basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: CHEMISTRY (P2)

2022

MARKS: 150

TIME: 3 hours

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

INSTRUCTIONS AND INFORMATION

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

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

1.1 Which ONE of the following compounds has the LOWEST melting point?

A Hexane

B Ethane

C Butane

D Octane (2)

1.2 When $CH_2 = CH_2$ is converted to CH_3CH_3, the type of reaction is …

A hydration.

B hydrolysis.

C halogenation.

D hydrogenation. (2)

1.3 Which ONE of the following compounds in solution will change the colour of bromothymol blue?

A CH_3CH_2CHO

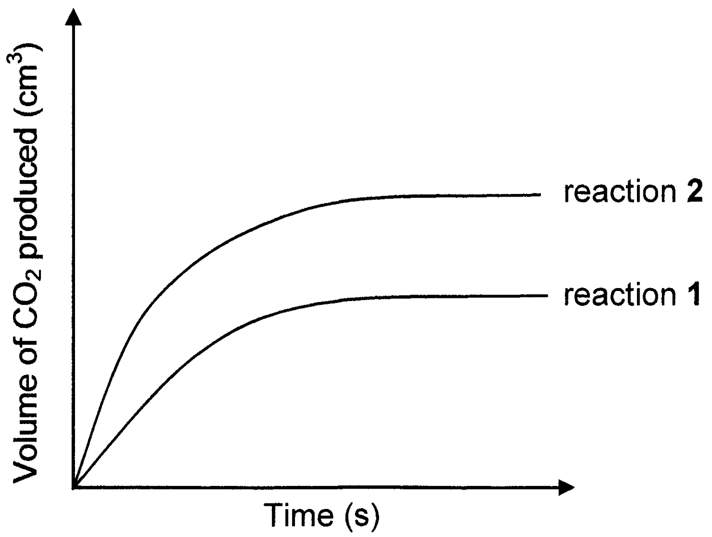
B CH_3CH_2COOH

C $CH_3CH_2COCH_3$

D $CH_3CH_2COOCH_3$ (2)

1.4 Two DIFFERENT samples of IMPURE $CaCO_3$ of EQUAL masses react with 0,1 mol·dm^{-3} H_2SO_4. Assume that the impurities do not react.

The graph below shows the volume of $CO_2(g)$ produced for each reaction.



When compared to reaction **2**, which ONE of the following statements BEST explains the curve obtained for reaction **1**?

A The temperature is higher in reaction **1**.

B The surface area is greater in reaction **2**.

C The amount of impurities is greater in reaction **2**.

D The amount of impurities is greater in reaction **1**. (2)

1.5 The equation below represents a hypothetical reaction.

$$A(g) + B(g) \rightleftharpoons C(g) \qquad \Delta H = -50\ kJ\cdot mol^{-1}$$

The activation energy for the REVERSE reaction is 110 kJ·mol^{-1}.

Which ONE of the following is the activation energy (in kJ·mol^{-1}) for the FORWARD reaction?

A 50

B 60

C 110

D 160 (2)

1.6 A reaction reaches equilibrium at 25 °C in a flask according to the following balanced equation:

$$\underset{\text{pink}}{Co(H_2O)_6^{2+}(aq)} + 4C\ell^-(aq) \rightleftharpoons \underset{\text{blue}}{CoC\ell_4^{2-}(aq)} + 6H_2O(\ell) \qquad \Delta H > 0$$

Which ONE of the following will change the colour of the mixture from pink to blue?

A Adding water

B Cooling the flask

C Adding NaOH(aq)

D Adding $NH_4C\ell(aq)$ (2)

1.7 Dilute nitric acid is added to distilled water at 25 °C.

How will this affect the hydronium ion concentration $[H_3O^+]$ and the ionisation constant (K_w) of water at 25 °C?

	$[H_3O^+]$	K_w
A	Increases	Increases
B	Increases	Decreases
C	Increases	Remains the same
D	Remains the same	Remains the same

(2)

1.8 Consider the ionisation reactions **I** and **II**.

I $H_2PO_4^- + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + \mathbf{X}$

II $\mathbf{X} + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + \mathbf{Y}$

Which ONE of the following combinations represents the formulae of **X** and **Y** respectively?

	X	Y
A	HPO_4^{2-}	PO_4^{3-}
B	HPO_4^{2-}	H_3PO_4
C	H_3PO_4	PO_4^{3-}
D	HPO_4^{2-}	$H_2PO_4^-$

(2)

1.9 An electrochemical cell was set up using a $Hg(\ell)|Hg^{2+}(aq)$ half-cell and another half-cell under standard conditions.

Which ONE of the following half-cells, when connected to the $Hg(\ell)|Hg^{2+}(aq)$ half-cell, will result in the HIGHEST cell potential?

A $A\ell(s)|A\ell^{3+}(aq)$

B $Zn(s)|Zn^{2+}(aq)$

C $Co(s)|Co^{2+}(aq)$

D $Pt(s)|H_2(g)|H^+(aq)$ (2)

1.10 The following reaction takes place in an electrochemical cell:

$$CuC\ell_2(aq) \rightarrow Cu(s) + C\ell_2(g)$$

Which ONE of the following is CORRECT for this cell?

A It is a galvanic cell.

B A power source is needed.

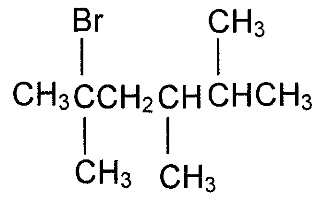
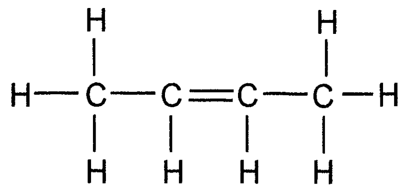
C The reaction is spontaneous.

D Copper acts as the oxidising agent. (2)

[20]

QUESTION 2 (Start on a new page.)

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

A		**B**	
C	Pent-2-ene	**D**	$CH_3CH_2CH_2CHO$
E	Butan-2-one	**F**	4,4-dimethylpent-2-yne
G	Butane	**H**	$CH_3CH_2CH_2COOH$

2.1 Write down the LETTER that represents a compound that:

2.1.1 Is a ketone (1)

2.1.2 Has the general formula C_nH_{2n-2} (1)

2.1.3 Is an isomer of 2-methylbut-2-ene (1)

2.1.4 Has the same molecular formula as ethyl ethanoate (1)

2.2 Write down the:

2.2.1 IUPAC name of compound **A** (3)

2.2.2 STRUCTURAL FORMULA of compound **F** (3)

2.3 For compound **D**, write down the:

2.3.1 Homologous series to which it belongs (1)

2.3.2 NAME of its functional group (1)

2.3.3 STRUCTURAL FORMULA of its functional isomer (2)

2.4 For compound **G**, write down:

2.4.1 The IUPAC name of a chain isomer (2)

2.4.2 A balanced equation, using molecular formulae, for its complete combustion (3)

[19]

QUESTION 3 (Start on a new page.)

Learners investigate factors that influence the boiling points of organic compounds. The boiling points of some organic compounds obtained are shown in the table below.

COMPOUND		MOLECULAR MASS ($g \cdot mol^{-1}$)	BOILING POINT (°C)
A	Propane	44	- 42
B	Butane	58	- 0,5
C	Pentane	72	36
D	Methylbutane	72	28
E	Ethanol	46	78
F	Ethanal	44	20

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

3.2 The boiling points of compounds **A**, **B** and **C** are compared.

3.2.1 How do the boiling points vary from compound **A** to compound **C**?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

3.2.2 Explain the answer to QUESTION 3.2.1. (3)

3.3 The boiling points of compounds **B**, **C** and **D** are compared.

Is this a fair comparison?

Choose from YES or NO. Give a reason for the answer. (2)

3.4 The boiling points of compounds **E** and **F** are compared.

3.4.1 State the independent variable for this comparison. (1)

3.4.2 Write down the name of the strongest Van der Waals force present in compound **F**. (1)

3.5 Which compound, **D** or **E**, has a higher vapour pressure? Give a reason for the answer. (2)

[12]

QUESTION 4 (Start on a new page.)

4.1 Study the following incomplete equations for organic reactions **I** and **II**.

Compounds **P** and **Q** are ORGANIC compounds and **T** is an INORGANIC compound.

I	$CH_3\overset{\displaystyle CH_3 \atop \vert}{CH}\,\underset{\vert \atop \displaystyle Br}{CH}CH_3 + NaOH\ (conc.) \longrightarrow \underset{\text{(major product)}}{\mathbf{P}} + NaBr + \mathbf{T}$
II	CH_3COOH + compound **Q** → butyl ethanoate + H_2O

For reaction **I**, write down the:

4.1.1 Type of reaction that takes place (1)

4.1.2 IUPAC name of compound **P** (2)

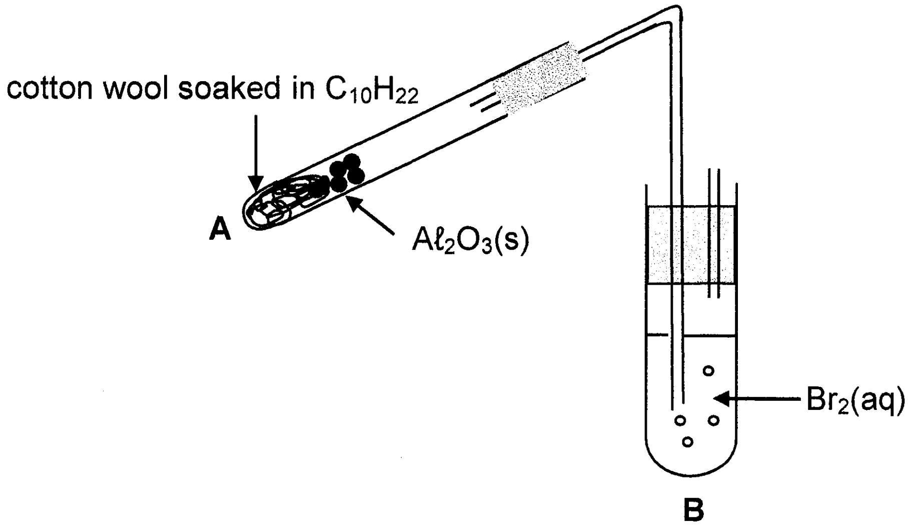
4.1.3 NAME or FORMULA of compound **T** (1)

For reaction **II**, write down:

4.1.4 TWO reaction conditions needed (2)

4.1.5 The STRUCTURAL FORMULA of compound **Q** (2)

4.2 The cracking of a long chain hydrocarbon, $C_{10}H_{22}$, takes place in test tube **A**, as shown below.



Two STRAIGHT CHAIN organic compounds, **X** and **Z**, are produced in test tube **A** according to the following balanced equation:

$$C_{10}H_{22}(\ell) \rightarrow 2\mathbf{X}(g) + \mathbf{Z}(g)$$

4.2.1 State the function of the $A\ell_2O_3(s)$ in test tube **A**. (1)

The organic compounds, **X** and **Z**, are now passed through bromine water, $Br_2(aq)$, at room temperature in test tube **B**. Only compound **X** reacts with the bromine water.

4.2.2 Apart from gas bubbles being formed, state another observable change in test tube **B**. (1)

4.2.3 Write down the TYPE of reaction that takes place in test tube **B**. (1)

4.2.4 Write down the molecular formula of compound **Z**. (3)

4.2.5 Write down the STRUCTURAL FORMULA of compound **X**. (3)
[17]

QUESTION 5 (Start on a new page.)

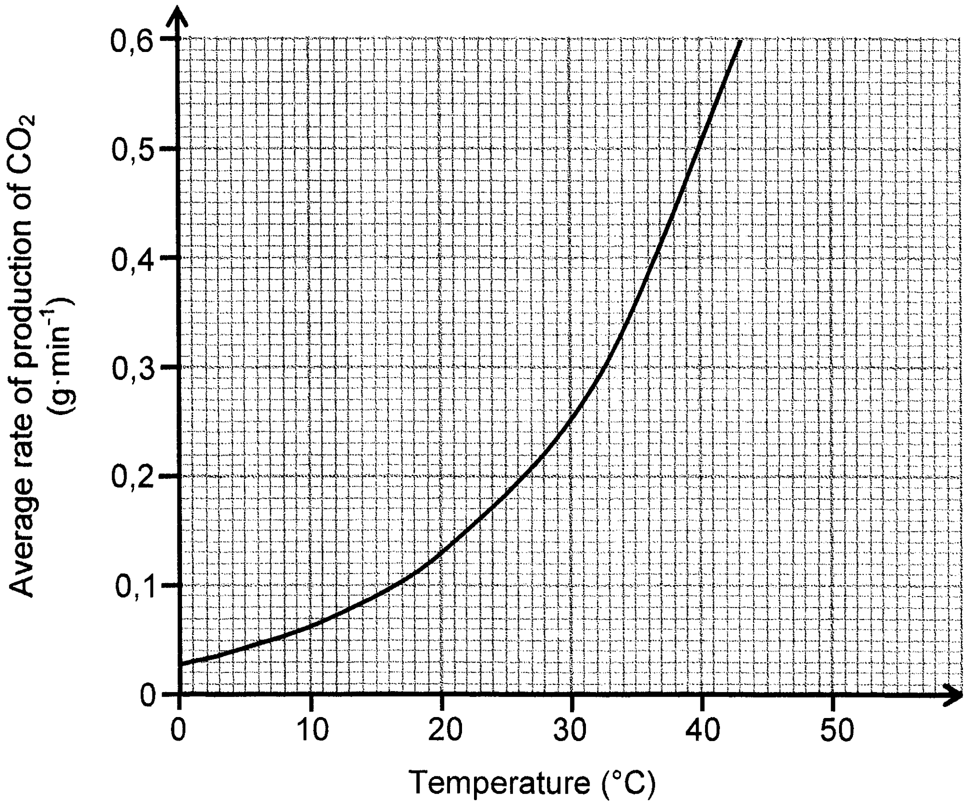
Learners use the reaction of $MgCO_3(s)$ with EXCESS dilute $HC\ell(aq)$ to investigate the relationship between temperature and the rate of a chemical reaction.

The balanced equation for the reaction is:

$$MgCO_3(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + CO_2(g) + H_2O(\ell)$$

The results obtained are represented in the graph below.

Graph of average rate of production of CO_2 (in $g \cdot min^{-1}$) versus temperature



5.1 Define the term *rate of reaction.* (2)

5.2 State TWO conditions that must be kept constant during this investigation. (2)

5.3 Use the collision theory to explain the relationship shown in the graph. (4)

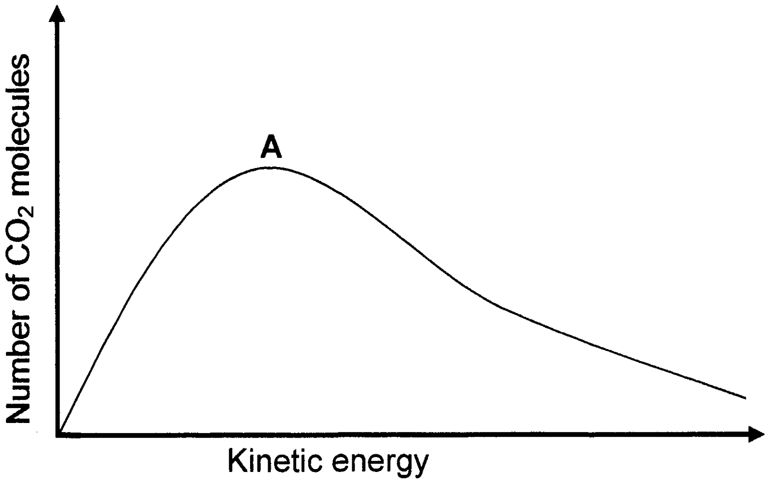
5.4 The learners obtained the graph above using 5 g $MgCO_3(s)$ with EXCESS $HC\ell$ at 40 °C.

Calculate the:

5.4.1 Time taken for the reaction to run to completion (6)

5.4.2 Molar gas volume at 40 °C if 1,5 dm^3 CO_2 is collected in a syringe (2)

5.5 The graph below represents the Maxwell-Boltzmann distribution curve for $CO_2(g)$ at 40 °C.



Redraw the graph above in the ANSWER BOOK. Clearly label the curve as **A**.

On the same set of axes, sketch the curve that will be obtained for the $CO_2(g)$ at 20 °C. Label this curve as **B**. (2)

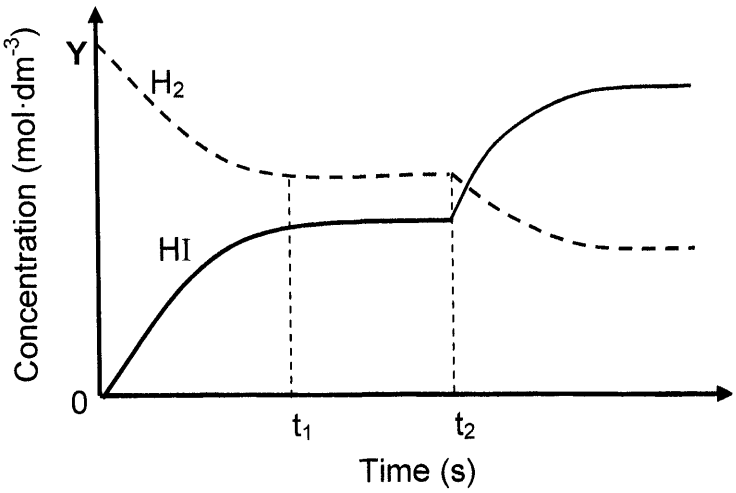
[18]

QUESTION 6 (Start on a new page.)

6.1 Initially, 4 moles $H_2(g)$ and 4 moles $I_2(g)$ are allowed to react in a sealed 2 dm^3 flask according to the following balanced equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H < 0$$

The graph below shows the concentrations of $H_2(g)$ and $HI(g)$ versus time during the reaction.



6.1.1 Write down the value of **Y**. (1)

6.1.2 State Le Chatelier's principle. (2)

6.1.3 Changes were made to the temperature of the flask at time t_2.

Was the flask HEATED or COOLED? (1)

6.1.4 Fully explain the answer to QUESTION 6.1.3. (3)

6.2 The equation below represents the reversible reaction that takes place when $NO_2(g)$ is converted to $N_2O_4(g)$.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

Initially, **x** mol of $NO_2(g)$ is sealed in a 1 dm^3 container at 350 K. When equilibrium is established at this temperature, 0,81 mol $N_2O_4(g)$ is present in the container.

6.2.1 Write down the meaning of the term *reversible reaction*. (1)

6.2.2 Show that the equilibrium constant for this reaction is given by $\frac{0{,}81}{(x-1{,}62)^2}$. (5)

0,79 moles of $N_2O_4(g)$ is now added to the equilibrium mixture above. When the NEW equilibrium is established at 350 K, it is found that the amount of $NO_2(g)$ increased by 1,2 moles.

6.2.3 Calculate the value of **x**. (6)

[19]

QUESTION 7 (Start on a new page.)

7.1 Two acids, HX and HY, of EQUAL CONCENTRATIONS are compared. The pH of HX is 2,7 and the pH of HY is 0,7.

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

7.1.2 Which acid, HX or HY, is STRONGER? Give a reason for the answer. (2)

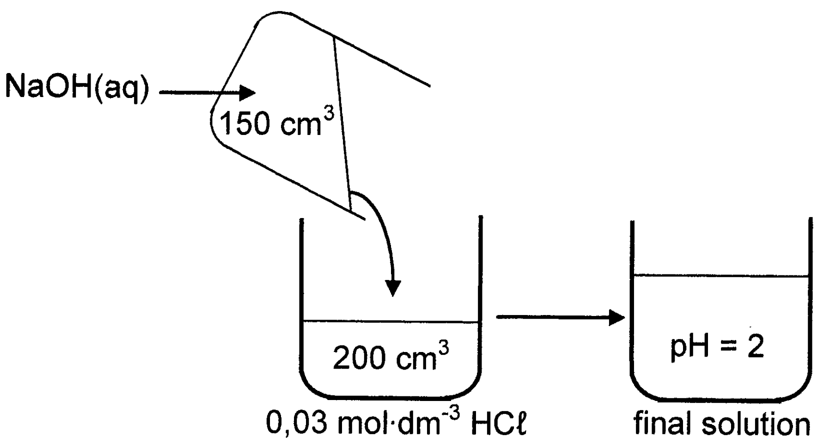
7.1.3 Acid HX ionises in water according to the following equation:

$$HX(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + X^-(aq)$$

The K_a value for the reaction is $1,8 \times 10^{-5}$ at 25 °C.

Is the concentration of the hydronium ions HIGHER THAN, LOWER THAN or EQUAL TO the concentration of HX? Give a reason for the answer. (2)

7.2 Learners add 150 cm^3 of a sodium hydroxide solution, NaOH, of unknown concentration to 200 cm^3 of a 0,03 mol·dm^{-3} hydrochloric acid solution, HCℓ, as illustrated below. They find that the pH of the final solution is 2. Assume that the volumes are additive.



The balanced equation for the reaction is:

$$HC\ell(aq) + NaOH(aq) \rightarrow NaC\ell(aq) + H_2O(\ell)$$

Calculate the:

7.2.1 Concentration of the H_3O^+ ions in the final solution (3)

7.2.2 Initial concentration of the NaOH(aq) (7)

[16]

QUESTION 8 (Start on a new page.)

8.1 An electrochemical cell is set up using an aluminium rod, $A\ell$, and a gas **X**.

The initial emf measured under standard conditions is 2,89 V.

8.1.1 State the standard conditions under which this cell operates. (3)

8.1.2 Use a calculation to identify gas **X**. (5)

8.1.3 Write down the FORMULA of the reducing agent in this cell. (1)

8.1.4 Write down the half-reaction that takes place at the cathode. (2)

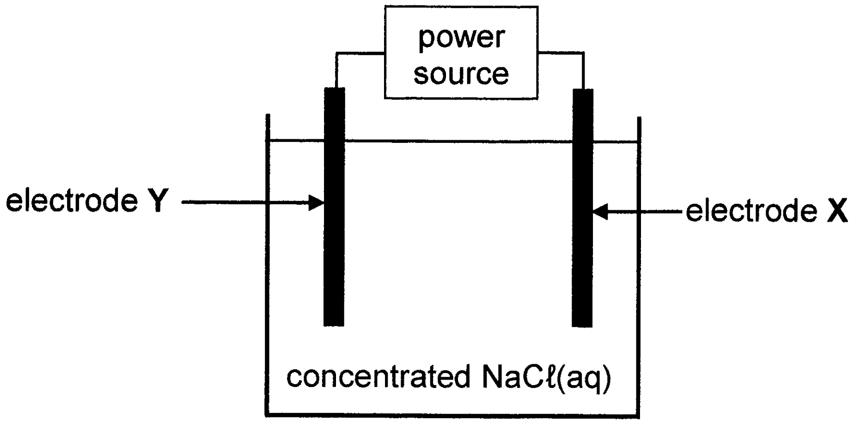
8.1.5 Write down the cell notation for this cell. (3)

8.2 Which container, ZINC or COPPER, will be more suitable to store an aqueous solution of nickel ions, Ni^{2+}?

Refer to the Table of Standard Reduction Potentials to fully explain the answer in terms of the relative strengths of reducing agents. (4)
[18]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents an electrochemical cell used for the electrolysis of a concentrated sodium chloride solution, NaCℓ(aq). **X** and **Y** are carbon electrodes.



9.1 Define the term *electrolysis*. (2)

9.2 Chlorine gas, $C\ell_2(g)$, is released at electrode **X**.

Write down the:

9.2.1 Letter (**X** or **Y**) of the electrode where oxidation takes place (1)

9.2.2 Half-reaction that takes place at electrode **Y** (2)

9.2.3 Direction in which electrons flow in the external circuit

Choose from **X** to **Y** OR **Y** to **X**. (1)

9.2.4 Balanced equation for the net (overall) cell reaction that takes place in the cell (3)

9.3 How will the pH of the electrolyte change during the reaction?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

9.4 Give a reason for the answer to QUESTION 9.3. (1)
[11]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

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

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

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

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

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

KEY/*SLEUTEL*

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

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

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

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

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

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

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

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

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 oxidising agents/*Toenemende sterkte van oksideermiddels*

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)

2022

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

Approved: DBE
DBE CM 3/06/2022
DBE IM 3/06/2022

Approved: Umalusi Modertors
3/06/2022 3/06/2022

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

QUESTION 1/*VRAAG 1*

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

QUESTION 2/*VRAAG 2*

2.1

2.1.1	E ✓	(1)
2.1.2	F ✓	(1)
2.1.3	C ✓	(1)
2.1.4	H ✓	(1)

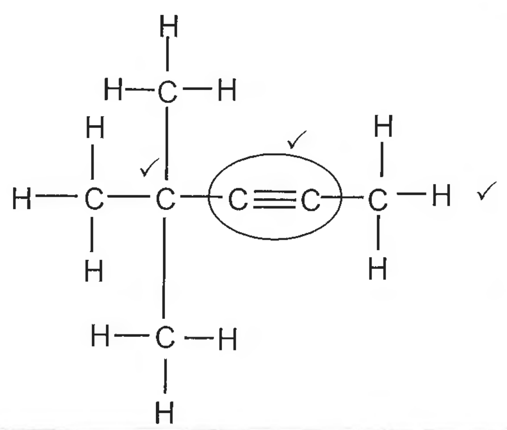
2.2

2.2.1 2-bromo-2,4,5-trimethylhexane/*2-broom-2,4,5-trimetielheksaan*

Marking criteria:	***Nasienkriteria:***
• Correct stem i.e. hexane. ✓ • All substituents (bromo and trimethyl) correctly identified. ✓ • IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓	• *Korrekte stam d.i. heksaan. ✓* • *Alle substituente (bromo and trimetiel) korrek geïdentifiseer. ✓* • *IUPAC-naam heeltemal korrek insluitende volgorde, koppeltekens en kommas. ✓*

(3)

2.2.2



Marking criteria/*Nasienkriteria:*
- Five C atoms in longest chain + triple bond. ✓
  Vyf C-atome in langste ketting + drievoudige binding.
- Two methyl substituents. ✓
  Twee metielsubstituente.
- Whole structure correct.
  Hele struktuur korrek. ✓

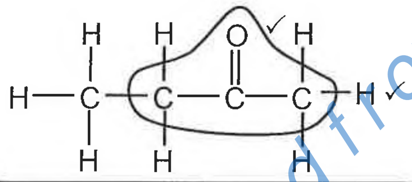
IF/*INDIEN*
- More than one functional group/wrong functional group:
  Meer as een funksionele groep/foutiewe funksionele groep: $\frac{0}{3}$
- If condensed structural formulae used/*Indien gekondenseerde struktuurformules gebruik:* Max/*Maks.*: $\frac{2}{3}$

(3)

2.3
2.3.1 Aldehyde/*Aldehied* ✓ (1)

2.3.2 Formyl/*Formiel* ✓ (1)

2.3.3



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

IF/*INDIEN*
- More than one functional group/wrong functional group:
  Meer as een funksionele groep/foutiewe funksionele groep: $\frac{0}{2}$
- If condensed structural formulae used/*Indien gekondenseerde struktuurformules gebruik:* Max/*Maks.*: $\frac{1}{2}$

(2)

2.4
2.4.1 Methyl✓propane✓/2-methylpropane/*Metielpropaan/2-metielpropaan* (2)

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

Ignore phases./*Ignoreer fases.*

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

IF: Structural formula for C_4H_{10} Max. 2/3
INDIEN: Structural formula for C_4H_{10} Max. 2/3

(3)
[19]

QUESTION 3/*VRAAG 3*

3.1

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

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

3.2

3.2.1 Increases/*Neem toe* ✓ (1)

3.2.2 **From A to C:**

- Increase in molecular mass/size/chain length/surface area/number of C atoms. ✓
- Strength of the intermolecular forces increases/More sites for London forces. ✓
- More energy is needed to overcome/break intermolecular forces. ✓

OR
From C to A:

- Decrease in molecular mass/size/chain length/surface area/number of C atoms. ✓
- Strength of the intermolecular forces decreases/Less sites for London forces. ✓
- Less energy is needed to overcome/break intermolecular forces. ✓

Van A na C:

- *Verhoging in molekulêre massa/molekulêre grootte/kettinglengte/reaksie-oppervlak/aantal C-atome.* ✓
- *Sterkte van die intermolekulêre kragte verhoog./Meer punte vir Londonkragte.* ✓
- *Meer energie benodig om intermolekulêre kragte te oorkom/breek.* ✓

OF
Van C na A:

- *Verlaging in molekulêre massa/molekulêre grootte/kettinglengte/reaksie-oppervlak/aantal C-atome.* ✓
- *Sterkte van die intermolekulêre kragte verlaag./Minder punte vir Londonkragte.* ✓
- *Minder energie benodig om intermolekulêre kragte te oorkom/breek.* ✓ (3)

3.3 No / *Nee* ✓
More than one independent variable./Molar mass and chain length (surface area) are changing. ✓
Meer as een onafhanklike veranderlike./Molêre massa (reaksie-oppervlak) en kettinglengte verander. (2)

3.4
3.4.1 Functional group/homologous series/type of intermolecular forces/type of compound ✓ (1)
Funksionele groep/homoloë reeks/soort intermolekulêre kragte/tipe verbinding

3.4.2 <u>Dipole-dipole</u> forces/<u>*Dipool-dipool*</u>*kragte* ✓ (1)

3.5 D / methylbutane / *metielbutaan* ✓

Lower boiling point/Weaker intermolecular forces ✓
Laer kookpunt/Swakker intermolekulêre kragte (2)
[12]

QUESTION 4/*VRAAG 4*

4.1
4.1.1 Dehydrohalogenation/elimination/dehydrobromination ✓
Dehidrohalogenering/eliminasie/dehidrobrominering (1)

4.1.2 2-methylbut-2-ene / 2-methyl-2-butene ✓✓
2-metielbut-2-een / 2-metiel-2-buteen ✓✓

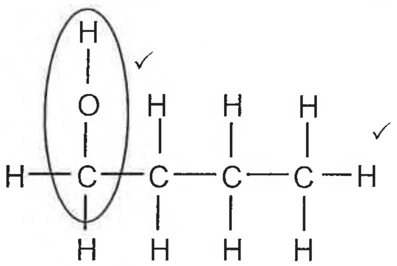
<u>Marking criteria/*Nasienkriteria*</u>
Methylbutene/*metielbuteen* ✓
IUPAC name correct/*IUPAC-naam korrek* ✓

IF/*INDIEN*
Any error, e.g. hyphens omitted and/or incorrect sequence/*Enige fout, bv. koppeltekens weggelaat en/of verkeerde volgorde:* Max/*Maks:* $\frac{1}{2}$ (2)

4.1.3 Water/H_2O ✓ (1)

4.1.4 Heat/*Hitte* ✓
(Concentrated) <u>sulphuric acid/catalyst</u> ✓
(Gekonsentreerde) <u>*swawelsuur/katalisator*</u>

<u>ACCEPT/*AANVAAR*:</u>
<u>High temperature/</u>
<u>*Hoë temperatuur*</u> (2)

4.1.5


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

IF/*INDIEN*
More than one functional group/*Meer as een funksionele groep* $\frac{0}{2}$ (2)

4.2
4.2.1 Catalyst/Lowers the activation energy./Increases the rate of the reaction. ✓
Katalisator/Verlaag die aktiveringsenergie./Laat reaksietempo toeneem. (1)

4.2.2 The bromine water/Br_2/solution decolourises. ✓
Die broomwater/Br_2/oplossing ontkleur.

OR/*OF*
Bromine water/Br_2/solution changes from brown/reddish to colourless.
Broomwater/Br_2/oplossing verander van bruin/rooi na kleurloos. (1)

4.2.3 Addition/halogenation/bromination ✓ (1)
Addisie/halogenering/brominering

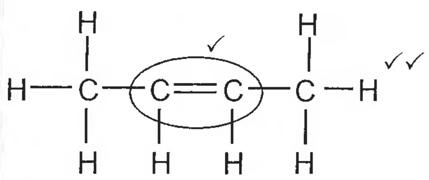
4.2.4 C_2H_6 ✓✓✓ **(3 or/*of* 0)** **OR/*OF*** C_4H_{10} **OR/*OF*** C_6H_{14}

IF structural/condensed formulae: **(2 or 0)**
INDIEN *struktuurformules/gekondenseerde formules gebruik:* ***(2 of 0)*** (3)

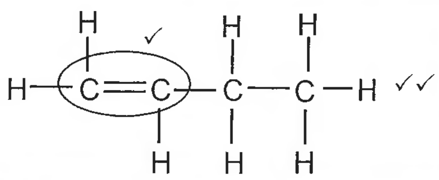
4.2.5

<u>Marking criteria</u>	<u>*Nasienkriteria*</u>
• Correct functional group i.e. double bond. ✓ • Correct number of C atoms in relation to answer in Q4.2.4. ✓ • Whole structure correct. ✓ **IF** condensed/molecular formulae used: Max. $^2/_3$	• *Korrekte funksionele groep d.i. dubbelbinding.* ✓ • *Korrekte aantal C-atome na aanleiding van antwoord in V4.2.4.* ✓ • *Hele struktuur korrek.* ✓ ***INDIEN*** *gekondenseerde/molekulêre formules gebruik: Maks.* $^2/_3$

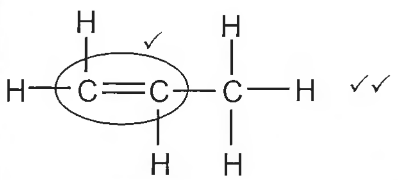
IF C_2H_6 in QUESTION 4.2.4/*INDIEN C_2H_6 in VRAAG 4.2.4*:



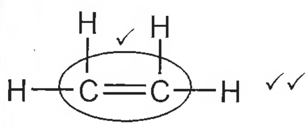
OR/*OF*



IF C_4H_{10} in QUESTION 4.2.4/
INDIEN C_4H_{10} in VRAAG 4.2.4:



IF C_6H_{14} in QUESTION 4.2.4:
INDIEN C_6H_{14} in VRAAG 4.2.4:



(3)
[17]

QUESTION 5/VRAAG 5

5.1

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

ANY ONE:

- Change in concentration ✓ of products/reactants per (unit) time. ✓
- Change in amount/number of moles/volume/mass of products or reactants per (unit) time.
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time.
- Rate of change in concentration/amount/number of moles/volume/ mass.✓✓ **(2 or 0)**

ENIGE EEN:

- *Verandering in konsentrasie van produkte/reaktanse per (eenheid) tyd.*
- *Verandering in hoeveelheid/getal mol/volume/massa van produkte of reaktanse per (eenheid) tyd.*
- *Hoeveelheid/getal mol/volume/massa van produkte gevorm/reaktanse gebruik per (eenheid) tyd.*
- *Tempo van verandering in konsentrasie/ hoeveelheid/getal mol/ volume/massa.* ***(2 of 0)*** (2)

5.2

- Surface area / state of division / particle size (of $MgCO_3$) ✓
- Concentration (of $HC\ell$) ✓

- *Reaksieoppervlak/toestand van verdeeldheid/deeltjie-grootte (van* $MgCO_3$*)*
- *Konsentrasie (van* $HC\ell$*)* (2)

5.3

- At a higher temperature particles move faster/have a higher kinetic energy. ✓
- More molecules have enough/sufficient kinetic energy for an effective collision. ✓
  OR More molecules have kinetic energy/E_k equal to or greater than the activation energy.
- More effective collisions per unit time/second. ✓
  OR Frequency of effective collisions increases.
- Reaction rate increases. ✓

- *By 'n hoër temperatuur beweeg die deeltjies vinniger/het die deeltjies hoër kinetiese energie.* ✓
- *Meer molekule het genoeg/voldoende kinetiese energie/*E_k *vir 'n effektiewe botsing.* ✓
  OF *Meer molekule het kinetiese energie gelyk aan of groter as die aktiveringsenergie.*
- *Meer effektiewe botsings per eenheidtyd/sekonde.* ✓
  OF *Frekwensie van effektiewe botsings verhoog.*
- *Reaksietempo neem toe.* ✓ (4)

5.4.1

Marking criteria	***Nasienkriteria***
• Formula: $n = \frac{m}{M}$ ✓ • Substitution of 84 $g \cdot mol^{-1}$ in $n = \frac{m}{M}$ ✓ • Use mole ratio: $n(MgCO_3)_{used} = n(CO_2)_{produced}$ ✓ • Substitution of 44 $g \cdot mol^{-1}$ in $n = \frac{m}{M}$ **or** to calculate rate in $mol \cdot min^{-1}$. ✓ • Correct substitution of 0,5 in rate equation. ✓ • Final answer: 5,238 to 5,28 min ✓	• *Formule:* $n = \frac{m}{M}$ ✓ • *Vervanging van 84 $g \cdot mol^{-1}$ in* $n = \frac{m}{M}$ ✓ • *Gebruik molverhouding:* $n(MgCO_3)_{gebruik} = n(CO_2)_{berei}$ ✓ • *Vervanging van 44 $g \cdot mol^{-1}$ in* $n = \frac{m}{M}$ ***of** om tempo te bereken in $mol \cdot min^{-1}$.* ✓ • *Korrekte vervanging van 0,5 in tempovergelyking.* ✓ • *Finale antwoord: 5,238 tot 5,28 min* ✓

$n(MgCO_3) = \frac{m}{M}$ ✓

$= \frac{5}{84}$ ✓

$= 0,06$ mol (0,0595 mol)

$n(CO_2)_{produced/gevorm} = n(MgCO_3)$ ✓ $= 0,06$ mol

$n(CO_2) = \frac{m}{M}$ $0,06 = \frac{m}{44}$ ✓ $m(CO_2) = 2,64$ g Ave rate/*gem tempo* $= \frac{\Delta m(CO_2)}{\Delta t}$ $0,5$ ✓ $= \frac{2,64}{\Delta t}$ $\Delta t = 5,28$ min ✓	Ave rate/*gem tempo* in $mol \cdot min^{-1}$: $\frac{0,5 ✓}{44 ✓} = 0,0114\ mol \cdot min^{-1}$ Ave rate/*gem tempo* $= \frac{\Delta n(CO_2)}{\Delta t}$ $0,0114 = \frac{0,06}{\Delta t}$ $\Delta t = 5,28$ min ✓

(6)

5.4.2 **POSITIVE MARKING FROM QUESTION 5.4.1.**
POSITIEWE NASIEN VANAF VRAAG 5.4.1.

Marking criteria	***Nasienkriteria***
• Substitution of $n(CO_2)$ AND 1,5 dm^3 in $n = \frac{V}{V_m}$. ✓ • Final answer: • \25 to 25,21 $dm^3 \cdot mol^{-1}$ ✓	• *Vervanging van* $n(CO_2)$ EN 1,5 dm^3 in $n = \frac{V}{V_m}$. ✓ • *Finale antwoord:* 25 dm^3 *tot* 25,21 $dm^3 \cdot mol^{-1}$ ✓

$n = \frac{V}{V_m}$

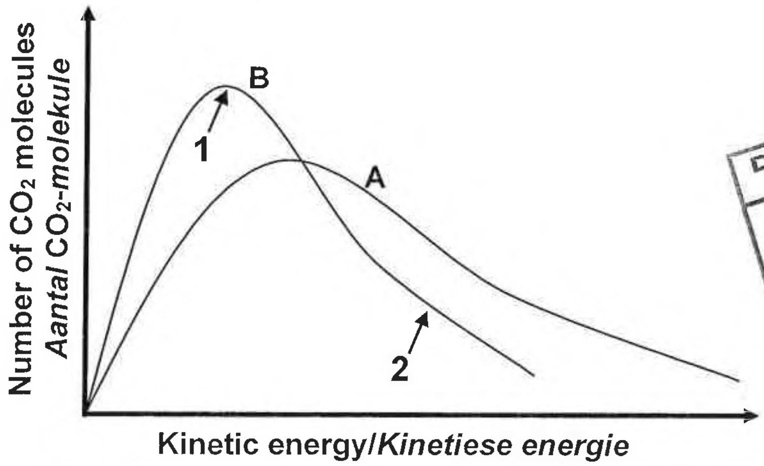
$0,06 = \frac{1,5}{V_m}$ ✓

$V_m = 25\ dm^3 \cdot mol^{-1}$ ✓ (25,21 $dm^3 \cdot mol^{-1}$)

ACCEPT/*AANVAAR*: 25 dm^3

(2)

5.5



Marking criteria/*Nasienkriteria*		
1	Curve **B** has a higher peak to the left of curve **A**. *Kurwe **B** het hoër piek aan die linkerkant van kurwe **A**.*	✓
2	Curve **B** is below curve **A** beyond the peak of curve **A**./*Kurwe **B** is onder kurwe **A** na die piek van kurwe **A**.*	✓
If BOTH graphs not labelled (**A** and **B**): no marks *Indien BEIDE grafieke nie benoem nie (**A** en **B**): geen punte*		

(2)
[18]

QUESTION 6/*VRAAG 6*

6.1.1 2 (mol·dm^{-3}) ✓ (1)

6.1.2

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

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

6.1.3 Cooled/*Afgekoel* ✓ (1)

6.1.4
- A decrease in temperature favours the exothermic reaction./An increase in temperature favours the endothermic reaction. ✓
- The forward reaction is favoured./HI concentration increases./Equilibrium (position) shifts to the right. ✓
- The forward reaction is exothermic./Reverse reaction is endothermic. ✓

- *Afname in temperatuur bevoordeel die eksotermiese reaksie./Toename in temperatuur bevoordeel die endotermiese reaksie.* ✓
- *Die voorwaartse reaksie word bevoordeel./ HI-konsentrasie neem toe./Die ewewigs(posisie) skuif na regs.* ✓
- *Voorwaatse reaksie is eksotermies./Die terugwaartse reaksie is endotermies.* ✓

(3)

6.2

6.2.1 Products can be converted back to reactants. ✓
OR
Both forward and reverse reactions can take place.
OR
A reaction which can take place in both directions.

Produkte kan omgeskakel word na reaktanse. ✓
OF
Beide voor-en terugwaartse reaksies kan plaasvind.
OF
'n Reaksie wat in beide rigtings kan plaasvind. (1)

6.2.2

Marking criteria	***Nasienkriteria:***
a) $\Delta n(N_2O_4) = n(N_2O_4)_{eq} - n(N_2O_4)_{ini}$. ✓	(a) $\Delta n(N_2O_4) = n(N_2O_4)_{ewe} - n(N_2O_4)_{aanv}$. ✓
b) USING ratio: $n(NO_2) : n(N_2O_4) = 2 : 1$ ✓	(b) *GEBRUIK verhouding:* $n(NO_2) : n(N_2O_4) = 2 : 1$ ✓
c) $n(NO_2)_{eq} = n(NO_2)_{ini} - \Delta n(NO_2)$ ✓	(c) $n(NO_2)_{ewe} = n(NO_2)_{aanv} - \Delta n(NO_2)$ ✓
d) Divide BOTH by 1 dm^3 ✓	(d) *Deel BEIDE deur* 1 dm^3 ✓
e) Correct K_c expression (formulae in square brackets). ✓	(e) *Korrekte K_c uitdrukking (formules in vierkantige hakies).* ✓

	NO_2	N_2O_4	
Initial amount (moles) *Aanvangshoeveelheid (mol)*	x	0	
Change in amount (moles) *Verandering in hoeveelheid* (mol)	1,62	0,81 ✓ (a)	ratio ✓ (b) *verhouding*
Equilibrium amount (moles) *Ewewigshoeveelheid (mol)*	x – 1,62 ✓ (c)	0,81	
Equilibrium concentration ($mol \cdot dm^{-3}$) *Ewewigskonsentrasie ($mol \cdot dm^{-3}$)*	x – 1,62	0,81	÷ dm^3 ✓ (d)

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark \text{ (e)}$$

$$= \frac{(0,81)}{(x - 1,62)^2}$$

Wrong or no K_c expression/*Verkeerde of geen K_c-uitdrukking*: Max./*Maks.* $\frac{4}{5}$

(5)

6.2.3 **POSITIVE MARKING FROM QUESTION 6.2.2**
POSITIEWE NASIEN VAN VRAAG 6.2.2.

Marking criteria	***Nasienkriteria:***
a) Add 0,79 mol to $n(N_2O_4)_{ini}$. ✓ b) USING ratio: $n(NO_2) : n(N_2O_4) = 2 : 1$ to calculate $\Delta n(N_2O_4)$ as 0,6 mol. ✓ c) $n(NO_2)_{eq} = n(NO_2)_{ini} + \Delta n(NO_2)$ $n(N_2O_4)_{eq} = n(N_2O_4)_{ini} - \Delta n(N_2O_4)$ ✓ d) Substitution of concentrations into correct K_c expression. ✓ e) Equating K_c expresssion from Q6.1.3 and Q6.2.3. ✓ f) Final answer: 12,42 ✓ (Range: 11,27 – 12,42)	*(a) Voeg 0,79 mol by $n(N_2O_4)_{aanv}$.* ✓ *(b) GEBRUIK verhouding:* *$n(NO_2) : n(N_2O_4) = 2 : 1$* *om $\Delta n(N_2O_4)$ as 0,6 mol te bereken.* ✓ *(c) $n(NO_2)_{ewe} = n(NO_2)_{aanv} + \Delta n(NO_2)$* *$n(N_2O_4)_{ewe} = n(N_2O_4)_{aanv} - \Delta n(N_2O_4)$* ✓ *(d) Vervanging van konsentrasies in korrekte K_c-uitdrukking.* *(e) Stel K_c-uitdrukking van Q6.1.3 en Q6.2.3 gelyk aan mekaar.* ✓ *(f) Finale antwoord: 12,42* ✓ *(Gebied: 11,27 – 12,42)*

	NO_2	N_2O_4	
Initial amount (moles) *Aanvangs hoeveelheid (mol)*	x – 1,62	0,81 + 0,79 ✓ = 1,6	(a)
Change in amount (moles) *Verandering in hoeveelheid* (mol)	1,2	0,6 ✓	(b)
Equilibrium amount (moles) *Ewewigshoeveelheid* (mol)	x – 1,62 +1,2	1	✓(c)
Equilibrium concentration ($mol{\cdot}dm^{-3}$) *Ewewigskonsentrasie ($mol{\cdot}dm^{-3}$)*	x – 0,42	1	

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

$$\frac{(0,81)}{(x-1,62)^2} \overset{(e)\checkmark}{=} \frac{1}{(x-0,42)^2} \checkmark(d)$$

$$x = 12,42 \text{ (mol)} \checkmark(f)$$

Wrong K_c expression/*Verkeerde K_c- uitdrukking*: Max./*Maks.* $^4/_6$
No K_c expression/*Geen K_c- uitdrukking*: $^6/_6$

(6)
[19]

QUESTION 7/VRAAG 7

7.1
7.1.1 An acid is a proton (H^+ ion) donor. ✓✓
'n Suur is 'n protondonor/skenker of H^+-ioon donor/skenker. (2)

7.1.2 HY ✓
For the SAME acid concentration:
Lower pH / higher H^+ or H_3O^+ concentration / more ionised. ✓
Vir DIESELFDE suurkonsentrasie:
Laer pH / hoër H^+/H_3O^+ konsentrasie / meer geïoniseer. (2)

7.1.3 Lower than./*Laer as* ✓
$K_a < 1$ / HX ionises incompletely. / HX has a small K_a value. / HX is a weak acid. ✓
$K_a < 1$ / HX ioniseer onvolledig. / HX het 'n klein K_a-waarde. / HX is 'n swak suur. (2)

7.2

7.2.1 $pH = -\log[H_3O^+]$ **OR/*OF*** $[H_3O^+] = 10^{-pH}$ ✓
2 ✓ $= -\log[H_3O^+]$
$[H_3O^+] = 0{,}01\ mol\cdot dm^{-3}$ ✓ $(1 \times 10^{-2}\ mol\cdot dm^{-3})$ (3)

7.2.2 **POSITIVE MARKING FROM QUESTION 7.2.1.**
POSITIEWE NASIEN VAN VRAAG 7.2.1.

Marking criteria for OPTION 1:	***Nasienkriteria vir OPSIE 1:***
• Substitute $c(HC\ell)_{excess}$ and $0{,}35\ dm^3$ to calculate $n(HC\ell)_{excess}$.✓ • Substitute to calculate $n(HC\ell)_{initial}$ ✓ • $n(HC\ell)_{react} = n(HC\ell)_{ini} - n(HC\ell)_{excess}$.✓✓ • Use ratio: $n(NaOH) = n(HC\ell)$ ✓ • Substitute $0{,}15\ dm^3$ in $c = \frac{n}{V}$. ✓ • Final answer: $0{,}02\ mol\cdot dm^{-3}$ ✓ **or** $0{,}0167\ mol\cdot dm^{-3}$ **or** $0{,}017\ mol\cdot dm^{-3}$	• *Vervang $c(HC\ell)_{oormaat}$ en $0{,}35\ dm^3$ om $n(HC\ell)_{oormaat}$ te bereken.*✓ • *Vervang om $n(HC\ell)_{aanv}$ te bereken.* ✓ • *$n(HC\ell)_{rea} = n(HC\ell)_{aanv} - (HC\ell)_{oormaat}$*✓✓ • *Gebruik verhouding: $n(NaOH) = n(HC\ell)$* ✓ • *Vervang $0{,}15\ dm^3$ in $c = \frac{n}{V}$* ✓ • *Finale antwoord:* $0{,}02\ mol\cdot dm^{-3}$ ✓ ***of*** *$0{,}0167\ mol\cdot dm^{-3}$* ***of*** *$0{,}017\ mol\cdot dm^{-3}$*

OPTION 1/*OPSIE 1*

$n(HC\ell)_{excess/oormaat} = cV$
$= \underline{0{,}01 \times 0{,}35}$ ✓
$= 3{,}5 \times 10^{-3}\ mol$

$n(HC\ell)_{initial/aanv} = cV$
$= 0{,}03 \times 0{,}2$ ✓
$= 0{,}006\ mol$

$n(HC\ell)_{reacted/reageer} = \underline{0{,}006 - 3{,}5 \times 10^{-3}}$ ✓✓
$= 0{,}0025\ mol$

$n(NaOH)_{reacted/reageer} = n(HC\ell)_{reacted/reageer} = 0{,}0025\ mol$ ✓

$c(NaOH) = \frac{n}{V}$
$= \frac{0{,}0025}{0{,}15}$ ✓
$= 0{,}02\ mol\cdot dm^{-3}$ ✓ $(0{,}0167\ mol\cdot dm^{-3}$ **or/*of*** $0{,}017\ mol\cdot dm^{-3})$

OPTION 2/*OPSIE 2* Concentration ratio in final solution: *Konsentrasie verhouding in finale oplossing:* $HC\ell : H_3O^+ = 1 : 1$ ✓ Thus/dus $[HC\ell] = 0{,}01\ mol{\cdot}dm^{-3}$ ✓✓ $[HC\ell]_{react} = [HC\ell]_{initial} - [HC\ell]_{excess}$ $= \underline{0{,}03 - 0{,}01}$ ✓✓ $= 0{,}02\ mol{\cdot}dm^{-3}$ Concentration ratio in final solution: *Konsentrasie verhouding in oorspronklike oplossing:* $HC\ell : NaOH = 1 : 1$ ✓ $[NaOH] = 0{,}02\ mol{\cdot}dm^{-3}$ ✓	**Marking criteria** • Ratio $HC\ell : H_3O^+ = 1 : 1$ ✓ • $c(HC\ell)_{excess} = 0{,}01\ (mol{\cdot}dm^{-3})$ ✓✓ • $n(HC\ell)_{react} = n(HC\ell)_{ini} - (HC\ell)_{excess}$. ✓✓ • Use ratio: $n(NaOH) = n(HC\ell)$ ✓ • Final answer: $0{,}02\ mol{\cdot}dm^{-3}$ ✓ ***Nasienkriteria*** • *Verhouding $HC\ell : H_3O^+ = 1 : 1$* ✓ • *$c(HC\ell)_{oormaat} = 0{,}01\ (mol{\cdot}dm^{-3})$* ✓✓ • *$n(HC\ell)_{reag} = n(HC\ell)_{aanv} - (HC\ell)_{oormaat}$*. ✓✓ • *Gebruik verhouding:* *$n(NaOH) = n(HC\ell)$* ✓ • *Finale antwoord: $0{,}02\ mol{\cdot}dm^{-3}$* ✓
OPTION 3/*OPSIE 3* $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$ $\frac{c_1(200)}{(0{,}01)(350)✓} = \frac{1}{1}$ ✓ $c_1 = 0{,}0175\ mol{\cdot}dm^{-3}$ $c(HC\ell)_{react} = c(HC\ell)_{ini} - c(HC\ell)_{excess}$ $= \underline{0{,}03 - 0{,}0175}$ ✓✓ $= 0{,}0125\ mol{\cdot}dm^{-3}$ $\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$ $\frac{(0{,}0125)(200)}{c_b(150)✓} = \frac{1}{1}$ ✓ $c(NaOH) = 0{,}0167\ mol{\cdot}dm^{-3}$ ✓ ($0{,}0167\ mol{\cdot}dm^{-3}$ **or/*of*** $0{,}017\ mol{\cdot}dm^{-3}$)	**Marking criteria** • Substitute 350 cm^3 in $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$ ✓ • Ratio of $HC\ell : H_3O^+ = 1 : 1$ ✓ • $n(HC\ell)_{react} = n(HC\ell)_{ini} - (HC\ell)_{excess}$. ✓✓ • Use ratio: $n(NaOH) = n(HC\ell)$ ✓ • Substitute 150 cm^3 in $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$ ✓ • Final answer: $0{,}02\ mol{\cdot}dm^{-3}$ ✓ **or** $0{,}0167\ mol{\cdot}dm^{-3}$ **or** $0{,}017\ mol{\cdot}dm^{-3}$ ***Nasienkriteria*** • *Vervang 350 cm^3 in $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$* ✓ • *Verhouding $HC\ell : H_3O^+ = 1 : 1$* ✓ • *$n(HC\ell)_{reag} = n(HC\ell)_{aanv} - (HC\ell)_{oormaat}$*. ✓✓ • *Gebruik verhouding:* *$n(NaOH) = n(HC\ell)$* ✓ • *Vervang 150 cm^3 in $\frac{c_1V_1}{c_2V_2} = \frac{n_1}{n_2}$* ✓ • *Finale antwoord: $0{,}02\ mol{\cdot}dm^{-3}$* ✓ ***of** $0{,}0167\ mol{\cdot}dm^{-3}$* ***of** $0{,}017\ mol{\cdot}dm^{-3}$*

(7)
[16]

QUESTION 8/*VRAAG 8*

8.1

8.1.1 Temperature/*Temperatuur*: 25 °C/298 K ✓
Pressure/*Druk*: 101,3 kPa/1 atmosphere ✓
Concentration/*Konsentrasie*: 1 mol·dm^{-3} ✓ (3)

8.1.2

OPTION 1/*OPSIE 1*	**Notes/*Aantekeninge***
$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ ✓ $2{,}89$ ✓ $= E^{\theta}_{reduction} - (-1{,}66)$ ✓ $E^{\theta}_{reduction} = 1{,}23$ (V) ✓ X is O_2/oxygen/*suurstof* ✓ [X marked independently/ *X onafhanklik nagesien*]	• Accept any other correct formula from the data sheet./*Aanvaar enige ander korrekte formule vanaf gegewensblad.* • Any other formula using unconventional abbreviations, e.g. $E°_{cell} = E°_{OA} - E°_{RA}$ followed by correct substitutions:/*Enige ander formule wat onkonvensionele afkortings gebruik bv.* $E°_{sel} = E°_{OM} - E°_{RM}$ *gevolg deur korrekte vervangings* $\frac{4}{5}$

OPTION 2/*OPSIE 2*

$O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O$ $E^{\theta} = +1{,}23$ V ✓
$A\ell(s) \rightarrow A\ell^{3+}(aq) + 3e^-$ ✓ $E^{\theta} = +1{,}66$ V ✓
$4A\ell(s) + 3O_2(g) + 12H^+ \rightarrow 4A\ell^{3+}(aq) + 6H_2O$ $E^{\theta} = +2{,}89$ (V) ✓

X is O_2/oxygen/*suurstof* ✓

[X marked independently/*X onafhanklik nagesien*] (5)

8.1.3 $A\ell$ ✓ (1)

8.1.4 $O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O$ ✓✓

Ignore phases./*Ignoreer fases.*

Marking criteria/*Nasienkriteria:*
- $2H_2O \leftarrow O_2(g) + 4H^+ + 4e^-$ ($\frac{2}{2}$) $O_2(g) + 4H^+ + 4e^- \rightleftharpoons 2H_2O$ ($\frac{1}{2}$)
  $O_2(g) + 4H^+ + 4e^- \leftarrow 2H_2O$ ($\frac{0}{2}$) $2H_2O \rightleftharpoons O_2(g) + 4H^+ + 4e^-$ ($\frac{0}{2}$)
- Ignore if charge omitted on electron./*Ignoreer indien lading weggelaat op elektron.*
- If charge (+) omitted on H^+/ *Indien lading (+) weggelaat op* H^+: Max./*Maks:* $\frac{1}{2}$
  Example/*Voorbeeld:* $O_2(g) + 4H + 4e^- \rightarrow 2H_2O$ ✓

(2)

8.1.5 $\underbrace{A\ell(s) \mid A\ell^{3+}(aq)}_{✓} \overset{✓}{\parallel} \underbrace{O_2(g) \mid H^+(aq) \mid H_2O(\ell) \mid Pt(s)}_{✓}$

OR/*OF*
$A\ell(s) \mid A\ell^{3+}(aq) \parallel O_2(g) \mid H^+(aq) \mid H_2O(\ell) \mid C(s)$

OR/*OF*
$A\ell \mid A\ell^{3+} \parallel O_2 \mid H^+ \mid H_2O \mid Pt$ (3)

8.2 Copper/*Koper* ✓

- Cu is a weaker reducing agent than Ni ✓and will not reduce Ni^{2+} (to Ni). / Cu will not be oxidised (to Cu^{2+}).✓
- Zn is a stronger reducing agent than Ni ✓and will reduce Ni^{2+} (to Ni). / Zn will be oxidised (to Zn^{2+}).

- *Cu is 'n swakker reduseermiddel as Ni en sal nie Ni^{2+} (na Ni) reduseer nie. / Cu sal nie geoksideer word nie na (Cu^{2+}).*
- *Zn is 'n sterker reduseermiddel as Ni en sal Ni^{2+} (na Ni) reduseer. / Zn sal geoksideer word (na Zn^{2+}).*

NOTE/LET WEL: The mark for 'reduce' can be awarded at any ONE of the two comparisons. *Die punt vir 'reduseer' kan toegeken word by ENIGEEN van die twee vergelykings.*

(4)
[18]

QUESTION 9/*VRAAG 9*

9.1

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

ANY ONE/*ENIGE EEN:*

- The chemical process in which electrical energy is converted to chemical energy. ✓✓
- The use of electrical energy to produce a chemical change.
- Decomposition of an ionic compound by means of electrical energy.
- The process during which an electric current passes through a solution/ionic liquid/molten ionic compound.

- *Die chemiese proses waarin elektriese energie omgeskakel word na chemiese energie.* ✓✓
- *Die gebruik van elektriese energie om 'n chemiese verandering te weeg te bring.*
- *Ontbinding van 'n ioniese verbinding met behulp van elektriese energie.*
- *Die proses waardeur 'n elektriese stroom deur 'n oplossing/ioniese vloeistof/gesmelte ioniese verbinding beweeg.*

(2)

9.2
9.2.1 X ✓ (1)

9.2.2 $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ ✓✓

Ignore phases/*Ignoreer fases*

<u>Marking criteria/*Nasienkriteria:*</u>

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

(2)

9.2.3 X to/*na* Y ✓ (1)

9.2.4 $2H_2O(\ell) + 2C\ell^-(aq)$ ✓ $\rightarrow C\ell_2(g) + H_2(g) + 2OH^-(aq)$ ✓ Bal ✓

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

Ignore phases/*Ignoreer fases*

<u>Marking criteria/*Nasienkriteria:*</u>

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

(3)

9.3 Increases / *Toeneem* ✓ (1)

9.4 Solution becomes basic / alkaline **OR** NaOH / OH^- (ions) form ✓
Oplossing word basies / alkalies ***OF*** *NaOH / OH^-(-ione) vorm* (1)

[11]

TOTAL/*TOTAAL*: 150