KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES P2 (CHEMISTRY)

PREPARATORY EXAMINATION

SEPTEMBER 2023

MARKS: 150

TIME : 3 Hours

This question paper consists of 14 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 sub-questions, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached DATA SHEETS.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your final numerical answers to a minimum of TWO decimal places.
11. Give brief motivations, discussions et cetera where required.
12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A-D) next to the question number (1.1-1.10) in the ANSWER BOOK, for example 1.11 D.

1.1 Which ONE of the following homologous series does NOT contain a CARBONYL GROUP?

A Esters

B Alcohols

C Aldehydes

D Carboxylic acids (2)

1.2 Which of the following statements COULD apply to compounds that are structural isomers of one another?

(I) They have the same structural formula.
(II) They have the same molecular formula.
(III) They may belong to the same homologous series.

A (I), (II) and (III)

B (I) and (III)

C (I) and (II)

D (II) and (III) (2)

1.3 Compound X undergoes a combustion reaction according to the following equation:

$$2\,X + 19\,O_2 \rightarrow 12\,CO_2 + 14\,H_2O$$

What is the IUPAC name of compound X?

A Hexane

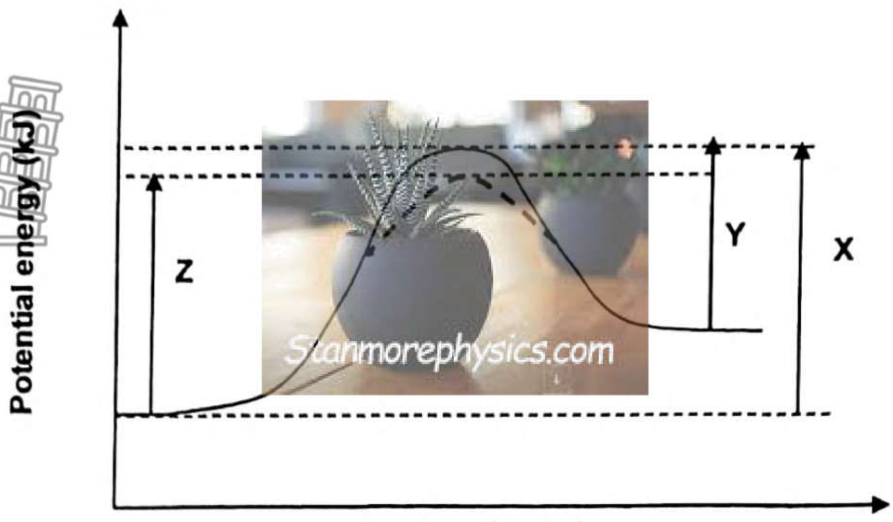
B Hex – 2 – ene

C Propane

D Hexanoic acid

(2)

1.4 The energy changes represented by X, Y and Z on the potential energy graph below takes place during a catalysed, reversible chemical reaction.



Which ONE of the following represents the heat of the reaction for the **FORWARD** reaction?

A X – Y

B Y – Z

C Z – X

D X – Z (2)

1.5 Which ONE of the following statements correctly describes the rate of reaction for the following reaction?

$$Mg(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g)$$

A The time it takes to use up the reactants.

B The decrease in the concentration of magnesium per unit time.

C The time it takes for one of the reactants to be completely used up.

D The increase in the concentration of $MgC\ell_2(aq)$ per unit time. (2)

1.6 Consider the reaction represented by the following balanced chemical equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The system is initially at equilibrium.

The pressure is increased by decreasing the volume of the container at constant temperature. How will the amount of HI(g) and the concentration of HI(g) change?

	AMOUNT OF HI (g)	CONCENTRATION OF HI (g)
A	Remains the same	Remains the same
B	Decreases	Decreases
C	Remains the same	Increases
D	Remains the same	Decreases

(2)

1.7 Consider the reaction represented by the balanced equation below:

$$H_2SO_4(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + HSO_4^-(aq)$$

Which ONE of the following is a conjugate acid-base pair?

A $H_3O^+(aq)$ and $H_2O(\ell)$

B $H_3O^+(aq)$ and HSO_4^- (aq)

C $H_2SO_4(aq)$ and $H_2O(\ell)$

D $H_2SO_4(aq)$ and $H_3O^+(aq)$ (2)

1.8 Which ONE of the following gives the approximate pH of an aqueous solution of sodium carbonate and the relevant hydrolysis equation?

	pH	HYDROLYSIS EQUATION
A	Less than 7	$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$
B	Less than 7	$Na^+ + H_2O \rightleftharpoons NaOH + H^+$
C	Greater than 7	$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$
D	Greater than 7	$Na^+ + H_2O \rightleftharpoons NaOH + H^+$

(2)

1.9 The emf of a galvanic cell is 1,2 V under standard conditions. The following half reactions and standard electrode potentials are provided.

HALF REACTION	STANDARD ELECTRODE POTENTIAL(E°) IN VOLTS(V)
$W^+ + e^- \rightleftharpoons W$	-1,8
$X^{2+} + 2e^- \rightleftharpoons X$	+0,3
$Y^+ + e^- \rightleftharpoons Y$	-0,9
$Z^{2+} + 2e^- \rightleftharpoons Z$	-0,3

Which ONE of the following combinations is correct for the above galvanic cell?

	ANODE	CATHODE
A	X	Y
B	Y	X
C	Y	Z
D	W	Z

(2)

1.10 Consider the following reactions for a metal P:

(i) P reacts with a solution of silver nitrate resulting in a deposit of metallic silver.

(ii) P does not react with a solution of zinc sulphate.

Which ONE of the following correctly lists the metals, P; Ag and Zn in order of **DECREASING** strengths of reducing agents?

A P; Ag; Zn

B Zn; P; Ag

C Ag; P; Zn

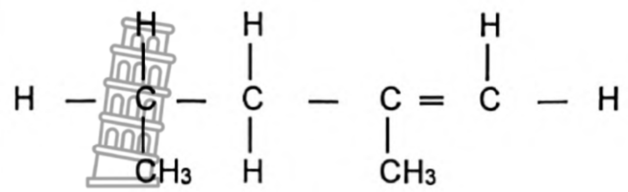
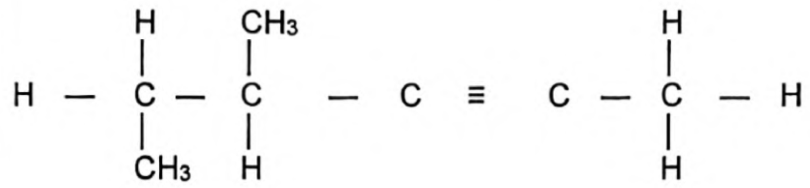
D Ag; Zn; P

(2)

[20]

QUESTION 2 (Start on a new page.)

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

A			
B			
C	$CH_3CH_2CH_2CH_2CH_2COOH$	**D**	$C_3H_6O_2$
E	Pentan – 2 – one	**F**	2,2 – dimethylpropane

Use the information in the table to answer the questions that follow.

2.1 Write down the letter/s that represent/s:

2.1.1 TWO compounds with a pH less than 7 (2)

2.1.2 A CHAIN ISOMER of $CH_3(CH_2)_3CH_3$ (1)

2.1.3 A substance with a fruity smell (1)

2.2 Write down the IUPAC name of compound **A**. (2)

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

2.4 Write down the general formula of the homologous series to which compound B belongs (1)

2.5 A straight chain organic acid **X**, ethanol and a catalyst are heated to produce the organic compound **G**. The equation below represents the reaction that takes place:

$$X + C_2H_5OH \rightarrow G + H_2O$$

The molecular mass of compound **G** is 116 g.mol^{-1} and its empirical formula is C_3H_6O.

2.5.1 Write down the name of the reaction that produces compound **G**. (1)

2.5.2 Write down the NAME or FORMULA of the catalyst that can be used in the above reaction. (1)

2.5.3 Write down the STRUCTURAL FORMULA of the organic compound **X**. (3)

2.6 Define the term *functional isomer*. (2)

2.7 Write down the STRUCTURAL FORMULA of the FUNCTIONAL isomer of compound **E**. (2)

[18]

QUESTION 3 (Start on a new page.)

Organic compounds **A**, **B**, **C** and **D** of comparable molecular mass are used to investigate the relationship between homologous series and vapour pressure at a temperature of 20^{0}C. The results obtained are shown in the table below.

ORGANIC COMPOUND	VAPOUR PRESSURE (kPa) at 20 °C
A	1,6
B	2
C	24,6
D	204

3.1 Define *vapour pressure*. (2)

3.2 Give a reason why the temperature is specified. (1)

3.3 For this experiment write down the:

3.3.1 Dependent variable (1)

3.3.2 Controlled variable (1)

3.4 Arrange the compounds **A**, **B**, **C** and **D** in order of INCREASING boiling point. (2)

The compounds **A**, **B**, **C** and **D** IN RANDOM ORDER represent propan–1–ol, ethanoic acid, butane and 2-propanone.

3.5 Write down the vapour pressure of ethanoic acid at 20 °C. (1)

3.6 Fully explain the answer to Question 3.5 by referring to intermolecular forces and vapour pressures. (3)

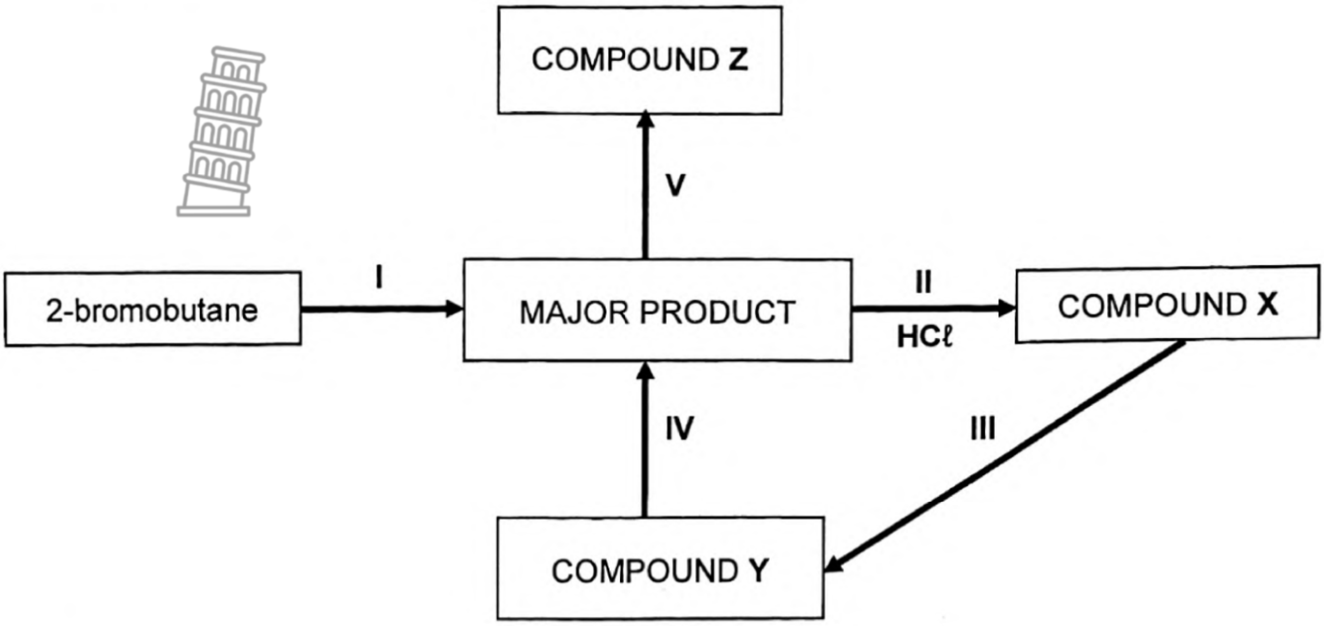
3.7 Which compound represents 2-propanone?

Explain how you arrived at the answer (4)

[15]

QUESTION 4 (Start on a new page.)

In the flow diagram below, **I, II, III, IV and V** are organic reactions. **X**, **Y** and **Z** represent organic compounds.



4.1 Reaction **I** is an elimination reaction.

4.1.1 Name the type of elimination reaction taking place. (1)

4.1.2 Write down the structural formula for the MAJOR PRODUCT formed. (2)

4.1.3 Write down the balanced equation for the reaction using MOLECULAR FORMULAE. (3)

4.2 Reaction **II** is an addition reaction.
Write down the IUPAC name of COMPOUND **X**. (2)

4.3 In reaction **III,** COMPOUND **X**, is heated with dilute sodium hydroxide.

4.3.1 Name the type of reaction taking place. (1)

4.3.2 Write down the IUPAC name of COMPOUND **Y**. (2)

4.4 In reaction **IV** COMPOUND **Y**, is heated under reflux with concentrated sulphuric acid.

4.4.1 Name the type of reaction taking place. (1)

4.4.2 Write down the NAME or FORMULA of the INORGANIC product formed. (1)

4.5 Compound **Z** is a saturated hydrocarbon.

4.5.1 Name the type of addition reaction represented by reaction **V**. (1)

4.5.2 Write down the NAME or FORMULA of the catalyst used in reaction **V**. (1)

[15]

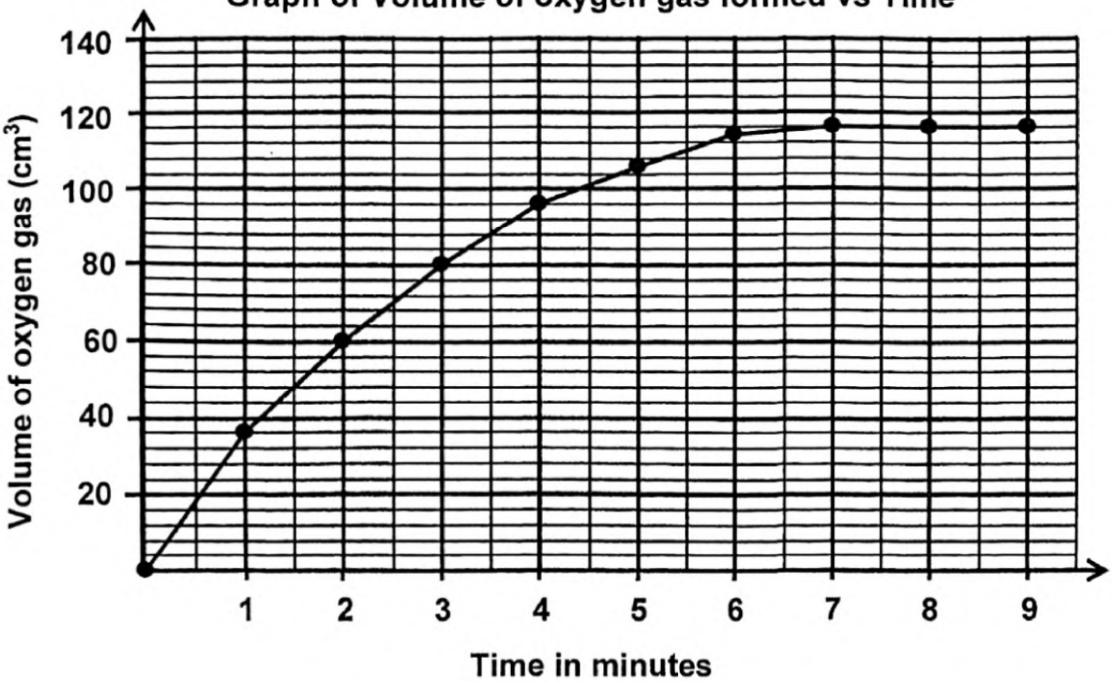
QUESTION 5 (Start on a new page)

Manganese dioxide (MnO_2) catalyses the decomposition of a solution of hydrogen peroxide, $H_2O_2(aq)$:

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(\ell) + O_2(g)$$

Manganese dioxide of mass 0,1 g was added to a flask containing 200 cm^3 of a solution of hydrogen peroxide of concentration 0,2 $mol.dm^{-3}$. The oxygen gas produced was collected at ***standard temperature and pressure*** and the volume measured every minute using a gas syringe. The following graph was obtained:

Graph of Volume of oxygen gas formed vs Time



The reaction stops before all the hydrogen peroxide decomposes.

5.1 How long did it take for the reaction to stop? (1)

5.2 How does the volume of oxygen gas collected compare for EVERY MINUTE as the reaction progresses? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

5.3 What mass of manganese dioxide is present in the flask after 8 minutes? (1)

5.4 Using the collision theory, fully explain the shape of the graph from the time the reaction starts to the time the reaction stops. (4)

5.5 Using the information provided and the graph, calculate the concentration of the hydrogen peroxide REMAINING when the reaction has stopped. (9)

[16]

QUESTION 6 (Start on a new page)

6.1 Consider the reaction represented by the balanced equation below:

$$NO_2(g) + SO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

Initially 2 moles of NO_2 (g) and 2 moles of SO_2 (g) were mixed in a sealed 2 dm^3 container. When equilibrium is reached at 700 °C there are 60 g of $SO_3(g)$ present in the container.

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

6.1.2 Calculate the value of the equilibrium constant, Kc, for this reaction. (7)

6.2 Nitrosyl chloride gas, $NOC\ell_2(g)$, is a yellow gas that decomposes into colourless nitrogen monoxide, NO(g), and green chlorine gas, $C\ell_2(g)$, at a temperature above 100 °C.

$$\underset{\text{Yellow}}{NOC\ell_2(g)} \rightleftharpoons \underset{\text{colourless}}{2\,NO(g)} + \underset{\text{green}}{C\ell_2(g)}$$

Some $NOC\ell_2$ gas is sealed in a container. When equilibrium is reached, a mixture of $NOC\ell_2$, NO and $C\ell_2$ with a yellow-green colour is present in the container.

6.2.1 State Le Chatelier's Principle. (2)

The pressure in the container is changed without changing the temperature, resulting in the colour of the mixture changing to green.

6.2.2 Was the pressure INCREASED or DECREASED?

Use Le Chatelier's Principle to explain the answer. (3)

6.2.3 How does the change in pressure affect the amount of NO(g) at equilibrium? Choose from INCREASES, DECREASES or NO EFFECT. (1)

6.2.4 State ONE other change that can be made to the above system at equilibrium to bring about the same change to the amount of NO(g) identified in QUESTION 6.2.3 (1)

[16]

QUESTION 7 (Start on a new page.)

7.1 The acid HF ionizes according to the following equation:

$$HF + H_2O \rightleftharpoons H_3O^+ (aq) + F^- (aq)$$

When a 0,10 mol·dm^{-3} solution of HF is prepared, it is found that the concentration of the F^- ions is 0,018 mol·dm^{-3} at 25 °C.

7.1.1 Define a *strong acid*. (2)

7.1.2 Is HF a strong acid? Choose from YES or NO.
Give a reason for the answer. (2)

7.1.3 Calculate the $[OH^-]$ in this solution. (3)

7.2 Sodium hydroxide (NaOH) pellets of mass **X** g are added to sufficient distilled water to prepare a solution of volume 25 cm^3 in a flask.

12 cm^3 of sulphuric acid, H_2SO_4, of concentration 0,10 mol·dm^{-3} is added to the flask containing the sodium hydroxide. The total volume of the mixture formed is 37 cm^3 and its pH is 12,56.

$$H_2SO_4 (aq) + 2 NaOH (aq) \rightarrow Na_2SO_4 (aq) + 2 H_2O (\ell)$$

7.2.1 Explain the term *dilute acid.* (2)

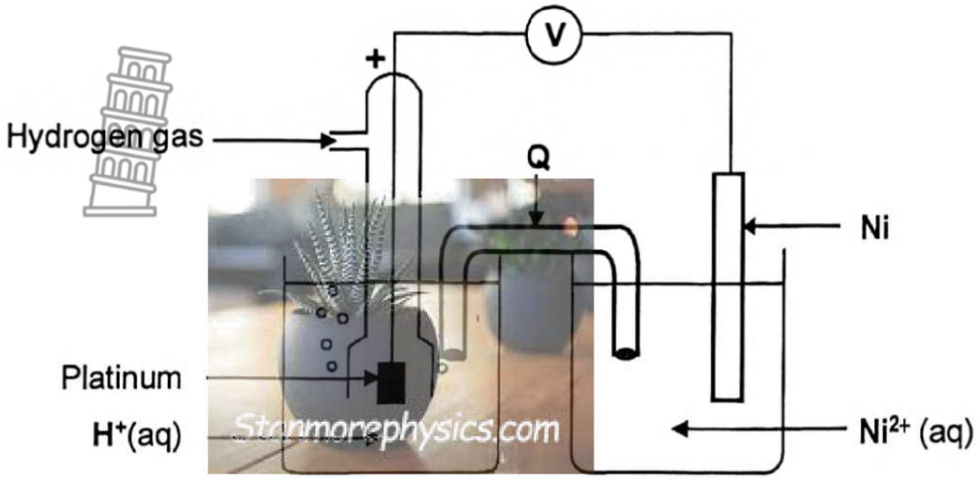
7.2.2 How does the concentration of the hydronium ions compare to the concentration of the hydroxide ions in the mixture? Choose from LARGER THAN, SMALLER THAN or EQUAL TO. (1)

7.2.3 Calculate the value of **X**. (8)

[18]

QUESTION 8 (Start on a new page.)

An electrochemical cell is set up under standard conditions using a hydrogen half-cell and a nickel half-cell as shown in the simplified diagram below.



8.1 State the standard conditions, besides a temperature of 25 °C, under which this cell operates. (2)

8.2 Calculate the *initial* reading on the voltmeter. (4)

8.3 For this electrochemical cell, write down:

8.3.1 The energy conversion that takes place (1)

8.3.2 One function of component Q (1)

8.3.3 Direction in which the anions in component Q will move. Choose from TOWARDS THE NICKEL HALF CELL or TOWARDS THE HYDROGEN HALF CELL (1)

8.3.4 Half reaction that takes place at the anode (2)

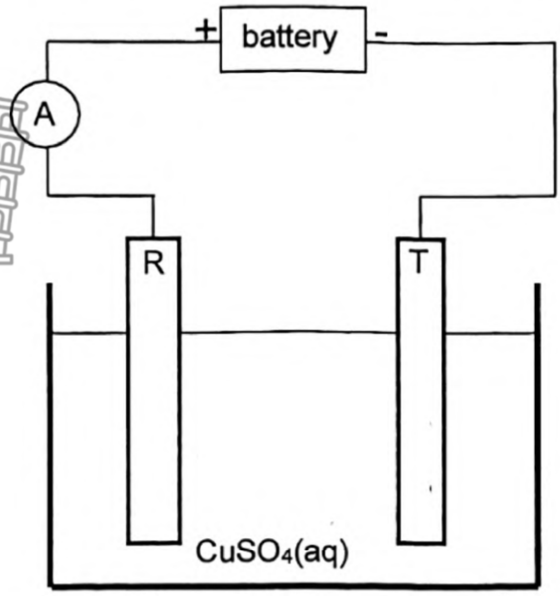
8.4 How will the pH of the solution in the hydrogen half-cell be affected after a while? Choose from INCREASES, DECREASES, or REMAINS THE SAME. Explain the answer. (3)

8.5 The platinum electrode is replaced with a larger platinum electrode. How will this affect the initial emf of the cell? (Choose from INCREASES, DECREASES or NO EFFECT) (1)

[15]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents an electrolytic cell used to purify copper.



9.1 Define the term *electrolysis.* (2)

9.2 Which electrode, R or T, consists of pure copper? Give a reason for the answer. (2)

9.3 Write down the half reaction that takes place at electrode R. (2)

9.4 How will the concentration of the electrolyte be affected while the cell is functioning? Choose from INCREASES, DECREASES, or REMAINS THE SAME.
Give a reason for the answer (2)

9.5 Zinc is one of the impurities found in the impure copper.
Will the presence of zinc ions influence the quality of the refined copper?
Choose from YES or NO.
Refer to relative strengths of oxidising agents to explain the answer. (3)

9.6 A constant current is registered on the ammeter and 1,72 g of the copper is deposited on the cathode in 30 minutes. Calculate the reading on the ammeter. (6)
[17]

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 electron*	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 (25°C)	
$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ / $E^\theta_{sel} = E^\theta_{katode} - E^\theta_{anode}$ or/*of* $E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ / $E^\theta_{sel} = E^\theta_{reduksie} - E^\theta_{oksidasie}$ or/*of* $E^\theta_{cell} = E^\theta_{oxidising\ agent} - E^\theta_{reducing\ agent}$ / $E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	
$q = I\Delta t$ $n = \frac{Q}{e}$ *or/of* $n = \frac{Q}{q_e}$ Where n is the number of electrons	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

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

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

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

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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Increasing reducing ability/*Toenemende reduserende vermoë* ↑

Half-reactions/*Halfreaksies*	E^{θ} (V)
$Li^+ + e^- \rightleftharpoons Li$	− 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

KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

GRADE 12

NATIONAL SENIOR CERTIFICATE

PHYSICAL SCIENCES P2 (CHEMISTRY)

PREPARATORY EXAMINATION

SEPTEMBER 2023

MARKING GUIDELINES

MARKS: 150

This marking guideline document consists of 13 pages.

QUESTION 1

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

QUESTION 2

2.1

2.1.1 C ✓ D ✓ (accept E) (2)

2.1.2 F✓ (1)

2.1.3 D or E ✓ (1)

2.2 2 – methylpent – 1 – ene✓✓

Marking criteria:
- correct stem and substituents: methyl and pentene✓
- IUPAC name completely correct including numbering, sequence and hyphen ✓

(2)

2.3 A series of organic compounds that can be described by the same general formula ✓✓

OR

A series of organic compounds in which one member differs from the next by a -CH_2 group.✓✓

Marking criteria:

If any one of the underlined key words/phrases in the correct context is omitted, deduct 1 mark.

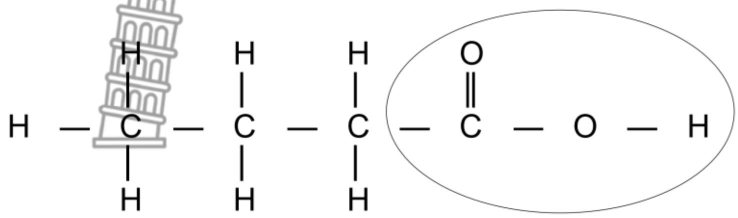
(2)

2.4 C_nH_{2n-2}✓ (1)

2.5.1 Esterification/ester formation✓ (1)

2.5.2 Sulphuric acid/H_2SO_4✓ (1)

2.5.3

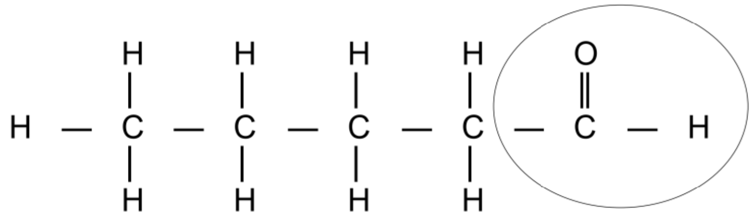


✓✓✓ (3)

Marking criteria:
• Functional group correctly drawn✓ • 4 carbons ✓ • Whole structure correctly drawn✓

2.6 Compounds with same molecular formula✓but different functional groups. ✓ (2)

2.7



✓✓

Marking criteria:
• Functional group correctly drawn✓ $\frac{1}{2}$ • Whole structure correct ✓ $\frac{2}{2}$

(2)

ACCEPT structures for: 2-methylbutanal, 3-methylbutanal and 2,2-dimethylpropanal.

[18]

QUESTION 3

3.1 The pressure exerted by a vapour at equilibrium with its liquid in a closed system. ✓✓

> **Marking criteria:**
>
> If any one of the underlined key words/phrases in the correct context (vapour pressure) is omitted, deduct 1 mark.

(2)

3.2 Vapour pressure is temperature dependent✓ (1)

3.3.1 Vapour pressure ✓ (1)

3.3.2 Molecular mass✓ OR Temperature. Accept: straight chain✓ (1)

3.4 D; C; B; A ✓✓ **(2 OR ZERO)** (2)

3.5 1,6 (kPa)✓ (1)

3.6 For ethanoic acid:
Strongest intermolecular forces between the molecules (Hydrogen bonds).✓
Most energy required to overcome the intermolecular forces.✓
Lowest vapour pressure✓ (3)

3.7

> **Marking criteria:**
> - Correct answer (C)
> - Compare strengths of IMFs of A and B, and relate to vapour pressure✓
> - Compare strengths of IMFs of D, and relate to vapour pressure✓
> - Compare strengths of IMFs of C with A, B and D.✓

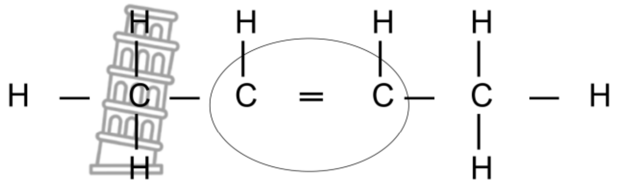
C ✓
Both the carboxylic acid/ethanoic acid/A and alcohol/propan-1-ol/B have strongest intermolecular forces resulting in lowest vapour pressures. ✓
Butane/D has weakest intermolecular forces resulting in the highest vapour pressure. ✓
2-propanone/propanone/C has intermolecular forces stronger than Butane/D, but weaker than carboxylic acid/ethanoic acid/A and alcohol/propan-1-ol/B. ✓

(4)
[15]

QUESTION 4

4.1.1 Dehydrohalogenation / Dehydrobromination✓ (1)

4.1.2



Marking criteria:
- Functional group correctly drawn✓ $\frac{1}{2}$
- Whole structure correct ✓ $\frac{2}{2}$

(2)

4.1.3 C_4H_9Br + NaOH → C_4H_8 + NaBr + H_2O (any strong base)
LHS✓ RHS✓ BAL✓
NOTE: If structural formulae used, max $^2/_3$
(3)

4.2 2 - chlorobutane✓✓

Marking criteria:
- correct stem and substituents: chloro and butane✓
- IUPAC name completely correct including numbering, sequence and hyphen ✓

(2)

4.3.1 Hydrolysis✓ or substitution (1)

4.3.2 butan – 2 - ol✓✓ OR 2-butanol

Marking criteria:
- correct stem and substituents: butanol✓
- IUPAC name completely correct including numbering, sequence and hyphen ✓

(2)

4.4.1 Elimination ✓or dehydration (1)

4.4.2 Water/H_2O✓ (1)

4.5.1 Hydrogenation✓ (1)

4.5.2 Platinum/Pt **OR** Nickel/Ni **OR** Palladium/Pd ✓ (1)
[15]

QUESTION 5

5.1 7 (minutes) ✓ (1)

5.2 Decreases ✓ (1)

5.3 0,1 g ✓ (1)

5.4 Gradient of the graph decreases as the reaction progresses. ✓
Rate of the reaction decreases. ✓
Concentration of H_2O_2 decreases as the reaction progresses / Amount of reacting molecules decreases in the same volume. ✓
Number of effective collisions per unit time decreases. ✓ (4)

5.5 **Marking criteria:**

- Formula: $n = \frac{V}{V_m}$ ✓ to calculate $n(O_2)$produced
- Correct substitution ($\frac{0,116}{22,4}$) in the above formula / Award mark for answer ($5,179 \times 10^{-3}$ if substitution is not shown)✓
- Ratio: $n(H_2O_2)$ used equals $2n(O_2)$ produced ✓
- Use n = cV to calculate $n(H_2O_2)$ initial ✓
- $n(H_2O_2)$ when reaction stops = $n(H_2O_2)$initial - $n(H_2O_2)$used/reacted ✓✓
- Formula: $C = \frac{n}{V}$✓ to calculate C required
- Correct substitution into the formula: $c = \frac{n}{V}$ ✓
- Final answer = 0,15 $mol \cdot dm^{-3}$ ✓

5.5 **OPTION 1:**

$n(O_2)\text{produced} = \frac{V}{V_m}$ ✓

$= \frac{0,116}{22,4}$

$= 5,179 \times 10^{-3}$ mol

Any one ✓

$n(H_2O_2)$ used $= 2n(O_2)$ produced ✓

$= 2(5,179 \times 10^{-3})$

$= 0,010358$ mol

$n(H_2O_2)$ initial $= cV$

$= (0,2)(0,2)$ ✓

$= 0,04$ mol

$n(H_2O_2)$ when reaction stops $= n(H_2O_2)\text{initial} - n(H_2O_2)\text{used/reacted}$

$= 0,04 - 0,010358$ ✓✓

$= 0,029642$ mol

$c = \frac{n}{V}$ ✓

$c = \frac{0,029642}{0,2}$ ✓

$= 0,15\ mol\cdot dm^{-3}$ ✓ Range: 0,1482 to 0,15

OPTION 2:

$n(O_2)\text{produced} = \frac{V}{V_m}$ ✓

$= \frac{0,116}{22,4}$

$= 5,179 \times 10^{-3}$ mol

	$2H_2O_2$	$2H_2O$	O_2
R	2	2	1
I	0,04✓		0
C	-0,010358✓(Ratio)		$+5,179 \times 10^{-3}$✓
END	0,029642✓✓		$5,179 \times 10^{-3}$

$c = \frac{n}{V}$ ✓

$c = \frac{0,029642}{0,2}$ ✓

$= 0,15\ mol\cdot dm^{-3}$ ✓ Range: 0,1482 to 0,15 (9)

[16]

QUESTION 6

6.1.1 When the <u>rate of forward reaction equals the rate of reverse reaction</u>. ✓✓
OR when the amounts of reactants and products remain constant.

<u>Notes</u>
IF: Forward reaction equals reverse reaction. $\frac{1}{2}$ (2)

6.1.2 **<u>Marking criteria</u>*:***
- n(SO_3) equilibrium = 0,75✓
- Using the correct mol ratio✓
- Calculating the quantity(mol) at equilibrium of all three substances ✓
- Divide number of moles at equilibrium by 2 dm^3✓
- K_c expression✓
- Correct substitution of equilibrium concentrations into K_c expression ✓
- Kc = 0,36✓

	NO_2	SO_2	SO_3	NO	
Ratio	1	1	1	1	
Initial quantity (mol)	2	2	0	0	
Change (mol)	0,75	0,75	0,75	0,75	Using ratio ✓
Quantity at equilibrium (mol)	1,25	1.25	0,75 ✓	0,75	✓
Equilibrium concentration (mol·dm^{-3})	0,625	0,625	0,375	0,375	Divide by 2 ✓

$$K_c = \frac{[SO_3]\ [NO]}{[NO_2][SO_2]} \checkmark$$

$$\therefore \ = \frac{(0,375)(0,375)}{(0,625)(0,625)} \checkmark$$

$$= 0,36 \checkmark$$

No K_c expression, correct substitution: Max $\frac{6}{7}$
Round brackets used for Kc expression: Max 6/7

Wrong K_c expression: Max $\frac{5}{7}$

(7)

6.2.1 When the <u>equilibrium in a closed system is disturbed</u>, the system will <u>re-instate a new equilibrium</u> by favouring the reaction that will oppose the disturbance. ✓✓

<u>Marking criteria</u>*:*
If any one of the underlined key words/phrases in the correct context is omitted, deduct 1 mark. Phrases must be in correct context.

(2)

6.2.2 Decreased✓
Green implies forward reaction/ reaction that produces a larger number of molecules is favoured. ✓
According to LCP a decrease in pressure favours the reaction that produces a larger number of gas molecules / gas moles✓ (3)

6.2.3 Increases. ✓ (1)

6.2.4 <u>Increase concentration of reactants</u>✓ (by adding more) OR <u>decrease concentration of products</u> (by removing some) (1)
[16]

QUESTION 7

7.1.1 <u>Ionises completely in water</u> ✓to form a <u>high concentration of H_3O^+ ions</u>.✓
ACCEPT: <u>Ionises completely in water</u> ✓✓ (for 2023 Prep Exams). (2)

7.1.2 No✓
Does not ionise completely✓/ ionises partially/0,018 mol.dm^{-3} is less than 0,10 mol·dm^{-3} (2)

7.1.3 $K_w = [H_3O^+][OH] = 1 \times 10^{-14}$✓
$(0{,}018)[OH^-] = 1 \times 10^{-14}$✓
$[OH^-] = 5.56 \times 10^{-13}$ mol·dm^{-3}✓ (3)

7.2.1 Contains a small amount (number of moles) of acid in proportion to the volume of water / in a given volume of water. ✓✓ (2)

7.2.2 SMALLER THAN✓ (1)

7.2.3 **<u>Marking criteria</u>*:***
- Substitute in the formula pH = - log[H_3O^+]/[H_3O^+][OH^-] = 1×10^{-14}/ pOH = -log[OH^-]/pH + pOH =14 to calculate c(OH^-)excess ✓✓
- Substitute in the formula n = cV to calculate n(OH^-) in excess ✓
- Calculation of moles of OH^- reacted with H_2SO_4. (ratio as well as n(H_2SO4)) ✓
- Addition of excess moles to moles reacted of NaOH (total number of moles of NaOH)✓✓
- Substitution of molar mass (40) to calculate mass of NaOH✓
- Final answer 0,144 g. ✓

RANGE: 0,144 g TO 0,149 g

<u>NOTE:</u> If the calculation is done using a table, mark within the table using the criteria above.

pH = - log[H_3O^+]
12,56 = - log[H_3O^+] ✓
[H_3O^+] = 2,75 x 10^{-13} mol·dm^{-3}
[H_3O^+][OH^-] = 1 x 10^{-14}
2,75 x 10^{-13}[OH^-] = 1 x 10^{-14}✓
[OH^-] = 0,0363 mol·dm^{-3}

OR 14 - pH = -log[OH^-]
14 – 12,56 ✓= -log[OH^-]✓
[OH^-] = 0,0363 mol·dm^{-3}

n(OH^-)excess = cV

$$n(OH^-) = \frac{(0,0363)(37)}{1000}$$ ✓ **OR** (0,0363)(0,037)

= 1,3431 x 10^{-3} mols

n(OH^-)reacted with H_2SO_4 = 2n(H_2SO_4)
= cV

$$n(OH^-)\text{in } 25\ cm^3 = \frac{(2)(0,1)(12)}{1000}$$ ✓ **OR** (2)(0,1)(0,012)

= 2,4 x 10^{-3} mols

OR

n(H_2SO_4) = cxV = 0,1 x 0,012 = 0,0012

n(NaOH) = 2 x 0,0012 = 0,0024 moles
Initial n(NaOH) = 0,0024 + 0,0013 = 0,0037 moles

m(NaOH) = n(total)M
= (2,4 x 10^{-3} + 1,3431 x 10^{-3}) ✓✓ (40) ✓
= 0,149 (g)✓

OR

m(NaOH) = n(total)M
= (0,0024 + 0,0013) ✓ (40) ✓
= 0,144 (g)✓

(8)

[18]

QUESTION 8

8.1 Pressure of 101,3 kPa / 1 atm✓
Concentration of electrolytes: 1 mol·dm^{-3}✓ (2)

8.2 $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ ✓
$= 0,00$ ✓ $- (-0,27)$ ✓
$= 0,27 V$ ✓

Notes
- Accept any other correct formula from the data sheet.
- Any other formula using unconventional abbreviations, e.g. $E^{\circ}_{cell} = E^{\circ}_{OA} - E^{\circ}_{RA}$ followed by correct substitutions Max: $\frac{3}{4}$

(4)

8.3.1 From chemical to electrical✓ (1)

8.3.2 Maintain electrical neutrality (of the electrolytes)✓
Complete the circuit (any ONE) (1)

8.3.3 Towards the nickel half cell✓ (1)

8.3.4 $Ni \rightarrow Ni^{2+} + 2e^-$ ✓✓ (Ignore phases)

Notes
- $Ni^{2+} + 2e^- \leftarrow Ni$ $(\frac{2}{2})$ $Ni \rightleftharpoons Ni^{2+} + 2e^-$ $(\frac{1}{2})$
  $Ni^{2+} + 2e^- \rightleftharpoons Ni$ $(\frac{0}{2})$ $Ni \leftarrow Ni^{2+} + 2e^-$ $(\frac{0}{2})$
- Ignore if charge on electron omitted.
  If a charge of an ion is omitted eg. $Ni \rightarrow Ni + 2e^-$ Max: $(\frac{1}{2})$

(2)

8.4. Increases✓
H^+ ions are reduced to H_2✓
Concentration of H^+ ions decreases✓ (3)

8.5 No effect✓ (1)
[15]

QUESTION 9

9.1
- The chemical process in which electrical energy is converted to chemical energy. ✓✓ (2 or 0) **OR**
- The use of electrical energy to produce a chemical change **OR**
- The process during which an electric current passes through a solution/molten ionic compound.

(2)

9.2 T ✓ Reduction takes place (at the cathode) / It is the negative electrode / R is the electrode that is impure Cu.✓
<u>ACCEPT</u>: So that the Cu forms on pure Cu.

(2)

9.3 $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ ✓✓
Ignore phases

<u>Notes</u>

- $Cu \leftarrow Cu^{2+} + 2e^-$ $\left(\frac{0}{2}\right)$ $Cu^{2+} + 2e^- \rightleftharpoons Cu$ $\left(\frac{0}{2}\right)$
  $Cu^{2+} + 2e^- \leftarrow Cu$ $\left(\frac{2}{2}\right)$ $Cu \rightleftharpoons Cu^{2+} + 2e^-$ $\left(\frac{1}{2}\right)$
- Ignore if charge on electron omitted.
- If a charge of an ion is omitted eg. $Cu + 2e^- \leftarrow Cu$ Max: $\left(\frac{1}{2}\right)$

(2)

9.4 REMAINS THE SAME✓
The <u>rate at which</u> <u>Cu is oxidised to Cu^{2+}</u> at the anode is equal to the <u>rate at which the Cu^{2+} is reduced</u> at the cathode ✓ (2)

9.5 No✓
<u>Zn^{2+} is a weaker oxidising agent than Cu^{2+}</u>✓ and <u>will not be reduced</u>. ✓ (3)

9.6 **Marking criteria:**

- Substitute in the formula: $n = \frac{m}{M}$ to calculate number of moles of Cu. ✓
- Ratio of number of mols of e to number of moles of Cu: 2 : 1✓
- Substitute in the formula $N = nN_A$ to calculate number of electrons✓
- Substitute in $Q = nq_e$ to calculate total charge✓
- Substitute in $Q = I\Delta t$✓
- Final answer 2,89 A✓

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

$$: \ n = \frac{1{,}72}{63{,}5} \checkmark$$

$$n(e) = 2\left(\frac{1{,}72}{63{,}5}\right) \checkmark$$

$$= 0{,}054 \text{ mol}$$

$$N(e) = nN_A$$
$$= \underline{0{,}054 \times 6{,}02 \times 10^{23}} \checkmark$$
$$= 3{,}2508 \times 10^{22}$$

$$Q = Nq_e$$
$$= \underline{(3{,}2508 \times 10^{22})(1{,}6 \times 10^{-19})} \checkmark$$
$$= 5201{,}28 \text{ C}$$

$$Q = I\Delta t$$
$$\underline{5201{,}28 = I(1800)} \checkmark$$
$$I = 2{,}89 \text{ A} \checkmark$$

(6)

[17]

TOTAL: 150