education

Department of Education
FREE STATE PROVINCE

PREPARATORY EXAMINATION

GRADE 12

PHYSICAL SCIENCES P2 (CHEMISTRY)



SEPTEMBER 2024

MARKS: 150

TIME: 3 HOURS

This question paper consists of 13 pages and 4 data sheets.

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INSTRUCTIONS AND INFORMATION

1. Write your name and other applicable information in the appropriate spaces on the ANSWER BOOK.
2. The 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 3.1 and QUESTION 3.2.
6. You may use a non-programmable pocket calculator.
7. You may use appropriate mathematical instruments.
8. Show ALL formulae and substitutions in ALL calculations.
9. Round off your FINAL numerical answers to a minimum of TWO decimal places where necessary.
10. Give brief motivations, discussions, etc. where required.
11. You are advised to use the attached DATA SHEETS.
12. Write neatly and legibly.

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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 your ANSWER BOOK, for example, 1.11 E.

1.1 The condensed structural formula of an organic molecule is given as:

$$CH_3CH(CH_3)CH_2CH_3$$

The molecule is …

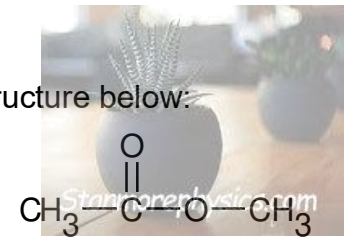
A unsaturated.

B saturated.

C a straight alkane.

D a straight alkene. (2)

1.2 Consider the organic structure below:



The IUPAC name of its FUNCTIONAL ISOMER is …

A methyl ethanoate.

B propanoic acid.

C ethyl methanoate.

D ethanoic acid. (2)

1.3 Consider the following organic molecule:

$$CH(CH_3)_2CH_2CH(CH_3)CH_3$$

The correct IUPAC name is …

A 1,1,4-trimethylbutane.

B 2-methyl-3,3-dimethylbutane.

C 2,4-dimethylpentane.

D 2,2,4-trimethylpentane. (2)

1.4 While a chemical reaction takes place, the rate of the reaction …

A remains the same.

B decreases because the concentration of products decreases.

C increases because the concentration of reactants increases.

D decreases because the concentration of reactants decreases. (2)

1.5 Consider the following **hypothetical** reaction:

$$A_2 + B \rightleftharpoons A_2B \qquad \Delta H < 0$$

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The activation energy (E_A) for this reaction is 100 kJ·mol^{-1}.

For the reverse reaction …

A E_A is equal to 100 kJ·mol^{-1}.

B E_A is greater than 100 kJ·mol^{-1}.

C E_A is less than 100 kJ·mol^{-1}.

D E_A and ΔH are equal. (2)

1.6 Write down the conjugate base of $HC\ell O_4$.

A $HClO_3^-$

B $HClO_4^-$

C ClO_4^-

D $H_2C\ell O_4$ (2)

1.7 A solution of sodium hydroxide …

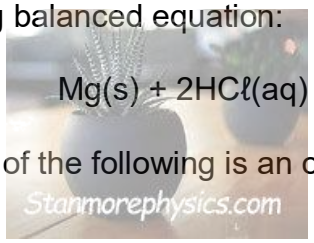
A turns bromothymol blue to yellow.

B is acidic.

C turns phenolphthalein to colourless.

D is basic. (2)

1.8 A piece of magnesium ribbon reacts with excess hydrochloric acid according to the following balanced equation:



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

Which ONE of the following is an oxidising agent?

A $C\ell^-$

B Mg^{2+}

C H^+

D H_2 (2)

1.9 In a galvanic cell the salt bridge …

A is responsible for the charge balance to be maintained in the cell.

B allows for the movement of electrons from one half-cell to the other.

C allows the mixing of the two solutions from different half-cells.

D is not necessary for the optimal functioning of the cell. (2)

1.10 What is the energy conversion in an electrolytic cell?

A Electrical to chemical

B Chemical to electrical

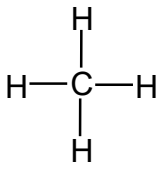
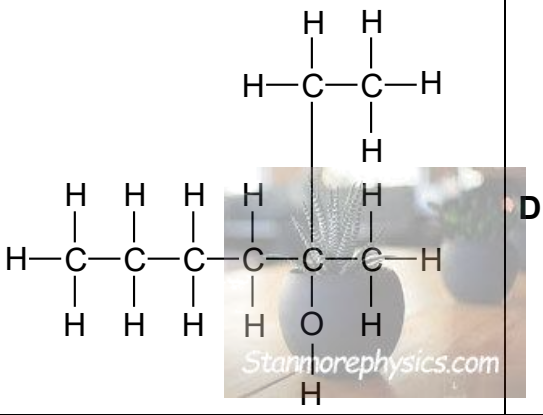
C Electrical to mechanical

D Chemical to mechanical (2)

[20]

QUESTION 2 (Start on a new page.)

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

A		**B**	Propyl ethanoate
C		**D**	Propanal
E	3,3-difloro-2-methylpentane		

2.1 Write down the letter(s) representing:

2.1.1 A compound with the general formula C_nH_{2n+2} (1)

2.1.2 A haloalkane (1)

2.1.3 A functional isomer of a ketone (1)

2.2 For compound **C**, write down the:

2.2.1 The type of alcohol it is, and give a reason for the answer. (2)

2.2.2 IUPAC name (3)

2.2.3 Name of its functional group (1)

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

2.3.1 Structural formulae of the TWO organic compounds it is formed from (4)

2.3.2 Structural formula of the functional group of its functional isomer (1)

2.4 Write down the structural formula of Compound **E.** (3)

2.5 Compound **A** undergoes complete combustion according to the following balanced equation:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

During the combustion, 2,75 kg of carbon dioxide is formed. Calculate the mass of CH_4 needed for this reaction. (5)
[22]

QUESTION 3 (Start on a new page.)

The boiling points of four organic compounds at a specific pressure are compared.

	COMPOUND	BOILING POINT (°C)
A	Pentane	36
B	2-methylbutane	28
C	2,2-dimethylpropane	10
D	Pentanal	103
E	Butanoic acid	…

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

3.2 Consider compounds **A** to **C**.

3.2.1 Fully explain the trend in boiling points from compound **A** to **C**. (4)

3.2.2 Which compound will have the highest vapour pressure? (1)

3.2.3 Explain your answer to QUESTION 3.2.2. (1)

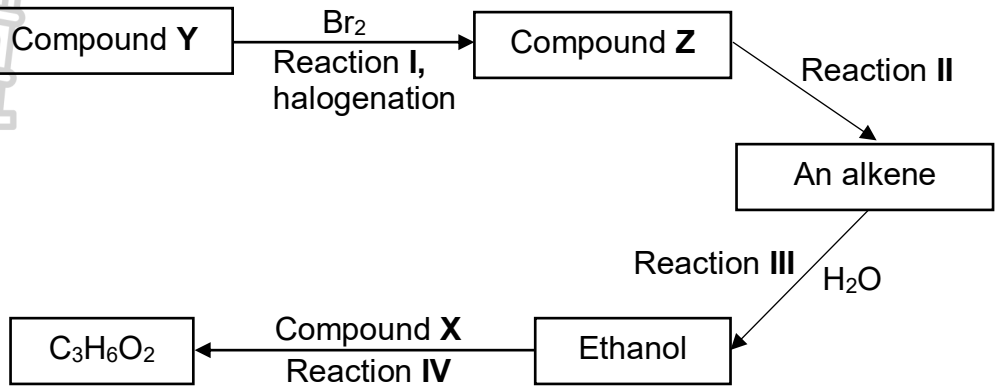
3.3 Compounds **D** and **E** are compared. Is the boiling point of compound **E** GREATER THAN, SMALLER THAN or EQUAL TO 103°C? Fully explain the answer. (4)

3.4 Is the comparison in QUESTION 3.3 fair? (1)

3.5 Explain the answer to QUESTION 3.4. (1)
[14]

QUESTION 4 (Start on a new page.)

The flow diagram below shows the steps in the preparation of an alcohol from compound **Y,** which is a SATURATED HYDROCARBON.



4.1 Explain the term *halogenation*. (2)

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

4.2.1 ONE reaction condition (1)

4.2.2 The formula of the inorganic product (1)

4.3 For **reaction II**, write down the balanced equation using CONDENSED STRUCTURAL FORMULAE. (5)

4.4 Write down the name of **reaction III.** (1)

In **reaction IV**, $C_3H_6O_2$ is formed when ethanol reacts with compound **X**.

4.5 Write down the IUPAC name of compound **X**. (2)

4.6 Write down the name of **reaction IV.** (1)

4.7 Using STRUCTURAL FORMULAE, write down the balanced equation for this reaction. (4)
[17]

QUESTION 5 (Start on a new page.)

Grade 12 learners use a reaction of $CaCO_3$ with EXCESS HCℓ to investigate the relationship between concentration and rate of reaction. The balanced equation for the reaction is:

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

They conduct the experiment twice, each with a different concentration of HCℓ. A decrease in the mass of the flask and the content is represented in the table below.

EXPERIMENT	**TIME(s)**	0	30	60	90	120	150	180
1	Mass of flask and contents (g)	270	268,4	267,4	266,75	266,3	266	266
2	Mass of flask and contents (g)	270	269	268,4	268,1	268	268	268

5.1 Write down the name of the apparatus used for measuring the mass. (1)

5.2 Write down the NAME of the limiting reagent. (1)

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

5.4 For **experiment 1**, calculate the rate of reaction in $mol \cdot s^{-1}$ in the first 30 s. (5)

5.5 In which experiment did the learner use a higher concentration of HCℓ? (1)

5.6 Use the collision theory to explain the answer to QUESTION 5.5. (3)

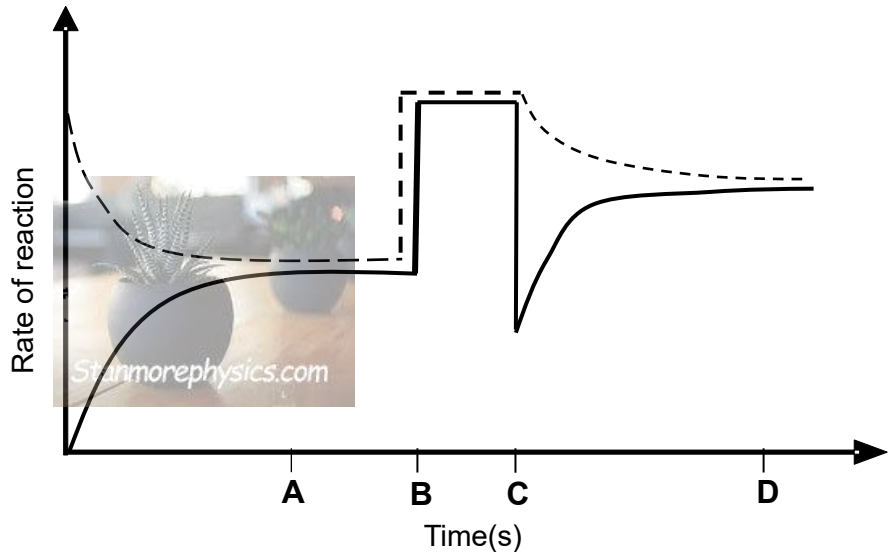
[13]

QUESTION 6 (Start on a new page.)

6.1 Ammonia gas is produced by pouring nitrogen gas and hydrogen gas in an empty container and allowed to react in a closed container according to the following balanced equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The graph of the rate of forward and reverse reactions is indicated below.



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

6.1.2 Identify the change made at time **B**. (2)

6.1.3 There was a temperature change at time **C,** while the pressure was kept constant.

(a) How did the temperature change? Write down only INCREASED or DECREASED. (1)

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

(c) Use Le Chatelier's principle to explain the answer to QUESTION 6.1.3 (b). (2)

6.2 The decomposition reaction of nitrosyl chloride (NOCℓ) is represented below:

$$2NOC\ell(g) \rightleftharpoons 2NO(g) + C\ell_2(g)$$

At a temperature of 50°C, 4 mol of NOCℓ is placed in a 2 dm^3 container. At equilibrium, it was found that 0,9 $mol \cdot dm^{-3}$ of NO was formed.

6.2.1 Define the term *reversible reaction*. (1)

6.2.2 Calculate the value of K_C at 50°C. (7)

[16]

QUESTION 7 (Start on a new page.)

7.1 According to the balanced equation below, A dilute solution of HCℓ is used in titration against an ammonia solution.

$$HC\ell(aq) + NH_3(aq) \rightarrow NH_4C\ell(aq)$$

7.1.1 Define the term *hydrolysis*. (2)

7.1.2 Will the final solution be ACIDIC or BASIC? (1)

7.1.3 Write down a balanced chemical equation that explains the answer to QUESTION 7.1.2. (3)

7.2 For the above titration, 25 cm^3 of a 0,1 $mol \cdot dm^{-3}$ NH_3 solution is titrated against 40 cm^3 HCℓ solution.

7.2.1 Is HCℓ a STRONG or a WEAK acid? (1)

7.2.2 Explain the answer to QUESTION 7.2.1. (2)

7.2.3 Write down the name of the indicator that is most suitable for this reaction. (1)

7.2.4 Explain your choice of indicator. (2)

7.2.5 Calculate the number of moles of NH_3 in 25 cm^3 of the ammonia. (3)

7.2.6 Calculate the pH of the final solution if the concentration of the original HCℓ was 0,1 $mol \cdot dm^{-3}$. (8)

[23]

QUESTION 8 (Start on a new page.)

The following balanced chemical equation represents a reaction taking place when a galvanic cell is in operation under STANDARD CONDITIONS. The initial reading on the voltmeter is 0,14V.

$$6C\ell^-(aq) + 2Au^{3+}(aq) \rightarrow 3C\ell_2(g) + 2Au(s)$$

8.1 Write down TWO standard conditions under which it operates. (2)

8.2 For this cell, write down the:

8.2.1 Name or formula of the electrolyte that can be used in the salt bridge (2)

8.2.2 Reducing agent (1)

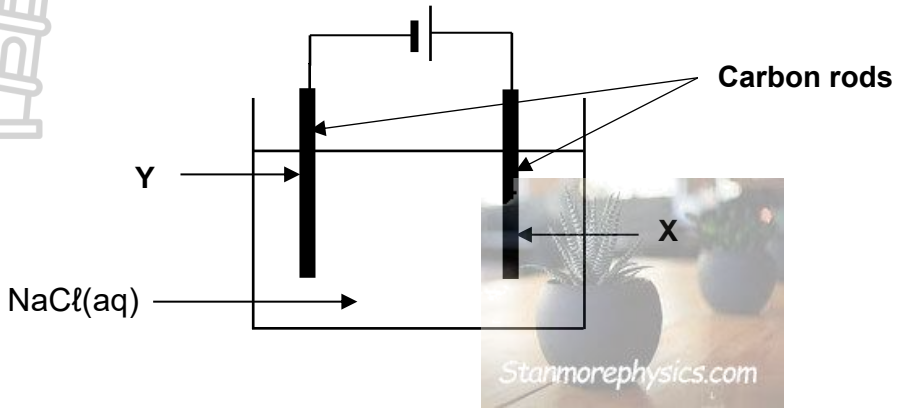
8.2.3 Cell notation (3)

8.3 Calculate the standard reduction potential of Au. (4)

[12]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents the electrolysis of a concentrated sodium chloride solution.



The balanced equation for the reaction taking place in the above cell is:

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

9.1 Define the term *electrolysis*. (2)

9.2 Which electrode is the anode? Write down only **X** or **Y**. (1)

9.3 Write down the half-reaction that takes place at:

9.3.1 Electrode **X** (2)

9.3.2 Electrode **Y** (2)

9.4 A current of 0,5 A is applied over a period of 5 hours. Calculate the volume of chlorine gas at STP that is formed during this time. (6)

[13]

TOTAL: 150

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DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

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VRAESTEL 2 (CHEMIE)

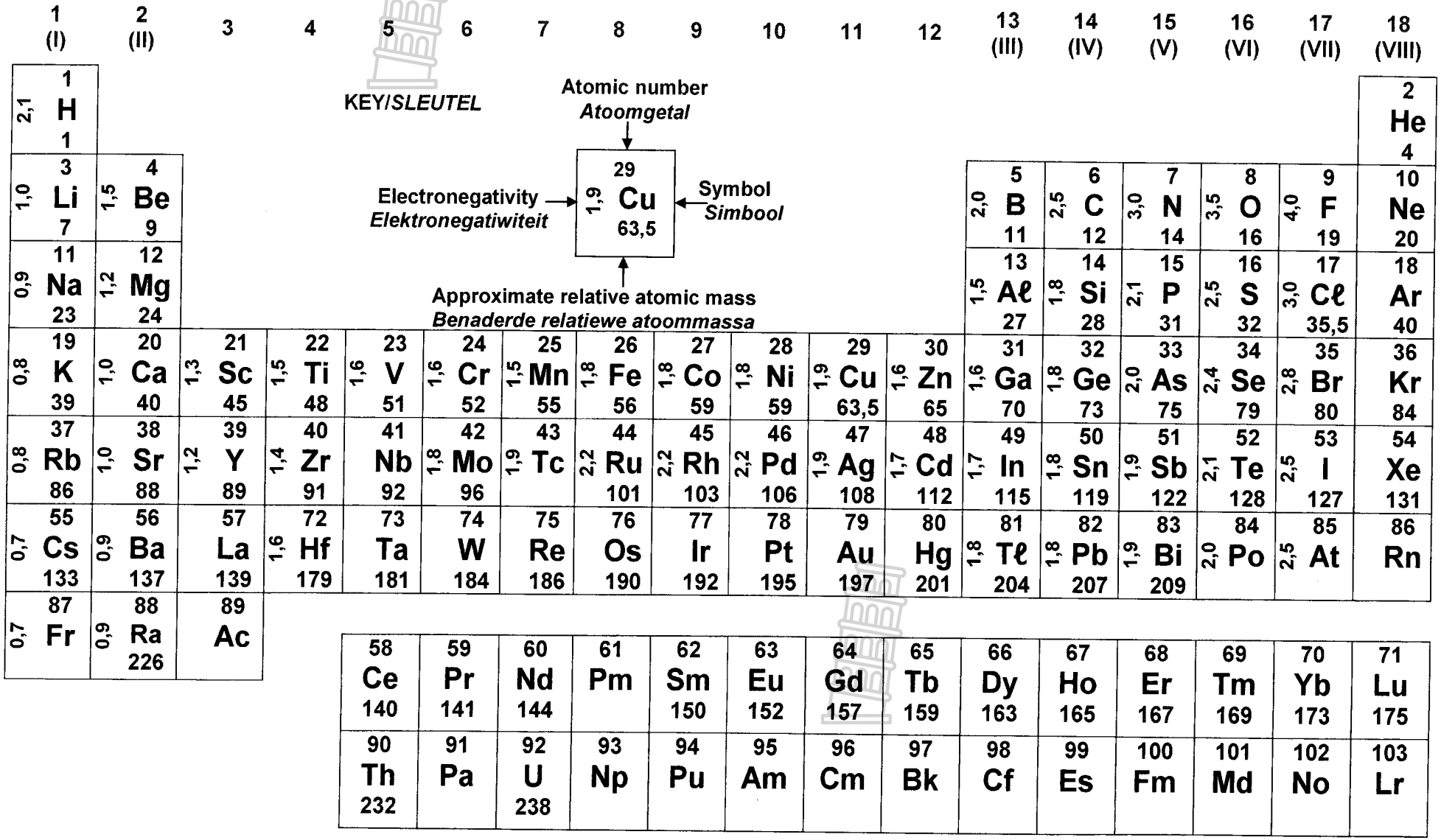
TABLE 1: PHYSICAL CONSTANTS / *TABEL 1: FISIESE KONSTANTES*

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*	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ *OR* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ *OR* $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{redusing\ agent}$	$E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ *OF* $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ *OF* $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$
$I = \frac{Q}{\Delta t}$	$n = \frac{Q}{q_e}$ where n is the number of electrons waar n die aantal elektrone is

TABLE 3: THE PERIODIC TABLE OF ELEMENTS



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

Half-reactions / *Halfreaksies*	E^{θ} (V)
$F_2(g) + 2e^- \rightleftharpoons 2F^-$	+ 2,87
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	+ 1,81
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^- \rightleftharpoons 2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^- \rightleftharpoons Pt$	+ 1,20
$Br_2(\ell) + 2e^- \rightleftharpoons 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^- \rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^- \rightleftharpoons Hg(\ell)$	+ 0,85
$Ag^+ + e^- \rightleftharpoons Ag$	+ 0,80
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+ 0,77
$O_2(g) + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+ 0,68
$I_2 + 2e^- \rightleftharpoons 2I^-$	+ 0,54
$Cu^+ + e^- \rightleftharpoons Cu$	+ 0,52
$SO_2 + 4H^+ + 4e^- \rightleftharpoons S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^- \rightleftharpoons 4OH^-$	+ 0,40
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+ 0,16
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+ 0,15
$S + 2H^+ + 2e^- \rightleftharpoons H_2S(g)$	+ 0,14
$2H^+ + 2e^- \rightleftharpoons H_2(g)$	**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 oxidising ability / *Toenemende oksiderende vermoë*

Increasing reducing ability / *Toenemende reduserende vermoë*

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

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

Increasing oxidising ability / *Toenemende oksiderende vermoë* ↓

Increasing reducing ability / *Toenemende reduserende vermoë* ↑

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