basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERFITICATE EXAMINATIONS/
NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: CHEMISTRY (P2)

MAY/JUNE 2025

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 How many types of Van der Waals forces are present between the molecules of CH_3CH_2Br?

A 1

B 2

C 3

D 4 (2)

1.2 Which ONE of the following is the CORRECT formula of methylbutanone?

A $CH_3CH(OH)CH(CH_3)CH_3$

B $HCOOCH(CH_3)CH_2CH_3$

C $CH_3CH_2CH(CH_3)CHO$

D $CH_3COCH(CH_3)CH_3$ (2)

1.3 A compound $CH_3(CH_2)_5CH_3$ undergoes the following reaction:

$$CH_3(CH_2)_5CH_3 \longrightarrow \mathbf{R} + CH_3(CH_2)_2CH_3$$

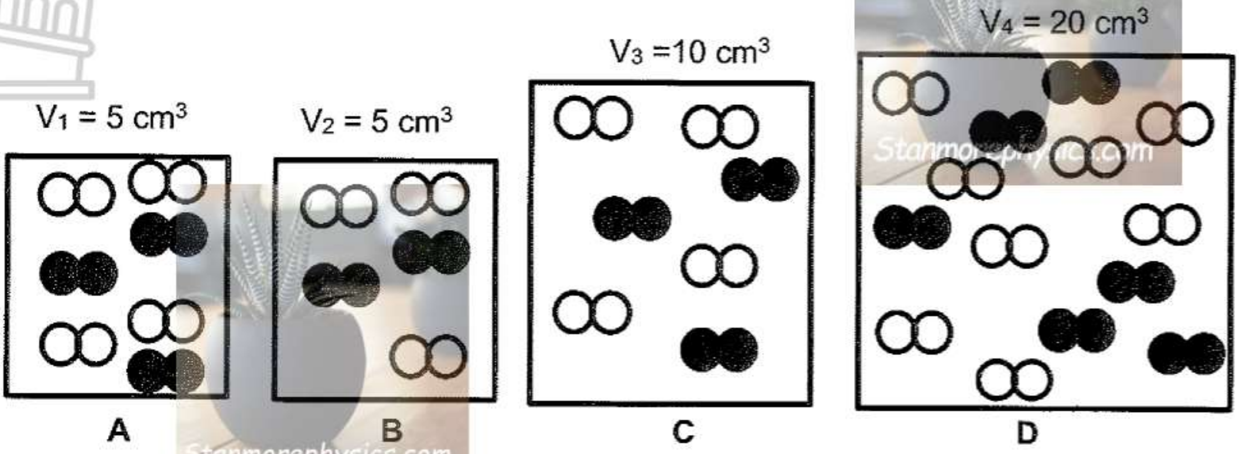
Which ONE of the following combinations CORRECTLY describes the type of reaction and the IUPAC name of compound **R**?

	TYPE OF REACTION	IUPAC NAME
A	Elimination	Propane
B	Addition	Propene
C	Cracking	Propane
D	Cracking	Propene

(2)

1.4 Two gases are added into each of four empty containers at the same temperature. The diagrams below show the molecules of the gases and the volumes of the containers at the start of the reaction.

In which ONE of the following containers is the initial reaction rate the highest?



(2)

1.5 Which ONE of the following statements is TRUE for the effect of a catalyst on a reaction at equilibrium?

A The equilibrium constant increases.

B The rate of the reverse reaction increases.

C The activation energy for the reverse reaction increases.

D The enthalpy change, ΔH, for the forward reaction decreases. (2)

1.6 Carbonyl chloride gas, $COC\ell_2(g)$, decomposes in a closed container and reaches equilibrium according to the following equation:

$$COC\ell_2(g) \rightleftharpoons CO(g) + C\ell_2(g) \qquad \Delta H > 0$$

Consider the following statements.

An increase in temperature will:

(i) Favour the reverse reaction
(ii) Increase the concentration of the products
(iii) Increase the equilibrium constant

Which of the statements above are TRUE?

A (i) and (ii) only

B (i) and (iii) only

C (ii) and (iii) only

D (i), (ii) and (iii) (2)

1.7 Consider the equation for the acid-base reaction below.

$$HSO_4^-(aq) + NH_3(aq) \rightleftharpoons SO_4^{2-}(aq) + NH_4^+(aq)$$

The two acids in this reaction are ...

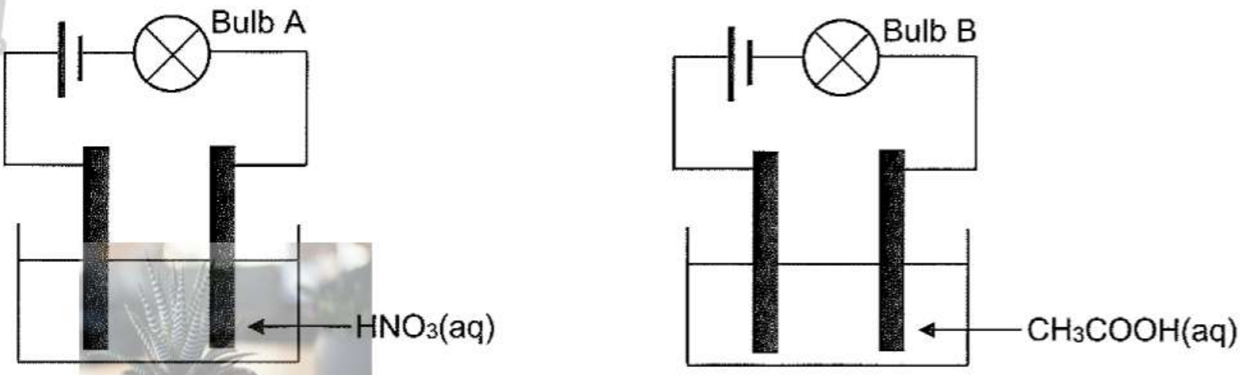
A $NH_3(aq)$ and $NH_4^+(aq)$

B $HSO_4^-(aq)$ and $SO_4^{2-}(aq)$

C $HSO_4^-(aq)$ and $NH_3(aq)$

D $HSO_4^-(aq)$ and $NH_4^+(aq)$ (2)

1.8 The conductivity of two acids, $HNO_3(aq)$ and $CH_3COOH(aq)$, each with a concentration of 1 mol·dm^{-3}, is compared at 25 °C. The simplified diagrams below show the apparatus used. The electrodes are made of carbon.



Which ONE of the following combinations CORRECTLY describes the brightness of bulb A and bulb B, and provides the reason for this?

	BRIGHTNESS OF BULBS	REASON
A	A is brighter than B	CH_3COOH is the stronger acid
B	A is brighter than B	HNO_3 is the stronger acid
C	B is brighter than A	CH_3COOH is the weaker acid
D	A and B have equal brightness	Acids are of equal concentration

(2)

1.9 Which ONE of the following combinations of temperature and pressure is CORRECT for the standard hydrogen half-cell?

	TEMPERATURE (°C)	PRESSURE (kPa)
A	0	273
B	25	273
C	25	101,3
D	0	101,3

(2)

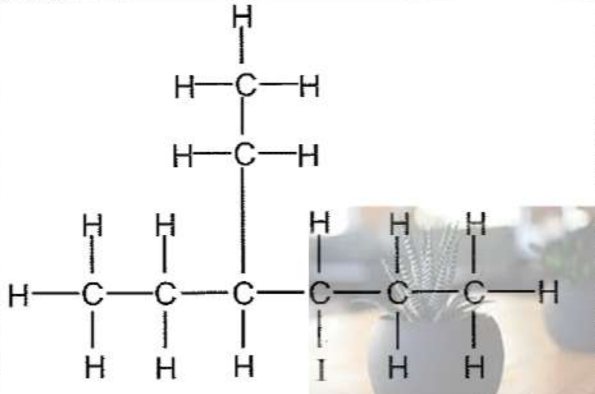
1.10 Impure copper is refined in an electrolytic cell. Which ONE of the following combinations CORRECTLY identifies the anode and the electrolyte for this cell?

	ANODE	ELECTROLYTE
A	Pure copper	$Cu(NO_3)_2(aq)$
B	Pure copper	$AgNO_3(aq)$
C	Impure copper	$Cu(NO_3)_2(aq)$
D	Impure copper	$AgNO_3(aq)$

(2)
[20]

QUESTION 2 (Start on a new page.)

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

A	$C_5H_{10}O$	**B**	
C	Butanoic acid	**D**	$(CH_3)_3COH$
E	$CH_2C(CH_3)_2$	**F**	$HCOOCH_2CH_2CH_3$

2.1 Define the term *unsaturated compound.* (2)

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

2.2.1 An unsaturated compound (1)

2.2.2 A functional isomer of compound **C** (1)

2.3 Name the TWO homologous series to which **A** belongs. (2)

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

2.5 Write down the IUPAC name of:

2.5.1 Compound **B** (3)

2.5.2 The POSITIONAL isomer of compound **D** (2)

2.6 Ethanol reacts with compound **C** to form an organic compound **Z**.

Write down the:

2.6.1 Type of reaction (1)

2.6.2 STRUCTURAL FORMULA of compound **Z** (2)

2.7 Write down the:

2.7.1 Empirical formula of compound **F** (1)

2.7.2 STRUCTURAL FORMULA of the CHAIN ISOMER of compound **E** (2)

[19]

QUESTION 3 (Start on a new page.)

3.1 The boiling points of straight chain aldehydes and straight chain carboxylic acids are compared. The table below shows the results obtained.

	INVESTIGATION 1	**INVESTIGATION 2**
Number of carbon atoms in the compound	**Boiling point of aldehydes (°C)**	**Boiling point of carboxylic acids (°C)**
1	-19	101
2	20	118
3	49	141
4	75	164

3.1.1 Define the term *homologous series*. (2)

3.1.2 Write down the:

(a) NAME of the FUNCTIONAL GROUP of the aldehydes (1)

(b) IUPAC NAME of the compound with the highest vapour pressure in this comparison (2)

3.1.3 For INVESTIGATION **2**:

(a) Write down the controlled variable. (1)

(b) Describe the trend in the boiling points. (1)

(c) Fully explain the answer to QUESTION 3.1.3(b). (2)

3.1.4 Write down the boiling point of butanal. (1)

3.2 The vapour pressures of compounds **A** and **B** are compared.

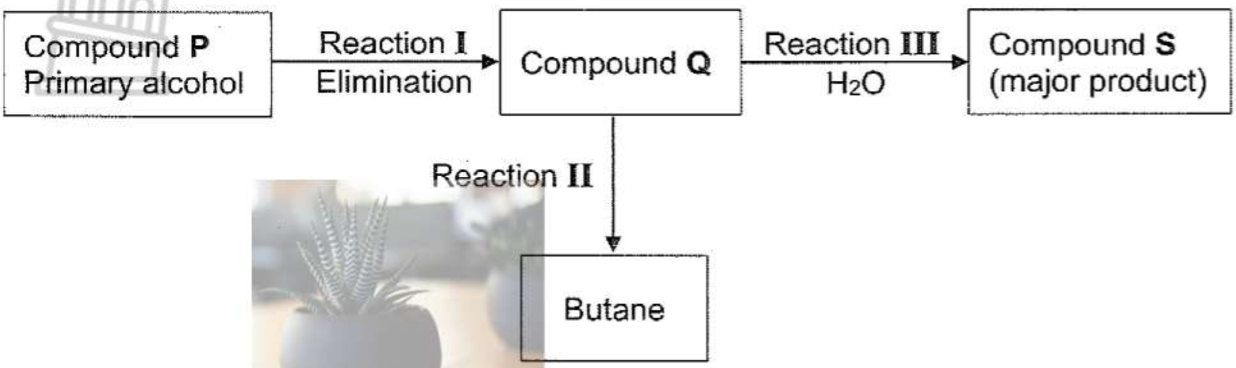
A	$CH_3CH_2CH_2CH_2CH_2OH$
B	$CH_3CH_2CH_2COOH$

How does the vapour pressure of compound **A** compare to that of compound **B**? Choose from HIGHER THAN, LOWER THAN or EQUAL TO.

Fully explain the answer. (4)
[14]

QUESTION 4 (Start on a new page.)

In the flow diagram below, a primary alcohol **P** is used as a starting reactant to form different organic compounds under different reaction conditions.



4.1 Write down the TYPE of:

4.1.1 Addition reaction represented by reaction II (1)

4.1.2 Elimination reaction represented by reaction I (1)

4.2 Write down the IUPAC name of compound **P**. (2)

4.3 Consider reaction III.

Write down:

4.3.1 The balanced equation using CONDENSED structural formulae (4)

4.3.2 The NAME or FORMULA of a suitable catalyst (1)

4.4 Butane can be converted to compound **P** in a TWO-STEP reaction. Use STRUCTURAL FORMULAE and write down the balanced equations for these TWO reactions. (5)

4.5 Write down a balanced equation using MOLECULAR FORMULAE for the complete combustion of butane. (3)

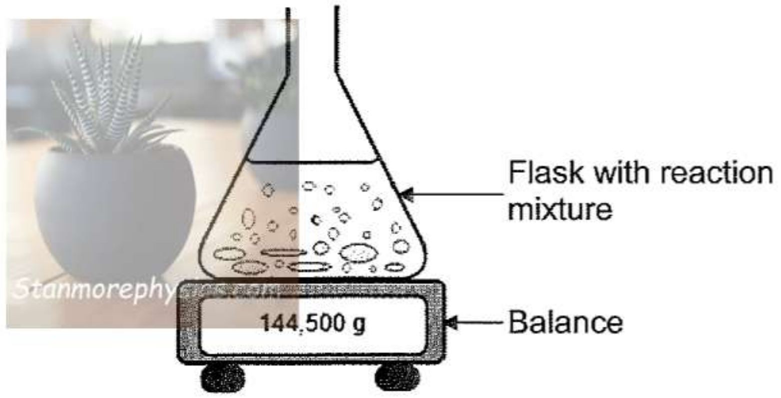
[17]

QUESTION 5 (Start on a new page.)

The reaction between magnesium carbonate pellets, $MgCO_3(s)$, and EXCESS dilute hydrochloric acid, $HC\ell(aq)$, is used to investigate the effect of concentration on the rate of a reaction.

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

The apparatus used for this investigation is shown below.



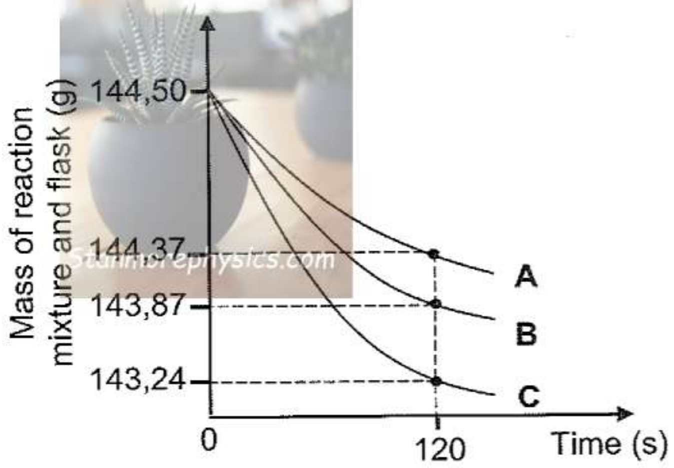
5.1 Define the term *rate of reaction*. (2)

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

Three experiments using different concentrations of $HC\ell(aq)$ are carried out. The concentration of the $HC\ell(aq)$ during each experiment does not change.

EXPERIMENT	CONCENTRATION OF $HC\ell(aq)$ ($mol \cdot dm^{-3}$)
1	0,1
2	0,5
3	1,0

The INCOMPLETE graph of the results of the experiments is shown below.



5.3 Give a reason why the mass of the reaction mixture and flask decreases. (1)

5.4 For curve **B**, calculate the average rate at which $CO_2(g)$ is produced for the first 120 s in $dm^3 \cdot s^{-1}$. The molar gas volume is 24,5 $dm^3 \cdot mol^{-1}$. (6)

5.5 Which curve represents EXPERIMENT **1**? Choose from **A**, **B** or **C**.

Use the collision theory to explain the answer. (5)

5.6 How will the final mass of $CO_2(g)$ produced in EXPERIMENT **2** compare to that of EXPERIMENT **3**? Choose from MORE THAN, LESS THAN or THE SAME.

Give a reason for the answer. (2)
[17]

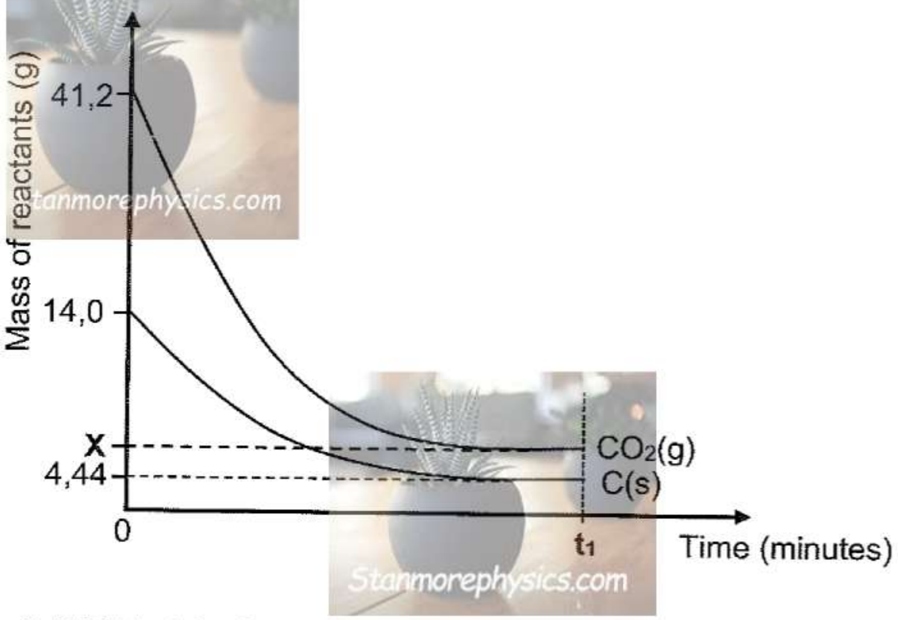
QUESTION 6 (Start on a new page.)

The reaction between powdered carbon, C(s), and carbon dioxide gas, $CO_2(g)$, takes place in a closed 3 dm^3 container according to the balanced equation below.

$$C(s) + CO_2(g) \rightleftharpoons 2CO(g) \qquad \Delta H < 0$$

Equilibrium is reached at temperature T °C.

The graph below, not drawn to scale, shows the curves for the mass of the reactants in the container against time.



6.1 How will EACH of the following changes affect the number of moles of $CO_2(g)$ at equilibrium?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

6.1.1 A catalyst is added. (1)

6.1.2 The volume of the container is increased at a constant temperature. (1)

6.1.3 More powdered carbon is added. (1)

6.2 Explain the answer to QUESTION 6.1.2 by referring to Le Chatelier's principle. (2)

6.3 Calculate the value of **X** shown on the graph. (6)

6.4 Calculate the equilibrium constant, K_c, at T °C. (5)

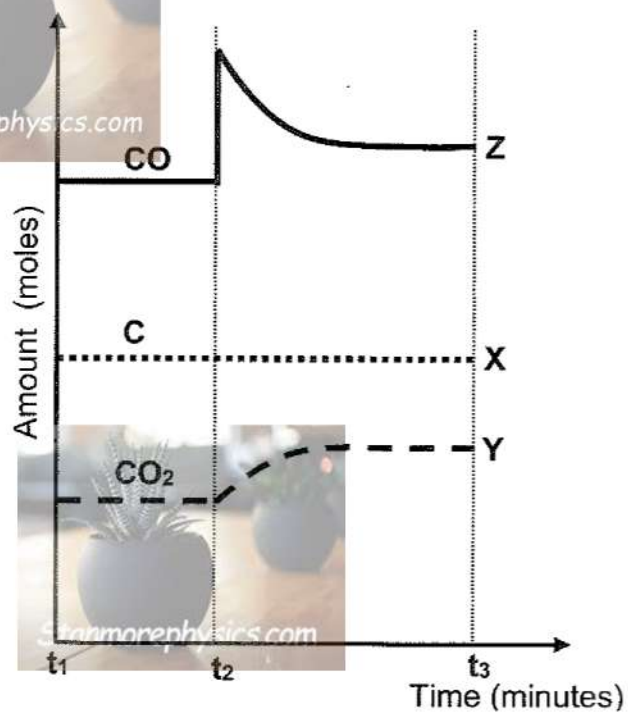
The balanced equation for this reaction is rewritten below for easy reference.

$$C(s) + CO_2(g) \rightleftharpoons 2CO(g) \qquad \Delta H < 0$$

6.5 The graph below shows the equilibrium number of moles of CO(g), C(s) and CO_2(g) in the flask at time t_1.

At t_2, some CO(g) is added to the flask and the reaction is allowed to reach equilibrium. Curve **Z** correctly shows the change in the amount of CO(g) between t_2 and t_3.

A learner draws corresponding curves, labelled **X** and **Y**, for C(s) and CO_2(g) respectively.



Which of these curves is the CORRECT representation for these changes?

Choose from: **X** or
Y or
X and **Y** (2)

6.6 What effect will the addition of CO(g) have on the equilibrium constant, K_c? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)
[19]

QUESTION 7 (Start on a new page.)

7.1 Define an *acid* according to the Arrhenius theory. (2)

7.2 The table below shows aqueous solutions of different substances, each of concentration 1 mol·dm^{-3} at room temperature.

$HNO_3(aq)$	$H_2SO_4(aq)$	$NaC\ell(aq)$	$NaOH(aq)$	
$(COOH)_2(aq)$	$HCO_3^-(aq)$	$Mg(OH)_2(aq)$	$NH_3(aq)$	$CH_3COOH(aq)$

Identify from the table and write down the FORMULA for:

7.2.1 A weak diprotic acid (1)

7.2.2 A solution with a pH of 7 (1)

7.2.3 An ampholyte (1)

7.2.4 The solution, which when neutralised with $(COOH)_2(aq)$, will have a pH greater than 7 (2)

7.3 An unknown acid H_xY is investigated.

During a titration, 23,64 cm^3 of a 0,11 mol·dm^{-3} H_xY solution neutralises 20 cm^3 of a 0,26 mol·dm^{-3} NaOH solution.

Calculate the value of x. Hence, write down the balanced equation for this reaction. (6)

7.4 In an experiment, 1,5 g of a powdered IMPURE calcium carbonate sample, $CaCO_3(s)$, is reacted with 200 cm^3 of a 0,15 mol·dm^{-3} hydrochloric acid solution, $HC\ell(aq)$. The balanced equation for the reaction is:

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

All the $CO_2(g)$ formed escapes from the solution.

The resulting solution has a pH of 1,61 and a volume of 200 cm^3.

Assume that ALL the $CaCO_3(s)$ in the impure sample reacted with the $HC\ell(aq)$ and none of the impurities reacted.

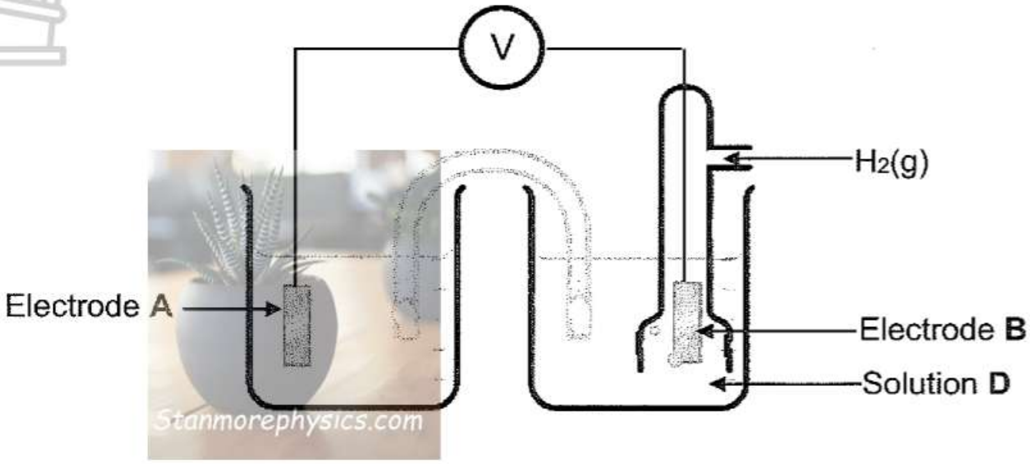
Calculate the mass of the impurities present in the 1,5 g sample of impure $CaCO_3(s)$. (9)

[22]

QUESTION 8 (Start on a new page.)

The simplified diagram below shows a cell that can be used to measure the standard electrode potential of the half-reaction represented by the equation below.

$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$$



8.1 For solution **D**, write down the NAME or FORMULA of the ions needed. (1)

8.2 Write down the initial reading on the voltmeter. (1)

8.3 Which electrode, **A** or **B**, is the cathode? (1)

8.4 Explain the answer to QUESTION 8.3 in terms of the relative strengths of the reducing agents. (3)

8.5 Write down the:

8.5.1 NAME or FORMULA of the metal used as electrode **A** (1)

8.5.2 Half-reaction that occurs at electrode **B** (2)

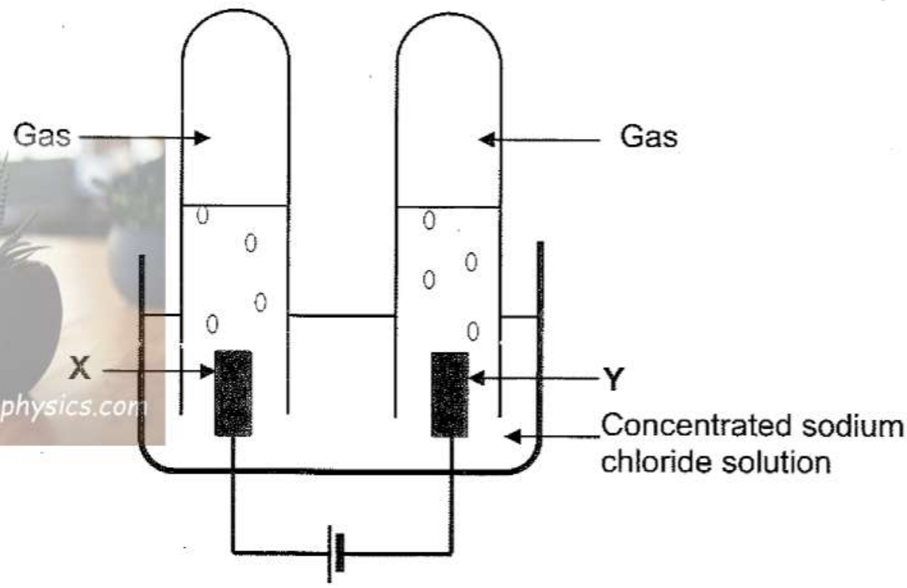
8.5.3 Cell notation for this cell (3)

8.6 Give a reason why the voltmeter reading drops to zero after the cell has operated for some time. (1)
[13]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents an electrolytic cell used to demonstrate 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 Write down the reduction half-reaction for this cell. (2)

9.3 What is the direction of the electron flow in the external circuit? Choose from **X** to **Y** or **Y** to **X**. (1)

9.4 Calculate the number of electrons transferred through the external circuit when 300 cm^3 gas is collected at electrode **X**.

Take the molar gas volume as 24 $dm^3 \cdot mol^{-1}$. (4)
[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

KEY/*SLEUTEL*

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

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

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

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

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

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* ↓

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

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

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

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

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

MAY/JUNE 2025/*MEI/JUNIE 2025*

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

These marking guidelines consist of 22 pages.
Hierdie nasienriglyne bestaan uit 22 bladsye.

QUESTION 1/*VRAAG 1*

1.1 B ✓✓ (2)

1.2 D ✓✓ (2)

1.3 D ✓✓ (2)

1.4 A ✓✓ (2)

1.5 B ✓✓ (2)

1.6 C ✓✓ (2)

1.7 D ✓✓ (2)

1.8 B ✓✓ (2)

1.9 C ✓✓ (2)

1.10 C ✓✓ (2)

[20]

QUESTION 2/*VRAAG 2*

2.1 Compounds with one or more <u>multiple bonds between C atoms</u> in the hydrocarbon chain. ✓✓ (2 or 0)
Verbindings met een of meer <u>meervoudige bindings tussen C-atome</u> in die koolwaterstofkettings. (2 of 0)

OR/*OF*
A hydrocarbon with <u>two or more bonds between the C-atoms</u>.
'n Koolwaterstof met <u>twee of meer bindings tussen die C-atome.</u>

OR/*OF*
Hydrocarbons containing not only single bonds between C atoms.
Koolwaterstowwe wat nie slegs enkelbindings tussen die C-atome bevat nie.

<u>ACCEPT/*AANVAAR:*</u>
Compounds with one or more <u>double/triple bonds between C atoms</u> in the hydrocarbon chain.
Verbindings met een of meer <u>dubbel/trippelbindings tussen C-atome</u> in die koolwaterstofkettings. (2)

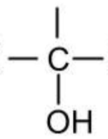
2.2
2.2.1 E ✓ (1)

2.2.2 C and/*en* F ✓ (1)

2.3 Ketones/*Ketone* ✓
Aldehydes/*Aldehiede* ✓ (2)

2.4 Tertiary/*Tersiêre* ✓

The hydroxyl group/functional group (-OH) is bonded to a C atom that is bonded to three other C atoms. ✓
Die hidroksiel/funksionele groep (-OH) is gebind aan 'n C-atoom wat aan drie ander C-atome gebind is.

OR/*OF*
The functional group () is bonded to three other C atoms.

Die funksionele groep ( *) is gebind aan drie ander C-atome.*

(2)

2.5
2.5.1

Marking criteria:
• Correct stem, i.e. <u>hexane</u>. ✓ • All substituents (ethyl and iodo) correctly identified. ✓ • IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓ ***Nasienkriteria:*** • *Korrekte stam, d.i. <u>heksaan</u>.* ✓ • *Substituente (etiel en jodo) korrek geïdentifiseer.* ✓ • *IUPAC-naam heeltemal korrek insluitende nommering, volgorde, koppeltekens en kommas.* ✓

3-ethyl-4-iodohexane/3-etiel-4-jodoheksaan ✓✓✓ (3)

2.5.2

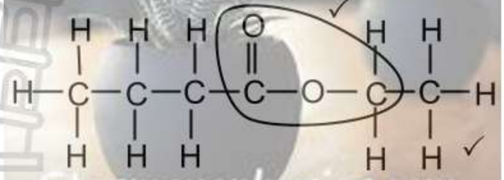
Marking criteria/*Nasienkriteria:*
• Correct stem and substituents: methyl and propanol ✓ *Korrekte stam en substituente: metiel en propanol* • IUPAC name completely correct including numbering, sequence, hyphens and commas. ✓ *IUPAC-naam heeltemal korrek insluitende nommering, volgorde, koppeltekens en kommas.*

2-methylpropan-1-ol/ 2-methyl-1-propanol/ methylpropan-1-ol/
methyl-1-propanol ✓✓
2-metielpropan-1-ol/ 2-metiel-1-propanol / metielpropan-1-ol/
metiel-1-propanol (2)

2.6

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

2.6.2



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

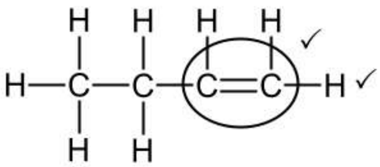
IF/*INDIEN*
- More than one functional group/wrong functional group:
  Meer as een funksionele groep/foutiewe funksionele groep: $^0/_2$
- If condensed structural formulae used/*Indien gekondenseerde struktuurformules gebruik:* Max./*Maks.* $^1/_2$

(2)

2.7

2.7.1 C_2H_4O ✓ (1)

2.7.2



Marking criteria/*Nasienkriteria*:
- Correct functional group. ✓
  Korrekte 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: $^0/_2$
- If condensed structural formulae used/*Indien gekondenseerde struktuurformules gebruik:* Max./*Maks.* $^1/_2$

(2)

[19]

QUESTION 3/*VRAAG 3*

3.1.1

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.*

A series of organic compounds that can be described by the same general formula and that have the same functional group. ✓✓
OR
A series of organic compounds in which one member differs from the next by a CH_2 group.

'n Reeks organiese verbindings wat deur dieselfde algemene formule beskryf kan worden wat dieselfde funksionele groep het.
OF
n Reeks organiese verbindings waarin die een lid van die volgende verskil met 'n CH_2-groep (2)

3.1.2
(a) Formyl (group)/*Formiel(groep)* ✓ (1)

(b)

Marking criteria:	***Nasienkriteria:***
• Correct chain length, i.e. Meth. ✓ • Everything else correct: IUPAC name completely correct including numbering. ✓	• *Korrekte kettinglengte d.i. Met.* ✓ • *Alles verder reg: IUPAC-naam heeltemal korrek insluitende nommering.* ✓

Methanal/*Metanaal* ✓✓ (2)

3.1.3 Homologous series/Functional group ✓
(a) *Homoloë reeks/Funksionele groep* (1)

(b) The boiling points of the carboxylic acids increase with an increase in the chain length/the number of carbon atoms./The boiling points of the carboxylic acids decrease with a decrease in the chain length/number of carbon atoms. ✓

Die kookpunte van die karboksielsure neem toe met 'n toename in die kettinglengte/aantal koolstofatome./Die kookpunte van die karboksielsure neem af met 'n afname in die kettinglengte/aantal koolstofatome. (1)

(c)

Marking criteria:
For increasing or decreasing number of C atoms
- Compare the strength of intermolecular forces. ✓
- Compare the energy required to overcome intermolecular forces. ✓

Nasienkriteria:
Vir toename of afname in aantal C-atome
- *Vergelyk die sterkte van intermolekulêre kragte.* ✓
- *Vergelyk die energie benodig om intermolekulêre kragte te oorkom.* ✓

As the number of C atoms/chain length/surface area/contact area increases
- The strength of intermolecular/London/dispersion forces increases. ✓
- More energy is needed to overcome intermolecular forces London/ dispersion forces. ✓

OR

As the number of C atoms/chain length/surface area/contact area decreases
- The strength of intermolecular/London/dispersion forces decreases. ✓
- Less energy is needed to overcome intermolecular forces London/ dispersion forces. ✓

Met toename in aantal C-atome/kettinglengte/oppervlakarea/kontakarea.
- *Die sterkte van die die intermolekulêre kragte/Londonkragte/ dispersiekragte neem toe.*
- *Meer energie word benodig om die intermolekulêre kragte/Londonkragte/ dispersiekragte te oorkom/breek.*

OF

Met afname in aantal C-atome/kettinglengte/oppervlakarea/kontakarea.
- *Die sterkte van die die intermolekulêre kragte/Londonkragte/ dispersiekragte neem af.*
- *Minder energie word benodig om die intermolekulêre kragte/ Londonkragte/dispersiekragte te oorkom/breek* (2)

3.1.4 75 °C ✓✓ (2)

3.2

Marking criteria:

- Higher ✓
- State that carboxylic acids have more than one (three) site for hydrogen bonding and alcohols have one site for hydrogen bonding. ✓
- Comparing the strength of IMFs. ✓
- Comparing the number of molecules at a given temperature/energy needed to overcome IMFs. ✓

Nasienkriteria:

- *Hoër* ✓
- *Stel dat karboksielsure het meer as een (drie) plekke vir waterstofbindings en dat alkohole een plek het vir waterstofbinding.* ✓
- *Vergelyk die sterkte van die IMK's/energie benodig om IMK's te oorkom.* ✓
- *Vergelyk die hoeveelheid molekules by 'n gegewe temperatuur/energie nodig om die IMK te oorkom.* ✓

- Higher ✓
- Compound B/$CH_3CH_2CH_2COOH$/Carboxylic acid/Butanoic acid has (in addition to London forces and dipole-dipole forces), more than one site (three) for hydrogen bonding between molecules and compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Alcohol/Pentan-1-ol has (in addition to London forces and dipole-dipole forces) one site for hydrogen bonding between molecules. ✓
- Intermolecular forces in compound B/$CH_3CH_2CH_2COOH$/Carboxylic acids/Butanoic acid are stronger. ✓
- At a given temperature there will be fewer molecules of compound B/$CH_3CH_2CH_2COOH$/Carboxylic acids/Butanoic acid in the vapour phase. ✓

OR

More energy needed to overcome/break intermolecular forces in compound B/ $CH_3CH_2CH_2COOH$/Carboxylic acid/Butanoic acid.

- Higher ✓
- Compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Alcohol/Pentan-1-ol has (in addition to London forces and dipole-dipole forces) one site for hydrogen bonding between molecules and compound B/$CH_3CH_2CH_2COOH$/ Carboxylic acid/Butanoic acid has, (in addition to London forces and dipole-dipole forces), more than one site (three) for hydrogen bonding between molecules. ✓
- Intermolecular forces in compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Alcohol/ Pentan-1-ol are weaker. ✓
- At a given temperature there will be more molecules of compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Alcohol/ Pentan-1-ol in the vapour phase. ✓

OR

Less energy needed to overcome/break intermolecular forces in compound A/$CH_3CH_2CH_2CH_2CH_2OH$/Pentan-1-ol/Alcohol.

- *Hoër*
- *Verbinding B/$CH_3CH_2CH_2COOH$/Karboksielsure/Butanoësuur het, (in toevoeging tot Londonkragte en dipool-dipoolkragte), meer as een punt (drie) vir waterstofbinding tussen molekule en verbinding A/ $CH_3CH_2CH_2CH_2CH_2OH$/Alkohol/Pentan-1-ol het, (in toevoeging tot Londonkragte en dipool-dipoolkragte), een punt vir waterstofbinding tussen molekule.*
- *Intermolekulêre kragte in verbinding B/$CH_3CH_2CH_2COOH$/Karboksielsure/ Butanoësuur is sterker.*
- *By 'n gegewe temperatuur sal daar minder molekules van verbinding B/$CH_3CH_2CH_2COOH$/Karboksielsure/Butanoësuur in die dampfase wees.*

OF

- *Meer energie word benodig om intermolekulêre kragte in verbinding B/$CH_3CH_2CH_2COOH$/Karboksielsure/Butanoësuur te oorkom/breek.*

- *Hoër*
- *Verbinding A/$CH_3CH_2CH_2CH_2CH_2OH$/Alkohol/Pentan-1-ol het, (in toevoeging tot Londonkragte en dipool-dipoolkragte), een punt vir waterstofbinding tussen molekule en verbinding B/$CH_3CH_2CH_2COOH$/ Karboksielsure/Butanoësuur het, (in toevoeging tot Londonkragte en dipool-dipoolkragte), meer as een punt (drie) vir waterstofbinding tussen molekule.*
- *Intermolekulêre kragte in verbinding A/ $CH_3CH_2CH_2CH_2CH_2OH$/Alkohol/ Pentan-1-ol is swakker.*
- *By 'n gegewe temperatuur sal daar meer molekules van verbinding A/ $CH_3CH_2CH_2CH_2CH_2OH$/Alkohol/Pentan-1-ol in die dampfase wees.*

OF

Minder energie word benodig om intermolekulêre kragte in A/ $CH_3CH_2CH_2CH_2CH_2OH$/Alkohol/Pentan-1-ol te oorkom/breek. (4)

[15]

QUESTION 4/*VRAAG 4*

4.1

4.1.1 Hydrogenation/*Hidrogenering/Hidrogenasie* ✓ (1)

4.1.2 Dehydration/*Dehidrasie/Dehidratering* ✓ (1)

4.2

Marking criteria:	***Nasienkriteria:***
• Correct chain length, i.e. But. ✓ • Everything else correct: IUPAC name completely correct including numbering. ✓	• *Korrekte kettinglengte d.i. But.*✓ • *Alles verder reg: IUPAC-naam heeltemal korrek insluitende nommering.* ✓

Butan-1-ol/1-butanol ✓✓ (2)

4.3

4.3.1

Marking criteria/*Nasienkriteria:*
- Whole condensed structural formula of alkene correct. ✓
  Hele gekondenseerde struktuurformule van die alkeen korrek.
- H_2O. ✓
- Hydroxyl group/OH on second C atom of alcohol. ✓
  Hidroksielgroep/OH op die tweede C-atoom van die alcohol.
- Whole condensed structural formula of alcohol correct (OH on second C-atom). ✓
  Hele gekondenseerde struktuurformule van alcohol korrek.

IF/*INDIEN*
- Any additional reactants or products /*Enige addisionele reaktanse of produkte:*
  Deduct 1 mark/Trek 1 punt af.
- Structural formulae used/*Struktuurformule gebruik.* Max./*Maks.* $^3/_4$
- Molecular formulae used/*Molekulêre formule gebruik.* Max./*Maks.* $^1/_4$

Marking rule 6.3.10/*Nasienreël 6.3.10*

$CH_2CHCH_2CH_3$ ✓ + H_2O ✓ → $CH_3CHOHCH_2CH_3$ ✓✓

OR/*OF*

$CH_2{=}CHCH_2CH_3$ ✓ + H_2O ✓ → $CH_3CH(OH)CH_2CH_3$ ✓✓ (OH drawn above second C atom) (4)

4.3.2 Sulphuric acid/H_2SO_4/Phosphoric acid/H_3PO_4/*Swaelsuur/Fosforsuur* ✓ (1)

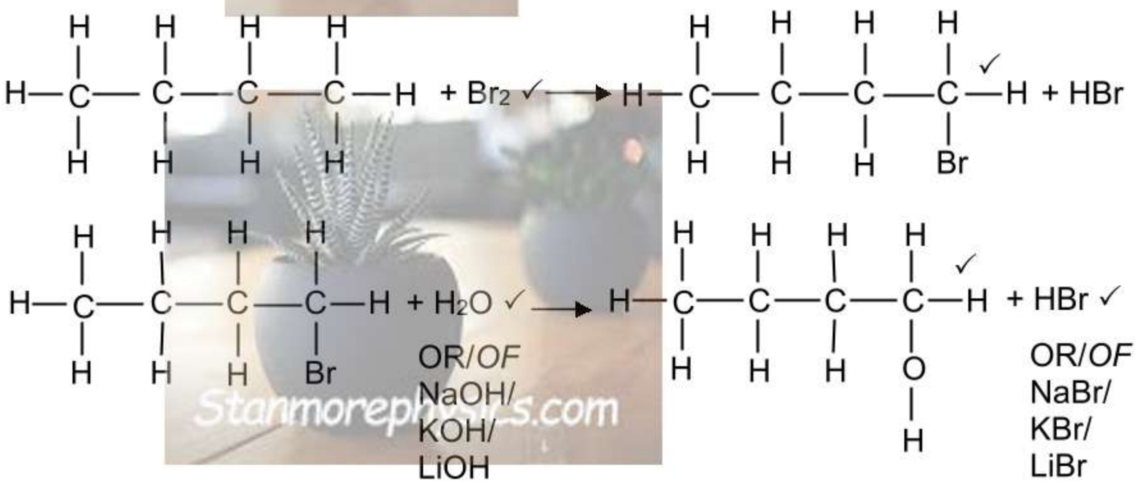
4.4

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

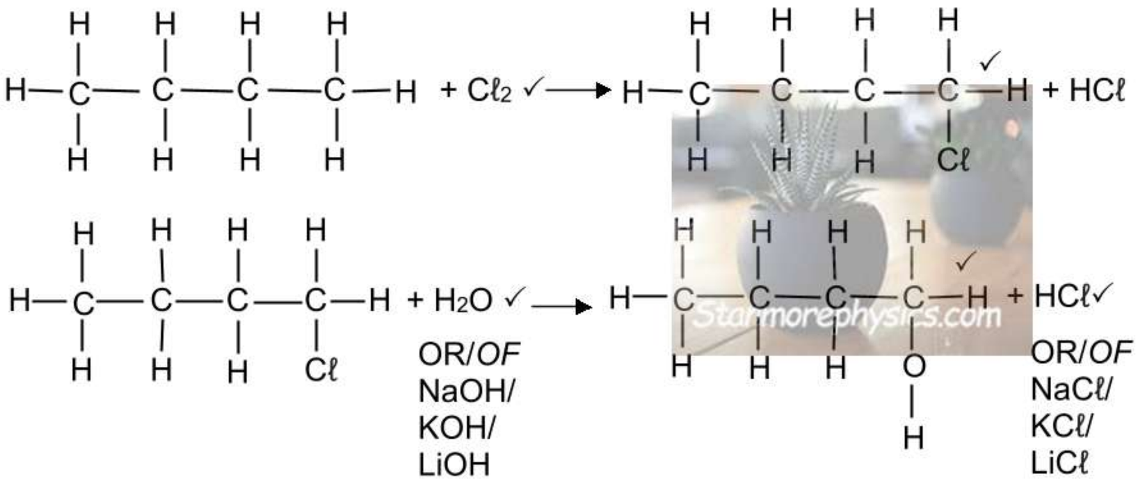
- $Br_2/C\ell_2$. ✓
- Whole structural formula of haloalkane. ✓
  Hele struktuurformule van haloalkaan korrek.
- $H_2O/NaOH/KOH/LiOH$. ✓
- Whole structural formula of alcohol. ✓
  Hele struktuurformule van alkohol korrek.
- $HBr/NaBr/KBr/LiBr/HC\ell/NaC\ell/KC\ell/LiC\ell$. ✓

IF/*INDIEN*

- Any additional reactants or products /*Enige addisionele reaktanse of produkte:* Max./*Maks.* $^4/_5$
- Condensed structural formulae used: deduct 1 mark/trek 1 punt af.
- If inorganic product does not correspond with inorganic reactant: no mark for inorganic product./*Indien anorganiese produk nie met die anorganiese reaktans ooreenstem nie, geen punt vir anorganiese produk.*
- Molecular formulae used:/*Molekulêre formule gebruik:* Max./*Maks.* $^3/_5$
- Marking rule 6.3.10/*Nasienreël 6.3.10*



OR/*OF*



(5)

4.5 $2C_4H_{10} + 13O_2$ ✓ $\rightarrow$ $8CO_2 + 10H_2O$ ✓ Bal. ✓

Ignore phases./*Ignoreer fases.*

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

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

IF/*INDIEN*:

- Structural formulae C_4H_{10} used:/*Struktuurformule C_4H_{10} gebruik:* Max./*Maks.* $^2/_3$ (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 van reaksietempo.*

ANY ONE

- Change in concentration ✓ of products/reactants per (unit) time. ✓
- Change in amount/number of moles/volume/mass of products or reactants per (unit) time.
- Amount/number of moles/volume/mass of products formed/reactants used per (unit) time.
- Rate of change in concentration/amount/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 **ANY 1/ENIGE 1:**
Temperature/*Temperatuur* ✓
(Initial) amount/mass of magnesium carbonate
(Aanvanklike) hoeveelheid/massa van magnesiumkarbonaat (1)

5.3 CO_2/gas escapes from the reaction flask. ✓
CO_2 is 'n gas/diffundeer/ontsnap die reaksiefles. (1)

5.4

Marking criteria	***Nasienkriteria*:**
(a) Mass subtraction ✓ **(b)** Formula: $n = \frac{m}{M}$ or $V = nV_m$ ✓ **(c)** Substitute M = 44 g·mol^{-1} in $n(CO_2) = \frac{m}{M}$ ✓ **(d)** Substitute 24,5 dm^3 in $V = nV_m$ ✓ **(e)** Substitute V_{CO_2} and 120 in rate formula. ✓ **(f)** Final correct answer: $2,92 \times 10^{-3}$ (dm^3·s^{-1}) ✓ Range: $2,08 \times 10^{-3}$ to $2,92 \times 10^{-3}$	**(a)** *Aftrek van massas.* ✓ **(b)** *Formula: $n = \frac{m}{M}$ or $V = nV_m$* ✓ **(c)** *Vervang M = 44 g·mol^{-1} in $n(CO_2) = \frac{m}{M}$* ✓ **(d)** *Vervang 24,5 dm^3 in $V = nV_m$* ✓ **(e)** *Vervang V_{CO_2} en 120 in tempo-formule.* ✓ **(f)** *Finale korrekte antwoord: $2,92 \times 10^{-3}$ (dm^3·s^{-1})* ✓ *Gebied:* $2,08 \times 10^{-3}$ *tot* $2,92 \times 10^{-3}$

$m(CO_2) = 144,5 - 143,87$ ✓ **(a)**
$= 0,63$ g

$n(CO_2) = \frac{m}{M}$ ✓ **(b)**
$= \frac{0,63}{44}$ ✓ **(c)**
$= 1,43 \times 10^{-2}$ mol

$V(CO_2) = nV_m$
$= (1,43 \times 10^{-2})(24,5)$ ✓ **(d)**
$= 0,35$ dm^3

Ave rate/*gem tempo* $= \frac{\Delta V(CO_2)}{\Delta t}$
$= \frac{0,35-(0)}{120-(0)}$ ✓ **(e)**
$= 2,92 \times 10^{-3}$ (dm^3·s^{-1}) ✓ **(f)** (6)

5.5 A ✓

- Gradient is least steep/lowest reaction rate/least amount of gas produced in 120 s. ✓
- Lowest concentration of HCℓ(aq). ✓
- Least/Less particles per unit volume. ✓
- Least/Less effective collisions per unit time/second. ✓
  OR
  Lowest/Lower frequency of effective collisions.

- *Gradient is die laagste/laagste reaksietempo/minste hoeveelheid gas geproduseer in 120 s.* ✓
- *Laagste konsentrasie van HCℓ(aq).* ✓
- *Minste/Minder deeltjies per eenheidsvolume.* ✓
- *Minste/Minder effektiewe botsings per eenheidstyd/sekonde.* ✓
  OF
  Laagste/Laer frekwensie van effektiewe botsings. (5)

5.6 The same/ *Dieselfde* ✓
$MgCO_3$ is the limiting reactant and the same amount is used in each experiment. ✓
$MgCO_3$ is die beperkte reaktans en dieselfde hoeveelheid is gebruik in elke eksperiment. (2)
[17]

QUESTION 6/*VRAAG 6*

6.1

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

6.1.2 Decreases/*Neem af* ✓ (1)

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

6.2
- Decrease in pressure favours the reaction that produces a greater number of moles/amount of gas. ✓
  'n Verlaging in druk bevoordeel die reaksie wat 'n groter aantal mol/hoeveelheid gas produseer.
- Forward reaction is favoured. ✓
  Voorwaartse reaksie word bevoordeel. (2)

6.3

Marking criteria:	***Nasienkriteria:***
(a) Substitute 44 in $n = \frac{m}{M}$ ✓ **(b)** Change in mass of carbon: $m(C_i) - m(C_f)$ ✓ **(c)** Substitute 12 in $n = \frac{m}{M}$ ✓ **(d)** Use mole ratio 1:1 ✓ **(e)** $n(CO_2)_{equilibrium} = n(CO_2)_{initial} - n(CO_2)_{used}$ OR $m(CO_2)_{equilibrium} = m(CO_2)_{initial} - m(CO_2)_{used}$ ✓ **(f)** Final answer: 6,16 g ✓ RANGE: 6 to 6,16 g	***(a)** Vervang 44 in $n = \frac{m}{M}$* ✓ ***(b)** Verandering in massa: $m(C_i) - m(C_f)$* ✓ ***(c)** Vervang 12 in $n = \frac{m}{M}$* ✓ ***(d)** Gebruik molverhouding 1:1* ✓ ***(e)*** $n(CO_2)_{ewewig} = n(CO_2)_{begin} - n(CO_2)_{gebruik}$ OF ***(f)*** $m(CO_2)_{ewewig} = m(CO_2)_{begin} - m(CO_2)_{gebruik}$ ✓ ***(g)** Finale anwtoord: 6,16 g* ✓ *GEBIED: 6 tot 6,16 g*
OPTION 1/*OPSIE 1:*	**OPTION 2/*OPSIE 2:***
$n(CO_2)_{initially} = \frac{m}{M}$ $= \frac{41,2}{44}$ ✓ **(a)** $= 0,94$ mol (0,936) $\Delta m(C) = 14 - 4,44$ ✓ **(b)** $= 9,56$ g $n(C)_{used} = \frac{m}{M}$ $n(C)_{used} = \frac{9,56}{12}$ ✓ **(c)** $= 0,80$ mol (0,797) $n(CO_2)_{used} = n(C)$ $= 0,80$ mol (0,797) ✓ **(d)** $n(CO_2)_{eq} = n(CO_2)_{initially} - n(CO_2)_{used}$ $= 0,94 - 0,80$ ✓ **(e)** $= 0,14$ mol $n(CO_2) = \frac{m}{M}$ $0,14 = \frac{m}{44}$ $m(CO_2) = 6,16$ g ✓ **(f)**	$\Delta m(C) = 14 - 4,44$ ✓ **(b)** $= 9,56$ g $n(C)_{used} = \frac{m}{M}$ $n(C)_{used} = \frac{9,56}{12}$ ✓ **(c)** $= 0,80$ mol (0,797) $n(CO_2)_{used} = n(C)$ $= 0,80$ mol (0,797) ✓ **(d)** $n(CO_2) = \frac{m}{M}$ $0,80 = \frac{m}{44}$ ✓ **(a)** $m(CO_2) = 35,05$ g $m(CO_2)_{eq} = m(CO_2)_{initially} - m(CO_2)_{used}$ $= 41,2 - 35,05$ ✓ **(e)** $= 6,15$ g ✓ **(f)**

(6)

6.4

POSITIVE MARKING FROM QUESTION 6.3:
POSITIEWE NASIEN VANAF VRAAG 6.3:

Marking criteria

(a) Use of ratio $n(CO_2) : n(CO) = 1: 2$. ✓
(b) Divide by 3 dm^3 ✓
(c) Correct Kc expression (formulae in square brackets). ✓
(d) Substitute of concentration into K_C expression. ✓
(e) Final answer: 5,98 ✓
RANGE: 5,98 – 7,29

Nasienkriteria:

(a) Gebruik verhouding $n(CO_2) : n(CO) = 1: 2$. ✓
(b) Deel deur 3 dm^3 ✓
(c) Korrekte K_c uitdrukking (formules in vierkantige hakies). ✓
(d) Vervang konsentrasies in korrekte K_c uitdrukking. ✓
(e) Finale antwoord: 5,98 ✓
GEBIED: 5,98 – 7,29

CALCULATIONS USING NUMBER OF MOLES
BEREKENINGE WAT GETAL MOL GEBRUIK
OPTION 1/*OPSIE 1:*

$n(CO_2)_{initial} = \frac{m}{M}$

$= \frac{41,2}{44}$

$= 0,936$ mol

	CO_2	CO	
Ratio/*Verhouding*	1	2	
Initial quantity (mol) Aanvangshoeveelheid (mol)	0,936	0	
Change (mol) *Verandering (mol)*	0,8	1,6	✓ **(a)**
Quantity at equilibrium (mol)/ *Hoeveelheid by ewewig (mol)*	0,14	1,6	
Equilibrium concentration ($mol \cdot dm^{-3}$) Ewewigskonsentrasie ($mol \cdot dm^{-3}$)	0,047	0,53	Divide by 3 ✓ **(b)**

$K_c = \frac{[CO]^2}{CO_2}$ ✓**(c)**

$= \frac{(0,53)^2}{0,047}$ ✓**(d)**

$= 5,98$ ✓ **(e)**

Wrong K_c expression
Verkeerde K_c-uitdrukking: Max./*Maks.* $^2/_5$
No K_c expression/*Geen K_c- uitdrukking*: $^4/_5$

CALCULATIONS USING CONCENTRATION
BEREKENINGE WAT KONSENTRASIE GEBRUIK

OPTION 2/*OPTION 2*

$C(CO_2) = \frac{m}{MV}$

$= \frac{41,2}{(44)(3)}$ Divide by 3 ✓ **(b)**

$= 0,31\ mol \cdot dm^{-3}$

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

$= \frac{0,8}{3}$

$= 0,27\ mol \cdot dm^{-3}$ (0,267)

	CO_2	CO	
Ratio/*Verhouding*	1	2	
Initial concentration ($mol \cdot dm^{-3}$) *Aanvangskonsentrasie ($mol \cdot dm^{-3}$)*	0,31	0	
Change in concentration ($mol \cdot dm^{-3}$) *Verandering in konsentrasie ($mol \cdot dm^{-3}$)*	0,27	0,54	✓ **(a)**
Equilibrium concentration ($mol \cdot dm^{-3}$) Ewewigskonsentrasie ($mol \cdot dm^{-3}$)	0,04	0,54	

$K_c = \frac{[CO]^2}{CO_2}$ ✓ **(c)**

$= \frac{(0,54)^2}{0,04}$ ✓ **(d)**

$= 7,29$ ✓ **(e)**

> Wrong K_c expression
> *Verkeerde K_c-uitdrukking*: Max./Maks. $^2/_5$
> No K_c expression/*Geen K_c- uitdrukking*: $^4/_5$

OPTION 3/OPSIE 3:

$n(CO_2)_{initial} = \frac{m}{M}$

$= \frac{41,2}{44}$

$= 0,936$ mol

$\Delta n(CO_2) = 0,8$ mol

$n(CO_2)_{equi} = n(CO_2)_{initial} - \Delta n(CO_2)$

$= 0,936 - 0,8$

$= 0,136$ mol ✓ (a)

$n(CO)_{formed} = 2\Delta n(CO)_{used} = 1,6$ mol

$n(CO)_{equil} = \Delta n(CO)_{formed} = 1,6$ mol

$[CO_2]_{eqm} = \frac{0,136}{3} = 4,53 \times 10^{-2}$ mol·dm^{-3}

$[CO]_{eqm} = \frac{1,6}{3} = 0,53$ mol·dm^{-3} ✓ (b)

$K_c = \frac{[CO]^2}{CO_2}$ ✓ (c)

$= \frac{(0,53)^2}{4,53 \times 10^{-2}}$ ✓ (d)

$= 6,2$ ✓ (e)

Wrong K_c expression
Verkeerde K_c-uitdrukking: Max./Maks. $^2/_5$
No K_c expression/*Geen K_c- uitdrukking*: $^4/_5$

(5)

6.5

6.5.1 Y ✓✓ (2)

6.5.2 Remains the same ✓ (1)

[19]

QUESTION 7/*VRAAG 7*

7.1 Acids produce <u>hydrogen ions</u> (H^+)/H_3O^+ /hydronium ions) in <u>aqueous solution</u>. ✓✓ (**2 or 0**)
'n Suur is 'n stof wat <u>waterstofione</u> (H^+)/hidroniumione (H_3O^+) vorm wanneer dit in <u>water oplos</u>. (2)

7.2

7.2.1 $(COOH)_2$ ✓ (1)

7.2.2 NaCℓ ✓ (1)

7.2.3 HCO_3^- / NH_3 ✓ (1)

7.2.4 NaOH/ $Mg(OH)_2$ ✓✓ (2)

7.3

<u>Marking criteria:</u>	***<u>Nasienkriteria:</u>***
• Calculate $n(H_xY)$ ✓ • Calculate n(NaOH) ✓ • Final answer: x = 2 ✓ • Reactants ✓ Products ✓ Balancing ✓ • Ignore ⇌ and phases • Marking rule 6.3.10	• Bereken $n(H_xY)$ ✓ • Bereken n(NaOH) ✓ • Finale antwoord: x = 2 ✓ • *Reaktanse* ✓ *Produkte* ✓ Balansering ✓ • *Ignoreer ⇌ en fases* • *Nasienreël 6.3.10*
<u>OPTION 1/*OPSIE 1:*</u> $n = cV$ $n_{acid} = (0,11)(0,02364)$ ✓ $= 2,60 \times 10^{-3}$ $n_{base} = (0,26)(0,02)$ ✓ $= 5,2 \times 10^{-3}$ (0,0052) $\frac{n(H_xY)}{n(NaOH)} = \frac{n_a}{n_b}$ $\frac{2,6 \times 10^{-3}}{5,2 \times 10^{-3}} = \frac{1}{2}$ $x = 2$ ✓	**<u>OPTION 2/*OPSIE 2:*</u>** $\frac{V_a \times C_a}{V_b \times C_b} = \frac{n_a}{n_b}$ $\frac{(20)(0,26)✓}{(23,64)(0,11)✓} = \frac{1}{2}$ $x = 2$ ✓

<u>$H_2Y(aq) + 2NaOH(aq)$</u> ✓ → <u>$Na_2Y(aq) + 2H_2O(\ell)$</u> ✓ Bal ✓ (6)

7.4

Marking criteria:

(a) Any formula: $pH = -\log[H_3O^+]$/$pH = -\log[H^+]$/$pOH = -\log[OH^-]$/ $[H_3O^+][OH^-] = 10^{-14}$ /$pH + pOH = 14$ ✓
(b) Substitute 1,61 in $pH = -\log[H_3O^+]$/$pH + pOH = 14$ ✓
(c) Calculate $n(HC\ell)_{unused}$ using $n = \frac{n}{V}$ ✓
(d) Calculate $n(HC\ell)_{initial}$ using $n = \frac{n}{V}$ ✓
(e) Calculate $n(HC\ell)_{used} = n(HC\ell)_{initial} - n(HC\ell)_{unused}$ ✓
(f) Using ratio 1:2 to calculate $n(CaCO_3)$ ✓
(g) Substitute 100 and n in $n = \frac{m}{M}$ ✓
(h) Mass of impurity = $m_{sample} - m(CaCO_3)$ ✓
(i) Final answer: 0,25g ✓ (Range: 0,20 g to 0,30 g)

Nasienkriteria:

(a) *Enige formule:* $pH = -\log[H_3O^+]$/$pH = -\log[H^+]$/$pOH = -\log[OH^-]$/ $[H_3O^+][OH^-] = 10^{-14}$/$pH + pOH = 14$ ✓
(b) *Vervang 1,61 in* $pH = -\log[H_3O^+]$/$pH + pOH = 14$ ✓
(c) *Bereken* $n(HC\ell)_{ongebruik}$ *using* $n = \frac{n}{V}$ ✓
(d) *Bereken* $n(HC\ell)_{begin}$ *using* $n = \frac{n}{V}$ ✓
(e) *Bereken* $n(HC\ell)_{gebruik} = n(HC\ell)_{begin} - n(HC\ell)_{ongebruik}$ ✓
(f) *Gebruik ratio 1:2 om* $n(CaCO_3)$ *te bereken* ✓
(g) *Vervang 100 en n in* $n = \frac{m}{M}$ ✓
(h) *Massa of onsuiwerheid* = $m_{monster} - m(CaCO_3)$ ✓
(i) *Finale antwoord: 0,25g* ✓ (Gebied: 0,20 g to 0,30 g)

$pH = -\log[H_3O^+]$ ✓ **(a)**
$1,61 = -\log[H_3O^+]$ ✓ **(b)**
$[H_3O^+] = 10^{-1,61}$
$= 2,45 \times 10^{-2}\ mol\cdot dm^{-3}$ (0,0245)

$n(HC\ell)_{unused} = n(H_3O^+) = cV$
$= (2,45 \times 10^{-2})(0,2)$ ✓ **(c)**
$= 4,90 \times 10^{-3}$ mol (0,0049)

$n(HC\ell)_{initial} = cV$
$= (0,15)(0,2)$ ✓ **(d)**
$= 3 \times 10^{-2}$ mol (0,03)

$n(HC\ell)_{used} = 3 \times 10^{-2} - 4,90 \times 10^{-3}$ ✓ **(e)**
$= 2,51 \times 10^{-2}$ mol (0,0251)

Reaction ratio $nCaCO_3 : nHC\ell = 1:2$
✓ **(f)**
$n(CaCO_3) = ½(2,51 \times 10^{-2}) = 1,25 \times 10^{-2}$ mol
$n(CaCO_3) = \frac{m}{M}$
$1,25 \times 10^{-2} = \frac{m}{100}$ ✓ **(g)**
$m(CaCO_3) = 1,25$ g

m of impurity in the sample = 1,50 – 1,25 ✓ **(h)**
= 0,25 g ✓ **(i)**

(9)
[22]

QUESTION 8/*VRAAG 8*

8.1 H^+/H_3O^+ ions/hydrogen ions/hydronium ions ✓
Waterstofione/hidrononiumione (1)

8.2 0,77 V ✓ (1)

8.3 A ✓ (1)

8.4 H_2 is a stronger reducing agent✓ than Fe^{2+}/Fe(II) ions ✓ and will reduce Fe^{3+}/Fe(III) ions ✓ (to Fe^{2+}/Fe(II) ions).

H_2 is 'n sterker reduseermiddel as Fe^{2+}/Fe(II)-ione en sal Fe^{3+}/Fe(III)-ione reduseer (na Fe^{2+}/Fe(II)-ione).

OR/*OF*

Fe^{2+}-ion is a weaker reducing agent✓ than H_2✓ and therefore Fe^{3+}/Fe(III) ions (to Fe^{2+}/Fe(II) ions)will be reduced. ✓

Fe^{2+}-ioon is 'n sterker reduseermiddel as H_2 en sal Fe^{3+}/Fe(III)-ione reduseer (na Fe^{2+}/Fe(II)-ione). (3)

8.5

8.5.1 Pt/Platinum ✓ (1)

8.5.2 $H_2 \rightarrow 2H^+ + 2e^-$ ✓✓

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

(2)

8.5.3 Pt(s) | H_2(g) | H^+(aq) ✓ || ✓ Fe^{3+}(aq),Fe^{2+}(aq) | Pt(s) ✓

OR/*OF*

Pt(s) | H_2(g) | H^+(1 mol·dm^{-3}) || Fe^{3+}(1 mol·dm^{-3}),Fe^{2+}(1 mol·dm^{-3}) | Pt(s)

ACCEPT/*AANVAAR*:

Pt | H_2 | H^+ || Fe^{3+},Fe^{2+} | Pt (3)

8.6 The reaction reaches equilibrium/no charges/electrons flow. ✓
Die reaksie bereik ewewig/geen ladings/elektrone vloei. (1)

[13]

QUESTION 9/*VRAAG 9*

9.1 **ANY ONE/*ENIGE EEN:***

- The chemical process in which electrical energy is converted to chemical energy. ✓✓ (2 or 0)
- 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.* ✓✓ *(2 of 0)*
- *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 $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ ✓✓

NOTE/AANTEKENING:

- $H_2(g) + 2OH^-(aq) \leftarrow 2H_2O(\ell) + 2e^-$ ($\frac{2}{2}$) $2H_2O(\ell) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$ ($\frac{1}{2}$)
  $H_2(g) + 2OH^-(aq) \rightleftharpoons 2H_2O(\ell) + 2e^-$ ($\frac{0}{2}$) $2H_2O(\ell) + 2e^- \leftarrow H_2(g) + 2OH^-(aq)$ ($\frac{0}{2}$)
- 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:* $\frac{1}{2}$
- Ignore phases/*Ignoreer fases* (2)

9.3 X to/*tot* Y ✓ (1)

9.4

Marking criteria: **(a)** Substitute 300 x 10^{-3} and 24 dm^3 into $n = \frac{V}{V_m}$ ✓ **(b)** Using ratio 1:2 to calculate $n(e^-)$ ✓ **(c)** Substitute 6,02 x 10^{23} mol^{-1} in $n = \frac{N}{N_A}$ ✓ **(d)** Final correct answer: 1,505 x 10^{22} electrons ✓ Range: 1,505 x 10^{22} to 2,41 x 10^{22} electrons	***Nasienkriteria:*** **(a)** *Vervang 300 x 10^{-3} en 24 dm^3 int $n = \frac{V}{V_m}$* ✓ **(b)** *Gebruik verhouding 1:2 om $n(e^-)$ te bereken* ✓ **(c)** *Vervang 6,02 x 10^{23} mol^{-1} in $n = \frac{N}{N_A}$* ✓ **(d)** *Finale korrekte antwoord: 1,505 x 10^{22} elektrone* ✓ *Gebied: 1,505 x 10^{22} tot 2,41 x 10^{22} elektrone*
OPTION 1/*OPSIE 1*: $n(C\ell_2) = \frac{V}{V_m}$ $= \frac{300 \times 10^{-3}}{24}$ ✓(a) $= 0{,}0125$ mol (0,01) $n(e^-) = 2n(C\ell_2)$ $= 2 \times 0{,}0125$ ✓(b) $= 0{,}025$ mol $n(e^-) = \frac{N}{N_A}$ $0{,}025 = \frac{N}{6{,}02 \times 10^{23}}$ ✓(c) $N = 1{,}505 \times 10^{22}$ electrons ✓(d)	**OPTION 2/*OPSIE 2*:** $n(C\ell_2) = \frac{V}{V_m}$ $= \frac{300 \times 10^{-3}}{24}$ ✓(a) $= 0{,}0125$ mol (0,01) $n(C\ell_2) = \frac{N}{N_A}$ $0{,}0125 = \frac{N}{6{,}02 \times 10^{23}}$ ✓(c) $N = 7{,}525 \times 10^{21}$ $C\ell_2$ $N(e^-) = 2n(C\ell_2)$ $= 2 \times 7{,}525 \times 10^{21}$ ✓(b) $= 7{,}525 \times 10^{21}0{,}025$ electrons ✓(d)

(4)
[9]

TOTAL/*TOTAAL*: 150