Hillcrest High School

PHYSICAL SCIENCE P2

June 2024

Grade 12

MARKS: 100
TIME: 2 Hours

EXAMINER: Ms N. Badenhorst
MODERATOR: Mrs J. Knox-Whitehead

Instructions:

1. Answer ALL the questions.
2. This question paper consists of TWO sections:
3. SECTION A (10)
   SECTION B (90)
4. Answer SECTIONS A and B in the ANSWER BOOK.
   Non-programmable calculators may be used.
5. Appropriate mathematical instruments may be used.
6. Number the answers correctly according to the numbering system used in this question paper.
7. Data sheets are attached for your use.
8. Give brief motivations, discussions, et cetera where required.
9. Numbers must be rounded off to two decimal places

SECTION A

QUESTION 1: MULTIPLE CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only one correct answer. Write only the letter (A-D) next to the question number (1.1-1.5) in the answer book..

1.1 When butane is subjected to high temperatures and pressures, the following reaction takes place:

$$\text{Butane} \rightarrow \text{methane} + \mathbf{Y}$$

Which ONE of the following represents **Y**?

A $CHCCH_3$

B CH_2CHCH_3

C $CH_3CH_2CH_3$

D $CH_3CHCHCH_3$

1.2 The heat of reaction (ΔH) and the activation energy (E_a) for a reaction are -111 kJ·mol^{-1} and 43 kJ·mol^{-1} respectively. The activation energy for the reverse reaction will be ...

A -43 kJ·mol^{-1}

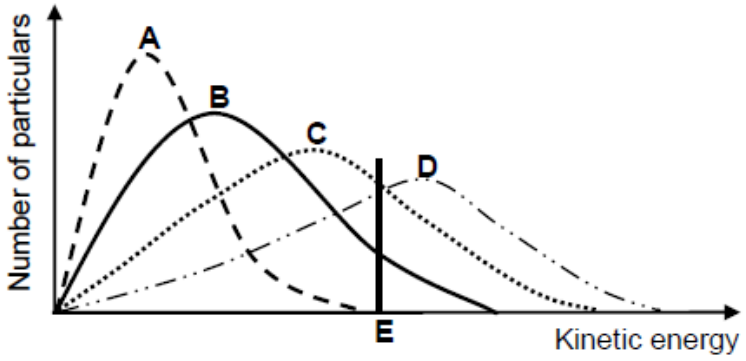
B 111 kJ·mol^{-1}

C 154 kJ·mol^{-1}

D 68 kJ·mol^{-1}

1.3 The Maxwell-Boltzmann energy distribution curves (**A, B, C** and **D**) below show the number of particles versus kinetic energy for a reaction at four different temperatures. The minimum kinetic energy needed for effective collisions to take place is represented by **E.**

Which ONE of the curves (**A, B, C** or **D**) represents the reaction that will take place the fastest?



1.4 The equilibrium constant, K_c, for the reaction $A(g) \rightleftharpoons B(g)$ is 1×10^{-4}.

Which ONE of the following statements is always CORRECT for this reaction?

The mixture at equilibrium consists of ...

A equal amounts of A(g) and B(g).

B very little of A(g).

C mostly A(g).

D mostly B(g).

1.5 Which ONE of the following indicators is most suitable for the titration of ethanoic acid with sodium hydroxide?

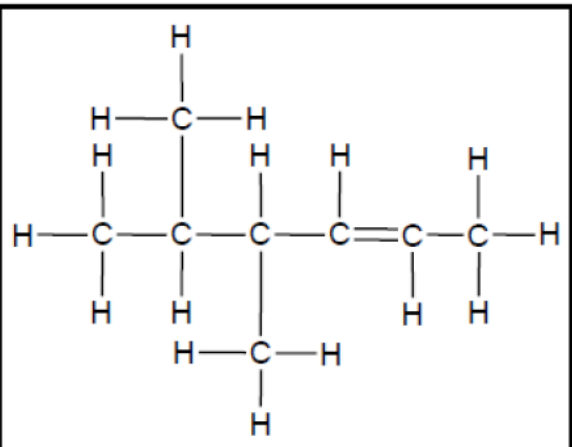
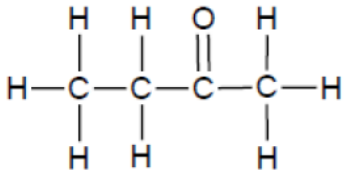
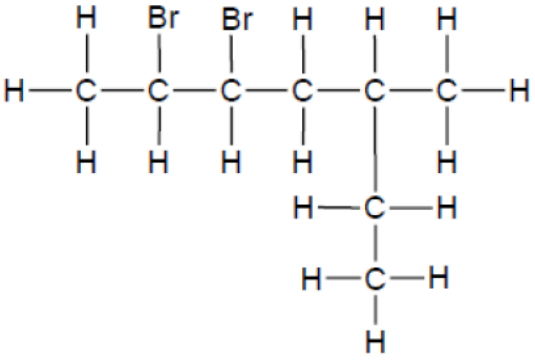
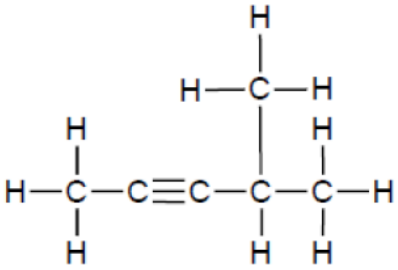
Indicator	pH
A	0,2 - 1,8
B	2,9 - 4,0
C	6,0 - 7,6
D	11,6 - 14,0

[2 x 5 = 10]

Section B

Question 2

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

A		**B**	
C	$CH_3CH=CHCH_2CH_2CH_3$	**D**	Pentyl propanoate
E		**F**	

2.1 Write down the letter(s) that represent(s) the following:

2.1.1 Alkene (1)

2.1.2 A ketone (1)

2.1.3 A compound with the general formula C_nH_{2n-2} (1)

2.1.4 A structural isomer of octanoic acid (1)

2.2 Write down the IUPAC name of compound:

2.2.1 A (2)

2.2.2 E (2)

2.2.3 F (2)

Compound **D** is prepared by reacting two organic compounds in the presence of an acid as a catalyst.

Write down the:

2.3.1 Structural formula of compound **D** (2)

2.3.2 IUPAC name of the alcohol used to prepare compound **D**. (1)

[13]

Question 3

The table below shows five organic compounds represented by the letters **A** to **E**.

A	CH_4
B	CH_3CH_3
C	$CH_3CH_2CH_3$
D	$CH_3CH_2CH_2CH_3$
E	CH_3CH_2OH

3.1 Is compound **B** SATURATED or UNSATURATED? Give a reason for the answer. (2)

Consider the boiling points of compounds **A** to **E** given in random order below and use them, where applicable, to answer the questions that follow.

0 °C	- 162 °C	- 42 °C	- 89 °C	78 °C

3.2 Write down the boiling point of:

3.2.1 Compound **C** (1)

3.2.2 Compound **E** (1)

3.3 Explain the difference in boiling points of compounds **C** and **E** by referring to the TYPE of intermolecular forces present in EACH of these compounds. (3)

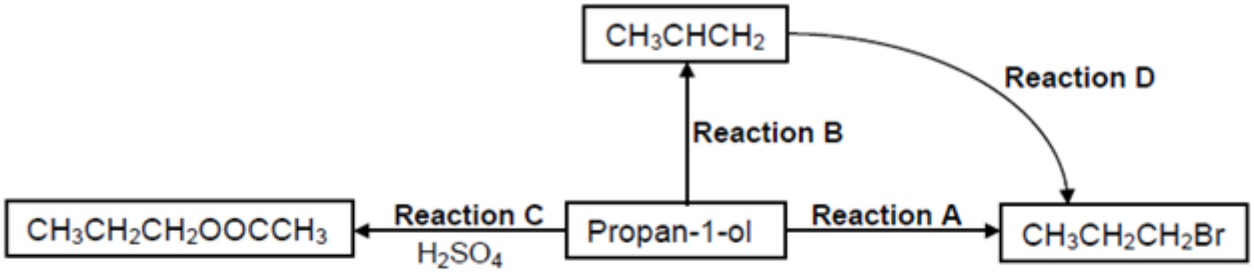
3.4 Does vapour pressure INCREASE or DECREASE from compounds **A** to **D**? Fully explain the answer. (4)

3.5 How will the vapour pressure of 2-methylpropane compare to the vapour pressure of compound **D**? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

[12]

Question 4

Propan-1-ol can undergo a number of organic reactions, as indicated by the letters **A** to **D** in the diagram below.



4.1 Write down the type of reaction represented by:

4.1.1 **A** (1)

4.1.2 **B** (1)

4.1.3 **C** (1)

4.1.4 **D** (1)

4.2 For reaction **C**, write down the:

4.2.1 Function of H_2SO_4 (1)

4.2.2 IUPAC name of the organic product (1)

4.2.3 Structural formula of the other organic reactant (2)

4.3 Use STRUCTURAL FORMULAE for all organic reactants and products to write a balanced equation for **reaction A**. (5)

[13]

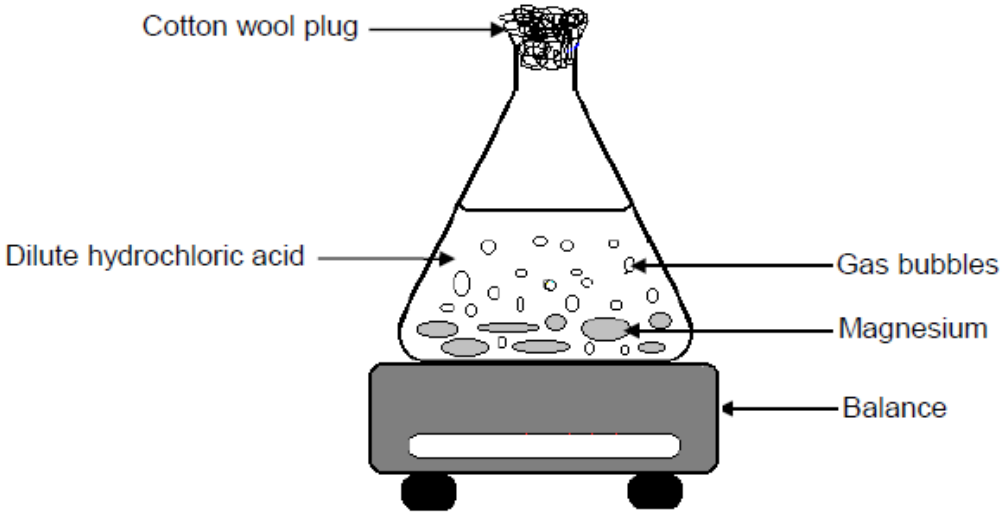
Question 5

Two experiments are carried out to investigate one of the factors that affects the reaction rate between magnesium and dilute hydrochloric acid. The balanced equation below represents the reaction that takes place.

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

In **experiment 1** a certain mass of magnesium *ribbon* reacts with excess dilute hydrochloric acid. In **experiment 2** magnesium *powder* of the same mass as the magnesium ribbon, reacts with the same volume of excess dilute hydrochloric acid. The concentration of the acid is the same in both experiments.

The apparatus below is used for the investigation.



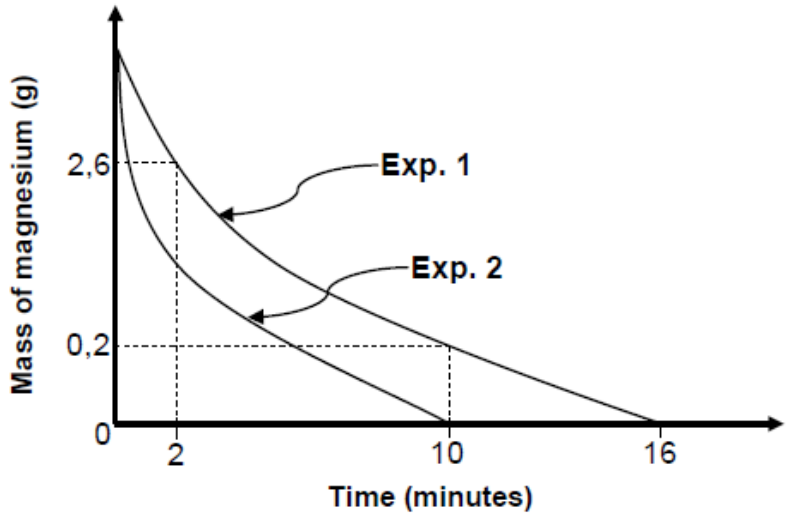
5.1 Define *reaction rate*. (2)

5.2 For this investigation, write down the:

5.2.1 Independent variable (1)

5.2.2 Control variable (1)

The change in mass of magnesium is calculated and recorded in 2-minute intervals for both experiments. The results obtained are shown in the graph below (NOT drawn to scale).



5.3 Use the information on the graph to:

5.3.1 Calculate the volume of hydrogen gas produced in **experiment 1** from t = 2 minutes to t = 10 minutes

Take the molar gas volume as 25 $dm^3 \cdot mol^{-1}$. (5)

5.3.2 Calculate the initial mass of magnesium used if the average rate of formation of hydrogen gas in **experiment 2** was 2,08 x 10^{-4} $mol \cdot s^{-1}$ (5)

5.4 Use the collision theory to explain why the curve of **experiment 2** is steeper than that of **experiment 1**. (3)

[17]

Question 6

Consider the following equation for the decomposition of ozone (O_3).

$$2O_3\,(g) \leftrightarrows 3O_2\,(g)$$

6.1 State *Le Chatelier's principle.* (2)

6.2 Use Le Chatelier's principle and explain how an increase in pressure will influence the amount of ozone at equilibrium. (3)

6.3 An increase in the temperature causes a decrease in the amount of oxygen.

6.3.1 Which reaction is favoured by the increase of temperature? Choose from FORWARDS or BACKWARDS. (1)

6.3.2 What will happen to the value of the equilibrium constant? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

6.4 Explain how the addition of a suitable catalyst will influence the amount of oxygen at equilibrium. (2)

Ozone (O_3) reacts with nitrogen oxide (NO) as indicated in the reaction below.

$$O_3(g) + NO(g) \leftrightarrows O_2(g) + NO_2(g) \quad \Delta H < 0$$
$$\text{BROWN}$$

Note that O_3, NO and O_2 are all colourless gases while NO_2 is a brown gas.
The colour of the gas mixture is light brown.

6.5 A mixture of the four gases is prepared in a 2 dm^3 sealed container with the following initial concentrations:

$[O_3] = 0{,}6\ mol{\cdot}dm^{-3}$ $[NO] = 0{,}9\ mol{\cdot}dm^{-3}$

$[O_2] = 0{,}73\ mol{\cdot}dm^{-3}$ $[NO_2] = 0{,}55\ mol{\cdot}dm^{-3}$

The mixture is then heated to 1500 K. After equilibrium is established, it is found that the concentration of NO is $0{,}36\ mol{\cdot}dm^{-3}$.

Use the information given and calculate the value of the equilibrium constant at 1500 K. (7)

6.6 A number of changes are made to the equilibrium mixture and the mixture is allowed to reach a new equilibrium after each change.

Choose from INCREASES, DECREASES or REMAINS THE SAME to answer each of the following questions.

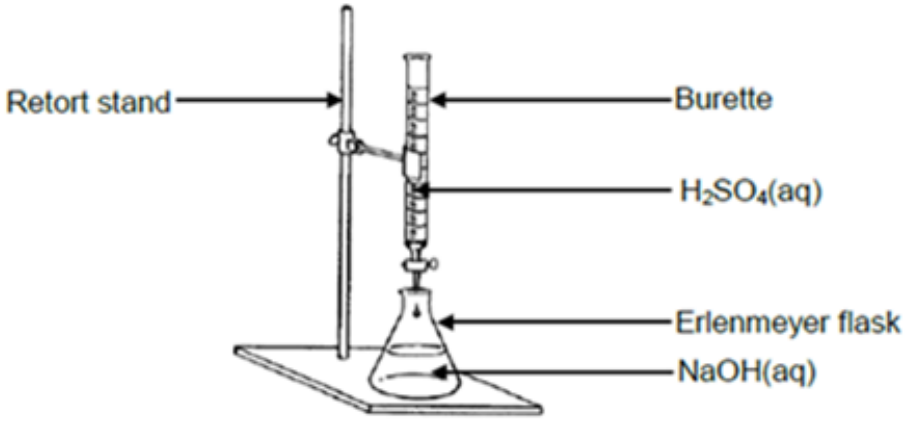
6.6.1 NO gas is added to the container.
How does the yield of NO_2 gas change? (1)

6.6.2 O_2 gas is added to the container.
What happens to the intensity of the brown colour? (1)

[18]

Question 7

The reaction between a sulphuric acid (H_2SO_4) solution and a sodium hydroxide (NaOH) solution is investigated using the apparatus illustrated below.



7.1 Write down the name of the experimental procedure illustrated above. (1)

7.2 Define an *acid* in terms of the Arrhenius theory. (2)

7.3 Give a reason why sulphuric acid is regarded as a strong acid. (2)

7.4 Bromothymol blue is used as indicator. Write down the colour change that will take place in the conical flask on reaching the endpoint of the titration.

Choose from the following:

BLUE TO GREEN YELLOW TO GREEN BLUE TO YELLOW (1)

During the titration a learner adds 25 cm^3 of NaOH(aq) of concentration 0,1 $mol \cdot dm^{-3}$ to a conical flask and titrates this solution with H_2SO_4(aq) of concentration 0,1 $mol \cdot dm^{-3}$. The balanced equation for the reaction that takes place is:

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

7.5 Determine the volume of H_2SO_4(aq) which must be added to neutralise the NaOH(aq) in the Erlenmeyer flask completely. (4)

7.6 If the learner passes the endpoint by adding 5 cm^3 of the same H_2SO_4(aq) in excess, calculate the pH of the solution in the flask. (7)

[17]

Total 100

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

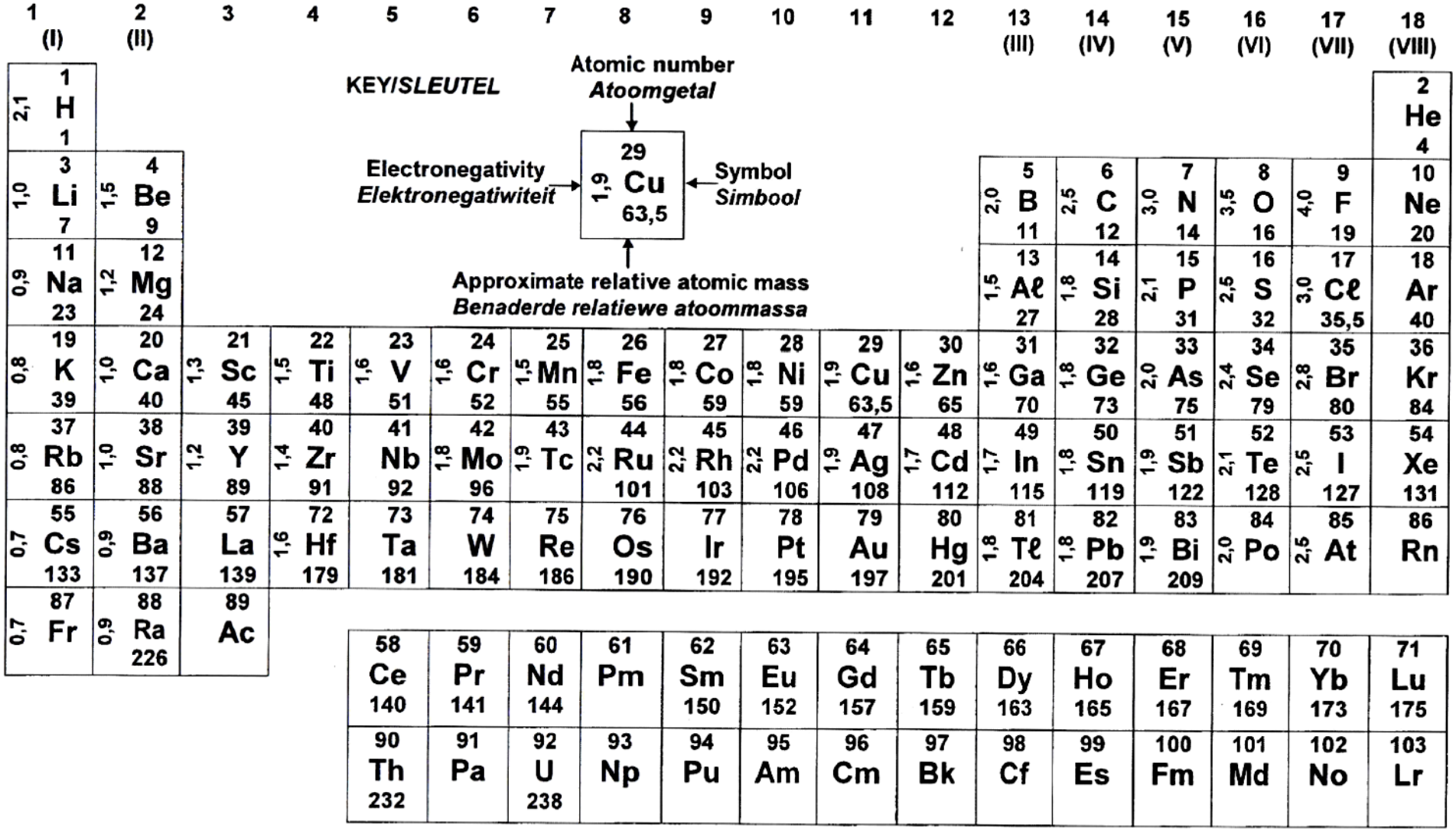
TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

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* $E^\theta_{cell} = E^\theta_{oxidising\ agent} - E^\theta_{reducing\ agent}$ / $E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE



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)
2,1 H 1																	2 He 4
1,0 Li 7	1,5 Be 9											2,0 B 11	2,5 C 12	3,0 N 14	3,5 O 16	4,0 F 19	10 Ne 20
0,9 Na 23	1,2 Mg 24											1,5 Aℓ 27	1,8 Si 28	2,1 P 31	2,5 S 32	3,0 Cℓ 35,5	18 Ar 40
0,8 K 39	1,0 Ca 40	1,3 Sc 45	1,5 Ti 48	1,6 V 51	1,6 Cr 52	1,5 Mn 55	1,8 Fe 56	1,8 Co 59	1,8 Ni 59	1,9 Cu 63,5	1,6 Zn 65	1,6 Ga 70	1,8 Ge 73	2,0 As 75	2,4 Se 79	2,8 Br 80	36 Kr 84
0,8 Rb 86	1,0 Sr 88	1,2 Y 89	1,4 Zr 91	41 Nb 92	1,8 Mo 96	1,9 Tc	2,2 Ru 101	2,2 Rh 103	2,2 Pd 106	1,9 Ag 108	1,7 Cd 112	1,7 In 115	1,8 Sn 119	1,9 Sb 122	2,1 Te 128	2,5 I 127	54 Xe 131
0,7 Cs 133	0,9 Ba 137	57 La 139	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	1,8 Tℓ 204	1,8 Pb 207	1,9 Bi 209	2,0 Po	2,5 At	86 Rn
0,7 Fr	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