDIEN*

- More than one functional group/wrong functional group/*Meer as een funksionele groep/foutiewe funksionele groep:* $^0/_2$
- If condensed structural formulae used/*Indien gekondenseerde struktuur-formules gebruik:* Max/*Maks*: $^1/_2$

ACCEPT/*AANVAAR*
(2 or/*of* 0)







(2)

3.3 A ✓
Lowest boiling point./Shortest chain length. ✓
Laagste kookpunt./Kortste kettinglengte. (2)

3.4

3.4.1 The same molecular mass/molecular size. ✓
Dieselfde molekulêre massa/molekulêre grootte. (1)

3.4.2 Primary/*Primêre* ✓
-OH group is bonded to a C atom bonded to one other C atom. ✓
-OH-groep is gebind aan 'n C-atoom wat aan een ander C-atoom gebind is.
OR/*OF*
-OH group is bonded to a C atom that has two H atoms.
-OH-groep is gebind aan 'n C-atoom wat twee H-atome bevat. (2)

3.4.3

Marking guidelines/Nasienriglyne

- BOTH have hydrogen bonding./*BEIDE het waterstofbindings.* ✓
- Compare number of sites for hydrogen bonding./*Vergelyk aantal punte vir waterstofbinding.* ✓
- Compare strength of IMFs./*Vergelyk sterkte van IMKe.* ✓
- Compare energy required./*Vergelyk energie benodig.* ✓

- Both compounds/**X** and **B** have (in addition to London forces and dipole-dipole forces) hydrogen bonding./*Beide verbindings/**X** en **B** het waterstofbindings (behalwe Londonkragte en dipool-dipoolkragte).* ✓
- Compound **X**/$CH_3CH_2CH_2OH$/propan-1-ol/alcohol has one site for hydrogen bonding and compound **B**/ethanoic acid/carboxylic acid has two/more sites for hydrogen bonding **OR** **B**/ethanoic acid/carboxylic acid has two/more sites for hydrogen bonding. ✓
  Verbinding **X**/$CH_3CH_2CH_2OH$/propan-1-ol/alkohol *het een punt vir waterstofbindings en verbinding **B**/etanoësuu/karboksielsuur het twee/meer punte vir waterstofbindings **OF** **B**/etanoësuu/karboksielsuur het twee/meer punte vir waterstofbindings.*
- Intermolecular forces in compound **B**/ethanoic acid/carboxylic acid are stronger than intermolecular forces in compound **X**/$CH_3CH_2CH_2OH$/propan-1-ol/alcohol. ✓
  *Intermolekulêre kragte in verbinding **B**/etanoësuur/karboksielsuur is sterker as die intermolekulêre kragte in* verbinding **X**/$CH_3CH_2CH_2OH$/ *propan-1-ol/alkohol.*
  OR/*OF*
  Intermolecular forces in compound **X**/$CH_3CH_2CH_2OH$/ propan-1-ol/alcohol are weaker than intermolecular forces in compound **B**/ethanoic acid/*carboxylic acid./Intermolekulêre kragte in verbinding **X**/$CH_3CH_2CH_2OH$/propan-1-ol/alkohol is swakker as intermolekulêre kragte in verbinding **B**/etanoësuur/karboksielsuur.*
- More energy is needed to overcome/break intermolecular forces in compound **B**/ethanoic acid/carboxylic acid than in compound **X**/$CH_3CH_2CH_2OH$/ propan-1-ol/alcohol. ✓
  *Meer energie word benodig om intermolekulêre kragte in verbinding **B**/etanoësuur as in verbinding **X**/$CH_3CH_2CH_2OH$/ propan-1-ol/alkohol te oorkom/breek.*
  OR/*OF*
  Less energy is needed to overcome/break intermolecular forces in compound **X**/$CH_3CH_2CH_2OH$/propan-1-ol/alcohol than in compound **B**/ethanoic acid/*carboxylic acid*.
  *Minder energie word benodig om intermolekulêre kragte in verbinding **X**/ $CH_3CH_2CH_2OH$/propan-1-ol/alkohol te oorkom/breek as in verbinding **B**/etanoësuur/karboksielsuur.*

(4)
[15]

QUESTION 4/*VRAAG 4*

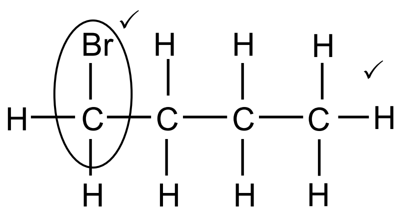
4.1

4.1.1 (A series of organic) compounds that can be described by the <u>same general formula/functional group</u>. ✓✓ **(2 or 0)**
('n Reeks organiese) verbindings wat deur <u>dieselfde algemene formule/ funksionele groep</u> beskryf kan word. ***(2 of 0)***
OR/*OF*
(A series of organic) compounds in which one member <u>differs from the next by a CH_2 group</u>./*('n Reeks organiese) verbindings waarin een lid van die volgende <u>verskil met 'n CH_2-groep</u>.* **(2 or/*of* 0)** (2)

4.1.2 Substitution/halogenation/bromination ✓
Substitusie/halogenasie/halogenering/brominasie/brominering (1)

4.1.3 HBr ✓ (1)

4.1.4



<u>Marking criteria/*Nasienriglyne*</u>
- Br on first C atom/*Br op eerste C-atoom:* Max/*Maks:* $\frac{1}{2}$
- Whole structure correct/*Hele struktuur korrek:* $\frac{2}{2}$

IF/INDIEN:
Br_2 but rest of structure correct/Br_2 maar res van struktuur korrek: $\frac{1}{2}$

(2)

4.1.5 C_5H_{12} + $8O_2$ ✓ → $5CO_2$ + $6H_2O$ ✓ Bal ✓

<u>Marking guidelines/*Nasienriglyne*</u>
- Reactants ✓ *Reaktanse* Products ✓ *Produkte* Balancing ✓ *Balansering*
- Ignore double arrows and phases./*Ignoreer dubbelpyle en fases.*
- Marking rule 6.3.10/*Nasienreël 6.3.10.*
- If condensed structural formulae used/*Indien gekondenseerde struktuur-formules gebruik:* Max/*Maks:* $\frac{2}{3}$

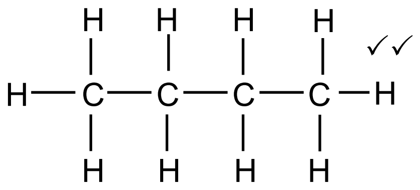
(3)

4.1.6

<u>Marking guidelines/*Nasienriglyne*</u>
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die* ***korrekte konteks*** *uitgelaat is, trek 1 punt af.*

The (chemical) process in which <u>longer chain hydrocarbons/longer chain alkanes</u> are <u>broken down to shorter/more useful hydrocarbons/molecules/ chains/alkanes and alkenes</u>.
Die (chemiese) proses waarin <u>langketting koolwaterstowwe/langketting-alkane afgebreek word in korter/meer bruikbare koolwaterstowwe/molekule/ kettings/alkane en alkene.</u> (2)

4.1.7



Marking guidelines/*Nasienriglyne*
- One or more H atoms omitted/*Een of meer H-atome uitgelaat:* Max/*Maks*: $\frac{1}{2}$
- Condensed or semi-structural formula: *Gekondenseerde of semi-struktuurformule:* Max/*Maks*: $\frac{1}{2}$

(2)

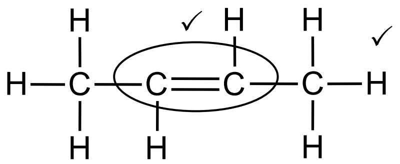
4.2

4.2.1 Butan-2-ol ✓✓ **OR/*OF*** 2-butanol ✓✓

IF/*INDIEN:*
Butanol or/*of* butan-1-ol $\frac{1}{2}$

(2)

4.2.2



Marking criteria/*Nasienriglyne*
- Only functional group correct/*Slegs funksionele groep korrek:* Max/Maks: $\frac{1}{2}$
- Whole structure correct: *Hele struktuur korrek:* $\frac{2}{2}$

(2)
[17]

QUESTION 5/*VRAAG 5*

5.1 Temperature/*Temperatuur* ✓ (1)

5.2

NOTE/*LET WEL*
Give the mark for per unit time only if in context of reaction rate.
Gee die punt vir per eenheidtyd slegs indien in konteks met reaksietempo.

ANY ONE/*ENIGE EEN*
- Change in concentration ✓ of products/reactants per (unit) time. ✓
  Verandering in konsentrasie van produkte/reaktanse per (eenheid) tyd.
- Change in amount/number of moles/volume/mass of products or reactants per (unit) time.
  Verandering in hoeveelheid/getal mol/volume/massa van produkte of reaktanse per (eenheid) tyd.
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time.
  Hoeveelheid/getal mol/volume/massa van produkte gevorm/reaktanse gebruik per (eenheid) tyd.
- Rate of change in concentration/amount/number of moles/volume/mass.
  Tempo van verandering in konsentrasie/ hoeveelheid/getal mol/ volume/massa. ✓✓ **(2 or/*of* 0)** (2)

5.3 14 (min) ✓✓ (2)

5.4

5.4.1 Graph/*grafiek* **B** ✓
(Experiment **3)** has the highest (acid) concentration/more particles/higher number of moles. ✓
(*Eksperiment* ***3)*** *het die hoogste (suur)konsentrasie/meer deeltjies/groter aantal mol.* (2)

5.4.2 (Graph/*grafiek*) **C** ✓
(Experiment 5) is at highest temperature/more particles with sufficient kinetic energy/HCℓ is at 35°C ✓
(*Eksperiment 5) is by die hoogste temperatuur/meer deeltjies met genoeg kinetiese energie/HCℓ is by 35°C.* (2)

5.5

5.5.1 Speeds up the reaction./Increases the reaction rate./Provides alternate pathway./Lowers the (net) activation energy. ✓
Versnel die reaksie./Verhoog die reaksietempo./Verskaf alternatiewe roete./Verlaag die (netto) aktiveringsenergie. (1)

5.5.2 Equal to/*Gelyk aan* ✓ (1)

5.6

$$n(Zn) = \frac{m}{M}$$
$$= \frac{1{,}5}{65}\checkmark$$
$$= 0{,}023 \text{ mol}$$
$$\text{rate/}\textit{tempo} = -\frac{\Delta n}{\Delta t}\checkmark$$
$$= -\left(\frac{0 - 0{,}023}{14\checkmark - 0}\right)$$
$$= 1{,}65 \times 10^{-3} \ (\text{mol}\cdot\text{min}^{-1})$$
✓

Marking guidelines/*Nasienriglyne*
- Substitute/*vervang* 65 g·mol^{-1} in $n = \frac{m}{M}$ ✓
- Substitute change in mol to calculate rate./*Vervang verandering in mol om tempo te bereken.* ✓
- Substitute change in time to calculate rate./*Vervang verandering in tyd om tempo te bereken.* ✓
- Final answer/*Finale antwoord*: $1{,}65 \times 10^{-3}$ mol·min^{-1} ✓
Range/*Gebied:*
$1{,}43 \times 10^{-3}$ to/*tot* $1{,}65 \times 10^{-3}$ (mol·min^{-1})

Notes/*Aantekeninge*
- Ignore if zeros omitted in calculation of reaction rate./*Ignoreer indien nulle uitgelaat in berekening van reaksietempo.*
- Accept negative answer i.e. $-1{,}65 \times 10^{-3}$ mol·min^{-1}/*Aanvaar negatiewe antwoord d.i. $-1{,}65 \times 10^{-3}$ mol·min^{-1}.* (4)

[15]

QUESTION 6/*VRAAG 6*

6.1 When the equilibrium in a closed system is disturbed, the system will re-instate a (new) equilibrium ✓ by favouring the reaction that will cancel/oppose the disturbance. ✓
Wanneer die ewewig in 'n geslote sisteem versteur word, sal die sisteem 'n (nuwe) ewewig instel deur die reaksie te bevoordeel wat die versteuring kanselleer/teenwerk. (2)

6.2 Endothermic/*Endotermies* ✓

- Decrease in temperature favours the exothermic reaction. ✓
  Afname in temperatuur bevoordeel die eksotermiese reaksie.
- The reverse reaction is favoured./*Die terugwaartse reaksie word bevoordeel.* ✓
  OR/*OF*
  Number of moles/amount/concentration of N_2O_4/colourless gas increases.
  Aantal mol/hoeveelheid/konsentrasie van N_2O_4/kleurlose gas neem toe.
  OR/*OF*
  Number of moles/amount of NO_2/brown gas decreases./*Aantal mol/ hoeveelheid NO_2 /bruin gas neem af.* (3)

6.3
6.3.1 Increases/*Verhoog* ✓ (1)

6.3.2 Remains the same/*Bly dieselfde* ✓ (1)

6.3.3 Increases/*Verhoog* ✓ (1)

6.4 **CALCULATIONS USING NUMBER OF MOLES**
BEREKENINGE WAT GETAL MOL GEBRUIK

Marking guidelines/*Nasienriglyne*

- $\Delta n(N_2O_4)$ = 20% of/*van* **x**/0,2**x**. ✓
- **USE** ratio/***GEBRUIK*** *verhouding:* $N_2O_4 : NO_2$: = 1 : 2. ✓
- $n(N_2O_4)_{eq/ewe} = n(N_2O_4)_{initial/begin} - \Delta n(N_2O_4)$.
  $n(NO_2)_{eq/ewe} = n(NO_2)_{initial/begin} + \Delta n(NO_2)$. ✓
- Divide equilibrium moles by 2 dm^3/*Deel ewewigsmol deur 2 dm³*. ✓
- Correct K_c expression (formulae in square brackets). ✓
  Korrekte K_c uitdrukking (formules in vierkanthakies).
- Substitution of K_c value/*Vervanging van K_c-waarde*. ✓
- Substitution of concentrations into correct K_c expression. ✓
  Vervanging van konsentrasies in korrekte K_c-uitdrukking.
- Final answer/*Finale antwoord*: 1,6 (mol) ✓

OPTION 1/*OPSIE 1*

	N_2O_4	NO_2	
Initial amount (moles) *Aanvangshoeveelheid (mol)*	**x**	0	
Change in amount (moles) *Verandering in hoeveelheid* (mol)	0,2**x** ✓	0,4**x**	ratio ✓ *verhouding*
Equilibrium amount (moles) *hoeveelheid* (mol)	0,8**x**	0,4**x**	✓
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	0,4**x**	0,2**x**	Divide by 2 dm^3 ✓

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} \checkmark$$

$$0,16 \checkmark = \frac{(0,2\mathbf{x})^2}{(0,4\mathbf{x})} \checkmark$$

$$\mathbf{x} = 1,6 \text{ (mol)} \checkmark$$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{7}{8}$

Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{5}{8}$

OPTION 2/*OPSIE 2*

$$\Delta n(N_2O_4) = \frac{20}{100}\mathbf{x} \checkmark = 0,2\mathbf{x}$$

$$\Delta n(NO_2) = 2\Delta n(N_2O_4) = 0,4\,\mathbf{x} \checkmark$$

$n(N_2O_4)_{eq/ewe} = \mathbf{x} - 0,2\mathbf{x} = 0,8\mathbf{x}$ **AND** $n(NO_2)_{eq/ewe} = 0 + 0,4\mathbf{x}$ ✓

$$\left.\begin{aligned} c(N_2O_4)_{eq/ewe} &= \frac{0,8\mathbf{x}}{2} = 0,4\mathbf{x} \\ c(NO_2)_{eq/ewe} &= \frac{0,4\mathbf{x}}{2} = 0,2\mathbf{x} \end{aligned}\right\} \checkmark$$

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} \checkmark$$

$$0,16 \checkmark = \frac{(0,2\mathbf{x})^2}{(0,4\mathbf{x})} \checkmark$$

$$\mathbf{x} = 1,6 \text{ (mol)} \checkmark$$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{7}{8}$

Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{5}{8}$

CALCULATIONS USING CONCENTRATION
BEREKENINGE WAT KONSENTRASIE GEBRUIK

Marking guidelines/*Nasienriglyne*

- Initial $n(N_2O_4)$/**x** divide by 2 dm^3. ✓
  *Aanvanklike $n(N_2O_4)$/**x** gedeel deur 2 dm^3.*
- $\Delta c(N_2O_4)$ = 20% of initial concentration/0,1x. ✓
- **USE** ratio/***GEBRUIK*** *verhouding:* $c(N_2O_4) : c(NO_2) = 1 : 2$. ✓
- $c(N_2O_4)_{eq/ewe} = c(N_2O_4)_{initial/begin} - \Delta c(N_2O_4)$.
  $c(NO_2)_{eq/ewe} = c(NO_2)_{initial/begin} + \Delta c(NO_2)$. ✓
- Correct K_c expression (formulae in square brackets). ✓
  Korrekte K_c uitdrukking (formules in vierkanthakies).
- Substitution of K_c value/*Vervanging van K_c-waarde.* ✓
- Substitution of concentrations into K_c expression. ✓
  Vervanging van konsentrasies in K_c-uitdrukking.
- Final answer/*Finale antwoord*: 1,6 (mol) ✓

OPTION 3/*OPSIE 3*

	N_2O_4	NO_2	
Initial concentration ($mol{\cdot}dm^{-3}$) *Aanvanklike konsentrasie ($mol{\cdot}dm^{-3}$)*	$\frac{x}{2} = 0{,}5\mathbf{x}$	0	Divide by 2 dm^3 ✓
Change ($mol{\cdot}dm^{-3}$) *Verandering ($mol{\cdot}dm^{-3}$)*	0,1**x** ✓	0,2**x**	ratio ✓ *verhouding*
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	0,4**x**	0,2**x**	✓

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} \checkmark$$

$$0{,}16 \checkmark = \frac{(0{,}2\mathbf{x})^2}{0{,}4\mathbf{x}} \checkmark$$

$$\mathbf{x} = 1{,}6 \text{ (mol)} \checkmark$$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie:* Max./*Maks.* $\frac{6}{8}$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{5}{8}$

(8)
[16]

QUESTION 7/*VRAAG 7*

7.1

7.1.1 An acid is a <u>proton donor</u>. ✓✓
'n Suur is 'n protondonor/skenker. (2)

7.1.2 H_2O ✓ (1)

7.1.3 HSO_4^- ✓✓ (2)

7.2

7.2.1 Reaction of a salt with water/H_2O. ✓✓
Reaksie van 'n sout met water/H_2O.

Accept/*Aanvaar*
Reaction of cations or anions with water
Reaksie van katione of anione met water (2)

7.2.2
- $CO_3^{2-}(aq) + 2H_2O(\ell)$ ✓ $\rightleftharpoons H_2CO_3(aq) + 2OH^-(aq)$ ✓
  OR/*OF*
  $CO_3^{2-}(aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$
  Accept/*Aanvaar:*
  $CaCO_3(aq) + 2H_2O(\ell) \rightleftharpoons H_2CO_3(aq) + Ca(OH)_2(aq)$
- The formation of $OH^-(aq)$ neutralises the excess acid. ✓
  Die vorming van $OH^-(aq)$ neutraliseer die oormaat suur.

<u>Marking guidelines/*Nasienriglyne*</u>
- Reactants ✓ Products ✓
  Reaktanse *Produkte*
- The formation of $OH^-(aq)$ neutralises the excess acid. ✓
  Die vorming van $OH^-(aq)$ neutraliseer die oormaat suur.
- Ignore single arrows and phases./*Ignoreer enkelpyle en fases.*
- Marking rule 6.3.10/*Nasienreël 6.3.10.*
- Ignore balancing./*Ignoreer balansering.*

(3)

7.3

7.3.1 $pH = -log[H_3O^+]$ ✓
5 ✓ $= -log[H_3O^+]$
$[H_3O^+] = 1 \times 10^{-5}\ mol\cdot dm^{-3}$ ✓ (3)

7.3.2 **POSITIVE MARKING FROM QUESTION 7.3.1.**
POSITIEWE NASIEN VAN VRAAG 7.3.1.

Marking guidelines/*Nasienriglyne*

- Any formula/*Enige formule*: $c = \frac{n}{V}$ /n = $\frac{m}{M}$ / $\frac{c_a \times V_a}{c_b \times V_b} = \frac{n_a}{n_b}$ /c = $\frac{m}{MV}$ ✓
- Substitute/*vervang* V = 4×10^9 dm^3 ✓
- Calculate n_a(reacted) = n_a(initial) – n_a(final) ✓✓
  Bereken n_a(reageer) = n_a(begin) – n_a(finaal)
- Use/*Gebruik* n(CaO) : n(H_3O^+) = 1:2 ✓
- Substitution of/*Vervanging van* 56 g·mol^{-1} ✓
- Final answer/*Finale antwoord*: m = $1,08 \times 10^6$ g to/*tot* $1,09 \times 10^6$ g ✓

IF final answer is negative:/***INDIEN*** finale antwoord negatief is Max/Maks: $\frac{6}{7}$

OPTION 1/*OPSIE 1*

$c(H_3O^+)_{ini/aanv.} = \frac{n}{V}$ ✓

$1 \times 10^{-5} = \frac{n}{4 \times 10^9}$ ✓

$n_a = 4 \times 10^4$ mol

$n(H_3O^+)_{react/rea}$
$= 4 \times 10^4 - 1,26 \times 10^3$ ✓✓
$= 3,87 \times 10^4$ mol

n(CaO) = ½n(H_3O^+)
= ½ x $3,87 \times 10^4$ ✓
= $1,94 \times 10^4$ mol

OPTION 2/*OPSIE 2*

$c(H_3O^+)_{fin} = \frac{n}{V}$ ✓

$= \frac{1,26 \times 10^3}{4 \times 10^9}$ ✓

$= 3,15 \times 10^{-7}$ mol·dm^{-3}

$c(H_3O^+)_{rea} = 1 \times 10^{-5} - 3,15 \times 10^{-7}$ ✓✓
$= 9,69 \times 10^{-6}$ mol·dm^{-3}

$n(H_3O^+)_{rea}$ = cV
$= (9,65 \times 10^{-6})(4 \times 10^9)$
$= 3,87 \times 10^4$ mol

n(CaO) = ½n(H_3O^+)
= ½ x $3,87 \times 10^4$ ✓
= $1,94 \times 10^4$ mol

$n(CaO) = \frac{m}{M}$

$1,94 \times 10^4 = \frac{m}{56}$ ✓

∴ m = $1,09 \times 10^6$ g ✓

OR/*OF*

1 mol : 56 g ✓

$1,94 \times 10^4$ mol : m

∴ m = $1,09 \times 10^6$ g ✓

OPTION 3/*OPSIE 3*

$c(H_3O^+)_{fin} = \frac{n}{V}$ ✓

$= \frac{1,26 \times 10^3}{4 \times 10^9}$ ✓

$= 3,15 \times 10^{-7}$ mol·dm^{-3}

$c(H_3O^+)_{rea} = 1 \times 10^{-5} - 3,15 \times 10^{-7}$ ✓✓
$= 9,69 \times 10^{-6}$ mol·dm^{-3}

c(CaO) = ½c(H_3O^+) ✓ = $4,845 \times 10^{-6}$ mol·dm^{-3}

$c = \frac{m}{MV}$ ∴ $4,845 \times 10^{-6} = \frac{m}{56(4 \times 10^9)}$ ✓ ∴ m = $1,09 \times 10^6$ g ✓

(7)
[20]

QUESTION 8/*VRAAG 8*

8.1

8.1.1 Loss of electrons./*Verlies aan elektrone*. ✓✓ **(2 or/*of* 0)** (2)

8.1.2 $Fe \rightarrow Fe^{3+} + 3e^-$ ✓✓

Marking guidelines/*Nasienriglyne*			
• $Fe \rightleftharpoons Fe^{3+} + 3e^-$	$\frac{1}{2}$	$Fe^{3+} + 3e^- \rightleftharpoons Fe$	$\frac{0}{2}$
$Fe^{3+} + 3e^- \leftarrow Fe$	$\frac{2}{2}$	$Fe^{3+} + 3e^- \rightarrow Fe$	$\frac{0}{2}$

- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (+) omitted on Fe^{3+}/*Indien lading (+) weggelaat op* Fe^{3+}:

  Example/*Voorbeeld:* $Fe \rightarrow Fe^3 + 3e^-$ ✓ Max./*Maks:* $\frac{1}{2}$

(2)

8.1.3 Reducing agent/*Reduseermiddel* ✓ (1)

8.1.4 Fe is a stronger reducing agent ✓ than Cu ✓ and (Fe) will be oxidised ✓ (to Fe^{3+})./*Fe is 'n sterker reduseermiddel as Cu en (Fe) sal geoksideer word (na* Fe^{3+}*).*

OR/*OF*

Cu is a weaker reducing agent ✓ than Fe ✓and (Cu) will not be oxidised ✓ (to Cu^{2+})./*Cu is 'n swakker reduseermiddel as Fe en (Cu) sal nie geoksideer word nie (na* Cu^{2+}*).* (3)

8.1.5 Zinc/Zn ✓

Stronger reducing agent (than Fe)./*Sterker reduseermiddel (as Fe).* ✓

OR/*OF*

Zn will undergo oxidation (before Fe)./*Zn sal oksidasie (voor Fe) ondergaan.*

OR/*OF*

Cu is a weaker reducing agent (than Fe)./*Cu is 'n swakker reduseermiddel (as Fe).* (2)

8.2

8.2.1 $3Cu^{2+} + 2Fe$ ✓ $\rightarrow 3Cu + 2Fe^{3+}$ ✓ Bal. ✓

Marking guidelines/*Nasienriglyne*

- Reactants ✓ *Reaktanse* | Products ✓ *Produkte* | Balancing ✓ *Balansering*
- Ignore double arrows./*Ignoreer dubbelpyle.*
- Marking rule 6.3.10/*Nasienreël 6.3.10.*

(3)

8.2.2

OPTION 1/*OPSIE 1*	**Notes/*Aantekeninge***
$E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ ✓ $= 0,34$ ✓ $- (-0,06)$ ✓ $= 0,40$ V ✓	• Accept any other correct formula from the data sheet./*Aanvaar enige ander korrekte formule vanaf gegewensblad.* • Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik bv.* $E°_{sel} = E°_{OM} - E°_{RM}$ *gevolg deur korrekte vervangings*: $\frac{3}{4}$

OPTION 2/*OPSIE 2*

$Cu^{2+} + 2e^- \rightarrow Cu$ ✓ $E^\theta = 0,34$ V ✓
$Fe \rightarrow Fe^{3+} + 3e^-$ $E^\theta = 0,06$ V ✓
$3Cu^{2+} + 2Fe \rightarrow 3Cu + 2Fe^{3+}$ $E^\theta = +0,40$ V ✓

(4)
[17]

QUESTION 9/*VRAAG 9*

9.1 A cell in which electrical energy is converted to chemical energy. ✓✓ **(2 or 0)**
'n Sel waarin elektriese energie omgeskakel word na chemiese energie. ***(2 of 0)***

OR/*OF*
A cell in which electrical energy/electricity is used to obtain a chemical change/reaction. **(2 or 0)**
'n Sel waarin elektriese energie/elektrisiteit gebruik word om 'n chemiese verandering/reaksie te veroorsaak. ***(2 of 0)*** (2)

9.2 Any soluble copper(II) salt e.g./*Enige oplosbare koper(II)-sout bv.*
$CuSO_4/Cu(NO_3)_2/CuCl_2$ ✓ (1)

9.3 B ✓

$Cu^{2+} + 2e^- \rightarrow Cu$ ✓✓

Marking guidelines/*Nasienriglyne*
- $Cu \leftarrow Cu^{2+} + 2e^-$ $(\frac{2}{2})$ $Cu \rightleftharpoons Cu^{2+} + 2e^-$ $(\frac{0}{2})$
  $Cu^{2+} + 2e^- \rightleftharpoons Cu$ $(\frac{1}{2})$ $Cu \rightarrow Cu^{2+} + 2e^-$ $(\frac{0}{2})$
- Ignore if charge on electron is omitted./*Ignoreer indien lading op elektron uitgelaat is.*
- If a charge of an ion is omitted e.g. $Cu^2 + 2e^- \rightarrow Cu$ /*Indien lading op ioon uitgelaat is bv.* $Cu^2 + 2e^- \rightarrow Cu$ Max./*Maks*: $\frac{1}{2}$

(3)

9.4 Platinum/Pt ✓ **AND/*EN*** silver/Ag/*silwer* ✓ (2)
[8]

QUESTION 10/*VRAAG 10*

10.1

10.1.1 Haber (process)/*Haber(proses)* ✓ (1)

10.1.2 Ostwald (process)/*Ostwald(proses)* ✓ (1)

10.2

10.2.1 Ammonium nitrate/*Ammoniumnitraat*/NH_4NO_3 ✓ (1)

10.2.2 Iron/iron oxide/Fe/FeO ✓
Yster/ysteroksied/Fe/FeO (1)

10.3 $2NH_3 + H_2SO_4$ ✓ → $(NH_4)_2SO_4$ ✓ Bal ✓ (3)

Marking guidelines/*Nasienriglyne*
- Reactants ✓ *Reaktanse* Products ✓ *Produkte* Balancing ✓ *Balansering*
- Ignore double arrows./*Ignoreer dubbelpyle.*
- Marking rule 6.3.10./*Nasienreël 6.3.10.*

10.4

Marking guidelines/*Nasienriglyne*
- Any ONE molar mass correct/*Enige EEN molêre massa korrek:*
  $80\ g\cdot mol^{-1}$/$164\ g\cdot mol^{-1}$/$74,5\ g\cdot mol^{-1}$ ✓
- m(N) = 7 (kg) **OR/*OF*** 0,14 ✓
- m(P) = 2,27 (kg) **OR/*OF*** 0,045 ✓
- m(K) = 9,42 (kg) **OR/*OF*** 0,188 ✓
- Final answer/*Finale antwoord*: 3 : 1 : 4 ✓
  ACCEPT/*AANVAAR*: 3,08 : 1 : 4,15 **OR/*OF*** 7 : 2,27 : 9,42

OPTION 1/*OPSIE 1*

NH_4NO_3:
80 g✓ → 28 g N

$20\ kg \rightarrow \frac{28}{80} \times 20$

∴ m(N) = 7 kg ✓

Na_3PO_4:
164 g → 31 g P

$12\ kg \rightarrow \frac{31}{164} \times 12$

∴ m(P) = 2,27 kg ✓

KCℓ:
74,5 g → 39 g K

$18\ kg \rightarrow \frac{39}{74,5} \times 18$

∴ m(K) = 9,42 kg ✓

∴ N : P : K
7 : 2,27 : 9,42
3 : 1 : 4 ✓

OPTION 2/*OPSIE 2*

$n(NH_4NO_3) = \frac{m}{M}$

$= \frac{20\ 000}{80✓} = 250\ mol$

$n(N) = 2n(NH_4NO_3) = 500\ mol$

m(N) = 500 x 14
= 7 000 g = 7 kg ✓

$n(Na_3PO_4) = \frac{12\ 000}{164} = 73,17\ mol$

m(P) = 73,17 x 31
= 2 268 g = 2,27 kg ✓

$n(KCℓ) = \frac{18\ 000}{74,5} = 241,61\ mol$

m(K) = 241,61 x 39
= 9 423 g = 9,42 kg ✓

∴ N : P : K
7 : 2,27 : 9,42
3 : 1 : 4 ✓

OPTION 3/*OPSIE 3*	**OPTION 4/*OPSIE 4***
NH_4NO_3: $\%N = \frac{28}{80}$ ✓ $\times 100 = 35\%$ $m(N) = \frac{35}{100} \times 20 = 7$ kg ✓ Na_3PO_4: $\%P = \frac{31}{164} \times 100 = 18,9\%$ $m(N) = \frac{18,9}{100} \times 12 = 2,27$ kg ✓ $KC\ell$: $\%K = \frac{39}{74,5} \times 100 = 52,34\%$ $m(K) = \frac{52,34}{100} \times 18 = 9,42$ kg ✓ $\therefore$ N : P : K = 7 : 2,27 : 9,42 = 3 : 1 : 4 ✓	NH_4NO_3: $\%N = \frac{28}{80}$ ✓ $\times 100 = 35\%$ Na_3PO_4: $\%P = \frac{31}{164} \times 100 = 18,9\%$ $KC\ell$: $\%K = \frac{39}{74,5} \times 100 = 52,34\%$ N: $\frac{20}{50} \times 35 = 0,14$ ✓ P: $\frac{12}{50} \times 18,9 = 0,045$ ✓ K: $\frac{18}{50} \times 52,34 = 0,188$ ✓ N : P : K = 0,14 : 0,045 : 0,188 = 3 : 1 : 4 ✓

(5)
[12]

TOTAL/*TOTAAL*: 150

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: CHEMISTRY (P2)

2019

MARKS: 150

TIME: 3 hours

This question paper consists of 15 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your examination number and centre number in the appropriate spaces on the ANSWER BOOK.

2. This question paper consists of TEN questions. Answer ALL the questions in the ANSWER BOOK.

3. Start EACH question on a NEW page in the ANSWER BOOK.

4. Number the answers correctly according to the numbering system used in this question paper.

5. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

8. Show ALL formulae and substitutions in ALL calculations.

9. Round off your FINAL numerical answers to a minimum of TWO decimal places.

10. Give brief motivations, discussions, etc. where required.

11. You are advised to use the attached DATA SHEETS.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 D.

1.1 Which ONE of the following is a SECONDARY alcohol?

A Ethanol

B Butan-1-ol

C Butan-2-ol

D 2-methylbutan-1-ol (2)

1.2 Which ONE of the following will RAPIDLY decolourise bromine water?

A CH_3CHCH_2

B $CH_3CH_2CH_3$

C CH_3COOCH_3

D CH_3CH_2COOH (2)

1.3 A FUNCTIONAL ISOMER of ethyl propanoate is …

A C_4H_9CHO.

B $C_5H_{11}OH$.

C C_4H_9COOH.

D $CH_3(CH_2)_3CHO$. (2)

1.4 Consider the balanced equation for a chemical reaction below.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

The activation energy of the forward and reverse reactions are 156 kJ·mol^{-1} and 175 kJ·mol^{-1} respectively.

The heat of reaction, in kJ·mol^{-1}, for this reaction is …

A –19.

B +19.

C +331.

D –331. (2)

1.5 The reaction given below reaches equilibrium in a closed container. The K_c value is 0,04 at a certain temperature.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H < 0$$

Which ONE of the following factors will change the K_c value to 0,4?

A Increase in pressure

B Decrease in pressure

C Increase in temperature

D Decrease in temperature (2)

1.6 Which ONE of the following statements best describes a state of dynamic equilibrium?

A The limiting reagent has been used up.

B The forward and reverse reactions have stopped.

C The rates of the forward and reverse reactions are equal.

D The concentration of products equals the concentration of reactants. (2)

1.7 During a titration to determine the concentration of an acid using a standard base, a learner pipettes the base into a conical flask. She then uses a small amount of water to rinse the inside of the flask so that all the base is part of the solution in the flask.

How will the extra water added to the flask affect the results of this titration?

The concentration of the acid …

A cannot be determined.

B will be lower than expected.

C will be higher than expected.

D will be the same as expected. (2)

1.8 The standard reduction potentials for two substances used to set up a galvanic cell are as follows:

$Sn^{2+} + 2e^- \rightleftharpoons Sn$ $E^\theta = -0{,}14$ V

$Cu^{2+} + 2e^- \rightleftharpoons Cu$ $E^\theta = 0{,}34$ V

Which ONE of the following combinations gives the substances formed at each electrode when the cell is functioning?

	Cathode	**Anode**
A	Cu^{2+}	Sn
B	Sn	Cu^{2+}
C	Sn^{2+}	Cu
D	Cu	Sn^{2+}

(2)

1.9 Which ONE of the following half-reactions takes place at the POSITIVE ELECTRODE of an electrochemical cell used to electroplate an iron rod with silver?

A $Ag^+ + e^- \rightarrow Ag$

B $Fe^{2+} + 2e^- \rightarrow Fe$

C $Ag \rightarrow Ag^+ + e^-$

D $Fe \rightarrow Fe^{2+} + 2e^-$ (2)

1.10 Which ONE of the following elements is a primary nutrient?

A Potassium

B Sulphur

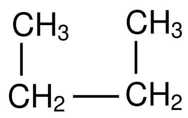
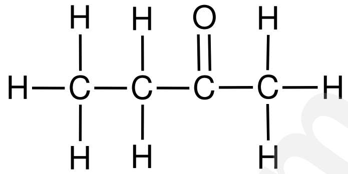
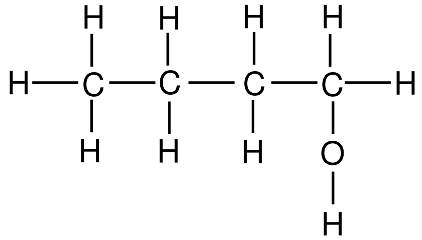
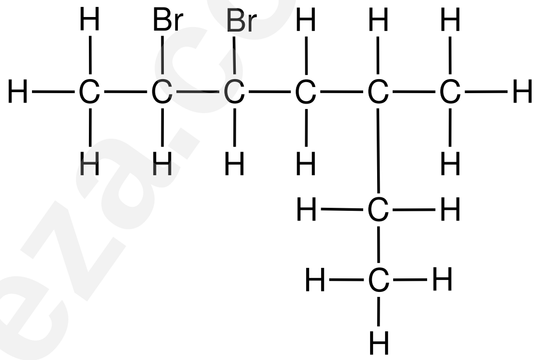
C Oxygen

D Carbon (2)

[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **F** in the table below represent six organic compounds.

A		**B**	
C	$CH_3CCCH_2CH_3$	**D**	Butyl propanoate
E		**F**	

2.1 Is compound **C** SATURATED or UNSATURATED? Give a reason for the answer. (2)

2.2 Write down the LETTER that represents each of the following:

2.2.1 An ester (1)

2.2.2 A FUNCTIONAL ISOMER of butanal (1)

2.2.3 A compound with the general formula C_nH_{2n-2} (1)

2.2.4 A compound used as reactant in the preparation of compound **D** (1)

2.3 Write down the STRUCTURAL FORMULA of:

2.3.1 The functional group of compound **C** (1)

2.3.2 Compound **D** (2)

2.3.3 A CHAIN ISOMER of compound **A** (2)

2.4 Write down the:

2.4.1 IUPAC name of compound **F** (3)

2.4.2 Balanced equation, using MOLECULAR FORMULAE, for the complete combustion of compound **A** (3)

[17]

QUESTION 3 (Start on a new page.)

Three compounds are used to investigate one of the factors that influences boiling point. The results obtained are shown in the table below.

COMPOUND		MOLECULAR MASS ($g \cdot mol^{-1}$)	BOILING POINT (°C)
A	Butane	58	– 0,5
B	Propan-1-ol	60	98
C	Ethanoic acid	60	118

3.1 In one investigation the boiling points of compound **B** and compound **C** are compared.

3.1.1 Is this a fair investigation? Write down YES or NO. Refer to the data in the table and give a reason for the answer. (2)

3.1.2 Write down the independent variable for this investigation. (1)

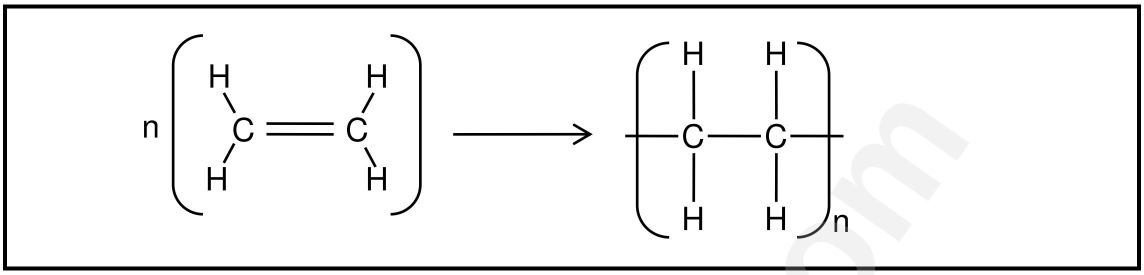
3.2 Which ONE of the compounds (**A**, **B** or **C**) has the highest vapour pressure? Give a reason for the answer. (2)

3.3 Refer to the intermolecular forces present in each compound and FULLY explain the trend in boiling points, as shown in the above table. (5)

3.4 Which compound, BUTAN-1-OL or PROPAN-1-OL, has the higher boiling point? Give a reason for the answer. (2)
[12]

QUESTION 4 (Start on a new page.)

4.1 The balanced equation for a polymerisation reaction is shown below.



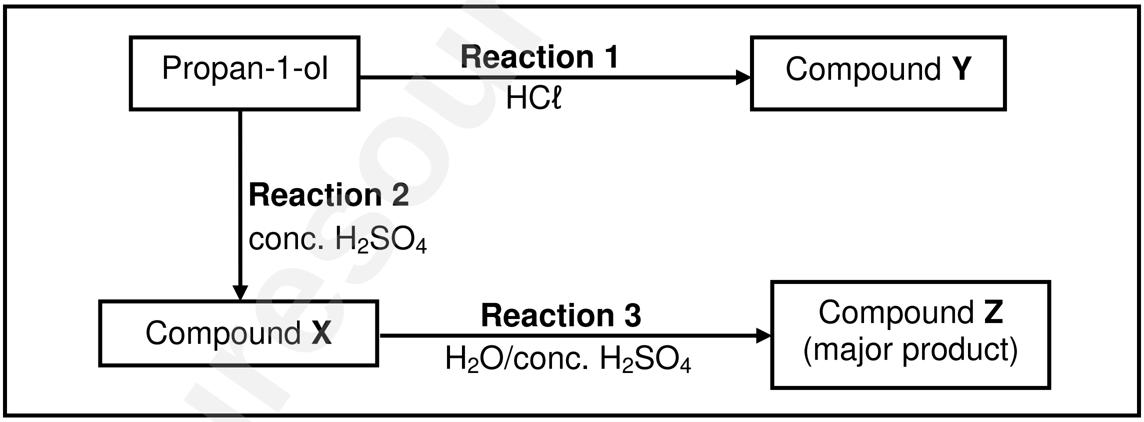
Write down the:

4.1.1 Type of polymerisation reaction represented by the equation (1)

4.1.2 IUPAC name of the monomer (1)

4.1.3 IUPAC name of the polymer (1)

4.2 Propan-1-ol undergoes two different reactions, as shown in the diagram below.



Write down the:

4.2.1 Type of reaction represented by **reaction 2** (1)

4.2.2 Function of concentrated H_2SO_4 in **reaction 2** (1)

4.2.3 IUPAC name of compound **X** (2)

4.2.4 STRUCTURAL FORMULA of compound **Y** (2)

4.2.5 Type of reaction represented by **reaction 3** (1)

4.2.6 IUPAC name of compound **Z** (2)
[12]

QUESTION 5 (Start on a new page.)

Learners use the reaction of a sodium thiosulphate solution with dilute hydrochloric acid to investigate several factors that affect the rate of a chemical reaction. The balanced equation for the reaction is:

$$Na_2S_2O_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + SO_2(g) + S(s) + H_2O(\ell)$$

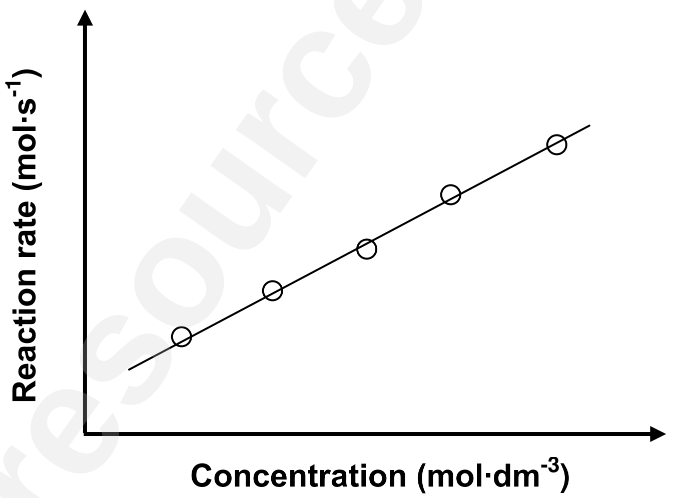
5.1 Define *reaction rate*. (2)

Three investigations (**I**, **II** and **III**) are carried out.

5.2 **INVESTIGATION I**

The results obtained in INVESTIGATION **I** are shown in the graph below.

GRAPH OF REACTION RATE VERSUS CONCENTRATION OF $Na_2S_2O_3$(aq)



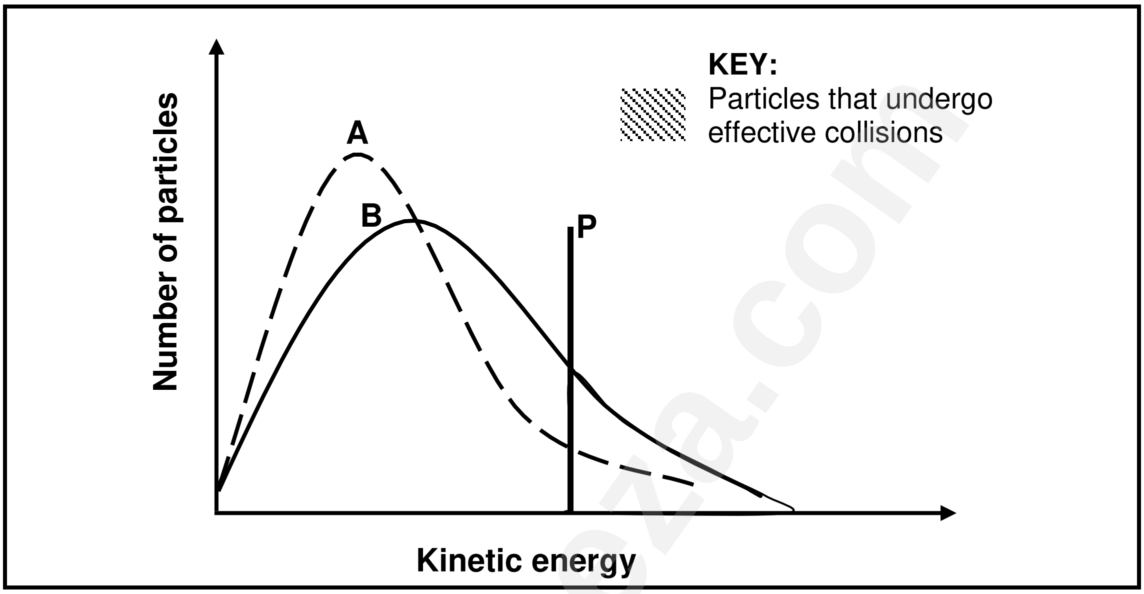
For this investigation, write down the:

5.2.1 Dependent variable (1)

5.2.2 Conclusion that can be drawn from the results (2)

5.3 **INVESTIGATION II**

The Maxwell-Boltzmann distribution curves, **A** and **B**, below represent the number of particles against kinetic energy for the reaction at two different temperatures.



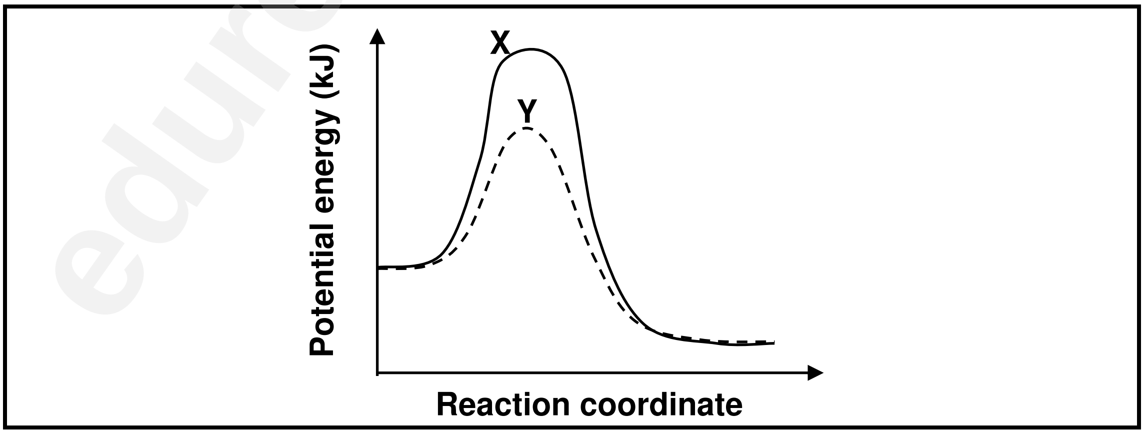
5.3.1 What does line **P** represent? (1)

5.3.2 Which curve (**A** or **B**) was obtained at the higher temperature? (1)

5.3.3 Explain, in terms of the collision theory, how an increase in temperature influences the rate of a reaction. (4)

5.4 **INVESTIGATION III**

The potential energy diagrams, **X** and **Y**, below represent the reaction under two different conditions.



Give a reason why curve **Y** differs from curve **X**. (1)

5.5 In one of the investigations, 100 cm^3 of 0,2 $mol \cdot dm^{-3}$ HCℓ(aq) reacts with excess $Na_2S_2O_3$(aq) and the solution is then filtered. After filtration of the solution, 0,18 g of sulphur is obtained. Calculate the PERCENTAGE YIELD of sulphur. (6)
[18]

QUESTION 6 (Start on a new page.)

The balanced equation below represents the reaction used in the Haber process to produce ammonia.

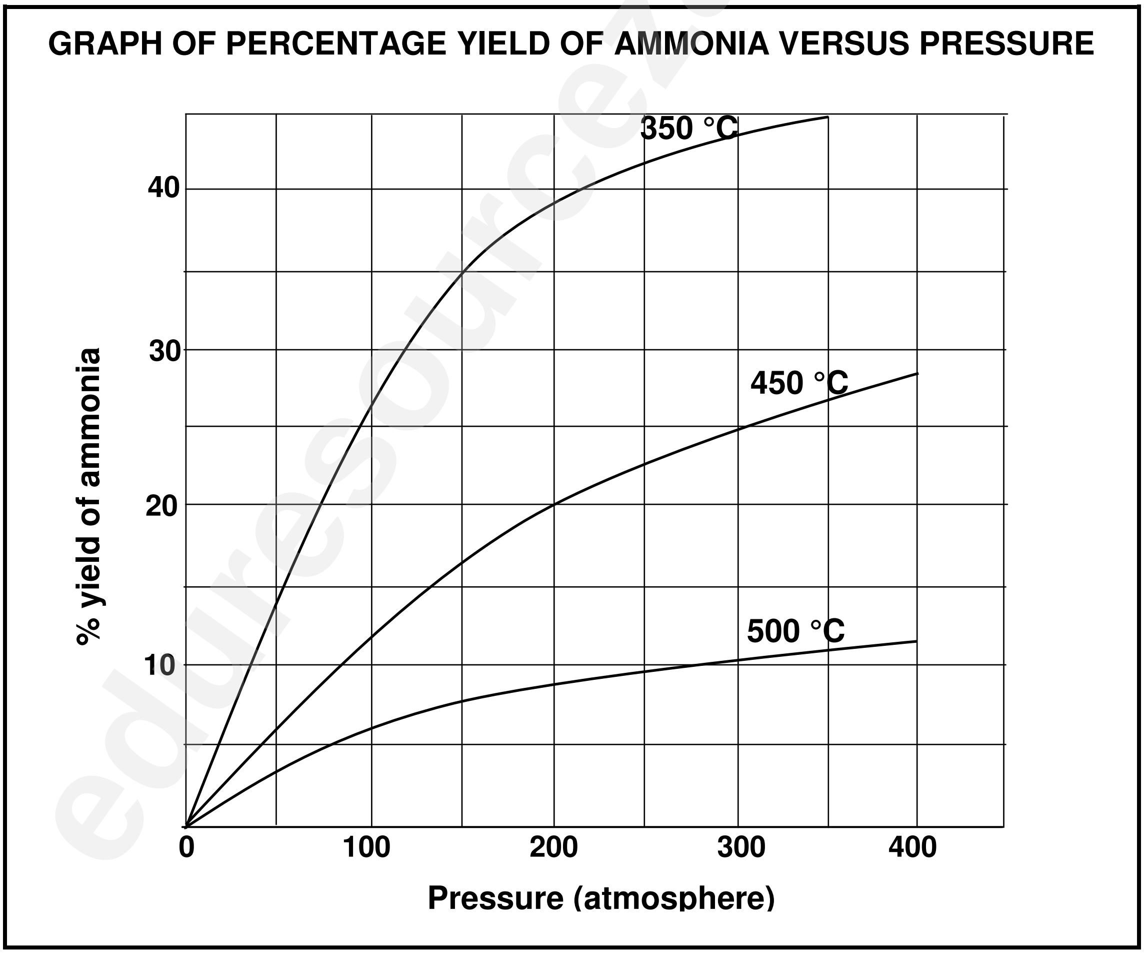
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0$$

In industry the product is removed as quickly as it forms.

6.1 Write down the meaning of the double arrow used in the equation above. (1)

6.2 Give ONE reason why ammonia is removed from the reaction vessel as quickly as it forms. (1)

The graph below shows the percentage yield of ammonia at different temperatures and pressures.



6.3 Write down the percentage yield of ammonia at a temperature of 450 °C and a pressure of 200 atmospheres. (1)

6.4 Refer to Le Chatelier's principle to explain EACH of the following deductions made from the graph:

6.4.1 For a given pressure, the yield of ammonia at 500 °C is much lower than that at 350 °C (3)

6.4.2 For a given temperature, the yield of ammonia at 350 atmospheres is much higher than that at 150 atmospheres (2)

6.5 A technician prepares $NH_3(g)$ by reacting 6 moles of $H_2(g)$ and 6 moles of $N_2(g)$.

6.5.1 Calculate the maximum number of moles of $NH_3(g)$ that can be obtained in this reaction. (2)

6.5.2 The above reaction now takes place in a 500 cm^3 container at a temperature of 350 °C and a pressure of 150 atmospheres. The system is allowed to reach equilibrium.

Use the graph above and calculate the equilibrium constant, K_c, for this reaction under these conditions. (7)
[17]

QUESTION 7 (Start on a new page.)

7.1 Define a *base* in terms of the Arrhenius theory. (2)

7.2 Explain how a *weak base* differs from a *strong base*. (2)

7.3 Write down the balanced equation for the hydrolysis of $NaHCO_3$. (3)

7.4 A learner wishes to identify element **X** in the hydrogen carbonate, $XHCO_3$. To do this she dissolves 0,4 g of $XHCO_3$ in 100 cm^3 of water. She then titrates all of this solution with a 0,2 mol dm^{-3} hydrochloric acid ($HC\ell$) solution. Methyl orange is used as the indicator during the titration.

7.4.1 Calculate the pH of the hydrochloric acid solution. (3)

7.4.2 Give a reason why methyl orange is a suitable indicator in this titration. (1)

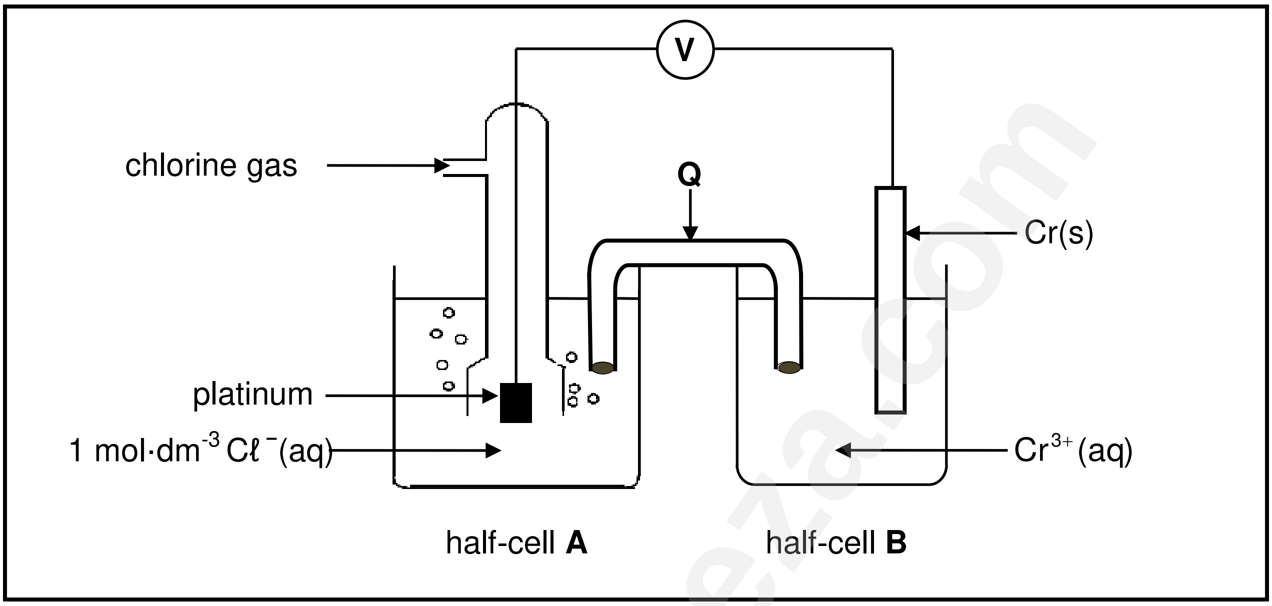
At the endpoint she finds that 20 cm^3 of the acid neutralised ALL the hydrogen carbonate solution. The balanced equation for the reaction is:

$$XHCO_3(aq) + HC\ell(aq) \rightarrow XC\ell(aq) + CO_2(g) + H_2O(\ell)$$

7.4.3 Identify element **X** by means of a calculation. (6)
[17]

QUESTION 8 (Start on a new page.)

The electrochemical cell below functions under standard conditions.



8.1 Give a reason why platinum is used as the electrode in half-cell **A**. (1)

8.2 Write down the:

8.2.1 Energy conversion that takes place in this cell (1)

8.2.2 Half-reaction that takes place at the cathode (2)

8.2.3 Cell notation for this cell (3)

8.3 Calculate the initial emf of this cell. (4)

8.4 Silver chloride is an insoluble salt.

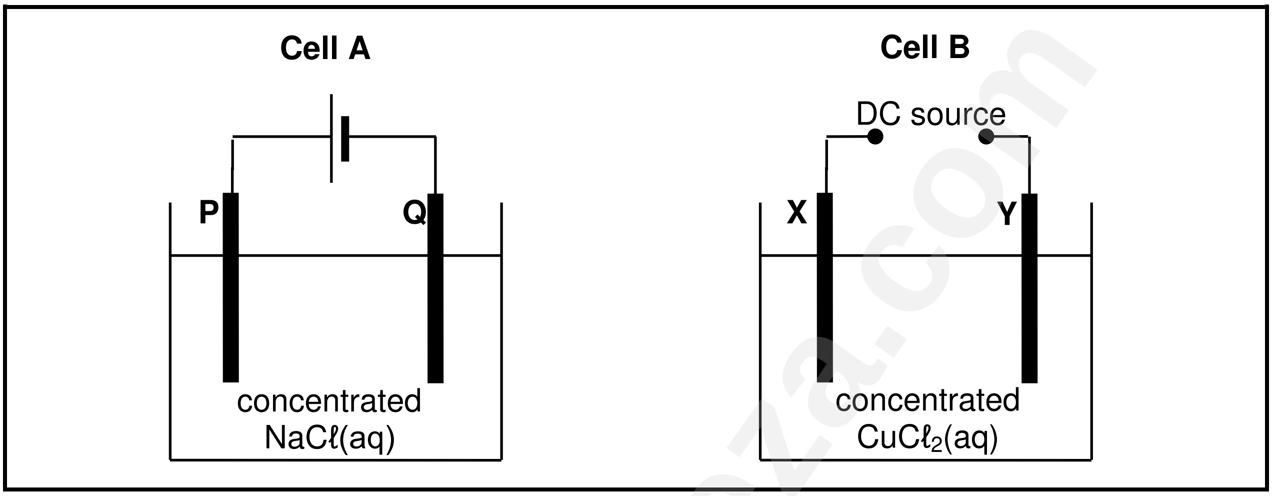
What will be the effect on the cell potential when a small amount of silver nitrate solution, $AgNO_3$(aq), is added to half-cell **A**? Choose from INCREASES, DECREASES or REMAINS THE SAME. (2)

[13]

QUESTION 9 (Start on a new page.)

The diagrams below represent two electrochemical cells.

P, **Q**, **X** and **Y** are carbon electrodes.



When cell **B** is functioning, the mass of electrode **X** increases.

9.1 What type of electrochemical cell, GALVANIC or ELECTROLYTIC, is illustrated above? (1)

9.2 Write down the half-reaction that takes place at electrode **Q**. (2)

9.3 The products formed in the two cells are compared.

9.3.1 Name ONE substance that is produced in BOTH cells. (1)

9.3.2 Write down the LETTERS of the TWO electrodes where this product is formed. Choose from **P**, **Q**, **X** and **Y**. (2)

9.4 Is electrode **X** the CATHODE or the ANODE? Give a reason for the answer. (2)

9.5 Write down the net (overall) cell reaction that takes place in cell **B**. (3)
[11]

QUESTION 10 (Start on a new page.)

10.1 The four steps in the manufacture of an inorganic fertiliser are listed below. These steps are NOT written in the order in which they occur.

Step I: Sulphuric acid reacts with ammonia to produce ammonium sulphate.
Step II: Sulphur dioxide reacts with oxygen to produce sulphur trioxide.
Step III: Oleum is diluted with water to produce sulphuric acid.
Step IV: Sulphur trioxide is bubbled in concentrated sulphuric acid to produce oleum.

Write down the:

10.1.1 Correct order in which the steps occur in the preparation of the inorganic fertiliser by using the numbers **I** to **IV** (1)

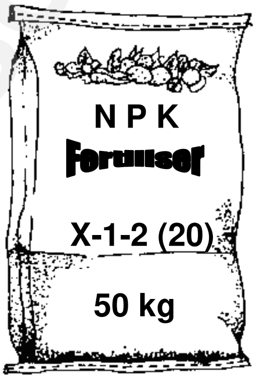
10.1.2 Balanced chemical equation for **step I** (3)

10.1.3 NAME of the catalyst used in **step II** (1)

10.1.4 Balanced chemical equation for **step IV** (3)

10.1.5 Reason why sulphur trioxide is NOT dissolved in water in **step IV** (1)

10.2 The diagram below shows a bag of NPK fertiliser. One of the numbers of the NPK ratio on the bag is labelled as **X**.



If the mass of potassium in the bag is 3,33 kg, calculate the value of **X**. (4)
[13]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1{,}013 \times 10^{5}$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22{,}4\ dm^{3}\cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising agent} - E^{\theta}_{reducing agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Electronegativity / *Elektronegatiwiteit*	Atomic number / *Atoomgetal* — Symbol / *Simbool* — Approximate relative atomic mass / *Benaderde relatiewe atoommassa*
1,9	29 Cu 63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
2,1 1 **H** 1																	2 **He** 4
1,0 3 **Li** 7	1,5 4 **Be** 9											2,0 5 **B** 11	2,5 6 **C** 12	3,0 7 **N** 14	3,5 8 **O** 16	4,0 9 **F** 19	10 **Ne** 20
0,9 11 **Na** 23	1,2 12 **Mg** 24											1,5 13 **Aℓ** 27	1,8 14 **Si** 28	2,1 15 **P** 31	2,5 16 **S** 32	3,0 17 **Cℓ** 35,5	18 **Ar** 40
0,8 19 **K** 39	1,0 20 **Ca** 40	1,3 21 **Sc** 45	1,5 22 **Ti** 48	1,6 23 **V** 51	1,6 24 **Cr** 52	1,5 25 **Mn** 55	1,8 26 **Fe** 56	1,8 27 **Co** 59	1,8 28 **Ni** 59	1,9 29 **Cu** 63,5	1,6 30 **Zn** 65	1,6 31 **Ga** 70	1,8 32 **Ge** 73	2,0 33 **As** 75	2,4 34 **Se** 79	2,8 35 **Br** 80	36 **Kr** 84
0,8 37 **Rb** 86	1,0 38 **Sr** 88	1,2 39 **Y** 89	1,4 40 **Zr** 91	41 **Nb** 92	1,8 42 **Mo** 96	1,9 43 **Tc**	2,2 44 **Ru** 101	2,2 45 **Rh** 103	2,2 46 **Pd** 106	1,9 47 **Ag** 108	1,7 48 **Cd** 112	1,7 49 **In** 115	1,8 50 **Sn** 119	1,9 51 **Sb** 122	2,1 52 **Te** 128	2,5 53 **I** 127	54 **Xe** 131
0,7 55 **Cs** 133	0,9 56 **Ba** 137	57 **La** 139	1,6 72 **Hf** 179	73 **Ta** 181	74 **W** 184	75 **Re** 186	76 **Os** 190	77 **Ir** 192	78 **Pt** 195	79 **Au** 197	80 **Hg** 201	1,8 81 **Tℓ** 204	1,8 82 **Pb** 207	1,9 83 **Bi** 209	2,0 84 **Po**	2,5 85 **At**	86 **Rn**
0,7 87 **Fr**	0,9 88 **Ra** 226	89 **Ac**															

58 **Ce** 140	59 **Pr** 141	60 **Nd** 144	61 **Pm**	62 **Sm** 150	63 **Eu** 152	64 **Gd** 157	65 **Tb** 159	66 **Dy** 163	67 **Ho** 165	68 **Er** 167	69 **Tm** 169	70 **Yb** 173	71 **Lu** 175
90 **Th** 232	91 **Pa**	92 **U** 238	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**

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

Half-reactions/*Halfreaksies*			E^{θ} (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
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 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
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 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
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**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
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	− 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

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Half-reactions/*Halfreaksies*			E^{θ} **(V)**
$Li^+ + e^-$	⇌	Li	− 3,05
$K^+ + e^-$	⇌	K	− 2,93
$Cs^+ + e^-$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$\mathbf{2H^+ + 2e^-}$	⇌	$\mathbf{H_2(g)}$	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

Increasing reducing ability/*Toenemende reduserende vermoë* ↑

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NASIONALE SENIORSERTIFIKAAT-EKSAMEN

PHYSICAL SCIENCES: CHEMISTRY (P2)
FISIESE WETENSKAPPE: CHEMIE (V2)

2019

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

These marking guidelines consist of 16 pages./
Hierdie nasienriglyne bestaan uit 16 bladsye.

QUESTION 1/*VRAAG 1*

1.1	C ✓✓	(2)
1.2	A ✓✓	(2)
1.3	C ✓✓	(2)
1.4	A ✓✓	(2)
1.5	D ✓✓	(2)
1.6	C ✓✓	(2)
1.7	D ✓✓	(2)
1.8	D ✓✓	(2)
1.9	C ✓✓	(2)
1.10	A ✓✓	(2)
		[20]

QUESTION 2/*VRAAG 2*

2.1 Unsaturated/*Onversadig* ✓

ANY ONE/*ENIGE EEN*:

- C/It has a triple/multiple bond. ✓
  C/Dit het 'n trippelbinding/meervoudige-binding.
- C/It has a triple/multiple bond between C atoms.
  C/Dit het 'n trippelbinding/meervoudige-binding tussen C-atome.
- C/It does NOT contain the maximum number of H atoms bonded to C atoms.
  C/Dit bevat NIE die maksimum getal H-atome gebind aan C-atome nie.
- Compound C is an alkyne./*Verbinding C is 'n alkyn.* (2)

2.2

2.2.1 D ✓ (1)

2.2.2 B ✓ (1)

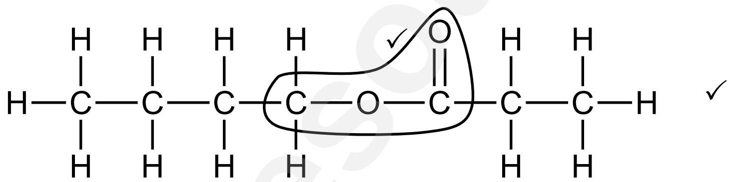
2.2.3 C ✓ (1)

2.2.4 E ✓ (1)

2.3

2.3.1 —C≡C— ✓ (1)

2.3.2



(2)

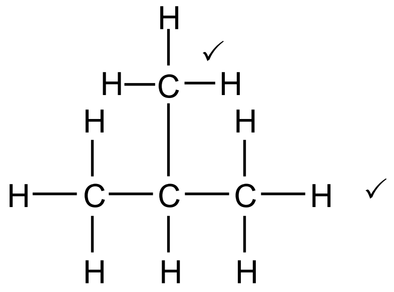
Marking criteria/*Nasienriglyne:*

- Whole structure correct:
  Hele struktuur korrek: $\frac{2}{2}$
- Only functional group correct:/*Slegs funksionele groep korrek:* Max/*Maks.*: $\frac{1}{2}$

IF/*INDIEN*:

- More than one functional group/*Meer as een funksionele groep:* $\frac{0}{2}$
- If condensed or semi structural formula used:/*Indien gekondenseerde of semi-struktuurformule gebruik:*
  Max/*Maks.* $\frac{1}{2}$

2.3.3



Marking criteria/*Nasienriglyne:*

- Three C atoms in longest chain. ✓
  Drie C-atome in langste ketting.
- One methyl substituent on C2. ✓
  Een metielsubstituent op C2.

IF/INDIEN
Any error e.g. omission of H atoms, condensed or semi structural formula/*Enige fout bv weglating van H-atome, gekondenseerde of semi-struktuurformule.* Max/*Maks.*: $\frac{1}{2}$ (2)

2.4
2.4.1 2,3-dibromo-5-methylheptane/2,3-dibromo-5-metielheptaan

Marking criteria/*Nasienriglyne:*

- Correct stem i.e. heptane./*Korrekte stam d.i. heptaan.* ✓
- All substituents (bromo and methyl) correctly identified./*Alle substituente (bromo en metiel) korrek geïdentifiseer.* ✓
- IUPAC name completely correct including numbering, sequence, hyphens and commas./*IUPAC-naam heeltemal korrek insluitende nommering, volgorde, koppeltekens en kommas* . ✓

(3)

2.4.2 $2C_4H_{10} + 13O_2$ ✓ $\rightarrow$ $8CO_2 + 10H_2O$ ✓ Bal ✓

Notes/*Aantekeninge:*

- Reactants ✓ *Reaktanse* Products ✓ *Produkte* Balancing ✓ *Balansering*
- Ignore double arrows and phases./*Ignoreer dubbelpyle en fases.*
- Marking rule 6.3.10/*Nasienreël 6.3.10.*
- If condensed structural formulae used:/*Indien gekondenseerde struktuur formules gebruik:* Max/*Maks.* $\frac{2}{3}$
- Accept coefficients that are multiples./*Aanvaar koëffisiënte wat veelvoude is.*

(3)
[17]

QUESTION 3/*VRAAG 3*

3.1
3.1.1 Yes/*Ja* ✓

ANY ONE/*ENIGE EEN*:

- Compounds have the same molecular mass. ✓
  Verbindings het dieselfde molekulêre massa.
- Only one independent variable./*Slegs een onafhanklike veranderlike.*

(2)

3.1.2 Functional group/Homologous series/Type of (organic) compound ✓
Funksionele groep/Homoloë reeks/Tipe (organiese) verbinding (1)

3.2 A/butane/*butaan* ✓

Lowest boiling point/weakest intermolecular forces. ✓
Laagste kookpunt/swakste intermolekulêre kragte. (2)

3.3

Marking guidelines/Nasienriglyne
- Type of IMF in A./*Tipe IMK in A*.
- BOTH B and C have hydrogen bonding./*BEIDE B en C het waterstofbinding*.
- Compare number of sites for hydrogen bonding in B and C./*Vergelyk aantal punte vir waterstofbinding in B en C.*
- Compare strength of IMFs./*Vergelyk sterkte van IMKe.*
- Compare energy required./*Vergelyk energie benodig.*

- Between molecules of butane/compound **A** are London forces/dispersion forces/induced dipole forces. ✓
- Molecules of compound **B**/propan-1-ol have one site for hydrogen bonding. ✓
- Molecules of compound **C**/ethanoic acid have two/more sites for hydrogen bonding. ✓
- Strength of intermolecular forces increases from compound **A**/butane to compound **B**/propan-1-ol to compound **C**/ethanoic acid. ✓
  OR
  Intermolecular forces in compound **A**/butane are the weakest and intermolecular forces in compound **C**/ethanoic acid are the strongest.
- More energy is needed to overcome/break intermolecular forces in compound **C** than in the other two compounds. ✓

- *Tussen molekule van butaan/verbinding **A** is Londonkragte/dispersie-kragte/geïnduseerde dipoolkragte.* ✓
- *Molekule van verbinding **B**/propan-1-ol het een punt vir waterstof-bindings.* ✓
- Molekule van verbinding ***C**/etanoësuur het twee punte vir waterstof-bindings.* ✓
- *Sterkte van intermolekulêre kragte neem toe van verbinding **A**/butaan na verbinding **B**/propan-1-ol na verbinding **C**/etanoësuur.* ✓
  OF
  *Intermolekulêre kragte tussen propaan is die swakste en intermolekulêre kragte in verbinding **C** is die sterkste.*
- *Meer energie word benodig om intermolekulêre kragte in verbinding **C** as in die ander twee verbindings te oorkom/breek.* ✓ (5)

3.4 Butan-1-ol ✓

Longer chain length./Larger molecule./Larger molecular mass./Larger molecular size./Stronger intermolecular forces./Larger surface area.✓
Langer kettinglengte./Groter molekuul./Groter molekulêre massa/Groter molekuul./Sterker intermolekulêre kragte./Groter oppervlakte. (2)

[12]

QUESTION 4/*VRAAG 4*

4.1

4.1.1 Addition (polymerisation)/*Addisie-(polimerisasie)* ✓ (1)

4.1.2 Ethene/*eteen* ✓ (1)

4.1.3 Polyethene/polythene ✓
Poli-eteen/politeen (1)

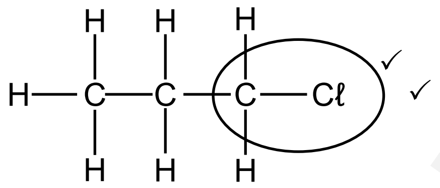
4.2

4.2.1 Dehydration/elimination ✓
Dehidrasie/dehidratering/eliminasie (1)

4.2.2 Catalyst/dehydrating agent/causes dehydration/removes water molecules ✓
Katalisator/dehidreermiddel/veroorsaak dehidrasie/verwyder watermolekule (1)

4.2.3 Prop-1-ene/propene/1-propene ✓✓ **(2 or 0)**
Prop-1-een/propeen/1-propeen **(2 of 0)** (2)

4.2.4



Marking criteria/*Nasienriglyne:*

- Whole structure correct:
  Hele struktuur korrek: $^2/_2$
- Only functional group correct:/*Slegs funksionele groep korrek:* Max/*Maks.*: $^1/_2$

IF/*INDIEN*:

- More than one functional group/*Meer as een funksionele groep:* $^0/_2$
- If condensed or semi structural formula used:/*Indien gekondenseerde of semi-struktuurformule gebruik:*
  Max/*Maks.* $^1/_2$

(2)

4.2.5 Addition/Hydration ✓
Addisie/Hidrasie/Hidratering (1)

4.2.6 Propan-2-ol/2-propanol✓✓

Marking criteria/*Nasienriglyne:*

- Correct stem and functional group i.e propanol/*Korrekte stam en funksionele groep d.i* propanol ✓
- Name completely correct/*Naam volledig korrek:* Propan-2-ol/2-propanol ✓✓

(2)
[12]

QUESTION 5/*VRAAG 5*

5.1

NOTE/*LET WEL*
Give the mark for per unit time only if in context of reaction rate. *Gee die punt vir per eenheidtyd slegs indien in konteks met reaksietempo.*

ANY ONE/*ENIGE EEN*

- Change in concentration ✓ of products/reactants per (unit) time. ✓
  Verandering in konsentrasie van produkte/reaktanse per (eenheid) tyd.
- Change in amount/number of moles/volume/mass of products or reactants per (unit) time.
  Verandering in hoeveelheid/getal mol/volume/massa van produkte of reaktanse per (eenheid) tyd.
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time.
  Hoeveelheid/getal mol/volume/massa van produkte gevorm/reaktanse gebruik per (eenheid) tyd.
- Rate of change in concentration/amount/number of moles/volume/mass.
  Tempo van verandering in konsentrasie/ hoeveelheid/getal mol/ volume/massa. ✓✓ **(2 or/*of* 0)** (2)

5.2

5.2.1 Rate of the reaction/*Reaksietempo* ✓ (1)

5.2.2

Criteria for conclusion/*Kriteria vir gevolgtrekking*:	
Dependent (reaction rate) and independent (concentration) variables correctly identified./*Afhanklike(reaksietempo) en onafhanklike (konsentrasie) veranderlikes korrek geïdentifiseer.*	✓
Relationship between the independent and dependent variables correctly stated. *Verwantskap tussen die afhanklike en onafhanklike veranderlikes korrek genoem.*	✓

Example/*Voorbeeld*:
Reaction rate increases with increase in concentration./Reaction rate is proportional to concentration.
Reaksietempo neem toe met toename in konsentrasie./Reaksietempo is eweredig aan konsentrasie.
IF/INDIEN
DIRECTLY proportional/*DIREK eweredig:* Max/*Maks.*: $\frac{1}{2}$ (2)

5.3

5.3.1 Activation energy/(The boundary line for the) molecules with (adequate) kinetic energy to make effective collisions. ✓
Aktiveringsenergie/(Die grenslyn vir die) molekule met (genoeg) kintiese energie vir effektiewe botsings. (1)

5.3.2 B ✓ (1)

5.3.3
- At a higher temperature particles move faster/have a higher kinetic energy. ✓
  By 'n hoër temperatuur beweeg die deeltjies vinniger/het die deeltjies hoër kinetiese energie.
- More molecules have enough/sufficient (kinetic) energy. ✓
  Meer molekule het genoeg/voldoende (kinetiese) energie.
  OR/*OF*
  More molecules have (kinetic) energy equal to or greater than activation energy.
  Meer molekule het (kinetiese) energie gelyk aan of groter as aktiveringsenergie.
- More effective collisions per unit time/second./Increased frequency of effective collisions.
  Meer effektiewe botsings per eenheidtyd/sekonde./Frekwensie van effektiewe botsings neem toe.
- Reaction rate increases. ✓
  Reaksietempo neem toe. (4)

5.4 Curve **Y**/it was obtained for the reaction where a catalyst was added. ✓
*Kurwe **Y**/dit is vir die reaksie waar 'n katalisator bygevoeg is, verkry.*

OR/*OF*
Curve **X** was obtained for the reaction in the absence of a catalyst.
*Kurwe **X** is verkry vir die reaksie sonder 'n katalisator.* (1)

5.5

Marking guidelines/*Nasienriglyne*

- Any formula/*Enige formule*: $n = \frac{m}{M}$ or/*of* $c = \frac{n}{V}$ ✓
- Substitute/*Vervang* 0,1 dm^3 in n = cV ✓
- Use mole ratio/*Gebruik molverhouding*:
  $n(S)_{expected/verwag} = ½n(HCℓ)_{used/gebruik}$ ✓
- Substitution of/*Vervanging van* 32 g·mol^{-1} in $n = \frac{m}{M}$ ✓
- SUBSTITUTE in/*VERVANG in:*
  $\frac{n(S)_{produced/berei}}{n(S)_{expected/verwag}} \times 100 \ / \ \frac{m(S)_{produced/berei}}{m(S)_{expected/verwag}} \times 100$ ✓
- Final answer/*Finale antwoord:* 56,25% to 60% ✓

<table>
<tr>
<td>

OPTION 1/*OPSIE 1*

$n(HC\ell)_{used/gebruik} = cV$ ✓
$= 0,2 \times 0,1$ ✓
$= 0,02$ mol

$n(S)_{expected/verwag} = \frac{1}{2}n(HC\ell)_{used/gebruik}$
$= \frac{1}{2}(0,02)$ ✓
$= 0,01$ mol

$n(S)_{produced/berei} = \frac{m}{M}$
$= \frac{0,18}{32}$ ✓
$= 0,0056$ mol

$\%yield/opbrengs = \frac{n(S)_{prod/berei}}{n(S)_{exp/verwag}} \times 100$
$= \frac{0,0056}{0,01} \times 100$ ✓
$= 56,25\%$ ✓

</td>
<td>

OPTION 2/*OPSIE 2*

$n(HC\ell)_{used/gebruik} = cV$ ✓
$= 0,2 \times 0,1$ ✓
$= 0,02$ mol

$n(S)_{expected/verwag} = \frac{1}{2}n(HC\ell)_{used/gebruik}$
$= \frac{1}{2}(0,02)$ ✓
$= 0,01$ mol

$m(S)_{expected/verwag} = nM$
$= (0,01)(32)$ ✓
$= 0,32$ g

$\%yield/opbrengs = \frac{m(S)_{prod/berei}}{m(S)_{exp/verwag}} \times 100$
$= \frac{0,18}{0,32} \times 100$ ✓
$= 56,25\%$ ✓

</td>
</tr>
</table>

(6)
[18]

QUESTION 6/*VRAAG 6*

6.1 Reversible reaction/Both forward and reverse reactions can take place./Products can be converted back to reactants. ✓
Omkeerbare reaksie/Beide voorwaartse en terugwaartse reaksies kan plaasvind./Produkte kan terugverander word na reaktanse. (1)

6.2 To favour the forward reaction/production of ammonia./To increase the yield of ammonia./Prevent the decomposition of NH_3. ✓
Om die voorwaartse reaksie/produksie van ammoniak te bevoordeel./Om die ammoniak-opbrengs te verhoog./Voorkom die ontbinding van NH_3. (1)

6.3 20(%) ✓ (1)

6.4

6.4.1 At 500 °C lower yield of ammonia:

- The (forward) reaction is exothermic./Reverse reaction is endothermic. ✓
  Die (voorwaartse) reaksie is eksotermies./Terugwaartse reaksie is endotermies.
- An increase in temperature favours the endothermic reaction. ✓
  'n Toename in temperatuur bevoordeel die endotermiese reaksie.
- The reverse reaction is favoured.✓
  Die terugwaartse reaksie word bevoordeel.

OR/*OF*

At 350 °C higher yield of ammonia:

- The (forward) reaction is exothermic./Reverse reaction is endothermic. ✓
  Die (voorwaartse) reaksie is eksotermies./Terugwaartse reaksie is endotermies.
- A decrease in temperature favours the exothermic reaction. ✓
  'n Afname in temperatuur bevoordeel die eksotermiese reaksie.
- The forward reaction is favoured. ✓
  Die voorwaartse reaksie word bevoordeel. (3)

6.4.2 At 350 atm higher yield of ammonia:

- An increase in pressure favours the reaction that produces the lower number of moles/number of molecules/volume of gas. ✓
  'n Toename in druk bevoordeel die reaksie wat die kleiner aantal mol/aantal molekule/volume gas lewer.
- The forward reaction is favoured. ✓
  Die voorwaartse reaksie word bevoordeel.

OR/*OF*

At 150 atm lower yield of ammonia:

- A decrease in pressure favours the reaction that produces the higher number of moles/number of molecules/volume of gas. ✓
  'n Afname in druk bevoordeel die reaksie wat die groter aantal mol/aantal molekule/volume gas lewer.
- Reverse reaction is favoured. ✓
  Die terugwaartse reaksie word bevoordeel. (2)

6.5

6.5.1 1 mol N_2 reacts with 3 mol H_2 to produce 2 mol NH_3
∴ 2 mol N_2 reacts with 6 mol H_2 to produce 4 (mol) NH_3 ✓✓ **(2 or 0)**

1 mol N_2 reageer met 3 mol H_2 om 2 mol NH_3 te lewer
∴ 2 mol N_2 reageer met 6 mol H_2 om 4 (mol) NH_3 te vorm ***(2 of 0)*** (2)

6.5.2 **POSITIVE MARKING FROM QUESTION 6.5.1.**

Marking criteria/*Nasienriglyne:*

- Calculate 35% of 4 mol NH_3 (answer from Q6.5.1). ✓
- Use mol ratio/*Gebruik molverhouding* $n(N_2) : n(H_2) : n(NH_3) = 1 : 3 : 2$ ✓
- Equilibrium/*Ewewig* $n(N_2)$ = initial/*aanvanklike* $n(N_2) - \Delta n(N_2)$
Equilibrium/*Ewewig* $n(H_2)$ = initial/*aanvanklike* $n(H_2) - \Delta n(H_2)$ ✓
- Divide by/*Deel deur* 0,5 dm^3. ✓
- Correct K_c expression (formulae in square brackets). ✓
Korrekte K_c uitdrukking (formules in vierkantige hakies).
- Substitution of concentrations into correct K_c expression. ✓
Vervanging van konsentrasies in korrekte K_c-uitdrukking.
- Final answer/*Finale antwoord*: 0,002 ✓
Range/*Gebied*: 0,00155 to 0,002 ($1,55 \times 10^{-3}$ to 2×10^{-3})

$$n(NH_3) = \frac{35}{100} \times 4 \checkmark$$
$$= 1,4 \text{ mol}$$

	N_2	H_2	NH_3	
Initial amount (moles) *Aanvangs hoeveelheid (mol)*	6	6	0	
Change in amount (moles) *Verandering in hoeveelheid* (mol)	0,7	2,1	1,4	ratio ✓ *verhouding*
Equilibrium amount (moles) *hoeveelheid* (mol)	5,3	3,9 ✓	1,4	
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	10,6	7,8	2,8	Divide by 0,5 dm^3 ✓

$$K_c = \frac{[NH_3]^2}{[H_2]^3[N_2]} \checkmark$$
$$= \frac{(2,8)^2}{(7,8)^3(10,6)} \checkmark$$
$$= 0,002 \checkmark$$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{6}{7}$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{4}{7}$

(7)
[17]

QUESTION 7/*VRAAG 7*

7.1 A base forms hydroxide ions (OH^-) in water/aqueous solution. ✓✓
'n Basis vorm hidroksiedione (OH^-) in water/waterige oplossing.

IF/*INDIEN*: A base ionises to form hydroxide ions (OH^-). ✓ *'n Basis ioniseer om hidroksiedione (OH^-) te vorm.* *Max./Maks.* $\frac{1}{2}$

(2)

7.2 A <u>strong base</u> <u>ionises/dissociates completely</u> ✓ and a <u>weak base</u> <u>ionises/dissociates incompletely</u>. ✓
'n <u>Sterk basis ioniseer/dissosieer volledig</u> en 'n <u>swak basis ioniseer/dissosieer onvolledig</u>. (2)

7.3 $HCO_3^-(aq) + H_2O(\ell)$ ✓ $\rightleftharpoons H_2CO_3(aq) + OH^-(aq)$ ✓ Bal. ✓

Accept/*Aanvaar*
$NaHCO_3(aq) + H_2O(\ell) \rightleftharpoons H_2CO_3(aq) + NaOH(aq)$

<u>Notes/*Aantekeninge:*</u> • Reactants/*Reaktanse* ✓ Products/*Produkte* ✓ Balancing/*Balansering* ✓ • Ignore single arrow./*Ignoreer enkelpyl.* • Marking rule 6.3.10./*Nasienreël 6.3.10.* • Ignore phases/*Ignoreer fases.*

(3)

7.4
7.4.1 pH $= -\log[H_3O^+]$ ✓
$= -\log(0,2)$ ✓
$= 0,70$ ✓ (0,699) (3)

7.4.2 Titration of a weak base and a strong acid. ✓
Titrasie van 'n swak basis en 'n sterk suur.

OR/*OF*
The endpoint will be at pH < 7./*Die eindpunt sal by 'n pH < 7.* (1)

7.4.3

Marking guidelines/*Nasienriglyne:*

- Any formulae/*Enige formule:* $c = \frac{n}{V}$ / $n = \frac{m}{M}$ / $\frac{c_a \times V_a}{c_b \times V_b} = \frac{n_a}{n_b}$ / $c = \frac{m}{MV}$ ✓
- Substitute/*Vervang* 0,2 mol·dm^{-3} & 20 x 10^{-3}/0,02 dm^3 or 20 cm^3. ✓
- Use mol ratio/*Gebruik molverhouding* n($XHCO_3$) : n(HCℓ) = 1 : 1 ✓
- Substitute/*Vervang* n($XHCO_3$) or/*of* c($XHCO_3$) AND/*EN* 0,4 g. ✓
- M(X) = 39 g·mol^{-1} ✓
- X = K/potassium/*kalium*. ✓

OPTION 1/*OPSIE 1*

c(HCℓ) = $\frac{n}{V}$ ✓

$\therefore\ 0,2 = \frac{n}{20 \times 10^{-3}}$ ✓

n(HCℓ) = 4 x 10^{-3} mol

n($XHCO_3$) = n(HCℓ) ✓
= 4 x 10^{-3} mol

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

$\therefore\ 4 \times 10^{-3} = \frac{0,4}{M}$ ✓

M = 100 g·mol^{-1}

M($XHCO_3$) = M(X) + 61
= 100

$\therefore$ M(X) = 39 g·mol^{-1} ✓

X = K ✓
OR/*OF*
potassium/*kalium*

1 mol M($XHCO_3$) → 4 x 10^{-3} mol → 0,4 g ✓
M($XHCO_3$) = 100 g·mol^{-1}

M($XHCO_3$) = M(X) + 61
= 100

$\therefore$ M(X) = 39 g·mol^{-1} ✓

X = K ✓
OR/*OF*
potassium/*kalium*

OPTION 2/*OPSIE 2*

$\frac{c_a \times V_a}{c_b \times V_b} = \frac{n_a}{n_b}$ ✓

$\frac{0,2 \times 20}{c_b \times 100}$ ✓ $= \frac{1}{1}$ ✓

c_b = 0,04 mol·dm^{-3}

$c(XHCO_3) = \frac{m}{MV}$

$\therefore 0,04 = \frac{0,4}{M(0,1)}$ ✓

M($XHCO_3$) = 100 g·mol^{-1}

M($XHCO_3$) = M(X) + 61
= 100

$\therefore$ M(X) = 39 g·mol^{-1} ✓

X = K ✓
OR/*OF*
potassium/*kalium*

(6)
[17]

QUESTION 8/*VRAAG 8*

8.1 It is a conductor of electricity/a solid to connect wires to./Pt is inert or unreactive. ✓
Dit is 'n geleier van elektrisiteit/'n vaste stof waaraan drade geskakel kan word./Pt is inert of onreaktief.

OR/*OF*
$C\ell^-$(aq) and chlorine gas are not solids and cannot be used as an electrode.
$C\ell^-$(aq) en chloorgas is nie vaste stowwe nie en kan nie as 'n elektrode gebruik word nie. (1)

8.2

8.2.1 Chemical (energy) to electrical (energy) ✓
Chemiese (energie) na elektriese (energie) (1)

8.2.2 $C\ell_2 + 2e^- \rightarrow 2C\ell^-$ ✓✓

<u>Marking guidelines/*Nasienriglyne*</u>

- $C\ell_2 + 2e^- \rightleftharpoons 2C\ell^-$ $\frac{1}{2}$ $2C\ell^- \rightleftharpoons C\ell_2 + 2e^-$ $\frac{0}{2}$
  $2C\ell^- \leftarrow C\ell_2 + 2e^-$ $\frac{2}{2}$ $2C\ell^- \rightarrow C\ell_2 + 2e^-$ $\frac{0}{2}$
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (-) omitted on $C\ell^-$/*Indien lading (-) weggelaat op $2C\ell^-$:*
  Max./*Maks:* $\frac{1}{2}$ Example/*Voorbeeld:* $C\ell_2 + 2e^- \rightarrow 2C\ell$ ✓

(2)

8.2.3 <u>$Cr(s) \mid Cr^{3+}(aq)$</u> ✓ ✓|| <u>$C\ell_2(g) \mid C\ell^-(aq) \mid Pt(s)$</u> ✓

OR/*OF*
$Cr(s) \mid Cr^{3+}(1\ mol{\cdot}dm^{-3}) \parallel C\ell_2(g) \mid C\ell^-\ (1\ mol{\cdot}dm^{-3}) \mid Pt(s)$

<u>Accept/*Aanvaar:*</u>
$Cr \mid Cr^{3+} \parallel C\ell_2 \mid C\ell^- \mid Pt$ (3)

8.3

<u>OPTION 1/*OPSIE 1*</u>

$E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ ✓
$= 1{,}36$ ✓ $- (-0{,}74)$ ✓
$E^\theta_{cell} = 2{,}10\ V$ ✓

<u>Notes/*Aantekeninge*</u>

- Accept any other correct formula from the data sheet./*Aanvaar enige ander korrekte formule vanaf gegewensblad.*
- Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik bv. $E°_{sel} = E°_{OM} - E°_{RM}$ gevolg deur korrekte vervangings:* $\frac{3}{4}$

<u>OPTION 2/*OPSIE 2*</u>

$C\ell_2 + 2e^- \rightarrow 2C\ell^-$ $E^\theta = 1{,}36\ V$ ✓
$Cr(s) \rightarrow Cr^{3+}(aq) + 3e^-$ $E^\theta = +0{,}74\ V$ ✓
✓
$2Cr(s) + 3C\ell_2(g) \rightarrow 2Cr^{3+}(aq) + 6C\ell^-(aq)$ $E^\theta = +2{,}10\ V$ ✓ (4)

8.4 Increases/*Verhoog* ✓✓ (2)
[13]

QUESTION 9/*VRAAG 9*

9.1 Electrolytic/*Elektrolities* ✓ (1)

9.2 $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ ✓✓

Marking guidelines/*Nasienriglyne*

- $2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$ $\frac{1}{2}$ $H_2 + 2OH^- \rightleftharpoons 2H_2O + 2e^-$ $\frac{0}{2}$

  $H_2 + 2OH^- \leftarrow 2H_2O + 2e^-$ $\frac{2}{2}$ $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$ $\frac{0}{2}$
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (-) omitted on OH^-/*Indien lading (-) weggelaat op* OH^-: Max./*Maks:* $\frac{1}{2}$ Example/*Voorbeeld:* $2H_2O + 2e^- \rightarrow H_2 + 2OH$ ✓

(2)

9.3

9.3.1 Chlorine (gas) / $C\ell_2$ /*Chloor(gas)* ✓ (1)

9.3.2 P ✓ & Y ✓ (2)

9.4 Cathode/*Katode* ✓
Reduction takes place here./Gains electrons.✓
Reduksie vind hier plaas./Wins van elektrone. (2)

9.5 $CuC\ell_2(aq)$ ✓ $\rightarrow Cu(s) + C\ell_2(g)$✓ Bal ✓
OR/OF
$Cu^{2+}(aq) + 2C\ell^- \rightarrow Cu(s) + C\ell_2(g)$

Notes/*Aantekeninge:*
- Reactants/*Reaktanse* ✓ Products/*Produkte* ✓ Balancing/*Balansering* ✓
- Ignore double arrows./*Ignoreer dubbelpyle.*
- Marking rule 6.3.10./*Nasienreël 6.3.10.*
- Ignore phases/*Ignoreer fases.*

(3)
[11]

QUESTION 10/*VRAAG 10*

10.1

10.1.1 II – IV – III - I ✓ (1)

10.1.2 $2NH_3 + H_2SO_4$ ✓ → $(NH_4)_2SO_4$ ✓ Bal ✓

Notes/*Aantekeninge:*
- Reactants/*Reaktanse* ✓ Products/*Produkte* ✓ Balancing/*Balansering* ✓
- Ignore double arrows./*Ignoreer dubbelpyle.*
- Marking rule 6.3.10./*Nasienreël 6.3.10.*

(3)

10.1.3 Vanadium pentoxide/*Vanadiumpentoksied* ✓ (1)

10.1.4 $SO_3(g) + H_2SO_4$ ✓→ $H_2S_2O_7$ ✓ Bal ✓

Notes/*Aantekeninge:*
- Reactants/*Reaktanse* ✓ Products/*Produkte* ✓ Balancing/*Balansering* ✓
- Ignore double arrows./*Ignoreer dubbelpyle.*
- Marking rule 6.3.10./*Nasienreël 6.3.10.*

(3)

10.1.5 Sulphuric acid will form (white) mists./The reaction is very exothermic/gives off too much heat./Corrosive reaction. ✓
Swawelsuur sal (wit) mis vorm./Die reaksie is té eksotermies/gee te veel warmte af./Vretende reaksie. (1)

10.2

Marking criteria/*Nasienriglyne:*
- Calculate m(fertiliser)./*Bereken m(kunsmis).* ✓
- Use ratio/*gebruik verhouding:* $\frac{2}{X+3}$/m(P) = ½m(K) ✓
- Use/*Gebruik* m(K) = 3,33 kg ✓
- Final answer/*Finale antwoord:* 3 ✓

OPTION 1/*OPSIE 1*

$m(\text{fertiliser}) = \frac{20}{100} \times 50$ ✓
$= 10\text{ kg}$

$m(K) = \frac{2}{X+3} \times 10$

$\therefore 3{,}33$ ✓ $= \frac{2}{X+3}$ ✓ $\times 10$

$\therefore X = 3$ ✓

OPTION 2/*OPSIE 2*

$m(K) = \frac{2}{X+3}$ ✓ $\times \frac{20}{100}$ x 50 ✓ = 3,33 ✓

X = 3 ✓

OPTION 3/*OPSIE 3*

$(\text{fertiliser}) = \frac{20}{100} \times 50$ ✓
$= 10\text{ kg}$

m(P) = ½m(K) ✓
= ½(3,33) = 1,665 kg

m(X) = 10 – 3,33 ✓– 1,665
= 5,005

N : P : K = 5,005 : 1,665 : 3,33
= 3 : 1 : 2

∴ X = 3 ✓

(4)
[13]

TOTAL/*TOTAAL*: 150

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2019

MARKS: 150

TIME: 3 hours

This question paper consists of 14 pages and 4 data sheets.

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INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.

2. This question paper consists of TEN questions. Answer ALL the questions in the ANSWER BOOK.

3. Start EACH question on a NEW page in the ANSWER BOOK.

4. Number the answers correctly according to the numbering system used in this question paper.

5. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

8. You are advised to use the attached DATA SHEETS.

9. Show ALL formulae and substitutions in ALL calculations.

10. Round off your FINAL numerical answers to a minimum of TWO decimal places.

11. Give brief motivations, discussions, etc. where required.

12. Write neatly and legibly.

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QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 Which ONE of the following compounds has the HIGHEST vapour pressure?

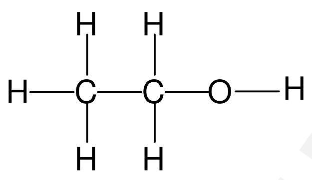
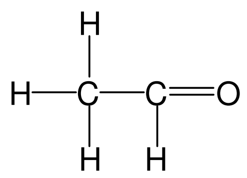
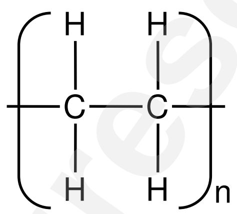
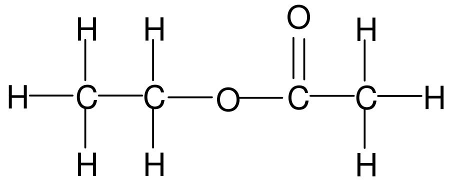
A $HCOOH$

B CH_3CHO

C CH_3CH_2OH

D $CH_3CH_2CH_3$ (2)

1.2 Which ONE of the formulae below represents the product of a POLYMERISATION reaction?

A		**B**	
C		**D**	

(2)

1.3 Which ONE of the following combinations are BOTH UNSATURATED HYDROCARBONS?

A Ethane and ethene

B Ethene and ethyne

C Ethane and ethanol

D Ethanoic acid and ethene (2)

1.4 Which ONE of the following sets of values for activation energy (**E_a**) and heat of reaction (Δ**H**) is possible for a reaction?

	ACTIVATION ENERGY (E_a) ($kJ \cdot mol^{-1}$)	**HEAT OF REACTION (ΔH) ($kJ \cdot mol^{-1}$)**
A	100	+100
B	50	+100
C	50	+50
D	100	-50

(2)

1.5 Consider the following balanced equation for a system at equilibrium:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

How will the addition of a catalyst to the equilibrium mixture affect the YIELD and REACTION RATE?

	YIELD	**REACTION RATE**
A	Increases	Increases
B	Remains the same	Remains the same
C	Remains the same	Increases
D	Decreases	Increases

(2)

1.6 A hypothetical reaction reaches equilibrium at a certain temperature in a closed container according to the following balanced equation:

$$A(g) + 2B(g) \rightleftharpoons 3C(s) \qquad \Delta H < 0$$

Which ONE of the following changes to the equilibrium conditions will result in an INCREASE in the equilibrium constant, K_c?

A Increase in temperature

B Decrease in temperature

C Increase in pressure at constant temperature

D Decrease in pressure at constant temperature (2)

1.7 A hydrochloric acid solution, HCℓ(aq), and an acetic acid solution, CH_3COOH(aq), of EQUAL CONCENTRATIONS are compared.

How do the H_3O^+(aq) concentration of HCℓ(aq) and the pH of HCℓ(aq) compare to that of CH_3COOH(aq)?

	[H_3O^+] of HCℓ(aq)	**pH of HCℓ(aq)**
A	Higher than	Higher than
B	Higher than	Lower than
C	Equal to	Equal to
D	Higher than	Equal to

(2)

1.8 Two hypothetical half-reactions and their respective reduction potentials are shown below:

$$B^+(aq) + e^- \rightleftharpoons B(s) \qquad E^\theta = -1{,}5\ V$$
$$A^{2+}(aq) + 2e^- \rightleftharpoons A(s) \qquad E^\theta = 2{,}5\ V$$

A galvanic cell is set up using the above substances.

Which ONE of the following statements is CORRECT for this galvanic cell?

A B(s) is the reducing agent.

B A(s) is the oxidising agent.

C The mass of B(s) will increase.

D The mass of A(s) will decrease. (2)

1.9 In an electrolytic cell …

A the anode is the positive electrode.

B oxidation takes place at the cathode.

C electrons flow from the cathode to the anode.

D the mass of the anode increases. (2)

1.10 Which ONE of the following is used as a catalyst in the Ostwald process?

A Iron

B Copper

C Platinum

D Vanadium (V) oxide (2)

[20]

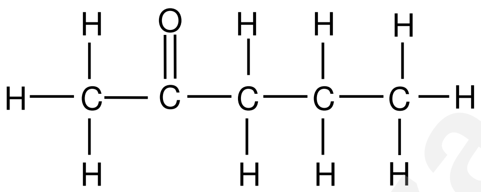
QUESTION 2 (Start on a new page.)

2.1 The IUPAC name of an organic compound is 4,4-dimethylpent-2-yne.

2.1.1 Write down the GENERAL FORMULA of the homologous series to which this compound belongs. (1)

2.1.2 Write down the STRUCTURAL formula of this compound. (3)

2.2 The organic compound below has one positional isomer and one functional isomer.



2.2.1 Define the term *positional isomer.* (2)

For this compound, write down the:

2.2.2 IUPAC name of its POSITIONAL isomer (2)

2.2.3 Structural formula of its FUNCTIONAL isomer (2)

2.3 Consider the condensed structural formula of an organic compound below.

$CH_3CH_2C(CH_3)CH_3$
|
OH

2.3.1 Is this a PRIMARY, SECONDARY or TERTIARY alcohol?
Give a reason for the answer. (2)

2.3.2 Write down the IUPAC name of the above compound. (2)

2.3.3 Write down the IUPAC name of the MAJOR ORGANIC PRODUCT formed when this compound undergoes an elimination reaction. (2)

[16]

QUESTION 3 (Start on a new page.)

The boiling points of five organic compounds (**P**, **Q**, **R, S** and **T**) are studied.

COMPOUND	IUPAC NAME
P	Pentanal
Q	2,2-dimethylbutane
R	3-methylpentane
S	Hexane
T	Pentan-1-ol

3.1 Define the term *boiling point.* (2)

The boiling points of compounds **Q**, **R** and **S** are compared.

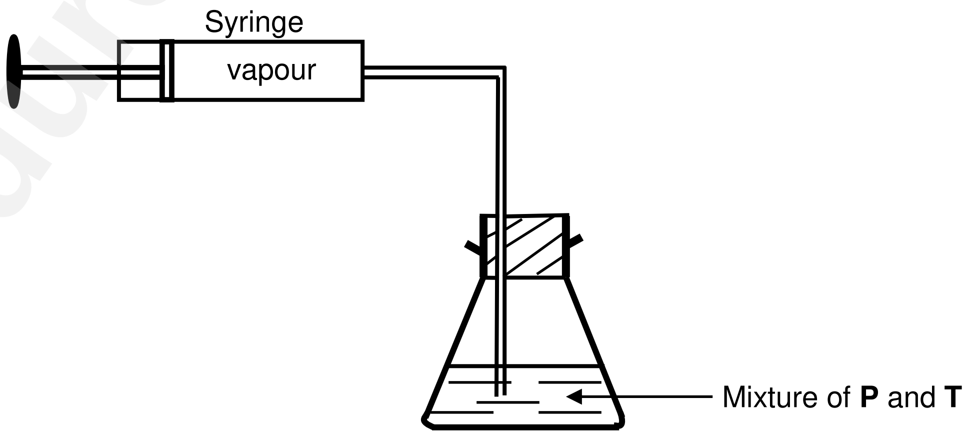
3.2 Give a reason why this is a fair comparison. (1)

The boiling points of **Q**, **R** and **S** are given below (NOT necessarily in the correct order).

55 °C	49,7 °C	68 °C

3.3 Which ONE of the three boiling points is most likely the boiling point of compound **R**? Explain the answer. (4)

3.4 A mixture of equal amounts of **P** and **T** is placed in a flask and heated to a temperature below their boiling points. Assume that no reaction or condensation takes place. The vapour produced is collected in a syringe.

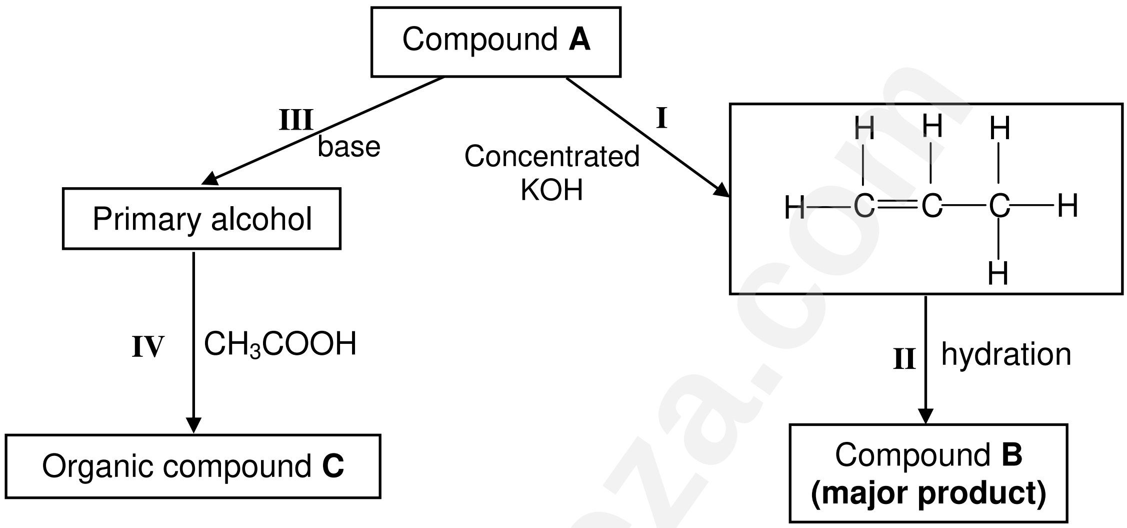


3.4.1 Which compound (**P** or **T**) will be present in a greater amount in the SYRINGE? (2)

3.4.2 Explain the answer to QUESTION 3.4.1 by referring to the TYPES and STRENGTHS of intermolecular forces. (3)
[12]

QUESTION 4 (Start on a new page.)

The flow diagram below shows how compound **A** can be used to prepare other organic compounds. The numbers **I**, **II**, **III** and **IV** represent different organic reactions.



Use the information in the flow diagram to answer the following questions.

4.1 Name the homologous series to which compound **A** belongs. (1)

4.2 Write down the TYPE of reaction represented by:

4.2.1 **I** (1)

4.2.2 **III** (1)

4.2.3 **IV** (1)

4.3 Consider **reaction III**. Write down the:

4.3.1 TWO reaction conditions for this reaction (2)

4.3.2 IUPAC name of the primary alcohol that is formed (2)

4.4 Draw the STRUCTURAL FORMULA for compound **B**. (2)

4.5 Consider **reaction IV**. Write down the:

4.5.1 Structural formula of organic compound **C** (2)

4.5.2 NAME or FORMULA of the catalyst that is used (1)
[13]

QUESTION 5 (Start on a new page.)

The calcium carbonate ($CaCO_3$) in antacid tablets reacts with dilute hydrochloric acid ($HC\ell$) according to the following balanced equation:

$$CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + CO_2(g) + H_2O(\ell) \quad \triangle H < 0$$

5.1 Is the above reaction EXOTHERMIC or ENDOTHERMIC? Give a reason for the answer. (2)

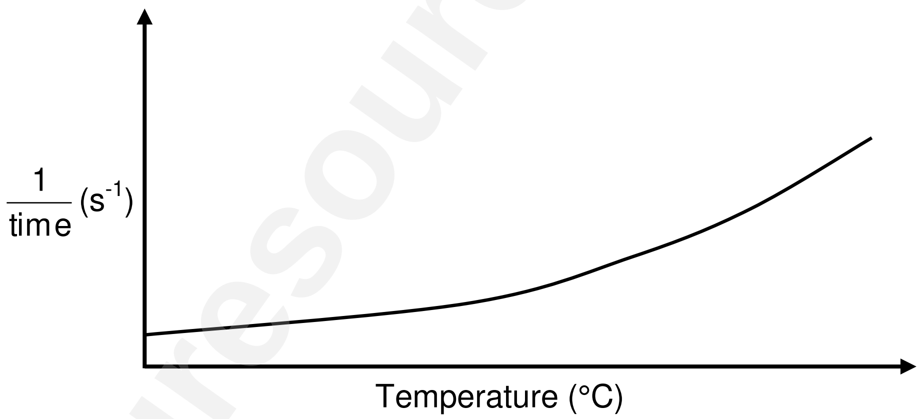
An antacid tablet of mass 2 g is placed in $HC\ell(aq)$. After 30 s the mass of the tablet was found to be 0,25 g.

5.2 Calculate the average rate (in $g \cdot s^{-1}$) of the above reaction. (3)

The antacid tablet contains 40% calcium carbonate. Another antacid tablet of mass 2 g is allowed to react completely with $HC\ell(aq)$.

5.3 Calculate the volume of carbon dioxide, $CO_2(g)$ that will be collected at STP. Assume that all the $CO_2(g)$ produced is from the calcium carbonate. (5)

The reaction rate of similar antacid tablets with excess $HC\ell(aq)$ of concentration 0,1 $mol \cdot dm^{-3}$ at DIFFERENT TEMPERATURES is measured. The graph below was obtained.



Use the information in the graph to answer the following questions.

5.4 Write down ONE controlled variable for this investigation. (1)

5.5 Write down a conclusion that can be made from the graph. (2)

5.6 Use the collision theory to fully explain the answer to QUESTION 5.5 (3)

5.7 Redraw the graph above in the ANSWER BOOK. On the same set of axes, sketch the curve that will be obtained if $HC\ell(aq)$ of concentration 0,2 $mol \cdot dm^{-3}$ is now used. Label this curve **Y**. (2)

[18]

QUESTION 6 (Start on a new page.)

Initially 60,8 g pure carbon dioxide, $CO_2(g)$, is reacted with carbon, C(s), in a sealed container of volume 3 dm^3. The reaction reaches equilibrium at temperature **T** according to the following balanced equation:

$$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$$

6.1 Define the term *chemical equilibrium*. (2)

6.2 At equilibrium it is found that the concentration of the carbon dioxide is 0,054 $mol \cdot dm^{-3}$.

Calculate the:

6.2.1 Equilibrium constant, K_C, for this reaction at temperature **T** (7)

6.2.2 Minimum mass of C(s) that must be present in the container to obtain this equilibrium (3)

6.3 How will EACH of the following changes affect the AMOUNT of CO(g) at equilibrium?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

6.3.1 More carbon is added to the container (1)

6.3.2 The pressure is increased by reducing the volume of the container at constant temperature.
Use Le Chatelier's principle to explain the answer. (3)

6.4 The table below shows the percentages of $CO_2(g)$ and CO(g) in the container at different temperatures.

TEMPERATURE (°C)	% CO_2(g)	% CO(g)
827	6,23	93,77
950	1,32	98,68
1 050	0,37	99,63
1 200	0,06	99,94

6.4.1 Is the reaction EXOTHERMIC or ENDOTHERMIC?
Refer to the data in the table and explain the answer. (3)

6.4.2 Use the information in the table to determine temperature **T**.
Show clearly how you arrived at the answer. (3)
[22]

QUESTION 7 (Start on a new page.)

A hydrogen bromide solution, HBr(aq), reacts with water according to the following balanced chemical equation:

$$HBr(aq) + H_2O(\ell) \rightleftharpoons Br^-(aq) + H_3O^+(aq)$$

The K_a value of HBr(aq) at 25 °C is 1 x 10^9.

7.1 Is hydrogen bromide a STRONG ACID or a WEAK ACID? Give a reason for the answer. (2)

7.2 Write down the FORMULAE of the TWO bases in the above reaction. (2)

7.3 HBr(aq) reacts with $Zn(OH)_2$(s) according to the following balanced equation:

$$Zn(OH)_2(s) + 2HBr(aq) \rightarrow ZnBr_2(aq) + 2H_2O(\ell)$$

An unknown quantity of $Zn(OH)_2$(s) is reacted with 90 cm^3 of HBr(aq) in a flask. (Assume that the volume of the solution does not change during the reaction.)

The EXCESS HBr(aq) is then neutralised by 16,5 cm^3 of NaOH(aq) of concentration 0,5 $mol{\cdot}dm^{-3}$. The balanced equation for the reaction is:

$$HBr(aq) + NaOH(aq) \rightarrow NaBr(aq) + H_2O(\ell)$$

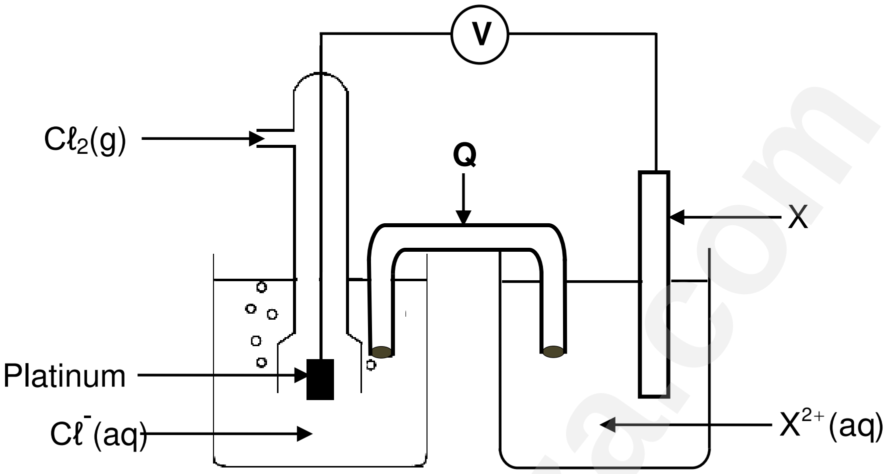
7.3.1 Calculate the pH of the HBr solution remaining in the flask AFTER the reaction with $Zn(OH)_2$(s). (7)

7.3.2 Calculate the mass of $Zn(OH)_2$(s) INITIALLY present in the flask if the initial concentration of HBr(aq) was 0,45 $mol{\cdot}dm^{-3}$. (6)

[17]

QUESTION 8 (Start on a new page.)

A standard electrochemical cell is set up using two standard half-cells, as shown in the diagram below.



8.1 State the energy conversion that takes place in this cell. (1)

8.2 What is the function of component **Q**? (1)

X is a metal. A voltmeter connected across the cell initially registers 1,49 V.

8.3 Use a calculation to identify metal **X**. (5)

8.4 Write down the NAME or FORMULA of the reducing agent. (1)

8.5 The reading on the voltmeter becomes ZERO after this cell operates for several hours.

8.5.1 Give a reason for this reading by referring to the rates of oxidation and reduction half-reactions taking place in the cell. (1)

A silver nitrate solution, $AgNO_3(aq)$, is NOW added to the chlorine half-cell and a precipitate forms.

8.5.2 How will the reading on the voltmeter be affected? (Choose from INCREASES, DECREASES or REMAINS the same) (1)

8.5.3 Use Le Chatelier's principle to explain the answer to QUESTION 8.5.2. (2)
[12]

QUESTION 9 (Start on a new page.)

Chlorine is produced industrially by the electrolysis of a concentrated sodium chloride solution, $NaC\ell(aq)$.

The balanced equation for the net (overall) cell reaction is as follows:

$$2NaC\ell(aq) + 2H_2O(\ell) \rightarrow H_2(g) + 2NaOH(aq) + C\ell_2(g)$$

9.1 Define the term *electrolysis*. (2)

9.2 For the above reaction, write down the:

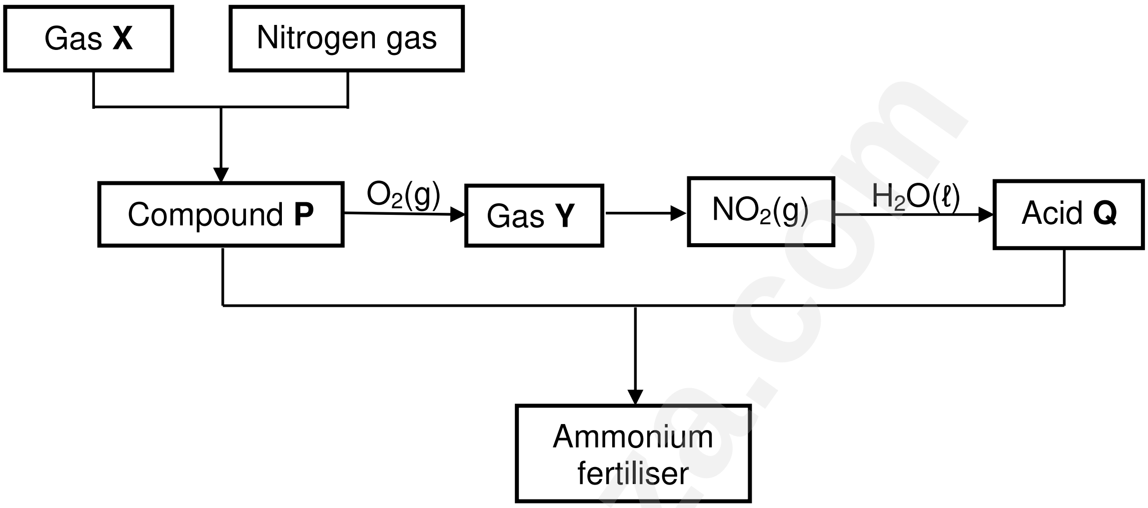
9.2.1 Half-reaction that takes place at the cathode (2)

9.2.2 NAME or FORMULA of the oxidising agent (1)

9.3 Refer to the Table of Standard Reduction Potentials to explain why sodium ions are not reduced during this process. (3)
[8]

QUESTION 10 (Start on a new page.)

The flow diagram below shows the processes involved in the industrial preparation of an ammonium fertiliser.



10.1 Write down the NAME or FORMULA of:

10.1.1 Gas **X** (1)

10.1.2 Gas **Y** (1)

10.1.3 Acid **Q** (1)

10.2 Write down the:

10.2.1 TYPE of chemical reaction that converts compound **P** into gas **Y** (1)

10.2.2 Balanced equation for the reaction between compound **P** and acid **Q** (3)

10.3 Two separate bags of fertilisers are labelled as follows:

BAG A

1 : 3 : 4 (21)
50 kg

BAG B

1 : 3 : 4 (27)
40 kg

10.3.1 What do the numbers (21) and (27) on the labels represent? (1)

10.3.2 Determine, by means of calculations, which bag (**A** or **B**) contains a greater mass of phosphorous. (4)
[12]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1,013 \times 10^{5}$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22,4$ dm$^{3}\cdot$mol^{-1}
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1,6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6,02 \times 10^{23}$ mol^{-1}

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidisingagent} - E^{\theta}_{reducingagent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Electronegativity / *Elektronegatiwiteit*	Atomic number / *Atoomgetal*	Symbol / *Simbool*	Approximate relative atomic mass / *Benaderde relatiewe atoommassa*
1,9	29	Cu	63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 **H** 1																	2 **He** 4
3 1,0 **Li** 7	4 1,5 **Be** 9											5 2,0 **B** 11	6 2,5 **C** 12	7 3,0 **N** 14	8 3,5 **O** 16	9 4,0 **F** 19	10 **Ne** 20
11 0,9 **Na** 23	12 1,2 **Mg** 24											13 1,5 **Aℓ** 27	14 1,8 **Si** 28	15 2,1 **P** 31	16 2,5 **S** 32	17 3,0 **Cℓ** 35,5	18 **Ar** 40
19 0,8 **K** 39	20 1,0 **Ca** 40	21 1,3 **Sc** 45	22 1,5 **Ti** 48	23 1,6 **V** 51	24 1,6 **Cr** 52	25 1,5 **Mn** 55	26 1,8 **Fe** 56	27 1,8 **Co** 59	28 1,8 **Ni** 59	29 1,9 **Cu** 63,5	30 1,6 **Zn** 65	31 1,6 **Ga** 70	32 1,8 **Ge** 73	33 2,0 **As** 75	34 2,4 **Se** 79	35 2,8 **Br** 80	36 **Kr** 84
37 0,8 **Rb** 86	38 1,0 **Sr** 88	39 1,2 **Y** 89	40 1,4 **Zr** 91	41 **Nb** 92	42 1,8 **Mo** 96	43 1,9 **Tc**	44 2,2 **Ru** 101	45 2,2 **Rh** 103	46 2,2 **Pd** 106	47 1,9 **Ag** 108	48 1,7 **Cd** 112	49 1,7 **In** 115	50 1,8 **Sn** 119	51 1,9 **Sb** 122	52 2,1 **Te** 128	53 2,5 **I** 127	54 **Xe** 131
55 0,7 **Cs** 133	56 0,9 **Ba** 137	57 **La** 139	72 1,6 **Hf** 179	73 **Ta** 181	74 **W** 184	75 **Re** 186	76 **Os** 190	77 **Ir** 192	78 **Pt** 195	79 **Au** 197	80 **Hg** 201	81 1,8 **Tℓ** 204	82 1,8 **Pb** 207	83 1,9 **Bi** 209	84 2,0 **Po**	85 2,5 **At**	86 **Rn**
87 0,7 **Fr**	88 0,9 **Ra** 226	89 **Ac**															

58 **Ce** 140	59 **Pr** 141	60 **Nd** 144	61 **Pm**	62 **Sm** 150	63 **Eu** 152	64 **Gd** 157	65 **Tb** 159	66 **Dy** 163	67 **Ho** 165	68 **Er** 167	69 **Tm** 169	70 **Yb** 173	71 **Lu** 175
90 **Th** 232	91 **Pa**	92 **U** 238	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Increasing oxidising ability/*Toenemende oksiderende vermoë* (↑)

Half-reactions/*Halfreaksies*			E^θ (V)
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	⇌	**$H_2(g)$**	**0,00**
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$Na^+ + e^-$	⇌	Na	− 2,71
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Cs^+ + e^-$	⇌	Cs	- 2,92
$K^+ + e^-$	⇌	K	− 2,93
$Li^+ + e^-$	⇌	Li	− 3,05

Increasing reducing ability/*Toenemende reduserende vermoë* (↓)

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Increasing oxidising ability/*Toenemende oksiderende vermoë* (↓)

Increasing reducing ability/*Toenemende reduserende vermoë* (↑)

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	⇌	Li	− 3,05
$K^+ + e^-$	⇌	K	− 2,93
$Cs^+ + e^-$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE
NASIONALE SENIOR SERTIFIKAAT

GRADE/*GRAAD* 12

PHYSICAL SCIENCES: CHEMISTRY (P2)
FISIESE WETENSKAPPE: CHEMIE (V2)

NOVEMBER 2019

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

These marking guidelines consist of 20 pages.
Hierdie nasienriglyne bestaan uit 20 bladsye.

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QUESTION 1/*VRAAG 1*

1.1	D ✓✓	(2)
1.2	C ✓✓	(2)
1.3	B ✓✓	(2)
1.4	D ✓✓	(2)
1.5	C ✓✓	(2)
1.6	B ✓✓	(2)
1.7	B ✓✓	(2)
1.8	A ✓✓	(2)
1.9	A ✓✓	(2)
1.10	C ✓✓	(2)

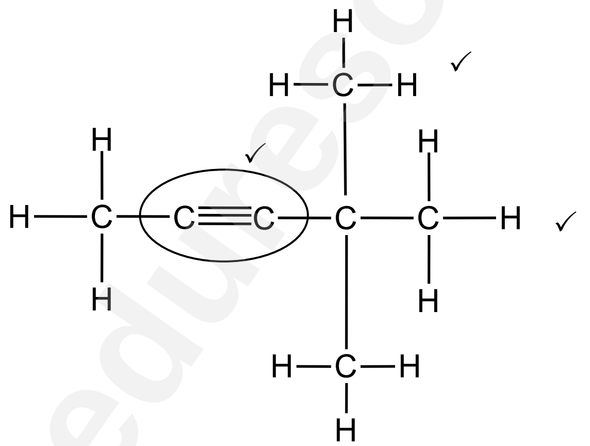
[20]

QUESTION 2/*VRAAG 2*

2.1

2.1.1 C_nH_{2n-2} ✓ (1)

2.1.2



Marking criteria/*Nasienriglyne*

- Functional group correct. ✓
  Funksionele groep korrek.
- 2 methyl substituents. ✓
  2 metielsubstituente.
- Whole structure correct:/*Hele struktuur korrek:* $^{3}/_{3}$

(3)

2.2

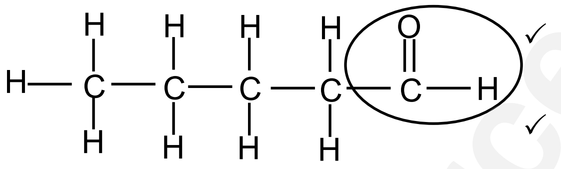
2.2.1 Compounds with the <u>same molecular formula</u>, ✓ but <u>different positions of the side chain/substituents/functional groups</u> ✓on the parent chain.
Verbindings met <u>dieselfde molekulêre formule</u>, maar <u>verskillende posisies van die syketting/substituente/funksionele groepe</u> op die stamketting. (2)

2.2.2 Pentan-3-one/3-pentanone ✓✓
Pentan-3-oon/3-pentanoon

<u>Marking criteria/*Nasienriglyne*</u>
- Functional group and correct position i.e. 3 /*Funksionele groep en korrekte posisie nl. 3.* ✓
- Whole name correct/*Hele naam korrek.* ✓

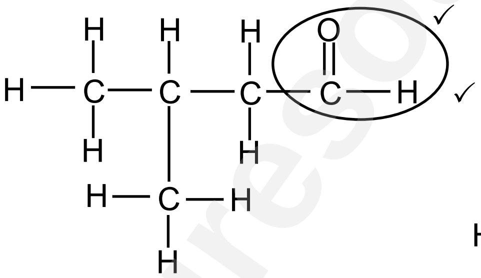
<u>Accept for ONE mark/Aanvaar vir EEN punt</u>
Pentanone with the 3 in incorrect place, e.g. penta-3-none.
Pentanoon met die 3 in foutiewe plek, bv. penta-3-noon. (2)

2.2.3

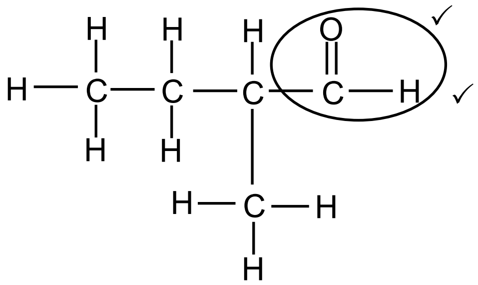


<u>Marking criteria/*Nasienriglyne*</u>
- Whole structure correct:/*Hele struktuur korrek:* $^2/_2$
- Only functional group correct/*Slegs funksionele groep korrek* Max: $^1/_2$

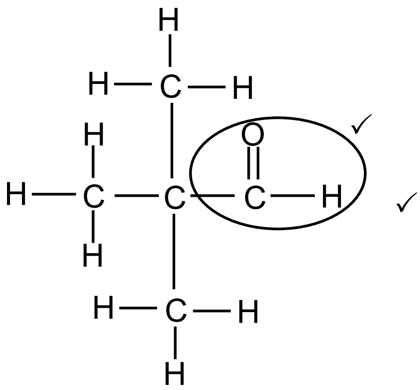
<u>OR: Any correct structure of an aldehyde with five carbon atoms.</u>
<u>OF:Enige korrekte struktuur van 'n aldehied met vyf koolstofatome.</u>



OR/*OF*



OR/*OF*



(2)

 Please turn the page/*Blaai om asseblief*

2.3

2.3.1 Tertiary (alcohol)/*Tersiêre (alkohol)* ✓

The C atom bonded to the functional group/hydroxyl (group)/-OH is bonded to three other C atoms. /The C-atom bonded to the hydroxyl (group) has no hydrogen atoms. ✓
Die C-atoom gebind aan die funksionele groep/hidroksiel(groep)/-OH is gebind aan drie ander C-atome./ Die C-atoom gebind aan die hidroksiel (groep) het geen waterstofatome nie. (2)

2.3.2 2-methylbutan-2-ol/2-methyl-2-butanol/*2-metielbutan-2-ol/2-metiel-2-butanol*

<u>Marking criteria/*Nasienriglyne*</u>
- 2-methyl/*2-metiel* ✓
- Butan-2-ol/2-butanol ✓
- Any error e.g. hyphens omitted and/or incorrect sequence:
  Enige fout, bv. koppeltekens weggelaat en/of verkeerde volgorde: Max./*Maks*: $\frac{1}{2}$

(2)

2.3.3 2-methylbut-2- ene/2-methyl-2-butene/*2-metielbut-2-een/2-metiel-2-buteen*

<u>Marking criteria/*Nasienriglyne*</u>
- 2-methyl/*2-metiel* ✓
- But-2-ene/2-butene/*But-2-een/2-buteen* ✓
- Any error e.g. hyphens omitted and/or incorrect sequence:
  Enige fout, bv. koppeltekens weggelaat en/of verkeerde volgorde: Max./*Maks*: $\frac{1}{2}$

(2)
[16]

QUESTION 3/*VRAAG 3*

3.1

<u>Marking guidelines/*Nasienriglyne*</u>
The <u>underlined key phrases</u> must be used in the **CORRECT CONTEXT (pressure/boiling)**. /*Die onderstreepte frases moet gebruik word in die **KORREKTE KONTEKS (druk/kook)**.*

The <u>temperature</u> ✓ at which the <u>vapour pressure</u> of a substance <u>equals atmospheric/external pressure</u>. ✓
Die <u>temperatuur</u> waar die <u>dampdruk</u> van 'n stof <u>gelyk is aan atmosferiese/ eksterne druk</u>. (2)

3.2 (**Q**, **R** and **S**) have <u>same molecular mass/formulae/number of carbon and hydrogen atoms</u>/are (chain) isomers. ✓
*(**Q**, **R** en **S**) het <u>dieselfde molekulêre massa/formule/aantal koolstof en waterstofatome/ is (ketting)isomere</u>.*

OR/*OF*
The compounds are all <u>alkanes</u> /<u>same homologous series</u> and have the <u>same number of carbon atoms</u>.
Die verbindings is almal <u>alkane</u> /<u>dieselfde homoloë reeks</u> en het die <u>dieselfde aantal koolstofatome.</u> (1)

Marking guidelines/*Nasienriglyne*
- 55 (°C) ✓
- Compare all three compounds or Q and S in terms of branches/chain lengths / surface area. ✓
  Vergelyk al drie verbindings of Q en S in terme van vertakkings/kettinglengte/ oppervlakarea.
- Compare strengths of all three or Q and S's IMF's / *Vergelyk sterkte van al drie of Q en S se IMK'e.*✓
- Compare energy of all three /*Vergelyk energie van al drie.* ✓

3.3 55 (°C) ✓

Compare compound R with compounds Q and S:
- Compound **R** is less branched/compact/spherical/surface area than compound **Q** and more branched/compact/spherical/surface area than compound **S**. ✓
  OR
  Q is the most branched/compact /spherical/surface area and **S** is least branced/compact/spherical/surface area.
- Intermolecular forces in compound **R** are stronger than in compound **Q** and weaker than in compound **S**. ✓
- More energy needed to overcome intermolecular forces in compound **R** than in compound **Q** and less energy needed to overcome (break) intermolecular forces in compound **R** than in compound **S**. ✓

OR
- Compound **R** has a longer chain length than compound **Q** and a shorter chain length than compound **S**. ✓
  OR
  S has the longest chain length and **Q** the shortest.
- Intermolecular forces increase with increase in chain length. ✓
- More energy needed to overcome intermolecular forces as chain length increases. ✓

Vergelyk verbinding R met verbindings Q en S:.
- *Verbinding **R** is minder vertak/kompak/sferieseoppervlak as verbinding **Q** en meer vertak as verbinding **S**.*
  OF
  Q is die meeste vertak/kompak en **S** is die minste vertak/kompak/series/oppervlak.
- *Intermolekulêre kragte in verbinding **R** is sterker as in verbinding **Q** en swakker as in verbinding **S**.*
- *Meer energie word benodig om intermolekulêre kragte in verbinding **R** te oorkom as in verbinding **Q**, en minder energie word benodig om intermolekulêre kragte in verbinding **R** te oorkom / breek as in verbinding **S**.*

OF
- *Verbinding **R** het 'n langer kettinglengte as verbinding **Q** en 'n korter kettinglengte as **S**.*
  OF
  S het die langste ketting en **Q** die kortste.
- *Intermolekulêre kragte neem toe met toename in kettinglengte.*
- *Meer energie word benodig om intermolekulêre kragte te oorkom wanneer kettinglengte toeneem.* (4)

3.4

3.4.1 P ✓✓ (2)

3.4.2

Marking guidelines/*Nasienriglyne*
• Name type of IMFs in **P/pentanal**. ✓ *Noem tipe IMK'e in **P/pentanaal**.* • Name type of IMFs in/*Noem tipe IMK'e in* **T/pentan-1-ol**.✓ • Compare strength of IMFs. /*Vergelyk sterkte van IMK'e.* ✓ **OR**/***OF*** Compare energy needed to overcome IMFs./*Vergelyk energie benodig om IMK'e te oorkom.*

- In **P**/ pentanal/aldehydes: <u>dipole-dipole forces</u> ✓(in addition to London forces/dispersion forces/induced dipole forces).
- In **T**/pentan-1-ol: <u>Hydrogen bonding</u>.✓ (in addition to London forces/dispersion forces/induced dipole forces).
- <u>Intermolecular forces in **P**/pentanal are weaker</u> ✓than in **T**/pentan-1-ol **OR** dipole-dipole forces are weaker than hydrogen bonds **OR** intermolecular forces in **T**/pentan-1-ol are stronger than in **P**/pentanal.
  OR
  <u>More energy needed to overcome/break intermolecular forces in **T**</u>.

- *In **P**/pentanaal/aldehiede: <u>dipool-dipoolkragte</u> (tesame met Londonkragte/ dispersiekragte/geïnduseerde dipoolkragte).*
- *In **T**/pentan-1-ol: Waterstofbinding. (tesame met Londonkragte/ dispersiekragte/geïnduseerde dipoolkragte).*
- *<u>Intermolekulêre kragte in **P** swakker</u> as in **T**/pentan-1-ol **OF** intermolekulêre kragte in **T**/pentan-1-ol sterker as in **P**/pentanaal **OF** dipool-dipoolkragte is swakker as waterstofbindings.*
  OF
  *<u>Meer energie benodig om intermolekulêre kragte te oorkom/breek in **T**</u>.* (3)

[12]

QUESTION 4/*VRAAG 4*

4.1 Haloalkane/alkyl halide ✓
Haloalkaan/alkielhalied (1)

4.2
4.2.1 Elimination/dehydrohalogenation ✓
Eliminasie/dehidrohalogenering (1)

4.2.2 Substitution/hydrolysis ✓
Substitusie/hidrolise (1)

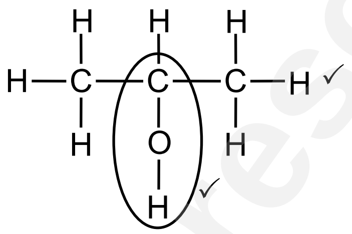
4.2.3 Esterification/condensation ✓
Esterifikasie/kondensasie/verestering (1)

4.3
4.3.1
- (Mild) heat/Heating/*(matige) hitte/ verhitting* ✓
- Dilute (strong base)/*Verdunde (sterk basis)*/(NaOH/KOH/LiOH) ✓
  OR/*OR*
  Add water/H_2O/*Voeg water/H_2O by* (2)

4.3.2 Propan-1-ol/1-propanol ✓✓

Marking criteria/*Nasienriglyne:*
- Correct stem and functional group i.e. propanol/*Korrekte stam en funksionele groep, d.i. propanol.* ✓
- Whole name correct:/*Hele naam korrek*: propan-1-ol ✓

(2)

4.4 

Marking criteria/*Nasienriglyne*
- Whole structure correct:/*Hele struktuur korrek:* $\frac{2}{2}$
- Only functional group correct/*Slegs funksionele groep korrek:* $\frac{1}{2}$

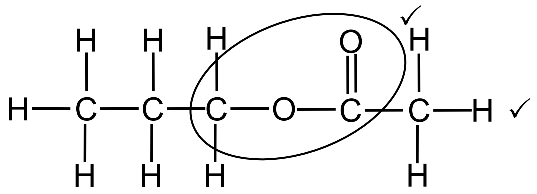
Notes/*Aantekeninge*
- Accept –OH as condensed. /*Aanvaar –OH as gekondenseerd.*
- Condensed or semi-structural formula:
  Gekondenseerde of semi-struktuurformule: Max./*Maks.* $\frac{1}{2}$
- Molecular formula/*Molekulêre formule*: $\frac{0}{2}$
- If functional group is incorrect/*Indien funksionele groep verkeerd is*: $\frac{0}{2}$
- If more than one functional group:
  Indien meer as een funksionele groep: $\frac{0}{2}$

(2)

4.5

<u>POSITIVE MARKING FROM Q4.3.2 ONLY IF THE COMPOUND IN Q4.3.2 IS AN ALCOHOL. /*POSITIEWE NASIEN VANAF V4.3.2 SLEGS INDIEN DIE VERBINDING IN Q4.3.2 'N ALKOHOL IS.*</u>

4.5.1



<u>Marking criteria/*Nasienriglyne*</u>
- Whole structure correct:/*Hele struktuur korrek:* $\frac{2}{2}$
- Only functional group correct/*Slegs funksionele groep korrek:* $\frac{1}{2}$

<u>Notes/*Aantekeninge*</u>
- Condensed or semi-structural formula:
  Gekondenseerde of semistruktuurformule: Max./*Maks.* $\frac{1}{2}$
- Molecular formula/*Molekulêre formule*: $\frac{0}{2}$
- If functional group is incorrect/*Indien funksionele groep verkeerd is*: $\frac{0}{2}$

(2)

4.5.2 (Concentrated) sulphuric acid/*(Gekonsentreerde) swawelsuur*/H_2SO_4 ✓ (1)

[13]

QUESTION 5/*VRAAG 5*

5.1 Exothermic/*Eksotermies* ✓

-

$\Delta H < 0$/Energy is released/*Energie word vrygestel* ✓ (2)

5.2

rate/*tempo* = $-\frac{\Delta m}{\Delta t}$	**OR/*OF*** rate/*tempo* = $-\frac{\Delta m}{\Delta t}$
$= -\frac{0,25-2}{30\checkmark}\checkmark$ $= 0,06\ (g\cdot s^{-1})\ \checkmark$ $(0,0583\ g\cdot s^{-1})$	$= -\frac{-1,75\checkmark}{30\checkmark}$ $= 0,06\ (g\cdot s^{-1})\ \checkmark$ $(0,0583\ g\cdot s^{-1})$

<u>Notes/*Aantekeninge*</u>
Accept negative answer i.e./***Aanvaar*** *negatiewe antwoord d.i.* $-0,06\ g\cdot s^{-1}$.

(3)

5.3

Marking guidelines

- Calculate/*Bereken*: m($CaCO_3$) reacted/*reageer* or / *of* V(CO_2) produced/*gevorm*. ✓
- Substitute/*Vervang*: 100 g·mol^{-1}. ✓
- USE mol ratio/*GEBRUIK molverhouding*: n(CO_2) : n($CaCO_3$) = 1 : 1 ✓
- Use of/ /*Gebruik van* 22,4 dm^{-3}·mol^{-1}.✓
- Final answer/*Finale antwoord*: 0,18 dm^3 (0,1792 dm^3) ✓

OPTION 1/*OPSIE 1*

$m(CaCO_3) = \frac{40}{100} \times 2$ ✓

$= 0,8$ g

$n(CaCO_3)_{reacted} = \frac{m}{M}$

$= \frac{0,8}{100}$ ✓

$= 8 \times 10^{-3}$ mol

$n(CO_2) = n(CaCO_3)$ ✓

$= 8 \times 10^{-3}$ mol

$V(CO_2) = 8 \times 10^{-3} \times 22,4$ ✓

$= 0,18$ dm^3 ✓

OPTION 2/*OPSIE 2*

For 2 g antacid/*teensuurtablet*:

100 g ✓$CaCO_3$ ......22,4 dm^3 ✓ CO_2

2 g $CaCO_3$ .....0,448 dm^3 ✓

100% CO_2 .... 0,448 dm^3 ✓

40% CO_2 .... 0,18 dm^3 ✓

OPTION 3/*OPSIE 3*

100% $CaCO_3$ ....2 g

40% ....0,8 g ✓

100 g ✓....... 1 mol

0,8 g .... 8 x 10^{-3} mol ✓

1 mol ....22,4 dm^3 ✓

8 x 10^{-3} mol ......0,18 dm^3 ✓

(5)

5.4 **ANY ONE/*ENIGE EEN***:

- Concentration (of acid)/*Konsenterasie (van suur)* ✓
- Size/mass of tablet/Identical tablet /Type of tablet.
  Grootte/massa van tablet/Identiese tablet./Tipe tablet.
- State of division / Surface area / *Toestand van verdeeldheid / reaksieoppervlak.* (1)

5.5

Criteria for conclusion/*Riglyne vir gevolgtrekking*:	
Dependent [(reaction) rate/time] and independent (temperature) variables correctly identified. *Afhanklike [(reaksie)tempo/tyd] en onafhanklike (temperatuur) veranderlikes korrek geïdentifiseer.*	✓
Relationship between the independent and dependent variables correctly stated./*Verwantskap tussen die afhanklike en onafhanklike veranderlikes korrek genoem.*	✓

Examples/*Voorbeelde*:

- Reaction rate ($\frac{1}{\text{time}}$) increases with increase in temperature.

  Reaksietempo ($\frac{1}{\text{time}}$) *neem toe met toename in temperatuur.*
- Reaction rate ($\frac{1}{\text{time}}$) decreases with decrease in temperature.

  Reaksietempo ($\frac{1}{\text{time}}$) *neem af met afname in temperatuur.*
- Time taken for reaction decreases when temperature increases.
  Tyd vir die reaksie neem af wanneer temperatuur toeneem.
- Time taken for reaction increases when temperature decreases.
  Tyd vir die reaksie neem toe as temperatuur afneem.

IF/*INDIEN*
Reaction rate is DIRECTLY proportional to temperature: Max. $\frac{1}{2}$
Reaksietempo is DIREK eweredig aan temperatuur: *Maks.* $\frac{1}{2}$

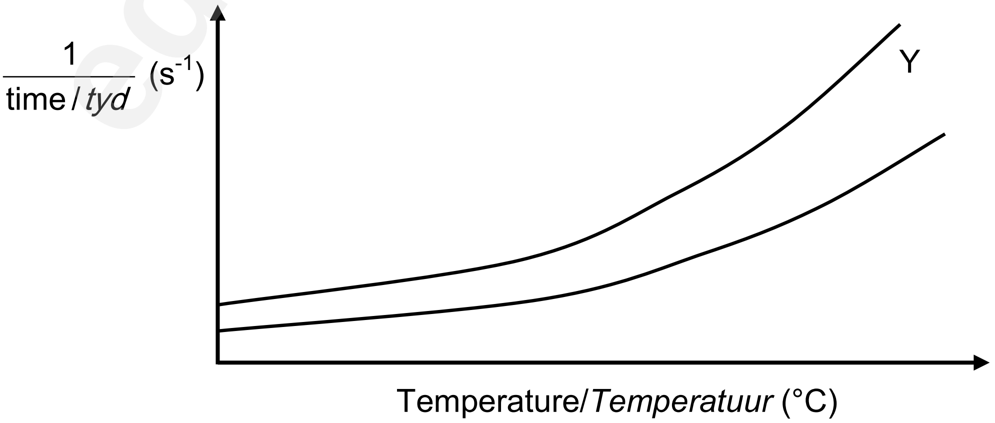
(2)

5.6
- Increase in temperature increases the average kinetic energy/molecules move faster. /*Toename in temperatuur verhoog die gemiddelde kinetiese energie/molekule beweeg vinniger.* ✓
- More molecules have enough/sufficient kinetic energy/More molecules have $E_k > E_a$. ✓
  Meer molekule het genoeg/voldoende kinetiese energie/Meer molekule het $E_k > E_a$.
- More effective collisions per unit time/second. /Frequency of effective collisions increases. ✓
  Meer effektiewe botsings per eenheidtyd/sekonde./Frekwensie van effektiewe botsings neem toe.

(3)

5.7

Marking guidelines/*Nasienriglyne*
• For each value of temperature, the CURVE Y must be above the given CURVE. / *Vir elke waarde van temperatuur, moet kurwe Y bo die gegewe kurwe wees.* ✓
• CURVE Y must have an increasing rate with an increase in temperature. / *KURWE Y moet 'n toenemende tempo het soos die temperatuur toeneem.* ✓



(2)
[18]

QUESTION 6/*VRAAG 6*

6.1 (The stage in a chemical reaction when the) <u>rate of forward reaction equals the rate of reverse reaction</u>. ✓✓
(Die stadium in 'n chemiese reaksie wanneer die) <u>tempo van die voorwaartse reaksie gelyk is aan die tempo van die terugwaartse reaksie</u>. **(2 or/*of* 0)**

OR/*OF*
(The stage in a chemical reaction when the) <u>concentrations of reactants and products remain constant.</u>
(Die stadium in 'n chemiese reaksie wanneer die) <u>konsentrasies van reaktanse en produkte konstant bly</u>. **(2 or/*of* 0)** (2)

6.2 **<u>CALCULATIONS USING NUMBER OF MOLES</u>**
<u>BEREKENINGE WAT AANTAL MOL GEBRUIK</u>

6.2.1 **<u>Marking guidelines/*Nasienriglyne*</u>**

- Substitute/*Vervang*: 44 g·mol^{-1}. ✓
- Equilibrium concentration of CO_2 multiply by 3 dm^3
  Ewewigskonsentrasie van CO_2 vermenigvuldig met 3 dm^3
  AND/*EN* $n(CO)_{eq}$ divide by /*deel* deur 3 dm^3 ✓
- Use mole ratio/*Gebruik molverhouding:* 1:2 / n(CO) = 2n(CO_2). ✓
- $n(CO_2)_{change} = n(CO_2)_{initial} - n(CO_2)_{final}$
  $n(CO)_{eq/ewe} = n(CO)_{initial/begin} + \Delta n(CO)$ ✓
- Correct K_c expression (<u>formulae in square brackets</u>). ✓
  Korrekte K_c-uitdrukking (<u>formules in vierkanthakies</u>).
- Substitution of concentrations into K_c expression. ✓
  Vervanging van konsentrasies in K_c-uitdrukking.
- Final answer/*Finale antwoord*: 12,24 (range/*gebied*: 11,85 – 12,66) ✓

OPTION 1/*OPSIE 1*

$n(CO_2) = \frac{m}{M}$

$= \frac{60,8}{44}$ ✓

$= 1,382$ mol

	CO_2	CO	
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	1,382	0	
Change (mol) *Verandering (mol)* ✓	1,22	2,44	Use ratio/*Gebruik verhouding* ✓
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	0,162	2,44	
Equilibrium concentration ($mol·dm^{-3}$) *Ewewigskonsentrasie ($mol·dm^{-3}$)*	0,054	0,813	Divide/multiply by 3/*Deel/ vermenigvuldig met 3* ✓

$K_c = \frac{[CO]^2}{[CO_2]}$ ✓

$= \frac{(0,813)^2}{0,054}$ ✓

$= 12,24$ ✓

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie:* Max./*Maks.* $\frac{6}{7}$
Wrong K_c expression/*Verkeerde K_c- uitdrukking*: Max./*Maks.* $\frac{4}{7}$

OPTION 2/*OPSIE 2*

$n(CO_2) = \frac{m}{M}$

$= \frac{60,8}{44}$ ✓

$= 1,382$ mol

$n(CO_2)_{change} = n(CO_2)_{initial/begin} - n(CO_2)_{final/finaal}$

$= 1,382 – 0,162$

$= 1,22$ mol

$n(CO)_{change} = 2(CO_2)$

$= 2(1,22)$ ✓

$= 2,44$ mol

$n(CO)_{eq} = n(CO)_{change} = 2,44$ mol ✓

$c(CO) = \frac{n}{V}$

$= \frac{2.44}{3}$ ✓

$= 0,813$ $mol·dm^{-3}$

$K_c = \frac{[CO]^2}{[CO_2]}$ ✓

$= \frac{(0,813)^2}{0,054}$ ✓

$= 12,24$ ✓ (Accept range/*Aanvaar gebied*: 11,85 – 12,66).

CALCULATIONS USING CONCENTRATION
BEREKENINGE WAT KONSENTRASIE GEBRUIK

Marking guidelines/*Nasienriglyne*

- Substitute 44 $g \cdot mol^{-1}$. ✓
- Initial $n(CO_2)$ divide by 3 dm^3. ✓
  Aanvanklike $n(CO_2)$ gedeel deur 3 dm^3.
- **USE** ratio/***GEBRUIK*** *verhouding:* $c(CO_2) : c(CO) = 1 : 2$ ✓
- $\Delta c(CO_2) = c(CO_2)_{initial/begin} - c(CO_2)_{eq/ewe}$
  $c(CO)_{eq/ewe} = c(CO)_{initial/begin} + \Delta c(CO)$. ✓
- Correct K_c expression (formulae in square brackets). ✓
  Korrekte K_c uitdrukking (formules in vierkanthakies).
- Substitution of concentrations into K_c expression. ✓
  Vervanging van konsentrasies in K_c-uitdrukking.
- Final answer/*Finale antwoord*: 12,15 (range/*gebied*: 11,85 – 12,66) ✓

OPTION 3/*OPSIE 3*

$$n(CO_2) = \frac{m}{M}$$
$$= \frac{60,8}{44} ✓$$
$$= 1,382 \text{ mol}$$

	CO_2	CO	
Initial concentration ($mol \cdot dm^{-3}$) *Aanvanklike konsentrasie ($mol \cdot dm^{-3}$)*	0,4607	0	Divide by /*Deel deur* 3 dm^3 ✓
Change ($mol \cdot dm^{-3}$) *Verandering ($mol \cdot dm^{-3}$)*	0,4067	0,813	ratio ✓ *verhouding*
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)*	0,054	0,813	

✓

$$K_c = \frac{[CO]^2}{[CO_2]} ✓$$
$$= \frac{(0,813)^2}{0,054} ✓$$
$$= 12,15 ✓$$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie:* Max./*Maks.* $\frac{6}{7}$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{4}{7}$

(7)

6.2.2 **POSITIVE MARKING FROM Q6.2.1/*POSITIEWE NASIEN VANAF V6.2.1***

$n(C)_{reacted/reageer} = n(CO_2)_{reacted/reageer}$
$= 1,22 \text{ mol}$ ✓

$m(C) = nM$
$= 1,22(12)$ ✓
$= 14,64 \text{ g}$ ✓

Marking guidelines
- **USE** mol ratio/ ***GEBRUIK*** *molverhouding*: $n(C) = n(CO_2)$. ✓
- Substitute/*Vervang*: 12 $g \cdot mol^{-1}$. ✓
- Final answer/*Finale antwoord*: 14,64 g. ✓

(3)

6.3

6.3.1 Remains the same/*Bly dieselfde* ✓ (1)

6.3.2 Decreases/*Afneem* ✓

- (When pressure is increased) the reaction that leads to the smaller amount/number of moles/volume of gas is favoured. ✓
  (Wanneer die druk verhoog word,) word die reaksie wat tot die kleiner hoeveelheid/aantal mol/volume gas lei, bevoordeel.
- The reverse reaction is favoured. / More CO_2 is formed. ✓
  Die terugwaartse reaksie word bevoordeel./ meer CO_2 word gevorm. (3)

6.4

6.4.1 Endothermic/*Endotermies* ✓

- When the temperature increases the mol/percentage CO(g)/product increases/forward reaction is favoured./*Wanneer die temperatuur toeneem, neem die mol/persentasie CO(g)/produk toe/voorwaartse reaksie word bevoordeel.* ✓
- An increase in temperature favours the endothermic reaction/*Toename in temperatuur bevoordeel die endotermiese reaksie.* ✓ (3)

6.4.2

POSITIVE MARKING FROM Q6.2.1./*POSITIEWE NASIEN VANAF V6.2.1.*

Marking guidelines/*Nasienriglyne*

- Calculate total volume/mol of gas at equilibrium/*Bereken totale volume/mol gas by ewewig:* 0,162 + 2,44 = 2,606 dm^3 /mol ✓
  OR/*OF*
  Calculate the total concentration at equilibrium/*Bereken die totale konsentrasie by ewewig*: 0,054 + 0,813 = 0,867 $mol{\cdot}dm^{-3}$
- Calculate percentage of ANY one gas/*Bereken persentasie van ENIGE een gas* (CO_2 or/*of* CO). ✓
- Final answer/*Finale antwoord*: T = 827 °C ✓

OPTION 1/*OPSIE 1*

$V_{total\ eq} = 0,162 + 2,44$ ✓
$= 2,606\ dm^3$

$\% CO_2 = \frac{0,162}{2,606} \times 100$ ✓
$= 6,225\ \%$

OR/*OF*

$\% CO = \frac{2,44}{2,606} \times 100$ ✓
$= 93,63\ \%$

OPTION 2/*OPSIE 2*

$c_{total\ eq} = 0,054 + 0,813$
$= 0,867\ mol{\cdot}dm^{-3}$

$\% CO_2 = \frac{0,054}{0,867} \times 100$ ✓
$= 6,228\ \%$

OR/*OF* $\% CO = \frac{0,813}{0,867} \times 100$ ✓
$= 93,77\ \%$

$\therefore$ T = 827 °C ✓ (3)

[22]

QUESTION 7/*VRAAG 7*

7.1 Strong (acid)/*Sterk (suur)* ✓

Large/*Groot* K_a value/*waarde*/ $K_a > 1$ / (HBr) ionises completely/*ioniseer volledig* ✓ (2)

7.2 H_2O ✓

Br^- ✓ (2)

7.3

7.3.1

Marking guidelines/*Nasienriglyne*

- Formula/*Formule:* $c = \frac{n}{V}$ /n = cV / $\frac{c_a \times V_a}{c_b \times V_b} = \frac{n_a}{n_b}$ ✓
- Substitution of/*Vervanging van:* (0,5)(0,0165)/(0,5)(16,5) ✓
- Use mol ratio/*Gebruik molverhouding:* 1:1/n(HBr) = n(NaOH) ✓
- Substitute/*Vervang*: V = 0,09 dm^3 /90 cm^3 ✓
- Formula/*Formule:* pH = -log[H_3O^+] ✓
- Substitute [H_3O^+] in pH formula. ✓
- Final answer/*Finale antwoord*: pH = 1,04 (range/*gebied*: 1,036 – 1,05) ✓

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
$n(NaOH)_{reacted/reageer} = cV$ ✓ $= 0{,}5(0{,}0165)$ ✓ $= 0{,}00825$ mol $n(HBr)_{excess/oormaat} = n(NaOH) = 0{,}00825$ mol ✓ $c(H_3O^+) = \frac{n}{V}$ $= \frac{0{,}00825}{0{,}09}$ ✓ $= 0{,}092\ mol{\cdot}dm^{-3}$ pH = -log[H_3O^+] ✓ = -log(0,092) ✓ = 1,04 ✓	$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$ ✓ $\frac{c_a(90)}{(0{,}5)(16{,}5)} = \frac{1}{1}$ ✓✓✓ $c_a = 0{,}092\ mol{\cdot}dm^{-3}$ pH = -log[H_3O^+] ✓ = -log(0,092) ✓ = 1,04 ✓

(7)

7.3.2

Marking guidelines/*Nasienriglyne*

- Calculate/*Bereken* $n(HBr)_{initial/aanvanklik}$: substitute/*vervang* (0,45)(0,09) in n = cV ✓
- Subtraction/*Aftrekking:*
  $n(HBr)_{reacted/reageer} = n(HBr)_{initial/aanvanklik} - n(HBr)_{reacted\ with/reageer\ met\ NaOH}$. ✓✓
  OR/*OF*: $c(HBr)_{reacted/reageer} = c(HBr)_{initial/aanvanklik} - c(H_3O^+)_{excess/oormaat}$
- Use mol ratio/*Gebruik molverhouding:* $n(Zn(OH)_2) : n(HBr) = 1 : 2$ ✓
- Substitution of/*Vervanging van:* 99 $g\cdot mol^{-1}$ ✓
- Final answer/*Finale antwoord:* 1,5964 g (range/*gebied:* 1,58 – 1,68) ✓

POSITIVE MARKING FROM Q7.3.1/*POSITIEWE NASIEN VANAF V7.3.1*

OPTION 1/*OPSIE 1*

$n(HBr)_{initial/begin} = cV$
$= (0,45)(0,09)$ ✓
$= 0,0405$ mol

$n(HBr\ reacted\ with/reageer\ met\ Zn(OH)_2) = \underline{0,0405 - 0,00825}$ ✓✓
$= 0,03224$ mol

$n(Zn(OH)_2) = \frac{1}{2}n(HBr) = \frac{1}{2}(0,03224)$ ✓ $= 0,016125$ mol

$m(Zn(OH)_2) = nM$
$= (0,016125)(99)$ ✓
$= 1,596$ g ✓

OPTION 2/*OPSIE 2*

$c(HBr) = 0,45 - 0,092$ ✓✓
$= 0,358\ mol\cdot dm^{-3}$

$n(HBr\ reacted/reageer) = cV$
$= 0,358 \times 0,09$ ✓
$= 0,0322$ mol

$n(Zn(OH)_2) = \frac{1}{2}n(HBr) = \frac{1}{2}(0,0322)$ ✓ $= 0,01611$ mol

$m(Zn(OH)_2) = nM$
$= 0,01611 \times 99$ ✓
$= 1,595$ g ✓ (1,60 g)

(6)
[17]

QUESTION 8/*VRAAG 8*

8.1 Chemical to electrical/*Chemies na elektries* ✓ (1)

8.2 Provides path for movement of ions./ Completes the circuit./Ensures electrical neutrality in the cell./Restore charge balance. ✓
Verskaf pad vir beweging van ione./Voltooi die stroombaan./Verseker elektriese neutraliteit in die sel./Herstel balans van lading. (1)

8.3 **OPTION 1/*OPTION 1***

$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ ✓

$1{,}49 = 1{,}36 - E^{\theta}_{anode}$ ✓ ✓

$E^{\theta}_{anode} = 1{,}36 - 1{,}49$

$= -0{,}13\ (V)$ ✓

X is Pb/Lead/*Lood* ✓

Notes/*Aantekeninge*
- Accept any other correct formula from the data sheet. /*Aanvaar enige ander korrekte formule vanaf gegewensblad.*
- Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik, bv. $E°_{sel} = E°_{OM} - E°_{RM}$ gevolg deur korrekte vervangings:* $\frac{4}{5}$

OPTION 2/*OPSIE 2*

✓ $C\ell_2 + 2e^- \rightarrow 2C\ell^-$ $E^{\theta} = 1{,}36\ V$ ✓
$X \rightarrow X^{2+} + 2e^-$ $E^{\theta} = 0{,}13\ V$ ✓
$C\ell_2 + X \rightarrow X^{2+} + 2C\ell^-$ $E^{\theta} = 1{,}49\ V$ ✓

X is Pb/Lead/*Lood* ✓ (5)

POSITIVE MARKING FROM Q8.3/*POSITIEWE NASIEN VANAF V8.3*

8.4 X/Pb/Lead/*Lood* ✓ (1)

8.5

8.5.1 Reaction reached equilibrium./(In each half cell) the rate of oxidation is equal to rate of reduction./Rate of the forward reaction is equal to the rate of the reverse reaction. ✓
Reaksie bereik ewewig./(In elke halfsel) die t*empo van oksidasie is gelyk aan tempo van reduksie./Tempo van die voorwaartse reaksie is gelyk aan die tempo van die terugwaartse reaksie.* (1)

8.5.2 Increases/*Toeneem* ✓ (1)

8.5.3
- $[C\ell^-]$ decreases/*neem af.* ✓
- Forward reaction is favoured./*Voorwaartse reaksie word bevoordeel.* ✓ (2)

[12]

QUESTION 9/*VRAAG 9*

9.1

<u>Marking guidelines/*Nasienriglyne*</u>
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

The chemical process in which <u>electrical energy is converted to chemical energy</u>. ✓✓
Die chemiese proses waarin <u>elektriese energie omgeskakel word na chemiese energie</u>.
OR/*OF*
The use of <u>electrical energy to produce a chemical change</u>.
Die gebruik van <u>elektriese energie om 'n chemiese verandering teweeg te bring.</u>
OR/*OF*
The process during which an <u>electrical current passes through a solution/molten ionic</u> compound.
Die proses waar 'n <u>elektriese stroom deur 'n oplossing/gesmelte ioniese verbinding gestuur word.</u> (2)

9.2

9.2.1 $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ ✓✓
Ignore phases/*Ignoreer fases*

<u>Marking guidelines/*Nasienriglyne*</u>
- $H_2(g) + 2OH^-(aq) \leftarrow 2H_2O(\ell) + 2e^-$ $(\frac{2}{2})$ $2H_2O(\ell) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$ $(\frac{1}{2})$
  $H_2(g) + 2OH^-(aq) \rightleftharpoons 2H_2O(\ell) + 2e^-$ $(\frac{0}{2})$ $2H_2O(\ell) + 2e^- \leftarrow H_2(g) + 2OH^-(aq)$ $(\frac{0}{2})$
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (-) omitted on OH^- /*Indien lading (-) weggelaat op* OH^-:
  Example/*Voorbeeld:* $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH(aq)$ ✓ Max./*Maks:* $\frac{1}{2}$

(2)

9.2.2 Water/ H_2O ✓ (1)

9.3 H_2O is a stronger oxidising agent ✓ than Na^+ ✓ and will be reduced ✓ (to H_2).
H_2O is 'n sterker oksideermiddel as Na^+ en sal gereduseer word (na H_2).
OR/*OF*
Na^+ is a weaker oxidizing agent ✓than H_2O ✓and therefore H_2O will be reduced ✓ (to H_2)
Na^+ is 'n swakker oksideermiddel as H_2O en daarom sal H_2O gereduseer word (na H_2)

OR/*OF*
The half-reaction that produces $H_2(g)$ has a more positive reduction potential (-0,83 V) ✓ than the half-reaction that produces Na (-2,71 V). ✓
Therefore water/H_2O will be reduced ✓ to H_2./Na^+ will not be reduced to Na.
Die halfreaksie wat $H_2(g)$ vorm, het 'n meer positiewe reduksiepotensiaal (-0,83 V) as die halfreaksie wat Na vorm (-2,71 V).
Daarom word water/H_2O na H_2 gereduseer./Na^+ sal nie gereduseer word na (3)

Na nie.

[8]

QUESTION 10/*VRAAG 10*

10.1
10.1.1 Hydrogen/*Waterstof*/H_2 ✓ (1)

10.1.2 Nitrogen monoxide/*Stikstofmonoksied*/NO ✓ (1)

10.1.3 Nitric acid/*Salpetersuur*/HNO_3 ✓ (1)

10.2
10.2.1 (Catalytic) oxidation/Redox/*(Katalitiese) oksidasie/Redoks* ✓ (1)

10.2.2 $NH_3 + HNO_3$ ✓ $\rightarrow NH_4NO_3$ ✓ Bal ✓

Notes/*Aantekeninge*		
• Reactants ✓ *Reaktanse*	Products ✓ *Produkte*	Balancing ✓ *Balansering*
• Ignore double arrows (⇌) and phases./Ignoreer dubbelpyle (⇌)*en fases.*		
• Marking rule 6.3.10./Nasienreël 6.3.10.		

(3)

10.3
10.3.1 (Total) percentage of nutrients/fertiliser/N,P,K. ✓
(Totale) persentasie nutriente/ kunsmis/N,P, K. (1)

10.3.2

Marking guidelines/*Nasienriglyne*

- Calculate mass fertiliser in A./*Bereken massa kunsmis in A* ✓
- Calculate mass fertiliser in B./ *Bereken massa kunsmis in B* ✓
- Calculate mass P in A and B ./*Bereken massa P in A en B*✓
- Final answer/*Finale antwoord*:
  B has more phosphorous than/*het meer fosfor as* A. ✓

OPTION 1/*OPSIE 1*

Mass fertiliser in A:
Massa kunsmis in A:

$m = \frac{21}{100} \times 50$ ✓ $= 10,5$ kg

Mass fertiliser in B:
/*Massa kunsmis in B*:

$m = \frac{27}{100} \times 40$ ✓ $= 10,8$ kg

Mass phosphorous in A/
Massa fosfor in A:

$\frac{3}{8} \times 10,5 = 3,94$ kg

Mass phosphorous in B/
Massa fosfor in B:

$\frac{3}{8} \times 10,8 = 4,05$ kg ✓

Fertiliser B has more phosphorous than fertiliser A. ✓

OPTION 2/*OPSIE 2*

Mass phosphorous in A/
Massa fosfor in A:

$m = \frac{3}{8} \times \frac{21}{100} \times 50$ ✓ $= 3,94$ kg

Mass(P) in B
Massa (P) in B:

$m = \frac{3}{8} \times \frac{27}{100} \times 40$ ✓ $= 4,05$ kg ✓

Fertiliser B has more phosphorous than fertiliser A. /*Kunsmis B het meer fosfor as kunsmis A.*✓

OPTION 3/*OPSIE 3*

Mass phosphorous in A/
Massa fosfor in A:

$\%P = \frac{3}{8} \times 21 = 7,88\%$

$m(P) = \frac{7,88}{100} \times 50$ ✓ $= 3,94$ kg

Mass(P) in B
Massa (P) in B:

$\%(P) = \frac{3}{8} \times 27 = 10,13\%$

$m = \frac{10,13}{100} \times 40$ ✓ $= 4,05$ kg ✓

Fertiliser B has more phosphorous than fertiliser A. /*Kunsmis B het meer fosfor as kunsmis A* ✓

OPTION 4/*OPSIE 4*

Mass fertiliser in A:
Massa kunsmis in A:

$m = \frac{21}{100} \times 50$ ✓ $= 10,5$ kg

Mass fertiliser in B:
/*Massa kunsmis in B*:

$m = \frac{27}{100} \times 40$ ✓ $= 10,8$ kg

For the same NPK ratio ✓
the bag with more fertiliser will have more phosphorous ∴ bag B✓
Vir dieselfde NPK verhouding, die sake met meer kunsmis sal meer fosfor het ∴ sak B

(4)
[12]

TOTAL/*TOTAAL*: 150

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

**SENIOR CERTIFICATE/
NATIONAL SENIOR CERTIFICATE**

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2020

MARKS: 150

TIME: 3 hours

This question paper consists of 15 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your examination number and centre number in the appropriate spaces on the ANSWER BOOK.

2. This question paper consists of TEN questions. Answer ALL the questions in the ANSWER BOOK.

3. Start EACH question on a NEW page in the ANSWER BOOK.

4. Number the answers correctly according to the numbering system used in this question paper.

5. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

8. Show ALL formulae and substitutions in ALL calculations.

9. Round off your FINAL numerical answers to a minimum of TWO decimal places.

10. Give brief motivations, discussions, etc. where required.

11. You are advised to use the attached DATA SHEETS.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 Which ONE of the following is the general formula for the alkanes?

A C_nH_{2n}

B C_nH_{2n-2}

C C_nH_{2n+2}

D $C_nH_{2n+2}O$ (2)

1.2 The EMPIRICAL FORMULA of hexanoic acid is …

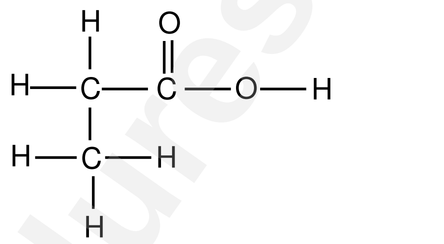
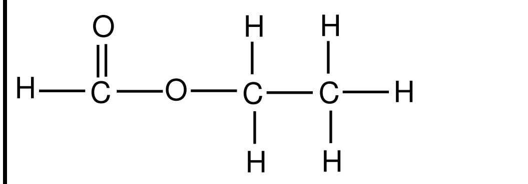
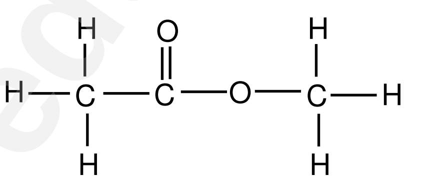
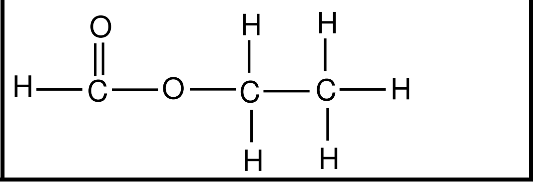
A $C_3H_6O_2$

B $C_6H_6O_2$

C $C_6H_{12}O_2$

D C_3H_6O (2)

1.3 Which ONE of the following is the CORRECT structural formula for METHYL ETHANOATE?

A		**B**	
C		**D**	

(2)

1.4 Zinc (Zn) granules react as follows with EXCESS hydrochloric acid solution, HCℓ(aq):

$$Zn(s) + HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$$

Which ONE of the following combinations of volume and concentration of HCℓ(aq) will result in the highest INITIAL reaction rate for the same mass of zinc granules used? (Assume that the zinc granules are completely covered by the acid in all cases.)

	VOLUME HCℓ(aq) (cm^3)	**CONCENTRATION HCℓ(aq) ($mol \cdot dm^{-3}$)**
A	50	0,5
B	100	1,0
C	200	0,1
D	200	0,5

(2)

1.5 The role of a catalyst in a chemical reaction is to increase the …

A yield.

B activation energy.

C heat of reaction.

D rate of the reaction. (2)

1.6 Consider the equilibrium represented by the balanced equation below:

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(\ell) \quad \Delta H < 0$$

Which ONE of the following changes to the equilibrium will favour the forward reaction?

	TEMPERATURE	**pH**
A	Decrease	Increase
B	Decrease	Decrease
C	Increase	Increase
D	Increase	Decrease

(2)

1.7 The conjugate base of HPO_4^{2-} is …

A OH^-

B PO_4^{3-}

C $H_2PO_4^-$

D H_3PO_4 (2)

1.8 Which ONE of the following reactions will proceed spontaneously under standard conditions?

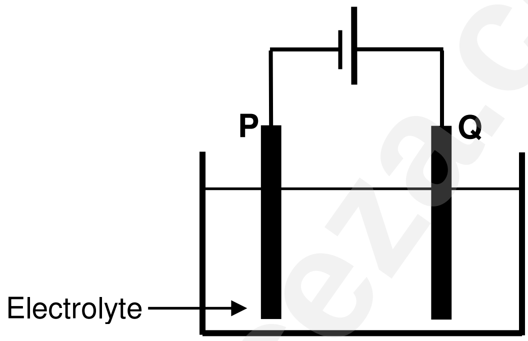
A $Ni^{2+}(aq) + H_2(g) \rightarrow Ni(s) + 2H^+(aq)$

B $Br_2(\ell) + 2C\ell^-(aq) \rightarrow 2Br^-(aq) + C\ell_2(g)$

C $2Fe^{3+}(aq) + 2I^-(aq) \rightarrow 2Fe^{2+}(aq) + I_2(s)$

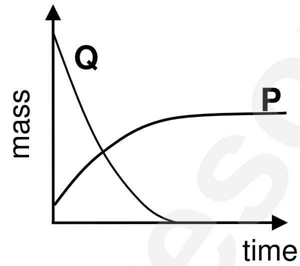
D $2Cu^+(aq) + Pb^{2+}(aq) \rightarrow 2Cu^{2+}(aq) + Pb(s)$ (2)

1.9 The simplified diagram below represents an electrochemical cell used for the PURIFICATION of copper.

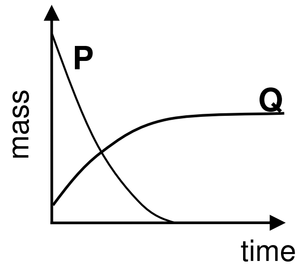


Which ONE of the graphs below represents the CHANGE IN MASS of electrodes **P** and **Q** during the purification process?

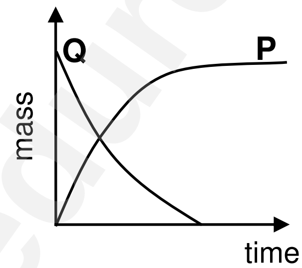
A



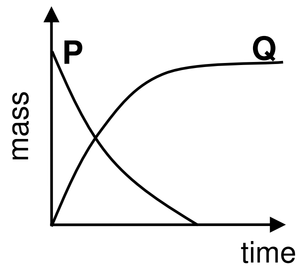
B



C



D



(2)

1.10 Eutrophication in water is caused by …

A algal bloom.

B bacterial nitrogen fixation.

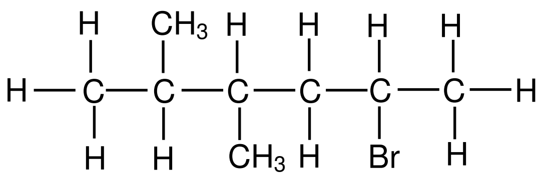
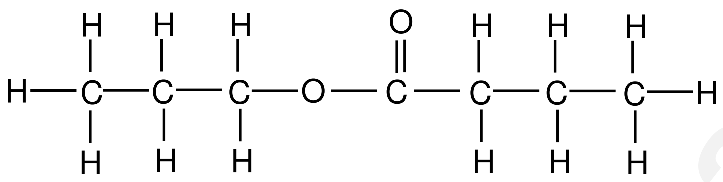
C an increase in plant nutrients.

D a depletion of oxygen concentration. (2)

[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **E** in the table below represent five organic compounds.

A		**B**	C_3H_8O
C		**D**	Pentan-2-one
E	4-methylpent-2-yne		

Use the information in the table to answer the questions that follow.

2.1 For compound **D**, write down the:

2.1.1 Homologous series to which it belongs (1)

2.1.2 IUPAC name of a FUNCTIONAL ISOMER (2)

2.2 Write down the:

2.2.1 IUPAC name of compound **A** (3)

2.2.2 STRUCTURAL FORMULA of compound **E** (2)

2.3 Compound **B** is a primary alcohol.

2.3.1 Write down the meaning of the term *primary alcohol*. (2)

Compound **B** reacts with another organic compound **X** to form compound **C**.

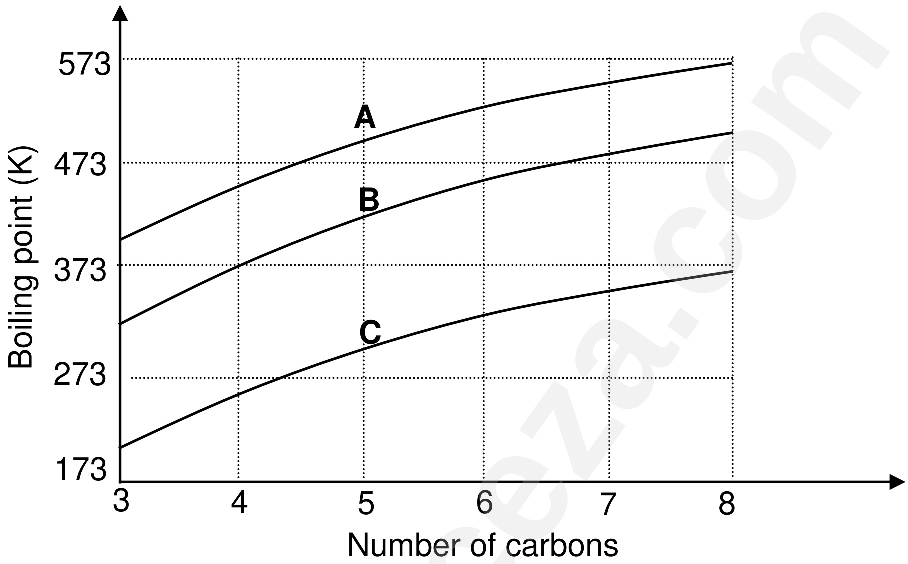
Write down the:

2.3.2 Type of reaction that takes place (1)

2.3.3 IUPAC name of compound **X** (1)
[12]

QUESTION 3 (Start on a new page.)

The relationship between boiling point and the number of carbon atoms in straight chain molecules of aldehydes, alkanes and primary alcohols is investigated. Curves **A**, **B** and **C** are obtained.



3.1 Define the term *boiling point*. (2)

3.2 Write down the STRUCTURAL FORMULA of the functional group of the aldehydes. (1)

3.3 The graph shows that the boiling points increase as the number of carbon atoms increases. Fully explain this trend. (3)

3.4 Identify the curve (**A**, **B** or **C**) that represents the following:

3.4.1 Compounds with London forces only (1)

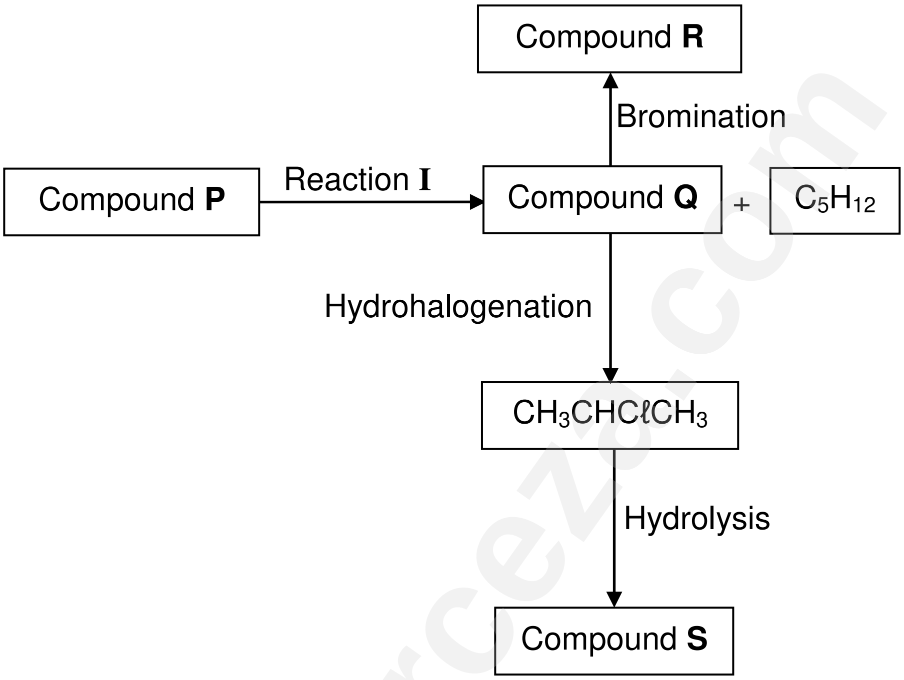
3.4.2 The aldehydes
Explain the answer. (4)

3.5 Use the information in the graph and write down the IUPAC name of the compound with a boiling point of 373 K. (2)

3.6 Write down the IUPAC name of the compound containing five carbon atoms, which has the lowest vapour pressure at a given temperature. (2)
[15]

QUESTION 4 (Start on a new page.)

The flow diagram below shows how various organic compounds can be prepared using compound **P** as starting reagent.



4.1 Write down the meaning of the term *hydrohalogenation*. (2)

4.2 Write down the STRUCTURAL FORMULA of compound **Q**. (2)

4.3 **Reaction I** is an elimination reaction.

Write down the:

4.3.1 TYPE of elimination reaction (1)

4.3.2 MOLECULAR FORMULA of compound **P** (1)

4.4 Write down the IUPAC name of compound **R**. (2)

4.5 For the HYDROLYSIS REACTION, write down the:

4.5.1 Balanced equation using structural formulae (5)

4.5.2 TWO reaction conditions (2)
[15]

QUESTION 5 (Start on a new page.)

The reaction of calcium carbonate ($CaCO_3$) and EXCESS dilute hydrochloric acid ($HC\ell$) is used to investigate one of the factors that affects reaction rate. The balanced equation for the reaction is:

$$CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g)$$

The same mass of $CaCO_3$ is used in all the experiments and the temperature of the hydrochloric acid in all experiments is 40 °C.

The reaction conditions for each experiment are summarised in the table below.

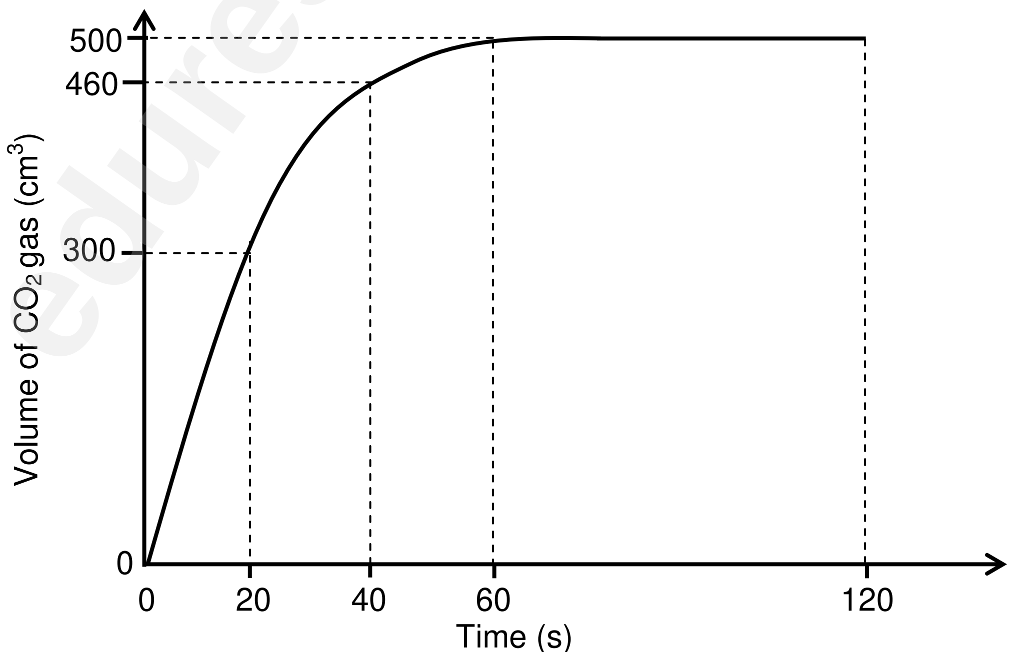
EXPERIMENT	VOLUME OF $HC\ell(aq)$ (cm^3)	CONCENTRATION OF $HC\ell(aq)$ ($mol{\cdot}dm^{-3}$)	STATE OF DIVISION OF $CaCO_3$
A	500	0,1	granules
B	500	0,1	lumps
C	500	0,1	powder

5.1 For this investigation write down the:

5.1.1 Dependent variable (1)

5.1.2 Independent variable (1)

The carbon dioxide gas, $CO_2(g)$, produced during EXPERIMENT **A**, is collected in a gas syringe. The volume of gas collected is measured every 20 s and the results obtained are shown in the graph below.



5.2 What can be deduced from the graph regarding the RATE OF THE REACTION during the time interval:

5.2.1 20 s to 40 s (1)

5.2.2 60 s to 120 s (1)

5.3 Calculate the average rate (in $cm^3 \cdot s^{-1}$) at which $CO_2(g)$ is produced in the experiment. (3)

5.4 How will the volume of $CO_2(g)$ produced in experiment **B** compare to that produced in experiment **A**? Choose from GREATER THAN, SMALLER THAN or EQUAL TO. (1)

5.5 A graph is now drawn for experiment **C** on the same set of axes. How will the gradient of this graph compare to the gradient of the graph for experiment **A**? Choose from GREATER THAN, SMALLER THAN or EQUAL TO.

Use the collision theory to fully explain the answer. (4)

5.6 Assume that the molar gas volume at 40 °C is 25,7 $dm^3 \cdot mol^{-1}$. Calculate the mass of $CaCO_3(s)$ used in experiment **A**. (4)
[16]

QUESTION 6 (Start on a new page.)

The dissociation of iodine molecules to iodine atoms (I) is a reversible reaction taking place in a sealed container at 727 °C. The balanced equation for the reaction is:

$$I_2(g) \rightleftharpoons 2I(g)$$

K_c for the reaction at 727 °C is 3,76 x 10^{-3}.

6.1 Write down the meaning of the term *reversible reaction*. (1)

6.2 At equilibrium the pressure of the system is increased by decreasing the volume of the container at constant temperature.

How will EACH of the following be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME.

6.2.1 The value of the equilibrium constant (1)

6.2.2 The number of I_2 molecules (1)

6.3 Explain the answer to QUESTION 6.2.2 by referring to Le Chatelier's principle. (2)

6.4 At 227 °C, the K_C value for the reaction above is 5,6 x 10^{-12}.

Is the forward reaction ENDOTHERMIC or EXOTHERMIC?
Fully explain the answer. (4)

6.5 A certain mass of iodine molecules (I_2) is sealed in a 12,3 dm^3 flask at a temperature of 727 °C (K_c = 3,76 x 10^{-3}).

When equilibrium is reached, the concentration of the iodine atoms is found to be 4,79 x 10^{-3} $mol{\cdot}dm^{-3}$. Calculate the INITIAL MASS of the iodine molecules in the flask. (9)
[18]

QUESTION 7 (Start on a new page.)

7.1 Ethanoic acid (CH_3COOH) is an ingredient of household vinegar.

7.1.1 Is ethanoic acid a WEAK acid or a STRONG acid? Give a reason for the answer. (2)

7.1.2 An ethanoic acid solution has a pH of 3,85 at 25 °C. Calculate the concentration of the hydronium ions, $H_3O^+(aq)$, in the solution. (3)

Sodium ethanoate, $CH_3COONa(aq)$, forms when ethanoic acid reacts with sodium hydroxide.

7.1.3 Will the pH of a sodium ethanoate solution be GREATER THAN 7, LESS THAN 7 or EQUAL TO 7? (1)

7.1.4 Explain the answer to QUESTION 7.1.3 with the aid of a balanced chemical equation. (3)

7.2 Household vinegar contains 4,52% ethanoic acid, CH_3COOH by volume.

A 1,2 g impure sample of calcium carbonate ($CaCO_3$) is added to 25 cm^3 household vinegar.

On completion of the reaction, the EXCESS ethanoic acid in the household vinegar is neutralised by 14,5 cm^3 of a sodium hydroxide solution of concentration 1 $mol{\cdot}dm^{-3}$. The balanced equation for the reaction is:

$$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(\ell)$$

7.2.1 Calculate the number of moles of the unreacted ethanoic acid. (3)

7.2.2 Calcium carbonate reacts with ethanoic acid according to the following balanced equation:

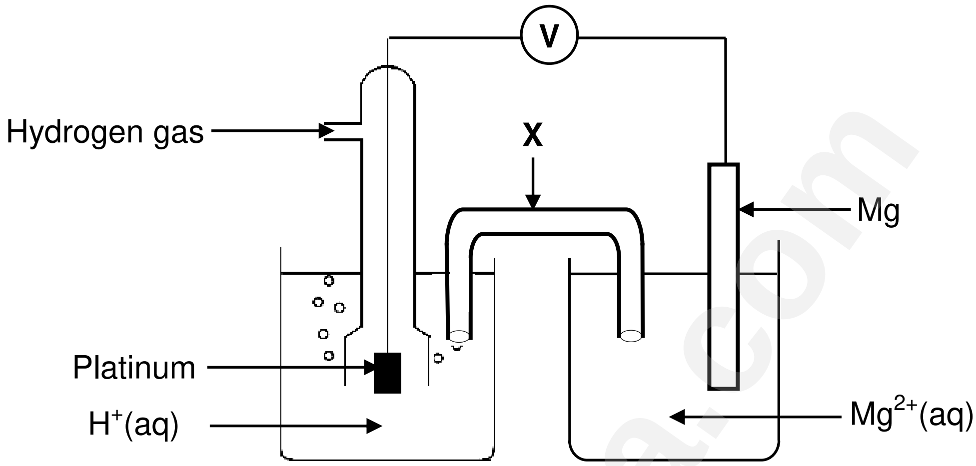
$$CaCO_3(s) + 2CH_3COOH(aq) \rightarrow (CH_3COO)_2Ca(aq) + H_2O + CO_2(g)$$

Calculate the percentage calcium carbonate in the impure sample if 1 cm^3 of household vinegar has a mass of 1 g. (8)

[20]

QUESTION 8 (Start on a new page.)

The electrochemical cell illustrated below is set up under standard conditions.



8.1 Component **X** completes the circuit in the cell. State ONE other function of component **X**. (1)

8.2 Define the term *anode*. (2)

8.3 Identify the anode in the cell above. (1)

8.4 Write down the:

8.4.1 Reduction half-reaction that takes place in this cell (2)

8.4.2 NAME or FORMULA of the reducing agent in this cell (1)

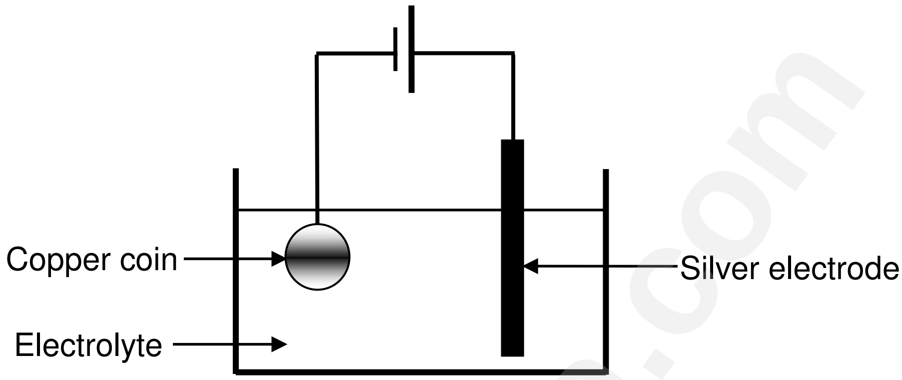
8.5 Calculate the initial voltmeter reading of this cell under standard conditions. (4)

8.6 The $Mg|Mg^{2+}$ half-cell is now replaced by a $Cu|Cu^{2+}$ half-cell. It is found that the direction of electron flow changes.

Fully explain why there is a change in direction of electron flow by referring to the relative strengths of the reducing agents involved. (3)
[14]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents an electrolytic cell used to electroplate a copper (Cu) coin with silver (Ag).



9.1 Define the term *electrolysis*. (2)

9.2 Which component in the diagram indicates that this is an electrolytic cell? (1)

9.3 Write down the NAME or FORMULA of the electrolyte. (1)

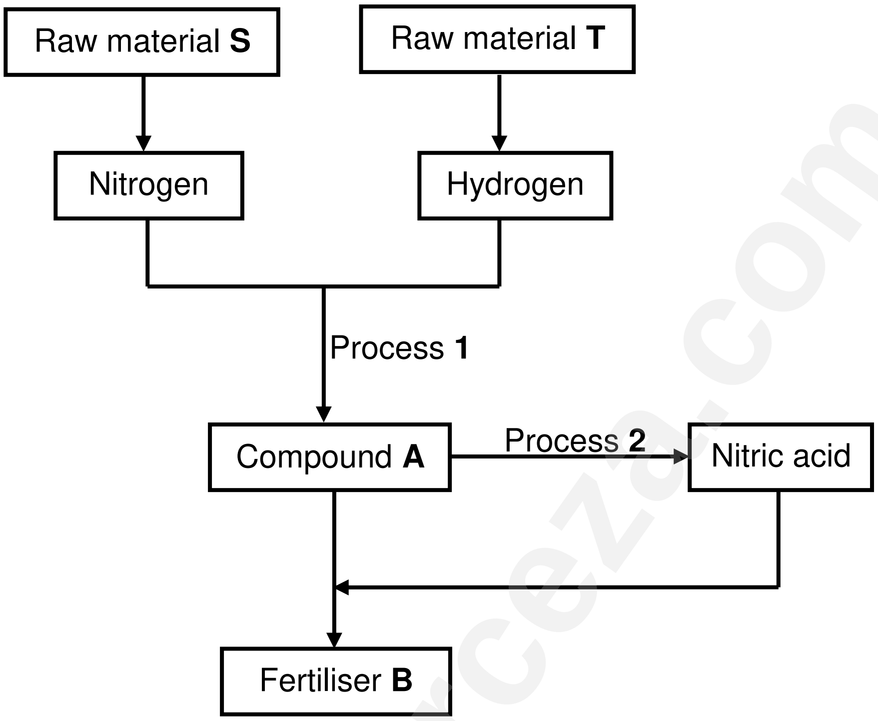
9.4 How will the concentration of the electrolyte change during electroplating? Choose from INCREASES, DECREASES or REMAINS THE SAME.

Give a reason for the answer. (2)

9.5 Write down the balanced equation of the half-reaction that takes place at the silver electrode. (2)
[8]

QUESTION 10 (Start on a new page.)

10.1 The flow diagram below shows how fertiliser **B** is produced in industry.



Write down the:

10.1.1 NAME of **S** (1)

10.1.2 NAME of **T** (1)

10.1.3 NAME or FORMULA of the catalyst used in process **1** (1)

10.1.4 NAME or FORMULA of compound **A** (1)

10.1.5 NAME of process **2** (1)

10.1.6 Balanced equation for the formation of fertiliser **B** (3)

10.2 A 20 kg bag of fertiliser is labelled as follows: **2 : 4 : 3 (X)**.

10.2.1 What does the ratio on the label represent? (1)

10.2.2 The bag contains 2,315 kg phosphorous.

Calculate the value of **X**. (3)
[12]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1{,}013 \times 10^{5}$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22{,}4\ dm^{3} \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode} / E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation} / E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent} / E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Electronegativity / *Elektronegatiwiteit*	Atomic number / *Atoomgetal*	Symbol / *Simbool*	Approximate relative atomic mass / *Benaderde relatiewe atoommassa*
1,9	29	Cu	63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Increasing oxidising ability/*Toenemende oksiderende vermoë* (↑)

Increasing reducing ability/*Toenemende reduserende vermoë* (↓)

Half-reactions/*Halfreaksies*			E^θ (V)
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	⇌	**$H_2(g)$**	**0,00**
$Fe^{3+} + 3e^-$	⇌	Fe	– 0,06
$Pb^{2+} + 2e^-$	⇌	Pb	– 0,13
$Sn^{2+} + 2e^-$	⇌	Sn	– 0,14
$Ni^{2+} + 2e^-$	⇌	Ni	– 0,27
$Co^{2+} + 2e^-$	⇌	Co	– 0,28
$Cd^{2+} + 2e^-$	⇌	Cd	– 0,40
$Cr^{3+} + e^-$	⇌	Cr^{2+}	– 0,41
$Fe^{2+} + 2e^-$	⇌	Fe	– 0,44
$Cr^{3+} + 3e^-$	⇌	Cr	– 0,74
$Zn^{2+} + 2e^-$	⇌	Zn	– 0,76
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	– 0,83
$Cr^{2+} + 2e^-$	⇌	Cr	– 0,91
$Mn^{2+} + 2e^-$	⇌	Mn	– 1,18
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	– 1,66
$Mg^{2+} + 2e^-$	⇌	Mg	– 2,36
$Na^+ + e^-$	⇌	Na	– 2,71
$Ca^{2+} + 2e^-$	⇌	Ca	– 2,87
$Sr^{2+} + 2e^-$	⇌	Sr	– 2,89
$Ba^{2+} + 2e^-$	⇌	Ba	– 2,90
$Cs^+ + e^-$	⇌	Cs	- 2,92
$K^+ + e^-$	⇌	K	– 2,93
$Li^+ + e^-$	⇌	Li	– 3,05

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Increasing reducing ability/*Toenemende reduserende vermoë* ↑

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	⇌	Li	− 3,05
$K^+ + e^-$	⇌	K	− 2,93
$Cs^+ + e^-$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$2H^+ + 2e^-$	⇌	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE/*SENIOR SERTIFIKAAT*
NATIONAL SENIOR CERTIFICATE/
NASIONALE SENIOR SERTIFIKAAT

GRADE/*GRAAD* 12

PHYSICAL SCIENCES: CHEMISTRY (P2)
FISIESE WETENSKAPPE: CHEMIE (V2)

NOVEMBER 2020

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

These marking guidelines consist of 17 pages./
Hierdie nasienriglyne bestaan uit 17 bladsye.

QUESTION 1/*VRAAG 1*

1.1	C ✓✓	(2)
1.2	D ✓✓	(2)
1.3	C ✓✓	(2)
1.4	B ✓✓	(2)
1.5	D ✓✓	(2)
1.6	B ✓✓	(2)
1.7	B ✓✓	(2)
1.8	C ✓✓	(2)
1.9	A ✓✓	(2)
1.10	C ✓✓	(2) **[20]**

QUESTION 2/*VRAAG 2*

2.1.1 Ketones/*Ketone* ✓ (1)

2.1.2 Pentanal/*Pentanaal* ✓✓

<u>ACCEPT/*AANVAAR*</u>
2,2-dimethylpropanal/*2,2-dimethylpropanaal*
2-methylbutanal/*2-metielbutanaal*
3-methylbutanal/*3-metielbutanaal*

<u>Marking criteria/*Nasienriglyne*</u>
- Correct functional group,i.e. – al / *Korrekte funksionele groep d.i. al* ✓
- Whole name correct/*Hele naam korrek* ✓

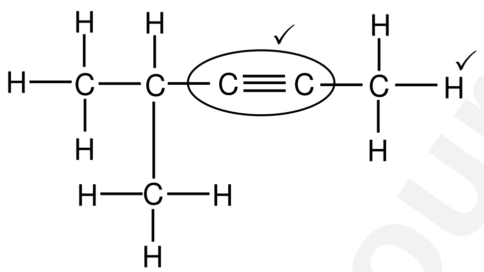
(2)

2.2.1 5 – bromo-2,3 – dimethylhexane/*5 – bromo-2,3 – dimetielheksaan*

<u>Marking criteria/*Nasienriglyne:*</u>
- Correct stem i.e. <u>hexane</u>./*Korrekte stam d.i. <u>heksaan</u>.* ✓
- All substituents (bromo and dimethyl) correctly identified./*Alle substituente (bromo en dimetiel) korrek geïdentifiseer.* ✓
- IUPAC name completely correct including numbering, sequence, hyphens and commas./*IUPAC-naam heeltemal korrek insluitende volgorde, koppeltekens en kommas .* ✓

(3)

2.2.2



<u>Marking criteria/*Nasienriglyne*</u>
- Whole structure correct/*Hele struktuur korrek:* $\frac{2}{2}$
- Only functional group correct:/*Slegs funksionele groep korrek:* Max/*Maks.*: $\frac{1}{2}$

IF/*INDIEN*
More than one functional group/*Meer as een funksionele groep* $\frac{0}{2}$

(2)

<u>IF/*INDIEN*</u>
Molecular formula/*Molekulêre formule* $\frac{0}{2}$

Condensed structural formula /*Gekondenseerde struktuurformule* $\frac{1}{2}$

2.3.1 The C atom bonded to the hydroxyl group is bonded to only one other C-atom. ✓✓ **(2 or 0)**
Die C-atoom wat aan die hidroksielgroep gebind is, is aan slegs een ander C-atoom gebind. ***(2 or 0)***

OR/*OF*
The hydroxyl group/-OH/ is bonded to a C atom which is bonded to two hydrogens atoms. **(2 or 0)**
Die hidroksielgroep/funksionele groep is gebind aan 'n C-atoom wat aan twee waterstofatome gebind is. ***(2 of 0)***

OR/*OF*
The hydroxyl group/functional group/-OH is bonded to:
a primary C atom / the first C atom **(2 or 0)**
Die hidroksielgroep/funksionele groep/-OH aan
'n primêre C-atoom gebind / die eerste C-atoom gebind ***(2 of 0)***

OR/*OF*

The functional group (— C - OH) is bonded to only one other C-atom.

Die funksionele groep (— C – OH) is aan slegs een ander C-atoom gebind. (2)

2.3.2 Esterification/condensation ✓
Verestering/esterifikasie/kondensasie (1)

2.3.3 <u>Butanoic acid</u>/<u>*Butanoësuur*</u> ✓ (1)
[12]

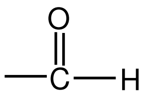
QUESTION 3/ *VRAAG 3*

3.1

Marking criteria/*Nasienriglyne*
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

The temperature at which the vapour pressure equals atmospheric (external) pressure. ✓✓
Die temperatuur waar die dampdruk gelyk is aan atmosferiese (eksterne) druk. (2)

3.2


✓ (1)

3.3

- Increase in the number of C-atoms increases molecular mass/size/chain length/surface area. ✓
- Strength of the intermolecular forces increases/More sites for London forces. ✓
- More energy is needed to overcome/break intermolecular forces. ✓

- *Toename in aantal C-atome verhoog molekulêre massa/molekulêre grootte/kettinglengte/reaksie-oppervlak.*
- *Sterkte van die intermolekulêre kragte verhoog./Meer punte vir Londonkragte.*
- *Meer energie benodig om intermolekulêre kragte te oorkom/breek.* (3)

3.4.1 C ✓ (1)

3.4.2 B ✓

Marking criteria/*Nasienriglyne*

- Compare strength of intermolecular forces of A, B and C. ✓
- Compare boiling points/energy required to overcome intermolecular forces of alcohols/A and aldehydes/B. ✓
  OR
  Alcohols have the highest boiling point.
- Compare boiling points/ energy required to overcome intermolecular force of aldehydes/B and alkanes/C .✓
  OR
  Alkanes have the lowest boiling point.

- *Vergelyk sterkte van intermolekulêre kragte van A, B en C.* ✓
- *Vergelyk kookpunte /energie benodig om intermolekulêre kragte van alkohole/A en aldehiede/B te oorkom.* ✓
  OF
  Alkohole het die hoogste kookpunt.
- *Vergelyk kookpunte /energie benodig om intermolekulêre kragte van aldehiede/B en alkane/C.*✓
  OF
  Alkane het die laagste kookpunt.

Aldehydes/B have (in addition to London forces) dipole-dipole forces which are stronger than London forces, but weaker than hydrogen bonds. ✓
Therefore aldehydes/B have lower boiling points/require less energy to overcome intermolecular forces than alcohols/A,✓but higher boiling points / require more energy to overcome intermolecular forces than alkanes/C. ✓

Aldehiede/B het (in toevoeging tot Londonkragte) dipool-dipoolkragte wat sterker is as Londonkragte, maar swakker is as waterstofbinding.
Dus het aldehiede/B laer kookpunte/benodig minder energie om intermolekulêre kragte te oorkom as alkohole/A, maar hoër kookpunte/benodig meer energie om intermolekulêre kragte te oorkom as alkane/C.

OR/*OF*
Aldehydes/B have stronger intermolecular forces than alkanes, but weaker intermolecular forces than alcohols/A. ✓
Therefore aldehydes/B have higher boiling points/ more energy required to overcome intermolecular forces than alkanes/C, ✓ but lower boiling points/ less energy to overcome intermolecular forces than alcohols/A. ✓

Aldehiede/B het sterker intermolekulêre kragte as alkane/C, maar swakker intermolekulêre kragte as alkohole/A.
Dus het aldehiede/B laer kookpunte/ benodig minder energie om intermolekulêre kragte te oorkom as alkohole/A, maar hoër kookpunte/ benodig meer energie om intermolekulêre kragte te oorkom as alkane/C. (4)

3.5 Butanal ✓✓
Butanaal

Marking criteria/*Nasienriglyne*
• Correct stem, i.e. but/*Korrekte stam d.i. but* ✓
• Whole name correct/*Hele naam korrek* ✓

(2)

3.6 Pentan-1-ol ✓✓
OR/*OF*
1-pentanol ✓✓ (2)
[15]

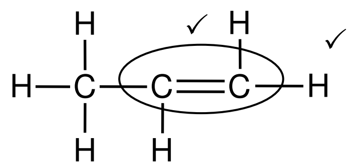
QUESTION 4/*VRAAG 4*

4.1

Marking criteria/*Nasienriglyne*
• Addition reaction / reaction of alkene / reaction of C – C double bond /reaction of unsaturated hydrocarbon✓ *Addisie reaksie / reaksie van 'n alkeen /reaksie van C – C dubbelbinding/reaksie van 'n onversadigde koolwaterstof.*
• (Addition of) hydrogen halide/HX/ hydrogen and halide. ✓ *(Addisie van) waterstofhalied/HX/waterstof en halied.*

The addition ✓of a hydrogen halide/HX ✓to an alkene.
Die addisie van 'n waterstofhalied/HX aan 'n alkeen. (2)

4.2



Marking criteria/*Nasienriglyne*
• Whole structure correct: *Hele struktuur korrek:* $^2/_2$ • Only functional group correct/*Slegs funksionele groep korrek:* Max/Maks: $^1/_2$

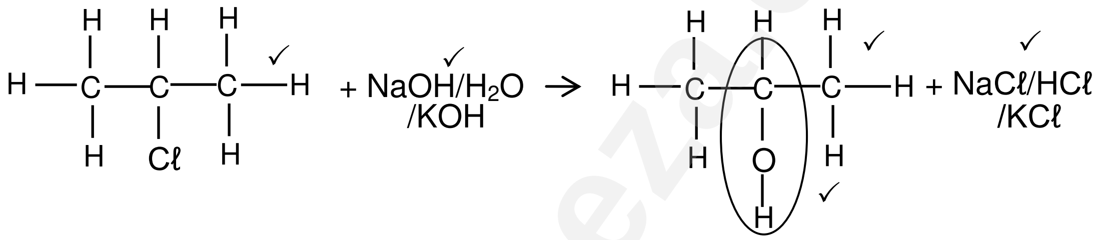
(2)

4.3.1 Cracking/*Kraking* ✓ (1)

4.3.2 C_8H_{18} ✓ (1)

4.4 <u>1,2–dibromo</u> ✓ <u>propane</u> ✓
<u>*1,2-dibromopropaan/1,2-dibroompropaan*</u> (2)

4.5.1



Marking criteria for the alcohol/*Nasienriglyne vir die alkohol*
• Whole structure of alcohol correct/*Hele struktuur van alkohol korrek:* $^2/_2$ • Only functional group correct/*Slegs funksionele groep korrek:* $^1/_2$

Notes/*Aantekeninge:*
• If 1-chloropropane used as reactant, 2 marks for the primary alcohol. *Indien 1-chloropropaan as reaktanse gebruik is, 2 punte vir die primêre alkohol.*   • Condensed or semi-structural formula: Max. $^4/_5$ *Gekondenseerde of semistruktuurformule*: *Maks.* $^4/_5$ • Molecular formula/*Molekulêre formule*: $^2/_5$ • Any additional reactants or products: Max. $^4/_5$ *Enige addisionele reaktanse of produkte: Maks.* $^4/_5$ • If arrow in completely correct equation omitted: Max. $^4/_5$ *Indien pyltjie in volledige korrekte vergelyking uitgelaat is*: *Maks.* $^4/_5$ • The product NaCℓ/KCℓ/HCℓ must be marked in conjunction with reactant NaOH/KOH/H_2O. *Die produk NaCℓ/KCℓ/HCℓ moet in samehang met die reaktans NaOH/KOH / H_2O nagesien word.*

(5)

4.5.2
- (Mild) heat/*(Matige) hitte* ✓
- <u>Dilute strong base</u>/NaOH/LiOH/KOH **OR** water/H_2O ✓
  <u>*Verdunde sterk basis/*</u>*NaOH/LiOH/KOH* ***OF*** *water/H_2O* (2)

[15]

QUESTION 5/*VRAAG 5*

5.1.1 (Reaction) rate/*Reaksietempo* ✓ (1)

5.1.2 Surface area/state of division /particle size ✓
Reaksie-oppervlak/*toestand van verdeeldheid/deeltjie grootte* (1)

5.2.1 (Decreasing gradient indicates) rate of reaction is decreasing. ✓
(*Afnemende gradiënt dui aan dat) reaksietempo afneem.* (1)

5.2.2 (Gradient is zero, indicates) reaction rate is zero ✓
(*Gradiënt is nul, wat aandui dat) reaksietempo nul is.* (1)

5.3

$$\text{ave rate/}\textit{gem tempo} = \frac{\Delta V}{\Delta t}$$

$$= \frac{500\checkmark(-0)}{60\checkmark(-0)} = 8{,}33\ (\text{cm}^3\cdot\text{s}^{-1})\ \checkmark$$

(3)

5.4 Equal to/*Gelyk aan* ✓ (1)

5.5 Greater than/*Groter as* ✓

Experiment C/*Eksperiment C*:

- Surface area of $CaCO_3$ powder is greater than that of $CaCO_3$ granules./ More particles are exposed /More particles with correct orientation ✓
- More effective collisions per unit time/Higher frequency of effective collisions. ✓
- Increase in reaction rate.✓

- *Reaksieoppervlak van $CaCO_3$-poeier is groter (as die van $CaCO_3$-korrels /Meer deeltjies met korrekte oriëntasie.*
- *Meer effektiewe botsings per eenheid tyd./Hoër frekwensie van effektiewe botsings*
- *Toename in reaksie tempo*

OR/*OF*
Experiment A/*Eksperiment A:*

- Surface area of $CaCO_3$ granules is smaller/Fewer particles are exposed (than that of powdered $CaCO_3$). Less particles with correct orientation ✓
- Less effective collisions per unit time./Lower frequency of effective collisions. ✓
- Decrease in reaction rate.✓.

- *Reaksieoppervlak van $CaCO_3$ is kleiner/Minder deeltjies is blootgestel (as die van die verpoeierde* $CaCO_3$)./ *Minder deeltjies met korrekte oriëntasie*
- *Minder effektiewe botsings per eenheidtyd./Laer frekwensie van effektiewe botsings.*
- *Afname in reaksie tempo* (4)

5.6

Marking criteria/*Nasienriglyne:*

- Divide volume by 25,7 in / *Deel volume deur 25,7 in* $n = \frac{V}{V_M}$. ✓

  If no substitution step shown, award mark for answer: 0,0195 mol
  Indien geen vervanging stap getoon is nie, ken punt toe vit antwoord: 0,0195 mol
- Ratio/*Verhouding*: $n(CO_2) = n(CaCO_3)$. ✓
- Substitute/*Vervang* 100 in $n = \frac{m}{M}$ or in ratio / *of in verhouding*. ✓
- Final answer/*Finale antwoord:* 1,95 g to/*tot* 2 g. ✓

OPTION 1/*OPSIE 1*

$n(CO_2) = \frac{V}{V_m} = \frac{0,5}{25,7}$ ✓

$= 0,0195$ mol

$n(CaCO_3) = n(CO_2) = 0,0195$ mol ✓

$m(CaCO_3) = nM$

$= 0,0195(100)$

$= 1,95$ g ✓

OPTION 2/*OPSIE 2*

25,7 dm^3 ....1 mol
0,5 dm^3 ....0,0195 mol ✓

100 g ✓...........1 mol
x ....0,0195 mol ✓

x = $m(CaCO_3)$ = 1,95 g ✓

OPTION 3/*OPSIE 3*

$n(CO_2) = \frac{V}{V_m} = \frac{0,5}{25,7}$ ✓

$= 0,0195$ mol

0,0195 mol CO_2 ≡ 0,856 g CO_2 ✓
$m(CO_2)$ produced : $m(CaCO_3)$
44 g : 100 g ✓
0,856 : x
x = 1,95 g ✓$CaCO_3$ (4)

[16]

QUESTION 6/*VRAAG 6*

6.1 Products can be converted back to reactants. ✓
Produkte kan omgeskakel word na reaktanse.

OR/*OF*
Both forward and reverse reactions can take place.
Beide voor-en terugwaartse reaksies kan plaasvind.

OR/*OF*
A reaction which can take place in both directions.
'n Reaksie wat in beide rigtings kan plaasvind. (1)

6.2.1 Remains the same/*Bly dieselfde* ✓ (1)

6.2.2 Increases/*Toeneem* ✓ (1)

6.3
- (When pressure is increased) the reaction that leads to the smaller amount of gas / side with less molecules/number of moles is favoured. ✓
  (Wanneer die druk verhoog word,) word die reaksie wat tot die kleiner hoeveelheid gas /minder gas molekule/aantal mol lei, bevoordeel.
- The reverse reaction is favoured. ✓
  Die terugwaartse reaksie word bevoordeel. (2)

6.4 Endothermic/*Endotermies* ✓

- K_c decreases with decrease in temperature. ✓
- Reverse reaction is favoured. / Concentration of reactants increases. / Concentration of products decreases./Yield decreases ✓
- Decrease in temperature favours an exothermic reaction. ✓

- *K_c neem af met afname in temperatuur.*
- *Terugwaartse reaksie word bevoordeel./Konsentrasie van reaktanse neem toe./Konsentrasie van produkte neem af./Opbrengs neem af*
- *Afname in temperatuur bevoordeel 'n eksotermiese reaksie.*

OR/*OF*

- K_c increases with increase in temperature. ✓
- Forward reaction is favoured. / Concentration of reactants decreases. / Concentration of products increases./Yield increases ✓
- Increase in temperature favours an endothermic reaction. ✓

- *K_c neem toename met toename in temperatuur.*
- *Voorwaartse reaksie word bevoordeel./Konsentrasie van produkte neem toe./Konsentrasie van reaktanse neem af./Opbrengs neem toe*
- *Toename in temperatuur bevoordeel 'n endotermiese reaksie* (4)

6.5

<u>CALCULATIONS USING NUMBER OF MOLES</u>
Mark allocation

- Correct K_c expression (<u>formulae in square brackets</u>). ✓
- Substitution of equilibrium concentrations into K_c expression. ✓
- Substitution of K_c value. ✓
- Multiply equilibrium concentrations of I_2 <u>and</u> I by 12,3 dm^3. ✓ (**OPTION 1**)
- Multiply equilibrium concentrations of I by 12,3 dm^3 and divide equilibrium mol of I_2 by 12,3 dm^3. ✓(**OPTION 2**)
- Change in n(I) = n(I at equilibrium). ✓
- **<u>USING</u>** ratio/***<u>GEBRUIK</u>*** *verhouding:* I_2 : I = 1 : 2 ✓
- Initial n(I_2) = equilibrium n(I_2) + change in n(I_2). ✓
- Substitute 254 g·mol^{-1} as molar mass for I_2.✓
- Final answer: (26 g - 27,94 g). ✓

<u>BEREKENINGE WAT AANTAL MOL GEBRUIK</u>
Puntetoekenning:

- *Korrekte K_c-uitdrukking (<u>formules in vierkanthakies</u>).*
- *Vervanging van ewewigskonsentrasies in K_c-uitdrukking.*
- *Vervanging van K_c-waarde.* ✓
- *Vermenigvuldig ewewigskonsentrasies van I_2 <u>en</u> I met 12,3 dm^3.(**OPSIE 1**)*
  *Vermenigvuldig ewewigskonsentrasies van I met 12,3 dm^3 en deel ewewigsmol I_2 met 12,3 dm^3(**OPSIE 2**)*
- *Verandering in n(I) = n(I by ewewig)*
- ***<u>GEBRUIK</u>*** *verhouding:* I_2 : I = 1 : 2 ✓
- *Aanvanklike n(I_2) = ewewigs n(I_2) + verandering in n(I_2).*
- *Vervang 254 g·mol^{-1} as molêre massa van I_2.*
- *Finale antwoord: (26 g – 27,94 g)*

OPTION 1/*OPSIE 1*

$K_c = \frac{[I]^2}{[I_2]}$ ✓

$3{,}76\times10^{-3}$ ✓ $= \frac{(4{,}79\times10^{-3})^2}{[I_2]}$ ✓

$\therefore [I_2] = 6{,}102 \times 10^{-3}\ mol{\cdot}dm^{-3}$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{8}{9}$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{6}{9}$

	I_2	I	
Initial mass (g) *Aanvangsmassa (g)*	(0,1045)(254) ✓ = 26,543 g ✓		
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	0,1045	0	
Change (mol) *Verandering (mol)*	✓ 0,0295	0,0589 ✓	Using ratio ✓
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	0,0751	0,0589	
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	$6{,}102 \times 10^{-3}$	$4{,}79 \times 10^{-3}$	x12,3 ✓

OPTION 2/*OPSIE 2*

	I_2	I	
Initial amount (moles) *Aanvangshoeveelheid (mol)*	x	0	
Change in amount (moles) *Verandering in hoeveelheid* (mol)	0,0295 ✓	0,0589	ratio ✓ *verhouding*
Equilibrium amount (moles) *hoeveelheid* (mol)	x - 0,0295	0,0589 ✓	
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	$\frac{x-0{,}0295}{12{,}3}$	$4{,}79 \times 10^{-3}$	x 12,3 and divide by 12,3✓

$K_c = \frac{[I]^2}{[I_2]}$ ✓

$3{,}76\times10^{-3}$ ✓ $= \frac{(4{,}79\times10^{-3})^2}{\frac{x-0{,}0295}{12{,}3}}$ ✓

$x = 0{,}1045$ mol

$\therefore m = nM$ ✓

$= (0{,}1045)(254)$

$= 26{,}543$ g ✓

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{8}{9}$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{6}{9}$

CALCULATIONS USING CONCENTRATION

Mark allocation

- Correct K_c expression (formulae in square brackets). ✓
- Substitution of equilibrium concentrations into K_c expression. ✓
- Substitution of K_c value ✓
- Change in n(I) = n(I at equilibrium). ✓
- **USING** ratio: $I_2 : I = 1 : 2$ ✓
- Initial $[I_2]$ = equilibrium $[I_2]$ + change in $[I_2]$. ✓
- Divide by 12,3 dm^3. ✓
- Substitute 254 $g \cdot mol^{-1}$ as molar mass for I_2.✓
- Final answer 26,543 g. ✓

BEREKENINGE WAT KONSENTRASIE GEBRUIK

Puntetoekenning

- *Korrekte K_c-uitdrukking (formules in vierkanthakies).*
- *Vervanging van ewewigskonsentrasies in K_c-uitdrukking.*
- *Vervanging van K_c-waarde.*
- *Verandering in n(I) = n(I by ewewig).*
- ***GEBRUIK** verhouding $I_2 : I = 1 : 2$*
- *Aanvanklike $[I_2]$ = ewewigs $[I_2]$ + verandering in $[I_2]$.*
- *Deel deur 12,3 dm^3.* ✓
- *Vervang 254 $g \cdot mol^{-1}$ as molêre massa van I_2.*
- *Finale antwoord: 26,543 g*

OPTION 3/*OPSIE 3*

$$K_c = \frac{[I]^2}{[I_2]} \ ✓$$

$$3{,}76\times10^{-3}\ ✓ = \frac{(4{,}79\times10^{-3})^2}{[I_2]}\ ✓$$

$[I_2] = 6{,}102 \times 10^{-3}$ $mol \cdot dm^{-3}$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{8}{9}$	
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{6}{9}$	

	I_2	I	
Initial concentration ($mol \cdot dm^{-3}$) *Aanvangskonsentrasie ($mol \cdot dm^{-3}$)*	$8{,}497\times10^{-3}$	0	
Change ($mol \cdot dm^{-3}$) *Verandering* ($mol \cdot dm^{-3}$)	✓ $2{,}395\times10^{-3}$	$4{,}79\times10^{-3}$ ✓	Using ratio ✓
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)*	$6{,}102 \times 10^{-3}$	$4{,}79 \times 10^{-3}$	

$$c = \frac{m}{MV}$$

$$8{,}497\times10^{-3} = \frac{m}{(254)✓(12{,}3)}✓$$

$\therefore m = 26{,}546$ g ✓

(9)
[18]

QUESTION 7/*VRAAG 7*

7.1.1 Weak/*Swak* ✓

Ionises/Dissociates incompletely/partially (in water) ✓
Ioniseer/Dissosieer/onvolledig/gedeeltelik (in water) (2)

7.1.2

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
pH = -log[H_3O^+] ✓ 3,85 ✓ = -log[H_3O^+] [H_3O^+] = 1,41 x 10^{-4} mol·dm^{-3} ✓	[H_3O^+] = 10^{-pH} ✓ = $10^{-3,85}$ ✓ = 1,41 x 10^{-4} mol·dm^{-3} ✓

(3)

7.1.3 Greater than/*Groter as* ✓ (1)

7.1.4 $CH_3COO^-(aq) + H_2O(\ell)$ ✓ $\rightleftharpoons$ $CH_3COOH(aq) + OH^-(aq)$ ✓

OR/*OF*
$CH_3COONa(aq) + H_2O(\ell)$ ✓ $\rightleftharpoons$ $CH_3COOH(aq) + NaOH(aq)$ ✓

Due to formation of hydroxide/OH^- / the solution is basic/alkaline /pH > 7. ✓
As gevolg van die vorming van hidroksied/OH^- is die oplossing basies/ alkalies /pH > 7 (3)

7.2.1 **Marking criteria/*Nasienriglyne***

- Substitute/*vervang*: 1 x 0,0145 **OR/*OF*** 1 x 14,5 in $c = \frac{n}{V} / \frac{c_a \times V_a}{c_b \times V_b} = \frac{n_a}{n_b}$. ✓
- Use/*Gebruik*: n(CH_3COOH) : n(NaOH) = 1:1 ✓
- Final answer/*Finale antwoord*: 0,0145 mol ✓

OPTION 1/*OPSIE 1*

n(NaOH)$_{reacted}$ = cV
= 1(0,0145) ✓
= 0,0145 mol

n(CH_3COOH)$_{diluted}$ = n(NaOH) ✓
= 0,0145mol ✓

(3)

7.2.2 **POSITIVE MARKING FROM 7.2.1./*POSITEWE NASIEN VANAF VRAAG 7.2.1.***

Marking criteria/*Nasienriglyne*

- Calculate mass/*Bereken massa* CH_3COOH in 25 cm^3 (1,13 g). ✓
- Formula/*Formule*: $n = \frac{m}{M}$. ✓
- Substitute/*Vervang*: M = 60 $g\cdot mol^{-1}$. ✓
- $n(CH_3COOH)_{reacted/reageer} = n_{initial/begin} - n_{unreacted/nie\ reageer}$ ✓
- USE mol ratio/*GEBRUIK molverhouding*: $n(CaCO_3) : n(CH_3COOH) = 1 : 2$.✓
- Substitution of/*Vervanging van* 100 $g\cdot mol^{-1}$ in m = nM. ✓
- Calculate percentage/*Bereken persentasie*: $\frac{0,217}{1,2} \times 100$ ✓
- Final answer/*Finale antwoord*: 18,08% ✓ (17,92 – 22,92)

$m(CH_3COOH) = \frac{4,52}{100} \times 25$ ✓ $= 1,13$ g

$n(CH_3COOH)_{ini/aanv.} = \frac{m}{M}$ ✓

$= \frac{1,13}{60}$ ✓ $= 0,01883$ mol

$n(CH_3COOH)_{rea} = 0,01883 - 0,0145 = 0,0043$ mol ✓

$n(CaCO_3) = \frac{1}{2} n(CH_3COOH)$

$= 0,5(0,0043)$ ✓

$= 0,00217$ mol

$m(CaCO_3) = nM$

$= 0,00217(100)$ ✓ $= 0,217$ g

$\% \ CaCO_3 = \frac{0,217}{1,2} \times 100$ ✓

$= 18,08 \%$ ✓

(8)

[20]

QUESTION 8/*VRAAG 8*

8.1 Provides path for movement of ions./Ensures(electrical)neutrality in the cell. ✓
Verskaf pad vir beweging van ione./Verseker (elektriese) neutraliteit in die sel. (1)

8.2 (The electrode) where oxidation takes place/electrons are lost. ✓✓
(Die elektrode) waar oksidasie plaasvind/elektrone verloor word. (2)

8.3 Mg/Magnesium ✓ (1)

8.4.1 $2H^+ + 2e^- \rightarrow H_2$ ✓✓

Marking criteria/*Nasienriglyne*

$H_2 \leftarrow 2H^+ + 2e^-$	$(\frac{2}{2})$	$2H^+ + 2e^- \rightleftharpoons H_2$	$(\frac{1}{2})$
$H_2 \rightleftharpoons 2H^+ + 2e^-$	$(\frac{0}{2})$	$2H^+ + 2e \leftarrow H_2$	$(\frac{0}{2})$

- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (+) omitted on H^+/*Indien lading (+) weggelaat op* H^+*:*

  Example/*Voorbeeld:* $2H + 2e^- \rightarrow H_2$ ✓ Max./*Maks:* $\frac{1}{2}$

(2)

8.4.2 Magnesium/Mg ✓ (1)

8.5

OPTION 1/*OPSIE 1*	**Notes/*Aantekeninge***
$E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ ✓ $= 0$ ✓ $- (-2{,}36)$ ✓ $E^\theta_{cell} = 2{,}36$ V ✓	• Accept any other correct formula from the data sheet./*Aanvaar enige ander korrekte formule vanaf gegewensblad.* • Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik bv. $E°_{sel} = E°_{OM} - E°_{RM}$ gevolg deur korrekte vervangings:* $\frac{3}{4}$

OPTION 2/*OPSIE 2*

✓ $2H^+ + 2e^- \rightarrow H_2$	$E^\theta = 0$ V ✓
$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$	$E^\theta = +2{,}36$ V ✓
$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$	$E^\theta = +2{,}36$ V ✓

(4)

8.6 H₂ is a stronger reducing agent ✓ than Cu ✓ and therefore Cu^{2+}/Cu ions are reduced/H_2 is oxidised ✓ Electrons flow from H_2 to Cu.

H_2 is 'n sterker reduseermiddel as Cu en dus word Cu^{2+}/Cu-ione gereduseer/H_2 is geoksideer. Elektrone vloei vanaf H_2 na Cu. (3)

[14]

 Please turn the page/*Blaai om asseblief*

QUESTION 9/*VRAAG 9*

9.1 **ANY ONE/*ENIGE EEN:***

- The chemical process in which <u>electrical energy is converted to chemical energy</u>. ✓✓ **(2 or 0)**
- The use of <u>electrical energy to produce a chemical change</u>. **(2 or 0)**
- <u>Decomposition of an ionic compound</u> by means of <u>electrical energy</u>. **(2 or 0)**
- The process during which and <u>electric current passes through a solution/ionic liquid/molten ionic</u> compound. **(2 or 0)**

- *Die chemiese proses waarin <u>elektriese energie omgeskakel word na chemiese energie</u>.* ***(2 of 0)***
- *Die gebruik van <u>elektriese energie om 'n chemiese verandering te weeg te bring</u>.* ***(2 of 0)***
- *<u>Ontbinding van 'n ioniese verbinding</u> met behulp van <u>elektriese energie</u>.* ***(2 of 0)***
- *Die proses waardeur 'n <u>elektriese stroom deur 'n oplossing/ioniese vloeistof/gesmelte ioniese</u> verbinding beweeg.* ***(2 of 0)*** (2)

9.2 Battery/cell/ power source ✓
Battery/sel/kragbron (1)

9.3 Silver nitrate/$AgNO_3$/ Silver ethanoate/CH_3COOAg / Silver fluoride /AgF/ Silver perchlorate $AgC\ell O_4$. ✓
Silwernitraat/$AgNO_3$/ Silweretanoaat/CH_3COOAg / Silwerfloried / AgF / Silwerperchloraat / $AgC\ell O_4$ (1)

9.4 Remains the same/*Bly dieselfde* ✓

Rate of oxidation is equal to the rate of reduction. ✓
Tempo van oksidasie is gelyk aan die tempo van reduksie. (2)

9.5 $Ag \rightarrow Ag^{+} + e^{-}$ ✓✓

> **<u>Notes/*Aantekeninge*</u>**
>
> $Ag^{+} + e^{-} \leftarrow Ag$ $(\frac{2}{2})$ $Ag \rightleftharpoons Ag^{+} + e^{-}$ $(\frac{1}{2})$
>
> $Ag \leftarrow Ag^{+} + e^{-}$ $(\frac{0}{2})$ $Ag^{+} + e^{-} \rightleftharpoons Ag$ $(\frac{0}{2})$
>
> - Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
> - If charge (+) omitted on Ag^{+}/*Indien lading (+) weggelaat op* Ag^{+}*:*
>
>   Example/*Voorbeeld:* $Ag \rightarrow Ag + e^{-}$ ✓

(2)
[8]

QUESTION 10/*VRAAG 10*

10.1.1 (Liquid) Air/*(Vloeibare)Lug* ✓ (1)

10.1.2 Natural gas/methane/oil/coal/coke✓
Aardgas/metaan/olie/steenkool/kooks (1)

10.1.3 Iron/iron oxide/Fe/FeO ✓
Yster/ysteroksied/Fe/FeO (1)

10.1.4 NH_3/Ammonia/*Ammoniak* ✓ (1)

10.1.5 Ostwald (process)/*Ostwald(proses)* ✓ (1)

10.1.6 $NH_3 + HNO_3$ ✓ $\rightarrow$ NH_4NO_3 ✓ Bal ✓

Marking criteria/*Nasienriglyne*
- Reactants ✓ *Reaktanse* Products ✓ *Produkte* Balancing ✓ *Balansering*
- Ignore double arrows./*Ignoreer dubbelpyle.*
- Marking rule 6.3.10./*Nasienreël 6.3.10.*

(3)

10.2.1 NPK ratio/Ratio of primary nutrients ✓
NPK-verhouding/Verhouding van primêre voedingstowwe (1)

10.2.2

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
$\frac{4}{9}$ ✓ x $\frac{X}{100}$ x 20 ✓ = 2,315 kg X = 26 ✓ (26,04)	m(P) = 2,315 kg Mass of 1 part P = $\frac{2,315}{4}$ = 0,57575 Mass of N = (0,57575)(2) = 1,1575 kg Mass of K = (0,57575)(3) = 1,73625 kg Total mass of fertiliser: 1,1575 + 2,315 + 1,73625 = 5,20875 kg ✓ X = $\frac{5,20875}{20}$ x 100 ✓= 26,04 ✓

(3)
[12]

TOTAL/*TOTAAL*: 150

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2021

MARKS: 150

TIME: 3 hours

This question paper consists of 15 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.

2. This question paper consists of NINE questions. Answer ALL the questions in the ANSWER BOOK.

3. Start EACH question on a NEW page in the ANSWER BOOK.

4. Number the answers correctly according to the numbering system used in this question paper.

5. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

8. Show ALL formulae and substitutions in ALL calculations.

9. Round off your FINAL numerical answers to a minimum of TWO decimal places.

10. Give brief motivations, discussions, etc. where required.

11. You are advised to use the attached DATA SHEETS.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 Which formula shows the way in which atoms are bonded in a molecule but does not show all the bond lines?

A Empirical

B Molecular

C Structural

D Condensed structural (2)

1.2 Which ONE of the following compounds has hydrogen bonds between its molecules?

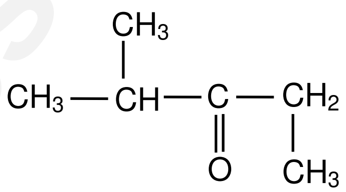
A $CH_3(CH_2)_2CH_3$

B $CH_3COCH_2CH_3$

C $CH_3COOCH_2CH_3$

D $CH_3CH(OH)CH_2CH_3$ (2)

1.3 Consider the compound below.



Which ONE of the following is the IUPAC name of this compound?

A 2-methylpentan-3-one

B 4-methylpentan-3-one

C 2,3-dimethylbutan-2-one

D 2,2,4-trimethylpropan-2-one (2)

1.4 A 2 g piece of magnesium reacts with EXCESS hydrochloric acid according to the following balanced equation:

$$Mg(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g)$$

Which ONE of the following changes will INCREASE the YIELD of $H_2(g)$?

A Crush the piece of magnesium.

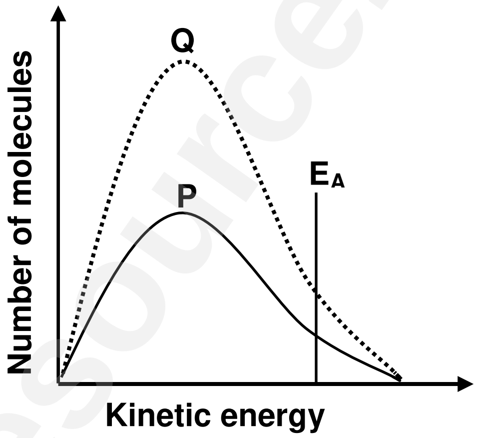
B Use a 3 g piece of magnesium.

C Use a greater volume of the acid.

D Use a higher concentration of the acid. (2)

1.5 The Maxwell-Boltzmann distribution curve **P** represents the number of molecules against kinetic energy for a certain reaction.

Curve **Q** is obtained after a change was made to one reaction condition.



Which ONE of the following changes resulted in curve **Q**?

A Addition of a catalyst

B Increase in temperature

C Increase in activation energy

D Increase in the concentration of the reactants (2)

1.6 The expression for the equilibrium constant (K_c) of a hypothetical reaction is given as follows:

$$K_c = \frac{[X]^3}{[Y]^2[Z]}$$

Which ONE of the following equations for a reaction at equilibrium matches the above expression?

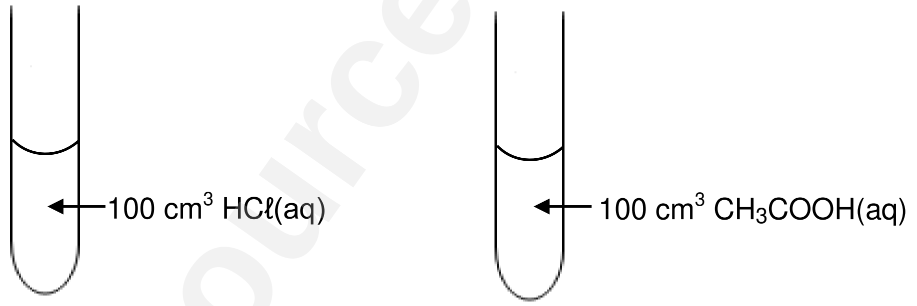
A $Z(g) + 2Y(g) \rightleftharpoons 3X(s)$

B $Z(aq) + 2Y(aq) \rightleftharpoons 3X(\ell)$

C $Z(g) + Y_2(g) \rightleftharpoons 3X(aq) + Q(s)$

D $Z(aq) + 2Y(aq) \rightleftharpoons 3X(aq) + Q(s)$ (2)

1.7 Two dilute acids of equal concentrations are added to separate test tubes as shown below.



Consider the following statements regarding these acids:

I: The pH of each is less than 7.
II: Both will react at the same rate with 5 g of magnesium powder.
III: Both will neutralise the same number of moles of NaOH(aq).

Which of the statements above is/are TRUE?

A **I** only

B **I**, **II** and **III**

C **I** and **III** only

D **II** and **III** only (2)

1.8 Which ONE of the following is the conjugate base of $H_2PO_4^-$?

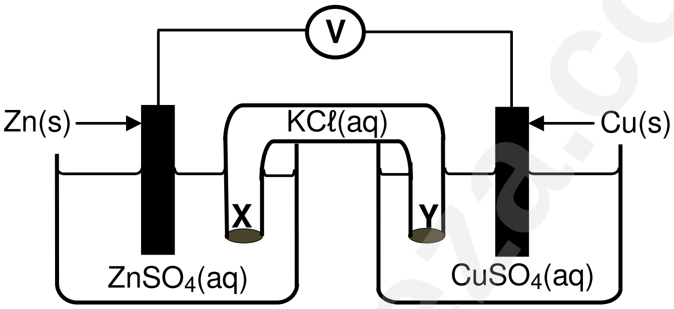
A PO_4^{3-}

B HPO_4^{2-}

C H_3PO_4

D $H_4PO_4^+$ (2)

1.9 The diagram below represents a voltaic cell.

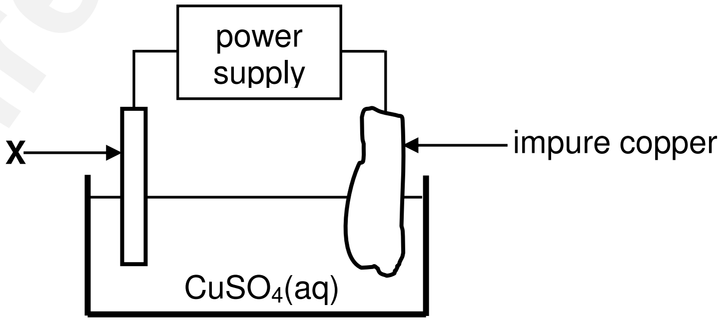


Which ONE of the following correctly describes the movement of ions in the cell?

	TYPE OF IONS	DIRECTION OF MOVEMENT
A	$Cl^-(aq)$	**Y** to **X**
B	SO_4^{2-} (aq)	**X** to **Y**
C	$Cu^{2+}(aq)$	**Y** to **X**
D	$K^+(aq)$	**Y** to **X**

(2)

1.10 The diagram below represents a cell that is used for the refining of copper.



Which ONE of the following statements is TRUE?

A **X** is made of platinum.

B The mass of **X** increases.

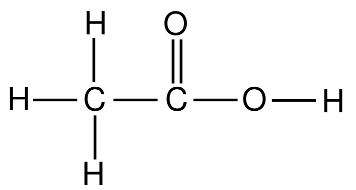
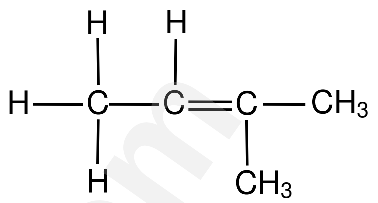
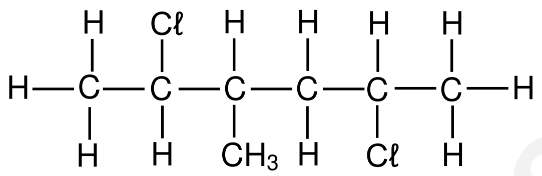
C **X** is the electrode where oxidation takes place.

D **X** is connected to the positive terminal of the power supply. (2)

[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **H** in the table below represent eight organic compounds.

A		**B**	
C	$CH_3CH_2CH_2COCH_3$	**D**	C_2H_6O
E	C_2H_4	**F**	3-methylbutan-2-one
G		**H**	3-methylbutanal

2.1 Define the term *unsaturated compound*. (2)

2.2 Write down the:

2.2.1 Letter that represents an UNSATURATED compound (1)

2.2.2 NAME of the functional group of compound **C** (1)

2.2.3 Letter that represents a CHAIN ISOMER of compound **C** (2)

2.2.4 IUPAC name of compound **G** (3)

2.2.5 General formula of the homologous series to which compound **E** belongs (1)

2.3 Define the term *functional isomers*. (2)

2.4 For compound **A**, write down the:

2.4.1 Homologous series to which it belongs (1)

2.4.2 STRUCTURAL FORMULA of its FUNCTIONAL isomer (2)

2.5 Compound **D** undergoes a dehydration reaction. Write down the:

2.5.1 IUPAC name of compound **D** (1)

2.5.2 Letter that represents a product of this reaction (1)

2.5.3 NAME or FORMULA of the inorganic reactant that is used in this reaction (1)

[18]

QUESTION 3 (Start on a new page.)

The melting points and boiling points of four straight-chain ALKANES are shown in the table below.

COMPOUND	MELTING POINT (°C)	BOILING POINT (°C)
Pentane	-130	36,1
Hexane	-94	69
Heptane	-90,6	98,4
Octane	-57	125

3.1 Define the term *melting point*. (2)

3.2 Write down the general conclusion that can be made about the melting points of straight-chain alkanes. (2)

3.3 Name the type of Van der Waals forces between molecules of octane. (1)

3.4 Write down the predominant phase of the following alkanes at -100 °C.

Choose from GAS, LIQUID or SOLID.

3.4.1 Pentane (1)

3.4.2 Octane (1)

3.5 Hexane is now compared to 2,2-dimethylbutane.

3.5.1 Is the molecular mass of hexane GREATER THAN, LESS THAN or EQUAL to that of 2,2-dimethylbutane?

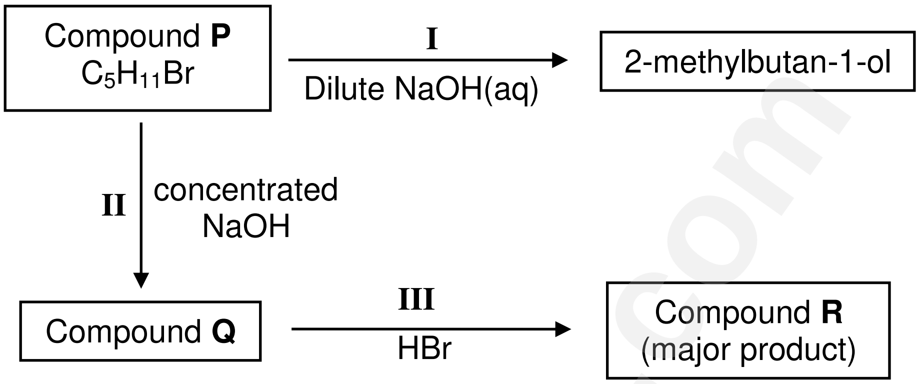
Give a reason for the answer. (2)

3.5.2 Is the boiling point of 2,2-dimethylbutane HIGHER THAN, LOWER THAN or EQUAL TO that of hexane? (1)

3.5.3 Fully explain the answer to QUESTION 3.5.2. (3)
[13]

QUESTION 4 (Start on a new page.)

4.1 Compound **P** is used as a starting reactant in each of two reactions as shown in the flow diagram below.



I, **II** and **III** represent organic reactions.

4.1.1 Name the type of reaction represented by **I**. (1)

4.1.2 Is 2-methylbutan-1-ol a PRIMARY, SECONDARY or TERTIARY alcohol?

Give a reason for the answer. (2)

4.1.3 Write down the STRUCTURAL FORMULA of compound **P**. (3)

4.1.4 Name the type of reaction represented by **II**. (1)

4.1.5 To which homologous series does compound **Q** belong? (1)

4.1.6 Name the type of reaction represented by **III**.

Choose from ADDITION, ELIMINATION or SUBSTITUTION. (1)

4.1.7 Write down the IUPAC name of compound **R**. (2)

4.2 1,2-dibromopropane can be prepared from but-2-ene by a three-step process as shown in the flow diagram below.

$$\text{But-2-ene} \xrightarrow{\textbf{step 1}} \text{Compound } \mathbf{A} \xrightarrow{\textbf{step 2}} \text{Compound } \mathbf{B} \xrightarrow{\textbf{step 3}} \text{1,2-dibromopropane}$$

4.2.1 Using CONDENSED STRUCTURAL FORMULAE, write down a balanced equation for **step 1**. Indicate the reaction conditions on the arrow. (4)

4.2.2 Write down the type of reaction in **step 2**. (1)

4.2.3 Write down the IUPAC name of compound **B**. (2)

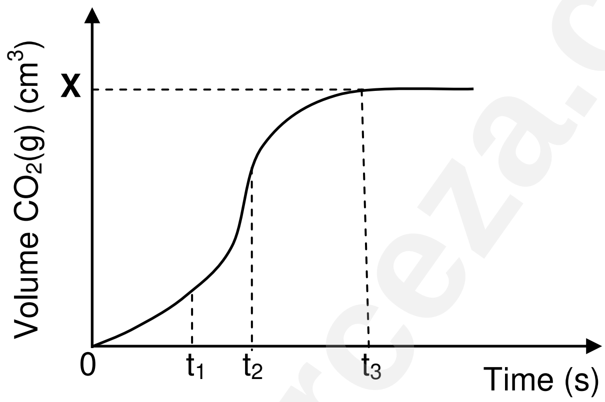
4.2.4 Using CONDENSED STRUCTURAL FORMULAE, write down a balanced equation for **step 3**. (3)
[21]

QUESTION 5 (Start on a new page.)

The reaction of 15 g of an IMPURE sample of calcium carbonate, $CaCO_3$, with EXCESS hydrochloric acid, HCℓ, of concentration 1,0 mol·dm^{-3}, is used to investigate the rate of a reaction. The balanced equation for the reaction is:

$$CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g)$$

The volume of $CO_2(g)$ produced is measured at regular intervals. A sketch graph representing the total volume of carbon dioxide gas produced as a function of time is shown below.



5.1 Define the term *reaction rate*. (2)

5.2 Give a reason why the gradient of the graph decreases between t_2 and t_3. (1)

5.3 Changes in the graph between t_1 and t_2 are due to temperature changes within the reaction mixture.

5.3.1 Is the reaction EXOTHERMIC or ENDOTHERMIC? (1)

5.3.2 Explain the answer by referring to the graph. (3)

5.4 The percentage purity of the sample is 82,5%.

Calculate the value of **X** on the graph assuming that the gas is collected at 25 °C. Take the molar gas volume at 25 °C as 24 000 cm^3. (5)

5.5 How will the reaction rate change if 15 g of a PURE sample of $CaCO_3$ reacts with the same HCℓ solution?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

5.6 Use the collision theory to explain the answer to QUESTION 5.5. (2)
[15]

QUESTION 6 (Start on a new page.)

Consider the balanced equation below for a hypothetical reaction that takes place in a sealed 2 dm^3 container at 300 K.

$$2P(g) + Q_2(g) \rightleftharpoons 2PQ(g)$$

6.1 Define the term *chemical equilibrium*. (2)

6.2 The amount of each substance present in the equilibrium mixture at 300 K is shown in the table below.

	AMOUNT (mol) AT EQUILIBRIUM
P	0,8
Q_2	0,8
PQ	3,2

The temperature of the container is now increased to 350 K.

When a NEW equilibrium is established, it is found that 1,2 mol P(g) is present in the container.

6.2.1 Is the heat of the reaction (ΔH) POSITIVE or NEGATIVE? (1)

6.2.2 Use Le Chatelier's principle to explain the answer to QUESTION 6.2.1. (3)

6.2.3 Calculate the equilibrium constant at 350 K. (8)

6.2.4 How will the equilibrium constant calculated in QUESTION 6.2.3 be affected when the volume of the container is decreased at constant temperature?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

Give a reason for the answer. (2)

6.3 More Q_2(g) is now added to the reaction mixture at constant temperature.

How will EACH of the following be affected?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

6.3.1 The yield of PQ(g) (1)

6.3.2 Number of moles of P(g) (1)
[18]

QUESTION 7 (Start on a new page.)

7.1 Sulphuric acid, H_2SO_4, ionises into two steps as follows:

I $H_2SO_4(aq) + H_2O(\ell) \rightarrow HSO_4^-(aq) + H_3O^+(aq)$ $K_a = 1 \times 10^3$

II $HSO_4^-(aq) + H_2O(\ell) \rightarrow SO_4^{2-}(aq) + H_3O^+(aq)$ $K_a = 1 \times 10^{-2}$

7.1.1 Define an *acid* in terms of the Lowry-Brønsted theory. (2)

7.1.2 Write down the NAME or FORMULA of the substance that acts as an ampholyte in the above equations.

Give a reason for the answer. (2)

7.1.3 The conductivity of solutions of $HSO_4^-(aq)$ and $H_2SO_4(aq)$ are compared. Which solution will have a LOWER conductivity?

Explain the answer. (3)

7.2 The pH of a hydrochloric acid solution, $HC\ell(aq)$, is 1,02 at 25 °C.

7.2.1 Calculate the concentration of the $HC\ell(aq)$. (3)

This $HC\ell$ solution reacts with sodium carbonate, Na_2CO_3, according to the following balanced equation:

$$2HC\ell(aq) + Na_2CO_3(aq) \rightarrow 2NaC\ell(aq) + CO_2(g) + H_2O(\ell)$$

50 cm^3 of the $HC\ell$ solution is added to 25 cm^3 of a 0,075 $mol \cdot dm^{-3}$ Na_2CO_3 solution.

7.2.2 Calculate the concentration of the EXCESS $HC\ell$ in the new solution. (8)
[18]

QUESTION 8 (Start on a new page.)

The table below shows two half-cells, **A** and **B**, used to assemble an electrochemical cell under STANDARD CONDITIONS.

Half-cell **A**	Cu^{2+} (aq) | Cu(s)
Half-cell **B**	Ag^{+} (aq) | Ag(s)

8.1 State the energy conversion that takes place in this cell. (1)

8.2 Calculate the mass of silver nitrate, $AgNO_3$, used to prepare 150 cm^3 of the electrolyte solution in half-cell **B**. (4)

8.3 Define the term *reducing agent*. (2)

8.4 Write down the:

8.4.1 NAME or FORMULA of the reducing agent (1)

8.4.2 Balanced equation for the reaction that takes place (3)

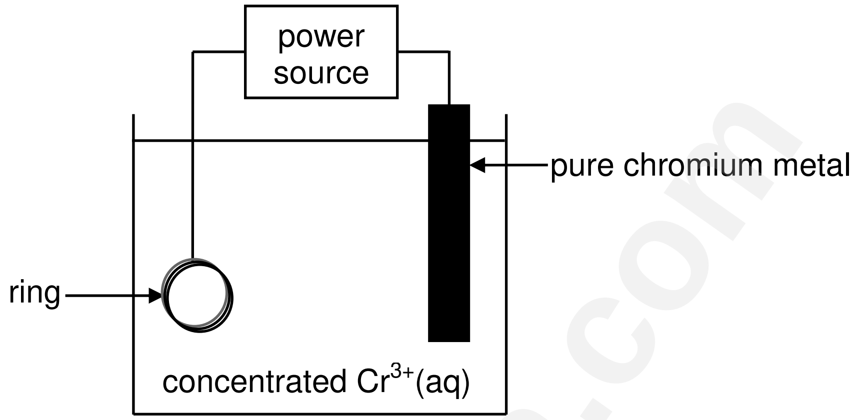
8.5 Calculate the initial emf of this cell. (4)

8.6 How will the emf of the cell be affected if the concentration of the copper ions in half-cell **A** increases?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)
[16]

QUESTION 9 (Start on a new page.)

The diagram below shows a simplified electrolytic cell used to electroplate a ring.



9.1 Define the term *electrolyte*. (2)

9.2 Is the pure chromium metal the ANODE or the CATHODE of the cell? Give a reason for the answer. (2)

9.3 Write down the half-reaction that takes place at the ring. (2)

9.4 Calculate the total charge transferred when the mass of the pure chromium changes by 2 g. (5)
[11]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1,013 \times 10^5$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22,4\ dm^3 \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1,6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6,02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}\ /\ E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}\ /\ E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidisingagent} - E^{\theta}_{reducingagent}\ /\ E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Electronegativity / *Elektronegatiwiteit*	Atomic number / *Atoomgetal*	Symbol / *Simbool*	Approximate relative atomic mass / *Benaderde relatiewe atoommassa*
1,9	29	Cu	63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Increasing strength of oxidising agents/*Toenemende sterkte van oksideermiddels* (increasing upwards)

Increasing strength of reducing agents/*Toenemende sterkte van reduseermiddels* (increasing downwards)

Half-reactions/*Halfreaksies*			E^{θ} (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
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 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

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Increasing strength of oxidising agents/*Toenemende sterkte van oksideermiddels* (↓)

Increasing strength of reducing agents/*Toenemende sterkte van reduseermiddels* (↑)

Half-reactions/*Halfreaksies*			E^θ (V)
$Li^+ + e^-$	⇌	Li	– 3,05
$K^+ + e^-$	⇌	K	– 2,93
$Cs^+ + e^-$	⇌	Cs	– 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	– 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	– 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	– 2,87
$Na^+ + e^-$	⇌	Na	– 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	– 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	– 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	– 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	– 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	– 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	– 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	– 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	– 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	– 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	– 0,40
$Co^{2+} + 2e^-$	⇌	Co	– 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	– 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	– 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	– 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	– 0,06
$2H^+ + 2e^-$	⇌	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

basic education

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NATIONAL
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NASIONALE
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GRADE/*GRAAD* 12

PHYSICAL SCIENCES: CHEMISTRY (P2)
FISIESE WETENSKAPPE: CHEMIE (V2)

NOVEMBER 2021

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

These marking guidelines consist of 21 pages.
Hierdie nasienriglyne bestaan uit 21 bladsye.

QUESTION 1/*VRAAG 1*

1.1	D ✓✓	(2)
1.2	D ✓✓	(2)
1.3	A ✓✓	(2)
1.4	B ✓✓	(2)
1.5	D ✓✓	(2)
1.6	D ✓✓	(2)
1.7	C ✓✓	(2)
1.8	B ✓✓	(2)
1.9	A ✓✓	(2)
1.10	B ✓✓	(2)
		[20]

QUESTION 2/*VRAAG 2*

2.1 A compound that <u>contains a double bond/multiple bond/does NOT contain only single bonds</u> (between C atoms). ✓✓ **(2 or 0)**
'n Verbinding <u>wat dubbelbindings/meervoudige bindings/NIE net enkel-bindings</u> (tussen C-atome) <u>bevat</u> NIE. ***(2 of 0)*** (2)

2.2

2.2.1 B / E ✓ (1)

2.2.2 Carbonyl (group bonded to two C atoms) ✓
Karboniel(groep gebind aan twee C-atome)

<u>ACCEPT/*AANVAAR*</u>
Ketone/*Ketoon*

(1)

2.2.3 F ✓✓ (2)

2.2.4 2,5-dichloro-3-methylhexane/*2,5-dichloro-3-metielheksaan*

<u>Marking criteria:</u>
- Correct stem i.e. <u>hexane</u>. ✓
- All substituents (dichloro and methyl) correctly identified. ✓
- IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓

<u>Nasienkriteria:</u>
- *Korrekte stam d.i. <u>heksaan</u>.* ✓
- *Alle substituente (dichloro en metiel) korrek geïdentifiseer.* ✓
- *IUPAC-naam heeltemal korrek insluitende nommering, volgorde, koppeltekens en kommas.* ✓

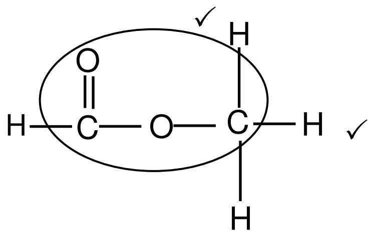
(3)

2.2.5 C_nH_{2n} ✓ (1)

2.3 Compounds with the <u>same molecular formula</u>, ✓ but <u>different functional groups/homologous series</u>. ✓
Verbindings met <u>dieselfde molekulêre formule</u>, maar <u>verskillende funksionele groepe/homoloë reekse</u>. (2)

2.4
2.4.1 Carboxylic acids/*Karboksielsure* ✓ (1)

2.4.2



<u>Marking criteria/*Nasienkriteria*:</u>

- Whole structure correct/ *Hele struktuur korrek:* $\frac{2}{2}$
- Only functional group correct/*Slegs funksionele groep korrek:* Max/*Maks.*: $\frac{1}{2}$

<u>IF/*INDIEN*</u>
More than one functional group:
Meer as een funksionele groep: $\frac{0}{2}$

<u>IF/*INDIEN*</u>

- Molecular formula/*Molekulêre formule* $\frac{0}{2}$
- Condensed structural formula /*Gekondenseerde struktuurformule* $\frac{1}{2}$

(2)

2.5
2.5.1 Ethanol/*Etanol* ✓ (1)

2.5.2 E ✓ **ACCEPT/*AANVAAR*:** C_2H_4 (1)

2.5.3 (Concentrated) sulphuric acid/H_2SO_4/(concentrated) phosphoric acid/H_3PO_4 ✓
(Gekonsentreerde) swawelsuur/ H_2SO_4/(gekonsentreerde) fosforsuur/ H_3PO_4 (1)
[18]

QUESTION 3/*VRAAG 3*

3.1

Marking criteria/*Nasienkriteria:*
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

The temperature at which solid and liquid phases are in equilibrium. ✓✓
Die temperatuur waarby die vastestof- en vloeistoffases van 'n stof in ewewig is. (2)

3.2

Marking criteria
• Identification of independent variable. ✓ • Stating the relationship between dependent and independent variable. ✓
Nasienkriteria
• *Identifikasie van onafhanklike veranderlike.* ✓ • *Stel verwantskap tussen afhanklike en onafhanklike veranderlikes.* ✓

- As the chain length/number of C atoms/molecular mass/surface area/strength of the intermolecular forces ✓ increases, the melting points increase. ✓
  OR
- As the chain length/ number of C atoms/molecular mass/surface area/strength of the intermolecular forces ✓ decreases, the melting points decrease. ✓

- *Wanneer die kettinglengte/aantal C-atome/molekulêre massa/oppervlak-area/sterkte van intermolekulêre kragte ✓ toeneem, neem die smeltpunte toe.*
  OF
- *Wanneer die kettinglengte/aantal C-atome/molekulêre massa/oppervlak-area/sterkte van intermolekulêre kragte afneem, neem die smeltpunte af.* (2)

3.3 London forces ✓
Londonkragte

ACCEPT/*AANVAAR*
Dispersion forces/induced dipole forces *Dispersiekragte/geïnduseerde dipoolkragte*

(1)

3.4
3.4.1 Liquid/*Vloeistof* ✓ (1)

3.4.2 Solid/*Vaste stof* ✓ (1)

3.5
3.5.1 Equal to/*Gelyk aan* ✓

Same molecular formula/Isomers/same number and types of atoms/same number of C and H atoms ✓
Dieselfde molekulêre formule/Isomere/dieselfde aantal en soort atome/ dieselfde aantal C- en H-atome (2)

3.5.2 Lower than/*Laer as* ✓ (1)

3.5.3

Marking criteria:
- Compare structures. ✓
- Compare the strength of intermolecular forces.✓
- Compare the energy required to overcome intermolecular forces. ✓

2,2-dimethylbutane:
- **Structure:**
  More branched/more compact/more spherical/smaller surface area (over which intermolecular forces act).✓
- **Intermolecular forces*:***
  Weaker/less intermolecular forces/Van der Waals forces/London forces/dispersion forces. ✓
- **Energy:**
  Lesser energy needed to overcome or break intermolecular forces/Van der Waals forces. ✓

OR

Hexane
- **Structure:**
  Longer chain length/unbranched/less compact/less spherical/larger surface area (over which intermolecular forces act). ✓
- **Intermolecular forces*:***
  Stronger/more intermolecular forces/Van der Waals forces/London forces/dispersion forces. ✓
- **Energy:**
  More energy needed to overcome or break intermolecular forces/Van der Waals forces. ✓

Nasienkriteria:
- *Vergelyk strukture* ✓
- *Vergelyk die sterkte van intermolekulêre kragte.* ✓
- Vergelyk die energie benodig om intermolekulêre kragte te oorkom. ✓

***2,2-dimetielbutaan*:**
- ***Struktuur*:**
  Meer vertak/meer kompak/meer sferies/kleiner oppervlak (waaroor intermolekulêre kragte werk). ✓
- ***Intermolekulêre kragte:***
  Swakker/minder intermolekulêre kragte/Van der Waalskragte/London-kragte/dispersiekragte. ✓
- ***Energie*:**
  Minder energie benodig om intermolekulêre kragte/Van der Waalskragte/dispersiekragte/Londonkragte te oorkom/breek. ✓

OF

Heksaan
- ***Struktuur*:**
  Langer kettinglengte/onvertak/minder kompak/minder sferies/groter oppervlak (waaroor intermolekulêre kragte werk). ✓
- ***Intermolekulêre kragte:***
  S*terker/meer intermolekulêre kragte/Van der Waalskragte/Londonkragte/dispersiekragte.* ✓
- ***Energie*:**
  Meer energie benodig om intermolekulêre kragte/Van der Waalskragte/dispersiekragte/Londonkragte te oorkom/breek. ✓ (3)

[13]

QUESTION 4/*VRAAG 4*

4.1

4.1.1 Substitution/Hydrolysis ✓
Substitusie/Hidrolise (1)

4.1.2 Primary (alcohol) ✓

ANY ONE:

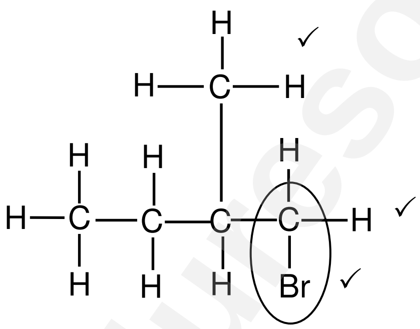
- The C atom of the functional group is the terminal C atom.
- The C-atom bonded to the hydroxyl/-OH is bonded to (only) one other C-atom. ✓
- The hydroxyl/-OH is bonded to a C-atom which is bonded to two hydrogen atoms.
- The hydroxyl/-OH is bonded to a primary C atom/terminal C atom/first C atom.

Primêre (alkohol) ✓

ENIGE EEN:

- *Die C-atoom van die funksionele groep is die terminale C-atoom.*
- *Die C-atoom wat aan die hidroksiel/-OH gebind is, is aan (slegs) een ander C-atoom gebind.* ✓
- *Die hidroksiel/-OH is gebind aan 'n C-atoom wat aan twee waterstofatome gebind is.*
- *Die hidroksiel/-OH is aan 'n primêre C-atoom/*terminale C-atoom/eerste C-atoom gebind. (2)

4.1.3



Marking criteria:

- Four C atoms in longest chain. ✓
- One methyl substituent on C2. ✓
- Bromo substituent on C1. ✓

Nasienkriteria:

- *Vier C-atome in langste ketting.* ✓
- *Een metielsubstituent op C2.* ✓
- *Broomsubstituent op C1.* ✓

IF/*INDIEN*
Any error e.g. omission of H atoms, condensed or semi structural formula/*Enige fout bv. weglating van H-atome, gekondenseerde of semi-struktuurformule.* Max/*Maks.*: $\frac{2}{3}$ (3)

4.1.4 Elimination/dehydrohalogenation/dehydrobromination ✓
Eliminasie/dehidrohalogenering/dehidrohalogenasie/dehidrobrominasie/dehidrobromonering (1)

4.1.5 Alkenes/*Alkene* ✓ (1)

4.1.6 Addition/*Addisie* ✓ (1)

4.1.7 2-bromo-2-methyl✓butane ✓
2-bromo-2-metiel✓butaan ✓ (2)

4.2

NOTE/*LET WEL*:
- Penalise only once for the use of structural formulae or molecular formulae.
- *Penaliseer slegs een keer vir die gebruik van struktuurformules of molekulêre formules.*

4.2.1

Marking criteria:
- Correct condensed structure for but-2-ene. ✓
- React but-2-ene with H_2/H — H. ✓
- Indicate the catalyst Pt/Ni/Pd on arrow/at the equation. ✓
- Correct condensed formula for butane as product. ✓

IF: Any additional products or reactants - minus 1 mark

Nasienkriteria:
- *Korrekte gekondenseerde struktuur vir but-2-een.* ✓
- *Reageer but-2-een met H_2/H — H.* ✓
- *Dui die katalisator Pt/Ni/Pd op die pyl/by die vergelyking aan.* ✓
- *Korrekte gekondenseerde formule vir butaan as produk.* ✓

***INDIEN:** Enige addisionele reaktanse of produkte – minus 1 punt*

$$CH_3CHCHCH_3 ✓ + H_2 ✓ \xrightarrow{\text{Pt/Ni/Pd ✓}} CH_3CH_2CH_2CH_3 ✓$$

ACCEPT/*AANVAAR*
As reactant/*reaktans*: $CH_3(CH)_2CH_3$ / $CH_3CH = CHCH_3$ / $CH_3 — CH = CH — CH_3$
As product/*produk*: $CH_3(CH_2)_2CH_3$ / $CH_3 — CH_2 — CH_2 — CH_3$ /$CH_3 — (CH_2)_2 — CH_3$ (4)

4.2.2 Elimination/Cracking ✓
Eliminasie/Kraking (1)

4.2.3 Propene/1-propene/prop-1-ene ✓✓
Propeen/1-propeen/prop-1-een (2)

4.2.4

Marking criteria:
- Correct condensed formula for propene as reactant. ✓
- React (propene) with Br_2/Br — Br ✓
- Correct condensed formula for 1,2-dibromopropane as product. ✓

IF: Any additional products or reactants - minus 1 mark

Nasienkriteria:
- *Korrekte gekondenseerde formule vir propeen as reaktans.* ✓
- *Reageer* (propeen) *met Br_2/Br — Br.* ✓
- *Korrekte gekondenseerde formule vir 1,2-dibromopropaan as produk.* ✓

***INDIEN:** Enige addisionele reaktanse of produkte – minus 1 punt*

$$CH_3CHCH_2 ✓ + Br_2 ✓ \longrightarrow CH_3CHBrCH_2Br ✓$$

ACCEPT/*AANVAAR*:
As reactant/*reaktans*: $CH_3CH = CH_2$ / $CH_2 = CHCH_3$
As product/*produk*: $CH_3CHBrCH_2Br$ / $\begin{array}{ccccc} CH_3 & — & CH & — & CH_2 \\ & & | & & | \\ & & Br & & Br \end{array}$ /

$BrCH_2CHBrCH_3$ / $\begin{array}{ccccc} CH_2 & — & CH & — & CH_3 \\ | & & | & & \\ Br & & Br & & \end{array}$

(3)
[21]

QUESTION 5/*VRAAG 5*

5.1

NOTE/*LET WEL*
Give the mark for per unit time only if in context of reaction rate.
Gee die punt vir per eenheidtyd slegs indien in konteks van reaksietempo.

ANY ONE

- Change in concentration ✓ of products/reactants per (unit) time. ✓
- Change in amount/number of moles/volume/mass of products or reactants per (unit) time.
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time.
- Rate of change in concentration/amount of moles/number of moles/volume/ mass. ✓✓ **(2 or 0)**

ENIGE EEN

- *Verandering in konsentrasie ✓ van produkte/reaktanse per (eenheid) tyd.✓*
- *Verandering in hoeveelheid/getal mol/volume/massa van produkte of reaktanse per (eenheid) tyd.*
- *Hoeveelheid/getal mol/volume/massa van produkte gevorm/reaktanse gebruik per (eenheid) tyd.*
- *Tempo van verandering in konsentrasie/ hoeveelheid mol/getal mol/ volume/ massa.* ✓✓ **(2 *of* 0)** (2)

5.2 Reaction rate decreases./Concentration of HCℓ decreases./Concentration of reactant decreases./Reactants are used up/Mass of $CaCO_3$ decreases or is used up. ✓
Reaksietempo neem af./Konsentrasie van HCℓ neem af./Konsentrasie van reaktans neem af./Reaktanse word opgebruik./Massa van $CaCO_3$ neem af of word opgebruik. ✓ (1)

5.3
5.3.1 Exothermic/*Eksotermies* ✓ (1)

5.3.2
- Gradient increases/becomes steeper. / Curve becomes steeper. ✓
- Reaction rate increases/More (or larger volume) of CO_2 is produced per unit time. ✓
- Temperature increases./Energy is released/Average kinetic energy of the molecules increases. ✓

- *Gradiënt neem toe/word steiler. / Kurwe word steiler.* ✓
- *Reaksietempo neem toe./Meer (of groter volume) CO_2 word produseer per eenheidtyd.* ✓
- *Temperatuur neem toe./Energie word vrygestel./Gemiddelde kinetiese energie van molekule neem toe.* ✓ (3)

5.4

Marking criteria

- m(pure $CaCO_3$) = $\frac{82,5}{100}$ x 15 ✓ / V(CO_2) = $\frac{82,5}{100}$ x V(CO_2) from/*uit* 15 g $CaCO_3$
- Divide by 100 g·mol^{-1}. ✓
- Use mol ratio: n(CO_2) = n($CaCO_3$). ✓
- Multiply n(CO_2) by 24 000 cm^3/24 dm^3. ✓
- Final answer: 2 976 cm^3 ✓
- **Range**: 2880 to 2970 cm^3 / 2,88 to 2,97 dm^3

Nasienkriteria

- m(*suiwer* $CaCO_3$) = $\frac{82,5}{100}$ *x 15* ✓ / *V(CO_2)* = $\frac{82,5}{100}$ *x V(CO_2) uit 15 g $CaCO_3$*
- *Deel deur 100 g·mol^{-1}*. ✓
- *Gebruik molverhouding*: n(CO_2) = n($CaCO_3$). ✓
- *Vermenigvuldig* n(CO_2) *met* 24 000 cm^3/24 dm^3. ✓
- *Finale antwoord*: 2 976 cm^3 ✓
  Gebied: 2880 *tot* 2970 cm^3 / 2,88 tot 2,97 dm^3

OPTION 1/*OPSIE 1*

$$m(\text{pure/}\textit{suiwer}\ CaCO_3) = \frac{82,5}{100} \times 15\ ✓$$
$$= 12,375\ g$$

$$n(\text{pure/}\textit{suiwer}\ CaCO_3) = \frac{m}{M}$$
$$= \frac{12,375}{100}\ ✓$$
$$= 0,124\ mol$$

$$n(CO_2) = n(CaCO_3)$$
$$= 0,124\ mol\ ✓$$

$$V(CO_2) = 0,124 \times 24\ 000\ ✓$$
$$= 2\ 976\ cm^3\ ✓$$

OR/*OF*

$$V(CO_2) = 0,124 \times 24\ ✓$$
$$= 2,98\ dm^3\ ✓$$

OPTION 2/*OPSIE 2*

IF 15 g **PURE** $CaCO_3$ reacts:
***INDIEN** 15 g **SUIWER** $CaCO_3$ reageer:*

$$n(CaCO_3) = \frac{m}{M}$$
$$= \frac{15}{100}\ ✓$$
$$= 0,15\ mol$$

$$n(CO_2) = n(CaCO_3)\ ✓$$
$$= 0,15\ mol$$

$$n(CO_2) = \frac{V}{V_M}$$

$$0,15 = \frac{V}{24\ 000}\ ✓ \quad / \quad 0,15 = \frac{V}{24}$$
$$V = 3\ 600\ cm^3 \quad / \quad V = 3,6\ dm^3$$

Actual CO_2 formed:
Werklike CO_2 gevorm:

$$V(CO_2) = \frac{82,5}{100} \times 3\ 600\ /\ 3,6\ ✓$$
$$= 2\ 976\ cm^3\ /\ 2,976\ dm^3\ ✓$$

(5)

OPTION 3/*OPSIE 3*

IF 15 g **PURE** $CaCO_3$ reacts:/***INDIEN*** *15 g* ***SUIWER*** *$CaCO_3$ reageer:*

$$n(CaCO_3) = \frac{m}{M}$$
$$= \frac{15}{100} \checkmark$$
$$= 0,15 \text{ mol}$$

$$n(CO_2) = n(CaCO_3) \checkmark$$
$$= 0,15 \text{ mol}$$

$$n(CO_2) = \frac{m}{M}$$
$$m(CO_2) = 0,15 \times 44$$
$$= 6,6 \text{ g}$$

$$82,5 = \frac{m_{actual/werklik}}{6,6} \times 100 \checkmark$$
$$m_{(actual/werklik)} = 5,445 \text{ g}$$

$$n(CO_2) = \frac{m}{M}$$
$$= \frac{5,445}{44}$$
$$= 0,12375 \text{ mol}$$

$$n(CO_2) = \frac{V}{V_M}$$

$$0,12375 = \frac{V}{24\ 000} \checkmark \ / \ 0,12375 = \frac{V}{24}$$

$V = 2\ 976\ cm^3 / 2,976\ dm^3$ ✓ (5)

5.5 Increases/*Toeneem* ✓ (1)

5.6
- <u>More ($CaCO_3$) particles</u> with correct orientation/exposed./ <u>Greater</u> (exposed) <u>surface area</u>. ✓
- <u>More effective collisions per unit time.</u>/<u>Higher frequency of effective collisions</u>. ✓

- *<u>Meer ($CaCO_3$)-deeltjies</u> met korrekte oriëntasie/blootgestel./ <u>Groter</u> (blootgestelde) <u>reaksieoppervlakte</u>.* ✓
- *<u>Meer effektiewe botsings per eenheid tyd.</u>/<u>Hoër frekwensie van effektiewe botsings</u>.* ✓

NOTE/*LET WEL*
- If explanation in terms of CONCENTRATION: No mark for bullet 1.
  Indien verduideliking in terme van KONSENTRASIE: Geen punt vir kolpunt 1.
- Bullets are marked independently./*Kolpunte word onafhanklik nagesien.*

(2)
[15]

QUESTION 6/*VRAAG 6*

6.1 (The stage in a chemical reaction when the) rate of forward reaction equals the rate of reverse reaction. ✓✓ **(2 or 0)**
OR
(The stage in a chemical reaction when the) concentrations of reactants and products remain constant. **(2 or 0)**

(Die stadium in 'n chemiese reaksie wanneer die) tempo van die voorwaartse reaksie gelyk is aan die tempo van die terugwaartse reaksie. **(2 *of* 0)**
OF
(Die stadium in 'n chemiese reaksie wanneer die) konsentrasies van reaktanse en produkte konstant bly. **(2 *of* 0)** (2)

6.2

6.2.1 Negative/*Negatief* ✓ (1)

6.2.2
- Increase in temperature favours an endothermic reaction. **Accept:** Decrease in temperature favours an exothermic. ✓
- Reverse reaction is favoured./Concentration of reactants increases./ Concentration of products decreases. ✓
- (Forward) reaction is exothermic.
  Accept: Reverse reaction is endothermic. ✓

- *Toename in temperatuur bevoordeel 'n endotermiese reaksie.* ✓
  Aanvaar: *Afname in temperatuur bevoordeel die eksotermiese reaksie.*
- *Terugwaartse reaksie word bevoordeel./Konsentrasie van reaktanse neem toe./Konsentrasie van produkte neem af.* ✓
- *(Voorwaartse) reaksie is eksotermies.*
  Aanvaar: *Terugwaartse reaksie is endotermies.* ✓ (3)

6.2.3

CALCULATIONS USING NUMBER OF MOLES
BEREKENINGE WAT GETAL MOL GEBRUIK

Marking criteria:

a) Initial n(P) and n(Q_2) and n(PQ) from table. ✓
b) Change in n(P) = equilibrium n(P) – initial n(P).✓
c) **USING** ratio: P : Q_2 : PQ = 2 : 1 : 2 ✓
d) Equilibrium n(Q_2) = initial n(Q_2) + change in n(Q_2)
Equilibrium n(PQ) = initial n(PQ) - change in n(PQ) } ✓
e) Divide **equilibrium** amounts of P and Q_2 and PQ by 2 dm^3. ✓
f) Correct K_c expression (formulae in square brackets). ✓
g) Substitution of equilibrium concentrations into K_c expression. ✓
h) Final answer: 10,889 ✓

Nasienkriteria:

a) Aanvanklike n(P) en n(Q_2) en n(PQ) uit tabel.✓
b) Verandering in n(P) = ewewigs n(P) – aanvanklike n(P).✓
*c) **GEBRUIK** verhouding:* P : Q_2 : PQ = 2 : 1 : 2 ✓
*d) Ewewig n(Q_2) = aanvanklike n(Q_2) + verandering in n(Q_2)
Ewewig* n(PQ) *= aanvanklike n(PQ) - verandering in n(PQ)* } ✓
*e) Deel **ewewigs**hoeveelhede van P en Q_2 en PQ deur 2 dm^3.* ✓
f) Korrekte K_c-uitdrukking (formules in vierkanthakies). ✓
g) Vervanging van ewewigskonsentrasies in K_c-uitdrukking. ✓
h) Finale antwoord: 10,89 / 10,889 ✓

(3)

OPTION 1/*OPSIE 1*

	P	Q_2	PQ	
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	0,8	0,8	3,2	✓(a)
Change (mol) *Verandering (mol)*	0,4 ✓(b)	0,2	0,4	✓(c)
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	1,2	1,0	2,8	✓(d)
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	0,6	0,5	1,4	✓(e)

$$K_c = \frac{[PQ]^2}{[Q_2][P]^2} \checkmark\text{(f)}$$

$$= \frac{1,4^2}{(0,5)(0,6)^2} \checkmark\text{ (g)}$$

$$= 10,89 \checkmark\text{ (h)}$$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{7}{8}$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{5}{8}$

OPTION 2/*OPSIE 2*

	PQ	P	Q_2	
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	3,2	0,8	0,8	✓(a)
Change (mol) *Verandering (mol)*	0,4	0,4 ✓(b)	0,2 ✓(c)	
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	2,8	1,2 ✓(d)	1,0	
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)*	1,4	0,6	0,5	✓(e)

Reverse reaction
Terugwaartse reaksie:

$$K_c = \frac{[P]^2[Q_2]}{[PQ]^2} \checkmark\text{(f)}$$

$$= \frac{(0,6)^2(0,5)}{(1,4)^2} \checkmark\text{(g)}$$

$K_c = 0,09$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $\frac{7}{8}$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $\frac{5}{8}$

Forward reaction/*Voorwaartse reaksie:*

$$K_c = \frac{1}{0,09}$$

$$= 10,89 \checkmark\text{ (h)}$$

CALCULATIONS USING NUMBER OF MOLES
BEREKENINGE WAT GETAL MOL GEBRUIK

Marking criteria:

a) Initial n(P) = 4 mol and $n(Q_2)$ = 2,4 mol and n(PQ) = 0 ✓
b) Change in n(P) = equilibrium n(P) – initial n(P) = 2,8 mol.✓
c) USING ratio: P : Q_2 : PQ = 2 : 1 : 2 ✓
d) Equilibrium $n(Q_2)$ = initial $n(Q_2)$ + change in $n(Q_2)$
   Equilibrium n(PQ) = initial n(PQ) - change in n(PQ) ✓
e) Divide equilibrium amounts of P and Q2 and PQ by 2 dm^3. ✓
f) Correct Kc expression (formulae in square brackets). ✓
g) Substitution of equilibrium concentrations into K_c expression. ✓
h) Final answer: 10,89 / 10,889 ✓

Nasienkriteria:

a) Aanvanklike n(P) = 4 mol en $n(Q_2)$ = 2,4 mol en n(PQ) = 0.✓
b) Verandering in n(P) = ewewigs n(P) – aanvanklike n(P) = 2,8 mol.✓
c) GEBRUIK verhouding: P : Q_2 : PQ = 2 : 1 : 2 ✓
d) Ewewig $n(Q_2)$ = aanvanklike $n(Q_2)$ + verandering in $n(Q_2)$
   Ewewig n(PQ) = aanvanklike n(PQ) - verandering in n(PQ) ✓
e) Deel ewewigshoeveelhede van P en Q_2 en PQ deur 2 dm^3. ✓
f) Korrekte K_c-uitdrukking (formules in vierkanthakies). ✓
g) Vervanging van ewewigskonsentrasies in K_c-uitdrukking. ✓
h) Finale antwoord: 10,89 / 10,889 ✓

OPTION 3/*OPSIE 3*

	P	Q_2	PQ	
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	4	2,4	0	✓(a)
Change (mol) *Verandering (mol)*	2,8 ✓(b)	1,4	2,8	✓(c)
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	1,2	1,0	2,8	✓(d)
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	0,6	0,5	1,4	✓(e)

$$K_c = \frac{[PQ]^2}{[Q_2][P]^2} \ ✓\text{(f)}$$

$$= \frac{1,4^2}{(0,5)(0,6)^2} \ ✓\text{(g)}$$

$$= 10,89 \ ✓\ \text{(h)}$$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $^7/_8$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $^5/_8$

CALCULATIONS USING CONCENTRATION
BEREKENINGE WAT KONSENTRASIE GEBRUIK

Marking criteria*:*

a) Initial c(P) and c(Q_2) and c(PQ) from table. ✓
b) Change in c(P) = equilibrium c(P) – initial c(P). ✓
c) **USING** ratio*:* P : Q_2 : PQ = 2 : 1 : 2 ✓
d) Equilibrium c(Q_2) = initial c(Q_2) + change in c(Q_2)
   Equilibrium c(PQ) = initial c(PQ) - change in c(PQ) } ✓
e) Divide **initial** amounts of P and Q_2 and PQ by 2 dm^3. ✓
f) Correct K_c expression (formulae in square brackets). ✓
g) Substitution of equilibrium concentrations into K_c expression. ✓
h) Final answer: 10,89 / 10,889 ✓

Nasienriglyne:

a) Aanvanklike c(P) en c(Q_2) en c(PQ) uit tabel.✓
b) Verandering in c(P) = ewewigs c(P) – aanvanklike c(P).
*c) **GEBRUIK** verhouding:* P : Q_2 : PQ = 2 : 1 : 2 ✓
d) Ewewig c(Q_2) = aanvanklike c(Q_2) + verandering in c(Q_2)
   Ewewig c(PQ) *= aanvanklike c(PQ) - verandering in c(PQ)* } ✓
*e) Deel **aanvangs**hoeveelhede van P en Q_2 en PQ deur 2 dm^3.* ✓
f) Korrekte K_c-uitdrukking (formules in vierkanthakies). ✓
g) Vervanging van ewewigskonsentrasies in K_c-uitdrukking. ✓
h) Finale antwoord: 10,89 / 10,889 ✓

OPTION 4/*OPSIE 4*

	P	Q_2	PQ	
Initial concentration ($mol{\cdot}dm^{-3}$) Aanvangskonsentrasie ($mol{\cdot}dm^{-3}$)	0,4	0,4	1,6 ✓(a)	✓(e)
Change in concentration ($mol{\cdot}dm^{-3}$) *Verandering in* konsentrasie ($mol{\cdot}dm^{-3}$)	0,2 ✓(b)	0,1	0,2	✓(c)
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	0,6	0,5	1,4	✓ (d)

$$K_c = \frac{[PQ]^2}{[Q_2][P]^2} \checkmark \text{ (f)}$$

$$= \frac{1{,}4^2}{(0{,}5)(0{,}6)^2} \checkmark \text{ (g)}$$

$$= 10{,}89 \checkmark \text{ (h)}$$

No K_c expression, correct substitution/*Geen K_c-uitdrukking, korrekte substitusie*: Max./*Maks.* $^7/_8$
Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $^5/_8$

(8)

6.2.4 Remains the same/*Bly dieselfde* ✓

Only temperature can change K_c./Temperature remains constant. ✓
Slegs temperatuur kan K_c verander./Temperatuur bly konstant. (2)

6.3

6.3.1 Increases/*Toeneem* ✓ (1)

6.3.2 Decreases/*Afneem* ✓ (1)

[18]

QUESTION 7/VRAAG 7

7.1

7.1.1 (It is a) proton/H_3O^+ (ion)/H^+ (ion) donor. ✓✓
(Dit is 'n) proton/H_3O^+-(ioon)/H^+-(ioon)skenker. (2)

7.1.2 HSO_4^-/hydrogen sulphate ion/*waterstofsulfaatioon* ✓

<u>ANY ONE:</u>

- It <u>acts as base</u> in reaction **I** <u>and as acid</u> in reaction **II**. ✓
- Acts as acid and base.

ENIGE EEN:

- *Dit reageer <u>as basis</u> in reaksie **I** <u>en as suur</u> in reaksie **II**.*
- *Reageer as suur en basis.* (2)

7.1.3 HSO_4^-/Reaction (solution) II/*Reaksie (oplossing) II* ✓

Smaller K_a value/weaker acid ✓
Lower ion concentration/Incompletely ionised. ✓

Kleiner K_a-waarde/swakker suur ✓
Laer ioonkonsentrasie/Onvolledig geïoniseer. ✓ (3)

7.2

7.2.1

<u>OPTION 1/*OPSIE 1*</u>	**<u>OPTION 2/*OPSIE 2*</u>**
pH = $-\log[H_3O^+]$ ✓ 1,02 ✓ = $-\log[H_3O^+]$ $[H_3O^+]$ = 0,0955 mol·dm^{-3} ✓ Therefore/*Dus* $[HC\ell]$ = 0,0955 mol·dm^{-3} (0,096/0,1 mol·dm^{-3})	pH = $-\log[H_3O^+]$ } ✓Any one/*Enige* $[H_3O^+]$ = 10^{-pH} } = $10^{-1,02}$ ✓ = 0,0955 mol·dm^{-3} ✓ Therefore/*Dus* $[HC\ell]$ = 0,0955 mol·dm^{-3} (0,096/0,1 mol·dm^{-3})

(3)

7.2.2 **POSITIVE MARKING FROM 7.2.1/*POSITIEWE NASIEN VAN VRAAG 7.2.1***

Marking citeria:

- Formula: $c = \frac{n}{V}$ / $\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$ ✓
- Calculate $n(Na_2CO_3)$: 0,075 x 0,025 ✓
- Calculate $n(HC\ell)$: 0,0955 x 0,05 / 0,096 x 0,05 ✓
- Use ratios: $n(HC\ell) = 2n(Na_2CO_3)$ ✓
- $n(HC\ell)_{excess} = n(HC\ell)_{initial} – n(HC\ell)_{used}$ = 0,00475 – 0,0038 ✓✓
- Substitute 0,075 dm^3 in $c = \frac{n}{V}$ ✓
- Final answer: 0,013 $mol{\cdot}dm^{-3}$ ✓ (1,3 x 10^{-2} $mol{\cdot}dm^{-3}$)

  Range: 0,01 to 0,02 $mol{\cdot}dm^{-3}$

Nasienkriteria:

- *Formule*: $c = \frac{n}{V}$ / $\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$ ✓
- *Bereken* $n(Na_2CO_3)$: 0,075 x 0,025 ✓
- *Bereken* $n(HC\ell)$: 0,0955 x 0,05 / 0,096 x 0,05 ✓
- *Gebruik molverhouding*: $n(HC\ell) = 2n(Na_2CO_3)$ ✓
- $n(HC\ell)_{oormaat} = n(HC\ell)_{aanvanklik} – n(HC\ell)_{gebruik}$ = 0,00475 – 0,0038 ✓✓
- *Vervang* 0,075 dm^3 in $c = \frac{n}{V}$ ✓
- *Finale antwoord*: 0,013 $mol{\cdot}dm^{-3}$ ✓ (1,3 x 10^{-2} $mol{\cdot}dm^{-3}$)

  ***Gebied:** 0,01 tot 0,02 mol·dm^{-3}*

OPTION 1/*OPSIE 1*

$n(Na_2CO_3) = cV$ ✓
= 0,075 x 0,025 ✓
= 0,001875 mol (1,875 x 10^{-3}/0,002 mol)

$n(HC\ell)_{initial/aanvanklik} = cV$
= 0,096 x 0,05 ✓
= 0,00475 mol (4,75 x 10^{-3}/0,005 mol)

$n(HC\ell)_{used/gebruik} = 2n(Na_2CO_3)$ ✓
= 2(0,001875)
= 0,0038 mol (3,75 x 10^{-3}/0,004 mol)

$n(HC\ell)_{excess/oormaat}$ = 0,00475 – 0,0038 ✓✓
= 0,00095mol (9,5 x 10^{-4}/1 x 10^{-3} mol)

$c(HC\ell) = \frac{n}{V}$

$= \frac{0,00095}{0,075}$ ✓

= 0,013 $mol{\cdot}dm^{-3}$ ✓ (1,3 x 10^{-2} $mol{\cdot}dm^{-3}$)

OPTION 2/*OPSIE 2*

$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$ ✓

$\frac{c_a(50)✓}{(0,075)(25)✓} = \frac{2}{1}$ ✓

$c(HC\ell)_{rea} = 0,075\ mol \cdot dm^{-3}$

$c(HC\ell)_{excess/oormaat} = 0,0955 - 0,075$ ✓✓
$= 0,0205\ mol \cdot dm^{-3}$

$c_1V_1 = c_2V_2$
$(0,0205)(50) = c_2(75)$ ✓
$c_2 = 0,014\ mol \cdot dm^{-3}$ ✓

(8)
[18]

QUESTION 8/*VRAAG 8*

8.1 Chemical (energy) to electrical (energy) ✓
Chemiese (energie) na elektriese (energie) (1)

8.2

Marking criteria:

- Any formula: $c = \frac{m}{MV}$ / $c = \frac{n}{V}$ / $n = \frac{m}{M}$ ✓
- Substitute 1 $mol \cdot dm^{-3}$.✓
- Substitute 170 $g \cdot mol^{-1}$ [or 108 + 14 + 3(16)] and 0,15 dm^3 in correct formulae. ✓
- Final answer: 25,50 g ✓

Nasienkriteria:

- *Enige formule*: $c = \frac{m}{MV}$ / $c = \frac{n}{V}$ / $n = \frac{m}{M}$ ✓
- *Vervang 1* $mol \cdot dm^{-3}$.✓
- *Vervang 170* $g \cdot mol^{-1}$ *[of 108 + 14 + 3(16)] en 0,15* dm^3 *in korrekte formules.* ✓
- *Finale antwoord*: 25,50 g ✓

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
$c = \frac{m}{MV}$ ✓ ✓ $1 = \frac{m}{170 \times 0,15}$ ✓ m = 25,50 g ✓	n = cV ✓ = 1 ✓ x 0,15 = 0,15 mol ✓ m = nM = (0,15)(170) = 25,50 g ✓

(4)

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8.3 **ANY ONE:**

- A substance that loses/donates electrons. ✓✓
- A substance that is oxidised.
- A substance whose oxidation number increases.

ENIGE EEN:

- *'n Stof wat elektrone verloor/skenk.* ✓✓
- *'n Stof wat geoksideer word.*
- *'n Stof wat waarvan die oksidasiegetal toeneem.* (2)

8.4

8.4.1 Copper/Cu/*Koper* ✓ (1)

8.4.2

Marking criteria/*Nasienkriteria:*

- Reactants ✓ *Reaktanse* Products ✓ *Produkte* Balancing ✓ *Balansering*
- Ignore double arrows./*Ignoreer dubbelpyle.*
- Ignore phases/*Ignoreer fases.*
- Marking rule 6.3.10./*Nasienreël 6.3.10.*

$Cu(s) + 2Ag^+(aq)$ ✓ → $Cu^{2+}(aq) + 2Ag(s)$ ✓ Bal ✓

ACCEPT/*AANVAAR:*

$Cu(s) + 2AgNO_3(aq)$ ✓ → $Cu(NO_3)_2(aq) + 2Ag(s)$ ✓ Bal ✓

NOTE/*LET WEL*

- **IF** electrons are not cancelled – minus 1 mark
- ***INDIEN*** *elektrone nie gekanselleer is nie – minus 1 punt* (3)

8.5

OPTION 1/*OPSIE 1*	**Notes/*Aantekeninge***
$E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ ✓ $= 0{,}80$ ✓ $- (0{,}34)$ ✓ $= 0{,}46$ V ✓	• Accept any other correct formula from the data sheet./*Aanvaar enige ander korrekte formule vanaf gegewensblad.* • Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik bv.* $E°_{sel} = E°_{OM} - E°_{RM}$ *gevolg deur korrekte vervangings:* $^3/_4$

OPTION 2/*OPSIE 2*

$2Ag^+ + 2e^- \rightarrow 2Ag$ ✓ $E^\theta = 0{,}80$ V ✓
$Cu \rightarrow Cu^{2+} + 2e^-$ $E^\theta = -0{,}34$ V ✓
$2Ag^+ + Cu \rightarrow 2Ag + Cu^{2+}$ $E^\theta = +0{,}46$ V ✓ (4)

8.6 Decreases/*Afneem* ✓ (1)

[16]

QUESTION 9/*VRAAG 9*

9.1 **ANY ONE**: **(2 or 0)**

- A substance whose (aqueous) solution contains ions. ✓✓
- Substance that dissolves in water to give a solution that conducts electricity.
- A substance that forms ions in water / when melted.
- A solution that conducts electricity through the movement of ions.

***ENIGE EEN**: (2 of 0)*

- *'n Stof waarvan die oplossing ione bevat.* ✓✓
- *'n Stof wat in water oplos om 'n oplossing te vorm wat elektrisiteit gelei.*
- *'n Stof wat ione in water vorm/ wanneer dit gesmelt word.*
- *'n Oplossing wat elektrisiteit gelei deur die beweging van ione.* (2)

9.2 Anode ✓

Chromium is oxidised./Oxidation takes place (at the anode)./Chromium (it) loses electrons./Mass decreases./$Cr \rightarrow Cr^{3+} + 3e^-$ ✓
Chroom word geoksideer./Oksidasie vind (by die anode) plaas./Chroom (dit) verloor elektrone./Massa neem af./$Cr \rightarrow Cr^{3+} + 3e^-$

NOTE/*LET WEL*:
If half-reaction is used, it must be correct/*Indien halfreaksie gebruik word, moet dit korrek wees*: $Cr \rightarrow Cr^{3+} + 3e^-$

(2)

9.3 $Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$ ✓✓

Ignore phases./*Ignoreer fases*.

Marking guidelines/*Nasienkriteria*

- $Cr^{3+} + 3e^- \rightleftharpoons Cr$ $\frac{1}{2}$ $Cr \rightleftharpoons Cr^{3+} + 3e^-$ $\frac{0}{2}$
  $Cr \leftarrow Cr^{3+} + 3e^-$ $\frac{2}{2}$ $Cr \rightarrow Cr^{3+} + 3e^-$ $\frac{0}{2}$
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (+) omitted on Cr^{3+}/*Indien lading (+) weggelaat op* Cr^{3+}: Max./*Maks:* $\frac{1}{2}$

  Example/*Voorbeeld:* $Cr^3 + 3e^- \rightarrow Cr$ ✓

(2)

9.4

Marking criteria:

- Substitute 52 g·mol^{-1} in $n = \frac{m}{M}$ /ratio ✓
- Use mol ratio: n(electrons): n(Cr) = 3 : 1. ✓
- Number of electrons = n x 6,02 x 10^{23}/No of *Cr atoms = n x 6,02 x 10^{23}*/ratio. ✓
- Total charge = number of electrons x 1,6 x 10^{-19}/ratio. ✓
- Final answer: 11 113,85 C ✓
  Range*: 11 076,8 to 11 580 C*

Nasienkriteria:

- *Vervang 52 g·mol^{-1} in $n = \frac{m}{M}$ /verhouding* ✓
- *Gebruik molverhouding: n(elektrone) : n(Cr^{3+}) = 3 : 1.* ✓
- *Aantal elektrone = n x 6,02 x 10^{23}/Aantal Cr-atome = n x 6,02 x 10^{23}/verhouding.*✓
- *Totale lading = aantal elektrone x 1,6 x 10^{-19}/verhouding.* ✓
- *Finale antwoord: 11 113,85 C* ✓
  ***Gebied:** 11 076,8 tot 11 580 C*

OPTION 1/*OPSIE 1*

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

$= \frac{2}{52}$ ✓

= 0,038 mol (0,04 mol)

n(e$^-$) = 3n(Cr) ✓
= 3(0,038)
= 0,115 mol (0,12 mol)

Number (e$^-$) = 0,115 x 6,02 x 10^{23} ✓
= 6,946 x 10^{22}

Q = 6,95 x 10^{22} x 1,6 x 10^{-19} ✓
= 11 113,85 C ✓

OPTION 2/*OPSIE 2*

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

$= \frac{2}{52}$ ✓

= 0,038 mol (0,04 mol)

Number Cr atoms
= 0,038 x 6,02 x 10^{23} ✓
= 2,315 x 10^{22}

Number (e$^-$) = 3N(Cr) ✓
= 3(2,315 x 10^{22})
= 6,946 x 10^{22}

Q = 6,95 x 10^{22} x 1,6 x 10^{-19} ✓
= 11 113,85 C ✓

OPTION 3/*OPSIE 3*

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

$= \frac{2}{52}$ ✓

= 0,038 mol

n(e$^-$) = 3n(Cr) ✓
= 3(0,038)
= 0,115 mol

1 mol …. 96 500 C ✓
0,115 mol 11 134,62 C ✓✓

(5)
[11]

TOTAL/*TOTAAL*: 150

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: CHEMISTRY (P2)

2022

MARKS: 150

TIME: 3 hours

This question paper consists of 16 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.

2. This question paper consists of NINE questions. Answer ALL the questions in the ANSWER BOOK.

3. Start EACH question on a NEW page in the ANSWER BOOK.

4. Number the answers correctly according to the numbering system used in this question paper.

5. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

8. Show ALL formulae and substitutions in ALL calculations.

9. Round off your FINAL numerical answers to a minimum of TWO decimal places.

10. Give brief motivations, discussions, etc. where required.

11. You are advised to use the attached DATA SHEETS.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 Which ONE of the following compounds has the LOWEST melting point?

A Hexane

B Ethane

C Butane

D Octane (2)

1.2 When $CH_2 = CH_2$ is converted to CH_3CH_3, the type of reaction is …

A hydration.

B hydrolysis.

C halogenation.

D hydrogenation. (2)

1.3 Which ONE of the following compounds in solution will change the colour of bromothymol blue?

A CH_3CH_2CHO

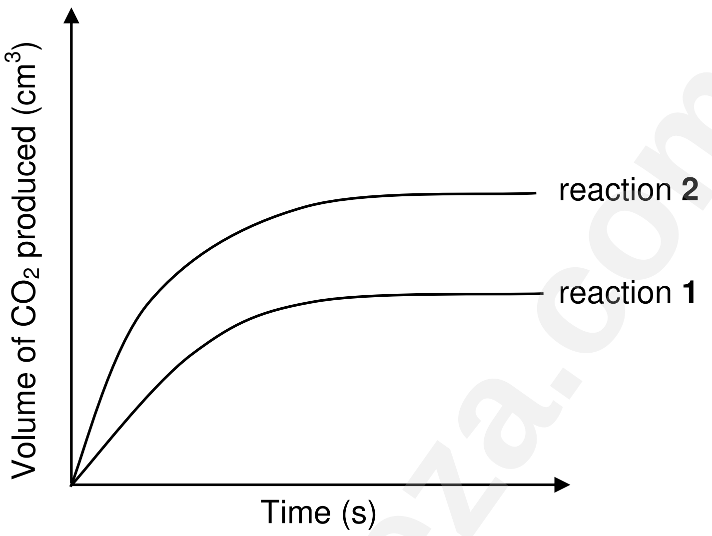
B CH_3CH_2COOH

C $CH_3CH_2COCH_3$

D $CH_3CH_2COOCH_3$ (2)

1.4 Two DIFFERENT samples of IMPURE $CaCO_3$ of EQUAL masses react with 0,1 mol·dm^{-3} H_2SO_4. Assume that the impurities do not react.

The graph below shows the volume of CO_2(g) produced for each reaction.



When compared to reaction **2**, which ONE of the following statements BEST explains the curve obtained for reaction **1**?

A The temperature is higher in reaction **1**.

B The surface area is greater in reaction **2**.

C The amount of impurities is greater in reaction **2**.

D The amount of impurities is greater in reaction **1**. (2)

1.5 The equation below represents a hypothetical reaction.

$$A(g) + B(g) \rightleftharpoons C(g) \qquad \Delta H = -50\ kJ\cdot mol^{-1}$$

The activation energy for the REVERSE reaction is 110 kJ·mol^{-1}.

Which ONE of the following is the activation energy (in kJ·mol^{-1}) for the FORWARD reaction?

A 50

B 60

C 110

D 160 (2)

1.6 A reaction reaches equilibrium at 25 °C in a flask according to the following balanced equation:

$$\underset{\text{pink}}{Co(H_2O)_6^{2+}(aq)} + 4C\ell^-(aq) \rightleftharpoons \underset{\text{blue}}{CoC\ell_4^{2-}(aq)} + 6H_2O(\ell) \qquad \Delta H > 0$$

Which ONE of the following will change the colour of the mixture from pink to blue?

A Adding water

B Cooling the flask

C Adding NaOH(aq)

D Adding $NH_4C\ell(aq)$ (2)

1.7 Dilute nitric acid is added to distilled water at 25 °C.

How will this affect the hydronium ion concentration $[H_3O^+]$ and the ionisation constant (K_w) of water at 25 °C?

	$[H_3O^+]$	K_w
A	Increases	Increases
B	Increases	Decreases
C	Increases	Remains the same
D	Remains the same	Remains the same

(2)

1.8 Consider the ionisation reactions **I** and **II**.

I $H_2PO_4^- + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + \mathbf{X}$

II $\mathbf{X} + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + \mathbf{Y}$

Which ONE of the following combinations represents the formulae of **X** and **Y** respectively?

	X	Y
A	HPO_4^{2-}	PO_4^{3-}
B	HPO_4^{2-}	H_3PO_4
C	H_3PO_4	PO_4^{3-}
D	HPO_4^{2-}	$H_2PO_4^-$

(2)

1.9 An electrochemical cell was set up using a $Hg(\ell)|Hg^{2+}(aq)$ half-cell and another half-cell under standard conditions.

Which ONE of the following half-cells, when connected to the $Hg(\ell)|Hg^{2+}(aq)$ half-cell, will result in the HIGHEST cell potential?

A $A\ell(s)|A\ell^{3+}(aq)$

B $Zn(s)|Zn^{2+}(aq)$

C $Co(s)|Co^{2+}(aq)$

D $Pt(s)|H_2(g)|H^+(aq)$ (2)

1.10 The following reaction takes place in an electrochemical cell:

$$CuC\ell_2(aq) \rightarrow Cu(s) + C\ell_2(g)$$

Which ONE of the following is CORRECT for this cell?

A It is a galvanic cell.

B A power source is needed.

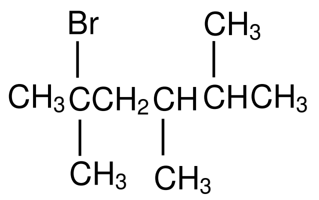
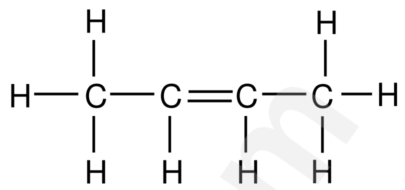
C The reaction is spontaneous.

D Copper acts as the oxidising agent. (2)

[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **H** in the table below represent eight organic compounds.

A		**B**	
C	Pent-2-ene	**D**	$CH_3CH_2CH_2CHO$
E	Butan-2-one	**F**	4,4-dimethylpent-2-yne
G	Butane	**H**	$CH_3CH_2CH_2COOH$

2.1 Write down the LETTER that represents a compound that:

2.1.1 Is a ketone (1)

2.1.2 Has the general formula C_nH_{2n-2} (1)

2.1.3 Is an isomer of 2-methylbut-2-ene (1)

2.1.4 Has the same molecular formula as ethyl ethanoate (1)

2.2 Write down the:

2.2.1 IUPAC name of compound **A** (3)

2.2.2 STRUCTURAL FORMULA of compound **F** (3)

2.3 For compound **D**, write down the:

2.3.1 Homologous series to which it belongs (1)

2.3.2 NAME of its functional group (1)

2.3.3 STRUCTURAL FORMULA of its functional isomer (2)

2.4 For compound **G**, write down:

2.4.1 The IUPAC name of a chain isomer (2)

2.4.2 A balanced equation, using molecular formulae, for its complete combustion (3)

[19]

QUESTION 3 (Start on a new page.)

Learners investigate factors that influence the boiling points of organic compounds. The boiling points of some organic compounds obtained are shown in the table below.

COMPOUND		MOLECULAR MASS ($g \cdot mol^{-1}$)	BOILING POINT (°C)
A	Propane	44	- 42
B	Butane	58	- 0,5
C	Pentane	72	36
D	Methylbutane	72	28
E	Ethanol	46	78
F	Ethanal	44	20

3.1 Define the term *boiling point.* (2)

3.2 The boiling points of compounds **A**, **B** and **C** are compared.

3.2.1 How do the boiling points vary from compound **A** to compound **C**?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

3.2.2 Explain the answer to QUESTION 3.2.1. (3)

3.3 The boiling points of compounds **B**, **C** and **D** are compared.

Is this a fair comparison?

Choose from YES or NO. Give a reason for the answer. (2)

3.4 The boiling points of compounds **E** and **F** are compared.

3.4.1 State the independent variable for this comparison. (1)

3.4.2 Write down the name of the strongest Van der Waals force present in compound **F**. (1)

3.5 Which compound, **D** or **E**, has a higher vapour pressure? Give a reason for the answer. (2)

[12]

QUESTION 4 (Start on a new page.)

4.1 Study the following incomplete equations for organic reactions **I** and **II**.

Compounds **P** and **Q** are ORGANIC compounds and **T** is an INORGANIC compound.

I	CH_3 | $CH_3CH\,CHCH_3$ + NaOH (conc.) $\longrightarrow$ **P** (major product) + NaBr + **T** | Br
II	CH_3COOH + compound **Q** → butyl ethanoate + H_2O

For reaction **I**, write down the:

4.1.1 Type of reaction that takes place (1)

4.1.2 IUPAC name of compound **P** (2)

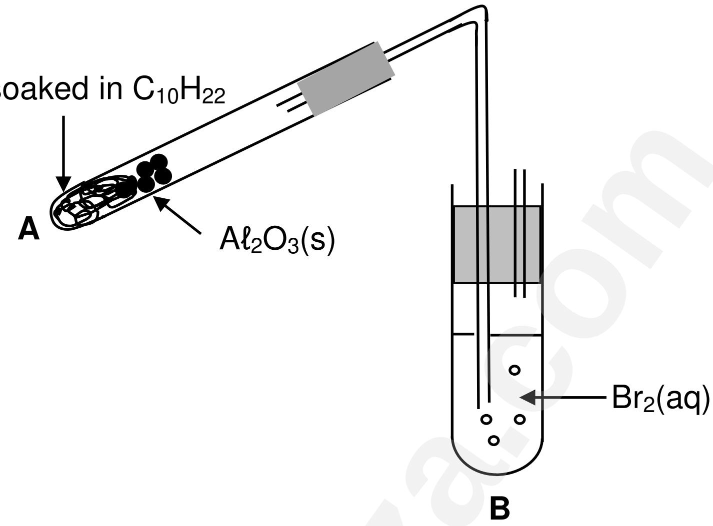
4.1.3 NAME or FORMULA of compound **T** (1)

For reaction **II**, write down:

4.1.4 TWO reaction conditions needed (2)

4.1.5 The STRUCTURAL FORMULA of compound **Q** (2)

4.2 The cracking of a long chain hydrocarbon, $C_{10}H_{22}$, takes place in test tube **A**, as shown below.



Two STRAIGHT CHAIN organic compounds, **X** and **Z**, are produced in test tube **A** according to the following balanced equation:

$$C_{10}H_{22}(\ell) \rightarrow 2\mathbf{X}(g) + \mathbf{Z}(g)$$

4.2.1 State the function of the $A\ell_2O_3$(s) in test tube **A**. (1)

The organic compounds, **X** and **Z**, are now passed through bromine water, Br_2(aq), at room temperature in test tube **B**. Only compound **X** reacts with the bromine water.

4.2.2 Apart from gas bubbles being formed, state another observable change in test tube **B**. (1)

4.2.3 Write down the TYPE of reaction that takes place in test tube **B**. (1)

4.2.4 Write down the molecular formula of compound **Z**. (3)

4.2.5 Write down the STRUCTURAL FORMULA of compound **X**. (3)
[17]

QUESTION 5 (Start on a new page.)

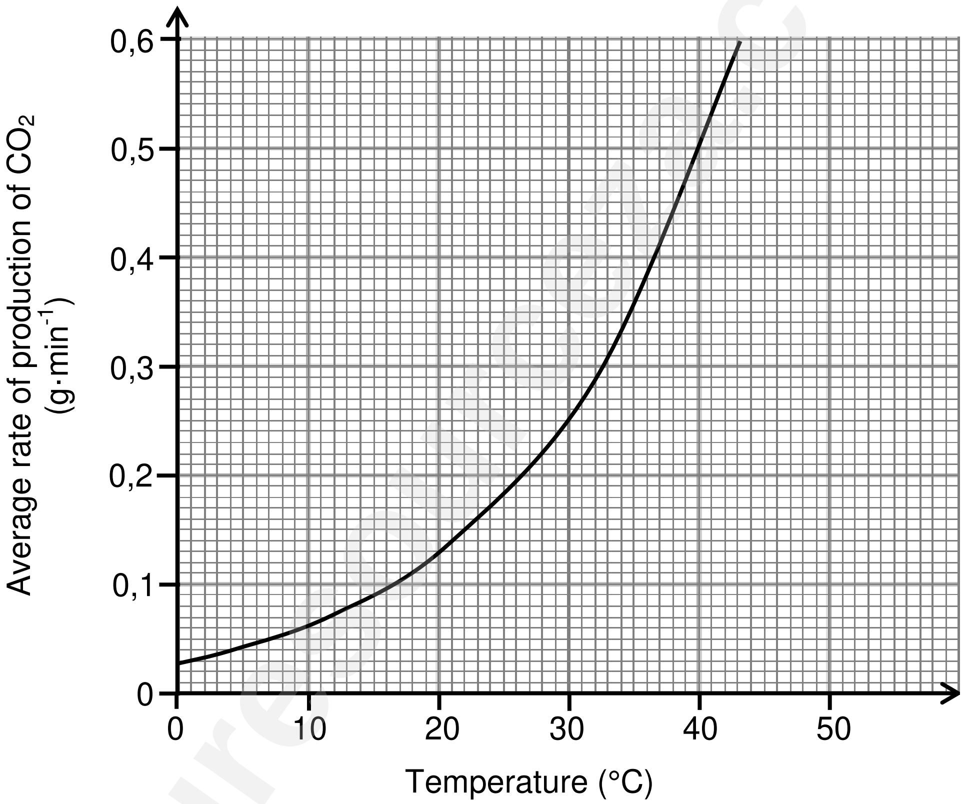
Learners use the reaction of $MgCO_3(s)$ with EXCESS dilute $HC\ell(aq)$ to investigate the relationship between temperature and the rate of a chemical reaction.

The balanced equation for the reaction is:

$$MgCO_3(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + CO_2(g) + H_2O(\ell)$$

The results obtained are represented in the graph below.

Graph of average rate of production of CO_2 (in $g \cdot min^{-1}$) versus temperature



5.1 Define the term *rate of reaction*. (2)

5.2 State TWO conditions that must be kept constant during this investigation. (2)

5.3 Use the collision theory to explain the relationship shown in the graph. (4)

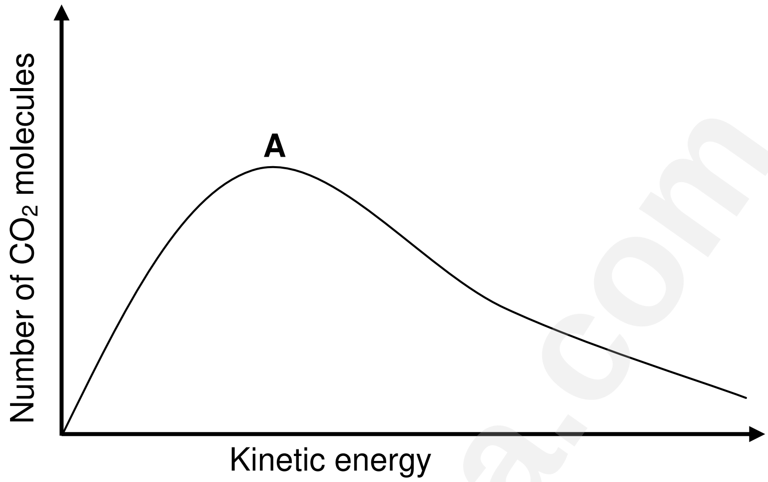
5.4 The learners obtained the graph above using 5 g $MgCO_3(s)$ with EXCESS $HC\ell$ at 40 °C.

Calculate the:

5.4.1 Time taken for the reaction to run to completion (6)

5.4.2 Molar gas volume at 40 °C if 1,5 dm^3 CO_2 is collected in a syringe (2)

5.5 The graph below represents the Maxwell-Boltzmann distribution curve for CO_2(g) at 40 °C.



Redraw the graph above in the ANSWER BOOK. Clearly label the curve as **A**.

On the same set of axes, sketch the curve that will be obtained for the CO_2(g) at 20 °C. Label this curve as **B**. (2)

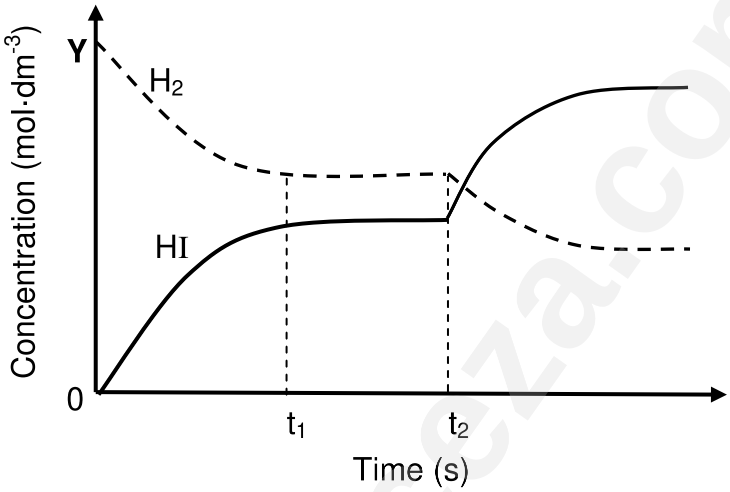
[18]

QUESTION 6 (Start on a new page.)

6.1 Initially, 4 moles $H_2(g)$ and 4 moles $I_2(g)$ are allowed to react in a sealed 2 dm^3 flask according to the following balanced equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H < 0$$

The graph below shows the concentrations of $H_2(g)$ and $HI(g)$ versus time during the reaction.



6.1.1 Write down the value of **Y**. (1)

6.1.2 State Le Chatelier's principle. (2)

6.1.3 Changes were made to the temperature of the flask at time t_2.

Was the flask HEATED or COOLED? (1)

6.1.4 Fully explain the answer to QUESTION 6.1.3. (3)

6.2 The equation below represents the reversible reaction that takes place when $NO_2(g)$ is converted to $N_2O_4(g)$.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

Initially, **x** mol of $NO_2(g)$ is sealed in a 1 dm^3 container at 350 K. When equilibrium is established at this temperature, 0,81 mol $N_2O_4(g)$ is present in the container.

6.2.1 Write down the meaning of the term *reversible reaction*. (1)

6.2.2 Show that the equilibrium constant for this reaction is given by $\frac{0{,}81}{(x-1{,}62)^2}$. (5)

0,79 moles of $N_2O_4(g)$ is now added to the equilibrium mixture above. When the NEW equilibrium is established at 350 K, it is found that the amount of $NO_2(g)$ increased by 1,2 moles.

6.2.3 Calculate the value of **x**. (6)
[19]

QUESTION 7 (Start on a new page.)

7.1 Two acids, HX and HY, of EQUAL CONCENTRATIONS are compared. The pH of HX is 2,7 and the pH of HY is 0,7.

7.1.1 Define an *acid* in terms of the Lowry-Brønsted theory. (2)

7.1.2 Which acid, HX or HY, is STRONGER? Give a reason for the answer. (2)

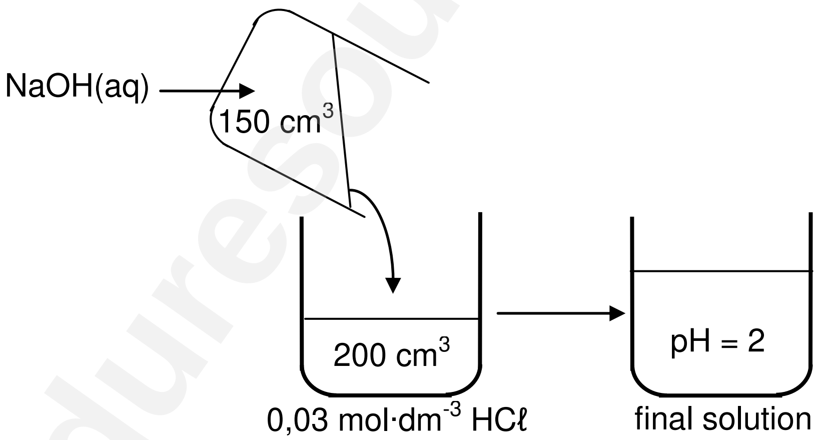
7.1.3 Acid HX ionises in water according to the following equation:

$$HX(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + X^-(aq)$$

The K_a value for the reaction is $1,8 \times 10^{-5}$ at 25 °C.

Is the concentration of the hydronium ions HIGHER THAN, LOWER THAN or EQUAL TO the concentration of HX? Give a reason for the answer. (2)

7.2 Learners add 150 cm^3 of a sodium hydroxide solution, NaOH, of unknown concentration to 200 cm^3 of a 0,03 $mol{\cdot}dm^{-3}$ hydrochloric acid solution, $HC\ell$, as illustrated below. They find that the pH of the final solution is 2. Assume that the volumes are additive.



The balanced equation for the reaction is:

$$HC\ell(aq) + NaOH(aq) \rightarrow NaC\ell(aq) + H_2O(\ell)$$

Calculate the:

7.2.1 Concentration of the H_3O^+ ions in the final solution (3)

7.2.2 Initial concentration of the NaOH(aq) (7)
[16]

QUESTION 8 (Start on a new page.)

8.1 An electrochemical cell is set up using an aluminium rod, Aℓ, and a gas **X**.

The initial emf measured under standard conditions is 2,89 V.

8.1.1 State the standard conditions under which this cell operates. (3)

8.1.2 Use a calculation to identify gas **X**. (5)

8.1.3 Write down the FORMULA of the reducing agent in this cell. (1)

8.1.4 Write down the half-reaction that takes place at the cathode. (2)

8.1.5 Write down the cell notation for this cell. (3)

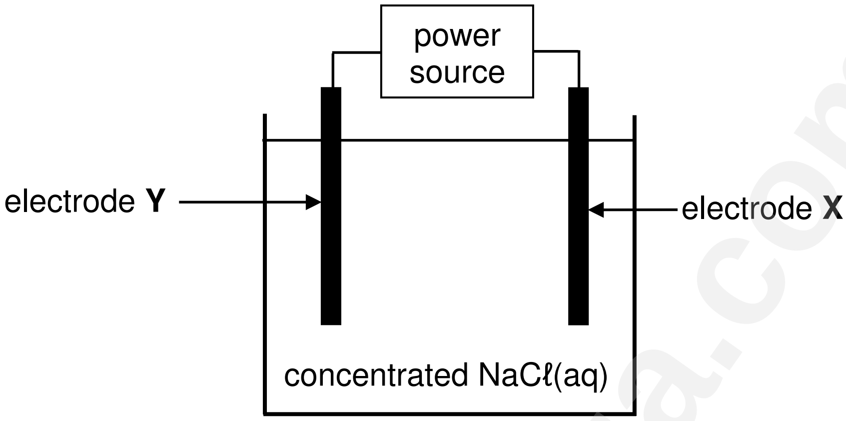
8.2 Which container, ZINC or COPPER, will be more suitable to store an aqueous solution of nickel ions, Ni^{2+}?

Refer to the Table of Standard Reduction Potentials to fully explain the answer in terms of the relative strengths of reducing agents. (4)

[18]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents an electrochemical cell used for the electrolysis of a concentrated sodium chloride solution, NaCℓ(aq). **X** and **Y** are carbon electrodes.



9.1 Define the term *electrolysis*. (2)

9.2 Chlorine gas, $C\ell_2(g)$, is released at electrode **X**.

Write down the:

9.2.1 Letter (**X** or **Y**) of the electrode where oxidation takes place (1)

9.2.2 Half-reaction that takes place at electrode **Y** (2)

9.2.3 Direction in which electrons flow in the external circuit

Choose from **X** to **Y** OR **Y** to **X**. (1)

9.2.4 Balanced equation for the net (overall) cell reaction that takes place in the cell (3)

9.3 How will the pH of the electrolyte change during the reaction?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

9.4 Give a reason for the answer to QUESTION 9.3. (1)
[11]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1{,}013 \times 10^{5}$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22{,}4\ dm^{3}\cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	
$n = \frac{Q}{e}$ or/*of* $n = \frac{Q}{q_e}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Atomic number / ***Atoomgetal*** → 29
Electronegativity / ***Elektronegatiwiteit*** → 1,9
Symbol / ***Simbool*** → Cu
Approximate relative atomic mass / ***Benaderde relatiewe atoommassa*** → 63,5

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Half-reactions/*Halfreaksies*			E^θ (V)
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$Fe^{3+} + 3e^-$	⇌	Fe	– 0,06
$Pb^{2+} + 2e^-$	⇌	Pb	– 0,13
$Sn^{2+} + 2e^-$	⇌	Sn	– 0,14
$Ni^{2+} + 2e^-$	⇌	Ni	– 0,27
$Co^{2+} + 2e^-$	⇌	Co	– 0,28
$Cd^{2+} + 2e^-$	⇌	Cd	– 0,40
$Cr^{3+} + e^-$	⇌	Cr^{2+}	– 0,41
$Fe^{2+} + 2e^-$	⇌	Fe	– 0,44
$Cr^{3+} + 3e^-$	⇌	Cr	– 0,74
$Zn^{2+} + 2e^-$	⇌	Zn	– 0,76
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	– 0,83
$Cr^{2+} + 2e^-$	⇌	Cr	– 0,91
$Mn^{2+} + 2e^-$	⇌	Mn	– 1,18
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	– 1,66
$Mg^{2+} + 2e^-$	⇌	Mg	– 2,36
$Na^+ + e^-$	⇌	Na	– 2,71
$Ca^{2+} + 2e^-$	⇌	Ca	– 2,87
$Sr^{2+} + 2e^-$	⇌	Sr	– 2,89
$Ba^{2+} + 2e^-$	⇌	Ba	– 2,90
$Cs^+ + e^-$	⇌	Cs	- 2,92
$K^+ + e^-$	⇌	K	– 2,93
$Li^+ + e^-$	⇌	Li	– 3,05

Increasing strength of oxidising agents/*Toenemende sterkte van oksideermiddels* (↑)

Increasing strength of reducing agents/*Toenemende sterkte van reduseermiddels* (↓)

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Increasing strength of oxidising agents/*Toenemende sterkte van oksideermiddels* (↓)

Increasing strength of reducing agents/*Toenemende sterkte van reduseermiddels* (↑)

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	⇌	Li	− 3,05
$K^+ + e^-$	⇌	K	− 2,93
$Cs^+ + e^-$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$2H^+ + 2e^-$	⇌	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS
SENIORSERTIFIKAAT-EKSAMEN/ NASIONALE SENIORSERTIFIKAAT-EKSAMEN

PHYSICAL SCIENCES: CHEMISTRY (P2)
FISIESE WETENSKAPPE: CHEMIE (V2)

2022

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

These marking guidelines consist of 16 pages./
Hierdie nasienriglyne bestaan uit 16 bladsye.

QUESTION 1/*VRAAG 1*

1.1	B ✓✓	(2)
1.2	D ✓✓	(2)
1.3	B ✓✓	(2)
1.4	D ✓✓	(2)
1.5	B ✓✓	(2)
1.6	D ✓✓	(2)
1.7	C ✓✓	(2)
1.8	A ✓✓	(2)
1.9	A ✓✓	(2)
1.10	B ✓✓	(2)

[20]

QUESTION 2/*VRAAG 2*

2.1

2.1.1	E ✓	(1)
2.1.2	F ✓	(1)
2.1.3	C ✓	(1)
2.1.4	H ✓	(1)

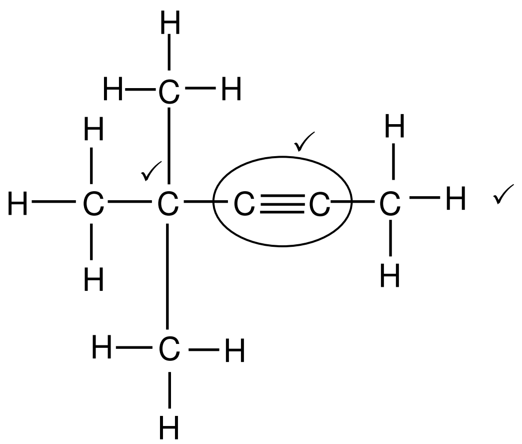
2.2

2.2.1 2-bromo-2,4,5-trimethylhexane/*2-broom-2,4,5-trimetielheksaan*

Marking criteria:	***Nasienkriteria:***
• Correct stem i.e. hexane. ✓ • All substituents (bromo and trimethyl) correctly identified. ✓ • IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓	• *Korrekte stam d.i. heksaan. ✓* • *Alle substituente (bromo and trimetiel) korrek geïdentifiseer. ✓* • *IUPAC-naam heeltemal korrek insluitende volgorde, koppeltekens en kommas. ✓*

(3)

2.2.2



<u>Marking criteria/*Nasienkriteria:*</u>
- <u>Five C atoms in longest chain + triple bond</u>. ✓
  <u>Vyf C-atome in langste ketting + drievoudige binding</u>.
- Two methyl substituents. ✓
  Twee metielsubstituente.
- Whole structure correct.
  Hele struktuur korrek. ✓

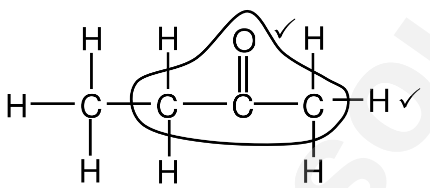
<u>IF/*INDIEN*</u>
- More than one functional group/wrong functional group:
  Meer as een funksionele groep/foutiewe funksionele groep: $\frac{0}{3}$
- If condensed structural formulae used/*Indien gekondenseerde struktuurformules gebruik:* Max/*Maks.*: $\frac{2}{3}$

(3)

2.3
2.3.1 Aldehyde/*Aldehied* ✓ (1)

2.3.2 Formyl/*Formiel* ✓ (1)

2.3.3



<u>Marking criteria/*Nasienkriteria:*</u>
- Functional group. ✓
  Funksionele groep.
- Whole structure correct.
  Hele struktuur korrek. ✓

<u>IF/*INDIEN*</u>
- More than one functional group/wrong functional group:
  Meer as een funksionele groep/foutiewe funksionele groep: $\frac{0}{2}$
- If condensed structural formulae used/*Indien gekondenseerde struktuurformules gebruik:* Max/*Maks.*: $\frac{1}{2}$

(2)

2.4
2.4.1 Methyl✓propane✓/2-methylpropane/*Metielpropaan/2-metielpropaan* (2)

2.4.2 $2C_4H_{10} + 13O_2$ ✓ $\rightarrow 8CO_2 + 10H_2O$ ✓ Bal. ✓

Ignore phases./*Ignoreer fases.*

<u>Marking criteria/*Nasienkriteria:*</u>

Reactants ✓ *Reaktanse*	Products ✓ *Produkte*	Balancing: ✓ *Balansering*

- Ignore double arrows./*Ignoreer dubbelpyle.*
- Marking rule 6.3.10/*Nasienreël 6.3.10.*

IF: Structural formula for C_4H_{10} Max. 2/3
INDIEN: Structural formula for C_4H_{10} Max. 2/3

(3)
[19]

QUESTION 3/*VRAAG 3*

3.1

Marking criteria/*Nasienkriteria*
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

The temperature at which the vapour pressure of a substance equals atmospheric/external pressure. ✓✓
Die temperatuur waar die dampdruk van 'n stof gelyk is aan atmosferiese/ eksterne druk. (2)

3.2

3.2.1 Increases/*Neem toe* ✓ (1)

3.2.2 **From A to C:**

- Increase in molecular mass/size/chain length/surface area/number of C atoms. ✓
- Strength of the intermolecular forces increases/More sites for London forces. ✓
- More energy is needed to overcome/break intermolecular forces. ✓

OR
From C to A:

- Decrease in molecular mass/size/chain length/surface area/number of C atoms. ✓
- Strength of the intermolecular forces decreases/Less sites for London forces. ✓
- Less energy is needed to overcome/break intermolecular forces. ✓

Van A na C:

- *Verhoging in molekulêre massa/molekulêre grootte/kettinglengte/reaksie-oppervlak/aantal C-atome.* ✓
- *Sterkte van die intermolekulêre kragte verhoog./Meer punte vir Londonkragte.* ✓
- *Meer energie benodig om intermolekulêre kragte te oorkom/breek.* ✓

OF
Van C na A:

- *Verlaging in molekulêre massa/molekulêre grootte/kettinglengte/reaksie-oppervlak/aantal C-atome.* ✓
- *Sterkte van die intermolekulêre kragte verlaag./Minder punte vir Londonkragte.* ✓
- *Minder energie benodig om intermolekulêre kragte te oorkom/breek.* ✓ (3)

3.3 No / *Nee* ✓
More than one independent variable./Molar mass and chain length (surface area) are changing. ✓
Meer as een onafhanklike veranderlike./Molêre massa (reaksie-oppervlak) en kettinglengte verander. (2)

3.4

3.4.1 Functional group/homologous series/type of intermolecular forces/type of compound ✓ (1)
Funksionele groep/homoloë reeks/soort intermolekulêre kragte/tipe verbinding

3.4.2 <u>Dipole-dipole</u> forces/*<u>Dipool-dipool</u>kragte* ✓ (1)

3.5 D / methylbutane / *metielbutaan* ✓

Lower boiling point/Weaker intermolecular forces ✓
Laer kookpunt/Swakker intermolekulêre kragte (2)
[12]

QUESTION 4/*VRAAG 4*

4.1

4.1.1 Dehydrohalogenation/elimination/dehydrobromination ✓
Dehidrohalogenering/eliminasie/dehidrobrominering (1)

4.1.2 2-methylbut-2-ene / 2-methyl-2-butene ✓✓
2-metielbut-2-een / 2-metiel-2-buteen ✓✓

> **<u>Marking criteria/*Nasienkriteria*</u>**
> Methylbutene/*metielbuteen* ✓
> IUPAC name correct/*IUPAC-naam korrek* ✓

(2)

> **IF/*INDIEN***
> Any error, e.g. hyphens omitted and/or incorrect sequence/*Enige fout, bv. koppeltekens weggelaat en/of verkeerde volgorde:* Max/*Maks:* $\frac{1}{2}$

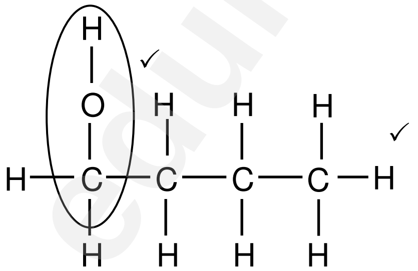
4.1.3 Water/H_2O ✓ (1)

4.1.4 Heat/*Hitte* ✓
(Concentrated) <u>sulphuric acid/catalyst</u> ✓
(Gekonsentreerde) <u>swawelsuur/katalisator</u>

> **<u>ACCEPT/*AANVAAR*:</u>**
> <u>High temperature/</u>
> *<u>Hoë temperatuur</u>*

(2)

4.1.5



> **<u>Marking criteria/*Nasienkriteria*</u>**
> - Whole structure correct/*Hele struktuur korrek:* $\frac{2}{2}$
> - Only functional group correct:/*Slegs funksionele groep korrek:* Max/*Maks.*: $\frac{1}{2}$
>
> **IF/*INDIEN***
> More than one functional group/*Meer as een funksionele groep* $\frac{0}{2}$

(2)

4.2

4.2.1 Catalyst/Lowers the activation energy./Increases the rate of the reaction. ✓
Katalisator/Verlaag die aktiveringsenergie./Laat reaksietempo toeneem. (1)

4.2.2 The bromine water/Br_2/solution decolourises. ✓
Die broomwater/Br_2/oplossing ontkleur.

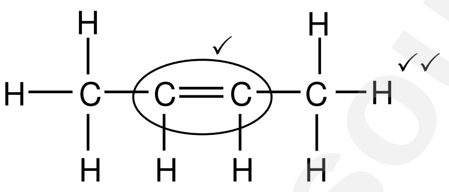
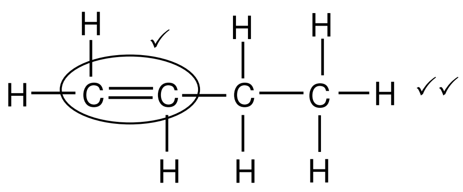
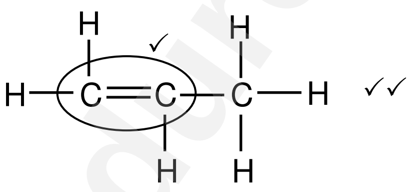
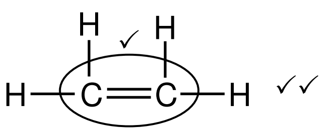
OR/***OF***
Bromine water/Br_2/solution changes from brown/reddish to colourless.
Broomwater/Br_2/oplossing verander van bruin/rooi na kleurloos. (1)

4.2.3 Addition/halogenation/bromination ✓ (1)
Addisie/halogenering/brominering

4.2.4 C_2H_6 ✓✓✓ (**3 or**/***of* 0**) **OR**/***OF*** C_4H_{10} **OR**/***OF*** C_6H_{14}

IF structural/condensed formulae: **(2 or 0)**
INDIEN *struktuurformules/gekondenseerde formules gebruik:* ***(2 of 0)*** (3)

4.2.5

Marking criteria	***Nasienkriteria***
• Correct functional group i.e. double bond. ✓ • Correct number of C atoms in relation to answer in Q4.2.4. ✓ • Whole structure correct. ✓ **IF** condensed/molecular formulae used: Max. $^2/_3$	• *Korrekte funksionele groep d.i. dubbelbinding.* ✓ • *Korrekte aantal C-atome na aanleiding van antwoord in V4.2.4.* ✓ • *Hele struktuur korrek.* ✓ ***INDIEN*** *gekondenseerde/molekulêre formules gebruik: Maks.* $^2/_3$
IF C_2H_6 in QUESTION 4.2.4/*INDIEN C_2H_6 in VRAAG 4.2.4*:  **OR**/***OF*** 	
IF C_4H_{10} in QUESTION 4.2.4/ ***INDIEN C_4H_{10} in VRAAG 4.2.4:*** 	**IF C_6H_{14} in QUESTION 4.2.4:** ***INDIEN C_6H_{14} in VRAAG 4.2.4:*** 

(3)
[17]

QUESTION 5/*VRAAG 5*

5.1

> **NOTE/*LET WEL***
> Give the mark for per unit time only if in context of reaction rate.
> *Gee die punt vir per eenheidtyd slegs indien in konteks met reaksietempo.*

ANY ONE:

- Change in concentration ✓ of products/reactants per (unit) time. ✓
- Change in amount/number of moles/volume/mass of products or reactants per (unit) time.
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time.
- Rate of change in concentration/amount/number of moles/volume/mass.✓✓ **(2 or 0)**

ENIGE EEN:

- *Verandering in konsentrasie van produkte/reaktanse per (eenheid) tyd.*
- *Verandering in hoeveelheid/getal mol/volume/massa van produkte of reaktanse per (eenheid) tyd.*
- *Hoeveelheid/getal mol/volume/massa van produkte gevorm/reaktanse gebruik per (eenheid) tyd.*
- *Tempo van verandering in konsentrasie/ hoeveelheid/getal mol/ volume/massa. **(2 of 0)*** (2)

5.2

- Surface area / state of division / particle size (of $MgCO_3$) ✓
- Concentration (of HCℓ) ✓

- *Reaksieoppervlak/toestand van verdeeldheid/deeltjie-grootte (van* $MgCO_3$)
- *Konsentrasie (van HCℓ)* (2)

5.3

- At a higher temperature particles move faster/have a higher kinetic energy. ✓
- More molecules have enough/sufficient kinetic energy for an effective collision. ✓
  OR More molecules have kinetic energy/E_k equal to or greater than the activation energy.
- More effective collisions per unit time/second. ✓
  OR Frequency of effective collisions increases.
- Reaction rate increases. ✓

- *By 'n hoër temperatuur beweeg die deeltjies vinniger/het die deeltjies hoër kinetiese energie.* ✓
- *Meer molekule het genoeg/voldoende kinetiese energie/*E_k *vir 'n effektiewe botsing.* ✓
  ***OF** Meer molekule het kinetiese energie gelyk aan of groter as die aktiveringsenergie.*
- *Meer effektiewe botsings per eenheidtyd/sekonde.* ✓
  ***OF** Frekwensie van effektiewe botsings verhoog.*
- *Reaksietempo neem toe.* ✓ (4)

5.4.1

Marking criteria	***Nasienkriteria***
• Formula: $n = \frac{m}{M}$ ✓ • Substitution of 84 g·mol^{-1} in $n = \frac{m}{M}$ ✓ • Use mole ratio: $n(MgCO_3)_{used} = n(CO_2)_{produced}$ ✓ • Substitution of 44 g·mol^{-1} in $n = \frac{m}{M}$ **or** to calculate rate in mol·min^{-1}. ✓ • Correct substitution of 0,5 in rate equation. ✓ • Final answer: 5,238 to 5,28 min ✓	• *Formule:* $n = \frac{m}{M}$ ✓ • *Vervanging van 84 g·mol^{-1} in* $n = \frac{m}{M}$ ✓ • *Gebruik molverhouding*: $n(MgCO_3)_{gebruik} = n(CO_2)_{berei}$ ✓ • *Vervanging van 44 g·mol^{-1} in* $n = \frac{m}{M}$ ***of*** *om tempo te bereken in mol·min^{-1}.* ✓ • *Korrekte vervanging van 0,5 in tempovergelyking.* ✓ • *Finale antwoord: 5,238 tot 5,28 min* ✓

$n(MgCO_3) = \frac{m}{M}$ ✓

$= \frac{5}{84}$ ✓

$= 0,06$ mol (0,0595 mol)

$n(CO_2)_{produced/gevorm} = n(MgCO_3)$ ✓ $= 0,06$ mol

$n(CO_2) = \frac{m}{M}$ $0,06 = \frac{m}{44}$ ✓ $m(CO_2) = 2,64$ g Ave rate/*gem tempo* $= \frac{\Delta m(CO_2)}{\Delta t}$ $0,5$ ✓ $= \frac{2,64}{\Delta t}$ $\Delta t = 5,28$ min ✓	Ave rate/*gem tempo* in mol·min^{-1}: $\frac{0,5}{44}$ ✓✓ $= 0,0114$ mol·min^{-1} Ave rate/*gem tempo* $= \frac{\Delta n(CO_2)}{\Delta t}$ $0,0114 = \frac{0,06}{\Delta t}$ $\Delta t = 5,28$ min ✓

(6)

5.4.2 **POSITIVE MARKING FROM QUESTION 5.4.1.**
POSITIEWE NASIEN VANAF VRAAG 5.4.1.

Marking criteria	***Nasienkriteria***
• Substitution of $n(CO_2)$ AND 1,5 dm^3 in $n = \frac{V}{V_m}$. ✓ • Final answer: • \25 to 25,21 dm^3·mol^{-1} ✓	• *Vervanging van* $n(CO_2)$ EN 1,5 dm^3 in $n = \frac{V}{V_m}$. ✓ • *Finale antwoord:* 25 dm^3 *tot* 25,21 dm^3·mol^{-1} ✓

$n = \frac{V}{V_m}$

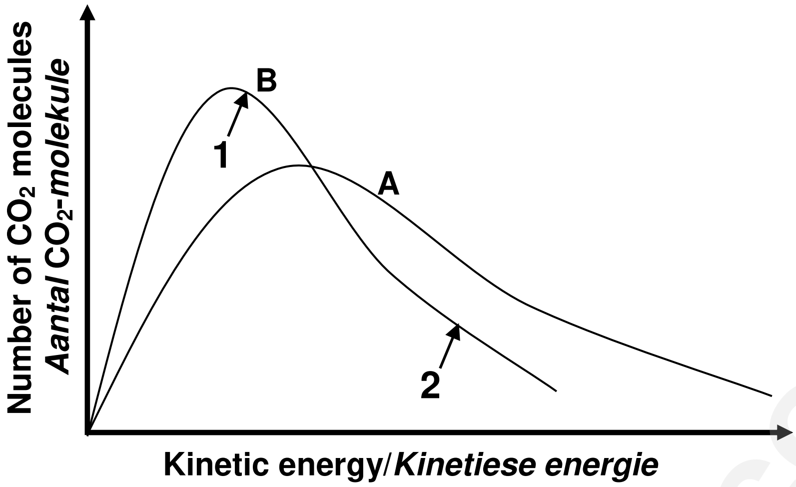
$0,06 = \frac{1,5}{V_m}$ ✓

$V_m = \underline{25 \text{ dm}^3\cdot\text{mol}^{-1}}$ ✓ (25,21 dm^3·mol^{-1})

ACCEPT/***AANVAAR***: 25 dm^3

(2)

5.5



Marking criteria/*Nasienkriteria*		
1	Curve **B** has a higher peak to the left of curve **A**. *Kurwe **B** het hoër piek aan die linkerkant van kurwe **A**.*	✓
2	Curve **B** is below curve **A** beyond the peak of curve **A**./*Kurwe **B** is onder kurwe **A** na die piek van kurwe **A**.*	✓
If BOTH graphs not labelled (**A** and **B**): no marks *Indien BEIDE grafieke nie benoem nie (**A** en **B**): geen punte*		

(2)
[18]

QUESTION 6/*VRAAG 6*

6.1.1 2 ($mol \cdot dm^{-3}$) ✓ (1)

6.1.2

<u>Marking criteria/*Nasienkriteria:*</u>
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

<u>When the equilibrium in a closed system is disturbed</u>, the system will <u>re-instate a (new) equilibrium</u> ✓ by favouring the reaction that will <u>cancel/oppose the disturbance.</u> ✓
<u>Wanneer die ewewig in 'n geslote sisteem versteur word</u>, sal die sisteem 'n (nuwe) <u>ewewig instel</u> deur die reaksie te bevoordeel wat die <u>versteuring kanselleer/teenwerk</u>. (2)

6.1.3 Cooled/*Afgekoel* ✓ (1)

6.1.4
- A decrease in temperature favours the exothermic reaction./An increase in temperature favours the endothermic reaction. ✓
- The forward reaction is favoured./HI concentration increases./Equilibrium (position) shifts to the right. ✓
- The forward reaction is exothermic./Reverse reaction is endothermic. ✓

- *Afname in temperatuur bevoordeel die eksotermiese reaksie./Toename in temperatuur bevoordeel die endotermiese reaksie.* ✓
- *Die voorwaartse reaksie word bevoordeel./ HI-konsentrasie neem toe./Die ewewigs(posisie) skuif na regs.* ✓
- *Voorwaatse reaksie is eksotermies./Die terugwaartse reaksie is endotermies.* ✓

(3)

6.2

6.2.1 Products can be converted back to reactants. ✓

OR

Both forward and reverse reactions can take place.

OR

A reaction which can take place in both directions.

Produkte kan omgeskakel word na reaktanse. ✓

OF

Beide voor-en terugwaartse reaksies kan plaasvind.

OF

'n Reaksie wat in beide rigtings kan plaasvind. (1)

6.2.2

Marking criteria	***Nasienkriteria:***
a) $\Delta n(N_2O_4) = n(N_2O_4)_{eq} - n(N_2O_4)_{ini}$. ✓ b) USING ratio: $n(NO_2) : n(N_2O_4) = 2 : 1$ ✓ c) $n(NO_2)_{eq} = n(NO_2)_{ini} - \Delta n(NO_2)$ ✓ d) Divide BOTH by 1 dm^3 ✓ e) Correct K_c expression (formulae in square brackets). ✓	(a) *$\Delta n(N_2O_4) = n(N_2O_4)_{ewe} - n(N_2O_4)_{aanv}$.* ✓ (b) *GEBRUIK verhouding: $n(NO_2) : n(N_2O_4) = 2 : 1$* ✓ (c) *$n(NO_2)_{ewe} = n(NO_2)_{aanv} - \Delta n(NO_2)$* ✓ (d) *Deel BEIDE deur* 1 dm^3 ✓ (e) *Korrekte K_c uitdrukking (formules in vierkantige hakies).* ✓

	NO_2	N_2O_4
Initial amount (moles) *Aanvangshoeveelheid (mol)*	x	0
Change in amount (moles) *Verandering in hoeveelheid* (mol)	1,62	0,81 ✓(a)
Equilibrium amount (moles) *Ewewigshoeveelheid (mol)*	x – 1,62 ✓(c)	0,81
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)*	x – 1,62	0,81

ratio ✓
verhouding

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark \text{ (e)}$$

$$= \frac{(0,81)}{(x-1,62)^2}$$

Wrong or no K_c expression/*Verkeerde of geen K_c-uitdrukking*: Max./*Maks.* $\frac{4}{5}$

(5)

6.2.3 **POSITIVE MARKING FROM QUESTION 6.2.2**
POSITIEWE NASIEN VAN VRAAG 6.2.2.

Marking criteria	***Nasienkriteria:***
a) Add 0,79 mol to $n(N_2O_4)_{ini}$. ✓ b) USING ratio: $n(NO_2) : n(N_2O_4) = 2 : 1$ to calculate $\Delta n(N_2O_4)$ as 0,6 mol. ✓ c) $n(NO_2)_{eq} = n(NO_2)_{ini} + \Delta n(NO_2)$ $n(N_2O_4)_{eq} = n(N_2O_4)_{ini} - \Delta n(N_2O_4)$ ✓ d) Substitution of concentrations into correct K_c expression. ✓ e) Equating K_c expresssion from Q6.1.3 and Q6.2.3. ✓ f) Final answer: 12,42 ✓ (Range: 11,27 – 12,42)	*(a) Voeg 0,79 mol by $n(N_2O_4)_{aanv}$. ✓* *(b) GEBRUIK verhouding: $n(NO_2) : n(N_2O_4) = 2 : 1$ om $\Delta n(N_2O_4)$ as 0,6 mol te bereken. ✓* *(c) $n(NO_2)_{ewe} = n(NO_2)_{aanv} + \Delta n(NO_2)$* *$n(N_2O_4)_{ewe} = n(N_2O_4)_{aanv} - \Delta n(N_2O_4)$ ✓* *(d) Vervanging van konsentrasies in korrekte K_c-uitdrukking.* *(e) Stel K_c-uitdrukking van Q6.1.3 en Q6.2.3 gelyk aan mekaar. ✓* *(f) Finale antwoord: 12,42 ✓* *(Gebied: 11,27 – 12,42)*

	NO_2	N_2O_4
Initial amount (moles) *Aanvangs hoeveelheid (mol)*	x – 1,62	0,81 + 0,79 ✓ = 1,6
Change in amount (moles) *Verandering in hoeveelheid* (mol)	1,2	0,6 ✓
Equilibrium amount (moles) *Ewewigshoeveelheid* (mol)	x – 1,62 +1,2	1 ✓(c)
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)*	x – 0,42	1

$$K_c = \frac{[N_2O_4]}{[NO_2]^2}$$

$$\frac{(0,81)}{(x-1,62)^2} \overset{\checkmark(e)}{=} \frac{1}{(x-0,42)^2} \checkmark(d)$$

$x = 12,42$ (mol) ✓(f)

Wrong K_c expression/*Verkeerde K_c- uitdrukking*: Max./*Maks.* $^4/_6$
No K_c expression/*Geen K_c- uitdrukking*: $^6/_6$

(6)
[19]

QUESTION 7/VRAAG 7

7.1

7.1.1 An acid is a proton (H^+ ion) donor. ✓✓
'n Suur is 'n protondonor/skenker of H^+-ioon donor/skenker. (2)

7.1.2 HY ✓

For the SAME acid concentration:
Lower pH / higher H^+ or H_3O^+ concentration / more ionised. ✓
Vir DIESELFDE suurkonsentrasie:
Laer pH / hoër H^+/H_3O^+ konsentrasie / meer geïoniseer. (2)

7.1.3 Lower than./*Laer as* ✓

$K_a < 1$ / HX ionises incompletely. / HX has a small K_a value. / HX is a weak acid. ✓
$K_a < 1$ / *HX ioniseer onvolledig. / HX het 'n klein K_a-waarde. / HX is 'n swak suur.* (2)

7.2

7.2.1 pH $= -\log[H_3O^+]$ **OR**/***OF*** $[H_3O^+] = 10^{-pH}$ ✓
2 ✓ $= -\log[H_3O^+]$
$[H_3O^+] = 0{,}01\ mol\cdot dm^{-3}$ ✓ $(1 \times 10^{-2}\ mol\cdot dm^{-3})$ (3)

7.2.2 **POSITIVE MARKING FROM QUESTION 7.2.1.**
POSITIEWE NASIEN VAN VRAAG 7.2.1.

Marking criteria for OPTION 1:	***Nasienkriteria vir OPSIE 1:***
• Substitute $c(HC\ell)_{excess}$ and $0{,}35\ dm^3$ to calculate $n(HC\ell)_{excess}$. ✓ • Substitute to calculate $n(HC\ell)_{initial}$ ✓ • $n(HC\ell)_{react} = n(HC\ell)_{ini} - n(HC\ell)_{excess}$. ✓✓ • Use ratio: $n(NaOH) = n(HC\ell)$ ✓ • Substitute $0{,}15\ dm^3$ in $c = \frac{n}{V}$. ✓ • Final answer: $0{,}02\ mol\cdot dm^{-3}$ ✓ **or** $0{,}0167\ mol\cdot dm^{-3}$ **or** $0{,}017\ mol\cdot dm^{-3}$	• *Vervang $c(HC\ell)_{oormaat}$ en $0{,}35\ dm^3$ om $n(HC\ell)_{oormaat}$ te bereken.* ✓ • *Vervang om $n(HC\ell)_{aanv}$ te bereken.* ✓ • *$n(HC\ell)_{rea} = n(HC\ell)_{aanv} - (HC\ell)_{oormaat}$* ✓✓ • *Gebruik verhouding: $n(NaOH) = n(HC\ell)$* ✓ • *Vervang $0{,}15\ dm^3$ in $c = \frac{n}{V}$.* ✓ • *Finale antwoord*: $0{,}02\ mol\cdot dm^{-3}$ ✓ ***of*** *$0{,}0167\ mol\cdot dm^{-3}$* ***of*** *$0{,}017\ mol\cdot dm^{-3}$*

OPTION 1/*OPSIE 1*

$n(HC\ell)_{excess/oormaat} = cV$
$= \underline{0{,}01 \times 0{,}35}$ ✓
$= 3{,}5 \times 10^{-3}$ mol

$n(HC\ell)_{initial/aanv} = cV$
$= 0{,}03 \times 0{,}2$ ✓
$= 0{,}006$ mol

$n(HC\ell)_{reacted/reageer} = \underline{0{,}006 - 3{,}5 \times 10^{-3}}$ ✓✓
$= 0{,}0025$ mol

$n(NaOH)_{reacted/reageer} = n(HC\ell)_{reacted/reageer} = 0{,}0025$ mol ✓

$c(NaOH) = \frac{n}{V}$
$= \frac{0{,}0025}{0{,}15}$ ✓
$= 0{,}02\ mol\cdot dm^{-3}$ ✓ $(0{,}0167\ mol\cdot dm^{-3}$ **or**/***of*** $0{,}017\ mol\cdot dm^{-3})$

OPTION 2/*OPSIE 2* Concentration ratio in final solution: *Konsentrasie verhouding in finale oplossing:* $HC\ell : H_3O^+ = 1 : 1$ ✓ Thus/dus $[HC\ell] = 0,01\ mol\cdot dm^{-3}$ ✓✓ $[HC\ell]_{react} = [HC\ell]_{initial} - [HC\ell]_{excess}$ $= \underline{0,03 - 0,01}$ ✓✓ $= 0,02\ mol\cdot dm^{-3}$ Concentration ratio in final solution: *Konsentrasie verhouding in oorspronklike oplossing:* $HC\ell : NaOH = 1 : 1$ ✓ $[NaOH] = 0,02\ mol\cdot dm^{-3}$ ✓	**Marking criteria** • Ratio $HC\ell : H_3O^+ = 1 : 1$ ✓ • $c(HC\ell)_{excess} = 0,01\ (mol\cdot dm^{-3})$ ✓✓ • $n(HC\ell)_{react} = n(HC\ell)_{ini} - (HC\ell)_{excess}$. ✓✓ • Use ratio: $n(NaOH) = n(HC\ell)$ ✓ • Final answer: $0,02\ mol\cdot dm^{-3}$ ✓ ***Nasienkriteria*** • *Verhouding* $HC\ell : H_3O^+ = 1 : 1$ ✓ • $c(HC\ell)_{oormaat} = 0,01\ (mol\cdot dm^{-3})$ ✓✓ • $n(HC\ell)_{reag} = n(HC\ell)_{aanv} - (HC\ell)_{oormaat}$. ✓✓ • *Gebruik verhouding:* $n(NaOH) = n(HC\ell)$ ✓ • *Finale antwoord:* $0,02\ mol\cdot dm^{-3}$ ✓
OPTION 3/*OPSIE 3* $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$ $\frac{c_1(200)}{(0,01)(350)✓} = \frac{1}{1}$ ✓ $c_1 = 0,0175\ mol\cdot dm^{-3}$ $c(HC\ell)_{react} = c(HC\ell)_{ini} - c(HC\ell)_{excess}$ $= \underline{0,03 - 0,0175}$ ✓✓ $= 0,0125\ mol\cdot dm^{-3}$ $\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$ $\frac{(0,0125)(200)}{c_b(150)✓} = \frac{1}{1}$ ✓ $c(NaOH) = 0,0167\ mol\cdot dm^{-3}$ ✓ ($0,0167\ mol\cdot dm^{-3}$ **or/*of*** $0,017\ mol\cdot dm^{-3}$)	**Marking criteria** • Substitute $350\ cm^3$ in $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$ ✓ • Ratio of $HC\ell : H_3O^+ = 1 : 1$ ✓ • $n(HC\ell)_{react} = n(HC\ell)_{ini} - (HC\ell)_{excess}$. ✓✓ • Use ratio: $n(NaOH) = n(HC\ell)$ ✓ • Substitute $150\ cm^3$ in $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$ ✓ • Final answer: $0,02\ mol\cdot dm^{-3}$ ✓ **or** $0,0167\ mol\cdot dm^{-3}$ **or** $0,017\ mol\cdot dm^{-3}$ ***Nasienkriteria*** • *Vervang* $350\ cm^3$ *in* $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$ ✓ • *Verhouding* $HC\ell : H_3O^+ = 1 : 1$ ✓ • $n(HC\ell)_{reag} = n(HC\ell)_{aanv} - (HC\ell)_{oormaat}$. ✓✓ • *Gebruik verhouding:* $n(NaOH) = n(HC\ell)$ ✓ • *Vervang* $150\ cm^3$ *in* $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$ ✓ • *Finale antwoord:* $0,02\ mol\cdot dm^{-3}$ ✓ ***of*** $0,0167\ mol\cdot dm^{-3}$ ***of*** $0,017\ mol\cdot dm^{-3}$

(7)
[16]

QUESTION 8/*VRAAG 8*

8.1

8.1.1 Temperature/*Temperatuur*: 25 °C/298 K ✓
Pressure/*Druk*: 101,3 kPa/1 atmosphere ✓
Concentration/*Konsentrasie*: 1 mol·dm^{-3} ✓ (3)

8.1.2

OPTION 1/*OPSIE 1*	**Notes/*Aantekeninge***
$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ ✓ $2{,}89$ ✓ $= E^{\theta}_{reduction} - (-1{,}66)$ ✓ $E^{\theta}_{reduction} = 1{,}23$ (V) ✓ X is O_2/oxygen/*suurstof* ✓ [X marked independently/ *X onafhanklik nagesien*]	• Accept any other correct formula from the data sheet./*Aanvaar enige ander korrekte formule vanaf gegewensblad.* • Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik bv. $E°_{sel} = E°_{OM} - E°_{RM}$ gevolg deur korrekte vervangings:* $\frac{4}{5}$

OPTION 2/*OPSIE 2*

$O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O$ ✓ $E^{\theta} = +1{,}23$ V ✓
$A\ell(s) \rightarrow A\ell^{3+}(aq) + 3e^-$ $E^{\theta} = +1{,}66$ V ✓
$4A\ell(s) + 3O_2(g) + 12H^+ \rightarrow 4A\ell^{3+}(aq) + 6H_2O$ $E^{\theta} = +2{,}89$ (V) ✓

X is O_2/oxygen/*suurstof* ✓

[X marked independently/*X onafhanklik nagesien*] (5)

8.1.3 $A\ell$ ✓ (1)

8.1.4 $O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O$ ✓✓

Ignore phases./*Ignoreer fases.*

Marking criteria/*Nasienkriteria:*

- $2H_2O \leftarrow O_2(g) + 4H^+ + 4e^-$ $(\frac{2}{2})$ $O_2(g) + 4H^+ + 4e^- \rightleftharpoons 2H_2O$ $(\frac{1}{2})$
  $O_2(g) + 4H^+ + 4e^- \leftarrow 2H_2O$ $(\frac{0}{2})$ $2H_2O \rightleftharpoons O_2(g) + 4H^+ + 4e^-$ $(\frac{0}{2})$
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (+) omitted on H^+/ *Indien lading (+) weggelaat op* H^+: Max./*Maks:* $\frac{1}{2}$
  Example/*Voorbeeld:* $O_2(g) + 4H + 4e^- \rightarrow 2H_2O$ ✓ (2)

8.1.5 $\underbrace{A\ell\,(s) \mid A\ell^{3+}(aq)}_{✓} \overset{✓}{\|} \underbrace{O_2(g) \mid H^+(aq) \mid H_2O(\ell) \mid Pt(s)}_{✓}$

OR/*OF*
$A\ell\,(s) \mid A\ell^{3+}(aq) \| O_2(g) \mid H^+(aq) \mid H_2O(\ell) \mid C(s)$

OR/*OF*
$A\ell \mid A\ell^{3+} \| O_2 \mid H^+ \mid H_2O \mid Pt$ (3)

8.2 Copper/*Koper* ✓

- Cu is a weaker reducing agent than Ni ✓and will not reduce Ni^{2+} (to Ni). / Cu will not be oxidised (to Cu^{2+}).✓
- Zn is a stronger reducing agent than Ni ✓and will reduce Ni^{2+} (to Ni). / Zn will be oxidised (to Zn^{2+}).

- *Cu is 'n swakker reduseermiddel as Ni en sal nie Ni^{2+} (na Ni) reduseer nie. / Cu sal nie geoksideer word nie na (Cu^{2+}).*
- *Zn is 'n sterker reduseermiddel as Ni en sal Ni^{2+} (na Ni) reduseer. / Zn sal geoksideer word (na Zn^{2+}).*

NOTE/LET WEL: The mark for 'reduce' can be awarded at any ONE of the two comparisons. *Die punt vir 'reduseer' kan toegeken word by ENIGEEN van die twee vergelykings.*

(4)
[18]

QUESTION 9/*VRAAG 9*

9.1

Marking criteria/*Nasienkriteria:* If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

ANY ONE/*ENIGE EEN:*

- The chemical process in which electrical energy is converted to chemical energy. ✓✓
- The use of electrical energy to produce a chemical change.
- Decomposition of an ionic compound by means of electrical energy.
- The process during which an electric current passes through a solution/ionic liquid/molten ionic compound.

- *Die chemiese proses waarin elektriese energie omgeskakel word na chemiese energie.* ✓✓
- *Die gebruik van elektriese energie om 'n chemiese verandering te weeg te bring.*
- *Ontbinding van 'n ioniese verbinding met behulp van elektriese energie.*
- *Die proses waardeur 'n elektriese stroom deur 'n oplossing/ioniese vloeistof/gesmelte ioniese verbinding beweeg.* (2)

9.2
9.2.1 X ✓ (1)

9.2.2 $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ ✓✓

Ignore phases/*Ignoreer fases*

Marking criteria/*Nasienkriteria:*
- $H_2(g) + 2OH^-(aq) \leftarrow 2H_2O(\ell) + 2e^-$ $(\frac{2}{2})$ $2H_2O(\ell) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$ $(\frac{1}{2})$
  $H_2(g) + 2OH^-(aq) \rightleftharpoons 2H_2O(\ell) + 2e^-$ $(\frac{0}{2})$ $2H_2O(\ell) + 2e^- \leftarrow H_2(g) + 2OH^-(aq)$ $(\frac{0}{2})$
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (-) omitted on OH^- /*Indien lading (-) weggelaat op* OH^-:
  Example/*Voorbeeld:* $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH(aq)$ ✓ Max./*Maks:* $\frac{1}{2}$

(2)

9.2.3 X to/*na* Y ✓ (1)

9.2.4 $2H_2O(\ell) + 2C\ell^-(aq)$ ✓ $\rightarrow C\ell_2(g) + H_2(g) + 2OH^-(aq)$ ✓ Bal ✓

OR/*OF*
$2H_2O(\ell) + 2NaC\ell(aq) \rightarrow C\ell_2(g) + H_2(g) + 2NaOH(aq)$

Ignore phases/*Ignoreer fases*

Marking criteria/*Nasienkriteria:*
- Reactants ✓ *Reaktanse* Products ✓ *Produkte* Balancing: ✓ *Balansering*
- Ignore double arrows./*Ignoreer dubbelpyle.*
- Marking rule 6.3.10/*Nasienreël 6.3.10.*

(3)

9.3 Increases / *Toeneem* ✓ (1)

9.4 Solution becomes basic / alkaline **OR** NaOH / OH^- (ions) form ✓
Oplossing word basies / alkalies ***OF*** *NaOH / OH^- (-ione) vorm* (1)

[11]

TOTAL/*TOTAAL*: 150

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2022

MARKS: 150

TIME: 3 hours

This question paper consists of 14 pages and 4 data sheets.

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INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.

2. This question paper consists of NINE questions. Answer ALL the questions in the ANSWER BOOK.

3. Start EACH question on a NEW page in the ANSWER BOOK.

4. Number the answers correctly according to the numbering system used in this question paper.

5. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

8. Show ALL formulae and substitutions in ALL calculations.

9. Round off your FINAL numerical answers to a minimum of TWO decimal places.

10. Give brief motivations, discussions, etc. where required.

11. You are advised to use the attached DATA SHEETS.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 Which ONE of the following terms describes hydrocarbons that contain only single bonds?

A Isomers

B Saturated

C Unsaturated

D Homologous series (2)

1.2 Which ONE of the following combinations correctly indicates the STRONGEST intermolecular forces found in ethanoic acid and methyl propanoate respectively?

	ETHANOIC ACID	METHYL PROPANOATE
A	Hydrogen bonds	Hydrogen bonds
B	Dipole-dipole forces	London forces
C	Hydrogen bonds	London forces
D	Hydrogen bonds	Dipole-dipole forces

(2)

1.3 A test tube contains a liquid hydrocarbon.

When bromine water (Br_2) is added to the test tube, the mixture decolourises IMMEDIATELY.

Which ONE of the following combinations correctly identifies the COMPOUND and the TYPE OF REACTION that takes place in the test tube?

	COMPOUND	TYPE OF REACTION
A	Hexane	Addition
B	Hexane	Substitution
C	Hex-2-ene	Addition
D	Hex-2-ene	Substitution

(2)

1.4 Which ONE of the following statements is the CORRECT definition for the rate of a reaction?

A The time taken for the reaction to take place

B The speed at which the reaction takes place

C The rate of change in concentration of the products or reactants

D The rate of change in concentration of the products or reactants per unit time (2)

1.5 Consider the balanced equation for the reaction between magnesium powder and EXCESS dilute hydrochloric acid, $HC\ell(aq)$:

$$Mg(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g)$$

Which ONE of the following will NOT increase the rate of this reaction?

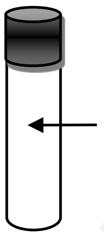
A Increasing the volume of $HC\ell(aq)$

B Increasing the temperature of $HC\ell(aq)$

C Increasing the concentration of $HC\ell(aq)$

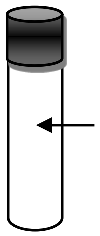
D Adding more magnesium powder (2)

1.6 Two identical sealed gas jars, **R** and **S**, initially contain gases as shown below.



1 mole $H_2(g)$ + 1 mole $I_2(g)$

Gas jar R



2 moles $HI(g)$

Gas jar S

Equilibrium is reached in both gas jars at 500 °C according to the following balanced equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Which ONE of the following statements is TRUE at equilibrium?

A **S** will contain 1 mole of $I_2(g)$.

B **R** will contain a larger amount of $I_2(g)$ than **S**.

C **R** and **S** will contain the same amount of $HI(g)$.

D **S** will contain a larger amount of $HI(g)$ than **R**. (2)

1.7 Which ONE of the following salts, when dissolved in water, will NOT change the pH of the water?

A Na_2CO_3

B $(COO)_2Na_2$

C $NH_4C\ell$

D $NaC\ell$ (2)

1.8 A dilute acid is titrated against a potassium hydroxide solution, KOH(aq).

At the equivalence point the pH is 7.

Which ONE of the following combinations correctly identifies the acid and the MOST SUITABLE indicator for this titration?

	ACID	INDICATOR
A	$(COOH)_2(aq)$	Phenolphthalein
B	$(COOH)_2(aq)$	Bromothymol blue
C	$HC\ell(aq)$	Phenolphthalein
D	$HC\ell(aq)$	Bromothymol blue

(2)

1.9 Which ONE of the following statements is TRUE for an oxidising agent?

A It gains electrons.

B It causes another species in the reaction to be reduced.

C Its oxidation number does not change during a chemical reaction.

D Its oxidation number increases during a chemical reaction. (2)

1.10 Which ONE of the following metals will reduce $Cd^{2+}(aq)$ to Cd(s), but will NOT reduce $Mn^{2+}(aq)$ to Mn(s)?

A Zn

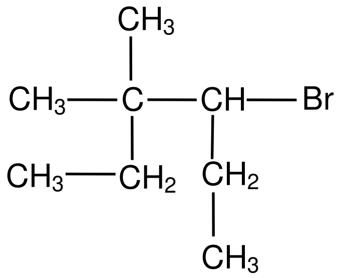
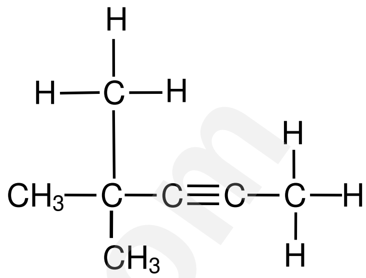
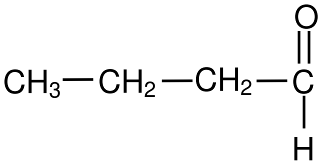
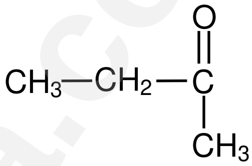
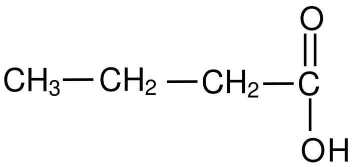
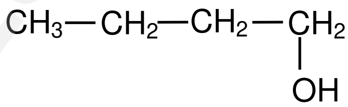
B Ag

C Ni

D Mg (2)
[20]

QUESTION 2 (Start on a new page.)

A to **F** in the table below represent six organic compounds.

A		**B**	
C		**D**	
E		**F**	

2.1 Write down the:

2.1.1 Letters that represent TWO organic compounds that are isomers of each other (1)

2.1.2 Type of isomers (CHAIN, FUNCTIONAL or POSITIONAL) identified in QUESTION 2.1.1 (1)

2.1.3 GENERAL FORMULA of the homologous series to which compound **B** belongs (1)

2.1.4 NAME of the functional group of compound **F** (1)

2.2 Write down the IUPAC name of:

2.2.1 Compound **A** (3)

2.2.2 Compound **B** (2)

2.2.3 Compound **C** (2)

2.3 Compound **F** reacts with a carboxylic acid to form compound **S** in the presence of a strong acid.

2.3.1 Write down the type of reaction that takes place. (1)

Compound **S** has an EMPIRICAL FORMULA of C_3H_6O and a molecular mass of 116 $g{\cdot}mol^{-1}$.

2.3.2 Write down the MOLECULAR FORMULA of the carboxylic acid. (3)
[15]

QUESTION 3 (Start on a new page.)

3.1 The melting points of some organic compounds are given in the table below.

COMPOUND	IUPAC NAME	MELTING POINTS (°C)
A	Propanone	-95,4
B	Butanone	-86,9
C	Pentan-2-one	-77,8
D	3-methylbutanone	-92

3.1.1 To which homologous series do the above compounds belong? (1)

The melting points of compounds **A**, **B** and **C** are compared.

3.1.2 Write down the controlled variable for this comparison. (1)

The melting points of compounds **C** and **D** are compared.

3.1.3 Fully explain the difference in the melting points of these two compounds. (4)

3.2 The table below shows the results obtained from an experiment to determine the vapour pressure of different STRAIGHT CHAIN primary alcohols at 300 K.

ALCOHOL	VAPOUR PRESSURE (kPa)
CH_3OH	16,8
C_2H_5OH	7,88
C_3H_7OH	2,8
C_4H_9OH	0,91
$C_5H_{11}OH$	0,88
$C_6H_{13}OH$	0,124

3.2.1 Define the term *vapour pressure*. (2)

3.2.2 Write down a suitable conclusion for this investigation. (2)

3.2.3 Write down the IUPAC name of the alcohol with the HIGHEST boiling point. (3)

3.2.4 The experiment is now repeated at 320 K.

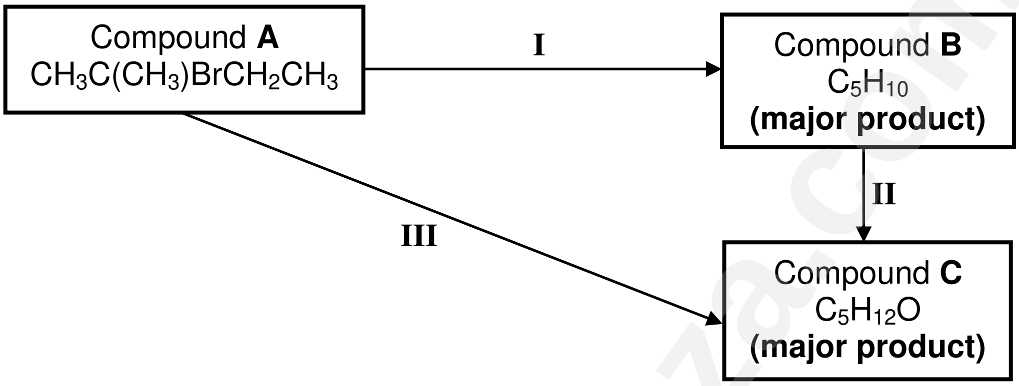
Will the vapour pressure of each compound INCREASE, DECREASE or REMAIN THE SAME? (1)

[14]

QUESTION 4 (Start on a new page.)

The flow diagram below shows how compound **A** can be used as a starting reactant to prepare two different compounds.

I, **II** and **III** represent three organic reactions.



4.1 Is compound **A** a PRIMARY, SECONDARY or TERTIARY haloalkane? Give a reason for the answer. (2)

4.2 Consider reaction **I**.

4.2.1 Besides heat, write down the other reaction condition needed. (1)

4.2.2 Write down the type of reaction that takes place. (1)

4.2.3 Using STRUCTURAL FORMULAE for the organic compounds, write down a balanced equation for the reaction. (5)

4.3 Consider reaction **II**.

Write down the:

4.3.1 STRUCTURAL FORMULA of compound **C** (2)

4.3.2 NAME or FORMULA of the inorganic reagent needed (1)

4.3.3 Type of addition reaction that takes place (1)

4.4 Consider reaction **III**.

4.4.1 Write down of the type of reaction that takes place. (1)

4.4.2 Besides heat, write down the other reaction condition needed. (1)
[15]

QUESTION 5 (Start on a new page.)

Three experiments, **A**, **B** and **C**, are carried out to investigate some of the factors that affect the rate of decomposition of hydrogen peroxide, $H_2O_2(\ell)$.

The balanced equation for the reaction is:

$$2H_2O_2(\ell) \rightarrow 2H_2O(\ell) + O_2(g)$$

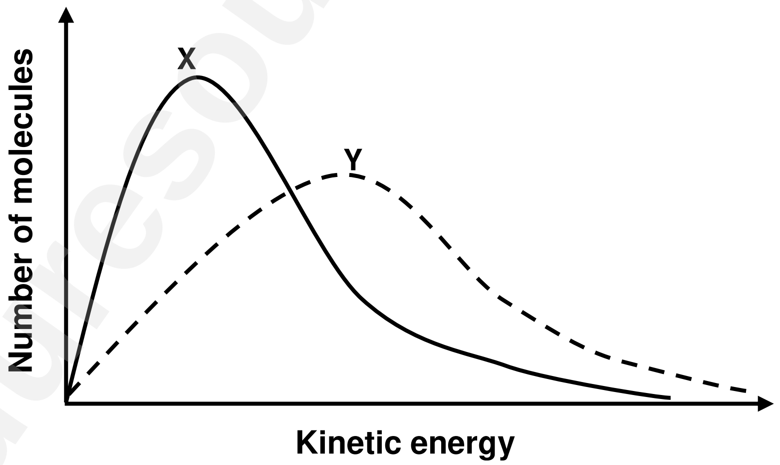
Identical samples of hydrogen peroxide are used in each experiment.

The conditions used in each experiment are summarised in the table below.

EXPERIMENT	TEMPERATURE (°C)	
A	25	Without catalyst
B	25	With catalyst
C	35	Without catalyst

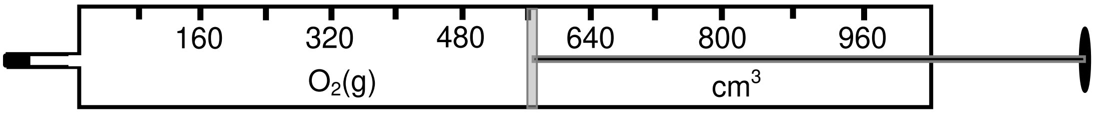
5.1 In which experiment, **A** or **B**, is the reaction rate higher? Use the collision theory to explain the answer. (4)

5.2 The Maxwell-Boltzmann distribution curves, **X** and **Y**, for two of the above experiments are shown below.



Identify the curve (**X** or **Y**) that represents experiment **C**. (2)

5.3 The volume of oxygen gas, $O_2(g)$, produced in experiment **B** during the first 3,6 s is collected in a syringe, as shown below.



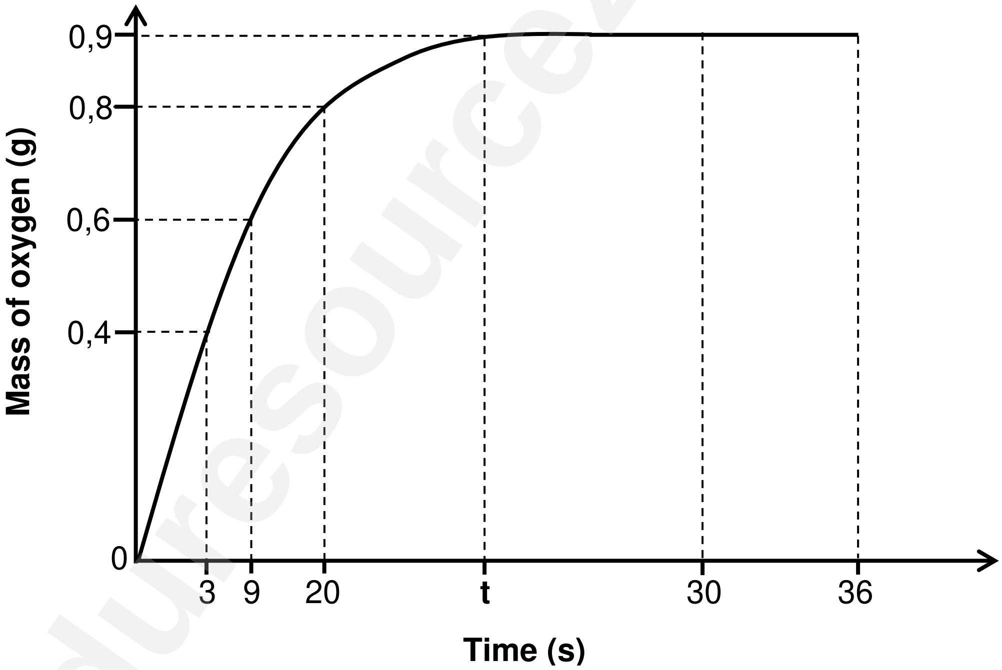
5.3.1 Write down the volume of $O_2(g)$ collected in the syringe. (2)

The balanced equation for the reaction is:

$$2H_2O_2(\ell) \rightarrow 2H_2O(\ell) + O_2(g)$$

5.3.2 Calculate the mass of water, $H_2O(\ell)$, that was produced during the first 3,6 s. Take the molar gas volume to be 24 000 $cm^3 \cdot mol^{-1}$ at 25 °C. (4)

5.4 The graph below, NOT drawn to scale, is obtained for the mass of oxygen gas produced over a period of time in experiment **A**.



Use the information in the graph to answer the following questions:

5.4.1 Write down the rate of production of oxygen gas for the interval 30 s to 36 s. (1)

5.4.2 Will the rate of the reaction in the interval 3 s to 9 s be GREATER THAN, SMALLER THAN or EQUAL TO the rate of the reaction in the interval 9 s to 20 s? (1)

5.4.3 The average rate of decomposition of hydrogen peroxide is $2{,}1 \times 10^{-3}$ $mol \cdot s^{-1}$.

Calculate the value of time **t** on the graph. (5)
[19]

QUESTION 6 (Start on a new page.)

Carbon, C(s), reacts with sulphur, S(g), according to the following balanced equation:

$$C(s) + 2S(g) \rightleftharpoons CS_2(g) \qquad \Delta H > 0$$

The system reaches equilibrium at temperature T in a sealed 2 dm^3 container.

The K_c value is 9,4 at temperature T.

6.1 State Le Chatelier's principle. (2)

At equilibrium, 1 mole of carbon disulphide, $CS_2(g)$, is present in the container.

6.2 Calculate the concentration of S(g) present at equilibrium. (4)

The volume of the container is now DOUBLED at temperature T. After a while, a NEW equilibrium is established.

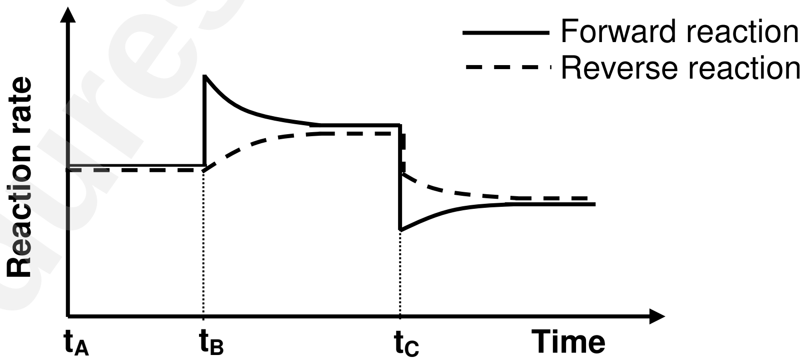
6.3 How will the amount of S(g) change as this new equilibrium is established? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

6.4 Explain the answer to QUESTION 6.3 in terms of Le Chatelier's principle. (3)

6.5 If the concentration of $CS_2(g)$ CHANGES by **x** $mol\cdot dm^{-3}$, write down an expression for the equilibrium constant, K_c, in terms of **x**.

Show ALL your workings. NO simplification or solving for **x** is required. (5)

6.6 The reaction rate-time graph below represents further changes made to the equilibrium mixture. The volume of the container is kept constant.



6.6.1 What do the parallel lines between t_A and t_B represent? (1)

6.6.2 What change was made to the equilibrium mixture at t_B? (1)

6.6.3 Give a reason for the sudden change in the reaction rate at t_C. (1)

6.6.4 Fully explain the answer to QUESTION 6.6.3. (3)

[21]

QUESTION 7 (Start on a new page.)

7.1 Ethanoic acid is a weak acid that reacts with water according to the following balanced equation:

$$CH_3COOH(aq) + H_2O(\ell) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$

7.1.1 Define an *acid* in terms of the Lowry-Brønsted theory. (2)

7.1.2 Give a reason why ethanoic acid is classified as a WEAK acid. (1)

7.1.3 Write down the formulae of the TWO bases in the equation above. (2)

7.2 A flask contains 300 cm^3 of dilute sodium hydroxide, NaOH(aq), of concentration 0,167 $mol{\cdot}dm^{-3}$.

7.2.1 Calculate the number of moles of sodium hydroxide in the flask. (3)

Ethanoic acid of volume 500 cm^3 and of unknown concentration, **X**, is now added to this flask to give a solution of volume 800 cm^3.

It is found that the pH of the mixture is 11,4.

The balanced equation for the reaction is:

$$NaOH(aq) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + H_2O(\ell)$$

Calculate the:

7.2.2 Concentration of the $OH^-(aq)$ in the mixture (4)

7.2.3 Initial concentration, **X**, of the ethanoic acid solution (6)
[18]

QUESTION 8 (Start on a new page.)

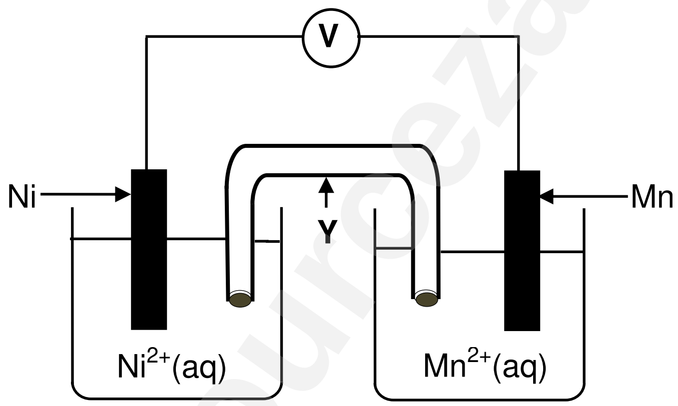
8.1 A piece of zinc (Zn) is placed in a test tube containing an acidified permanganate solution, $MnO_4^-(aq)$. After some time, it is found that a redox reaction has taken place.

Use the Table of Standard Reduction Potentials to answer the following questions:

8.1.1 Write down the NAME or FORMULA of the reducing agent. (1)

8.1.2 Refer to the relative strengths of the OXIDISING AGENTS to explain why a redox reaction has taken place. (3)

8.2 A standard electrochemical cell is set up as shown below.



8.2.1 Write down the function of component **Y**. (1)

8.2.2 In which direction will electrons flow in the external circuit? Choose from 'Ni to Mn' OR 'Mn to Ni'. (2)

8.2.3 Calculate the initial emf of this cell. (4)

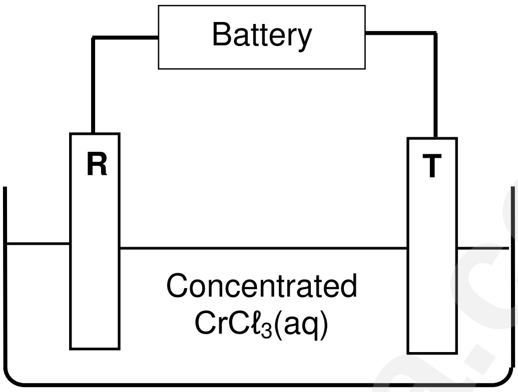
8.2.4 Write down the balanced equation for the net cell reaction taking place. (3)

8.2.5 The concentration of $Ni^{2+}(aq)$ is now increased.

Will the reading on the voltmeter INCREASE, DECREASE or REMAIN THE SAME? (1)
[15]

QUESTION 9 (Start on a new page.)

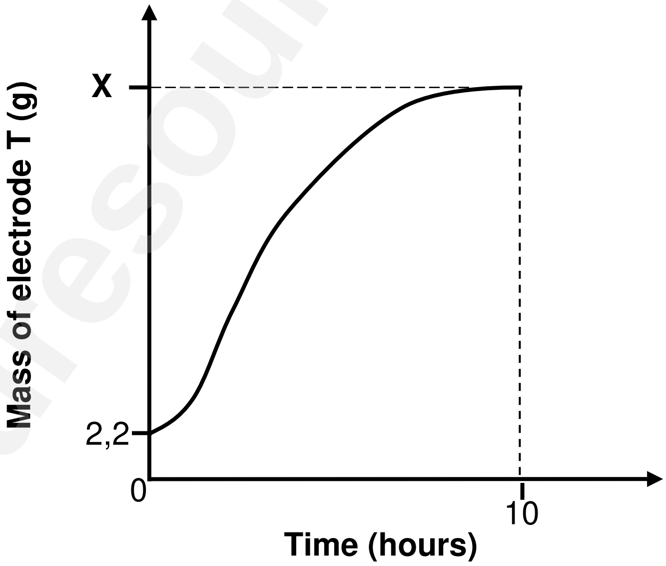
The diagram below represents a simplified cell used for the electrolysis of CONCENTRATED chromium(III) chloride, $CrC\ell_3(aq)$. Electrodes **R** and **T** are made of carbon.



The net cell reaction is: $2CrC\ell_3(aq) \rightarrow 2Cr(s) + 3C\ell_2(g)$

9.1 Define the term *electrolysis*. (2)

9.2 The graph below, NOT drawn to scale, represents the changes in the mass of electrode **T** during electrolysis.



9.2.1 Write down the half-reaction that takes place at electrode **T**. (2)

A current of 2,5 A passes through the cell for 10 hours.

Calculate the:

9.2.2 Total charge that flows through the cell during this time (3)

9.2.3 Value of **X** as shown on the graph (6)
[13]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^θ	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22{,}4\ dm^3 \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^θ	273 K
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode} / E^\theta_{sel} = E^\theta_{katode} - E^\theta_{anode}$ or/*of* $E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation} / E^\theta_{sel} = E^\theta_{reduksie} - E^\theta_{oksidasie}$ or/*of* $E^\theta_{cell} = E^\theta_{oxidising agent} - E^\theta_{reducing agent} / E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	
$q = I\Delta t$ $n = \frac{Q}{e}$ or/*of* $n = \frac{Q}{q_e}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Electronegativity *Elektronegatiwiteit*	29 1,9 Cu 63,5	**Symbol** *Simbool*

Atomic number / *Atoomgetal*: 29 (top)
Approximate relative atomic mass / *Benaderde relatiewe atoommassa*: 63,5 (bottom)

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Increasing strength of oxidising agents/*Toenemende sterkte van oksideermiddels*

Increasing strength of reducing agents/*Toenemende sterkte van reduseermiddels*

Half-reactions/*Halfreaksies*			E^θ **(V)**
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$\mathbf{2H^+ + 2e^-}$	⇌	$\mathbf{H_2(g)}$	**0,00**
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$Na^+ + e^-$	⇌	Na	− 2,71
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Cs^+ + e^-$	⇌	Cs	- 2,92
$K^+ + e^-$	⇌	K	− 2,93
$Li^+ + e^-$	⇌	Li	− 3,05

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Increasing strength of oxidising agents/*Toenemende sterkte van oksideermiddels* (↓)

Increasing strength of reducing agents/*Toenemende sterkte van reduseermiddels* (↑)

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^{+} + e^{-}$	⇌	Li	− 3,05
$K^{+} + e^{-}$	⇌	K	− 2,93
$Cs^{+} + e^{-}$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^{-}$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^{-}$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^{-}$	⇌	Ca	− 2,87
$Na^{+} + e^{-}$	⇌	Na	− 2,71
$Mg^{2+} + 2e^{-}$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^{-}$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^{-}$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^{-}$	⇌	Cr	− 0,91
$2H_2O + 2e^{-}$	⇌	$H_2(g) + 2OH^{-}$	− 0,83
$Zn^{2+} + 2e^{-}$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^{-}$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^{-}$	⇌	Fe	− 0,44
$Cr^{3+} + e^{-}$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^{-}$	⇌	Cd	− 0,40
$Co^{2+} + 2e^{-}$	⇌	Co	− 0,28
$Ni^{2+} + 2e^{-}$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^{-}$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^{-}$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^{-}$	⇌	Fe	− 0,06
$2H^{+} + 2e^{-}$	⇌	**$H_2(g)$**	**0,00**
$S + 2H^{+} + 2e^{-}$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^{-}$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^{-}$	⇌	Cu^{+}	+ 0,16
$SO_4^{2-} + 4H^{+} + 2e^{-}$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^{-}$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^{-}$	⇌	$4OH^{-}$	+ 0,40
$SO_2 + 4H^{+} + 4e^{-}$	⇌	$S + 2H_2O$	+ 0,45
$Cu^{+} + e^{-}$	⇌	Cu	+ 0,52
$I_2 + 2e^{-}$	⇌	$2I^{-}$	+ 0,54
$O_2(g) + 2H^{+} + 2e^{-}$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^{-}$	⇌	Fe^{2+}	+ 0,77
$NO_3^{-} + 2H^{+} + e^{-}$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^{+} + e^{-}$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^{-}$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^{-} + 4H^{+} + 3e^{-}$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^{-}$	⇌	$2Br^{-}$	+ 1,07
$Pt^{2+} + 2e^{-}$	⇌	Pt	+ 1,20
$MnO_2 + 4H^{+} + 2e^{-}$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^{+} + 4e^{-}$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^{+} + 6e^{-}$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^{-}$	⇌	$2C\ell^{-}$	+ 1,36
$MnO_4^{-} + 8H^{+} + 5e^{-}$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^{+} + 2e^{-}$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^{-}$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^{-}$	⇌	$2F^{-}$	+ 2,87

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE
NASIONALE SENIOR SERTIFIKAAT

GRADE/*GRAAD* 12

PHYSICAL SCIENCES: CHEMISTRY (P2)
FISIESE WETENSKAPPE: CHEMIE (V2)

NOVEMBER 2022

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

These marking guidelines consist of 19 pages.
Hierdie nasienriglyne bestaan uit 19 bladsye.

QUESTION 1/*VRAAG 1*

1.1	B ✓✓	(2)
1.2	D ✓✓	(2)
1.3	C ✓✓	(2)
1.4	C ✓✓	(2)
1.5	A ✓✓	(2)
1.6	C ✓✓	(2)
1.7	D ✓✓	(2)
1.8	D ✓✓	(2)
1.9	A ✓✓	(2)
1.10	A ✓✓	(2) **[20]**

QUESTION 2/*VRAAG 2*

2.1

2.1.1 C & D ✓ (1)

2.1.2 Functional/*Funksionele* ✓ (1)

2.1.3 C_nH_{2n-2} ✓ (1)

2.1.4 Hydroxyl (group)/*Hidroksiel(groep)* ✓ (1)

2.2

2.2.1 4-bromo-3,3-dimethylhexane/*4-bromo-3,3-dimetielheksaan* ✓✓✓

Marking criteria:
- Correct stem i.e. hexane. ✓
- All substituents (bromo and dimethyl) correctly identified. ✓
- IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓

Nasienkriteria:
- *Korrekte stam d.i. heksaan.* ✓
- *Alle substituente (bromo en dimetiel) korrek geïdentifiseer.* ✓
- *IUPAC-naam heeltemal korrek insluitende nommering, volgorde, koppeltekens en kommas.* ✓

(3)

2.2.2 4,4-dimethylpent-2-yne/4,4-dimethyl-2-pentyne ✓✓
4,4-dimetielpent-2-yn/4,4-dimetiel-2-pentyn

Marking criteria/*Nasienkriteria:*
- Correct stem and substituents: dimethyl and pentyne ✓
  Korrekte stam en substituente: dimetiel en pentyn
- IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓
  IUPAC-naam heeltemal korrek insluitende nommering, volgorde, koppeltekens en kommas.

(2)

2.2.3 Butanal/*Butanaal* ✓✓

Marking criteria/*Nasienkriteria*:
- Correct functional group: -al / *Korrekte funksionele groep: –aal* ✓
- IUPAC name correct/*IUPAC-naam korrek* ✓

(2)

2.3

2.3.1 Esterification/condensation ✓
Esterfikasie/verestering/kondensasie (1)

2.3.2 $M(C_3H_6O) = 58\ g\cdot mol^{-1}$

$$\frac{\text{molecular mass of molecular formula}}{\text{molecular mass empirical formula}}$$

$$= \frac{116}{58} = 2$$

Compound S = $C_6H_{12}O_2$ ✓
$C_2H_4O_2$ ✓✓

Marking criteria/*Nasienkriteria*:
- $C_6H_{12}O_2$ ✓
- $C_2H_4O_2$ ✓✓
- If only correct answer given ✓✓✓
  Indien slegs korrekte antwoord gegee

NOTE/*LET WEL*
- Condensed or structural formula/*Gekondenseerde of struktuurformule*:
  Max./*Maks.* $^2/_3$

(3)
[15]

QUESTION 3/*VRAAG 3*

3.1.1 Ketone/*Ketoon* ✓ (1)

3.1.2 Functional group/homologous series ✓
Funksionele groep/homoloë reeks (1)

3.1.3

Marking criteria:
- Compare structures. ✓
- Compare the strength of intermolecular forces. ✓
- Compare the energy required to overcome intermolecular forces. ✓
- State the difference in melting point. ✓

Nasienkriteria:
- *Vergelyk strukture.* ✓
- *Vergelyk die sterkte van intermolekulêre kragte.* ✓
- *Vergelyk die energie benodig om intermolekulêre kragte te oorkom.* ✓
- *Noem die verskil in smeltpunte.* ✓

Pentan-2-one/C
- **Structure:**
  Longer chain length/less branched/less compact/less spherical/larger surface area (over which intermolecular forces act). ✓
- **Intermolecular forces:**
  Stronger/more intermolecular forces/Van der Waals forces/*London forces/* dipole-dipole forces. ✓
- **Energy:**
  More energy needed to overcome or break intermolecular forces/Van der Waals forces/dipole-dipole forces. ✓
- Higher melting point. ✓

NOTE
IF higher boiling point - Max. $^3/_4$

OR

3-methylbutanone/D
- **Structure:**
  Shorter chain length/more branched/more compact more spherical/smaller surface area (over which intermolecular forces act). ✓
- **Intermolecular forces:**
  Weaker/less intermolecular forces/Van der Waals forces/*London forces/* dipole-dipole forces. ✓
- **Energy:**
  Less energy needed to overcome or break intermolecular forces/Van der Waals force/dipole-dipole forces. ✓
- Lower melting point.✓

NOTE
IF lower boiling point - Max. $^3/_4$

Pentan-2-oon/C

- ***Struktuur***:
  Langer kettinglengte/minder vertak/minder kompak/minder sferies/groter oppervlak (waaroor intermolekulêre kragte werk). ✓
- ***Intermolekulêre kragte***:
  Sterker/meer intermolekulêre kragte/Van der Waalskragte/Londonkragte/ dipool-dipoolkragte. ✓
- *Meer energie benodig om intermolekulêre kragte/Van der Waalskragte/ Londonkragte/dipool-dipoolkragte te oorkom/breek.* ✓
- *Hoër smeltpunt.* ✓

LET WEL
***INDIEN** hoër kookpunt - Maks.* $^{3}/_{4}$

OF
3-metielbutanoon/D

- ***Struktuur***:
  Korter kettinglengte/meer vertak/meer kompak/meer sferies/kleiner oppervlak (waaroor intermolekulêre kragte werk). ✓
- ***Intermolekulêre kragte***:
  Swakker/minder intermolekulêre kragte/Van der Waalskragte/ Londonkragte/dipool-dipoolkragte. ✓
- ***Energie***:
  Minder energie benodig om intermolekulêre kragte/Van der Waalskragte/ Londonkragte/dipool-dipoolkragte te oorkom/breek. ✓
- *Laer smeltpunt.* ✓

LET WEL
***INDIEN** laer kookpunt - Maks.* $^{3}/_{4}$ (4)

3.2.1

Marking criteria/*Nasienkriteria*
If any one of the underlined key words phrases in the **correct context** (vapour pressure) is omitted, deduct 1 mark./*Indien enige van die onderstreepte sleutelwoorde of frases in die* ***korrekte konteks*** *(dampdruk) uitgelaat is, trek 1 punt af.*

The pressure exerted by a vapour at equilibrium with its liquid in a closed system. ✓✓
Die druk uitgeoefen deur 'n damp in ewewig met sy vloeistof in 'n geslote sisteem. (2)

3.2.2

Marking criteria/*Nasienkriteria:*
• Dependent and independent variables correctly identified. ✓ *Afhanklike en onafhanklike veranderlikes korrek geïdentifiseer.* • Correct relationship between dependent and independent variables stated. ✓ *Korrekte verwantskap tussen die afhanklike en onafhanklike veranderlikes gestel.*

Vapour pressure decreases with increase in number of C atoms/chain length. ✓✓
Dampdruk neem af met toename in aantal C-atome/kettinglengte.
OR/*OF*
Vapour pressure increases with decrease in number of C atoms/chain length.
Dampdruk neem toe met afname in aantal C-atome/kettinglengte. (2)

3.2.3 Hexan-1-ol/1-Hexanol ✓✓✓
Heksan-1-ol/1-Heksanol

Marking criteria/*Nasienkriteria*
• Correct chain length i.e. hex ✓ *Korrekte kettinglengte d.i. heks* • **IF** hexanol/***INDIEN*** *heksanol* Max/*Maks*: $^2/_3$ • Whole name correct./*Volledige naam korrek.* $^3/_3$

(3)

3.2.4 Increases/*Toeneem* ✓ (1)
[14]

QUESTION 4/*VRAAG 4*

4.1 Tertiary/*Tersiêre* ✓

The halogen/bromine/functional group (-X) is bonded to a C atom that is bonded to three other C atoms/ a tertiary C atom. ✓
Die halogeen/broom/funksionele groep (-X) is gebind aan 'n C-atoom wat aan drie ander C-atome gebind is/ 'n tersiêre C-atoom.

OR/*OF*
The functional group ($-\overset{|}{\underset{\underset{X/Br}{|}}{C}}-$) is bonded to three other C atoms.

Die funksionele groep ($-\overset{|}{\underset{\underset{X/Br}{|}}{C}}-$ *) is gebind aan drie ander C-atome.* (2)

4.2.1 Concentrated strong base ✓
OR
Concentrated NaOH/KOH/LiOH/sodium hydroxide/ potassium hydroxide/ lithium hydroxide
OR
Strong base/NaOH/KOH/LiOH/sodium hydroxide/ potassium hydroxide/lithium hydroxide in ethanol.

Gekonsentreerde sterk basis
OF
Gekonsentreerde NaOH /KOH/ LiOH /natriumhidroksied/ kaliumhidroksied/ litiumhidroksied
OF
Sterk basis/NaOH /KOH/ LiOH / natriumhidroksied/kaliumhidroksied/litium-hidroksied in etanol (1)

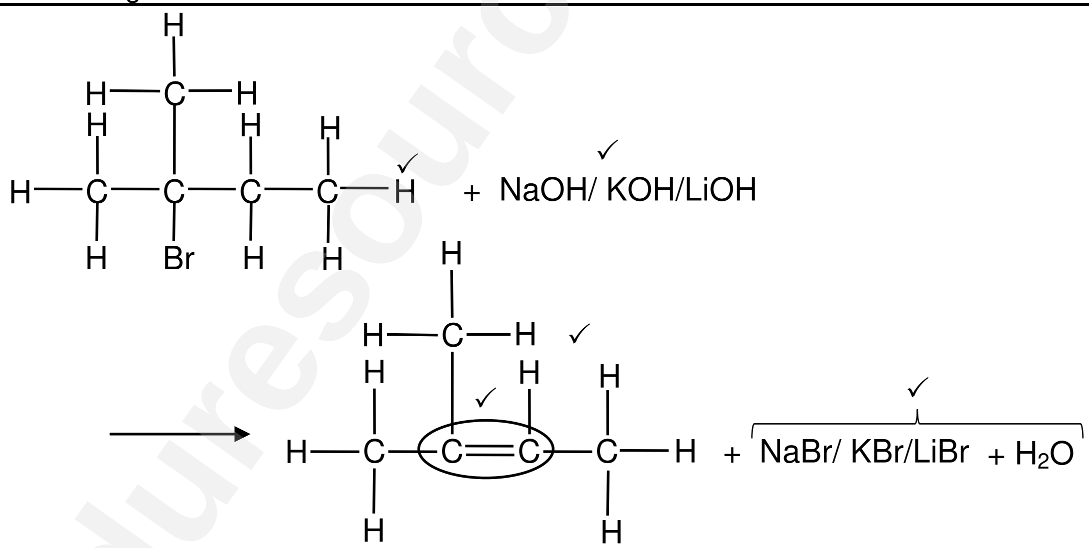
4.2.2 Elimination/dehydrohalogenation/dehydrobromination ✓
Eliminasie/dehidrohalogenering/dehidrohalogenasie/dehidrobrominasie/ dehidrobromonering (1)

4.2.3

Marking criteria*:*
- Whole structural formula correct for compound A. ✓
- React (2-bromo-2-methylbutane) with NaOH/KOH/LiOH. ✓
- Functional group of alkene correct. ✓
- Whole structural formula of alkene correct. ✓
- NaBr/KBr/LiBr + H_2O ✓

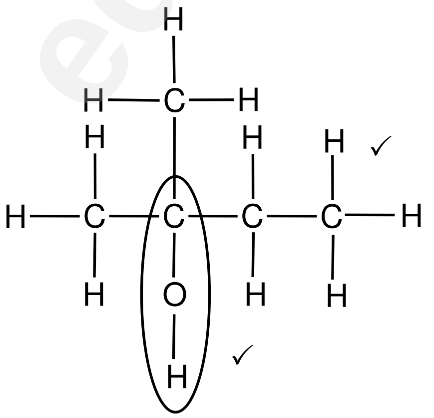
Nasienkriteria:
- *Hele struktuurformule vir verbinding A korrek.* ✓
- *Reageer (2-bromo-2-metielbutaan) met NaOH/KOH/LiOH.* ✓
- *Funksionele groep van alkeen korrek.* ✓
- *Hele struktuurformule van alkeen korrek.* ✓
- *NaBr/KBr/LiBr + H_2O* ✓

IF/***INDIEN***
- Any error e.g. omission of H atoms, condensed or semi structural formula/*Enige fout bv. weglating van H-atome, gekondenseerde of semi-struktuurformule:* Max/*Maks.* $^3/_5$
- Any additional reactants or products /*Enige addisionele reaktanse of produkte:* Max./*Maks.* $^4/_5$
- Molecular formulae used:/M*olekulêre formule gebruik:* Max./*Maks.* $^2/_5$
- No or incorrect inorganic reactants or products:/ *Geen of verkeerde anorganiese reaktanse of produkte:* Max./*Maks.* $^3/_5$
- Marking rule 6.3.10/*Nasienreël 6.3.10*



(5)

4.3.1



Marking criteria/***Nasienkriteria***:
- Functional group correct ✓
  Funksionele groep korrek
- Whole structure correct ✓
  Hele struktuur korrek

(2)

4.3.2 Water/H_2O ✓ (1)

4.3.3 Hydration/*Hidrasie* ✓ (1)

4.4.1 Substitution/Hydrolysis/*Substitusie/Hidrolise* ✓ (1)

4.4.2 Dilute strong base ✓
OR: Dilute NaOH/KOH/LiOH/sodium hydroxide/potassium hydroxide/lithium hydroxide
OR: NaOH(aq)/KOH(aq)/LiOH(aq)
OR: (Add) water/H_2O

Verdunde sterk basis
OF: *Verdunde NaOH/KOH/LiOH/natriumhidroksied/ kaliumhidroksied/ litiumhidroksied*
OF: *NaOH(aq)/KOH(aq)/LiOH(aq)*
OF: *(Voeg) water/H_2O (by)* (1)

[15]

QUESTION 5/*VRAAG 5*

5.1 B ✓

- The catalyst provides an alternative route of lower activation energy. ✓
- More molecules have enough/sufficient (kinetic) energy./More molecules have (kinetic) energy equal to or higher than the activation energy. ✓
- More effective collisions per unit time./Higher frequency of effective collisions. ✓

- *Die katalisator verskaf 'n alternatiewe roete van laer aktiveringsenergie.*
- *Meer molekule het genoeg/voldoende (kinetiese) energie./Meer molekule het (kinetiese) energie gelyk aan of groter hoër as die aktiveringsenergie.*
- *Meer effektiewe botsings per eenheidtyd./Hoër frekwensie van effektiewe botsings.* (4)

5.2 Y ✓✓ (2)

5.3

5.3.1 560 (cm^3) / 0,56 dm^3 ✓✓ (2)

5.3.2 **POSITIVE MARKING FROM QUESTION 5.3.1.**
POSITIEWE NASIEN VANAF VRAAG 5.3.1.

<u>Marking criteria:</u> (a) Substitute <u>24 000 and 560</u>/<u>24 and 0,56</u> in $n = \frac{V}{V_m}$ ✓ (b) USE mol ratio: $n(H_2O) : n(O_2) = 2 : 1$ ✓ (c) Substitute <u>18 and n(H_2O)</u> in $m = nM$ ✓ (d) Final answer: 0,83 g ✓ Range: 0,72 to 0,9 g	***<u>Nasienkriteria:</u>*** *(a) Vervang <u>24 000 en 560</u>/<u>24 en 0,56</u> in* $n = \frac{V}{V_m}$ ✓ *(b) GEBRUIK molverhouding:* $n(H_2O) : n(O_2) = 2 : 1$ ✓ *(c) Vervang <u>18 en n(H_2O)</u> in* $m = nM$ ✓ *(d) Finale antwoord: 0,83 g* ✓ *Gebied: 0,72 tot 0,9 g*
<u>OPTION 1/*OPSIE 1*</u> $n(O_2) = \frac{V}{V_m}$ $= \frac{560}{24\,000}$ ✓**(a)** = 0,023 mol (0,0233) $n(H_2O) = 2n(O_2)$ $n(H_2O) = 2(0{,}023)$ ✓**(b)** = 0,046 mol (0,0467) $m = nM$ = <u>0,046 x 18</u> ✓**(c)** = 0,83 g ✓**(d)**	**<u>OPTION 2/*OPSIE 2*</u>** 1 mol …….24 000 cm^3 x mol …….560 cm^3 ✓**(a)** x = 0,023 mol (0,0233) $n(H_2O) = 2n(O_2)$ $n(H_2O) = 2(0{,}023)$ ✓**(b)** = 0,046 mol (0,0467) $m = nM$ = <u>0,0466 x 18</u> ✓**(c)** = 0,83 g ✓**(d)**

(4)

5.4
5.4.1 0 ($g \cdot s^{-1}$) / zero / *nul* ✓ (1)

5.4.2 Greater than/*Groter as* ✓ (1)

5.4.3

Marking criteria a) Substitute 0,9 g in $\frac{m}{M}$ ✓ b) Substitute 32 in $\frac{m}{M}$ ✓ c) USE mol /rate ratio: $n(H_2O_2) : n(O_2) = 2 : 1$ ✓ d) Substitute <u>2,1 x 10⁻³ and n(H₂O₂)</u> in rate formula ✓ **OR:** Substitute <u>rate O_2</u> (1,05 x 10^{-3}) <u>and $n(O_2)$</u> in rate formula **OR:** Substitute rate O_2 (0,0336 g·s^{-1}) in rate formula e) Final correct answer: 26,67 (s) ✓ Range: 26,67 to 28,57 (s)	***Nasienkriteria:*** *a) Vervang 0,9 g in $\frac{m}{M}$* ✓ *b) Vervang 32 in $\frac{m}{M}$* ✓ *c) GEBRUIK mol-/tempoverhouding:* *$n(H_2O_2) : n(O_2) = 2 : 1$* ✓ *d) Vervang <u>2,1 x 10⁻³ en n(H₂O₂)</u> in tempoformule* ✓ ***OF:** Vervang <u>tempo O_2</u> (1,05 x 10^{-3}) <u>en $n(O_2)$</u> in tempoformule* ***OF:** Vervang tempo O_2 (0,0336 g·s^{-1}) in tempoformule* *e) Finale korrekte antwoord: 26,67 (s)* ✓ *Gebied: 26,67 tot 28,57 (s)*
<u>OPTION 1/*OPSIE 1*</u> $n(O_2) = \frac{m}{M}$ $= \frac{0,9 ✓(a)}{32 ✓(b)}$ $= 0,028$ mol (0,0281) $n(H_2O_2) = 2n(O_2)$ $= 2(0,028)$ ✓**(c)** $= 0,056$ rate/*tempo* $= \frac{\Delta n}{\Delta t}$ $2,1 \times 10^{-3} = \frac{0,056 - 0}{\Delta t}$ ✓**(d)** $\Delta t = 26,67$ (s) ✓**(e)**	**<u>OPTION 2/*OPSIE 2*</u>** 1 mol ……………….32 g ✓**(b)** x mol ……………….0,9 g ✓**(a)** x = 0,0275 mol $n(H_2O_2) = 2n(O_2)$ $= 2(0,0275)$ ✓**(c)** $= 0,056$ mol rate/*tempo* $= \frac{\Delta n}{\Delta t}$ $2,1 \times 10^{-3} = \frac{0,056 - 0}{\Delta t}$ ✓**(d)** $\Delta t = 26,67$ (s) ✓**(e)**
<u>OPTION 3/*OPSIE 3*</u> $n(O_2) = \frac{m}{M}$ $= \frac{0,9 ✓(a)}{32 ✓(b)}$ $= 0,028$ mol (0,0281) $Rate(O_2) = ½ \, rate(H_2O_2)$ $= ½ (2,1 \times 10^{-3})$ ✓**(c)** $= 1,05 \times 10^{-3}$ rate/*tempo* $= \frac{\Delta n}{\Delta t}$ $1,05 \times 10^{-3} = \frac{0,028}{\Delta t}$ ✓**(d)** $\Delta t = 26,67$ (s) ✓**(e)**	**<u>OPTION 4/*OPSIE 4*</u>** rate $H_2O_2 = 2,1 \times 10^{-3}$ mol·s^{-1} $Rate(O_2) = ½ \, rate(H_2O_2)$ $= ½ (2,1 \times 10^{-3})$ ✓**(c)** $= 1,05 \times 10^{-3}$ In one second: $n(O_2) = \frac{m}{M}$ $1,05 \times 10^{-3} = \frac{m}{32}$ ✓**(b)** $m(O_2) = 0,0336$ g rate = 0,0336 g·s^{-1} rate $= \frac{\Delta m}{\Delta t}$ $0,0336 = \frac{0,9 - 0}{\Delta t}$ ✓**(a)** ✓**(d)** $\Delta t = 26,79$ (s) ✓**(e)**

(5)
[19]

QUESTION 6/*VRAAG 6*

6.1

Marking criteria/*Nasienkriteria*
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will cancel/oppose the disturbance. ✓✓
Wanneer die ewewig in 'n geslote sisteem versteur word, sal die sisteem 'n nuwe ewewig instel deur die reaksie te bevoordeel wat die versteuring kanselleer/teenwerk. (2)

6.2

$$K_c = \frac{[CS_2]}{[S]^2} \checkmark$$

$$\checkmark\ 9,4 = \frac{0,5\ \checkmark}{[S]^2}$$

$[S] = 0,23\ mol\cdot dm^{-3}$ ✓

NOTE/*LET WEL*
- Wrong K_c expression/*Verkeerde K_c-uitdrukking*: Max./*Maks.* $^2/_4$
- No K_c expression but correct substitution/*Geen K_c-uitdrukking but korrekte vervanging: Max/Maks.* $^3/_4$

(4)

6.3 Increases/*Neem toe* ✓ (1)

6.4

- Increasing/doubling the volume will decrease the pressure. ✓
- The reaction that produces a greater number of moles/amount of gas (1 mole gas to 2 moles gas) is favoured. ✓
- Reverse reaction is favoured. ✓

- *Verhoging/verdubbeling van volume sal die druk verlaag.*
- *Die reaksie wat 'n groter aantal mol/hoeveelheid gas (1 mol gas na 2 mol gas) lewer word bevoordeel.*
- *Terugwaartse reaksie word bevoordeel.*

(3)

6.5 **POSITIVE MARKING FROM 6.2./*POSITIEWE NASIEN VAN VRAAG 6.2.***

CALCULATIONS USING CONCENTRATION
BEREKENINGE WAT KONSENTRASIE GEBRUIK

Marking criteria*:*

(a) Initial concentration is halved. ✓
(b) Change in [CS_2] and [S] **USING** ratio*: S* : CS_2 = 2 : 1 ✓
(c) Equilibrium [S] = initial [S] + change in [S] ✓
(d) Equilibrium [CS_2] = initial [CS_2] - change in [CS_2] ✓
(e) ***CORRECT*** final answer. ✓

Nasienkriteria:

(a) Aanvanklike konsentrasie is gehalveer.✓
*(b) Verandering in [CS_2] en [S] deur **GEBRUIK** van verhouding S : CS_2 = 2 : 1* ✓
(c) Ewewig [S] = aanvanklike [S] + verandering in [S] ✓
(d) Ewewig [CS_2] = aanvanklike [CS_2] - verandering in [CS_2] ✓
(e) ***KORREKTE** finale antwoord.* ✓

OPTION 1/*OPSIE 1*

	S	CS_2	
Initial concentration ($mol \cdot dm^{-3}$) *Aanvangskonsentrasie ($mol \cdot dm^{-3}$)*	0,23 x ½ = 0,115	0,5 x ½ = 0,25	✓(a)
Change in concentration ($mol \cdot dm^{-3}$) *Verandering in konsentrasie ($mol \cdot dm^{-3}$)*	2x	x	✓(b)
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)*	0,115 + 2x	0,25 - x	
	✓(c)	✓(d)	

$$K_c = \frac{[CS_2]}{[S]^2}$$

$$9,4 = \frac{0,25 - x}{(0,115 + 2x)^2} \checkmark\text{(e)}$$

Wrong K_c expression *Verkeerde K_c- uitdrukking*: Max./*Maks.* $^4/_5$

CALCULATIONS USING NUMBER OF MOLES
BEREKENINGE WAT GETAL MOL GEBRUIK

Marking criteria*:*
(a) n(initial) = c(initial) x 2. ✓
(b) Change in n(S) and n(CS_2) **USING** ratio*: S* : CS_2 = 2 : 1 ✓
(c) Equilibrium n(S) = initial n(S) + change in n(S) ✓
(d) Equilibrium n(CS_2) = initial n(CS_2) - change in n(CS_2) ✓
(e) **CORRECT** final answer. ✓

Nasienkriteria:
(a) n(aanvanklik) = c(aanvanklik) x 2 ✓
(b) Verandering in n(S) en n(CS_2) deur ***GEBRUIK*** *van verhouding: S : CS_2 = 2 : 1* ✓
(c) Ewewig n(S) = aanvanklike n(S) + verandering in n(S) ✓
(d) Ewewig n(CS_2) = aanvanklike n(CS_2) - verandering in n(CS_2) ✓
(e) ***KORREKTE*** *finale antwoord.* ✓

OPTION 2/*OPSIE 2*

	S	CS_2	
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	0,46	1	✓(a)
Change (mol) *Verandering (mol)*	8x	4x	✓(b)
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)* ✓(c)	0,46 + 8x	1 – 4x	✓(d)
Equilibrium concentration (mol·dm^{-3}) *Ewewigskonsentrasie (mol·dm^{-3})*	$\frac{0,46 + 8x}{4}$	$\frac{1 - 4x}{4}$	

$$K_c = \frac{[CS_2]}{[S]^2}$$

$$9,4 = \frac{\frac{1 - 4x}{4}}{\left(\frac{0,46 + 8x}{4}\right)^2} \checkmark\text{(e)}$$

Wrong K_c expression
Verkeerde K_c-uitdrukking: Max./*Maks.* $^4/_5$

(5)

6.6

6.6.1 (Chemical) equilibrium / Rate of the forward and reverse reactions are equal. / Concentrations of reactants and products are constant. ✓
(Chemiese) ewewig / Tempo van voorwaartse en terugwaartse reaksie dieselfde./Konsentrasies van reaktante en produkte is konstant. (1)

6.6.2 Increase in the amount/concentration of S/reactant **OR** S was added. ✓
Toename in die hoeveelheid/konsentrasie S/reaktans ***OF*** *S is bygevoeg.* (1)

6.6.3 Decrease in temperature/*Verlaging in temperatuur* ✓ (1)

6.6.4
- The rates of the forward and reverse reactions decrease. ✓
- The reverse reaction is favoured / faster than the forward reaction.
  OR
  The forward reaction decreases more. ✓
- A decrease in temperature favours the exothermic reaction. ✓

- *Die voorwaartse en terugwaartse reaksietempo neem af.*
- *Die terugwaartse reaksie word bevoordeel/is vinniger as die voorwaartse reaksie.*
  OF
  Die voorwaartse reaksie neem meer af.
- *'n Verlaging in die temperatuur bevoordeel die eksotermiese reaksie.* (3)

[21]

QUESTION 7/*VRAAG 7*

7.1

7.1.1 (An acid is a) proton donor/H^+ (ion) donor. ✓✓ **(2 or 0)**
('n Suur is 'n) protonskenker/H^+(-ioon) skenker. ***(2 of 0)*** (2)

7.1.2 (Weak acids) ionise/dissociate incompletely/partially (in water)/have a low K_a value. ✓
(Swak sure) ioniseer/dissosieer onvolledig/gedeeltlik (in water)/het 'n lae K_a-waarde. (1)

7.1.3 H_2O ✓ and CH_3COO^- ✓ (2)

7.2

7.2.1

n(NaOH) = cV ✓

n = $\underline{(0{,}167)(0{,}300)}$ ✓

∴ n(NaOH) = 0,05 mol ✓ (5×10^{-2} mol) (3)

7.2.2

Marking criteria:	***Nasienkriteria:***
a) Any formula: $pH = -\log[H_3O^+]$ / $pH = -\log[H^+]$ / $pOH = -\log[OH^-]$ / $[H_3O^+][OH^-] = 10^{-14}$ / $pH + pOH = 14$ ✓ b) Substitute 11,4 in $pH = -\log[H_3O^+]$/ $pH + pOH = 14$ ✓ c) Substitute calculated $[H_3O^+]$ in $[H_3O^+][OH^-]$ / 2,6 in $pOH = -\log[OH^-]$ ✓ d) Final answer: $2{,}51 \times 10^{-3}$ mol·dm^{-3} ✓ (0,003 mol·dm^{-3})	*a)* Enige formule: $pH = -\log[H_3O^+]$ / $pH = -\log[H^+]$ / $pOH = -\log[OH^-]$ / $[H_3O^+][OH^-] = 10^{-14}$ / $pH + pOH = 14$ ✓ *b) Vervang* 11,4 in $pH = -\log[H_3O^+]$/ $pH + pOH = 14$ ✓ *c) Vervang berekende* $[H_3O^+]$ in $[H_3O^+][OH^-]$ / 2,6 in $pOH = -\log[OH^-]$ ✓ *d) Finale antwoord:* $2{,}51 \times 10^{-3}$ mol·dm^{-3} ✓ (0,003 mol·dm^{-3})

OPTION 1/*OPSIE 1*

$pH = -\log[H_3O^+]$

$11{,}4$ ✓**(b)** $= -\log[H_3O^+]$ **OR/*OF*** $[H_3O^+] = 10^{-11,4}$

$[H_3O^+] = 3{,}98 \times 10^{-12}$

$[H_3O^+][OH^-] = 10^{-14}$

Any one/*Enige een* ✓**(a)**

✓**(c)**

$(3{,}98 \times 10^{-12})[OH^-] = 1 \times 10^{-14}$

$[OH^-] = 2{,}51 \times 10^{-3}$ mol·dm^{-3} ✓**(d)** (0,003)

OPTION 2/*OPSIE 2*

$pH + pOH = 14$

$\underline{11{,}4 + pOH = 14}$ ✓**(b)**

$pOH = 2{,}6$

Any one/*Enige een* ✓**(a)**

$pOH = -\log[OH^-]$ ✓

$2{,}6$ ✓**(c)** $= -\log[OH^-]$

$[OH^-] = 2{,}51 \times 10^{-3}$ mol·dm^{-3} ✓**(d)** (0,003) (4)

7.2.3 **POSITIVE MARKING FROM QUESTION 7.2.1. AND 7.2.2.**
POSITIEWE NASIEN VANAF VRAAG 7.2.1. EN 7.2.2.

Marking criteria*:*

a) Substitute [NaOH] = 0,00251 mol·dm^{-3} (answer from Q7.2.2) and 0,8 in $c = \frac{n}{V}$ ✓
b) Subtract: $n(NaOH)_{initial}$ (from Q7.2.1) – $n(NaOH)_{mixture}$ ✓✓
c) Use of ratio: $n(OH^-) = n(CH_3COOH)$ ✓
d) Substitute 0,5 and $\Delta n(CH_3COOH)$[calculated by subtraction] into $c = \frac{n}{V}$ ✓
e) Final correct answer: 0,096 mol·dm^{-3} ✓
Range: 0,095 to 0,1 mol·dm^{-3}

Nasienkriteria:

a) *Vervang [NaOH] = 0,00251 mol·dm^{-3} (antwoord van Q7.2.2) en 0,8 in $c = \frac{n}{V}$* ✓
b) *Trek af: $n(NaOH)_{aanvanklik}$ (vanaf Q7.2.1) – $n(NaOH)_{mengsel}$* ✓✓
c) *Gebruik verhouding: $n(OH^-) = n(CH_3COOH)$* ✓
d) *Vervang 0,5 en $\Delta n(CH_3COOH)$ [bereken deur aftrekking] in $c = \frac{n}{V}$* ✓
e) *Finale korrekte antwoord: 0,096 mol·dm^{-3}* ✓
Gebied: 0,095 tot 0,1 mol·dm^{-3}

$n(NaOH)_{mixture} = cV$
$= 0{,}00251 \times 0{,}8$ ✓**(a)**
$= 0{,}002$ mol (0,0024)

$n(NaOH)_{reacted} = 0{,}05 - 0{,}002$ ✓✓**(b)**
$= 0{,}048$ mol (0,0476)

$n(NaOH)_{reacted} = n(CH_3COOH)_{used}$
$= 0{,}048$ mol ✓**(c)**

$[CH_3COOH] = \frac{n}{V}$
$= \frac{0{,}048}{0{,}5}$ ✓**(d)**
$= 0{,}096$ mol·dm^{-3} ✓**(e)**
(0,0952)

NOTE/*LET WEL*
IF/*INDIEN:*

- $\frac{c_aV_a}{c_bV_b} = \frac{1}{1}$ Max./*Maks.* $^1/_6$
- Answer from Q7.2.1 substituted in $c = \frac{n}{V}$ to obtain an answer of 0,01 mol·dm^{-3}./ *Antwoord van Q7.2.1 vervang in $c = \frac{n}{V}$ om 0,01 mol·dm^{-3} as antwoord te kry.* Max./*Maks.* $^1/_6$

(6)
[18]

QUESTION 8/*VRAAG 8*

8.1

8.1.1 Zn/zinc/*sink* ✓ (1)

8.1.2 MnO_4^- is a stronger oxidising agent ✓ than Zn^{2+}/Zn(II) ions ✓ and will oxidise Zn ✓ (to Zn^{2+}/Zn(II) ions).

MnO_4^- is 'n sterker oksideermiddel as Zn^{2+}/Zn(II)-ione en sal Zn oksideer (na Zn^{2+}/Zn(II)-ione).

OR/*OF*

Zn^{2+}/Zn(II) ion is a weaker oxidising agent ✓ than MnO_4^- ✓ and therefore MnO_4^- will be reduced ✓ (to Mn^{2+}/Mn(II) ions).

Zn^{2+}/Zn(II) ione is 'n swakker oksideermiddel as MnO_4^- en dus word MnO_4^- gereduseer (to Mn^{2+}/Mn(II)-ione). (3)

8.2

8.2.1 Provides path for movement of ions. / Completes the circuit. / Ensures electrical neutrality in the cell. / Restore charge balance. ✓

Verskaf pad vir beweging van ione. / Voltooi die stroombaan. / Verseker elektriese neutraliteit in die sel. / Herstel balans van lading. (1)

8.2.2 Mn to/*na* Ni ✓✓ (2)

8.2.3

OPTION 1/*OPTION 1* $E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ ✓ $= -0{,}27$ ✓ $- (-1{,}18)$ ✓ $= 0{,}91$ V ✓	**NOTE/*LET WEL*** • Accept any other correct formula from the data sheet. /*Aanvaar enige ander korrekte formule vanaf gegewensblad.* • Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik, bv. $E°_{sel} = E°_{OM} - E°_{RM}$ gevolg deur korrekte vervangings* $^3/_4$
OPTION 2/*OPSIE 2* ✓ $Ni^{2+} + 2e^- \rightarrow Ni$ E = -0,27 ✓ $Mn \rightarrow Mn^{2+} + 2e^-$ E = 1,18 ✓ $Ni^{2+} + Mn \rightarrow Mn^{2+} + Ni$ E = 0,91 V ✓	

(4)

8.2.4 $Ni^{2+} + Mn$ ✓ $\rightarrow$ $Mn^{2+} + Ni$ ✓ Bal. ✓

Marking criteria/*Nasienkriteria:*		
• Reactants ✓ *Reaktanse* ✓	Products ✓ *Produkte* ✓	Balancing ✓ *Balansering* ✓
• Ignore/*Ignoreer* ⇌ and phases/*en fases*		
• Marking rule 6.3.10/*Nasienreël 6.3.10*		

(3)

8.2.5 Increase/*Toeneem* ✓ (1)

[15]

QUESTION 9/*VRAAG 9*

9.1 **ANY ONE*:***

- The chemical process in which <u>electrical energy is converted to chemical energy</u>. ✓✓ **(2 or 0)**
- The use of <u>electrical energy to produce a chemical change</u>.
- The process during which an <u>electric current passes through a solution / molten ionic</u> compound.

***ENIGE EEN*:**

- *Die chemiese proses waarin <u>elektriese energie omgeskakel word na chemiese energie.</u>* ***(2 of 0)***
- *Die gebruik van <u>elektriese energie om 'n chemiese verandering te veroorsaak</u>.*
- *Die proses waar 'n <u>elektriese stroom deur 'n oplossing / gesmelte ioniese verbinding beweeg.</u>* (2)

9.2.1 $Cr^{3+}(aq) + 3e^- \rightarrow Cr$ ✓✓

<u>Marking criteria/*Nasienkriteria:*</u>

- $Cr \leftarrow Cr^{3+}(aq) + 3e^-$ $(\frac{2}{2})$

  $Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr$ $(\frac{1}{2})$

  $Cr \rightleftharpoons Cr^{3+}(aq) + 3e^-$ $(\frac{0}{2})$

  $Cr^{3+}(aq) + 3e^- \leftarrow Cr$ $(\frac{0}{2})$
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (+) omitted on Cr^{3+}/*Indien lading (+) weggelaat op* Cr^{3+}:
  Example/*Voorbeeld:* $Cr^3(aq) + 3e^- \rightarrow Cr$ Max./*Maks:* $\frac{1}{2}$

(2)

9.2.2 $q = I\Delta t$ ✓
$= \underline{(2,5)(10 \times 60 \times 60)}$ ✓
$= 9 \times 10^4$ C ✓ (90 000 C) (3)

9.2.3 **POSITIVE MARKING FROM QUESTION 9.2.2.**
POSITIEWE NASIEN VANAF VRAAG 9.2.2.

Marking criteria:	***Nasienkriteria:***
a) Substitute $1,6 \times 10^{-19}$ C in $n = \frac{Q}{e}$ ✓ b) N(Cr) = n(electrons) divide by 3 ✓ c) n(Cr) = N(Cr) divided by N_A ✓ d) Substitution of 52 into $n = \frac{m}{M}$ ✓ e) m(Cr) $\underline{+ 2,2}$ ✓ f) Final answer*:* 18,32 (g) ✓ Range: *18,32 to 18,40* (g)	a) *Vervang $1,6 \times 10^{-19}$ C in $n = \frac{Q}{e}$* ✓ b) *N(Cr) = n(elektrone) gedeel deur 3* ✓ c) *n(Cr) = N(Cr) gedeel deur N_A* ✓ d) *Vervang 52 in $n = \frac{m}{M}$* ✓ e) *m(Cr) $\underline{+ 2,2}$* ✓ f) *Finale antwoord: 18,32 (g)* ✓ *Gebied: 18,32 tot 18,40 (g)*
OPTION 1/*OPSIE 1* $n = \frac{Q}{e} / \frac{Q}{q_e}$ $= \frac{9 \times 10^4}{1,6 \times 10^{-19}}$ ✓**(a)** $= 5,63 \times 10^{23}$ electrons N(Cr atoms) $= \frac{5,63 \times 10^{23}}{3}$ ✓**(b)** $= 1,88 \times 10^{23}$ $n(Cr) = \frac{N}{N_A}$ $= \frac{1,88 \times 10^{23}}{6,02 \times 10^{23}}$ ✓**(c)** = 0,31 mol $n(Cr) = \frac{m}{M}$ m(Cr) = 0,31 x 52 ✓**(d)** = 16,12 g m(X) = 16,12 $\underline{+ 2,2}$ ✓**(e)** = 18,32 (g) ✓**(f)**	**OPTION 2/*OPSIE 2*** $n(Cr) = \frac{9 \times 10^4}{3 \times 96\,500}$ ✓✓**(a & c)** ✓**(b)** = 0,31 mol m(Cr) = 0,31 x 52 ✓**(d)** = 16,12 g m(X) = 16,12 $\underline{+ 2,2}$ ✓**(e)** = 18,32 (g) ✓**(f)**

(6)
[13]

TOTAL/*TOTAAL*: 150