basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: CHEMISTRY (P2)

MAY/JUNE 2024

MARKS: 150

TIME: 3 hours

This question paper consists of 16 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

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

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

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

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

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

6. You may use a non-programmable calculator.

7 Show ALL formulae and substitutions in ALL calculations.

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

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

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

11. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

1.1 The functional group for an ALDEHYDE is a …

A formyl group.

B carboxyl group.

C carbonyl group.

D hydroxyl group. (2)

1.2 Which ONE of the following equations represents the reaction for the IDENTIFICATION of an UNSATURATED organic compound in the laboratory?

A $CH_3CH_2CH_2CHCH_2 + H_2 \rightarrow CH_3CH_2CH_2CH_2CH_3$

B $CH_3CH_2CH_2CHCH_2 + HBr \rightarrow CH_3CH_2CH_2CHBrCH_3$

C $CH_3CH_2CH_2CHCH_2 + Br_2 \rightarrow CH_3CH_2CH_2CHBrCH_2Br$

D $CH_3CH_2CH_2CH_2CH_3 + Br_2 \rightarrow CH_3CH_2CH_2CH_2CH_2Br + HBr$ (2)

1.3 Which ONE of the following is the EMPIRICAL formula of ethyl ethanoate?

A C_2H_4O

B C_2H_2O

C C_4H_8O

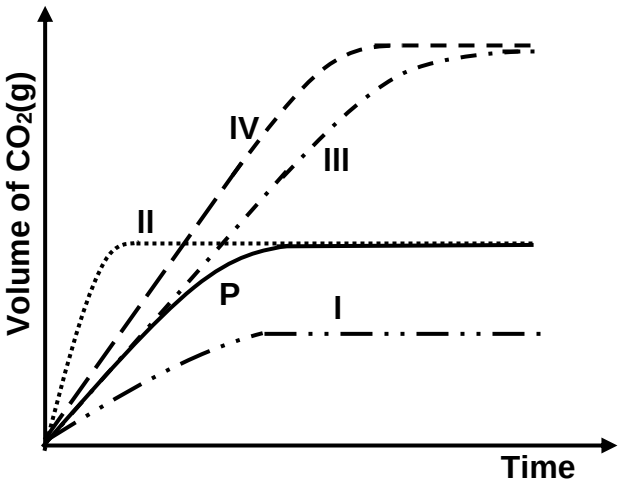
D $C_4H_8O_2$ (2)

1.4 In an experiment 5 g of calcium carbonate, $CaCO_3(s)$, reacts with EXCESS hydrochloric acid, $HC\ell(aq)$, at a temperature of 40 °C.

$$CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g)$$

The volume of $CO_2(g)$ produced versus time is shown by CURVE **P** in the graph below.

The experiment is repeated with 10 g of the same $CaCO_3(s)$ sample and an excess of $HC\ell(aq)$ with the same concentration at 40 °C. Which ONE of the curves will now be obtained?



A Curve **I**

B Curve **II**

C Curve **III**

D Curve **IV** (2)

1.5 The balanced equation below represents a reaction at equilibrium.

$$\underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H_3O^+(aq) \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + 3H_2O(\ell)$$

Which statement(s) is/are TRUE when a few drops of concentrated hydrochloric acid, HCℓ(conc), are added to the mixture?

(i) The reverse reaction will be favoured.
(ii) The concentration of $Cr_2O_7^{2-}(aq)$ increases.
(iii) The colour of the solution changes from yellow to orange.

A (i) only

B (i) and (ii) only

C (i) and (iii) only

D (ii) and (iii) only (2)

1.6 Consider the equation below for a hypothetical reaction.

$$A(aq) + B(s) \rightleftharpoons C(aq) + D(aq)$$

If the equilibrium constant $K_c = 1 \times 10^{-4}$, then …

A [A][B] < [C][D]

B [A][B] > [C][D]

C [A] > [C][D]

D [A] < [C][D] (2)

1.7 Which ONE of the following shows the PRODUCTS for the reaction of oxalic acid with sodium hydroxide?

A $(COO)_2Na_2(aq) + H_2O(\ell) + CO_2(g)$

B $(COO)_2Na_2(aq) + H_2O(\ell)$

C $CH_3COONa(aq) + H_2O(\ell)$

D $CH_3COONa(aq) + H_2O(\ell) + CO_2(g)$ (2)

1.8 Four solutions of different acids of the same concentration are compared.

Which ONE of the following K_a values represents the WEAKEST acid at 25 °C?

A $4,5 \times 10^{-6}$

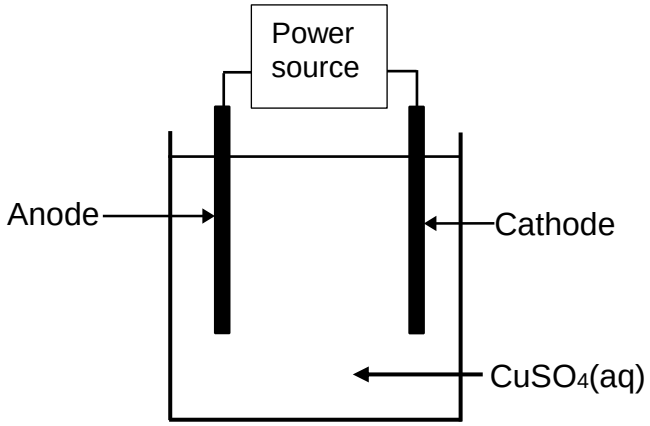
B $2,5 \times 10^{-5}$

C $1,8 \times 10^{-2}$

D $6,5 \times 10^{-2}$ (2)

1.9 Copper is purified by electrolysis.

Which ONE of the following combinations is CORRECT for the changes occurring at the anode, cathode and in the electrolyte when the cell is in operation?



	MASS OF THE ANODE	MASS OF THE CATHODE	COLOUR OF THE ELECTROLYTE
A	Increases	Decreases	No change
B	Decreases	Increases	No change
C	Increases	Decreases	Becomes darker
D	Decreases	Increases	Becomes lighter

(2)

1.10 Which ONE of the following redox reactions is SPONTANEOUS under standard conditions?

A $Br_2 + 2C\ell^- \rightarrow 2Br^- + C\ell_2$

B $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$

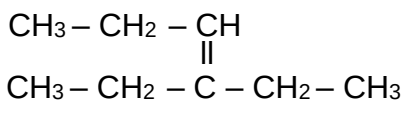
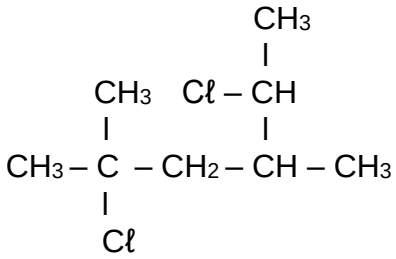
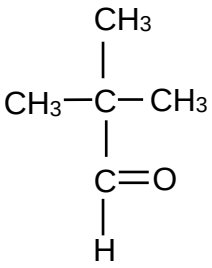
C $Ni^{2+} + H_2 \rightarrow Ni + 2H^+$

D $Cu + Pb^{2+} \rightarrow Cu^{2+} + Pb$ (2)

[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **H** in the table below represent eight organic compounds.

A	Butan-2-ol	**B**	$CH_3C(CH_3)_2(CH_2)_2CH_3$
C	3-ethylpent-1-yne	**D**	$CH_3CH_2CH_2CH_2CHO$
E		**F**	Butan-1-ol
G		**H**	

2.1 Define the term *hydrocarbon*. (2)

2.2 Write down the letter(s) for:

2.2.1 TWO compounds that are UNSATURATED hydrocarbons (1)

2.2.2 TWO compounds that are CHAIN ISOMERS of each other (2)

2.2.3 A secondary alcohol (1)

2.3 Write down the:

2.3.1 STRUCTURAL formula of the FUNCTIONAL ISOMER of compound **D** (2)

2.3.2 General formula of the homologous series to which compound **B** belongs (1)

2.3.3 STRUCTURAL formula of compound **C** (2)

2.4 Write down the IUPAC name of compound:

2.4.1 **E** (3)

2.4.2 **G** (3)

2.4.3 **H** (2)

2.5 Compound **B** undergoes complete combustion. Using MOLECULAR FORMULAE, write down the balanced equation for this reaction. (3)

[22]

QUESTION 3 (Start on a new page.)

The boiling points of some organic compounds are shown in the table below. The atmospheric pressure is 101,3 kPa.

	ORGANIC COMPOUND	BOILING POINT (°C)
A	$CH_3CH_2CH_2CH_2C\ell$	78
B	$CH_3CH(CH_3)CH_2C\ell$	46
C	$CH_3CH_2CH_2CH_2OH$	118
D	$CH_3CH_2CH_2CHO$	**X**

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

3.2 Which ONE of compounds **A**, **B** or **C** is mainly in the liquid phase at 100 °C? (1)

3.3 Explain the difference in the boiling points of compounds **A** and **B**. (3)

3.4 Consider the boiling points below.

75 °C	120 °C	126 °C

3.4.1 Which ONE of these values represents **X**, the boiling point of compound **D**? (1)

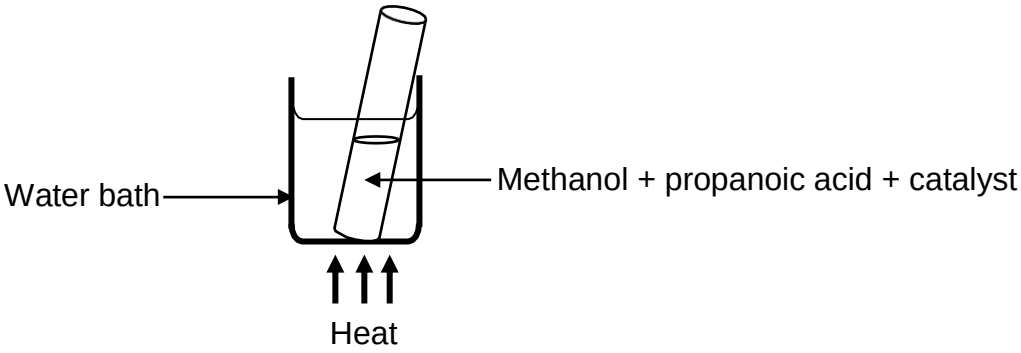
3.4.2 Fully explain the answer to QUESTION 3.4.1. (2)

3.5 The atmospheric pressure is now changed to 83 kPa.

How will the boiling points of these organic compounds be affected? Choose from INCREASE, DECREASE or REMAIN THE SAME. (1)
[10]

QUESTION 4 (Start on a new page.)

4.1 In an experiment, a test tube containing methanol, propanoic acid and a catalyst is heated in a water bath.



Write down:

4.1.1 The NAME or FORMULA of the catalyst (1)

4.1.2 The type of reaction taking place (1)

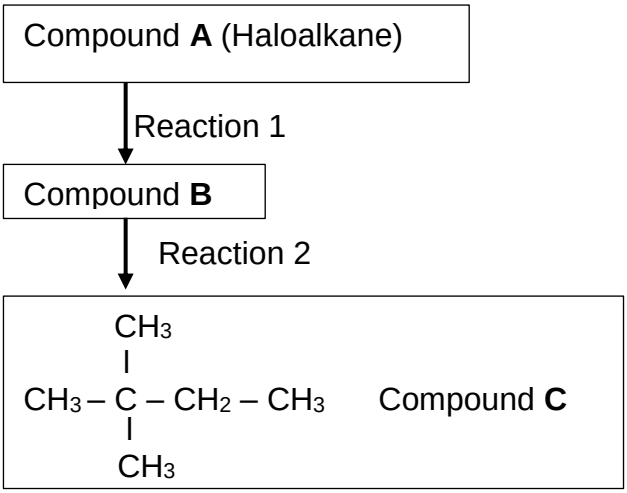
4.1.3 TWO reasons why the use of a water bath is preferred in this experiment (2)

4.1.4 The balanced equation for this reaction using STRUCTURAL FORMULAE (5)

4.1.5 The IUPAC name of the organic product for this reaction (2)

4.2 Compound **A**, a six-carbon branched haloalkane, is used in a two-step reaction to prepare compound **C**.

Reaction 2 is an ADDITION reaction.



Write down:

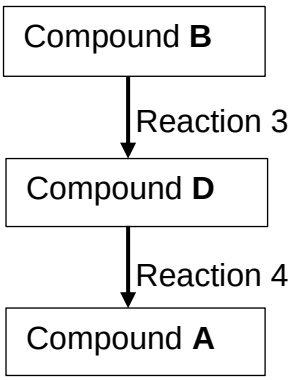
4.2.1 The NAME or FORMULA of the inorganic reactant in reaction 2 (1)

4.2.2 The IUPAC name of compound **B** (2)

4.2.3 The type of reaction represented by reaction 1 (1)

Compound **B** is now used in two-step reaction to prepare compound **A**.

Reaction 4 is a SUBSTITUTION reaction.



Write down:

4.2.4 The NAME or FORMULA of the catalyst used in reaction 3 (1)

4.2.5 The IUPAC name of compound **D** (2)

4.2.6 The type of reaction represented by reaction 3 (1)

4.2.7 The type of haloalkane represented by compound **A** (Choose from primary, secondary or tertiary.) (1)

[20]

QUESTION 5 (Start on a new page.)

The reaction between aluminium and EXCESS sulphuric acid is used to investigate factors affecting rates of reactions.

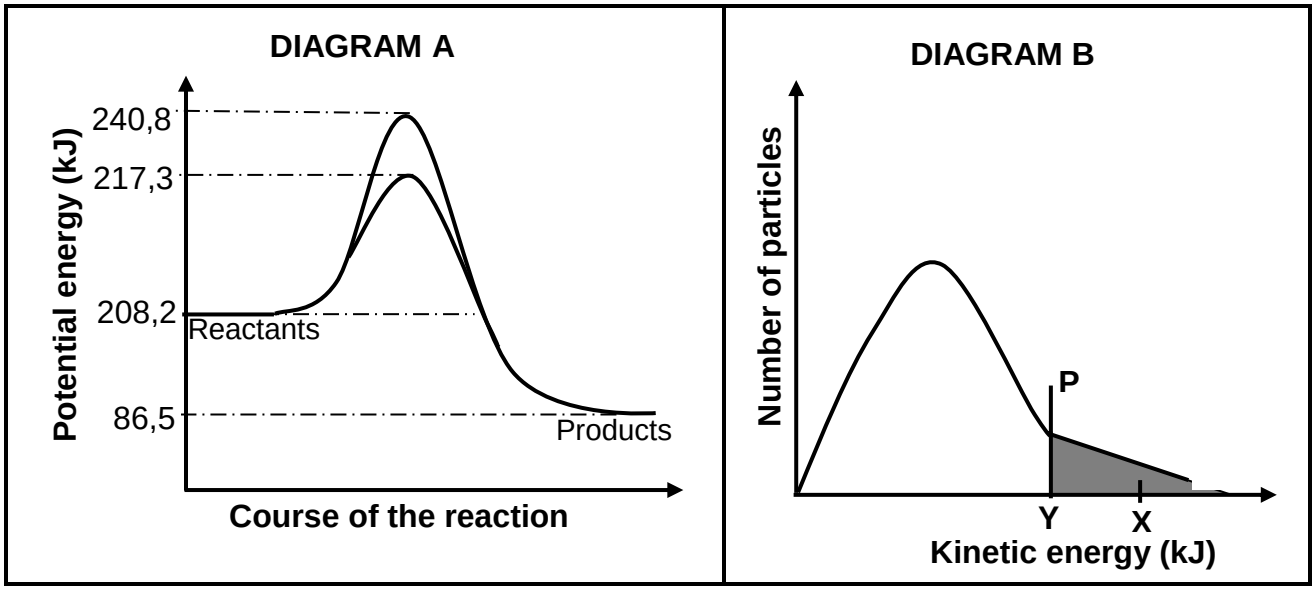
$$2A\ell(s) + 3H_2SO_4(aq) \rightarrow A\ell_2(SO_4)_3(aq) + 3H_2(g)$$

5.1 **INVESTIGATION I**

The effect of a catalyst on the rate of reaction is determined.

Aluminium powder of mass 5 g reacts with excess 0,1 mol·dm^{-3} H_2SO_4 at 60 °C.

Consider the following energy diagrams (not drawn to scale) for this investigation. **X** and **Y** in diagram **B** represent the activation energies.



5.1.1 Is the reaction between Aℓ(s) and dilute H_2SO_4(aq) ENDOTHERMIC or EXOTHERMIC? Give a reason for the answer by referring to the above diagrams. (2)

5.1.2 What does the shaded area to the right of line **P** represent? (1)

5.1.3 Determine the numerical value represented by the letter **X** on diagram **B**. (2)

5.2 **INVESTIGATION II**

The investigation is now repeated at 30 °C using the same reactants (5g Aℓ powder and excess 0,1 mol·dm^{-3} H_2SO_4) and catalyst.

How will this affect EACH of the following when compared to INVESTIGATION I? Choose from INCREASES, DECREASES or REMAINS THE SAME.

5.2.1 The size of the shaded area (diagram **B**) (1)

5.2.2 The value of **Y** (1)

5.2.3 The TOTAL volume of hydrogen gas produced (1)

5.3 **INVESTIGATION III**

In this investigation, 5 g of the same sample of IMPURE aluminium powder reacts with an EXCESS diluted H_2SO_4 at 60 °C in each of three runs. The table below summarises the conditions and the results obtained. (Assume that the impurities do not react.)

$$2A\ell(s) + 3H_2SO_4(aq) \rightarrow A\ell_2(SO_4)_3(aq) + 3H_2(g)$$

RUN	**CONCENTRATION H_2SO_4(aq) (mol·dm^{-3})**	**AVERAGE RATE OF VOLUME H_2(g) PRODUCED (cm^3·s^{-1})**
1	0,1	15
2	0,2	19
3	0,4	40

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

5.3.2 Use the collision theory to explain how the average rate of the reaction is affected in this investigation. (3)

5.3.3 The time for the reaction to reach completion in RUN **3** is 2,6 minutes.

Calculate the percentage purity of the aluminium. Take the molar gas volume at 60 °C to be 27 000 cm^3·mol^{-1}. (6)
[18]

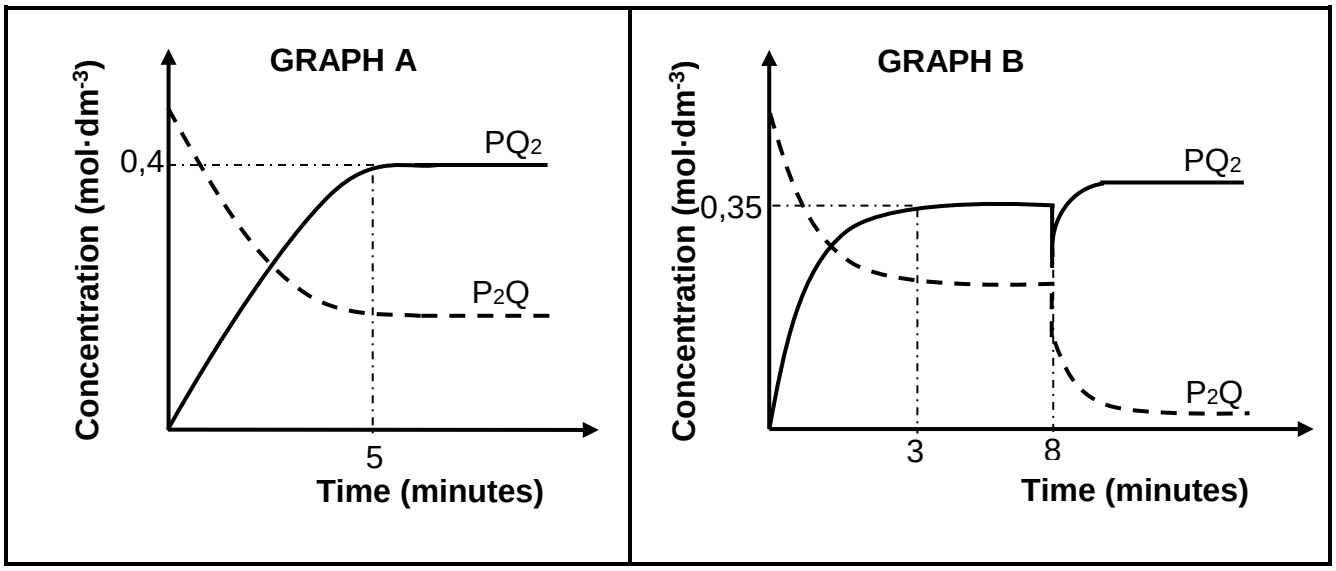
QUESTION 6 (Start on a new page.)

Consider the balanced equation for a hypothetical reaction that takes place in 2 dm^3 sealed containers.

$$P_2Q(g) + 3Q(s) \rightleftharpoons 2PQ_2(g)$$

The graphs below, not drawn to scale, are obtained for the same reaction at two different temperatures.

Graph **A** is obtained at 298 K and graph **B** at 398 K.



6.1 State Le Chatelier's principle. (2)

6.2 What do the parallel lines after t = 5 minutes in graph **A** represent? (1)

6.3 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? (1)

6.4 Explain the answer to QUESTION 6.3. (2)

6.5 How does the value of the equilibrium constant, K_c, for the reaction in graph **B** compare to that in graph **A**? Choose from GREATER THAN, LESS THAN or EQUAL TO. (1)

6.6 The equilibrium constant, K_c, is 0,49 at 398 K (graph **B**).

Calculate the initial number of moles of P_2Q. (8)

6.7 Describe the change made to the equilibrium system at t = 8 minutes, as shown in graph **B**, at a constant temperature. (1)

6.8 Explain by using Le Chatelier's principle how the system reacts to the change in QUESTION 6.7. (2)

[18]

QUESTION 7 (Start on a new page.)

7.1 A standard solution is prepared by dissolving 10 g of sodium carbonate, $Na_2CO_3(s)$, in 0,7 dm^3 of water.

7.1.1 Calculate the concentration of the solution. (3)

7.1.2 Will the pH of the solution be GREATER THAN or LESS THAN 7? (1)

7.1.3 Write an equation that explains the answer to QUESTION 7.1.2. (2)

The sodium carbonate solution is titrated with dilute hydrochloric acid, $HC\ell(aq)$. The following indicators are available for this titration.

INDICATOR	pH RANGE
P	3,4–4,5
Q	6,8–7,2
R	8,3–10

7.1.4 Which ONE of the indicators (**P**, **Q** or **R**) is most suitable for this titration? Give a reason for the answer by referring to the data in the table. (2)

7.2 When 0,01 moles of *dilute* sulphuric acid, $H_2SO_4(aq)$, is mixed with 0,024 moles of potassium hydroxide, KOH(aq), the total volume of the final solution is 0,2 dm^3.

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(\ell)$$

7.2.1 What is meant by a *dilute* acid? (2)

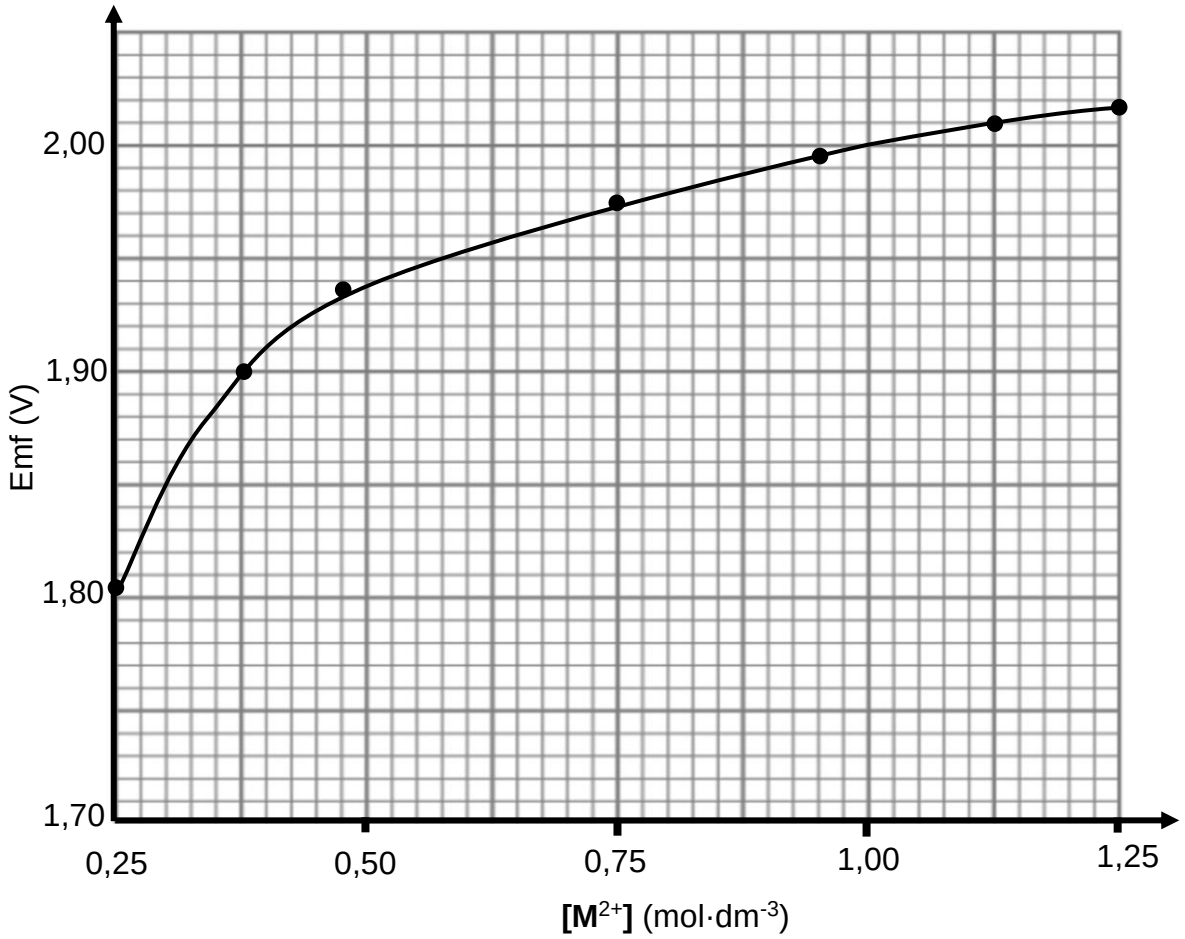
7.2.2 Calculate the pH of the final solution. (8)
[18]

QUESTION 8 (Start on a new page.)

The relationship between the concentration of the electrolyte and the cell potential is investigated using the following electrochemical cell represented by the cell notation:

$$A\ell(s) \mid A\ell^{3+}(aq) \parallel M^{2+}(aq) \mid M(s)$$

The concentration of M^{2+} is changed and the corresponding emf is measured. The concentration of $A\ell^{3+}(aq)$ and the temperature are at standard conditions. The graph below shows the results of this investigation.



8.1 Identify the reducing agent in this cell. (1)

8.2 Determine the concentration of $M^{2+}(aq)$ that will produce an emf of 1,87 V. (2)

8.3 How will the concentration of $M^{2+}(aq)$ be affected as the cell operates? Choose from INCREASES, DECREASES or REMAINS THE SAME.

Give a reason for the answer. (2)

8.4 Potassium nitrate, $KNO_3(aq)$, is used in the salt bridge of this cell.

To which electrode will the K^+ ions move in the salt bridge (Aℓ or M)? (1)

8.5 Identify metal **M** with the aid of a calculation. (6)

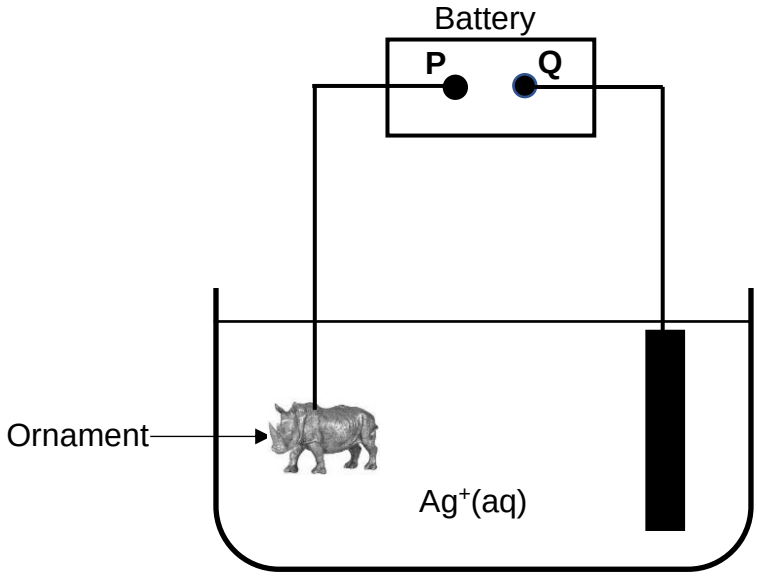
8.6 Metal **M** is now replaced with magnesium, Mg.

8.6.1 Which electrode, Aℓ or Mg, will be the anode? (1)

8.6.2 Refer to the relative strengths of the oxidising agents to explain the answer. (2)
[15]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents the cell used for electroplating ornaments with silver, Ag. **P** and **Q** are the two terminals of the battery.



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

9.2 Which terminal of the battery (**P** or **Q)** is negative? (1)

9.3 Write down the equation for the half-cell reaction that takes place at the cathode. (2)

9.4 Calculate the current needed to electroplate the ornament with 3,25 g of silver in 30 minutes. (5)
[9]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

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

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

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

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

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

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

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

KEY/*SLEUTEL*

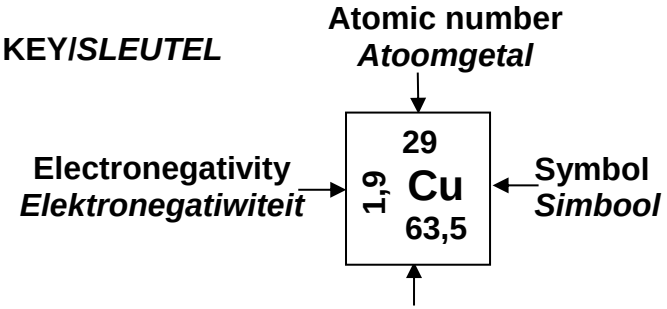


TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Increasing strength of oxidising agents/*Toenemende sterkte van oksideermiddels* ↑

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

Increasing strength of reducing agents/*Toenemende sterkte van reduseermiddels* ↓

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

Increasing strength of oxidising agents/*Toenemende sterkte van oksideermiddels* ↓

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

Increasing strength of reducing agents/*Toenemende sterkte van reduseermiddels* ↑

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/
NATIONAL SENIOR CERTIFICATE EXAMINATIONS
SENIORSERTIFIKAAT-EKSAMEN/
NASIONALE SENIORSERTIFIKAAT-EKSAMEN

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

MAY/JUNE/*MEI/JUNIE* 2024

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

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

QUESTION 1/*VRAAG 1*

1.1 A ✓✓ (2)

1.2 C ✓✓ (2)

1.3 A ✓✓ (2)

1.4 D ✓✓ (2)

1.5 D ✓✓ (2)

1.6 C ✓✓ (2)

1.7 B ✓✓ (2)

1.8 A ✓✓ (2)

1.9 B ✓✓ (2)

1.10 B ✓✓ (2)

[20]

QUESTION 2/*VRAAG 2*

2.1 Organic compounds that consist of hydrogen and carbon only. ✓✓ (**2 or 0)**
Organiese verbindings wat slegs uit waterstof en koolstof bestaan. (**2 *of* 0)** (2)

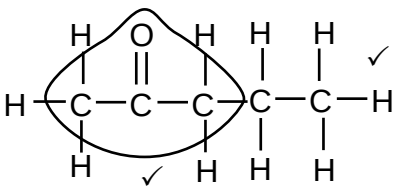
2.2.1 C and/*en* E ✓ (1)

2.2.2 D and/*en* H ✓✓ **(2 or/*of* 0)** (2)

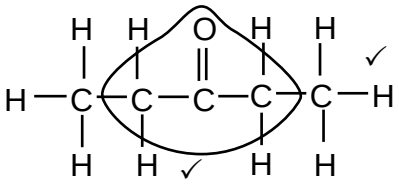
2.2.3 A ✓ (1)

2.3
2.3.1

Marking criteria/*Nasienkriteria:*	**IF/*INDIEN:***
• Functional group. ✓ *Funksionele groep.* • Whole structure correct. ✓ *Hele struktuur korrek.*	• More than one functional group/wrong functional group: *Meer as een funksionele groep/foutiewe funksionele groep:* 0/2 • If condensed structural formulae used/*Indien gekondenseerde struktuurformules gebruik:* Max/*Maks.* 1/2



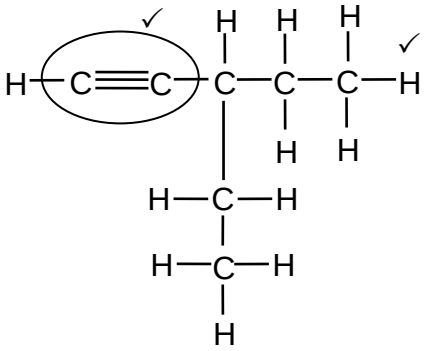
OR/OF



(2)

2.3.2 C_nH_{2n+2} ✓ (1)

2.3.3



Marking criteria/*Nasienkriteria:*
- Functional group -C≡C-. ✓
  Funksionele groep -C≡C-.
- Whole structure correct. ✓
  Hele struktuur korrek.

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

(2)

2.4.1 3-ethylhex-3-ene ✓✓✓/3-ethyl-3-hexene/*3-etielheks-3-een/3-etiel-3-hekseen*

Marking criteria:
- Correct stem i.e. hexene. ✓
- Substituent (ethyl) correctly identified. ✓
- IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓

Nasienkriteria:
- *Korrekte stam d.i. hekseen.* ✓
- *Substituent (etiel) korrek geïdentifiseer.* ✓
- *IUPAC-naam heeltemal korrek insluitende nommering, volgorde, koppeltekens en kommas.* ✓

(3)

2.4.2 2,5-dichloro-2,4-dimethylhexane ✓✓✓/ *2,5-dichloro-2,4-dimetielheksaan*

Marking criteria:
- Correct stem i.e. hexane. ✓
- All substituents (dichloro and dimethyl) correctly identified. ✓
- IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓

Nasienkriteria:
- *Korrekte stam d.i. heksaan.* ✓
- *Alle substituente (dichloro en dimetiel) korrek geïdentifiseer.* ✓
- *IUPAC-naam heeltemal korrek insluitende nommering, volgorde, koppeltekens en kommas.* ✓

(3)

2.4.3 2,2-dimethyl✓propanal✓/dimethylpropanal

2,2-dimetielpropanaal/dimetielpropanaal (2)

NOTE/*NOTA*:

2,2-dimethyl✓propan-1-al (Max/*Maks*: $^1/_2$)

2.5

Marking criteria/*Nasienkriteria:*
- Correct molecular formula: C_7H_{16} ✓
  Korrekte molekulêre formula: C_7H_{16}
- Correct molecular formula of inorganic reactant and products. ✓
  Korrekte molekulêre formule vir die anorganiese reaktans en produkte.
- Balancing/*Balansering* ✓

C_7H_{16} ✓+ $\underline{11O_2}$ $\rightarrow$ $\underline{7CO_2 + 8H_2O}$ ✓ Bal ✓

Notes/*Aantekeninge:*
- Ignore double arrows and phases./*Ignoreer dubbelpyle en fases.*
- Marking rule 6.3.10/*Nasienreël 6.3.10.*
- If condensed structural formulae used:/*Indien gekondenseerde struktuurformules gebruik:* Max/*Maks.* $^2/_3$

(3)
[22]

QUESTION 3/*VRAAG 3*

3.1

Marking criteria/*Nasienkriteria*
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*
The underlined phrases must be in the correct context. / *Die onderstreepte frases moet in die korrekte konteks wees.*

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

3.2 C ✓ (1)

3.3

Marking criteria:
- Compare structures. ✓
- Compare the strength of intermolecular forces. ✓
- Compare the energy required to overcome intermolecular forces. ✓

Nasienkriteria:
- *Vergelyk strukture.* ✓
- *Vergelyk die sterkte van intermolekulêre kragte.* ✓
- *Vergelyk die energie benodig om intermolekulêre kragte te oorkom.* ✓

Accept: IMF for this exam/***Aanvaar**: IMK vir hierdie eksamen*

A/$CH_3CH_2CH_2CH_2C\ell$ /1-chlorobutane

- **Structure:**
  Longer chain length/larger surface area (over which intermolecular forces act). ✓
- **Intermolecular forces:**
  Stronger/more intermolecular forces/Van der Waals forces/London forces/dipole-dipole forces. ✓
- **Energy:**
  More energy needed to overcome or break intermolecular forces/Van der Waals forces/dipole-dipole forces. ✓

OR

B/$CH_3CH(CH_3)CH_2C\ell$/1-chloro-2-methylpropane

- **Structure:**
  Shorter chain length / branched / compact / more spherical / smaller surface area (over which intermolecular forces act). ✓
- **Intermolecular forces:**
  Weaker/less intermolecular forces/Van der Waals forces/*London forces*/ dipole-dipole forces. ✓
- **Energy:**
  Less energy needed to overcome or break intermolecular forces/Van der Waals forces/dipole-dipole forces. ✓

A/$CH_3CH_2CH_2CH_2C\ell$ /1-chlorobutaan

- ***Struktuur*:**
  Langer kettinglengte/groter oppervlak (waaroor intermolekulêre kragte werk). ✓
- ***Intermolekulêre kragte*:**
  Sterker/meer intermolekulêre kragte/Van der Waalskragte/Londonkragte/ dipool-dipoolkragte. ✓
- *Meer energie benodig om intermolekulêre kragte/Van der Waalskragte/ Londonkragte/dipool-dipoolkragte te oorkom/breek.* ✓

OF

B/$CH_3CH(CH_3)CH_2C\ell$/1-chloro-2-metielpropaan

- ***Struktuur*:**
  Korter kettinglengte / vertak / kompak / meer sferies / kleiner oppervlak (waaroor intermolekulêre kragte werk). ✓
- ***Intermolekulêre kragte*:**
  Swakker/minder intermolekulêre kragte/Van der Waalskragte/ Londonkragte/dipool-dipoolkragte. ✓
- ***Energie*:**
  Minder energie benodig om intermolekulêre kragte/Van der Waalskragte/ Londonkragte/dipool-dipoolkragte te oorkom/breek. ✓ (3)

3.4.1 75 (°C) ✓ (1)

3.4.2

Marking criteria:
- Compare the strength of intermolecular forces. ✓
- Compare the energy required to overcome intermolecular forces. ✓

Nasienkriteria:
- *Vergelyk die sterkte van intermolekulêre kragte.* ✓
- *Vergelyk die energie benodig om intermolekulêre kragte te oorkom.* ✓

- **Intermolecular forces:**
  C ($CH_3CH_2CH_2CH_2OH$/butanol) has stronger intermolecular forces than D ($CH_3CH_2CH_2CHO$/butanal). ✓
- **Energy:**
  More energy needed to overcome or break intermolecular forces. ✓
  Accept: Boiling point of C will be more (in relation to C and D/118°C vs 75°C).

OR

- **Intermolecular forces:**
  D ($CH_3CH_2CH_2CHO$/butanal) has weaker intermolecular forces than C ($CH_3CH_2CH_2CH_2OH$/butanol)
- **Energy:**
  Less energy is needed to overcome or break intermolecular forces.
  Accept: Boiling point of D will be less (in relation to C and D/118°C vs 75°C).

OR

- **Intermolecular forces:**
  A ($CH_3CH_2CH_2CH_2C\ell$) is a more polar molecule than D ($CH_3CH_2CH_2CHO$) increasing the intermolecular forces
- **Energy:**
  More energy is needed to overcome or break intermolecular forces.
  Accept: Boiling point of D will be less (in relation to A and D).

OR

- **Intermolecular forces:**
  Electron density of A ($CH_3CH_2CH_2CH_2C\ell$) is greater than D ($CH_3CH_2CH_2CHO$) increasing the intermolecular forces
- **Energy:**
  More energy is needed to overcome or break intermolecular forces.
  Accept: Boiling point of D will be less (in relation to A and D).

- ***Intermolekulêre kragte:***
  C ($CH_3CH_2CH_2CH_2OH$/butanol) het sterker intermolekulêre kragte as D ($CH_3CH_2CH_2CHO$/butanaal). ✓
- *Meer energie benodig om intermolekulêre kragte te oorkom/breek.* ✓
  Aanvaar: Kookpunt van D sal minder wees (met betrekking tot C en D)

OF

- ***Intermolekulêre kragte:***
  D ($CH_3CH_2CH_2CHO$/butanaal) het swakker intermolekulêre kragte as C ($CH_3CH_2CH_2CH_2OH$/butanol).
- *Minder energie benodig om intermolekulêre kragte/te oorkom/breek.*
  Aanvaar: Kookpunt van C sal meer wees (met betrekking tot C en D)

OF

- ***Intermolekulêre kragte:***
  A ($CH_3CH_2CH_2CH_2C\ell$) is 'n meer polêre molekule as D wat sterker intermolekulêre kragte tot gevolg het.
- *Meer energie benodig om intermolekulêre kragte te oorkom/breek.*
  Aanvaar: Kookpunt van D sal minder wees (met betrekking tot A en D)

OF

- ***Intermolekulêre kragte:***
  Elektrondigtheid van A ($CH_3CH_2CH_2CH_2C\ell$) is groter wat sterker intermolekulêre kragte tot gevolg het.
- *Meer energie benodig om intermolekulêre kragte te oorkom/breek.*
- *Aanvaar: Kookpunt van D sal minder wees (met betrekking tot A en D)* (2)

3.5 Decreases/*Neem af* ✓ (1)

[10]

QUESTION 4/*VRAAG 4*

4.1

4.1.1 (Concentrated) sulphuric acid/H_2SO_4(aq) ✓
(Gekonsentreerde) swawelsuur (1)

4.1.2 Esterification / Condensation ✓/ *Verestering / Esterifikasie / Kondensasie* (1)

4.1.3 **ANY TWO/*ENIGE TWEE*:**

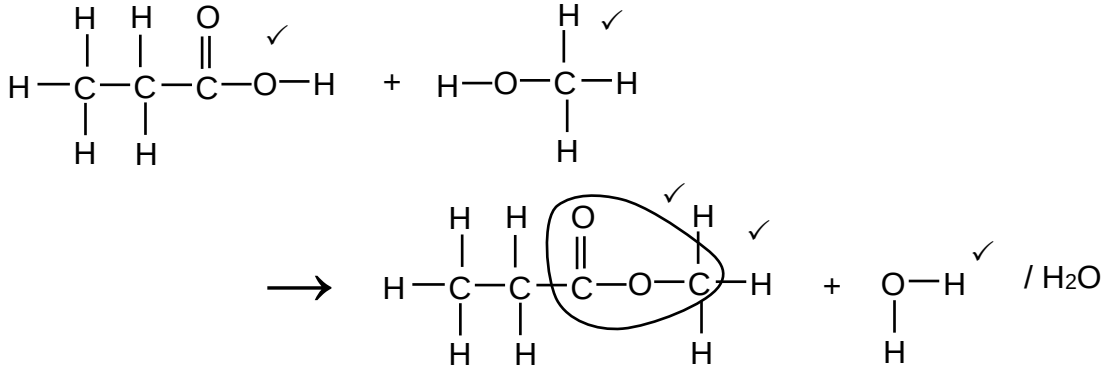
- Alcohol/methanol/reactant is flammable/catches fire easily. ✓
  Alkohol/metanol/reaktans is vlambaar/slaan maklik aan die brand.
- To heat evenly/A steady/controlled/gradual increase in temperature. ✓
  Om eweredig/gekontroleerd/gelydelik te verhit/'n Eweredige toename in temperatuur.
- Alcohol/methanol will evaporate too quickly/is volatile.
  Alkohol/metanol sal te vinnig verdamp/is vlugtig. (2)

4.1.4

Marking criteria*:*
- Whole structural formula correct for propanoic acid. ✓
- Whole structural formula correct for methanol. ✓
- Functional group of ester correct. ✓
- Whole structural formula of ester correct. ✓
- H_2O ✓

Nasienkriteria:
- *Hele struktuurformule vir propanoësuur korrek.* ✓
- *Hele struktuurformule vir metanol korrek.* ✓
- *Funksionele groep van ester korrek.* ✓
- *Hele struktuurformule van ester korrek.* ✓
- *H_2O* ✓

IF/*INDIEN*
- Any error e.g. omission of all H atoms, condensed or semi structural formula/*Enige fout bv. weglating van alle H-atome, gekondenseerde of semi-struktuurformule:* Max/*Maks.* $^2/_5$ (Functional group,H_2O/*Funksionele groep,H_2O*)
- Any additional reactants or products /*Enige addisionele reaktanse of produkte:* Subtract 1 mark./*Trek 1 punt af.*
- Molecular formulae used:/*Molekulêre formule gebruik:* Max/*Maks.* $^1/_5$ (water)
- No arrows: The first two structures given are considered as reactants and can be marked/*Geen pyltjie: die eerste twee strukture geskryf, word beskou as reaktanse en kan gemerk word.*



(5)

4.1.5 Methyl ✓propanoate ✓/*Metielpropanoaat* (2)

4.2.1 Hydrogen/H_2 ✓/*Waterstof(gas)* (1)

4.2.2 3,3-dimethyl✓but-1-ene✓/3,3-dimethyl-1-butene
3,3-dimetiel but-1-een/3,3-dimetiel-1-buteen (2)

4.2.3 elimination **OR** dehydrohalogenation ✓ *eliminasie **OF** dehidrohalogenering* (1)

4.2.4 H_2SO_4/H_3PO_4 **OR/*OF*** Sulphuric acid/Phosphoric acid ✓
Swawelsuur/Fosforsuur (1)

4.2.5 3,3-dimethyl✓butan-2-ol✓/3,3-dimethyl-2-butanol
3,3-dimetiel butan-2-ol/3,3-dimetiel-2-butanol (2)

4.2.6 Addition/hydration ✓ *Addisie/hidrasie* (1)

4.2.7 Secondary ✓/*Sekondêr* (1)

[20]

QUESTION 5/*VRAAG 5*

5.1.1 Exothermic/*Eksotermies* ✓

Lower (potential) energy of the products than reactants. /$\Delta H < 0$/ΔH negative / $\Delta H = -121,7$ kJ/More energy is released than absorbed. ✓
Laer (potensiële) energie van produkte as die reaktanse./$\Delta H < 0$/ΔH negatief / $\Delta H = -121,7$ kJ/Meer energie word afgegee as wat opgeneem is. (2)

5.1.2 (The number of) particles with sufficient/enough (kinetic) energy (with a catalyst) OR $E_K \geq E_A$ (which can undergo effective collisions.) ✓
(Die hoeveelheid) deeltjies met genoeg/voldoende (kinetiese) energie (met 'n katalisator) OF $E_K \geq E_A$ (om effektiewe botsings te ondergaan). (1)

5.1.3 240,8 – 208,2 ✓= 32,6 (kJ) ✓ (2)
IF: only answer award 2 marks/*I**NDIEN:** slegs antwoord gee 2 punte*

5.2

5.2.1 Decreases/*Afneem* ✓ (1)

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

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

5.3.1 Concentration (of sulphuric acid/$H_2SO_4(aq)$)/*Konsentrasie (van swawelsuur)*✓ (1)

5.3.2
- More (H_2SO_4) particles per unit volume. ✓
- More effective collisions per unit time./Higher frequency of effective collisions. ✓
- Higher reaction rate. ✓

OR

- Less (H_2SO_4) particles per unit volume. ✓
- Less effective collisions per unit time./Lower frequency of effective collisions. ✓
- Lower reaction rate ✓

- *Meer (H_2SO_4) deeltjies per eenheid volume.* ✓
- *Meer effektiewe botsings per eenheidtyd./Hoër frekwensie van effektiewe botsings.* ✓
- *Hoër reaksietempo*. ✓

OF

- *Minder (H_2SO_4)-deeltjies per eenheid volume.* ✓
- *Minder effektiewe botsings per eenheidtyd./Laer frekwensie van effektiewe botsings.* ✓
- *Laer reaksietempo.* ✓

(3)

5.3.3

Marking criteria:	***Nasienkriteria:***
(a) Substitute (2,6)(60)(40) cm^3 OR (156)(40) in rate formula ✓ **(b)** Substitute 27 000 cm^3 / 27 dm^3 and volume in $n(H_2) = \frac{V}{V_m}$ ✓ **(c)** USE mole ratio $n(A\ell) = \frac{2}{3}n(H_2)$ ✓ **(d)** Substitution 27 and reacting mole in $n(A\ell) = \frac{m}{M}$ ✓ **(e)** Substitution of $\frac{4,05}{5}(100)$ ✓ **(f)** Final answer: 83,2 % ✓ Range: 81 – 83,3 %	**(a)** *Vervang 2,6(60)(40) cm^3 OF (156)(40) in tempo formule* ✓ **(b)** *Vervang 27 000 cm^3 / 27 dm^3 en volume in* $n(H_2) = \frac{V}{V_m}$ ✓ **(c)** *GEBRUIK molverhouding* $n(A\ell) = \frac{2}{3}n(H_2)$ ✓ **(d)** *Vervang 27 en mol gereageer in* $n(A\ell) = \frac{m}{M}$ ✓ **(e)** *Vervang van* $\frac{4,05}{5}(100)$ ✓ **(f)** *Finale antwood: 81 %* ✓ *Gebied: 81 – 83,3 %*

OPTION 1/*OPSIE 1:*

$\text{Rate/Tempo} = \frac{\Delta V_{H_2}}{\Delta t}$

$40 = \frac{\Delta V_{H_2}}{2,6(60)}$ ✓ **(a)**

$V(H_2) = 6\,240\ cm^3$

$n(H_2) = \frac{V}{V_m}$

$= \frac{6\,240}{27\,000}$ ✓ **(b)**

$= 0,23\ mol$

$n(A\ell) = \frac{2}{3}n(H_2)$

$n(A\ell) = \frac{2}{3}(0,23)$ ✓ **(c)**

$= 0,15\ mol$

$n(A\ell) = \frac{m}{M}$

$0,15 = \frac{m}{27}$ ✓ **(d)**

$m = 4,05\ g$

✓ **(e)**

$\%\ \text{purity/}suiwerheid = \frac{4,05}{5}(100)$

$= 81\ \%$ ✓ **(f)**

OPTION 2/*OPSIE 2:*

rate $H_2 = 40\ cm^3 \cdot s^{-1}$

Rate in $n(H_2) = \frac{V}{V_m}$

$= \frac{40}{27\,000}$ ✓ **(b)**

$= 0,00148\ mol \cdot s^{-1}$

(a) ✓ both/ beide

Rate$(A\ell) = \frac{2}{3}n(H_2)$

$= \frac{2}{3}(0,00148)$ ✓ **(c)**

$= 9,88 \times 10^{-4}\ mol \cdot s^{-1}$

$n(A\ell) = \frac{m}{M}$

$9,88 \times 10^{-4} = \frac{m}{27}$ ✓ **(d)**

$m = 0,0267\ g \cdot s^{-1}$

Rate/Tempo $= \frac{\Delta m_{Al}}{\Delta t}$

$0,0267 = \frac{\Delta m_{Al}}{2,6(60)}$

$m(A\ell) = 4,16\ g$

$\%\ \text{purity/}suiwerheid = \frac{4,16}{5}(100)$ ✓ **(e)**

$= 83,2\ \%$ ✓ **(f)**

(6)
[18]

QUESTION 6/*VRAAG 6*

6.1

Marking criteria/*Nasienkriteria:*
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*
The underlined phrases must be in the correct context. / *Die onderstreepte frases moet in die korrekte konteks wees.*

When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will cancel/oppose the disturbance. ✓✓
Wanneer die ewewig in 'n geslote sisteem versteur word, sal die sisteem 'n nuwe ewewig instel deur die reaksie te bevoordeel wat die versteuring kanselleer/teenwerk.
IF "isolated" system -1/***INDIEN:** "geïsoleerde" sisteem -1)* (2)

6.2 (Chemical) equilibrium/Concentrations of reactants and products remain constant./Rate of the forward and reverse reactions are equal. ✓
(Chemiese) ewewig/K*onsentrasies van reaktanse en produkte bly konstant./ Tempo van voorwaartse en terugwaartse reaksie is gelyk.* (1)

6.3 Exothermic/*Eksotermies* ✓ (1)

6.4
- With an increase in temperature the endothermic reaction is favoured. ✓
- The reverse reaction is favoured./ Equilibrium shifts to the left. / Reactants / [P_2Q] increases OR Products / [PQ_2] decreases ✓

- *'n Toename in temperatuur bevoordeel die endotermiese reaksie.*
- *Die terugwaartse reaksie word bevoordeel./ Ewewig skuif na links. / Reaktante / [P_2Q] neem toe OF Produkte / [PQ_2] neem af* (2)

6.5 Less than/*Kleiner as* ✓ (1)

6.6

CALCULATIONS USING CONCENTRATION

Marking criteria*:*

(a) Correct K_c expression (formulae in square brackets). ✓✓
(If solid is included deduct 1 mark)
(b) Substitute 0,49 into Kc expression. ✓
(c) Substitute equilibrium concentration (0,35) into correct K_c expression. ✓
(d) Change in concentration/mole ✓
(e) **USE** ratio: P_2Q : $2PQ_2$ = 1 : 2 ✓
(f) Substitute 2 dm^3 in n = cV. ✓
(g) Final answer = 0,85 (mol) OR 1,11 (mol) OR 3,09 (mol) ✓

***Nasienkriteria*:**

(a) *Korrekte K_c uitdrukking (formules in vierkantige hakies).* ✓✓
(Indien vastestof invervang is, trek 1 punt af)
(b) *Vervang 0,49 in K_c-uitdrukking.* ✓
(c) *Vervang ewewigkonsentrasie (0,35) in korrekte K_c-uitdrukking.* ✓
(d) *Verandering in konsentrasie/mol* ✓
(e) ***GEBRUIK*** *verhouding: P_2Q : PQ_2 = 1 : 2* ✓
(f) *Vervang 2 dm^3 in n = cV.* ✓
(g) *Finale antwoord = 0,85 (mol) OF 1,11 (mol) OF 3,09 (mol)* ✓

OPTION 1/*OPSIE 1:*

	P_2Q	PQ_2
Initial concentration ($mol \cdot dm^{-3}$) *Aanvangskonsentrasie ($mol \cdot dm^{-3}$)*	x	0
Change in concentration ($mol \cdot dm^{-3}$) *Verandering in konsentrasie ($mol \cdot dm^{-3}$)*	0,175 ✓**(e)**	0,35
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)* ✓**(d)**	x - 0,175	0,35

$$K_c = \frac{[PQ_2]^2}{[P_2Q]}$$ ✓✓ **(a)**

$$0,49 \overset{\checkmark\textbf{(b)}}{=} \frac{(0,35)^2}{(x - 0,175)}$$ ✓**(c)**

$x = 0,425 \text{ mol} \cdot dm^{-3}$

$n(P_2Q) = cV$
$= 0,425 \times 2$ ✓**(f)**
$= 0,85 \text{ mol}$ ✓**(g)**

No K_c expression, correct substitution/*Geen K_c-uitdrukking*, *korrekte substitusie*: Max./*Maks.* $^6/_8$

Wrong K_c expression/
Verkeerde K_c-uitdrukking: Max./*Maks.* $^5/_8$

OPTION2/*OPSIE 2:*

$K_c = \frac{[PQ_2]^2}{[P_2Q]}$ ✓✓

$0,49$ ✓**(b)** $= \frac{(0,35)^2}{P_2Q}$ ✓**(c)**

$P_2Q = 0,25 \text{ mol·dm}^{-3}$

No K_c expression, correct substitution/*Geen K_c-uitdrukking*, *korrekte substitusie*: Max./*Maks.* $^6/_8$

Wrong K_c expression/
Verkeerde K_c-uitdrukking: Max./*Maks.* $^5/_8$

	P_2Q	PQ_2
Initial concentration (mol·dm^{-3}) *Aanvangskonsentrasie (mol·dm^{-3})*	✓**(d)** 0,425	0
Change in concentration (mol·dm^{-3}) *Verandering in konsentrasie (mol·dm^{-3})*	-0,175	✓**(e)** 0,35
Equilibrium concentration (mol·dm^{-3}) *Ewewigskonsentrasie (mol·dm^{-3})*	0,25	0,35

$n(P_2Q) = cV$
$= 0,425(2)$ ✓**(f)**
$= 0,85 \text{ mol}$ ✓**(g)**

CALCULATIONS USING NUMBER OF MOLES
OPTION 3/*OPSIE 3:*

	P_2Q	PQ_2
Initial quantity (mol) Aanvangshoeveelheid (mol)	x	0
Change (mol) *Verandering (mol)*	✓**(e)** 0,35	0,7
Quantity at equilibrium (mol) *Hoeveelheid by ewewig (mol)*	✓**(d)** x – 0,35	0,7
Equilibrium concentration (mol·dm^{-3}) Ewewigskonsentrasie (mol·dm^{-3})	✓**(f)** $\frac{x - 0,35}{2}$	0,35

$K_c = \frac{[PQ_2]^2}{[P_2Q]}$ ✓✓**(a)**

$0,49$ ✓**(b)** $= \frac{(0,35)^2}{(\frac{x - 0,35}{2})}$ ✓**(c)**

$x = 0,85 \text{ mol}$ ✓**(g)**

No K_c expression, correct substitution/*Geen K_c-uitdrukking*, *korrekte substitusie*: Max./*Maks.* $^6/_8$

Wrong K_c expression/
Verkeerde K_c- uitdrukking: Max./*Maks.* $^5/_8$

OPTION 4/*OPSIE 4:*

$$K_c = \frac{[PQ_2]^2}{[P_2Q]}$$ ✓✓ **(a)**

$$0{,}49^{\checkmark\,(b)} = \frac{(0{,}35)^2}{[P_2Q]}$$ ✓ **(c)**

$[P_2Q] = 0{,}25\ mol{\cdot}dm^{-3}$

Wrong K_c expression/
Verkeerde K_c-uitdrukking: Max./M*aks.* $^5/_8$

No K_c expression, correct substitution/*Geen K_c-uitdrukking*, *korrekte substitusie*: Max./*Maks.* $^6/_8$

	P_2Q	PQ_2
Initial quantity (mol) *Aanvangshoeveelheid (mol)*	✓**(g)** 0,85	0
Change (mol) *Verandering (mol)*	✓**(e)** -0,35	0,7 ✓**(d)**
Quantity at equilibrium (mol) *Hoeveelheid by ewewig (mol)*	0,5 ✓**(f)**	0,7
Equilibrium concentration ($mol{\cdot}dm^{-3}$) Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)	0,25	0,35

6.7 Pressure was decreased/volume of the container was increased. ✓
Druk is verlaag/volume van die houer is vergroot. (1)

6.8
- Favours the reaction that increases the number of moles (of gas) ✓/ *Bevoordeel die reaksie wat aantal mol (gas) laat toeneem*
- $[P_2Q]$ increased/*neem toe* ✓

(2)
[18]

QUESTION 7/*VRAAG 7*

7.1

Marking criteria:	***Nasienkriteria:***
• Any formula $c = \frac{m}{MV}$ or $n = \frac{m}{M}$ or $c = \frac{n}{V}$ ✓	• *Enige formule* $c = \frac{m}{MV}$ *of* $n = \frac{m}{M}$ *of* $c = \frac{n}{V}$ ✓
• Substitute 10, 106 and 0,7 into formula ✓	• *Vervang 10, 106 and 0,7 in formula* ✓
• Final answer: 0,13 mol·dm^{-3} ✓	• *Finale antwoord: 0,13 mol·dm^{-3}* ✓

7.1.1

OPTION 1/*OPSIE 1:*	**OPTION 2/*OPSIE 2:***
$c = \frac{m}{MV}$ ✓ $= \frac{10}{(106)(0,7)}$ ✓ = 0,13 mol·dm^{-3} ✓	$n = \frac{m}{M}$ Any one/*Enige een* ✓ $= \frac{10}{106}$ ✓ = 0,09 $c = \frac{n}{V}$ $= \frac{0,09}{0,7}$ = 0,13 mol·dm^{-3} ✓

(3)

7.1.2 Greater than/*Groter as* ✓ (1)

7.1.3 $CO_3^{2-}(aq) + H_2O(\ell)$ ✓ ⇌ $HCO_3^-(aq) + OH^-(aq)$ ✓
OR/*OF*
$CO_3^{2-}(aq) + 2H_2O(\ell)$ ✓ ⇌ $H_2CO_3(aq) + 2OH^-(aq)$ ✓
OR/*OF*
$Na_2CO_3(aq) + H_2O(\ell)$ ✓ ⇌ $NaHCO_3(aq) + NaOH(aq)$ ✓
OR/*OF*
$Na_2CO_3(aq) + 2H_2O(\ell)$ ✓ ⇌ $H_2CO_3(aq) + 2NaOH(aq)$ ✓

Marking criteria/*Nasienkriteria:*
• Reactants ✓ Products ✓ *Reaktanse* ✓ *Produkte* ✓
• Ignore/*Ignoreer* → and phases/*en fases*
• Marking rule 6.3.10/*Nasienreël 6.3.10*

(2)

7.1.4 P ✓
(Titration of) weak base and a strong acid./The equivalence point is lower than pH 7. ✓
(Titrasie van) 'n swak basis en 'n sterk suur./ Die ekwivalente punt is laer as 'n pH van 7. (2)

7.2
7.2.1 Dilute acid contains small amount/number of moles of acid in proportion to the volume of water. ✓✓ **(2 or/*of* 0)**
Verdunde sure bevat 'n klein hoeveelheid/getal mol suur in verhouding met die volume water. (2)

7.2.2

Marking criteria*:*

(a) USE of ratio:
$n(KOH)_{reacted} = 2n(H_2SO_4)_{reacted}$/
$[KOH]_{reacted} = 2n[H_2SO_4]_{reacted}$ ✓
(b) Subtract: $n(KOH)_{initial} - n(KOH)_{reacted}$/
$[KOH]_{initial} - [KOH]_{reacted}$ ✓✓
(c) Divide n by 0,20 dm^3 in $c = \frac{n}{V}$ ✓
(d) Either formulae: $pH = -\log[H_3O^+]$ /
$pH = -\log[H^+]$ / $pOH = -\log[OH^-]$ AND
$[H_3O^+][OH^-] = 10^{-14}$ /
$pH + pOH = 14$ ✓
(e) Substitute calculated $[OH^-]$ in
$[H_3O^+][OH^-]$ / in $pOH = -\log[OH^-]$ ✓
(f) Substitute calculated $[H_3O^+]$ in pH
formula/ pOH in $pH + pOH = 14$ ✓
(g) Final answer: 12,3 ✓

Nasienkriteria:

(a) *GEBRUIK verhouding:*
$n(KOH)_{gereageer} = 2n(H_2SO_4)_{gereageer}$
$[KOH]_{gereageer} = 2n[H_2SO_4]_{gereageer}$ ✓
(b) *Aftrek:* $n(KOH)_{aanvanklik} - n(KOH)_{gereageer}$
$[KOH]_{aanvanklik} - [KOH]_{gereageer}$ ✓✓
(c) *Deel n deur 0,20 dm^3 in* $c = \frac{n}{V}$ ✓
(d) *Enige een v formules:* $pH = -\log[H_3O^+]$ /
$pH = -\log[H^+]$ / $pOH = -\log[OH^-]$ *EN*
$[H_3O^+][OH^-] = 10^{-14}$ /
$pH + pOH = 14$ ✓
(e) *Vervang berekende* $[OH^-]$ *in*
$[H_3O^+][OH^-]$ / *in* $pOH = -\log[OH^-]$ ✓
(f) *Vervang berekende* $[H_3O^+]$ *in pH*
formule/ pOH in $pH + pOH = 14$ ✓
(g) *Finale antwoord: 12,3* ✓

OPTION 1/*OPSIE 1:*

$n(KOH)_{reacted} = 2n(H_2SO_4)_{reacted}$
$= 2(0,01)$ ✓**(a)**
$= 0,02$

$n(KOH)_{excess} = 0,024 - 0,02$ ✓✓ **(b)**
$= 0,004$ mol

$[OH^-] = \frac{n}{V}$
$= \frac{0,004}{0,20}$ ✓**(c)**
$= 0,02$ mol·dm^{-3}

Either/ *Enige een* ✓**(d)**

$[H_3O^+][OH^-] = 10^{-14}$
$[H_3O^+]\,(0,02) = 1 \times 10^{-14}$ ✓**(e)**
$[H_3O^+] = 5 \times 10^{-13}$ mol·dm^{-3}

$pH = -\log[H_3O^+]$
$= -\log(5 \times 10^{-13})$ ✓ **(f)**
$= 12,3$ ✓ **(g)**

OPTION 2/*OPSIE 2:*

$[KOH] = \frac{n}{V}$
$= \frac{0,024}{0,20}$ ✓**(c)**
$= 0,12$ mol·dm^{-3}

Both/ *Beide*

$[H_2SO_4] = \frac{n}{V}$
$= \frac{0,01}{0,20}$
$= 0,05$ mol·dm^{-3}

$[KOH]_{reacted} = 2[H_2SO_4]_{reacted}$
$= 2(0,05)$ ✓**(a)**
$= 0,1$ mol·dm^{-3}

$[KOH]_{excess} = 0,12 - 0,1$ ✓✓ **(b)**
$= 0,02$ mol·dm^{-3}

$[H_3O^+][OH^-] = 10^{-14}$
$[H_3O^+]\,(0,02) = 1 \times 10^{-14}$ ✓**(e)**
$[H_3O^+] = 5 \times 10^{-13}$ mol·dm^{-3}

✓**(d)** Either/ *Enige een*

$pH = -\log[H_3O^+]$
$= -\log(5 \times 10^{-13})$ ✓ **(f)**
$= 12,3$ ✓ **(g)**

OPTION 3/*OPSIE 3*

$pOH = -\log[OH^-]$
$pOH = -\log(0,02)$ ✓**(e)**
$pOH = 1,7$

$pH + pOH = 14$
$pH + 1,7 = 14$ ✓**(f)**
$pH = 12,3$ ✓ **(g)**

Any one/*Enige een* ✓**(d)**

(8)
[18]

QUESTION 8/*VRAAG 8*

8.1 Aluminium/Aℓ ✓ (1)

8.2 0,325 (mol·dm^{-3}) ✓✓
Range/*Gebied:* 0,32 – 0,33 (mol·dm^{-3}) (2)

8.3 Decreases / *Neem af*✓
M^{2+} is reduced/ M^{2+} used up/M^{2+} is the oxidising agent. ✓ (2)
M^{2+} word gereduseer/ M^{2+} opgebruik/M^{2+} is die oksideermiddel.

8.4 M ✓ (1)

8.5

OPTION 1/*OPTION 1*	**NOTE/*LET WEL***
$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ ✓ 2 ✓✓= $E^{\theta}_{cathode}$ – (-1,66) ✓ $E^{\theta}_{cathode}$ = 0,34 (V) ✓ M is copper/Cu/*koper* ✓	• Accept any other correct formula from the data sheet. /*Aanvaar enige ander korrekte formule vanaf gegewensblad.* • Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik, bv. $E°_{sel} = E°_{OM} - E°_{RM}$ gevolg deur korrekte vervangings* $^{5}/_{6}$

OPTION 2/*OPSIE 2*	
✓ $M^{2+}(aq) + 2e^- \rightarrow M(aq)$	E = +x V
✓ $A\ell(s) \rightarrow A\ell^{3+}(aq) + 3e^-$	E = +1,66 V ✓
$2A\ell(s) + 3M^{2+}(aq) \rightarrow 2A\ell^{3+}(aq) + 3M(s)$	E = 2,00 (V) ✓✓
x = 0,34 (V) ✓	
M is copper/Cu/*koper* ✓	

(6)

8.6.1 Magnesium/Mg ✓ (1)

8.6.2 $A\ell^{3+}$ is a stronger oxidising agent than Mg^{2+}✓, therefore, Mg will be oxidised ✓ (to Mg^{2+})./
Mg^{2+} is a weaker oxidising agent than $A\ell^{3+}$✓, therefore, Mg will be oxidised ✓ (to Mg^{2+}).

$A\ell^{3+}$ is 'n sterker oksideermiddel as Mg^{2+}, daarom sal Mg geoksideer word (tot Mg^{2+})./
Mg^{2+} is 'n swakker oksideermiddel as $A\ell^{3+}$, daarom sal Mg geoksideer word (tot Mg^{2+}). (2)
[15]

QUESTION 9/*VRAAG 9*

9.1 Electrical to chemical (energy)/*Elektriese na chemiese (energie)* ✓ (1)

9.2 P ✓ (1)

9.3 $Ag^+ + e^- \rightarrow Ag$ ✓✓

Marking criteria/*Nasienkriteria:*

$Ag \leftarrow Ag^+ + e^-$ $(2/2)$

$Ag^+ + e^- \rightleftharpoons Ag$ $(1/2)$

$Ag \rightleftharpoons Ag^+ + e^-$ $(0/2)$

$Ag^+ + e^- \leftarrow Ag$ $(0/2)$

Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.* (2)

9.4

Marking criteria:	***Nasienkriteria**:*
(a) Substitute 3,25 and 108 in the formula $n = \frac{m}{M}$ ✓	**(a)** *Vervang 3,25 en 108 in die formule* $n = \frac{m}{M}$ ✓
(b) Substitute 6,02 x 10^{23} in $n(e^-) = \frac{N}{N_A}$ ✓	**(b)** *Vervang 6,02 x 10^{23} in* $n(e^-) = \frac{N}{N_A}$ ✓
(c) Substitute 0,03 mol in $n(e^-) = \frac{N}{N_A}$ ✓ (Substitute 96 500 in formula Q = nF)	**(c)** *Vervang 0,03 mol in* $n(e^-) = \frac{N}{N_A}$ ✓ (*Vervang 96 500 in formule Q = nF)*
(d) Substitute 30(60) OR 1 800 ✓	**(d)** *Vervang 30(60) OF 1 800* ✓
(e) Final answer: 1,61 A ✓	**(e)** *Finale antwoord: 1,61 A* ✓

OPTION 1/*OPSIE 1:*

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

$= \frac{3,25}{108}$ ✓**(a)**

$= 0,03$ mol

$n(e^-) = \frac{N}{N_A}$

(c) ✓ $0,03 = \frac{N}{6,02 \times 10^{23}}$ ✓**(b)**

$N\ e^- = 1,81 \times 10^{22}$

$N\ e^- = \frac{Q}{e}$ **OF/OR** $\frac{Q}{q_e}$

$1,81 \times 10^{22} = \frac{Q}{1,6 \times 10^{-19}}$

$Q = 2\ 889,6$ C

$I = \frac{Q}{\Delta t}$

$= \frac{2\ 889,6}{30(60)}$ ✓**(d)**

$= 1,61$ A ✓**(e)**

OPTION 2/*OPSIE 2:*

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

$= \frac{3,25}{108}$ ✓**(a)**

$= 0,03$ mol = $n\ e^-$

✓**(b)**

$Q = 0,03 \times 96\ 500$ ✓ **(c)**

$= 2\ 895$ C

$I = \frac{Q}{\Delta t}$

$= \frac{2\ 895}{30(60)}$ ✓**(d)**

$= 1,61$ A ✓**(e)**

(5)

[9]

TOTAL/*TOTAAL*: 150