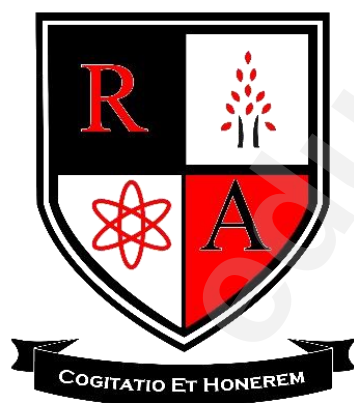




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REDWOOD ACADEMY



PHYSICAL SCIENCES 12

PAPER 2

SECTION REVISION

BY NAEEM MOHAMED

MODULE 0: IMPORTANT INFORMATION

A. CONTENTS

Module	Name	Page
0	Important Information	1
1	Organic Chemistry	13
2	Rates of Reactions	25
3	Chemical Equilibrium	29
4	Acids and Bases	33
5	Electrochemical Cells	36

B. GENERAL ADVICE FOR 2021 MATRICULANTS

2021 – The year you write your final school examinations! Those who excel during this vital year will open up your learning and earning opportunities. Use your final year of study well. Attend all your classes in school and any extra tuition offered to you, both privately and by your school. Eat healthy, play sports and avoid any activity that undermines your studying and preparation. At the same time, remain calm as stressing too much can work against you.

Keep up to date with the latest matric news in newspapers and on the internet. Work through previous year's examination papers, exemplar papers as well as departmental papers and any sample papers prepared for you by your tutors and teachers. Ask your tutors / teachers to work through the questions, answers and examination technique with you.

Do everything you possibly can to convert twelve years of school into a National Senior Certificate with excellent marks, while making the most of probably the most enjoyable year of your schooling life.

Good luck!



Naeem Mohamed

C. COURSE STRUCTURE

The physical science course accompanying this booklet is focused on preparing you for the trial and final examinations. Each module is based on a specific section in the paper and includes important aspects in the subject guideline as well as tips from experts and suggested time and mark allocations. Theory and questions from national, IEB and exemplar papers are then worked through during the course.



C. MATRIC HELP ON THE INTERNET

Visit the following websites regularly to download past papers, media publications, workbooks and other valuable physics resources:

- **MIND THE GAP STUDYGUIDES:**
[https://www.education.gov.za/Curriculum/LearningandTeachingSupportMaterials\(LTSM\)/MindtheGapStudyGuides.asp](https://www.education.gov.za/Curriculum/LearningandTeachingSupportMaterials(LTSM)/MindtheGapStudyGuides.asp)
- **NSC PAST PAPERS:** [https://www.education.gov.za/Curriculum/NationalSeniorCertificate\(NSC\)Examinations.aspx](https://www.education.gov.za/Curriculum/NationalSeniorCertificate(NSC)Examinations.aspx)
- **EXAM RESOURCES:**
<https://www.ecexams.co.za/>

D. FORMAT OF PHYSICS AND CHEMISTRY PAPER

Duration: 3 hours	Marks
SECTION A: Multiple-choice questions	20
SECTION B: Longer questions assessing all themes	130
Total	150

E. MARK DISTRIBUTION FOR PHYSICAL SCIENCE CAPS GRADE 12

Paper 1:

Knowledge Area	Theme	Marks
Mechanics	Momentum, Impulse and change in momentum	±42%
	Vertical projectile motion	
	Work, power and energy	
	Newton's Laws Grade 11	
Waves, sound and light	Doppler effect	±11%
Electricity and magnetism	Electrostatics Grade 11	±37%
	Electric circuits (including Grade 11)	
	Electrodynamics	
Matter and materials	Optical phenomena and properties of materials	±10%

Paper 2:

Knowledge Area	Theme	Marks
Matter and materials	Organic Chemistry	±36%
Chemical Change	Rates of Reaction and Chemical Equilibrium	±62%
	Acids and Bases	
	Electrochemical Reactions	

G. PRIOR KNOWLEDGE REQUIRED FROM GRADES 10 AND 11

Physics from grade 11	Chemistry from grades 10 and 11
Newton's Laws (Newton 1, 2, 3 and Newton's Law of Universal Gravitation) and Application of Newton's Laws.	Representing chemical change (grade 10)
Electrostatics (Coulomb's Law and Electric field)	Intermolecular forces (grade 11)
Electric circuits (Ohm's Law, Power and Energy)	Stoichiometry (grade 11)
	Energy and Change (grade 11)



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

TABLE 2: FORMULAE/TABEL 2: FORMULES

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/of $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$
$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14} \text{ at/by } 298 \text{ K}$	
$E_{\text{cell}}^\theta = E_{\text{cathode}}^\theta - E_{\text{anode}}^\theta / E_{\text{sel}}^\theta = E_{\text{katode}}^\theta - E_{\text{anode}}^\theta$ or/of $E_{\text{cell}}^\theta = E_{\text{reduction}}^\theta - E_{\text{oxidation}}^\theta / E_{\text{sel}}^\theta = E_{\text{reduksie}}^\theta - E_{\text{oksidasie}}^\theta$ or/of $E_{\text{cell}}^\theta = E_{\text{oxidisingagent}}^\theta - E_{\text{reducingagent}}^\theta / E_{\text{sel}}^\theta = E_{\text{oksideermiddel}}^\theta - E_{\text{reduseermiddel}}^\theta$	

CHEMISTRY PAPER 2: PERIODIC TABLE

(011) 852-4744, 5 Capella Str., Lenasia

0

(011) 852-4744, 5 Capella Str., Lenasia									
GROUP NAMES BY COLOUR									
Non-metals									
Alkali Metals									
Alkal Earth Metals									
Transition Metals									
Other Metals									
Halogens									
Noble Gases									
Metalloids									
Transition Elements									
KEY									
Atomic Number									
Electronegativity									
Relative atomic Mass									
+2									
II									
+3									
III									
+4									
IV									
-3									
V									
-2									
VI									
-1									
VII									
He									
Helium									
4									
Ne									
Neon									
20									
Ar									
Argon									
40									
Kr									
Krypton									
84									
Xe									
Xenon									
131									
Rn									
Radon									
(222)									
At									
Astatine									
(209)									
Po									
Polonium									
(209)									
Bi									
Bismuth									
209									
Pb									
Lead									
207									
Tl									
Thallium									
204									
Hg									
Mercury									
200									
Au									
Gold									
197									
Pt									
Platinum									
195									
Ir									
Iridium									
192									
Rh									
Rhodium									
103									
Ru									
Ruthenium									
101									
Mo									
Molybdenum									
96									
Tc									
Technetium									
99									
Re									
Rhenium									
186									
W									
Tungsten									
184									
Ta									
Tantalum									
181									
Hf									
Hafnium									
178.5									
Zr									
Zirconium									
91									
Y									
Yttrium									
89									
La									
Lanthanum									
139									
Ac									
Actinium									
(227)									
Db									
Dubnium									
(261)									
Jl									
Joliotium									
(262)									
Rf									
Rutherfordium									
(261)									
Hn									
Hahnium									
(265)									
Mt									
Meitnerium									
(266)									
Fr									
Francium									
(223)									
Ra									
Radium									
(226)									
Mg									
Magnesium									
24.3									
Na									
Sodium									
23									
K									
Potassium									
39									
Sr									
Strontium									
88									
Rb									
Rubidium									
85.5									
Cs									
Caesium									
133									
Ba									
Barium									
137									
Li									
Lithium									
7									
Be									
Beryllium									
9									
H									
Hydrogen									
1									



CHEMISTRY: TABLE 4B: STANDARD REDUCTION POTENTIALS



Increasing Oxidising Ability

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

Increasing Reducing Ability

Dark Green
Orange
Light Green
Blue
Yellow
Violet
Purple
Reddish-Brown
Brown





TERMS AND DEFINITIONS

MATTER AND MATERIALS: ORGANIC MOLECULES	
Addition reaction	A reaction in which a double bond in the starting material is broken and elements are added to it.
Addition polymer	A polymer formed when monomers (usually containing a double bond) combine through an addition reaction.
Addition polymerisation	A reaction in which small molecules join to form very large molecules by adding on double bonds.
Alcohol	An organic compound in which H atoms in an alkane have been substituted with hydroxyl groups (-OH groups). General formula: $C_nH_{2n+1}OH$
Aldehydes	Organic compounds having the general structure $RCHO$ where $R = H$ or alkyl. General formula: $RCHO$ ($R = \text{alkyl group}$)
Alkane	An organic compound containing only C-H and C-C single bonds. General formula: C_nH_{2n+2}
Alkene	A compound of carbon and hydrogen that contains a carbon-carbon double bond. General formula: C_nH_{2n}
Alkyl group	A group formed by removing one H atom from an alkane.
Alkyne	A compound of carbon and hydrogen that contains a carbon-carbon triple bond.
Boiling point	The temperature at which the vapour pressure of a liquid equals atmospheric pressure.
Carbonyl group	Functional group of ketones ($>C=O$)
Carboxyl group	Functional group of carboxylic acids ($-COOH$)
Carboxylic acid	An organic compound containing a carboxyl group ($-COOH$ group). General formula: $C_nH_{2n+1}COOH$ (or $RCOOH$)
Chain isomers	Compounds with the same molecular formula, but different types of chains.
Condensation polymer	A polymer formed by two monomers with different functional groups that are linked together in a condensation reaction in which a small molecule, usually water, is lost.
Condensation polymerisation	Molecules of two monomers with different functional groups undergo condensation reactions with the loss of small molecules, usually water
Condensed structural formula	A formula that shows the way in which atoms are bonded together in the molecule, but DOES NOT SHOW ALL bond lines.
Cracking	The chemical process in which longer chain hydrocarbon molecules are broken down to shorter more useful molecules.
Dehydration	Elimination of water from a compound usually such as an alcohol.
Dehydrohalogenation	The elimination of hydrogen and a halogen from a haloalkane.
Dipole-dipole force	Intermolecular forces found between polar molecules i.e. molecules in which there is an uneven distribution of charge so that the molecule has a positive and a negative side.
Elimination reaction	A reaction in which elements of the starting material are "lost" and a double bond is formed.
Esterification	The preparation of an ester from the reaction of a carboxylic acid with an alcohol.
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.
Functional isomers	Compounds with the same molecular formula, but different functional groups.
Haloalkane (Alkyl halide)	An organic compound in which one or more H atoms in an alkane have been replaced with halogen atoms. General formula: $C_nH_{2n+1}X$ ($X = F, Cl, Br \text{ or } I$)



Halogenation	The reaction of a halogen (Br_2 , Cl_2) with a compound.
Homologous series	A series of organic compounds that can be described by the same general formula. OR A series of organic compounds in which one member differs from the next with a CH_2 group.
Hydration	The addition of water to a compound.
Hydrocarbon	Organic compounds that consist of hydrogen and carbon only.
Hydrogenation	The addition of hydrogen to an alkene
Hydrogen bond	A strong intermolecular force found between molecules in which an H atom is covalently bonded to wither an N, O or F atom.
Hydrohalogenation	The addition of a hydrogen halide to an alkene.
Hydrolysis	The reaction of a compound with water.
Intermolecular force	Forces between molecules that determine physical properties of compounds.
IUPAC name	A chemical nomenclature (set of rules) created and developed by the International Union of Pure and Applied Chemistry (IUPAC) to generate systematic names for chemical compounds.
London force	A weak intermolecular force between non-polar molecules.
Macromolecule	A molecule that consists of a large number of atoms.
Melting point	The temperature at which the solid and liquid phases of a substance are at equilibrium.
Molecular formula	A chemical formula that indicates the type of atoms and the correct number of each in a molecule, e.g. CH_4 .
Monomer	Small organic molecules that can be covalently bonded to each other in a repeating pattern.
Organic chemistry	Chemistry of carbon compounds.
Polymer	A large molecule composed of smaller monomer units covalently bonded to each other in a repeating pattern
Polymerisation	A chemical reaction in which monomer molecules join to form a polymer
Positional isomer	Compounds with the same molecular formula, but different positions of the side chain, substituents or functional groups on the parent chain.
Primary alcohol	One C atom is bonded to the C atom bonded to hydroxyl group. Example: $\begin{array}{c} \text{H} & & \text{H} \\ & & \\ \text{H}-\text{C} & - & \text{C}-\text{O}-\text{H} \\ & & \\ \text{H} & & \text{H} \end{array}$
Primary haloalkane	One C atom is bonded to the C atom bonded to the halogen. Example: $\begin{array}{c} \text{H} & & \text{H} \\ & & \\ \text{H}-\text{C} & - & \text{C}-\text{Br} \\ & & \\ \text{H} & & \text{H} \end{array}$
Saturated compounds	Compounds in which there are no multiple bonds between C atoms in their hydrocarbon chains. OR Compounds with only single bonds between C atoms in their hydrocarbon chains.



Secondary alcohol	Two C atoms bonded to the C atom that is bonded to hydroxyl group. Example: $ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H}-\text{C}-\text{H} \\ \quad \\ \quad \text{H} \end{array} $
Secondary haloalkane	Two C atoms bonded to the C atom bonded to the halogen. Example: $ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{Br} \\ \quad \\ \text{H} \quad \text{H}-\text{C}-\text{H} \\ \quad \\ \quad \text{H} \end{array} $
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.
Structural isomer	Organic molecules with the same molecular formula, but different structural formulae.
Substituent (branch)	A group or branch attached to the longest continuous chain of C atoms in an organic compound.
Substitution reaction	A reaction in which an atom or a group of atoms in a molecule is replaced by another atom or group of atoms.
Tertiary alcohol	Three C atoms bonded to carbon that is bonded to hydroxyl group. Example: $ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H}-\text{C}-\text{H} \\ \quad \\ \quad \text{H} \end{array} $
Tertiary haloalkane	Three C atoms bonded to the C atom bonded to the halogen. Example: $ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{C}-\text{Br} \\ \quad \\ \text{H} \quad \text{H}-\text{C}-\text{H} \\ \quad \\ \quad \text{H} \end{array} $
Unsaturated compounds	Compounds in which there are multiple bonds (double or triple bonds) between C atoms in their hydrocarbon chains.
Van der Waals forces	A combined name used for the different types of intermolecular forces.
Vapour pressure	The pressure exerted by a vapour at equilibrium with its liquid in a closed system.



CHEMICAL CHANGE: QUANTITATIVE ASPECTS OF CHEMICAL CHANGE	
Mole	One mole of a substance is the amount of substance having the same number of particles as there are atoms in 12 g carbon-12.
Molar gas volume at STP	The volume of one mole of a gas. (1 mole of any gas occupies 22,4 dm ³ at 0 °C (273 K) and 1 atmosphere (101,3 kPa).
Molar mass	The mass of one mole of a substance. Symbol: M Unit: g·mol ⁻¹
Avogadro's Law	Under the same conditions of temperature and pressure, the same number of moles of all gases occupy the same volume.
Concentration	The amount of solute per litre/cubic decimeter of solution. In symbols: $c = \frac{n}{V}$ Unit: mol·dm ⁻³
Empirical formula	The simplest positive integer ratio of atoms present in a compound.
Percentage yield	Yield is the amount of product obtained from a reaction. percentage yield = $\frac{\text{actual mass obtained}}{\text{calculated mass}} \times 100$
Percentage purity	percentage purity = $\frac{\text{mass of pure chemical}}{\text{total mass of sample}} \times 100$
Percentage composition	The percentage of each of the components in a substance. Percentage of component = $\frac{\text{mass contributed by component}}{\text{mass of all components}} \times 100$
Limiting reagents	The substance that is totally consumed when the chemical reaction is complete.

CHEMICAL CHANGE: ENERGY AND CHANGE	
Heat of reaction (ΔH)	The energy absorbed or released in a chemical reaction.
Exothermic reactions	Reactions that release energy. (ΔH < 0)
Endothermic reactions	Reactions that absorb energy. (ΔH > 0)
Activation energy	The minimum energy needed for a reaction to take place.
Activated complex	The unstable transition state from reactants to products.

CHEMICAL CHANGE: RATE OF REACTION	
Reaction rate	The change in concentration of reactants or products per unit time. Rate = $\frac{\Delta c}{\Delta t}$ Unit: mol·dm ⁻³ ·s ⁻¹
Collision theory	a model that explains reaction rate as the result of particles colliding with a certain minimum energy.
Catalyst	A substance that increases the rate of a chemical reaction without itself undergoing a permanent change. (A catalyst increases the rate of a reaction by providing an alternative path of lower activation energy. It therefore decreases the net/total activation energy.)
Factors that affect reaction rate	Nature of reacting substances, surface area, concentration (pressure for gases), temperature and the presence of a catalyst.



CHEMICAL CHANGE: CHEMICAL EQUILIBRIUM	
Open system	A system which continuously interacts with the environment – it exchanges matter and energy with its environment.
Closed system	A system that only exchanges energy with its surroundings, but it does not exchange matter with its surroundings.
Reversible reaction	A reaction is reversible when products can be converted back to reactants.
Chemical equilibrium	Dynamic equilibrium when the rate of the forward reaction equals the rate of the reverse reaction.
Factors that influence the equilibrium position	Pressure (gases only), concentration and temperature.
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.

CHEMICAL CHANGE: ACIDS AND BASES	
Acid-base indicator	A dye used to distinguish between acidic and basic solutions by means of the colour changes it undergoes in these solutions.
Amphiprotic substance/ampholyte	A substance that can act as either an acid or a base.
Arrhenius theory	An acid is a substance that produces hydrogen ions (H^+)/ hydronium ions (H_3O^+) when it dissolves in water. A base is a substance that produces hydroxide ions (OH^-) when it dissolves in water.
Auto-ionisation of water	A reaction in which water reacts with itself to form ions (hydronium ions and hydroxide ions).
Concentrated acids/bases	Contain a large amount (number of moles) of acid/base in proportion to the volume of water.
Conjugate acid-base pair	A pair of compounds or ions that differ by the presence of one H^+ ion. Example: CO_3^{2-} and HCO_3^- OR HCl and Cl^-
Conjugate acid and base	A conjugate acid has one H^+ ion more than its conjugate base. Example: HCO_3^- is the conjugate acid of base CO_3^{2-} . CO_3^{2-} is the conjugate base of acid HCO_3^- .
Dilute acids/bases	Contain a small amount (number of moles) of acid/base in proportion to the volume of water.
Diprotic acid	An acid that can donate two protons. Example: H_2SO_4
Dissociation	The process in which ionic compounds split into ions.
Endpoint	The point in a titration where the indicator changes colour.
Equivalence point	The point in a reaction where equivalent amounts of acid and base have reacted completely.
Hydrolysis	The reaction of a salt with water. OR The reaction of an ion with water to produce the conjugate acid and a hydroxide ion or the conjugate base and a hydronium ion.
Ionisation	The process in which ions are formed during a chemical reaction.
Ion product of water	The product of the ions formed during auto-ionisation of water i.e. $[H_3O^+][OH^-]$ at $25^\circ C$.
Ionisation constant of water (K_w)	The equilibrium value of the ion product $[H_3O^+][OH^-]$ at $25^\circ C$.
K_a value	Ionisation constant for an acid.
K_b value	Dissociation or ionisation constant for a base.



Lowry-Brønsted theory	An acid is a proton (H^+ ion) donor. A base is a proton (H^+ ion) acceptor.
Monoprotic acid	An acid that can donate one proton. Example: HCl
Neutralisation	The reaction of an acid with a base to form a salt (ionic compound) and water.
pH	The negative of the logarithm of the hydronium ion concentration in $mol \cdot dm^{-3}$. In symbols: $pH = -\log[H_3O^+]$ Unit: None
pH scale	A scale from 0 – 14 used as a measure of the acidity and basicity of solutions where $pH = 7$ is neutral, $pH > 7$ is basic and $pH < 7$ is acidic.
Salt	The ionic compound that is the product of a neutralisation reaction.
Standard solution	A solution of precisely known concentration.
Strong bases	Dissociate completely in water to form a high concentration of OH^- ions. Examples: sodium hydroxide ($NaOH$) and potassium hydroxide (KOH)
Strong acids	Ionise completely in water to form a high concentration of H_3O^+ ions. Examples: hydrochloric acid (HCl), sulphuric acid (H_2SO_4) and nitric acid (HNO_3)
Titration	The procedure for determining the amount of acid (or base) in a solution by determining the volume of base (or acid) of known concentration that will completely react with it.
Weak acids	Ionise incompletely in water to form a low concentration of H_3O^+ ions. Examples: ethanoic acid (CH_3COOH) and oxalic acid ($(COOH)_2$)
Weak bases	Dissociate/ionise incompletely in water to form a low concentration of OH^- ions. Examples: ammonia (NH_3), sodium hydrogen carbonate ($NaHCO_3$), sodium carbonate (Na_2CO_3), potassium carbonate (K_2CO_3), calcium carbonate ($CaCO_3$)

CHEMICAL CHANGE: ELECTROCHEMICAL REACTIONS

Galvanic cell	A cell in which chemical energy is converted into electrical energy. A galvanic (voltaic) cell has self-sustaining electrode reactions.
Electrolytic cell	A cell in which electrical energy is converted into chemical energy.
Redox reaction	A reaction in which an electron transfer takes place.
Oxidation	A loss of electrons./An increase in oxidation number.
Reduction	A gain of electrons./A decrease in oxidation number.
Oxidising agent	A substance that is reduced/gains electrons/whose oxidation number decreases.
Reducing agent	A substance that is oxidised/loses electrons/whose oxidation number increases.
Anode	The electrode where oxidation takes place.
Cathode	The electrode where reduction takes place.
Electrolyte	A solution that conducts electricity through the movement of ions.
Electrolysis	The chemical process in which electrical energy is converted to chemical energy OR the use of electrical energy to produce a chemical change.
Salt bridge	The connection between two half-cells needed to ensure electrical neutrality in the cell. OR A component used in a galvanic cell to complete the circuit.
Electrodes	An electrical conductor used in a galvanic cell to make contact with a non-metallic part of the circuit e.g. the electrolyte.



Cell notation	A short way to represent a galvanic cell. When writing cell notation, the following convention should be used: - The $\text{H}_2 \text{H}^+$ 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: $\text{Pt} \text{Cl}^-(\text{aq}) \text{Cl}_2(\text{g}) \text{F}_2(\text{g}) \text{F}^-(\text{aq}) \text{Pt}$
Overall cell reaction	The reaction obtained by combining two half-reactions.
Positive value of the standard emf	The reaction is spontaneous under standard conditions.
Standard conditions for a galvanic cell	Temperature: $25^\circ\text{C} / 298\text{ K}$ Concentration: $1\text{ mol}\cdot\text{dm}^{-3}$ Pressure (gases only): $101,3\text{ kPa} / 1\text{ atmosphere}$
Standard hydrogen electrode	The reference electrode used to compile the Table of Standard Reduction Potentials. The hydrogen half-cell was given a standard reduction potential of 0 V. Half-cell notation: $\text{Pt} \text{H}_2(\text{g}) \text{H}^+(\text{aq})$ Half-reaction: $2\text{H}^+ + 2\text{e}^- = \text{H}_2$
Electroplating	The covering of an object with a metal by making it the cathode in an electrolytic cell.
Bauxite	The ore from which aluminium is recovered.
Cryolite	An aluminium compound in which aluminium oxide is dissolved to reduce the cost of the extraction of aluminium. Cryolite has a lower melting point than aluminium oxide.

CHEMICAL SYSTEMS: FERTILISERS

Non-mineral nutrients in plants	C, H and O Obtained from the atmosphere (CO_2) and rain (H_2O)
Primary nutrients for plants	Nitrogen (N), phosphorous (P) and potassium (K) Function: N: essential for plant growth, green leaves P: development of roots, stems and seeds K: resistance against diseases and production of flowers/fruits
NPK fertilisers	Fertilisers containing the three primary nutrients for plants. They contain ammonium nitrate (NH_4NO_3), ammonium phosphate $[(\text{NH}_4)_3\text{PO}_4]$ and potassium chloride (KCl).
N : P : K ratio	The percentage nitrogen, phosphorous and potassium in a fertiliser.
Fractional distillation of liquid air	Industrial preparation of nitrogen from air.
Steam reforming	Preparation of hydrogen from earth gas (methane) Reaction: $\text{CH}_4 + \text{H}_2\text{O} \rightarrow 3\text{H}_2 + \text{CO}$
Haber process	Industrial preparation of ammonia Reaction: $\text{N}_2 + 3\text{H}_2 = 2\text{NH}_3$ Iron catalyst



Ostwald process	Industrial preparation of nitric acid Reactions: Catalytic oxidation of ammonia; catalyst: Pt $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$ $2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$ $3\text{NO}_2 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_3 + \text{NO}$ OR $4\text{NO}_2 + 2\text{H}_2\text{O} + \text{O}_2 \rightarrow 4\text{HNO}_3$
Contact process	Industrial preparation of sulphuric acid Reactions: $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$ $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$ Contact catalyst: vanadium pentoxide (V_2O_5) $\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S}_2\text{O}_7$ ($\text{H}_2\text{S}_2\text{O}_7$: fuming sulphuric acid OR pyro sulphuric acid OR oleum) $\text{H}_2\text{S}_2\text{O}_7 + \text{H}_2\text{O} \rightarrow 2\text{H}_2\text{SO}_4$
Preparation of ammonium sulphate	ammonia + sulphuric acid $\rightarrow$ ammonium sulphate $2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4$
Preparation of ammonium nitrate	ammonia + nitric acid $\rightarrow$ ammonium nitrate $\text{NH}_3 + \text{HNO}_3 \rightarrow \text{NH}_4\text{NO}_3$
Eutrophication	The process by which an ecosystem, e.g. a river or dam, becomes enriched with inorganic plant nutrients, especially phosphorus and nitrogen, resulting in excessive plant growth. As plant growth becomes excessive, the amount of dead and decaying plant material increases rapidly.



MODULE 1: ORGANIC CHEMISTRY

1. ORGANIC MOLECULAR STRUCTURES

QUESTIONS – NOMENCLATURE

QUESTIONS SET 1

QUESTION 2 (Start on a new page.)

A few organic compounds (**A–E**) are represented in the table below.

A	$\text{CH}_3\text{—CHBr—CHBr—CH}_3$
B	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
C	pentanal
D	2-methylpentanoic acid
E	$\begin{array}{c} \text{CH}_3 - \text{CH} = \text{C} - \text{CH}_3 \\ \\ \text{CH}_3 \end{array}$

Write down the:

- 2.1 IUPAC name for compound **A** (2)
 - 2.2 GENERAL FORMULA of the homologous series to which compound **B** belongs (1)
 - 2.3 STRUCTURAL FORMULA of the functional group for compound **C** (1)
 - 2.4 STRUCTURAL FORMULA for compound **D** (2)
 - 2.5 STRUCTURAL FORMULA of a positional isomer for compound **E** (2)
- [8]



QUESTION 1

Consider the organic compounds represented by the letters A to F in the table below.

A	2,2,4-trimethylhexane	B	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$
C	$ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{Cl} & & \text{Br} & & \text{H} \\ & & & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & & & & \\ & \text{H} & & & & \text{H} & & \text{H} & & \text{H} \\ & & & & & & & & & & \text{H} \\ & & & & & & & & & & \\ & & & & & & & & & & \text{H} \end{array} $	D	$ \left[\begin{array}{cc} \text{H} & \text{H} \\ & \\ - \text{C} & - & \text{C} - \\ & \\ \text{H} & \text{H} \end{array} \right]_n $
E	$ \left[\begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{O} & & \text{H} & & \text{O} \\ & & & & & & & & & \\ - \text{O} & - \text{C} & - & \text{C} & - & \text{O} & - & \text{C} & - & \text{C} & - \\ & & & & & & & & & & \\ & \text{H} & & \text{H} & & & & \text{H} & & & \end{array} \right]_n $	F	Pentan-2-one

- 1.1 Write down the LETTER that represents the following:
- 1.1.1 An aldehyde (1)
- 1.1.2 A condensation polymer (1)
- 1.1.3 A compound which has a carbonyl group bonded to two carbon atoms as its functional group (1)
- 1.2 Write down the IUPAC name of:
- 1.2.1 Compound C (3)
- 1.2.2 The monomer of compound D (1)
- 1.3 Write down the structural formula of:
- 1.3.1 Compound A (2)
- 1.3.2 Compound F (2)
- 1.4 The table contains compounds which are functional isomers.
- 1.4.1 Define the term *functional isomer*. (2)
- 1.4.2 Write down the LETTERS that represent two compounds that are functional isomers. (1)

[14]



QUESTION 3

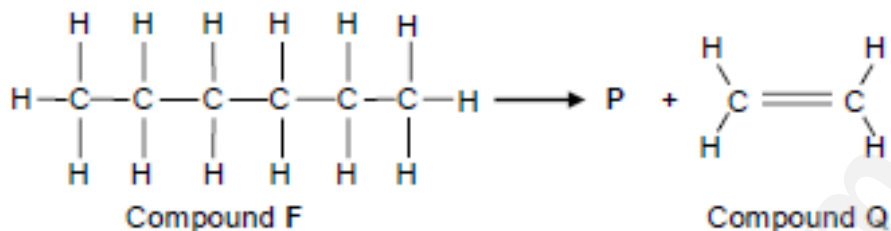
The letters A to F in the table below represent six organic compounds.

A	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $	B	$ \begin{array}{ccccccc} & & & & \text{H} & & \\ & & & & & & \\ & & & & \text{H}-\text{C}-\text{H} & & \\ & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & & \text{H} & \text{H} \\ & & & & & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & & & & & \\ \text{H} & & \text{H} & \text{Cl} & \text{H} & \text{H} & \text{H} \\ & & & & & & \\ & & \text{H}-\text{C}-\text{H} & & & & \\ & & & & & & \\ & & \text{H} & & & & \end{array} $
C	C_4H_8	D	$\text{CH}_3\text{CH}_2\text{COCH}_3$
E	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$	F	$ \begin{array}{ccccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \\ & & & & & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \end{array} $

Use the information in the table (where applicable) to answer the questions that follow.

- 3.1 Write down the LETTER that represents a compound that:
(A compound may be used more than once.)
- 3.1.1 Is a haloalkane (1)
- 3.1.2 Has a hydroxyl group as functional group (1)
- 3.1.3 Belongs to the same homologous series as ethanoic acid (1)
- 3.2 Write down the:
- 3.2.1 IUPAC name of compound B (3)
- 3.2.2 IUPAC name of compound E (2)
- 3.2.3 Structural formula of the functional group of compound D (1)
- 3.3 Compound C has CHAIN and POSITIONAL isomers.
- 3.3.1 Define the term *positional isomer*. (2)
- 3.3.2 Write down the IUPAC name of each of the TWO positional isomers of compound C. (4)
- 3.3.3 Write down the structural formula of a chain isomer of compound C. (2)

- 3.4 Compound F reacts at high pressure and high temperature to form compounds P and Q as given below.



Write down the:

- 3.4.1 Type of reaction that takes place (1)
 3.4.2 IUPAC name of compound Q (1)
 3.4.3 Molecular formula of compound P (1)

Compound Q is the monomer of a polymer used to make plastic bags.

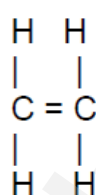
- 3.4.4 Write down the NAME and CONDENSED FORMULA of this polymer. (3)
 [23]

4. TYPES OF REACTIONS

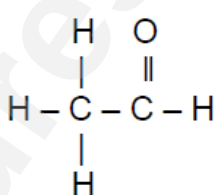
QUESTIONS – TYPES OF REACTIONS

QUESTIONS SET 1

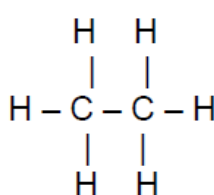
- 1.1 Which ONE of the following compounds will decolourise bromine water the fastest under normal conditions?



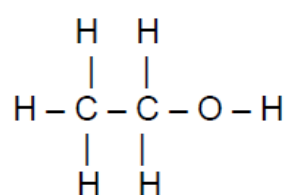
A



B



C



D

(2)

- 1.2 A renewable source of energy that can be produced by the fermentation of the sugar in sugarcane or corn is ...

- A ethane.
 B ethanol.
 C methanol.
 D methane.

(2)



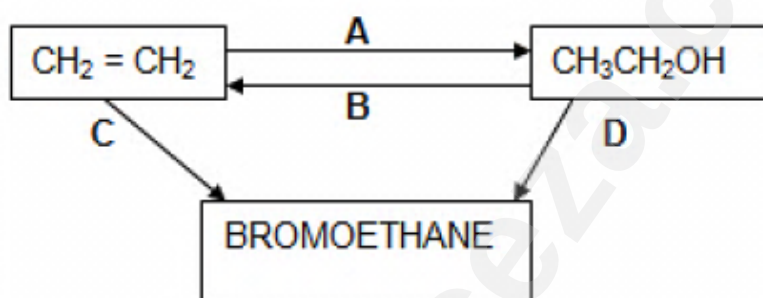
1.4 Which ONE of the following is a balanced equation for the combustion of octane?

- A $2\text{C}_8\text{H}_{18} + 25\text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O}$
B $\text{C}_8\text{H}_{18} + 16\text{O}_2 \rightarrow 8\text{CO}_2 + 9\text{H}_2\text{O}$
C $\text{C}_8\text{H}_{18} + 32\text{O}_2 \rightarrow 8\text{CO}_2 + 18\text{H}_2\text{O}$
D $2\text{C}_8\text{H}_{18} + 8\text{O}_2 \rightarrow 16\text{CO}_2 + 9\text{H}_2\text{O}$

(2)

QUESTION 3 (Start on a new page.)

The letters **A–D** in the flow diagram below represent some organic reactions that involve ethene.



3.1 Name the type of reaction (ADDITION, SUBSTITUTION or ELIMINATION) represented by:

3.1.1 **A** (1)

3.1.2 **B** (1)

3.1.3 **D** (1)

3.2 Apart from the alkene, another reactant and a catalyst are needed in Reaction **A**.

Write down the NAME of the: (1)

3.2.1 Other reactant

3.2.2 Catalyst which was added to the alkene (1)

3.3 Use STRUCTURAL FORMULAE to write down a balanced chemical equation for the reaction represented by **C**. (4)



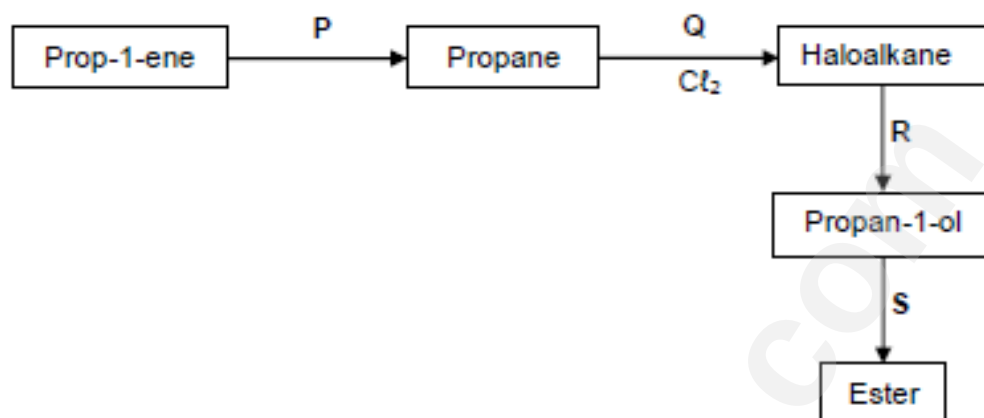
- 3.4 The ethanol produced in reaction **A** is made to react with a carboxylic acid in the presence of an acid catalyst. The compound formed is a STRAIGHT CHAIN ESTER which is a functional isomer of pentanoic acid.

Write down the:

- 3.4.1 IUPAC NAME of the carboxylic acid that reacted with the alcohol (2)
- 3.4.2 Name given to this type of reaction (1)
- 3.4.3 STRUCTURAL FORMULA of the ester formed (2)

QUESTION 1

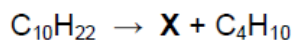
The flow diagram below shows the preparation of an ester using prop-1-ene as a starting reagent. P, Q, R and S represent different organic reactions.



- 1.1 Write down the type of reaction represented by:
- 1.1.1 Q (1)
- 1.1.2 R (1)
- 1.2 For reaction P write down the:
- 1.2.1 Type of addition reaction (1)
- 1.2.2 Balanced equation using structural formulae (3)
- 1.3 Write down the structural formula of the haloalkane formed in reaction Q. (2)
- 1.4 In reaction S propan-1-ol reacts with ethanoic acid to form the ester.
- For this reaction write down the:
- 1.4.1 Name of the reaction that takes place (1)
- 1.4.2 FORMULA or NAME of the catalyst needed (1)
- 1.4.3 Structural formula of the ester formed (2)
- 1.4.4 IUPAC name of the ester formed (2)
- 1.5 The propan-1-ol formed in reaction R can be converted to prop-1-ene. Write down the FORMULA or NAME of the inorganic reagent needed. (1)
- [15]

QUESTION 7

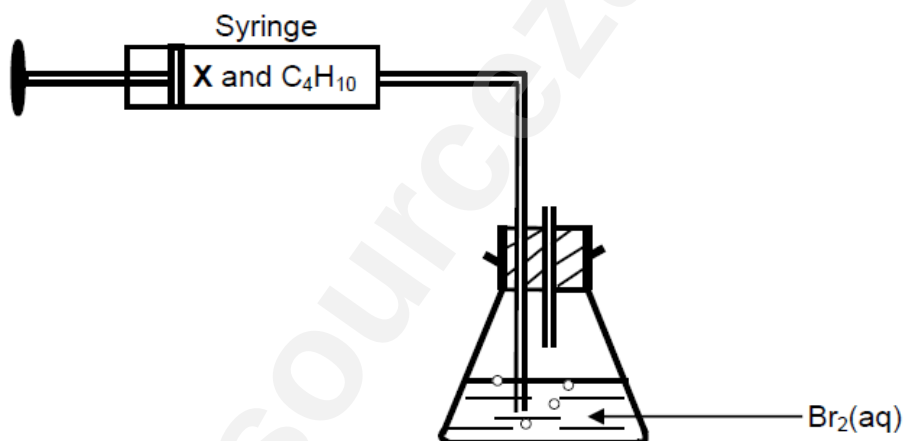
Butane (C_4H_{10}) is produced in industry by the THERMAL cracking of long-chain hydrocarbon molecules, as shown in the equation below. **X** represents an organic compound that is produced.



7.1 Write down:

- 7.1.1 ONE condition required for THERMAL cracking to take place (1)
- 7.1.2 The molecular formula of compound **X** (1)
- 7.1.3 The homologous series to which compound **X** belongs (1)

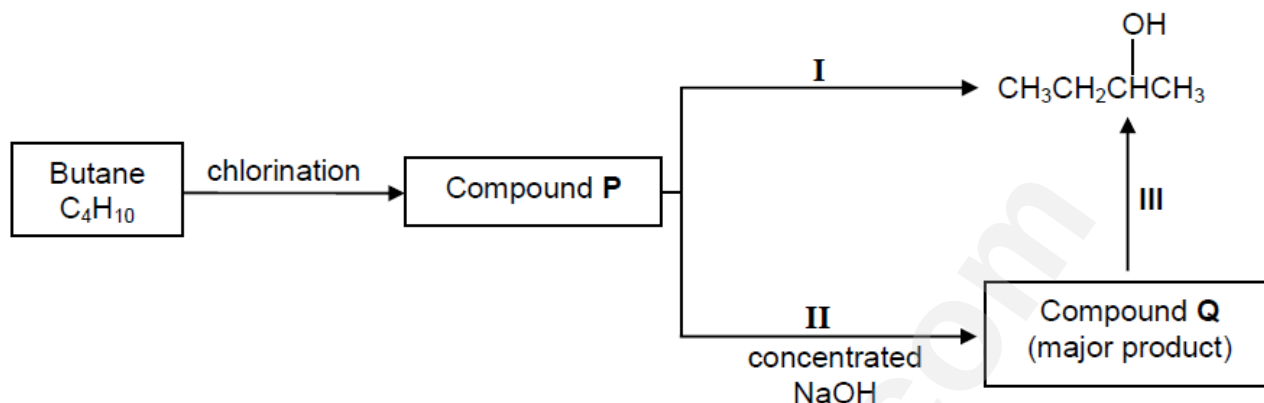
7.2 A mixture of the two gases, compound **X** and butane, is bubbled through bromine water, $Br_2(aq)$, in a conical flask, as illustrated below. THE REACTION IS CARRIED OUT IN A DARKENED ROOM.



The colour of the bromine water changes from reddish brown to colourless when the mixture of the two gases is bubbled through it.

Which ONE of the gases (**X** or BUTANE) decolorises the bromine water? Explain the answer. (4)

- 7.3 Study the flow diagram below, which represents various organic reactions, and answer the questions that follow.



Write down the:

- 7.3.1 IUPAC name of compound P (2)
- 7.3.2 Type of reaction labelled I (1)
- 7.3.3 Structural formula of compound Q (2)
- 7.3.4 The type of addition reaction represented by reaction III (1)
- [13]

5. PLASTICS AND POLYMERS

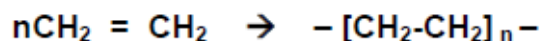
QUESTIONS – POLYMERS

QUESTIONS SET 1

- 1.3 Which ONE of the following polymers is the product of a condensation polymerisation reaction?
- A Polypropylene
 - B Polyvinyl chloride
 - C Polytetrafluoroethene
 - D Polyactic acid
- (2)



- 3.5 The polymerisation of ethene to produce polythene is represented by the equation below:



- 3.5.1 Define the term *macromolecule*. (1)
- 3.5.2 Classify this type of polymerisation. (1)
- 3.5.3 Name TWO industrial uses of polythene. (2)

[18]



6. INTERMOLECULAR FORCES AND PHYSICAL PROPERTIES

QUESTIONS – INTERMOLECULAR FORCES

QUESTIONS SET 1

QUESTION 4 (Start on a new page.)

The table below shows data collected for three organic compounds, represented by the letters **A**, **B** and **C**, during a practical investigation:

	Organic compound	Relative molecular mass	Boiling point (°C)
A	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	58	-0,5
B	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	60	97
C	CH_3COOH	60	118

- 4.1 Which variable was controlled during this investigation? (1)
- 4.2 Name the following in this investigation:
- 4.2.1 The dependent variable (1)
- 4.2.2 The independent variable (1)
- 4.3 Consider compound **A**:
- 4.3.1 Is compound **A** a saturated or an unsaturated hydrocarbon? Give a reason for your answer. (2)
- 4.3.2 The compound 2-methylpropane is an isomer of compound **A**.
Predict whether the boiling point of 2-methylpropane will be HIGHER THAN, LOWER THAN or THE SAME as the boiling point of compound **A**. (1)
- 4.3.3 Explain your prediction in QUESTION 4.3.2. (3)
- 4.4 Refer to intermolecular forces and energy to explain why compound **B** will have a higher vapour pressure than compound **C** at 20 °C. (3)

[12]



QUESTION 1

- 1.1 Give a reason why alkanes are *saturated* hydrocarbons. (1)
- 1.2 Write down the structural formula of:
- 1.2.1 The functional group of alcohols (1)
- 1.2.2 A tertiary alcohol that is a structural isomer of butan-1-ol (2)
- 1.3 Learners investigate factors that influence the boiling points of alkanes and alcohols. In one of the investigations they determine the boiling points of the first three alkanes.
- 1.3.1 Write down an investigative question for this investigation. (2)
- 1.3.2 Fully explain why the boiling point increases from methane to propane. (3)
- 1.4 The learners find that the boiling point of propan-1-ol is higher than that of propane. Explain this observation by referring to the TYPE of INTERMOLECULAR FORCES present in each of these compounds. (3)
- [12]

QUESTION 2

Learners use compounds A to C, shown in the table below, to investigate a factor which influences the boiling point of organic compounds.

A	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
B	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
C	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

- 2.1 Which ONE of the compounds (A, B or C) has the highest boiling point? (1)
- 2.2 For this investigation, write down the:
- 2.2.1 Independent variable (1)
- 2.2.2 Dependent variable (1)
- 2.3 Write down the name of the type of Van der Waals force that occurs between the molecules of compound B. (1)
- 2.4 How will the vapour pressure of 2-methylpentane compare to that of compound C? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

The learners now compare the boiling points of compounds D and E, shown in the table below.

D	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
E	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$

- 2.5 How does the boiling point of compound D compare to that of compound E? Write down HIGHER THAN, LOWER THAN or EQUAL TO. Fully explain the answer. (4)
- [9]

MODULE 2: RATES OF REACTION

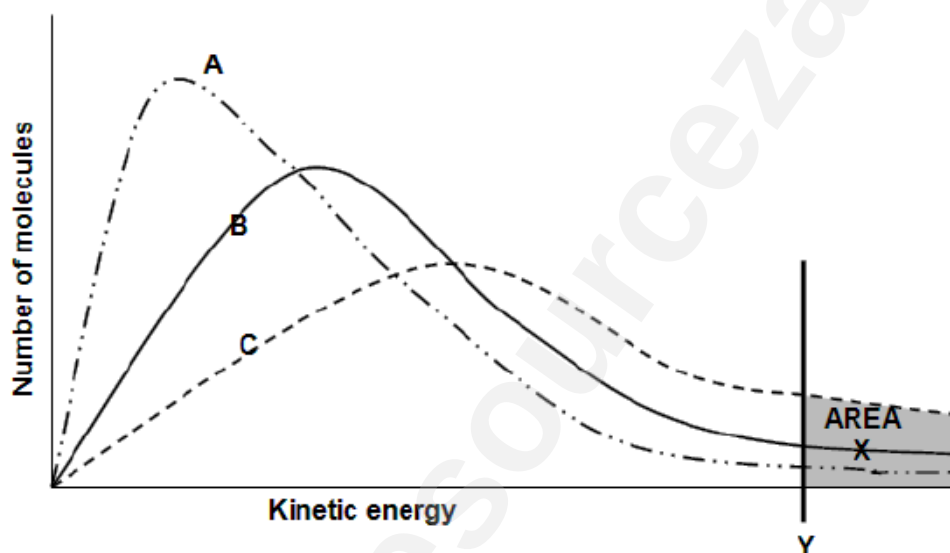
1. RATE OF REACTIONS

QUESTIONS – RATES OF REACTION

QUESTIONS SET 1

QUESTION 5 (Start on a new page.)

Graph **B** below represents the Maxwell-Boltzmann energy distribution curve for a reaction mixture at a temperature of 300°C . Area **X** represents the number of molecules in the mixture that have enough kinetic energy for the reaction to take place.



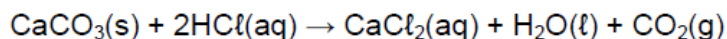
- 5.1 Give a term for the "minimum energy needed for a reaction to take place", as indicated by Y. (1)
- 5.2 The temperature of the mixture is now increased to 500°C .
- 5.2.1 Which ONE of graph **A** or **C** represents the distribution curve of the mixture at this higher temperature? Give a reason for the answer. (2)
- 5.2.2 Use the collision theory to explain how this increase in temperature will influence the rate of the reaction. (4)
- 5.3 A catalyst is added to the mixture.
- 5.3.1 Write down the definition of a *positive catalyst*. (2)
- 5.3.2 How will the above-mentioned action affect the size of **area X** (shaded area)?
- Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)
- 5.3.3 Explain your answer to QUESTION 5.3.2. (2)

[12]

QUESTION 1

- 1.1 Define the term *reaction rate* in words. (2)

Learners use the reaction between IMPURE POWDERED calcium carbonate and excess hydrochloric acid to investigate reaction rate. The balanced equation for the reaction is:



They perform four experiments under different conditions of concentration, mass and temperature as shown in the table below. They use identical apparatus in the four experiments and measure the volume of gas released in each experiment.

	EXPERIMENT			
	1	2	3	4
Concentration of acid ($\text{mol} \cdot \text{dm}^{-3}$)	1	0,5	1	1
Mass of impure calcium carbonate (g)	15	15	15	25
Initial temperature of acid ($^{\circ}\text{C}$)	30	30	40	40

- 1.2 The results of experiments 1 and 3 are compared in the investigation.

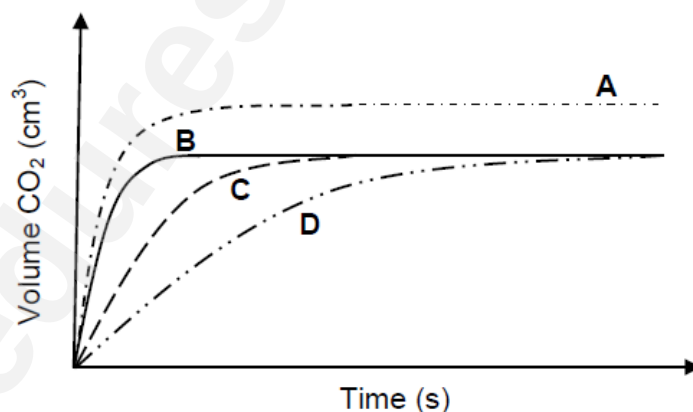
Write down the:

- 1.2.1 Independent variable (1)

- 1.2.2 Dependent variable (1)

- 1.3 Use the collision theory to explain why the reaction rate in experiment 4 will be higher than that in experiment 3. (3)

The learners obtain graphs A, B, C and D below from their results.



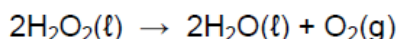
- 1.4 Which ONE of the graphs (A, B, C or D) represents experiment 1? Fully explain the answer by comparing experiment 1 with experiments 2, 3 and 4. (6)

- 1.5 When the reaction in experiment 4 reaches completion, the volume of gas formed is $4,5 \text{ dm}^3$. Assume that the molar gas volume at 40°C is equal to $25,7 \text{ dm}^3$.

Calculate the mass of the impurities present in the calcium carbonate. (5)
[18]

QUESTION 7

Hydrogen peroxide, H_2O_2 , decomposes to produce water and oxygen according to the following balanced equation:



- 7.1 The activation energy (E_A) for this reaction is 75 kJ and the heat of reaction (ΔH) is – 196 kJ.

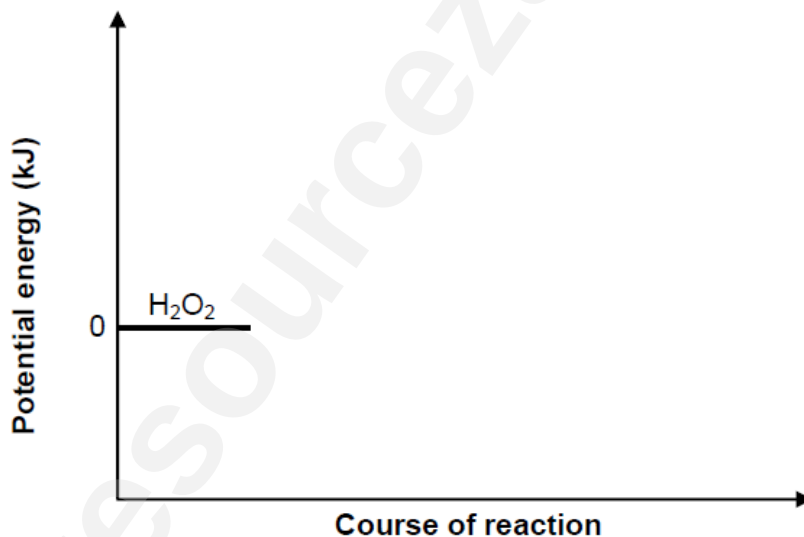
7.1.1 Define the term *activation energy*. (2)

7.1.2 Redraw the set of axes below in your ANSWER BOOK and then complete the potential energy diagram for this reaction.

Indicate the value of the potential energy of the following on the y-axis:

- Activated complex
- Products

(The graph does NOT have to be drawn to scale.)



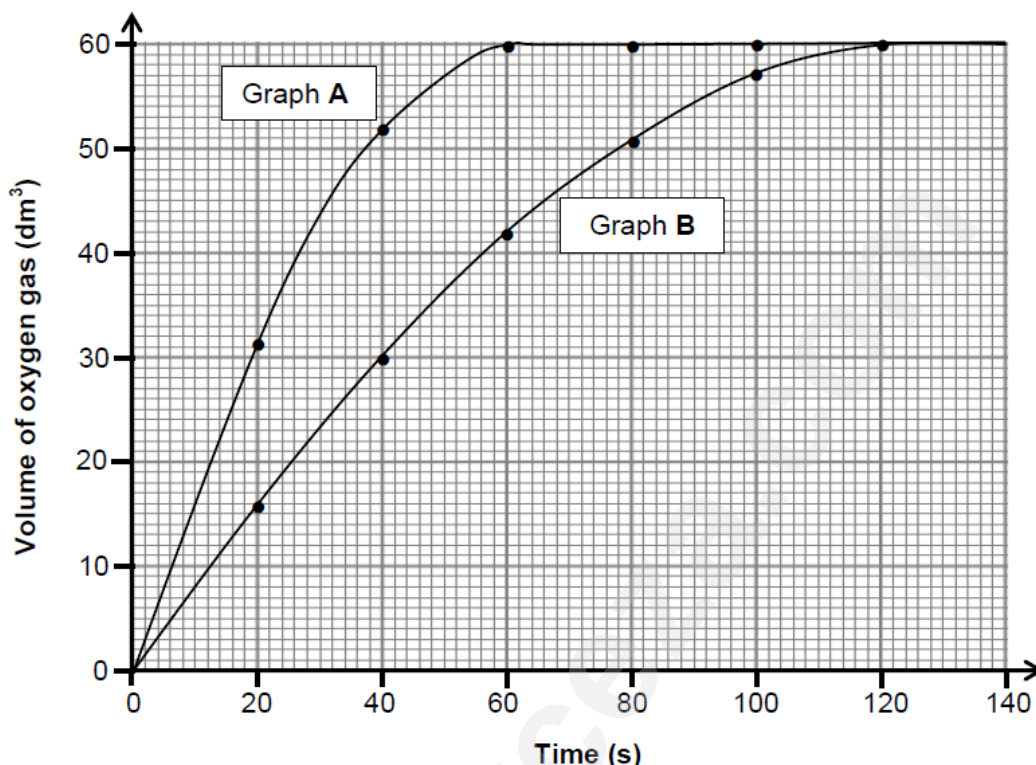
(3)

When powdered manganese dioxide is added to the reaction mixture, the rate of the reaction increases.

7.1.3 On the graph drawn for QUESTION 7.1.2, use broken lines to show the path of the reaction when the manganese dioxide is added. (2)

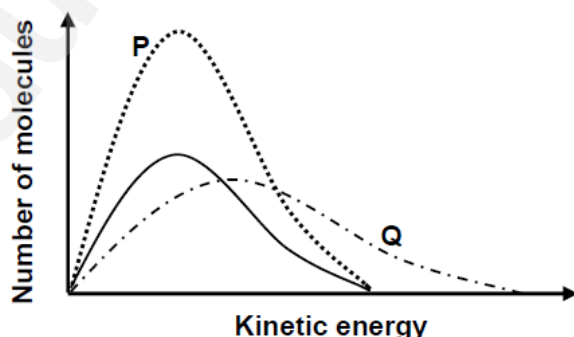
7.1.4 Use the collision theory to explain how manganese dioxide influences the rate of decomposition of hydrogen peroxide. (3)

- 7.2 Graphs **A** and **B** below were obtained for the volume of oxygen produced over time under different conditions.



- 7.2.1 Calculate the average rate of the reaction (in $\text{dm}^3 \cdot \text{s}^{-1}$) between $t = 10 \text{ s}$ and $t = 40 \text{ s}$ for graph **A**. (3)
- 7.2.2 Use the information in graph **A** to calculate the mass of hydrogen peroxide used in the reaction. Assume that all the hydrogen peroxide decomposed. Use $24 \text{ dm}^3 \cdot \text{mol}^{-1}$ as the molar volume of oxygen. (4)
- 7.2.3 How does the mass of hydrogen peroxide used to obtain graph **B** compare to that used to obtain graph **A**? Choose from GREATER THAN, SMALLER THAN or EQUAL TO. (1)

- 7.3 Three energy distribution curves for the oxygen gas produced under different conditions are shown in the graph below. The curve with the solid line represents 1 mol of oxygen gas at 90°C .



Choose the curve (**P** or **Q**) that best represents EACH of the following situations:

- 7.3.1 1 mol of oxygen gas produced at 120°C (1)
- 7.3.2 2 moles of oxygen gas produced at 90°C (1)
- [20]



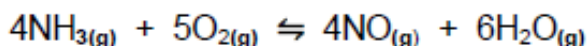
MODULE 3: CHEMICAL EQUILIBRIUM

QUESTIONS – CHEMICAL EQUILIBRIUM

QUESTIONS SET 1

QUESTION 6 (Start on a new page.)

The catalytic oxidation of ammonia is represented by the equation below:



2,0 mol of ammonia gas and 1,0 mol of oxygen gas are placed in a 2,0 dm³ container at 1 000 kPa and allowed to reach equilibrium at 1 000 °C. At this temperature and pressure the amount of water vapour present is 0,6 mol.

6.1 Calculate the value of the equilibrium constant at this temperature. (8)

6.2 Briefly explain the significance of the value obtained in QUESTION 6.1. (1)

6.3 What effect will the addition of a platinum catalyst have on the yield of NO_(g) at the given temperature?

Write down only INCREASE, DECREASE or REMAIN THE SAME. (1)

6.4 The pressure on the system is decreased by increasing the volume. Use Le Chatelier's principle to explain how this change affects the yield of NO_(g). (3)

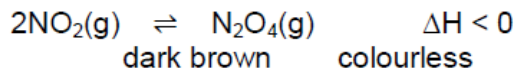
6.5 It is found that at a temperature of 500 °C the value of the equilibrium constant is greater than the value calculated in QUESTION 6.1.

What is the sign of ΔH for the reaction mentioned above? (1)

6.6 Explain your answer to QUESTION 6.5. (4)
[18]

QUESTION 1

A certain amount of nitrogen dioxide gas (NO_2) is sealed in a gas syringe at 25°C . When equilibrium is reached, the volume occupied by the reaction mixture in the gas syringe is 80 cm^3 . The balanced chemical equation for the reaction taking place is:



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

1.2 At equilibrium the concentration of the $\text{NO}_2(\text{g})$ is $0,2\text{ mol}\cdot\text{dm}^{-3}$. The equilibrium constant for the reaction is 171 at 25°C .

Calculate the initial number of moles of $\text{NO}_2(\text{g})$ placed in the gas syringe. (8)

1.3 The diagram below shows the reaction mixture in the gas syringe after equilibrium is established.



The pressure is now increased by decreasing the volume of the gas syringe at constant temperature as illustrated in the diagram below.



1.3.1 IMMEDIATELY after increasing the pressure, the colour of the reaction mixture in the gas syringe appears darker than before. Give a reason for this observation. (1)

After a while a new equilibrium is established as illustrated below. The colour of the reaction mixture in the gas syringe now appears lighter than the initial colour.



1.3.2 Use Le Chatelier's principle to explain the colour change observed in the gas syringe. (3)

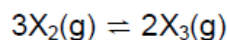
1.4 The temperature of the reaction mixture in the gas syringe is now increased and a new equilibrium is established. How will each of the following be affected?

1.4.1 Colour of the reaction mixture
Write down only DARKER, LIGHTER or REMAINS THE SAME. (1)

1.4.2 Value of the equilibrium constant (K_c)
Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)
[16]

QUESTION 4

An unknown gas, $X_2(g)$, is sealed in a container and allowed to form $X_3(g)$ at $300\text{ }^{\circ}\text{C}$. The reaction reaches equilibrium according to the following balanced equation:



- 4.1 How will the rate of formation of $X_3(g)$ compare to the rate of formation of $X_2(g)$ at equilibrium? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

The reaction mixture is analysed at regular time intervals. The results obtained are shown in the table below.

TIME (s)	[X_2] (mol·dm ⁻³)	[X_3] (mol·dm ⁻³)
0	0,4	0
2	0,22	0,120
4	0,08	0,213
6	0,06	0,226
8	0,06	0,226
10	0,06	0,226

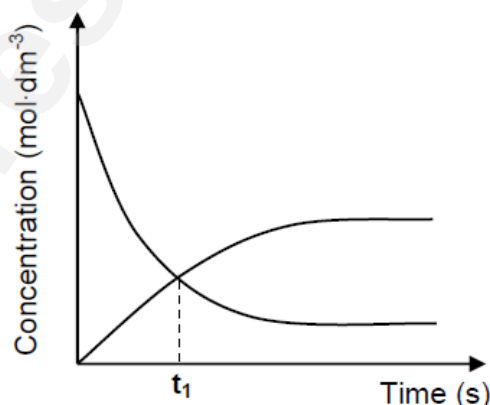
- 4.2 Calculate the equilibrium constant, K_c , for this reaction at $300\text{ }^{\circ}\text{C}$. (4)

- 4.3 More $X_3(g)$ is now added to the container.

- 4.3.1 How will this change affect the amount of $X_2(g)$? Write down INCREASES, DECREASES or REMAINS THE SAME. (1)

- 4.3.2 Use Le Chatelier's principle to explain the answer to QUESTION 4.3.1. (2)

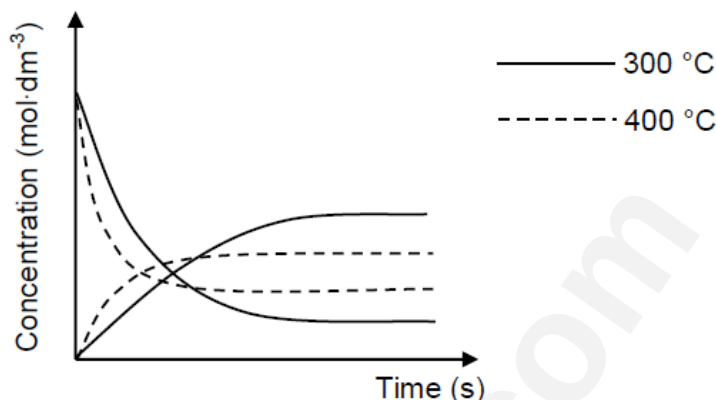
The curves on the set of axes below (not drawn to scale) was obtained from the results in the table on page 10.



- 4.4 How does the rate of the forward reaction compare to that of the reverse reaction at t_1 ? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

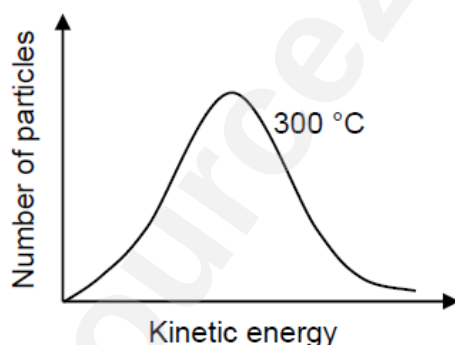


The reaction is now repeated at a temperature of 400 °C. The curves indicated by the dotted lines below were obtained at this temperature.



- 4.5 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Fully explain how you arrived at the answer. (4)

The Maxwell-Boltzmann distribution curve below represents the number of particles against kinetic energy at 300 °C.



- 4.6 Redraw this curve in the ANSWER BOOK. On the same set of axes, sketch the curve that will be obtained at 400 °C. Clearly label the curves as 300 °C and 400 °C respectively. (2)

[15]



MODULE 4: ACIDS AND BASES AND STOICHIOMETRY

QUESTIONS – ACIDS AND BASES

QUESTIONS SET 1

QUESTION 7 (Start on a new page.)

7.1 Define a *strong acid*. (2)

7.2 A solution of an unknown, monoprotic acid has a concentration of $0,01 \text{ mol} \cdot \text{dm}^{-3}$ and a pH of 3.

7.2.1 Calculate the concentration of the hydrogen ions in this solution. (2)

7.2.2 How will the strength of this unknown acid compare to that of hydrochloric acid of the same concentration?

Write down only STRONGER THAN, WEAKER THAN or EQUAL TO (1)

7.2.3 Give a reason for your answer in QUESTION 7.2.2. (2)

7.3 Ammonium chloride is an example of a salt that can undergo hydrolysis.

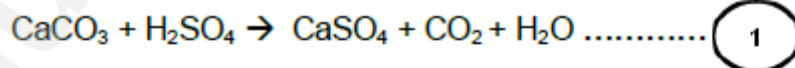
7.3.1 Define the underlined term. (2)

7.3.2 Write an equation to show the hydrolysis of ammonium chloride. (3)

7.3.3 Methyl orange is red in an acidic medium and yellow in an alkaline medium. What will the colour of methyl orange be in an ammonium chloride solution? (2)

7.4 A learner adds a sample of calcium carbonate to $50,0 \text{ cm}^3$ of sulphuric acid. The sulphuric acid is in excess and has a concentration of $1,0 \text{ mol} \cdot \text{dm}^{-3}$.

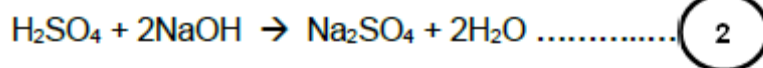
The balanced equation for the reaction that takes place is:



The reaction is allowed to proceed until all the CaCO_3 is used up.

The H_2SO_4 **left over** from REACTION 1 is now neutralised by $28,0 \text{ cm}^3$ of a $0,5 \text{ mol} \cdot \text{dm}^{-3}$ sodium hydroxide solution.

The balanced equation for this reaction is:



Calculate the **mass** of calcium carbonate in the sample used in REACTION 1. (10)
[24]

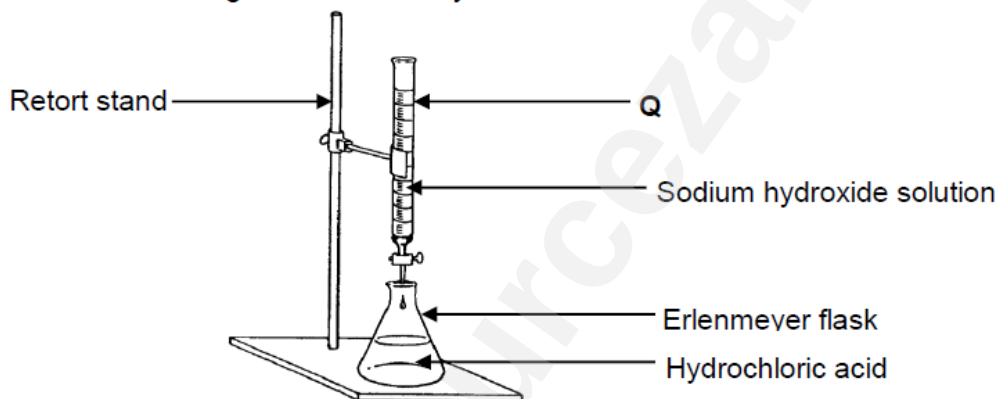
QUESTION 1

- 1.1 Nitric acid (HNO_3), an important acid used in industry, is a strong acid.
- 1.1.1 Give a reason why nitric acid is classified as a strong acid. (1)
- 1.1.2 Write down the NAME or FORMULA of the conjugate base of nitric acid. (1)
- 1.1.3 Calculate the pH of a $0,3 \text{ mol}\cdot\text{dm}^{-3}$ nitric acid solution. (3)

- 1.2 A laboratory technician wants to determine the percentage purity of magnesium oxide. He dissolves a $4,5 \text{ g}$ sample of the magnesium oxide in 100 cm^3 hydrochloric acid of concentration $2 \text{ mol}\cdot\text{dm}^{-3}$.

- 1.2.1 Calculate the number of moles of hydrochloric acid added to the magnesium oxide. (3)

He then uses the apparatus below to titrate the EXCESS hydrochloric acid in the above solution against a sodium hydroxide solution.



- 1.2.2 Write down the name of apparatus **Q** in the above diagram. (1)
- 1.2.3 The following indicators are available for the titration:

INDICATOR	pH RANGE
A	3,1 – 4,4
B	6,0 – 7,6
C	8,3 – 10,0

Which ONE of the above indicators (**A**, **B** or **C**) is most suitable to indicate the exact endpoint in this titration? Give a reason for the answer. (3)

- 1.2.4 During the titration, the technician uses distilled water to wash any sodium hydroxide spilled against the sides of the Erlenmeyer flask into the solution. Give a reason why the addition of distilled water to the Erlenmeyer flask will not influence the results. (1)
- 1.2.5 At the endpoint of the titration he finds that 21 cm^3 of a $0,2 \text{ mol dm}^{-3}$ sodium hydroxide solution has neutralised the EXCESS hydrochloric acid. Calculate the number of moles of hydrochloric acid in excess. (3)
- 1.2.6 The balanced equation for the reaction between hydrochloric acid and magnesium oxide is: $\text{MgO(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{O(l)}$

Calculate the percentage purity of the magnesium oxide. Assume that only the magnesium oxide in the $4,5 \text{ g}$ sample reacted with the acid.

(5)
[21]



QUESTION 7

- 7.1 A learner dissolves ammonium chloride (NH_4Cl) crystals in water and measures the pH of the solution.

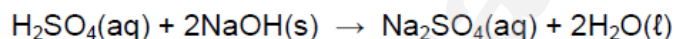
7.1.1 Define the term *hydrolysis* of a salt. (2)

7.1.2 Will the pH of the solution be GREATER THAN, SMALLER THAN or EQUAL TO 7? Write a relevant equation to support your answer. (3)

- 7.2 A sulphuric acid solution is prepared by dissolving 7,35 g of $\text{H}_2\text{SO}_4(\ell)$ in 500 cm^3 of water.

7.2.1 Calculate the number of moles of H_2SO_4 present in this solution. (2)

Sodium hydroxide (NaOH) pellets are added to the 500 cm^3 H_2SO_4 solution.
The balanced equation for the reaction is:



After completion of the reaction, the pH of the solution was found to be 1,3. Assume complete ionisation of H_2SO_4 .

7.2.2 Calculate the mass of NaOH added to the H_2SO_4 solution. Assume that the volume of the solution does not change. (9)

[16]

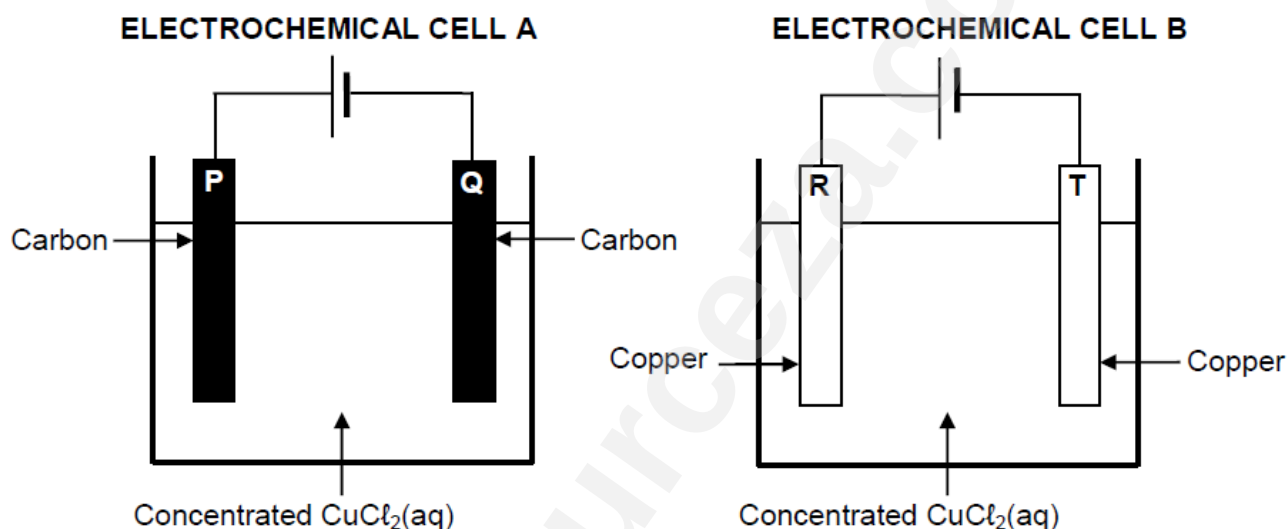
MODULE 5: REDOX REACTIONS

QUESTIONS – ELECTROLYTIC CELLS

QUESTIONS SET 1

QUESTION 1

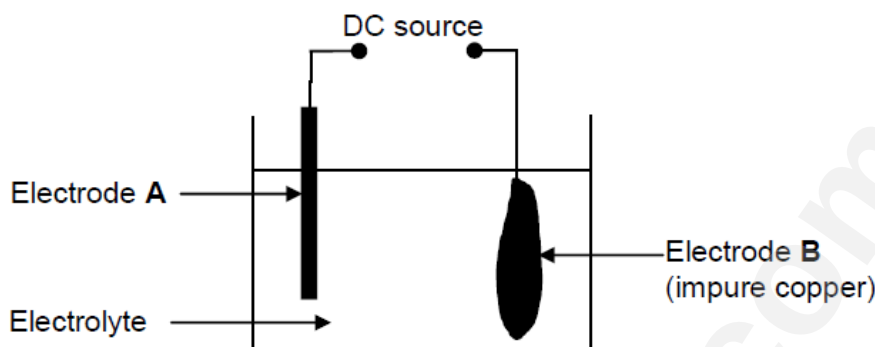
The simplified diagrams below represent two electrochemical cells, **A** and **B**. A concentrated copper(II) chloride solution is used as electrolyte in both cells.



- 1.1 Are **A** and **B** ELECTROLYTIC or GALVANIC cells? (1)
 - 1.2 Which of the electrodes (**P**, **Q**, **R** or **T**) will show a mass increase? Write down a half-reaction to motivate the answer. (4)
 - 1.3 Write down the NAME or FORMULA of the product formed at:
 - 1.3.1 Electrode **P** (1)
 - 1.3.2 Electrode **R** (1)
 - 1.4 Fully explain the answer to QUESTION 1.3.2 by referring to the relative strengths of the reducing agents involved. (3)
- [10]**

QUESTION 4

The simplified diagram below represents an electrochemical cell used for the purification of copper.



- 4.1 Define the term *electrolysis*. (2)
- 4.2 Give a reason why a direct-current (DC) source is used in this experiment. (1)
- 4.3 Write down the half-reaction which takes place at electrode **A**. (2)
- 4.4 Due to small amounts of zinc impurities in the impure copper, the electrolyte becomes contaminated with Zn^{2+} ions.

Refer to the attached Table of Standard Reduction Potentials to explain why the Zn^{2+} ions will not influence the purity of the copper obtained during this process. (3)

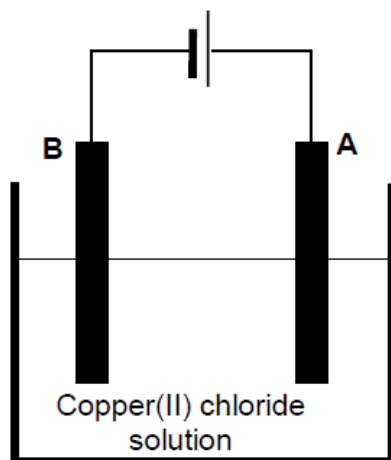
- 4.5 After the purification of the impure copper was completed, it was found that $2,85 \times 10^{-2}$ moles of copper were formed.

The initial mass of electrode **B** was 2,0 g. Calculate the percentage of copper that was initially present in electrode **B**.

(4)
[12]

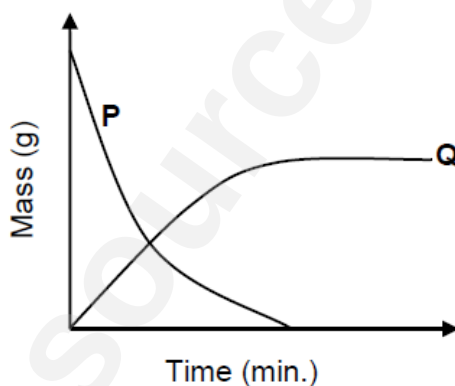
QUESTION 5

The electrochemical cell below is set up to demonstrate the purification of copper.



- 5.1 Write down the type of electrochemical cell illustrated above. (1)

The graphs below show the change in mass of the electrodes whilst the cell is in operation.

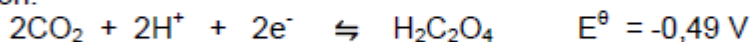


- 5.2 Define a *reducing agent* in terms of electron transfer. (2)
- 5.3 Which graph represents the change in mass of electrode **A**? (1)
- 5.4 Write down the half-reaction that takes place at electrode **A**. (2)
- 5.5 Electrodes **A** and **B** are now replaced by graphite electrodes. It is observed that chlorine gas (Cl_2) is released at one of the electrodes.
- At which electrode (**A** or **B**) is chlorine gas formed? Fully explain how it is formed. (3)
- [9]

QUESTIONS SET 1

QUESTION 8 (Start on a new page.)

- 8.1 Consider the following half reaction involving oxalic acid solution.



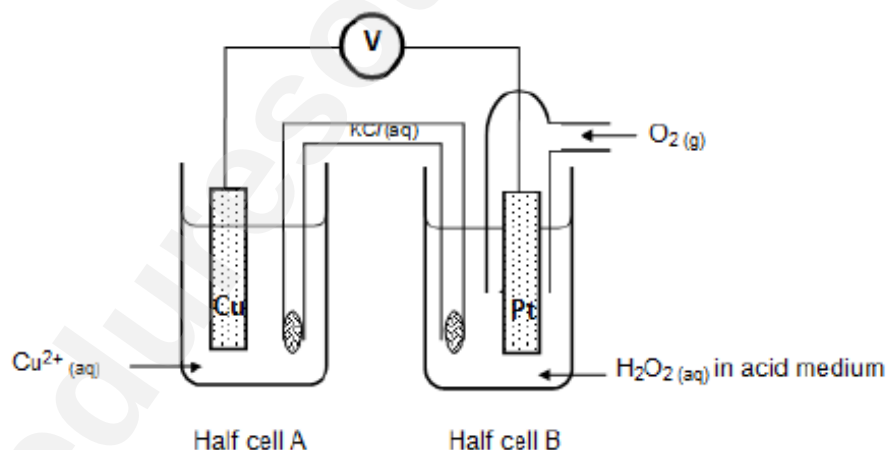
A solution of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$ (aq)) is added to an oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$ (aq)) solution.

- 8.1.1 Explain why the reaction between the solution of oxalic acid and potassium dichromate will be spontaneous. Refer to the relative strengths of the oxidising and reducing agents in your answer. (3)
- 8.1.2 Use half-reactions to write down a balanced equation for the reaction between oxalic acid and potassium dichromate. Leave the answer in ionic form without spectator ions. (4)

- 8.2 A learner sets up a standard electrochemical cell using the following half-cells:



Potassium chloride (KCl (aq)) solution is used in the salt bridge.

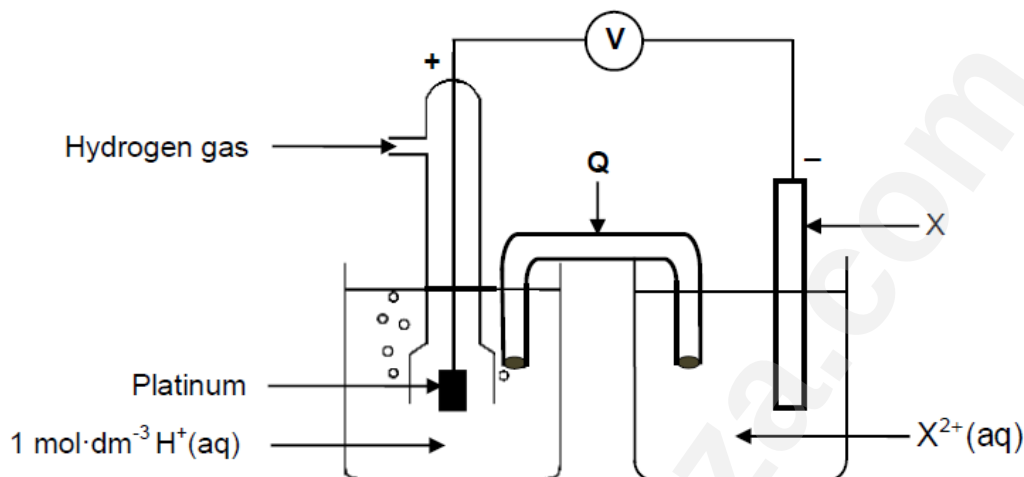


- 8.2.1 Which half cell (A or B) contains the cathode? (2)
- 8.2.2 Write down the oxidation half-reaction. (2)
- 8.2.3 Write down the cell notation for this cell. (3)
- 8.2.4 Calculate the potential difference of the cell ($E^\ominus_{\text{cell}}$). (4)
- 8.2.5 After several days, the reading on the voltmeter is 0,00 V. Explain why this reading is obtained. (4)

[22]

QUESTION 1

A standard electrochemical cell is set up using a standard hydrogen half-cell and a standard $X|X^{2+}$ half-cell as shown below. A voltmeter connected across the cell, initially registers 0,31 V.



- 1.1 Besides concentration write down TWO conditions needed for the hydrogen half-cell to function under standard conditions. (2)
- 1.2 Give TWO reasons, besides being a solid, why platinum is suitable to be used as electrode in the above cell. (2)
- 1.3 Write down the:
 - 1.3.1 NAME of component Q (1)
 - 1.3.2 Standard reduction potential of the $X|X^{2+}$ half-cell (1)
 - 1.3.3 Half-reaction that takes place at the cathode of this cell (2)
- 1.4 The hydrogen half-cell is now replaced by a $M|M^{2+}$ half-cell. The cell notation of this cell is:

$$M(s) | M^{2+}(aq) || X^{2+}(aq) | X(s)$$

The initial reading on the voltmeter is now 2,05 V.

 - 1.4.1 Identify metal **M**. Show how you arrived at the answer. (5)
 - 1.4.2 Is the cell reaction EXOTHERMIC or ENDOTHERMIC? (1)
- 1.5 The reading on the voltmeter becomes zero after using this cell for several hours. Give a reason for this reading by referring to the cell reaction. (1)

[15]

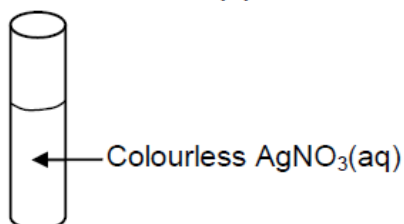
QUESTION 2

A learner conducts two experiments to investigate the reaction between copper (Cu) and a silver nitrate solution, $\text{AgNO}_3(\text{aq})$.

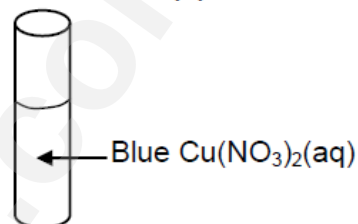
EXPERIMENT 1

The learner adds a small amount of copper (Cu) powder to a test tube containing silver nitrate solution, $\text{AgNO}_3(\text{aq})$. The solution changes from colourless to blue after a while.

Before addition of Cu(s)



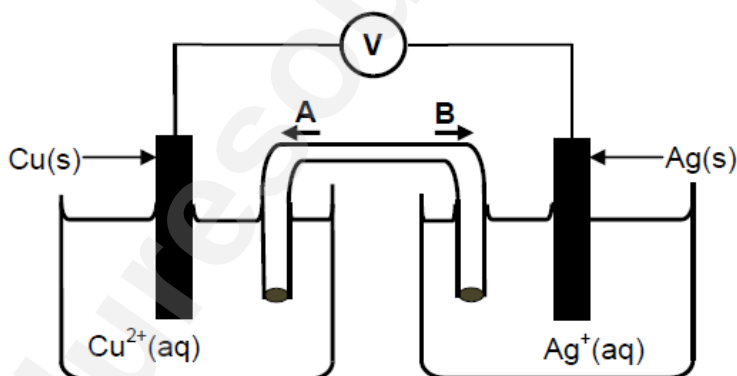
After addition of Cu(s)



- 2.1 Define the term *oxidising agent*. (2)
- 2.2 Explain why the solution turns blue by referring to the relative strength of oxidising agents. (4)

EXPERIMENT 2

The learner now sets up a galvanic cell as shown below. The cell functions under standard conditions.

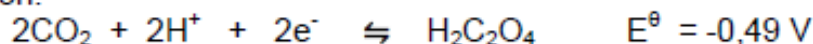


- 2.3 Write down the energy conversion that takes place in this cell. (1)
- 2.4 In which direction (A or B) will ANIONS move in the salt bridge? (1)
- 2.5 Calculate the emf of the above cell under standard conditions. (4)
- 2.6 Write down the balanced equation for the net cell reaction that takes place in this cell. (3)
- 2.7 How will the addition of 100 cm^3 of a $1 \text{ mol} \cdot \text{dm}^{-3}$ silver nitrate solution to the silver half-cell influence the initial emf of this cell? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

[16]

QUESTION 8 (Start on a new page.)

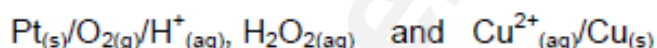
- 8.1 Consider the following half reaction involving oxalic acid: solution.



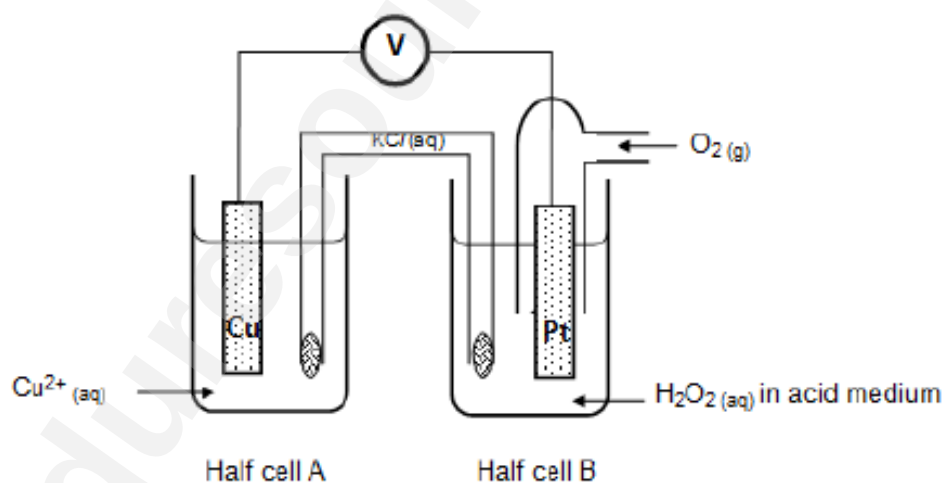
A solution of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$ (aq)) is added to an oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$ (aq)) solution.

- 8.1.1 Explain why the reaction between the solution of oxalic acid and potassium dichromate will be spontaneous. Refer to the relative strengths of the oxidising and reducing agents in your answer. (3)
- 8.1.2 Use half-reactions to write down a balanced equation for the reaction between oxalic acid and potassium dichromate. Leave the answer in ionic form without spectator ions. (4)

- 8.2 A learner sets up a standard electrochemical cell using the following half-cells:



Potassium chloride (KCl (aq)) solution is used in the salt bridge.



- 8.2.1 Which half cell (A or B) contains the cathode? (2)
- 8.2.2 Write down the oxidation half-reaction. (2)
- 8.2.3 Write down the cell notation for this cell. (3)
- 8.2.4 Calculate the potential difference of the cell ($E^\ominus_{\text{cell}}$). (4)
- 8.2.5 After several days, the reading on the voltmeter is 0,00 V. Explain why this reading is obtained. (4)

[22]



MEMOS

MULTIPLE CHOICE QUESTIONS

QUESTIONS SET 1

SECTION/AFDELING A

QUESTION/VRAAG 1

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

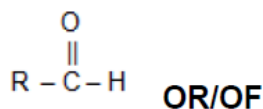
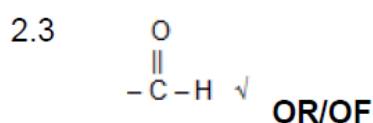
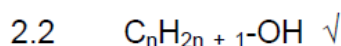
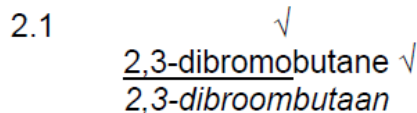
TOTAL SECTION/TOTAAL AFDELING A: 20



MODULE 1: ORGANIC CHEMISTRY

NOMENCLATURE QUESTIONS SET 1

QUESTION/VRAAG 2



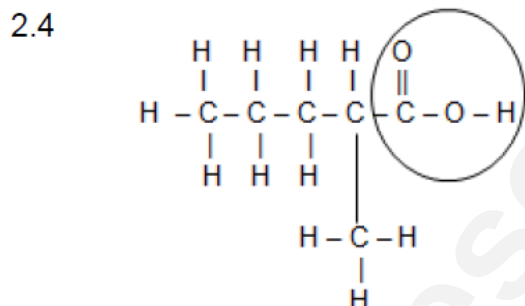
CORRECT IUPAC NAME, BUT ONE OR MORE OF THE FOLLOWING ERRORS: OMITTING HYPHENS AND/OR COMMAS; INCLUDING EXTRA HYPHENS AND /OR SPACES

(2)

MAX/MAKS ½

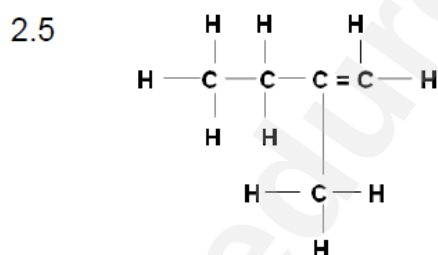
KORREKTE IUPAC-NAAM MAAR EEN OF MEER VD VOLGENDE FOUTE GEMAAK: WEGLATING VAN KOPPELTEKENS EN/OF KOMMAS; INSLUITING VAN EKSTRA SPASIES EN/OF KOPPELTEKENS

(1)



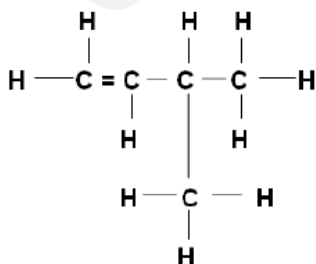
$\checkmark$ – functional group/funksionele groep
 $\checkmark$ – rest of structure correct/res van struktuur korrek

(2)



$\checkmark$ – functional group/funksionele groep
 $\checkmark$ – rest of structure correct/ res van struktuur korrek

OR/OF



(2)

[8]

NUMBERING INCORRECT – SHOULD START AT 1.1



QUESTION 1

2.1
2.1.1 B ✓ (1)

2.1.2 E ✓ (1)

2.1.3 F ✓ (1)

2.2
2.2.1 2-bromo-3-chloro-4-methylpentane

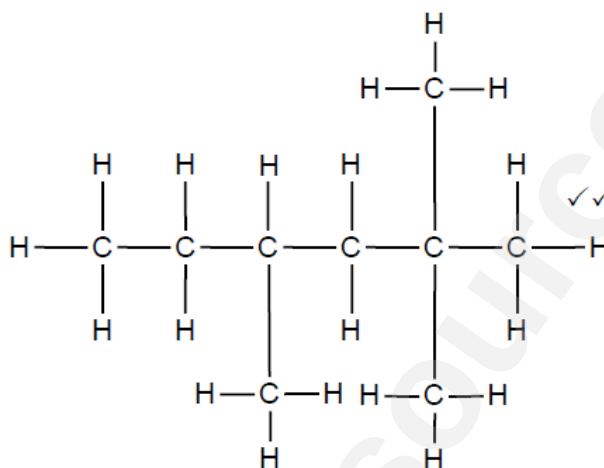
Marking criteria:

- Correct stem i.e. pentane. ✓
- All substituents correctly identified. ✓
- Substituents correctly numbered, in alphabetical order, hyphens and commas correctly used. ✓

(3)

2.2.2 Ethene ✓ (1)

2.3
2.3.1

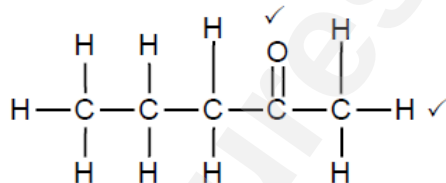


Marking criteria:

- Six saturated C atoms in longest chain i.e. hexane. ✓
- Three methyl substituents on 2nd C and 4th C atom. ✓

(2)

2.3.2



Marking criteria:

- Whole structure correct: ✓✓
- Only functional group correct: ✓

(2)

2.4
2.4.1 Compounds with the same molecular formula ✓ but DIFFERENT functional groups. ✓ (2)

2.4.2 B & F ✓ (1)

[14]



QUESTION 3

3.1
3.1.1 B ✓ (1)

3.1.2 E ✓ (1)

3.1.3 A ✓ (1)

3.2

3.2.1 4-chloro-2,5-dimethylheptane

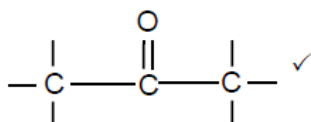
Marking criteria:

- Correct stem i.e. heptane. ✓
- All substituents (chloro and dimethyl) correctly identified. ✓ Substituents correctly numbered, in alphabetical order, hyphens and commas correctly used. ✓

(3)

3.2.2 2-methyl✓ propan-1-ol ✓ (2)

3.2.3



(1)

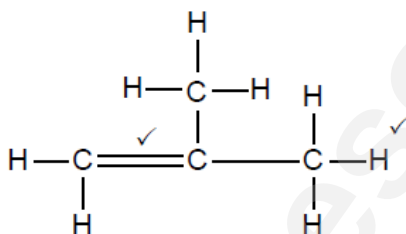
3.3

3.3.1 Compounds with the same molecular formula ✓ but different POSITIONS of the functional group / side chain / substituents on parent chain. ✓ (2)

3.3.2 But-1-ene ✓✓ AND But-2-ene ✓✓ (4)

KKH

3.3.3



Marking criteria:

- Whole structure correct: ✓✓
- Only functional group correct: ✓

(2)

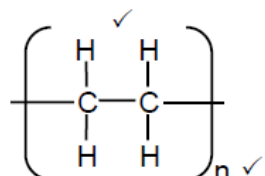
3.4

3.4.1 Cracking / elimination ✓ (1)

3.4.2 Ethene ✓ (1)

3.4.3 C₄H₁₀ ✓ (1)

3.4.4 Polyethene ✓



(3)

[23]



TYPES OF REACTIONS

QUESTION 3

3.1 3.1.1 addition ✓
addisie

3.1.2 elimination ✓
eliminasië

3.1.3 substitution ✓
substitusie

3.2.1/3.2.2/3.4.1 **NAMES ONLY/
ALLEENLIK NAME
AND/EN
V3.3/3.4.3 FORMULAE ONLY/
ALLEENLIK FORMULES**

(1)

(1)

(1)

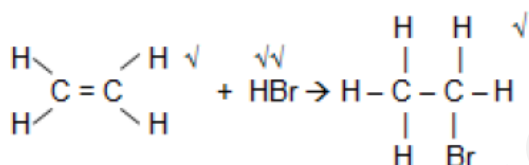
3.2 3.2.1 water ✓

(1)

3.2.2 (dilute)sulphuric acid / (dilute)phosphoric acid ✓
(verdunde)swawelsuur / (verdunde)fosforsuur

(1)

3.3



-1 FOR CONDENSED/ MOLECULAR FORMULAE

-1 VIR GEKONDENSEERD/
MOLEKULÊRE FORMULES

IGNORE RULE 3.10/IGNOREER REËL 3.10

-1 FOR ADDITIONAL REACTANTS/ PRODUCTS /
VIR ADDISIONELE REAGENSE /PRODUKTE

-1 IF ARROW OMITTED/ GEEN PYLTJIE

(4)

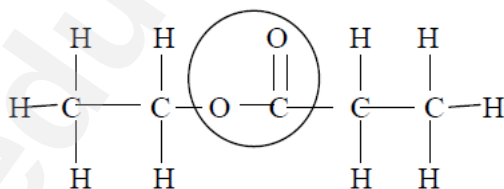
3.4 3.4.1 propanoic acid ✓✓
propanoësuur

(2)

3.4.2 esterification ✓ or (acid catalysed) condensation
esterifikasie of (suur gekataliseerde) kondensasie

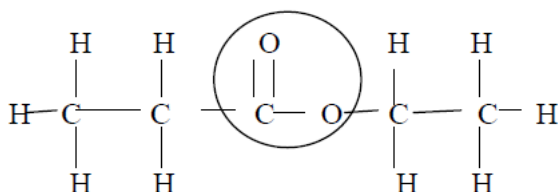
(1)

3.4.3



✓ – functional
group/funksionele groep
✓ – rest of structure correct/
res van struktuur korrek

OR/OF



(2)

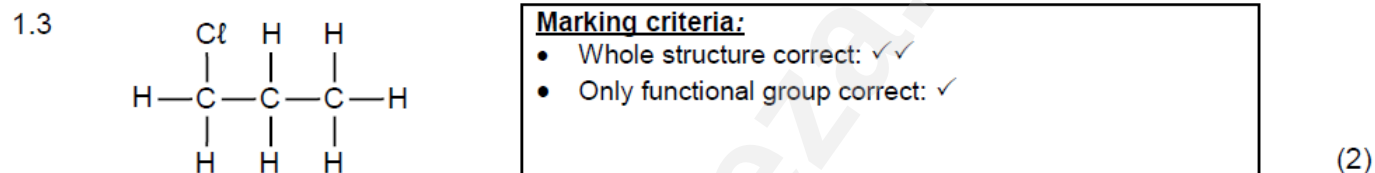
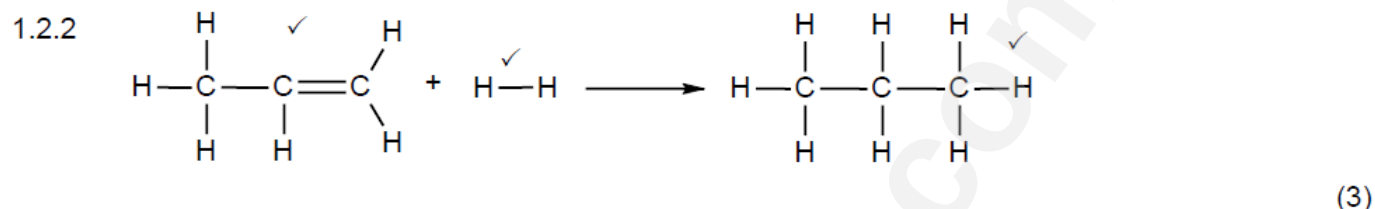


QUESTION 1

1.1
1.1.1 Substitution / chlorination / halogenation ✓ (1)

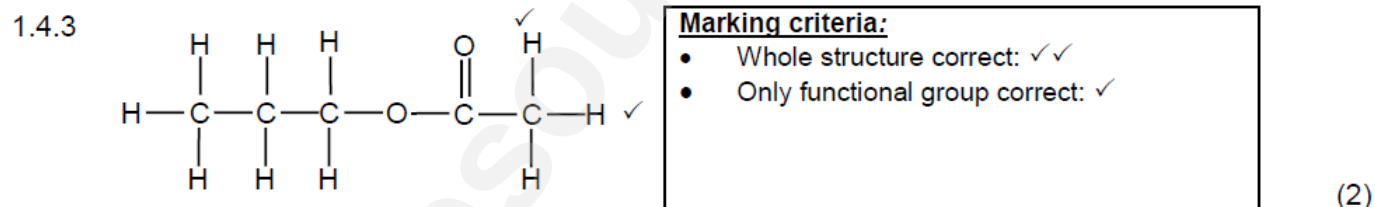
1.1.2 Substitution / hydrolysis ✓ (1)

1.2
1.2.1 Hydrogenation ✓ (1)



1.4
1.4.1 Esterification ✓ (1)

1.4.2 Concentrated H_2SO_4 / sulphuric acid ✓ (1)



1.4.4 Propyl ✓ ethanoate ✓ (2)

1.5 Sulphuric acid / H_2SO_4 ✓ (1)
[15]



QUESTION 7

- 7.1
7.1.1 High temperature / heat / high energy / high pressure ✓ (1)
7.1.2 C_6H_{12} ✓ (1)
7.1.3 Alkenes ✓ (1)
7.2 X / C_6H_{12} / Alkene ✓

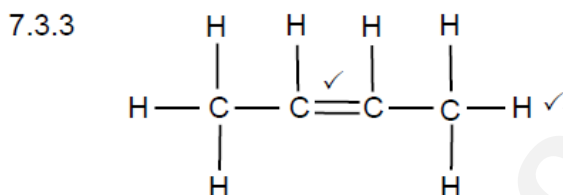
OPTION 1

- X has a double bond. / X is unsaturated. ✓
- X can undergo addition. ✓
- X will react without light / heat. ✓

OPTION 2

- Butane is an alkane **OR** butane is saturated. ✓
- Butane can only undergo substitution. ✓
- Butane will only react in the presence of light or heat. ✓ (4)

- 7.3
7.3.1 2-chloro ✓ butane ✓ (2)
7.3.2 Substitution / Hydrolysis ✓ (1)



Marking criteria:

- Whole structure correct ✓✓
- Only functional group correct: ✓

- 7.3.4 Hydration ✓ (1)
[13]

POLYMERS

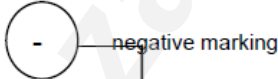
QUESTIONS SET 1

- 3.5 3.5.1 a molecule containing a large number of atoms ✓
'n molekule wat uit 'n groot aantal atome bestaan (1)
3.5.2 addition ✓ (polimerisation)/*addisie* (polimerisasie) (1)
3.5.3 (Any TWO of)/(enige TWEE van)
used to make plastic bags/squeeze bottles/clingwrap ✓✓
word gebruik om plastieksakke/spuitbottels/kleefplastiek te maak (2)
[18]



INTERMOLECULAR FORCES
QUESTIONS SET 1

QUESTION 4

- 4.1 Relative molecular mass/molar mass ✓
Relatiewe molekulêre massa/molêre massa (1)
- 4.2 4.2.1 Boiling point ✓
Kookpunt (1)
- 4.2.2 Type of organic compound/homologous series/functional group ✓
Tipe organiese verbinding/homoloë reeks/funksionele groep (1)
- 4.3 4.3.1 Saturated ✓ – single bonds only between C-atoms ✓
Versadig – alleenlik enkelbindings tussen C-atome (2)
- 4.3.2 LOWER THAN/LAER AS ✓  (1)
- 4.3.3
- 2-methylpropane is a spherical molecule, therefore smaller surface area ✓ is presented to other molecules (sphere is 3D shape with lowest surface-to-volume ratio)
 - Less surface area at which van der Waals interactions with other molecules can occur ✓ /fewer van der Waals interactions/fewer cohesive interactions
 - Less energy required ✓ to overcome cohesive forces as liquid hydrocarbon is vaporised
- 4.4 ethanoic acid – it is possible for 2 ✓ H-bonds (at C=O and O-H) to form
C between adjacent carboxylic acid molecules
Therefore H-bonds stronger in carboxylic acid ✓
Therefore more energy required to ✓ overcome the stronger
Forces of attraction/to break the bonds BETWEEN molecules

OR

- propan-1-ol – H-bonds weaker in alcohol ✓ as it is only possible for 1 H ✓
B bond at O-H to form between adjacent molecules of alcohol
therefore less energy required ✓ to overcome the strong
forces of attraction/to break the bonds BETWEEN
molecules



QUESTION 1

- 1.1 • Alkanes have ONLY single bonds. ✓

OR

- Alkanes have single bonds between C atoms.

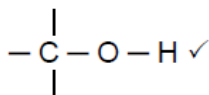
OR

- Alkanes have no double OR triple bonds OR multiple bonds.

(1)

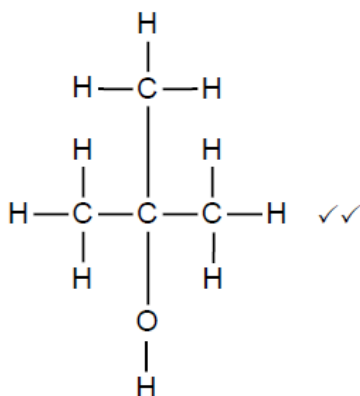
1.2

1.2.1



(1)

1.2.2



Marking criteria:

- - OH group on second C atom of longest chain. ✓
- Tertiary group consisting of four C atoms with methyl group on 2nd C atom. ✓

(2)

1.3

1.3.1

Criteria for investigative question:

The dependent and independent variables are stated.

✓

Ask a question about the relationship between the independent and dependent variables.

✓

Examples:

- How does an increase in chain length influence boiling point?
- What is the relationship between chain length and boiling point?

(2)

1.3.2

• **Structure:**

The chain length increases. ✓

• **Intermolecular forces:**

Increase in strength of intermolecular. ✓

• **Energy:**

More energy needed to overcome intermolecular forces. ✓

OR

• **Structure:**

From propane to methane the chain length decreases. ✓

• **Intermolecular forces:**

Decrease in strength of intermolecular. ✓

• **Energy:**

Less energy needed to overcome intermolecular forces. ✓

(3)

1.4

- Between propane molecules are London forces. ✓
- Between propan-1-ol molecules are London forces, dipole-dipole forces and hydrogen bonds. ✓
- Hydrogen bonds are stronger than London forces. ✓

(3)

[12]



QUESTION 2

- 2.1 C ✓ (1)
- 2.2
- 2.2.1 Chain length ✓ (1)
- 2.2.2 Boiling point ✓ (1)
- 2.3 London forces ✓ (1)
- 2.4 Higher than ✓ (1)
- 2.5 Lower than ✓
- Both compounds **D** and **E** have hydrogen bonding between molecules. ✓
 - Compound **D** has one site for hydrogen bonding whilst compound **E** has two sites for hydrogen bonding OR can form dimers. ✓
 - More energy needed to overcome intermolecular forces in compound **E**. ✓
- (4)
[9]

MODULE 2: CHEMICAL CHANGE

RATES OF REACTION

QUESTIONS SET 1

QUESTION 5

- 5.1 activation energy ✓
aktiveringsenergie (1)
- 5.2 5.2.1
- ⊖ negative marking
C → total area under graphs A and C more or less the same, but more molecules with greater average E_k therefore area X of graph C greater – more molecules with greater average E_k ✓
- ⊖ negatiewe merk
C → totale area onder grafieke A en C min of meer dieselfde, maar meer molekule met hoër gemiddelde E_k , dus is area X van grafiek C groter meer molekule met hoër gemiddelde E_k (2)
- 5.2.2
- Increased temperature therefore increased average kinetic energy of molecules ✓
 - More of these molecules will have sufficient kinetic energy ✓ to react
 - More effective collisions per second/unit time ✓
 - Increased rate of reaction ✓



5.3 5.3.1 A catalyst will speed up a chemical reaction ✓
without itself undergoing permanent change ✓ (2)

'n Katalisator versnel 'n chemiese reaksie
sonder dat dit self 'n permanente verandering ondergaan

5.3.2 INCREASES/NEEM TOE ✓  negative marking (1)

5.3.3 A catalyst will create an alternative path of lower activation energy ✓
"line Y" moves to the left ✓ – therefore area X increases in size.



QUESTION 1

1.1 Change in concentration of products / reactants ✓ per unit time. ✓ (2)

1.2
1.2.1 Temperature ✓ (1)

1.2.2 Rate of reaction / Volume of gas formed per unit time ✓ (1)

1.3

- Larger mass / amount / surface area. ✓
- More effective collisions per unit time. / More particles collide with sufficient kinetic energy & correct orientation per unit time. ✓✓ (3)

1.4 **Marking criteria**

Compare Exp.1 with Exp. 2:	The reaction in <u>exp. 1</u> is <u>faster</u> than in <u>exp. 2</u> due to the <u>higher acid concentration</u> .	✓
	Therefore the <u>gradient</u> of the graph representing <u>exp. 1</u> is <u>greater / steeper</u> than that of <u>exp. 2</u> .	✓
Compare Exp. 1 with Exp 3 & 4:	The reaction in <u>exp. 3</u> is <u>faster</u> than that in <u>exp. 1</u> due to the <u>higher temperature</u> .	✓
	The reaction in <u>exp. 4</u> is <u>faster</u> than that in <u>exp. 1</u> due to the <u>higher temperature / larger surface area</u> . OR Graph <u>A</u> represents <u>exp. 4</u> due to the <u>greater mass</u> of CaCO_3 - <u>greater yield</u> of CO_2 at a faster rate.	✓
	Therefore the <u>gradient</u> of the graphs of <u>exp. 3 & 4</u> are <u>greater/steeper</u> than that of <u>exp. 1</u> .	✓
Final answer	C	✓

(6)

1.5

Marking criteria:

- Divide volume by: 25,7 ✓
- Use ratio: $n(\text{CO}_2) = n(\text{CaCO}_3) = 1:1$ ✓
- Substitute 100 in $n = \frac{m}{M}$. ✓
- Subtraction. ✓
- Final answer: 7,00 g to 7,5 g ✓

$$\begin{aligned}
 n(\text{CO}_2) &= \frac{V}{V_m} \\
 &= \frac{4,5}{25,7} \checkmark \\
 &= 0,18 \text{ mol} \\
 n(\text{CaCO}_3) &= n(\text{CO}_2) = 0,18 \text{ mol} \checkmark \\
 n(\text{CaCO}_3) &= \frac{m}{M} \\
 0,18 &= \frac{m}{100} \therefore m(\text{CaCO}_3) = 18 \text{ g} \\
 m(\text{CaCO}_3) \text{ not reacted: } 25 - 18 \checkmark &= 7,00 \text{ g} \checkmark
 \end{aligned}$$

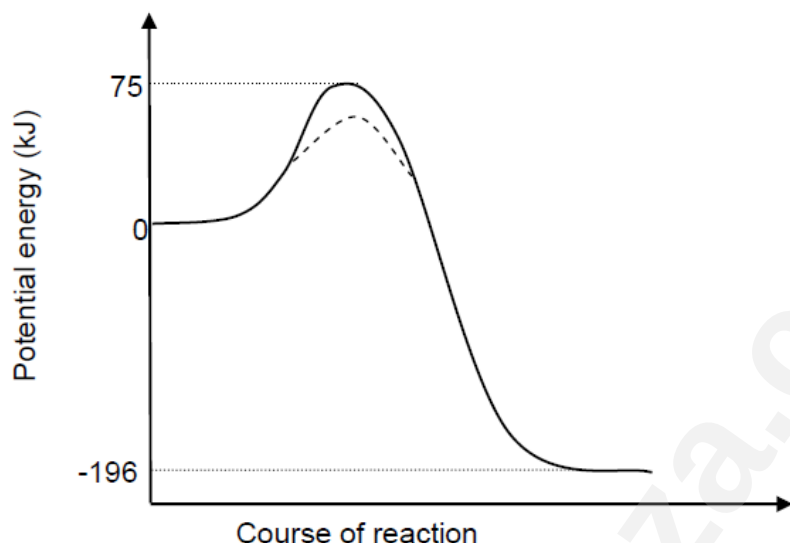
(5)
[18]

QUESTION 7

7.1

7.1.1 The minimum energy needed for a reaction to take place. ✓✓ (2)

7.1.2



Marking criteria:	
Shape of curve for exothermic reaction as shown.	✓
Energy of activated complex shown as 75 kJ in line with the peak.	✓
Energy of products shown as - 196 kJ below the zero.	✓
IF: Wrong shape, e.g. straight line.	0/3

(3)

7.1.3 **Marking criteria**

- Dotted line (---) on graph in QUESTION 7.1.2 showing lower energy for activated complex. ✓
- Dotted curve starts at/above energy of reactants and ends at/above energy of products on the inside of the original curve. ✓

(2)

7.1.4

- A catalyst provides an alternative pathway of lower activation energy. ✓
- More molecules have sufficient kinetic energy. ✓
- More effective collisions per unit time. ✓

(3)

7.2

7.2.1

$$\begin{aligned}
 \text{Ave rate} &= \frac{\Delta V}{\Delta t} \\
 &= \frac{52 - 16}{40 - 10} \checkmark \\
 &= 1,2 \text{ (dm}^3 \cdot \text{s}^{-1}) \checkmark
 \end{aligned}$$

(3)



7.2.2

Marking criteria:		
$V(\text{O}_2) = 60 \text{ dm}^3$ AND divide volume by 24. ✓ - Use ratio: $n(\text{H}_2\text{O}_2) = 2n(\text{O}_2) = 1:2$ ✓ - Use $34 \text{ g} \cdot \text{mol}^{-1}$ in $n = \frac{m}{M}$ or in ratio calculation. ✓ - Final answer: 170 g ✓		
OPTION 1	OPTION 2	OPTION 3
$n(\text{O}_2) = \frac{V}{V_M}$ $= \frac{60}{24} \checkmark$ $= 2,5 \text{ mol}$ $n(\text{H}_2\text{O}_2) = 2n(\text{O}_2)$ $= 2(2,5) \checkmark$ $= 5 \text{ mol}$ $n(\text{H}_2\text{O}_2) = \frac{m}{M}$ $\therefore 5 = \frac{m}{34} \checkmark$ $\therefore m = 170 \text{ g} \checkmark$	$24 \text{ dm}^3 : 1 \text{ mol}$ $60 \text{ dm}^3 : 2,5 \text{ mol} \checkmark$ $n(\text{H}_2\text{O}_2) = 2n(\text{O}_2)$ $= 2(2,5) \checkmark$ $= 5 \text{ mol}$ $34 \text{ g} \checkmark : 1 \text{ mol}$ $x : 5 \text{ mol}$ $x = 170 \text{ g} \checkmark$	$n(\text{O}_2) = \frac{V}{V_M}$ $= \frac{60}{24} \checkmark$ $= 2,5 \text{ mol}$ $n(\text{O}_2) = \frac{m}{M}$ $\therefore 2,5 = \frac{m}{32}$ $\therefore m = 80 \text{ g}$ $\checkmark$ $2(34) \text{ g} \checkmark \text{ H}_2\text{O}_2 \dots\dots\dots 32 \text{ g O}_2$ $x \text{ g H}_2\text{O}_2 \dots\dots\dots 80 \text{ g O}_2$ $m(\text{H}_2\text{O}_2) = 170 \text{ g} \checkmark$

(4)

7.2.3 Equal to ✓

(1)

7.3

7.3.1 Q ✓

(1)

7.3.2 P ✓

(1)

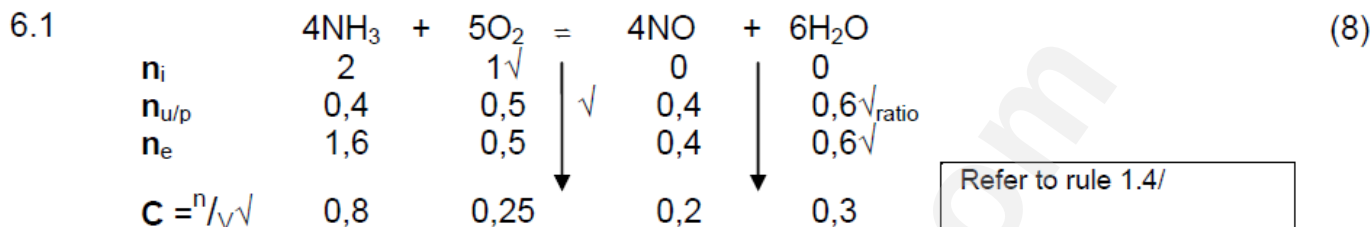
[20]



MODULE 3: CHEMICAL EQUILIBRIUM

QUESTIONS SET 1

QUESTION 6/VRAAG 6



Refer to rule 1.4/

Verwys na reël 1.4

$$K_c = \frac{[\text{H}_2\text{O}]^6 [\text{NO}]^4}{[\text{NH}_3]^4 [\text{O}_2]^5} \sqrt{}$$

$$= \frac{(0,3)^6 (0,2)^4}{(0,8)^4 (0,25)^5} \sqrt{} = 0,0029\sqrt{}$$

- $n_i(\text{NH}_3) = 2$ and $n_i(\text{O}_2) = 1$
- $n_e(\text{H}_2\text{O}) = 0.6$
- **USE** correct ratio (4:5:4:6)
GEbruik die regte verhouding (4:5:4:6)
- Add and subtract correctly.
Tel op en trek korrek af
- Calculate concentration ($n_e \div 2$ in every column)
Bereken die konsentrasie ($n_e \div 2$ in elke kolom)
- Correct K_c expression/ korrekte uitdrukking
- Substitution correct/Korrekte substitusie
- Answer correct/Korrekte antwoord



Option 2/Opsie 2

	4NH ₃	+ 5O ₂	⇌	4NO	+ 6H ₂ O
c _i	1	0,5√		0	0
c _{u/p}	0,2	0,25	↓	0,2	0,3√ ratio√
c _e	0,8	0,25 √		0,2	0,3√

$$K_c = \frac{[H_2O]^6 [NO]^4}{[NH_3]^4 [O_2]^5} \sqrt{ } = \frac{(0,3)^6 (0,2)^4}{(0,8)^4 (0,25)^5} \sqrt{ } = 0,0029\sqrt{ }$$

- Calculate concentration(n_e / 2 in every column)
- Bereken die konsentrasie (n_e / 2 in elke kolom)
- [NH₃] = 1 AND [O₂] = 0,5
- [H₂O] = 0,3 (+ marking)
- **USE** correct ratio (4:5:4:6)



GEBRUIK die regte verhouding (4:5:4:6)

- Add and subtract correctly (+marking)
Tel op en trek korrek af
- Correct Kc-expression/korrekte uitdrukking
- Substitution correct/Korrekte substitusie (+marking)
- Answer correct/Korrekte antwoord

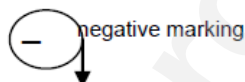
6.2 [products] < [reactants] ✓ **OR/OF** (1)
Incomplete forward rxn/onvolledige voorwaartse reaksie **OR/OF**
Low yield/Lae opbrengs

6.3 REMAIN THE SAME ✓/BLY DIESELFDE (1)

6.4 A decrease in pressure causes/n afname in druk veroorsaak (3)

- equilibrium to shift towards side with greater number of gas moles ✓
- ewewig verskuif na die kant met die groter hoeveelheid mol gas
- equilibrium shifts to the right (9 : 10) ✓ /forward reaction is favoured
- ewewig verskuif na regs (9:10)/ voorwaartse reaksie word bevoordeel
- Yield of NO increases ✓ / increased yield/toename in opbrengs
- Number of moles of NO increases/Aantal mol NO neem toe

6.5 negative ✓/negatief (1)



6.6

- decrease in temp favours exothermic reaction ✓
- increase in Kc implies greater [products] ✓
- forward reaction is favoured ✓ therefore
forward reaction is exothermic ✓



QUESTION 1

- 1.1 The stage in a chemical reaction when the rate of forward reaction equals the rate of reverse reaction. ✓✓

OR

The stage in a chemical reaction when the concentrations of reactants and products remain constant.

(2)

1.2 CALCULATIONS USING NUMBER OF MOLES

- Correct K_c expression (formulae in square brackets). ✓
- Substitution of concentrations into K_c expression. ✓
- Substitution of K_c value. ✓
- Equilibrium concentration of both NO_2 & N_2O_4 multiplied by $0,08 \text{ dm}^3$. ✓
- Change in $n(\text{N}_2\text{O}_4) = \text{equilibrium } n(\text{N}_2\text{O}_4) - \text{initial } n(\text{N}_2\text{O}_4)$ ✓
- **USING** ratio: $\text{NO}_2 : \text{N}_2\text{O}_4 = 2 : 1$ ✓
- Initial $n(\text{NO}_2) = \text{equilibrium } n(\text{NO}_2) + \text{change } n(\text{NO}_2)$. ✓
- Final answer: $1,11 \text{ (mol)}$ ✓

OPTION 1

$$K_c = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2} \quad \checkmark$$

$$171 \checkmark = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2} \quad \checkmark$$

$$\therefore [\text{N}_2\text{O}_4] = 171 \times (0,2)^2 \\ = 6,84 \text{ mol} \cdot \text{dm}^{-3}$$

	NO_2	N_2O_4
Initial quantity (mol)	1,11 ✓	0
Change (mol) subtract ✓	1,094	0,55 ✓
Quantity at equilibrium (mol)/	0,016	0,55
Equilibrium concentration ($\text{mol} \cdot \text{dm}^{-3}$)	0,2	6,84

ratio ✓

$\times 0,08 \checkmark$

OPTION 2

$$K_c = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2} \quad \checkmark$$

$$171 \checkmark = \frac{[\text{N}_2\text{O}_4]}{(0,2)^2} \quad \checkmark$$

$$\therefore [\text{N}_2\text{O}_4] = 171 \times (0,2)^2 \\ = 6,84 \text{ mol} \cdot \text{dm}^{-3}$$

Equilibrium moles:

$$\left. \begin{aligned} n(\text{N}_2\text{O}_4) &= (6,84)(0,080) \\ &= 0,55 \text{ mol} \\ n(\text{NO}_2) &= (0,2)(0,080) \\ &= 0,016 \text{ mol} \end{aligned} \right\} \checkmark \times 0,08 \text{ dm}^3$$

$$n(\text{N}_2\text{O}_4 \text{ formed}) = 0,55 - 0 = 0,55 \text{ mol} \quad \checkmark$$

Ratio:

$$n(\text{NO}_2 \text{ reacted}) = 2n(\text{N}_2\text{O}_4 \text{ formed}) = 2(0,55) = 1,094 \text{ mol} \quad \checkmark$$

$$\text{Initial } n(\text{NO}_2) = 0,016 + 1,094 \checkmark = 1,11 \text{ (mol)} \quad \checkmark$$

(8)

1.3

- 1.3.1 Concentration (of the gases) increases. / Molecules become more condensed or move closer to each other. ✓

(1)



- 1.3.2
- Increase in pressure favours the reaction that leads to smaller number of moles of gas. ✓
 - Forward reaction is favoured. ✓
 - Number of moles/amount of N_2O_4 / colourless gas increases. ✓
OR Number of moles/amount of NO_2 / brown gas decreases. ✓
- (3)
- 1.4
- 1.4.1 Darker ✓ (1)
- 1.4.2 Decreases ✓ (1)
- [16]

QUESTION 4

4.1 Equal to ✓ (1)

4.2
$$K_c = \frac{[X_3]^2}{[X_2]^3} \checkmark$$

$$= \frac{(0,226)^2}{(0,06)^3} \checkmark$$

$$= 236,46 \checkmark$$
 (4)

4.3 (1)

4.3.1 Increases ✓

4.3.2

- The increase in $[X_3]$ is opposed. / Change is opposed. ✓
- The reverse reaction is favoured. / X_3 is used. / $[X_3]$ decreases. ✓

 (2)

4.4 Higher than ✓ (1)

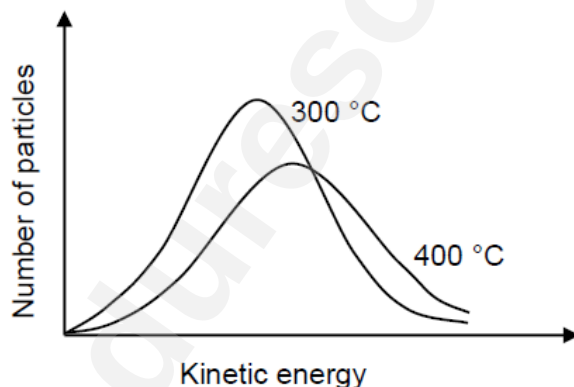
4.5 Exothermic ✓

- The concentration of the product / $X_3(g)$ is lower. / The concentration of the reactant / $X_2(g)$ is higher. ✓
- The increase in temperature favoured the reverse reaction. ✓
- According to Le Chatelier's principle an increase in temperature favours the endothermic reaction. ✓

OR

- $[X_3]$ decreases and $[X_2]$ increases. ✓
 - K_c decreases if temperature increases. ✓
 - Decrease in temperature favoured the forward reaction. ✓
- (4)

4.6



Marking criteria	
Peak of curve at 400 °C lower than at 300 °C and shifted to the right.	✓
Curve at 400 °C has larger area at the higher E_k .	✓

(2)
[15]



MODULE 4: ACIDS AND BASES

QUESTIONS SET 1

QUESTION 7 (Start on a new page.)

7.1 complete ionisation in solution ✓ to produces a high concentration of H_3O^+ -ions in solution ✓

volledige ionisasie in oplossing en lewer 'n hoë konsentrasie H_3O^+ (2)

7.2 7.2.1 $pH = 3 \therefore pH = -\log [H^+] \checkmark$
 $3 = -\log [H^+]$
 $[H^+] = 10^{-3} \text{ mol} \cdot \text{dm}^{-3} \checkmark$ OR/OF $pH=3 \therefore [H^+] = 10^{-3} \text{ mol} \cdot \text{dm}^{-3}$ (2)

7.2.2 Weaker than HCl ✓  negative marking
Swakker as HCl (1)

7.2.3 $[H^+] = 10^{-3} \text{ mol} \cdot \text{dm}^{-3}$ which is less than the $[H^+] = 10^{-2} \text{ mol} \cdot \text{dm}^{-3}$ of HCl ✓
 $\therefore$ acid not ionised completely ✓ therefore weaker than HCl

OR

$pH = 3$ is greater than $pH = 2$ for the same concentration of HCl
 (Higher pH implies weaker acid)

7.3 7.3.1 Reaction of a salt ✓ with water ✓ / reaksie van 'n sout ✓ met water ✓ (2)

7.3.2 ✓ ✓ ✓
 $NH_4Cl + H_2O \rightarrow NH_3 + H_3O^+ + Cl^-$

OR/OF

$NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$ (3)

7.3.3 red ✓✓ / rooi (2)



7.4 Consider reaction 2/Beskou reaksie 2

$$\begin{aligned} n_a &= c_a \cdot V_a \checkmark \\ n_b &= c_b \cdot V_b \checkmark \\ \therefore \frac{1}{2} \checkmark &= \frac{(1) \cdot V_a}{(0,5) \cdot 28} \checkmark \\ V_a &= 7 \text{ cm}^3 \checkmark \end{aligned}$$

$$\begin{aligned} V_a &= 7 \text{ cm}^3 \text{ used in reaction 2} \\ \therefore V_a &= (50-7) = 43 \text{ cm}^3 \text{ used in reaction 1 } \checkmark \end{aligned}$$

Consider reaction 1/Beskou reaksie 1

$$\begin{aligned} n_a &= C_a V_a = (1)(0,043) = 0,043 \checkmark \text{ mol } \text{H}_2\text{SO}_4 \\ n_{\text{H}_2\text{SO}_4} &= n_{\text{CaCO}_3} = 0,043 \text{ mol } \checkmark \text{ (ratio 1:1)} \\ \therefore m_{\text{CaCO}_3} &= nM \checkmark \\ &= (0,043)(40 + 12 + 3(16)) \checkmark \\ &= \underline{4,3\text{g}} \checkmark \end{aligned}$$

OR/OF

Consider reaction 2/Beskou reaksie 2

$$\begin{aligned} n_{\text{NaOH}} &= cV \checkmark \\ (0,5)(0,028) &= 0,014 \text{ mol NaOH } \checkmark \\ 2n_{\text{H}_2\text{SO}_4} : n_{\text{NaOH}} \checkmark &\Rightarrow 0,007 \text{ mol } \text{H}_2\text{SO}_4 \checkmark \text{ (ratio 2:1)} \\ V_{\text{H}_2\text{SO}_4} &= \frac{n}{c} = \frac{0,007}{1} = 0,007 \text{ dm}^3 \checkmark \end{aligned}$$

Consider reaction 1/Beskou reaksie 1

$$\begin{aligned} V_{\text{H}_2\text{SO}_4} \text{ reacting with } \text{CaCO}_3 &= 0,05 - 0,007 \text{ dm}^3 = 0,043 \text{ dm}^3 \checkmark \\ n_{\text{H}_2\text{SO}_4} \text{ reacting with } \text{CaCO}_3 &= cV \\ &= (1)(0,043) \\ &= 0,043 \text{ mol } \checkmark \\ n_{\text{H}_2\text{SO}_4} &= n_{\text{CaCO}_3} = 0,043 \text{ mol } \checkmark \text{ (ratio 1:1)} \\ m_{\text{CaCO}_3} &= nM \checkmark = (0,043)(100) \checkmark = \underline{4,3 \text{ g}} \end{aligned}$$

OR/OF

Consider reaction 2/Beskou reaksie 2

$$\begin{aligned} n_{\text{NaOH}} &= cV \checkmark \\ (0,5)(0,028) &= 0,014 \text{ mol } \checkmark \text{ NaOH} \\ 2n_{\text{H}_2\text{SO}_4} \text{ excess} &= n_{\text{NaOH}} \checkmark = 0,007 \text{ mol } \checkmark \text{ (ratio 2:1)} \end{aligned}$$

Consider reaction 1/ Beskou reaksie 1

$$\begin{aligned} n_{\text{H}_2\text{SO}_4} \text{ total} &= cV = 1(0,05) = 0,05 \text{ mol } \checkmark \\ n_{\text{H}_2\text{SO}_4} \text{ reacting with } \text{CaCO}_3 &= 0,05 - 0,007 \\ &= 0,043 \text{ mol } \checkmark \\ n_{\text{H}_2\text{SO}_4} &= n_{\text{CaCO}_3} = 0,043 \text{ mol } \checkmark \text{ (ratio 1:1)} \\ m_{\text{CaCO}_3} &= nM \checkmark = (0,043)(100) \checkmark = \underline{4,3 \text{ g}} \checkmark \end{aligned}$$

(10)
[24]



QUESTION 1

- 1.1
1.1.1 Ionises / dissociates completely in water. ✓ (1)
1.1.2 NO_3^- / Nitrate ion ✓ (1)
1.1.3 $\text{pH} = -\log[\text{H}_3\text{O}^+] / -\log[\text{H}^+] \checkmark = -\log(0,3) \checkmark = 0,52 \checkmark$ (3)
1.2
1.2.1 $c = \frac{n}{V} \checkmark$
 $2 = \frac{n}{0,1} \checkmark$
 $\therefore n(\text{HCl}) = 0,2 \text{ mol} \checkmark$ (3)
1.2.2 Burette ✓ (1)
1.2.3 B ✓
Titration of strong acid and strong base. ✓✓ (3)
1.2.4 The number of moles of acid in the flask remains constant. ✓ (1)
1.2.5 $c = \frac{n}{V} \checkmark \therefore 0,2 = \frac{n}{0,021} \checkmark \therefore n = 4,2 \times 10^{-3} \text{ mol} \checkmark$
 $n(\text{HCl})_{\text{excess}} = n(\text{NaOH}) = 4,2 \times 10^{-3} \text{ mol}$ (3)
1.2.6 **POSITIVE MARKING FROM QUESTION 1.2.1 AND 1.2.5.**

Marking criteria:

- $n(\text{HCl reacted}) = \text{initial (from Q1.2.1)} - \text{excess (from Q1.2.5).} \checkmark$
- Use mol ratio of acid: base = 2 : 1. ✓
- Substitute 40 into $n = \frac{m}{M} \checkmark$
- $\frac{m(\text{MgO})_{\text{reacted}}}{4,5} \times 100 \checkmark$
- Final answer: 87,11 % ✓

OPTION 1

$$n(\text{HCl reacted}):$$

$$0,2 - 4,2 \times 10^{-3} \checkmark = 0,196 \text{ mol}$$

$$n(\text{MgO reacted}):$$

$$\frac{1}{2}n(\text{HCl}) = \frac{1}{2}(0,196)$$

$$= 9,8 \times 10^{-2} \text{ mol} \checkmark$$

$$n(\text{MgO reacted}) = \frac{m}{M}$$

$$\therefore 0,098 = \frac{m}{40} \checkmark$$

$$\therefore m = 3,92 \text{ g}$$

$$\% \text{ purity} = \frac{3,92}{4,5 \times 100} \checkmark$$

$$= 87,11\% \checkmark$$

OPTION 2

$$n(\text{HCl reacted}):$$

$$0,2 - 4,2 \times 10^{-3} \checkmark = 0,196 \text{ mol}$$

$$n(\text{HCl reacted}) = \frac{m}{M}$$

$$0,196 = \frac{m}{36,5}$$

$$\therefore m(\text{HCl reacted}) = 7,154 \text{ g}$$

$$40 \text{ g MgO} \checkmark \dots\dots\dots 73 \text{ g HCl} \checkmark$$

$$x \text{ g MgO} \dots\dots\dots 7,154 \text{ g}$$

$$\therefore x = 3,92 \text{ g}$$

$$\% \text{ purity} = \frac{3,92}{4,5 \times 100} \checkmark$$

$$= 87,11\% \checkmark$$

(5)
[21]



QUESTION 7

7.1

7.1.1 Hydrolysis is the reaction of a salt with water. ✓✓ (2)

7.1.2 Smaller than (7) ✓

• $\text{NH}_4^+ + \text{H}_2\text{O} \checkmark \rightarrow \text{NH}_3 + \text{H}_3\text{O}^+ \checkmark$ (3)

7.2

7.2.1

Marking guidelines:

- Substitution of $98 \text{ g} \cdot \text{mol}^{-1}$. ✓
- Final answer: $0,08 \text{ mol}$ ✓

OPTION 1

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

$$= \frac{7,35}{98}$$

$$= 0,08 \text{ mol} \checkmark \quad (0,075 \text{ mol})$$

OPTION 2

$$98 \text{ g} \checkmark : 1 \text{ mol}$$

$$7,35 : 0,08 \text{ mol} \checkmark$$

OPTION 3

$$c = \frac{m}{MV}$$

$$= \frac{7,35}{98 \times 0,5}$$

$$= 0,15 \text{ mol} \cdot \text{dm}^{-3}$$

$$n = cV$$

$$= 0,15 \times 0,5$$

$$= 0,08 \text{ mol} \checkmark$$

(2)

7.2.2

POSITIVE MARKING FROM QUESTION 7.2.1.

OPTION 1

$$\text{pH} = -\log[\text{H}_3\text{O}^+] \checkmark$$

$$1,3 \checkmark = -\log[\text{H}_3\text{O}^+] \checkmark$$

$$[\text{H}_3\text{O}^+] = 0,05 \text{ mol} \cdot \text{dm}^{-3}$$

$$[\text{H}_2\text{SO}_4] = \frac{1}{2}[\text{H}_3\text{O}^+] \checkmark$$

$$= \frac{1}{2} \times 0,05 \checkmark$$

$$= 0,025 \text{ mol} \cdot \text{dm}^{-3}$$

$$n(\text{H}_2\text{SO}_4)_{\text{excess}} = cV \checkmark$$

$$= 0,025 \times 0,5 \checkmark$$

$$= 0,0125 \text{ mol}$$

$$n(\text{H}_2\text{SO}_4)_{\text{react}} = 0,075 - 0,0125 \checkmark$$

$$= 0,0625 \text{ mol}$$

$$n(\text{NaOH}) = 2n(\text{H}_2\text{SO}_4)$$

$$= 2 \times 0,0625 \checkmark$$

$$= 0,125 \text{ mol}$$

$$n(\text{NaOH}) = \frac{m}{M}$$

$$\therefore 0,125 = \frac{m}{40} \checkmark$$

$$m = 5 \text{ g} \checkmark$$

OR

Marking guidelines:

- Formula: $\text{pH} = -\log[\text{H}_3\text{O}^+] \checkmark$
- Substitution of 1,3 ✓
- Use $[\text{H}_2\text{SO}_4] : [\text{H}_3\text{O}^+] = 1 : 2 \checkmark$
- Formula: $c = \frac{n}{V} \checkmark$
- Multiply by $0,5 \text{ dm}^3 \checkmark$
- Subtract $n_{\text{initial}} - n_{\text{excess}} \checkmark$
- Use $n(\text{NaOH}) : n(\text{H}_2\text{SO}_4) = 2:1 \checkmark$
- Substitution of $40 \text{ g} \cdot \text{mol}^{-1} \checkmark$
- Final answer: $m = 5 \text{ g} \checkmark$
- Range: 4,8 – 5,6 g

$$1 \text{ mol} : 40 \text{ g} \checkmark$$

$$0,125 \text{ mol} : 5 \text{ g} \checkmark$$



OPTION 2

Q7.2.1

$$[\text{H}_2\text{SO}_4]_{\text{in}} = \frac{n}{V} \checkmark$$

$$= \frac{0,075}{0,5} \checkmark$$

$$= 0,15 \text{ mol} \cdot \text{dm}^{-3}$$

$$[\text{H}_3\text{O}^+]_{\text{initially}} = 2[\text{H}_2\text{SO}_4]$$

$$= 2 \times 0,15 \checkmark$$

$$= 0,3 \text{ mol} \cdot \text{dm}^{-3}$$

$$\text{pH} = -\log[\text{H}_3\text{O}^+] \checkmark$$

$$1,3 \checkmark = -\log[\text{H}_3\text{O}^+] \checkmark$$

$$[\text{H}_3\text{O}^+] = 0,05 \text{ mol} \cdot \text{dm}^{-3}$$

$$[\text{H}_3\text{O}^+]_{\text{react}} = 0,3 - 0,05 \checkmark$$

$$= 0,25 \text{ mol} \cdot \text{dm}^{-3}$$

$$[\text{H}_2\text{SO}_4]_{\text{react}} = \frac{1}{2}[\text{H}_3\text{O}^+] \checkmark$$

$$= \frac{1}{2} \times 0,25 \checkmark$$

$$= 0,125 \text{ mol} \cdot \text{dm}^{-3} \text{ (0,14)}$$

OR

Marking guidelines:

- Formula: $c = \frac{n}{V} \checkmark$
- Divide by $0,5 \text{ dm}^3 \checkmark$
- Use $[\text{H}_3\text{O}^+] : [\text{H}_2\text{SO}_4] = 2:1 \checkmark$
- Formula: $\text{pH} = -\log[\text{H}_3\text{O}^+] \checkmark$
- Substitution of $1,3 \checkmark$
- Subtract $[\text{H}_3\text{O}^+]_{\text{initial}} - [\text{H}_3\text{O}^+]_{\text{excess}} \checkmark$
- Use $n(\text{NaOH}) : n(\text{H}_2\text{SO}_4) = 2:1 \checkmark$
- OR
- Use $[\text{H}_2\text{SO}_4] : [\text{NaOH}] = 1 : 2 \checkmark$
- Substitution of $40 \text{ g} \cdot \text{mol}^{-1} \checkmark$
- Final answer: $m = 5 \text{ g} \checkmark$
- Range: $4,8 - 5,6 \text{ g}$

$$n(\text{H}_2\text{SO}_4)_{\text{react}} = cV$$

$$= (0,125)(0,5)$$

$$= 0,0625 \text{ mol}$$

$$n(\text{NaOH}) = 2n(\text{H}_2\text{SO}_4)$$

$$= 2 \times 0,0625 \checkmark$$

$$= 0,125 \text{ mol}$$

$$n(\text{NaOH}) = \frac{m}{M}$$

$$0,125 = \frac{m}{40} \checkmark$$

$$\therefore m = 5 \text{ g} \checkmark$$

$$[\text{H}_2\text{SO}_4] : [\text{NaOH}]$$

$$1 : 2$$

$$0,125 : 0,25 \checkmark$$

$$m = cMV$$

$$= 0,25 \times 40 \checkmark \times 0,5$$

$$= 5 \text{ g} \checkmark$$

(9)
[16]



MODULE 5: ELECTROCHEMICAL CELLS

ELECTROLYTIC CELLS

QUESTIONS SET 1

QUESTION 1

- 1.1 Electrolytic ✓ (1)
- 1.2 Q ✓ & T ✓
 $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ ✓✓ (4)
- 1.3
1.3.1 Cl_2 / chlorine gas ✓ (1)
- 1.3.2 Cu^{2+} ions / copper(II) ions / CuCl_2 / copper(II) chloride ✓ (1)
- 1.4 Cu is a stronger reducing agent ✓ than Cl^- ions ✓ and Cu will be oxidised ✓ to Cu^{2+} .
OR
 Cl^- ions is a weaker reducing agent ✓ than Cu ✓ and Cu will be oxidised ✓ to Cu^{2+} . (3)
[10]

QUESTION 4

- 4.1 **ANY ONE:**
• The chemical process in which electrical energy is converted to chemical energy. ✓✓
• The use of electrical energy to produce a chemical change.
• The process during which an electric current passes through a solution / molten ionic compound. (2)
- 4.2 **ANY ONE:**
• To keep the polarity of the electrodes constant. ✓
• To prevent the anode and cathode from swapping.
• DC provides a one way flow of electrons ensuring that the same chemical reaction occurs all the time at the same electrodes. (1)
- 4.3 $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$ ✓✓ (2)
- 4.4 • Cu^{2+} is a stronger oxidising agent ✓ than Zn^{2+} . ✓
• Cu^{2+} will be reduced to Cu. ✓
OR
• Zn is a stronger reducing agent than Cu.
• Cu^{2+} will be reduced to Cu. (3)



QUESTION 5

- 5.1 Electrolytic cell ✓ (1)
- 5.2 The substance/species which loses electrons. ✓✓ (2)
- 5.3 P ✓ (1)
- 5.4 $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$ ✓✓ (2)
- 5.5 A ✓
 Cl^- ions move to the positive electrode / anode where they are oxidised to Cl_2 . ✓✓ (3)
- [12]

GALVANIC CELLS
QUESTIONS SET 1

QUESTION 8

- 8.1 8.1.1
- Oxalic acid half-reaction has a lower E^θ value than the dichromate half reaction ✓
 - dichromate ions are therefore the strongest oxidising agents ✓
 - and will therefore be reduced ✓ while oxalic acid is oxidized

OR

- Oxalic acid half-reaction has a lower E^θ value than the dichromate half reaction ✓
- oxalic acid molecules will therefore be the strongest reducing agents ✓
- and will therefore be oxidised while dichromate ions are reduced ✓

OR

$$E^\theta_{\text{cell}} = E^\theta_{\text{oxidising agent}} - E^\theta_{\text{reducing agent}}$$

$$= (1,33) - (-0,49)$$

$$= + \text{ (positive) } 1,82 \text{ V}$$

- Oksaalsuur half-reaksie het 'n laer E^θ waarde as die dichromaat half-reaksie*
- dichromaat ione is dus sterkste oksideermiddels en sal dus*
- gereduseer word terwyl oksaalsuur geoksideer word*

OF

- Oksaalsuur half-reaksie het 'n laer E^θ waarde as die dichromaat half-reaksie*
- Oksaalsuurmolekule is dus sterkste reduseermiddels en sal*
- dus geoksideer word terwyl dichromaatione gereduseer word*

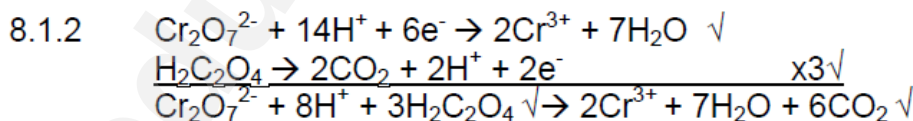
OF

$$E^\theta_{\text{sel}} = E^\theta_{\text{oksideermiddel}} - E^\theta_{\text{reduseermiddel}}$$

$$= (1,33) - (-0,49)$$

$$= + \text{ (positief) } 1,82 \text{ V}$$

(3)



-1 for charges omitted/
-1 as lading uitgelaat is

-1 for/vir ⇌

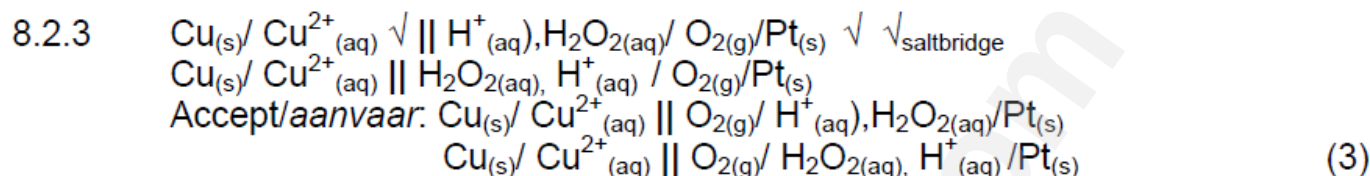
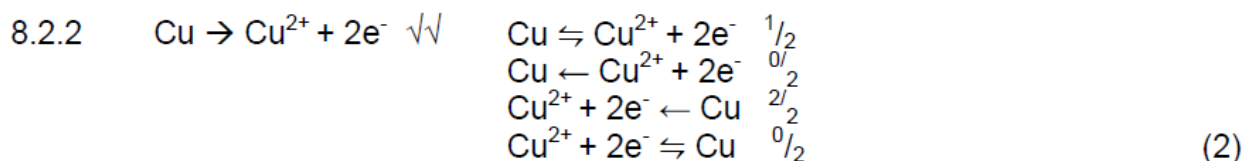
-1 for additional reactants/products

-1 vir addisionele reaktante/produkte

(4)



8.2 8.2.1 B ✓✓ (2)



8.2.4 $E^{\theta}_{\text{cell}} = E^{\theta}_{\text{cathode/katode}} - E^{\theta}_{\text{anode}}$ ✓

$= 0,68 \text{ V} - (0,34 \text{ V})$ ✓

$= 0,34 \text{ V}$ ✓

OR any other formula from datasheet/ OF enige ander formule van inligtingsblaaie af

-1 for using unconventional abbreviations/ onkonvensionele afkortings gebruik (4)

8.2.5 decrease in V_{cell} as [product ions] increase ✓

and [reactant ions] decrease ✓

rate of forward reaction decrease while rate of reverse reaction increase ✓

$V_{\text{cell}} = 0$ and no current flows when dynamic equilibrium is reached i.e. when rate of forward reaction = rate of reverse reaction ✓

afname in V_{sel} as [produk ione] toeneem

[reaktant ione] afneem

reaksietempo vir voorwaartse reaksie neem af terwyl reaksietempo vir terugwaartse reaksie toeneem

$V_{\text{sel}} = 0$ en geen stroom vloei meer nie sodra dinamiese ewewig ingestel word, dus as reaksietempo van voorwaartse reaksie = reaksietempo van terugwaartse reaksie

(4)
[22]



QUESTION 1

- 1.1
- Pressure: 1 atmosphere (atm) / 101,3 kPa / $1,013 \times 10^5$ Pa ✓
 - Temperature: 25 °C / 298 K ✓
- (2)
- 1.2
- Platinum is inert / does not react with the H^+ ions OR acid. ✓
 - Platinum is a conductor (of electricity). ✓
- (2)
- 1.3
- 1.3.1 Salt bridge ✓ (1)
- 1.3.2 -0,31 V ✓ (1)
- 1.3.3 $2H^+ + 2e^- \rightarrow H_2$ ✓✓ (2)
- 1.4
- 1.4.1 **POSITIVE MARKING FROM QUESTION 1.3.2.**
- $$E_{\text{cell}}^{\theta} = E_{\text{reduction}}^{\theta} - E_{\text{oxidation}}^{\theta} \quad \checkmark$$
- $$2,05 \checkmark = -0,31 \checkmark - E_{M/M^{2+}}^{\theta}$$
- $$E_{M/M^{2+}}^{\theta} = -2,36 \text{ (V)} \quad \checkmark$$
- M is magnesium/ Mg. ✓ (5)
- 1.4.2 Exothermic ✓ (1)
- 1.5 The cell reaction reaches equilibrium. ✓ (1)
- [15]

QUESTION 2

- 2.1 A substance that is being reduced. ✓✓
OR
A substance that gains/accepts electrons.
OR
A substance whose oxidation number decreases. (2)
- 2.2 Ag^+ is a stronger oxidising agent ✓ than Cu^{2+} ✓ and will oxidise Cu ✓ to (blue) Cu^{2+} ions. ✓
OR
 Cu^{2+} is a weaker oxidising agent ✓ than Ag^+ ✓ and Cu will be oxidised ✓ to Cu^{2+} ions. ✓ (4)
- 2.3 Chemical energy to electrical energy ✓ (1)
- 2.4 A ✓ (1)
- 2.5 $E_{\text{cell}}^{\theta} = E_{\text{reduction}}^{\theta} - E_{\text{oxidation}}^{\theta} \quad \checkmark$
 $= +0,80 \checkmark - 0,34 \checkmark$
 $= +0,46 \text{ V} \quad \checkmark$ (4)
- 2.6 $Cu + 2Ag^+(aq) \checkmark \rightarrow Cu^{2+}(aq) + 2Ag(s) \checkmark$ Balancing ✓ (3)
- 2.7 Remains the same ✓ (1)
- [16]