education

Department of Education
FREE STATE PROVINCE

EXAMINATION

GRADE 12

PHYSICAL SCIENCES
(PAPER 2: CHEMISTRY)

JUNE 2025

MARKS: 150

TIME: 3 HOURS

This paper consists of 16 pages and two information sheets.

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INSTRUCTIONS AND INFORMATION

1. Write your name and other information in the appropriate spaces on the ANSWER BOOK.

2. This question paper consists of eight questions. Answer ALL 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 pocket 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 where applicable.

11. Give brief motivations, discussions, et cetera where required.

12. Write neatly and legibly.

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QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write down only the letter A, B, C or D next to the question number (1.1–1.10) in your ANSWER BOOK.

1.1 Which ONE of the following is the correct name of the functional group of the alkynes?

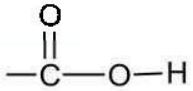
A Formyl group

B Carbonyl group

C Carbon-carbon triple bond

D Carbon-carbon double bond (2)

1.2 Consider the structural formula of the functional group below.



Which ONE of the following homologous series can be functional isomers of the homologous series having the above functional group?

A Esters

B Ketones

C Aldehydes

D Carboxylic acids (2)

1.3 Which ONE of the following decreases as the relative molecular masses of the straight chain alkanes increases?

A Melting point

B Boiling point

C Vapour pressure

D Strength of intermolecular forces (2)

1.4 Compound **Q** reacts with $C_3H_7C\ell$ according to the following balanced chemical equation.

$$Q + C_3H_7C\ell \rightarrow C_3H_7OH + HC\ell$$

What type of a reaction is represented above?

A Dehydrohalogenation

B Hydrohalogenation

C Hydration

D Hydrolysis (2)

1.5 The NAME of the catalyst used in esterification reaction is … acid.

A carbonic

B sulphuric

C phosphoric

D hydrochloric (2)

1.6 Which ONE of the following best describes the effect of temperature on the reaction rate?

A Hydrogen peroxide decomposes faster in the presence of manganese (IV) oxide.

B 5 g sodium reacts faster with the same volume oxygen than 5 g of copper.

C 10 g of calcium carbonate reacts faster with 0,4 $mol \cdot dm^{-3}$ hydrochloric acid than 0,04 $mol \cdot dm^{-3}$ of hydrochloric acid.

D 10 g of sodium reacts slower with 100 mℓ water at 50 °C than at 100 °C. (2)

1.7 Learners use the reaction between sodium thiosulphate and hydrochloric acid to determine the reaction rate according to the balanced chemical equation below.

$$Na_2S_2O_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + SO_2(g) + H_2O(\ell) + S(s)$$

Which method will lead to the MOST inaccurate practical results?

A Measuring the rate at which the mass of the of reaction mixture decrease.

B Measuring the rate of change in concentration of hydrochloric acid.

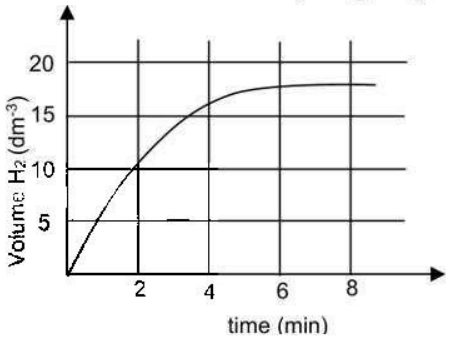
C Measuring the rate at which the precipitate is formed.

D Measuring the rate at which the gas is formed. (2)

1.8 The experiment was conducted by reacting a certain mass of zinc with an excess hydrochloric acid. The balance equation for the reaction is:

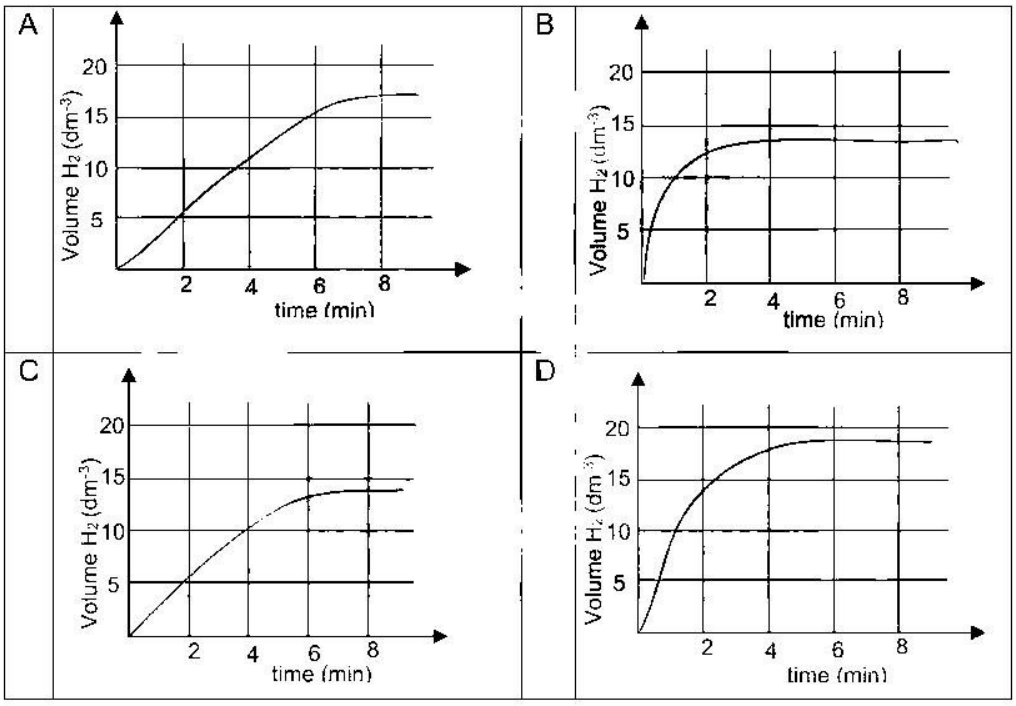
$$Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g)$$

The graph below shows the results of the hydrogen gas produced per unit time.



The experiment was repeated with the same amount of zinc reacting with same the volume of HCℓ with twice the concentration.

Which ONE of the graphs below represents the results of the second experiment?



(2)

1.9 A hypothetical reaction below reaches equilibrium in a closed container according to the following balanced chemical equation.

$$X_2(g) + Y_2(g) \rightleftharpoons 2XY(g) \qquad \Delta H > 0$$

The YIELD of XY can be increased by:

A Increasing the pressure

B Heating the container

C Addition of a catalyst

D Removing $X_2(g)$ (2)

1.10 The balanced chemical reaction below reaches equilibrium in a closed container.

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(\ell)$$
Yellow Orange

Which ONE of the following is correct when you add concentrated HCℓ to the mixture?

A Concentration of $Cr_2O_7^{2-}$ decreases.

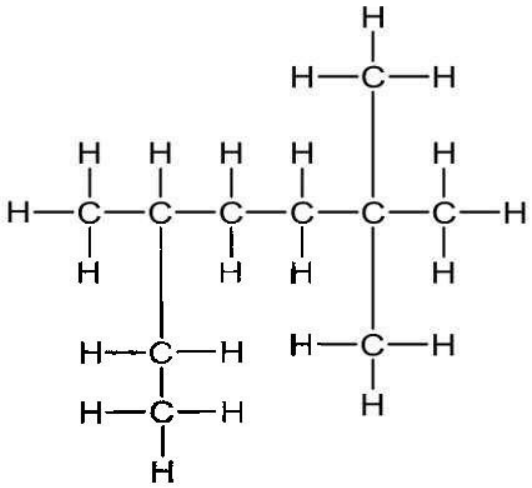
B Concentration of $2CrO_4^{2-}$ increases.

C Reverse reaction is favoured.

D The solution turns orange. (2)
[20]

QUESTION 2

2.1 Consider the structural formula of the hydrocarbon below.



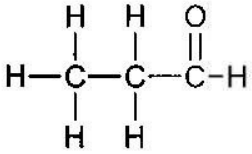
2.1.1 Define the term *hydrocarbon*. (2)

2.1.2 Write down the general formula of the homologous series of the above compound. (1)

2.1.3 Give the IUPAC name of the compound. (3)

2.2 An unknown compound **X** is a functional isomer of compound **A** below.

A



Write down the:

2.2.1 Name of the homologous series of compound **A** (1)

2.2.2 Condensed structural formula of compound **X** (2)

2.2.3 IUPAC name of compound **X** (2)

2.3 Propanoic acid reacts with alcohol in the presence of concentrated acid to produce organic compound **E** as shown by the incomplete equation below.

$$\text{Propanoic acid} + \text{alcohol} \rightarrow \mathbf{E} + H_2O$$

The percentage composition of compound **E** is as follows

COMPOUND E		
Carbon	Hydrogen	Oxygen
58,82%	9,81%	31,37%

The molecular mass of compound **E** is EQUAL to its empirical formula mass.

2.3.1 Define the term *empirical formula*. (2)

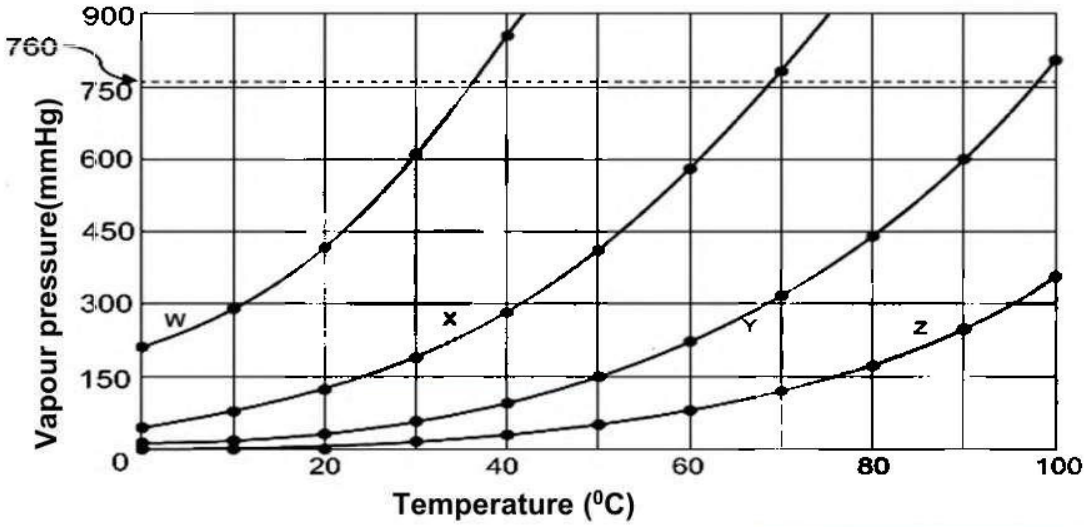
2.3.2 Determine by calculation, the molecular formula of compound **E**. (5)

2.3.3 Write down the molecular formula of the alcohol. (2)
[20]

QUESTION 3

A group of learners investigate the relationship between the strength of the intermolecular forces and the vapour pressure of four UNBRANCHED organic compounds W, X, Y and Z. The compounds have the SAME NUMBER of carbon atoms but belong to different homologous series. Their results are represented in the graph below. 760 mmHg is equal to 1atm.

Graph of the vapour pressure vs temperature



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

3.2 Formulate the investigative question for this investigation. (2)

3.3 Use the graph to determine the boiling point of **X**. (2)

3.4 Which ONE of the compounds **W** or **Y** has the strongest intermolecular forces? Explain the answer by referring to the vapour pressure and boiling point. (3)

3.5 Compound **Z** has two sites for hydrogen bonding. Write down the NAME of its functional group. (2)

3.6 Compound **X** is an aldehyde and **Y** is an alcohol. Refer to the TYPE of intermolecular forces to fully explain the difference in vapour pressure between compound **X** and **Y**. (4)

3.7 Compound **Y** is butan-2-ol.

3.7.1 Draw the structural formula of its CHAIN isomer. (2)

3.7.2 Identify the structure drawn in 3.7.1 as a primary, secondary or tertiary alcohol? Explain the answer. (2)

[19]

QUESTION 4

Four reactions of organic compounds are given in the table below.

Reaction **1**	Butane + Br_2 → 2-bromobutane + **P**
Reaction **2**	Pentane + O_2 → $CO_2(g)$ + $H_2O(\ell)$
Reaction **3**	Hexane → $3C_2H_4$ + **Q**
Reaction **4**	2-bromobutane + **NaOH** → **R** (major product) + NaBr(aq) + $H_2O(\ell)$

4.1 Consider **REACTION 1**:

4.1.1 Is butane a SATURATED or UNSATURATED compound? Give a reason for the answer. (2)

4.1.2 Write down the NAME of the inorganic product **P**. (1)

4.1.3 Write down a complete balanced equation using STRUCTURAL formulae. (4)

4.2 Consider **REACTION 2**:

Write down the:

4.2.1 NAME of the chemical reaction that takes place. (1)

4.2.2 Balanced chemical equation using MOLECULAR formulae. (3)

4.3 Consider **REACTION 3**:

4.3.1 Except high temperature, write down ONE other reaction condition for this chemical reaction. (1)

4.3.2 Using CONDENSED STRUCTURAL formulae, write a complete chemical equation. (3)

4.3.3 The product C_2H_4 then reacts with an unknown substance in the presence of nickel as a catalyst. Identify the type of reaction that takes and hence write down the molecular formula of product formed. (2)

4.4 Consider **REACTION 4**:

4.4.1 Identify the type of reaction that takes place. (1)

4.4.2 Is the NaOH that reacted diluted or concentrated. (1)

4.4.3 Draw a STRUCTURAL formula of compound **R**. (2)

[21]

QUESTION 5

In the experiments to investigate factors that influence the reaction rate, 5 g of Mg reacts with excess hydrochloric acid.
The balanced chemical equation for the reaction is given below.

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

The same mass of Mg was used in all the experiments. Reaction condition for each experiment is summarised below.

EXPERIMENT	CONCENTRATION OF ACID ($mol \cdot dm^{-3}$)	STATE OF DIVISION OF Mg	VOLUME OF $HC\ell$ (cm^3)
A	0,6	granules	500
B	0,6	powder	500
C	0,9	granules	500

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

5.2 Will it be a fair comparison to compare reaction rate of experiment **B** and **C**? Explain the answer. (2)

5.3 Experiment **A** and **B** are compared.
Write down the following:

5.3.1 Dependant variable. (1)

5.3.2 Controlled variable. (1)

5.4 Use the collision theory and explain which experiment **A** or **C** will have a higher reaction rate. (5)

5.5 Calculate the number of moles of unreacted $HC\ell$ in experiment **C**. (6)

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5.6 In another experiment **D**, 500 cm^3 excess HCℓ with a concentration of 0,6 $mol \cdot dm^{-3}$ reacts with 5 g of Ca powder.
The balanced equation for the reaction is represented below:

$$Ca(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2(g)$$

Experiment **D** is now compared with experiment **B**.

5.6.1 Identify the limiting reagent in experiment **D**.
Explain the answer. (2)

5.6.2 Write down the independent variable for these investigations. (1)

5.6.3 Which ONE of the reactions will produce more hydrogen gas?
Write down only **B** or **D**. (1)

5.6.4 Explain the answer in QUESTION 5.6.3. (2)

5.7 Which metal between Mg and Ca reacts faster with HCℓ?
Write down Mg or Ca. (1)

5.8 Explain the answer in QUESTION 5.7 above. (1)
[25]

QUESTION 6

Carbon reacts with carbon dioxide in a closed system at room temperature. The reaction reaches equilibrium according to the balanced chemical equation below.

$$2C(s) + CO_2(g) \rightleftharpoons 2CO(g)$$

6.1 State *Le Chatelier* principle. (2)

6.2 Carbon dioxide is added to the system at room temperature.
How will the following be affected?

6.2.1 The rate of the forward reaction. (1)

6.2.2 The yield of the CO. (1)

6.2.3 Explain the answer to QUESTION 6.2.2. (2)

6.3 At equilibrium, the pressure of the system is increased by decreasing the volume of the container at the same temperature.
How will this affect the:

6.3.1 Amount of CO_2? Explain the answer (3)

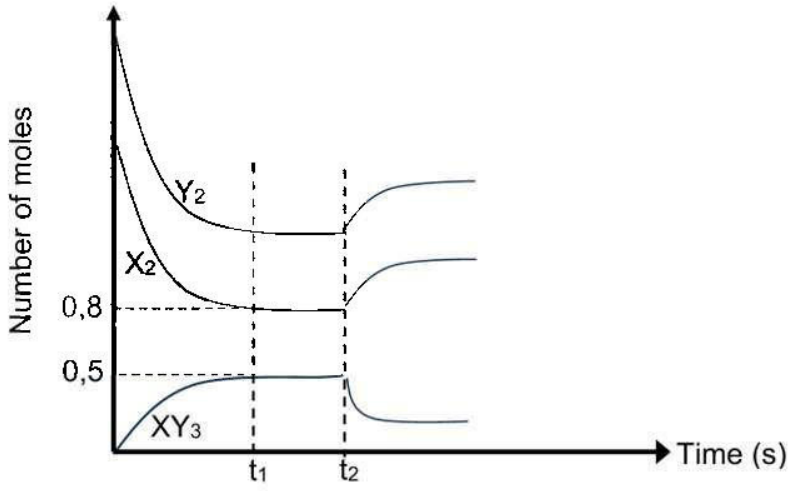
6.3.2 K_C value? (1)
[10]

QUESTION 7

Consider the hypothetical reaction below that takes place in a 2 dm^3 closed container. The balanced chemical equation for the reaction is as follows.

$$X_2(g) + 3Y_2(g) \rightleftharpoons 2XY_3(g) \qquad \Delta H < 0$$

The graph of the number of moles versus time for the reaction is shown below.



7.1 Define the following:

7.1.1 *closed system* (2)

7.1.2 *Chemical equilibrium* (2)

7.2 What is represented by the horizontal lines between t_1 and t_2 ? (1)

7.3 The Kc value between t_1 and t_2 is 0,2197. Calculate the concentration of Y_2 gas between t_1 and t_2. (5)

7.4 Calculate the volume of Y_2 injected in the system at STP. (6)

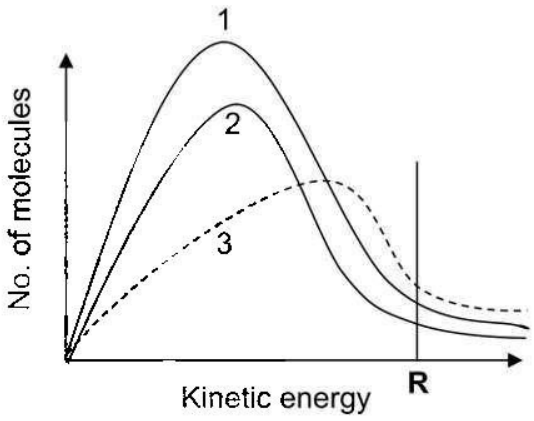
7.5 The size of the container is kept constant. Identify the disturbance at t_2. Explain the answer. (4)

[20]

QUESTION 8

8.1 Three energy distribution curves 1,2 and 3 for oxygen gas under different conditions are shown in the graph below:

Curve 2 represents 1 mol of oxygen gas at 70 °C



8.1.1 What does the line **R** represents? (1)

8.1.2 How will the addition of a suitable catalyst influence the position of **R**? Explain. (2)

8.1.3 Which curve best represents each of the following conditions?

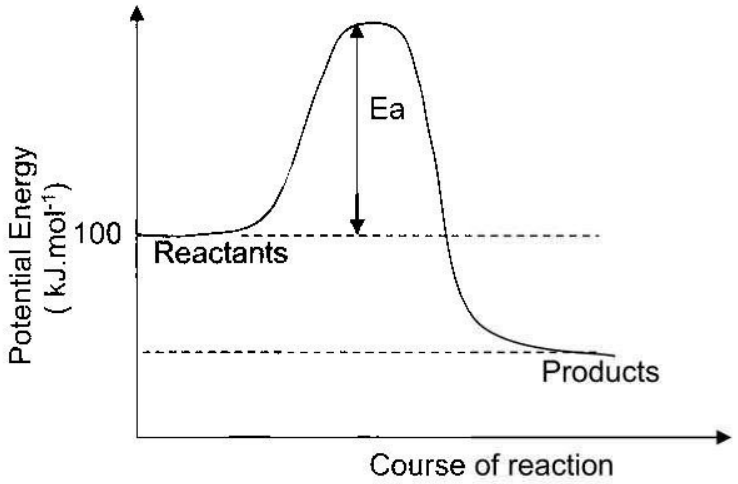
(a) 1 mol of oxygen gas at 90 °C (1)

(b) 2 mol of oxygen gas at 70 °C (1)

8.2 Consider the balanced chemical equation below:

$$Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g) \qquad \Delta H = -150\ kJ{\cdot}mol^{-1}$$

The potential energy diagram for the reaction is drawn below.



8.2.1 Is the reaction exothermic or endothermic?
Explain the answer. (2)

8.2.2 How will the heat of the reaction (ΔH) change if the concentration of hydrochloric acid is decreased? Choose from INCREASES, DECREASES OR REMAINS THE SAME (1)

8.2.3 Calculate the energy of the product. (3)

8.2.4 Calculate the energy of the activated complex if the activation energy for the forward reaction is 90 $kJ{\cdot}mol^{-1}$. (2)

8.2.5 Re-draw the potential energy diagram in the ANSWER BOOK, and on the same set of axes use dotted lines to indicate the effect of adding a catalyst on this reaction. (2)

[15]

GRAND 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*

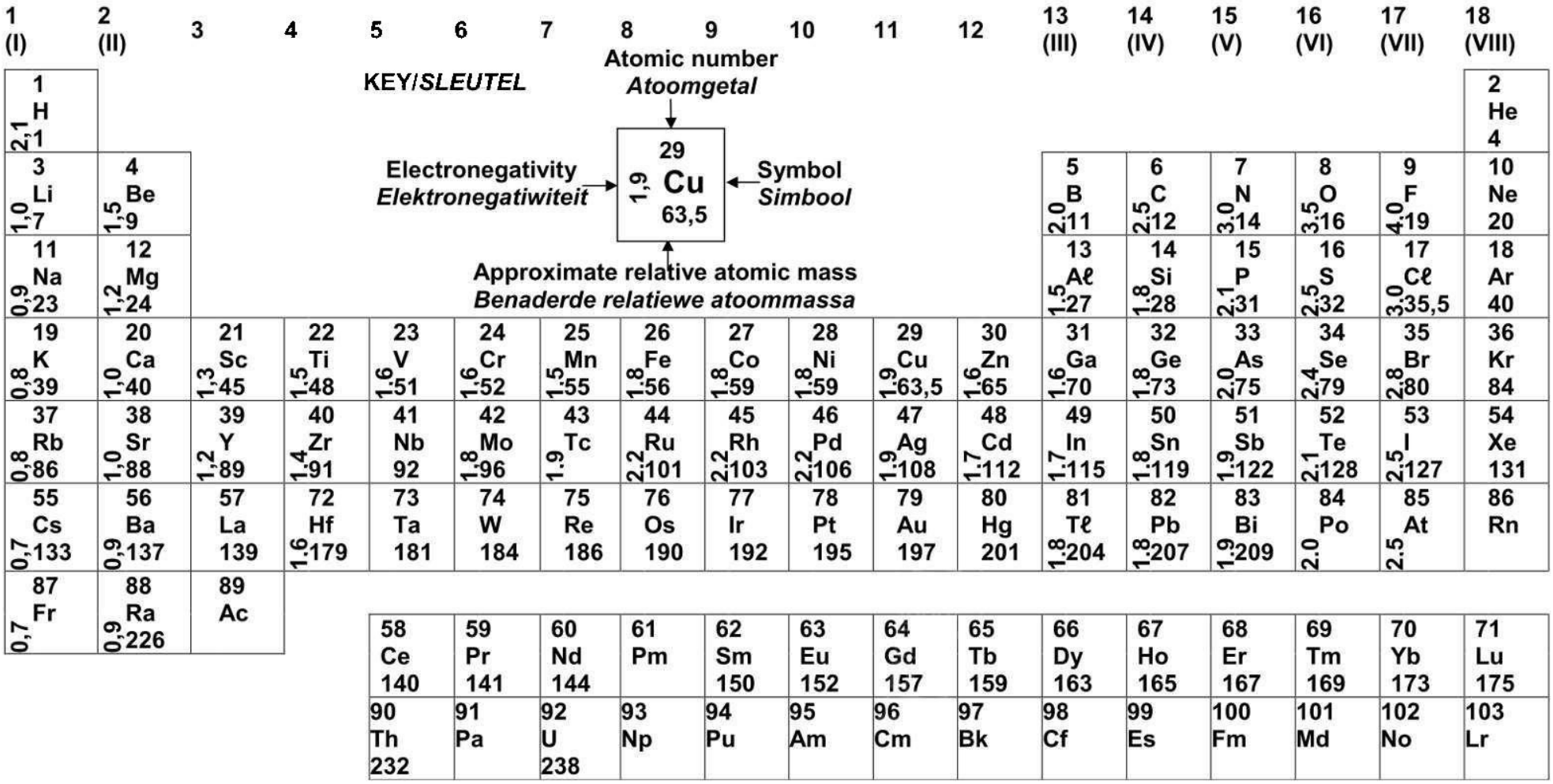
NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ 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* $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

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TABLE 3: THE PERIODIC TABLE OF ELEMENTS



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