LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES
PAPER 2 (CHEMISTRY)

SEPTEMBER 2023

MARKS: 150

TIME: 3 hours

EPHSCP2

This question paper consists of 20 pages including DATA SHEETS

INSTRUCTIONS AND INFORMATION

1. The question paper consists of nine questions. Answer ALL the questions.
2. Start EACH question on a NEW page.
3. Number your answers correctly according to the numbering system used in this question paper.
4. Leave ONE line between two sub-questions, e.g., between QUESTION 2.1 and QUESTION 2.2.
5. A non-programmable calculator may be used.
6. Appropriate mathematical instruments may be used.
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

Four 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), for example 1.10 E

1.1 Which ONE of the following pairs represents compounds that are isomers?

A. $CHCl_3$ and $CHBr_3$

B. CH_3OH and CH_3CH_2OH

C. $CH_3 - CH = CH_2$ and $CH_2 = CH - CH_3$

D. CH_3COOCH_3 and CH_3CH_2COOH (2)

1.2 Which ONE of the following organic reactions will take place only when exposed to light?

A. $CH_2CH_2 + H_2 \rightarrow CH_3CH_3$

B. $CH_3CH_3 \rightarrow CH_2CH_2 + H_2$

C. $CH_3CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + HCl$

D. $CH_2CH_2 + Cl_2 \rightarrow CH_2ClCH_2Cl$ (2)

1.3 What is the name of the reaction between an unsaturated hydrocarbon and hydrogen gas?

A. halogenation

B. hydrogenation

C. dehydrohalogenation

D. hydration (2)

1.4 When an alkane, containing ***n*** carbons, undergoes combustion in excess oxygen, the mole ratio of the combusted products, $\boldsymbol{CO_2 : H_2O}$, will be equal to:

A. $n : n$

B. $n : n + 2$

C. $n : n + 1$

D. $n : 2n$ (2)

1.5 Ammonia gas $NH_3(g)$ and oxygen gas, O_2, react in a closed container at a constant temperature according to the following equation below.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad (\Delta H < 0)$$

Which ONE of the combinations of pressure and temperature will result in an increase in the yield of nitrogen monoxide NO(g)?

	Pressure	**Temperature**
A.	decrease	decrease
B.	decrease	increase
C.	increase	increase
D.	increase	decrease

(2)

1.6 Dinitrogen tetra oxide,$N_2O_4(g)$ decomposes to produce nitogen dioxide, $NO_2(g)$, in a closed container according to the following balanced equation:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \quad \Delta H = -xkJ$$

Consider the following statements regarding this equation:

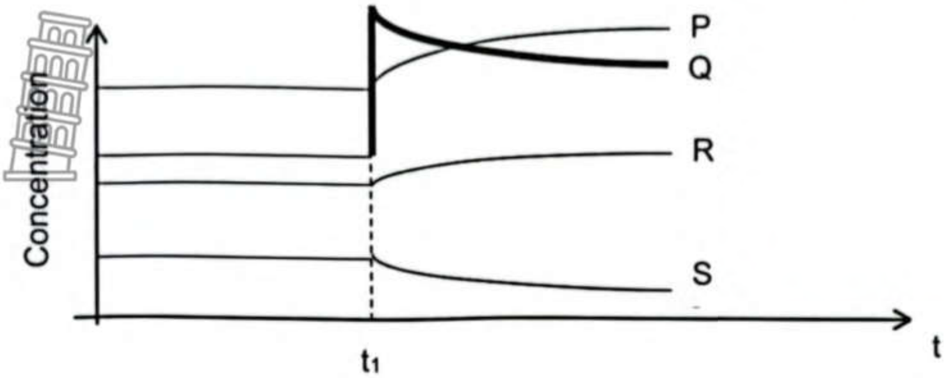
(i): The forward reaction is endothermic.
(ii): The temperature of the container decreases.
(iii): For each mole of $NO_2(g)$ which is formed, xkJ of energy is released

Which ONE of the following statements are/is true about this reaction?

A. (i) only
B. (i) and (ii) only
C. (ii) and (iii) only
D. (i), (ii) and (iii)

(2)

1.7 Four gases, ***P***, ***Q***, ***R***, and ***S*** are in equilibrium in a closed container. The diagram below shows their relative concentrations over a period of time. The equilibrium position is altered at t_1 by the addition of more of gas ***Q***.



The equilibrium reaction is shown by:

A. $P + Q \leftrightarrows R + S$

B. $Q + S \leftrightarrows P + R$

C. $P + S \leftrightarrows Q + R$

D. $Q \leftrightarrows P + R + S$ (2)

1.8 The ionisation constant,Kw, for pure water at 25°C is:

A. 14

B. 7

C. 1×10^{-7}

D. 1×10^{-14} (2)

1.9 The electrode potential of the Ag^+/Ag-electrode is determined with the aid of a standard H^+/H_2, Pt-electrode as reference electrode. The equation for the half-reaction which occurs at the ANODE of this cell, is:

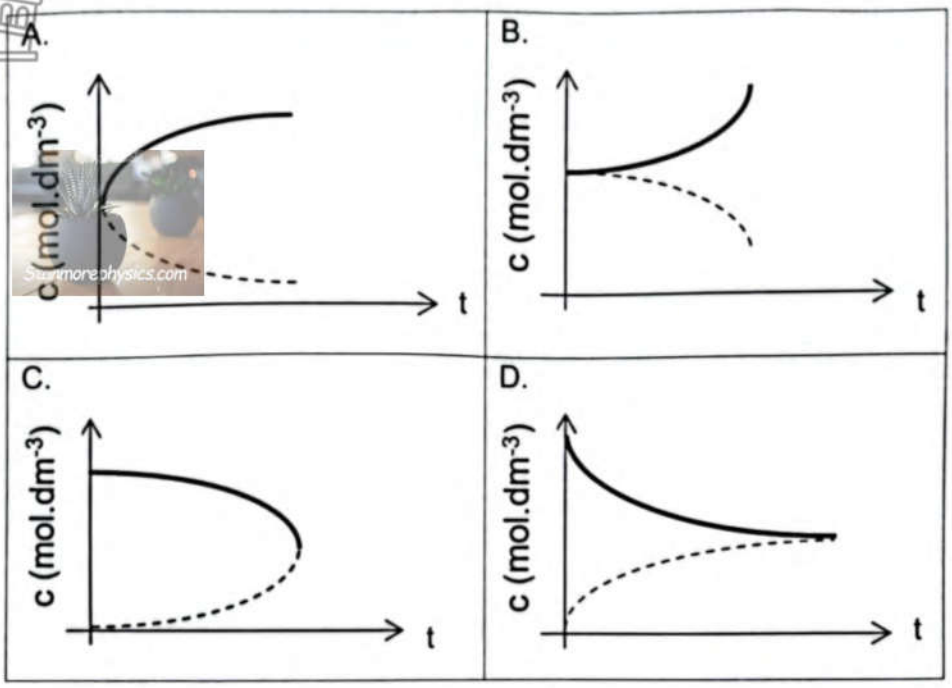
A. $Ag \rightarrow Ag^+ + e^-$

B. $Ag^+ + e^- \rightarrow Ag$

C. $H_2 \rightarrow 2H^+ + 2e^-$

D. $2H^+ + 2e^- \rightarrow H_2$ (2)

1.10 An electrochemical cell, consisting of two standard half cells, is allowed to deliver current for a period. Which one of the following combinations best represents the change in CONCENTRATION of the two electrolytes over the period.

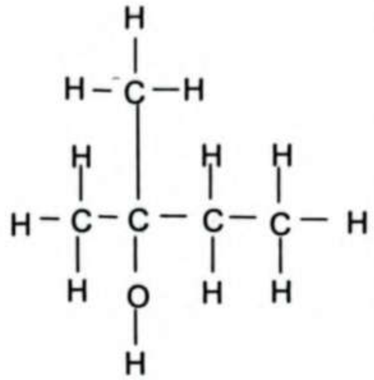
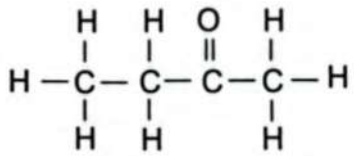


(2)

[20]

QUESTION 2 (Start on a new page.)

The table below shows six organic molecules A to F

A. butane	**B.** $CH_3\text{-}CH_2\text{-}OH$
C. CH_3COOH	**D.** 
E. methanal	**F.** 

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

2.2 Write down the:

2.2.1 Structural formula of compound **C** (2)

2.2.2 IUPAC name of compound **D** (3)

2.2.3 Homologous series to which **F** belongs (1)

2.2.4 Structural formula of the functional group of **E** (1)

2.3 For compound **A**, write down:

2.3.1 The general formula. (1)

2.3.2 The balanced equation for the oxidation reaction. (3)

2.4 Compound **B** reacts with another organic compound from the table to form an ester.

2.4.1 Write down the LETTER of the other organic compound that reacts with **B**. (1)

2.4.2 Write down the NAME of the ester that forms. (2)
[16]

QUESTION 3 (Start on a new page.)

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

	Organic compound	Boiling point (°C)
A	propane	-42
B	pentane	36
C	2-methylbutane	27,8
D	pentan-1-ol	137

3.1 Define the term *vapour pressure*. (2)

3.2 Which ONE of the compounds **A** or **B** has the higher vapour pressure? (1)

3.3 Consider compound **C.**

3.3.1 Is compound **C** a SATURATED or UNSATURATED hydrocarbon? (1)

3.3.2 Give a reason for your answer in QUESTION 3.3.1. (1)

3.3.3 Which type of intermolecular forces are mainly present between these molecules? (1)

3.4 **Compounds B** and **C** are structural isomers of each other.

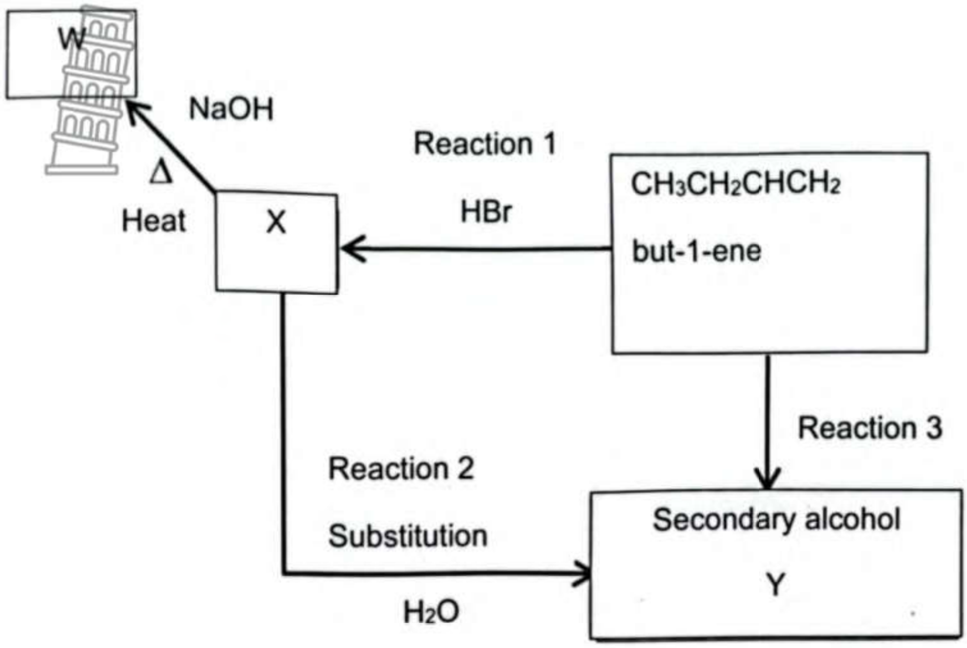
3.4.1 Define the term *structural isomer*. (2)

3.4.2 Refer to structure, intermolecular forces, and energy in your explanation to explain why B has a higher boiling point than C (3)

3.5 Explain the difference in the boiling points of **B** and **D**. Refer to intermolecular forces and energy in your explanation. (4)
[15]

QUESTION 4 (Start on a new page.)

The flow chart below shows the preparation of various organic compounds using but-1-ene as starting material.



4.1 Using STRUCTURAL formulas, write down a balanced chemical equation for Reaction 1 (4)

Write down the:

4.2. Name of the type of the reaction that occurs when but-1-ene is converted to compound X (1)

4.3 Write the structural formula and IUPAC name of the secondary alcohol, **Y**, that forms. (3)

4.4 Name the type of substitution reaction that occurs when compound X is converted to the secondary alcohol **Y** (1)

4.5 But-1-ene can be converted directly to the secondary alcohol, without the formation of the intermediate product **X**, with the help of a catalyst.

4.5.1 Except but-1-ene, write the NAME of the reactant needed for this reaction. (1)

4.5.2 Write down the FORMULA of the catalyst that can be used. (1)

4.5.3 Name the type of reaction that will occur during this direct conversion. (1)

4.6 Instead of using water as a reactant in reaction 2 , concentrated sodium hydroxide is used, and the mixture is heated.

4.6.1 Write down the IUPAC name of the compound **W** that forms. (1)

4.6.2 Name the TYPE of reaction that occurs. (1)

[14]

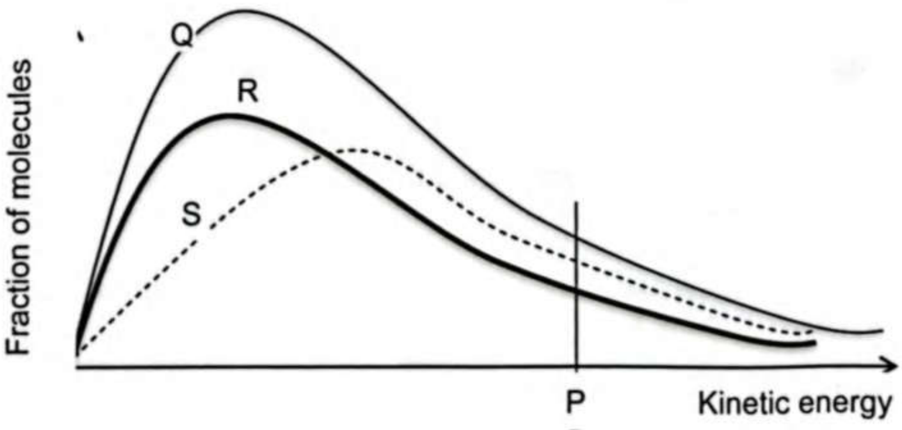
QUESTION 5 (Start on a new page.)

5.1 The collision theory can be used to explain how different factors affect the rate of a chemical reaction.

5.1.1 Name TWO conditions that determine whether a collision between two molecules will lead to a chemical reaction. (2)

5.1.2 In terms of the collision theory, explain why the rate of a chemical reaction increases with increasing temperature. (2)

5.2 Curve **R** represents the Maxwell-Boltzman distribution curve for gas in a closed container at a certain temperature. Curve Q and S represents the curves of the same molecules at different conditions.



5.2.1 Write down the NAME of the energy represented by **P**. (1)

5.2.2 Write down the change in the condition(s) which results in:

(a) Curve Q (1)

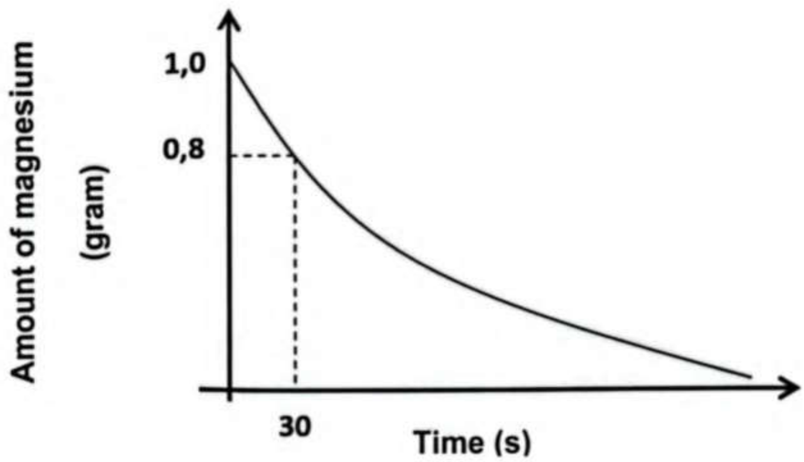
(b) Curve S (1)

5.3 A teacher uses the reaction between magnesium ribbon, Mg(s) and nitric acid, HNO_3 (aq), to investigate ONE of the factors that influence reaction rate. The balanced equation of the reaction between Mg(s) and HNO_3 (aq) is given below.

$$Mg(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2(g)$$

5.3.1 Write down an investigative question for this investigation. (3)

The results obtained when using DILUTED nitric acid are shown on the graph below.



5.3.2 Which compound, Mg or HNO_3, is in excess, and give a reason for your answer using the information on the graph. (2)

5.3.3 Calculate the average reaction rate (in grams per second) during the first 30 s. (5)

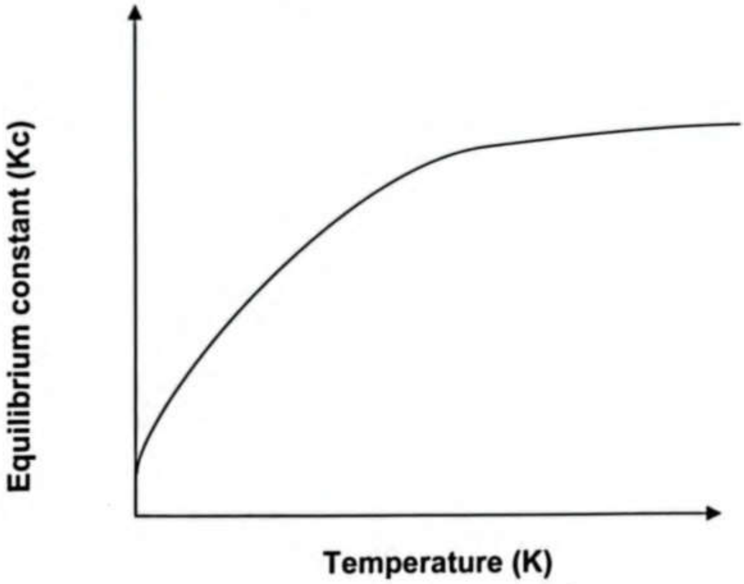
5.3.4 Copy the above graph in your answer book.
On the same set of axes, use a **DOTTED LINE** to show the curve that will be obtained when CONCENTRATED nitric acid was used.
No numerical values are required. (2)

[19]

QUESTION 6 (Start on a new page.)

6.1 The graph below shows the effect of the temperature on the value of K_c for the following reaction taking place in a closed container.

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



6.1.1 Write down the effect of increasing temperature has on the amount of NO_2 (g) formed. (1)

6.1.2 Which reaction was favoured due to an increase in temperature? Write only FORWARD or REVERSE. (1)

6.1.3 State Le Chatelier's Principle. (2)

6.1.4 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Explain your answer. (4)

6.1.5 Write down TWO changes, that can be introduced to decrease the rate of the forward reaction (2)

6.2 1 mol SO_2 (g) and x mole O_2 (g) is initially placed in an empty 2dm^3 container and sealed at a specific temperature. At equilibrium 6 mole SO_3 (g) was present in the container. If the value for the following equilibrium at this temperature is 9, calculate x, the initial quantity O_2 (g) that was placed in the container. (6)

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$ [16]

QUESTION 7 (Start on a new page.)

7.1 Define an acid according to Bronsted and Lowry (2)

7.2 Explain the difference between a WEAK ACID and a DILUTE ACID. (2)

7.3 When 500 cm^3 of sodium hydroxide solution, $NaOH(aq)$ is added to 500 cm^3 of 0,25 $mol\ dm^{-3}$ of hydrochloric acid solution $HCl(aq)$, the temperature rises and the pH of the solution changes to 2,3. The reaction between $NaOH(aq)$ and $HCl\ (aq)$ is as follows:

$$NaOH(aq) + HCl\ (aq) \rightarrow NaCl(aq) + H_2O\ (l)$$

7.3.1 Is the reaction between $NaOH\ (aq)$ and $HCl\ (aq)$ EXOTHERMIC or ENDOTHERMIC? (1)

Calculate the:

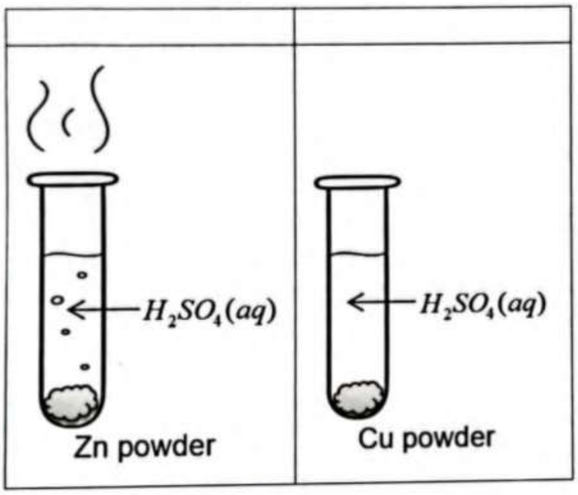
7.3.2 Final concentration of the hydronium ions, $H_3O^+(aq)$ ions. (3)

7.3.3 Initial concentration of the $NaOH\ (aq)$ solution in $500cm^3$ (8)

[16]

QUESTION 8 (Start on a new page.)

An investigation to compare the relative reducing ability of copper, Cu(s) and zinc, Zn (s) is carried out. The two metals are reacted with dilute sulphuric acid and the experiment set up as shown below.



8.1 In test tube A, bubbles of gas are observed whilst in test tube B no bubbles are observed.

8.1.1 Write down the name of the gas produced in test tube A (1)

8.1.2 Refer to the relative reducing abilities of Cu and Zn to explain why no bubbles of gas are produced in test tube B (3)

8.1.3 Use the STANDARD REDUCTION POTENTIAL TABLE to write down a balanced equation of the reaction which takes place in test tube A (3)

8.2 An electrochemical cell is set up using a redox reaction given below.

$$Mg(s) + 2AgNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + 2Ag(s)$$

8.2.1 Write the cell notation of this cell. (3)

8.2.2 Write down the conditions needed for the cell to operate under standard conditions. (2)

8.2.3 Calculate the initial emf of the cell under standard conditions (4)

This cell is now connected to a light bulb which is marked 3 V; 6 W. In theory, the bulb should glow, but in practice it doesn't.

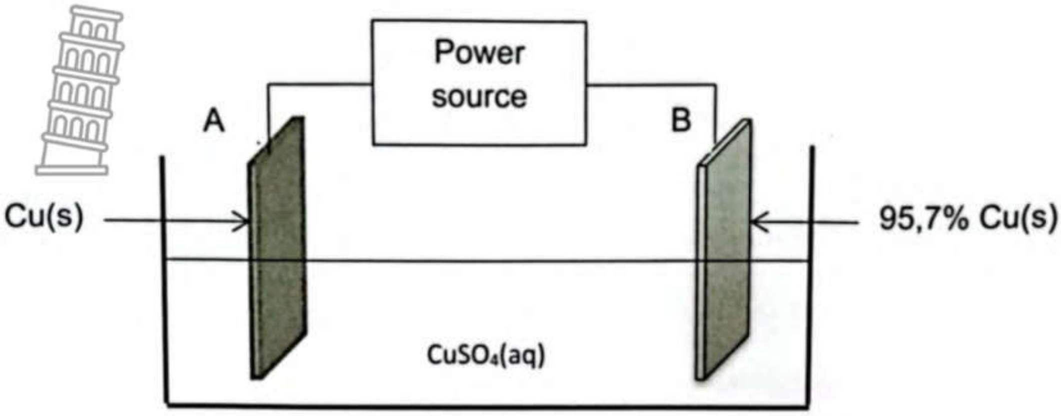
8.2.4 Without any calculation, give an explanation for this. (1)

The volume of the electrolyte in each standard half-cell is 0,4 dm^3.

8.2.5 Calculate the maximum loss of mass that can occur at the anode. (6)
[23]

QUESTION 9 (Start on a new page.)

The electrolytic cell shown below is used to purify IMPURE copper.
Copper sulphate solution, $CuSO_4(aq)$, is used as the electrolyte. Electrode B contains 95,7% Cu by mass.



9.1 Is electrode A, the POSITIVE or NEGATIVE electrode? (1)

9.2 Pure copper is used to make electrical wires. Give one reason why the copper must be purified first before it is used in electrical wires. (2)

9.3 Will the mass of electrode **B** INCREASE or DECREASE when the cell is operating?
Write down the relevant half-reaction to support your answer. (3)

9.4 If 2 moles of electrons are transferred from the anode to the cathode during electrolysis, calculate the mass of the IMPURE copper sample. (5)

[11]

TOTAL: 150

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
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$	+ 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
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^- \rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^- \rightleftharpoons Hg(l)$	+ 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
$Al^{3+} + 3e^- \rightleftharpoons Al$	− 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 oxidising ability/*Toenemende oksiderende vermoë* ↑

Increasing reducing ability/*Toenemende reduserende vermoë* ↓

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

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TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIESE KONSTANTES

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Avogadro's constant *Avogadro-konstante*	N_A	$6,02 \times 10^{23}$ mol^{-1}
Charge on electron *Lading op elektron*	e	$-1,6 \times 10^{-19}$ C
Electron mass *Elektronmassa*	m_e	$9,11 \times 10^{-31}$ kg
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22,4$ $dm^3 \cdot mol^{-1}$
Standard pressure *Standaarddruk*	p^θ	$1,013 \times 10^5$ Pa
Standard temperature *Standaardtemperatuur*	T^θ	273 K

TABLE 2: FORMULAE/TABEL 2: FORMULES

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$K_W = [H_3O^+][OH^-] = 1 \times 10^{-14}$ *at / by* 298 K pH= $-\log[H_3O^+]$	
$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode} / E^\theta_{sel} = E^\theta_{katode} - E^\theta_{anode}$ *or / of* $E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation} / E^\theta_{sel} = E^\theta_{reduksie} - E^\theta_{oksidasie}$ *or / of* $E^\theta_{cell} = E^\theta_{oxidising\ agent} - E^\theta_{redusing\ agent} / E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	