basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

TECHNICAL SCIENCES P2

2019

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 subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.

6.   You may use a non-programmable calculator.

7.   You are advised to use the attached DATA SHEETS.

8.   Round off your FINAL numerical answers to a minimum of TWO decimal places.

9.   Give brief motivations, discussions, etc. where required.

10.   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 numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 D.

1.1   Which ONE of the following compounds is an example of a saturated hydrocarbon?

    A   Ethene

    B   Butane

    C   Bromoethane

    D   Methanoic acid   (2)

1.2   Which ONE of the following is the functional group of the alkenes?

A

B

C

D
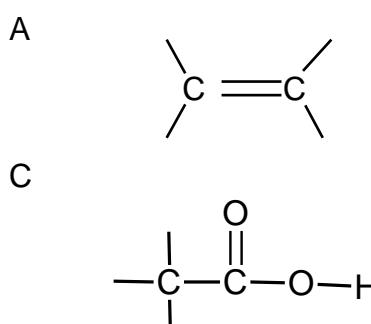
(2)

1.3   The structural formula of an organic compound is given below.
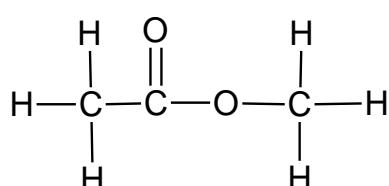
    Which ONE of the following is the CORRECT IUPAC name of the organic compound above?

    A   Propanone

    B   Propanoic acid

    C   Ethyl methanoate

    D   Methyl ethanoate   (2)

1.4   The vapour pressure of ethanol is lower than the vapour pressure of ethane because ethane has a … intermolecular forces.

    A   higher boiling point and weaker

    B   lower boiling point and stronger

    C   higher boiling point and stronger

    D   lower boiling point and weaker   (2)

1.5   Ion migration in a functioning electrochemical cell takes place through the …

    A   anode.

    B   cathode.

    C   salt bridge.

    D   external circuit.   (2)

1.6   Consider the redox reaction: $Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$

    Which ONE of the following is the CORRECT representation of the oxidation half-reaction?

    A $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$

    B $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

    C $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

    D $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ (2)

1.7   Which ONE combination of the fields below changes in the propagation of an electromagnetic wave?

    A   Electric and gravitational fields

    B   Electric and magnetic fields

    C   Gravitational and magnetic fields

    D   Gravitational and electrical fields   (2)

1.8   The speed of gamma rays is …

   A $6,63 \times 10^{-34}$ m·s^{-1}

   B $1,01 \times 10^{5}$ m·s^{-1}

   C $1,55 \times 10^{9}$ m·s^{-1}

   D $3,00 \times 10^{8}$ m·s^{-1} (2)

1.9   An image formed by a concave lens is …

   A   inverted.

   B   virtual.

   C   real.

   D   large.   (2)

1.10   In the diagram below, ray **B** is the … ray.
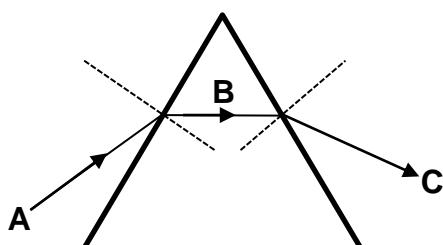
   A   refracted

   B   emergent

   C   incidence

   D   reflected   (2)
                                                                              [20]

QUESTION 2 (Start on a new page.)

A to **F** in the table below represent SIX organic molecules from different functional groups.

A	C_5H_{12}	B	$-C\equiv C-$
C	H Br H H | | | | H—C—C—C—C—H | | | | H H H H	D	H H H | | | C=C—C—H | | H H
E	[C—C]$_n$ structure	F	H H H O | | | || H—C—C—C—C | | | | H H H H

2.1 Define the term *organic molecules*. (2)

2.2 Write down the:

    2.2.1 Letter representing an alkene (1)

    2.2.2 Letter of a molecule with the general formula C_nH_{2n-2} (1)

    2.2.3 Letter representing a saturated hydrocarbon (1)

    2.2.4 Letter representing an aldehyde (1)

    2.2.5 Structural formula of the POSITIONAL ISOMER of molecule **C** (2)

    2.2.6 IUPAC name of the organic molecule in QUESTION 2.2.5 (2)

    2.2.7 Structural formula of compound **A** (2)

2.3 Molecule **E** represents polythene.

    2.3.1 Define the term *monomer.* (2)

    2.3.2 Write down the NAME of the reaction that results in the formation of polythene. (1)

    2.3.3 Draw the structural formula of a monomer of polythene. (2)

[17]

QUESTION 3 (Start on a new page.)

Three hydrocarbons, **A**, **B** and **C**, were used in an investigation to determine the effect of BRANCHING on VAPOUR PRESSURE. Compounds **A**, **B** and **C** are isomers.

HYDROCARBON	VAPOUR PRESSURE (kPa)
A	450
B	592
C	1 102
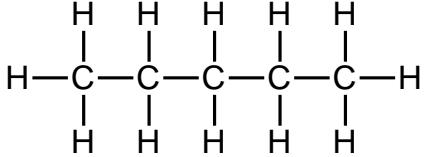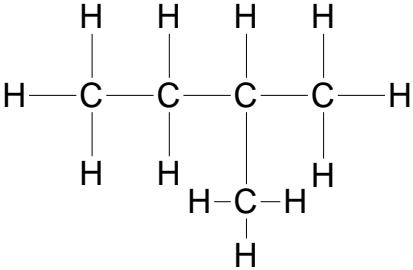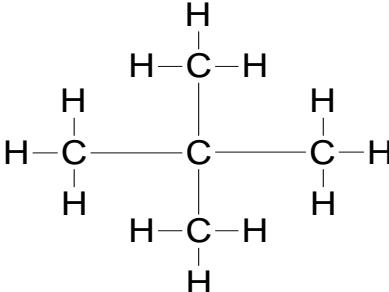
3.1   What is meant by *vapour pressure*?   (2)

3.2   Write down the molecular formula of compounds **A**, **B** and **C**.   (2)

3.3   What type of isomers are these compounds?   (1)

3.4   Identify the type of intermolecular forces acting between the molecules of compound **A**.   (1)

3.5   What is the trend in the vapour pressure of compounds **A**, **B** and **C**?   (1)

3.6   Explain the trend in the vapour pressure of compounds **A**, **B** and **C**.   (3)

3.7   Which ONE of these compounds will have the highest boiling point?   (1)

3.8   Explain the answer to QUESTION 3.7.   (2)

[13]

QUESTION 4 (Start on a new page.)

The diagram below shows some reactions of organic compounds.
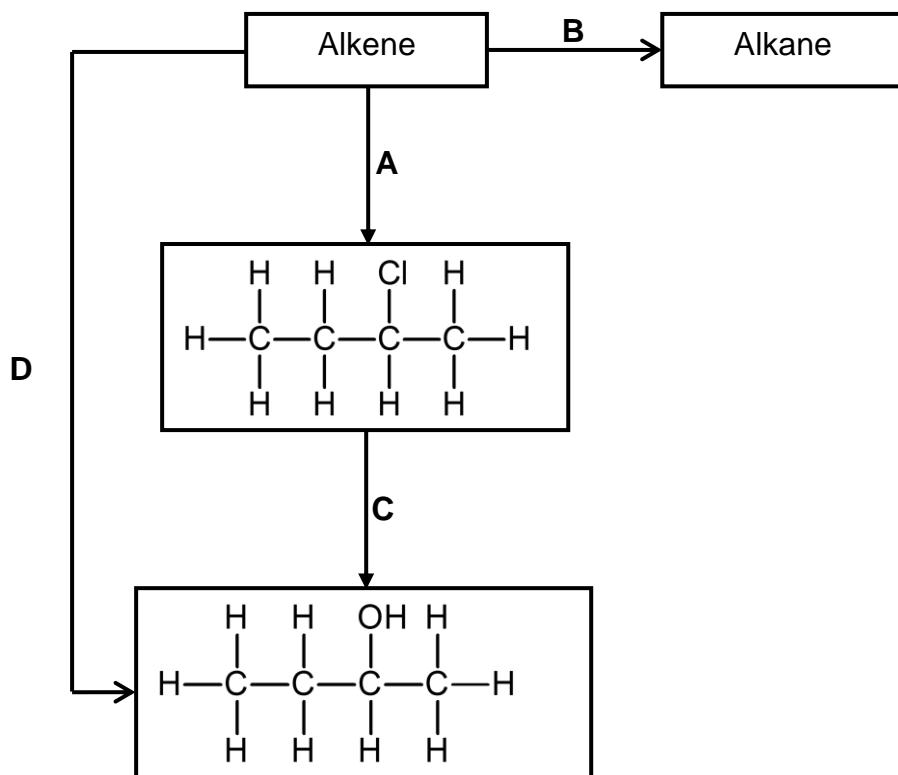
4.1   Identify the type of reaction represented by:

      4.1.1   **B**   (1)

      4.1.2   **C**   (1)

      4.1.3   **D**   (1)

4.2   Consider reaction **A**.

      4.2.1   Use structural formulae to write down a balanced chemical equation
               for the reaction.   (5)

      4.2.2   Name ONE reaction condition required for this reaction to take
               place.   (1)

4.3   Reaction **B** results in the formation of an alkane.

      4.3.1   Write down the IUPAC name of the alkane formed during this
               reaction.   (2)

      4.3.2   Write down the NAMES or SYMBOLS of any TWO catalysts that can
               be used during this reaction.   (2)

4.4 The alkane formed during reaction **B** reacts with excess oxygen.

    4.4.1 Name the type of reaction that takes place when an alkane reacts with oxygen. (1)

    4.4.2 Write down the name or formulae of the TWO products formed during the reaction in QUESTION 4.4.1. (2)

[16]

QUESTION 5 (Start on a new page.)

The electrochemical cell represented in the diagram below was used for the decomposition of molten copper (II) chloride.

molten copper (II) chloride
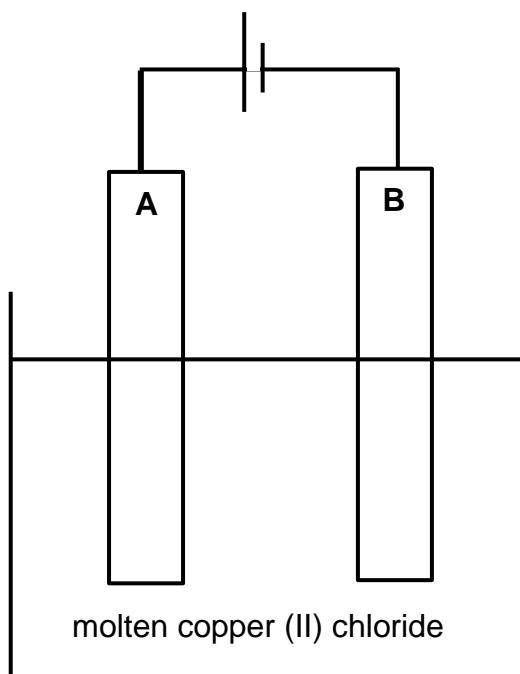
5.1	What type of electrochemical cell is represented in the diagram above?		(1)
5.2	Write down the energy conversion that takes place in this cell.		(2)
5.3	Which electrode is the:		
	5.3.1	Anode	(1)
	5.3.2	Cathode	(1)
5.4	Write down the half-reaction that occurs at the following electrode:		
	5.4.1	**A**	(2)
	5.4.2	**B**	(2)
5.5	Is the reaction taking place in this electrochemical cell SPONTANEOUS or NON-SPONTANEOUS?		(1)
5.6	Explain the answer to QUESTION 5.5.		(2)

[12]

QUESTION 6 (Start on a new page.)

The Grade 12 learners conducted an experiment to determine the emf of a Zn-Cu galvanic cell under standard conditions.

6.1   Draw a labelled diagram representing the set-up of the cell above.   (7)

6.2   Define the term *oxidation*.   (2)

6.3   Write down the NAME or the FORMULA of the:

     6.3.1   Reducing agent   (1)

     6.3.2   Oxidising agent   (1)

6.4   For the Zn-Cu galvanic cell, write down the:

     6.4.1   Net reaction   (3)

     6.4.2   Cell notation   (3)

6.5   Write down the standard conditions for the Zn-Cu galvanic cell.   (2)

6.6   Use the Table of the Standard Reduction Potentials to calculate the emf of the cell.   (4)

[23]

QUESTION 7 (Start on a new page.)

7.1 A ray of light moves from a less optically dense medium to a more optically dense medium at an angle.

    7.1.1 Which phenomena will occur when the ray of light moves from a less optically dense medium to a more optically dense medium? Write only DISPERSION, REFLECTION or REFRACTION. (1)

    7.1.2 Explain the answer to QUESTION 7.1.1. (2)

7.2 Define the term *critical angle*. (2)

7.3 Name TWO conditions necessary for total internal reflection to occur. (2)

7.4 An incident light ray passes from water to air. The critical angle is 45°. Draw a labelled diagram to show the path of the ray of light when the angle of incidence is increased to 50°. (4)

7.5 A ray of white light falls at an angle onto a triangular prism and splits into its constituent colours.

    7.5.1 Write down the NAME of the phenomenon described above. (1)

    7.5.2 Into how many colours does white light split? (1)

    7.5.3 Which colour in white light has the fastest speed when it travels through a triangular prism? (1)

    7.5.4 How does the wavelength of the light change when entering the prism? Write only INCREASES, DECREASES or STAYS THE SAME. (1)

    7.5.5 Explain the answer to QUESTION 7.5.4. (2)

7.6 Calculate the frequency of blue light if the wavelength is 2,63 x 10^{-7} m. (4)

[21]

QUESTION 8 (Start on a new page.)

The picture below shows a magnifying glass.

8.1 Which type of lens is used in a simple magnifying glass? (1)

8.2 An object, represented by an arrow, is placed in front of a concave lens.

8.2.1 Draw a ray diagram to indicate the position and size of the image formed when the object is placed between the focal point (F) and 2F. (Use an arrow to represent the object.) (5)

8.2.2 Write down THREE properties of the image that will be observed. (3)

8.2.3 The lens in QUESTION 8.2 is now replaced with a convex lens. Will the image be LARGER, SMALLER or THE SAME SIZE? (1)

8.3 Name the eye condition that can be corrected using a concave lens. (1)

8.4 Name ONE difference between *convex lenses* and *concave lenses*. (2)

[13]

QUESTION 9 (Start on a new page.)

9.1   State TWO properties of *electromagnetic waves*.   (2)

9.2   What is a *photon*?   (2)

9.3   Write down the NAME of the type of electromagnetic wave in the ANSWER
        BOOK indicated as **A**, **B**, **C** and **D** in the table below.

Lowest frequency					Highest frequency
Radio waves	**A**	Infrared	**B**	**C**	X-rays	**D**

(4)

9.4   Which ONE of the electromagnetic waves above has the shortest
        wavelength?   (1)

9.5   Name TWO uses of X-rays.   (2)

9.6   Calculate the energy of a photon of a microwave with a frequency of
        3, 2 x 10^{10} hertz.   (4)

[15]

TOTAL: 150

**DATA FOR TECHNICAL SCIENCES GRADE 12
PAPER 2**

***GEGEWENS VIR TEGNIESE WETENSKAPPE GRAAD 12
VRAESTEL 2***

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

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1{,}01 \times 10^5$ Pa
Standard temperature *Standaardtemperatuur*	T^{θ}	298 K/25 °C
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	$3{,}0 \times 10^8$ m·s⁻¹
Planck's constant *Planck se konstante*	h	$6{,}63 \times 10^{-34}$ J·s

TABLE 2/*TABEL 2*: WAVES, SOUND AND LIGHT/*GOLWE, KLANK EN LIG*

$v = f\lambda$	$T = \dfrac{1}{f}$
$E = hf$ or/*of* $E = h\dfrac{c}{\lambda}$	

TABLE 3/*TABEL 3*: ELECTROCHEMISTRY/*ELEKTROCHEMIE*

$$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode} \quad / \quad E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$$

or/*of*

$$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation} \quad / \quad E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$$

or/*of*

$$E^{\theta}_{cell} = E^{\theta}_{oxidisingagent} - E^{\theta}_{reducingagent} \quad / \quad E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$$

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)
$F_2(g) + 2e^- \rightleftharpoons 2F^-$	+ 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

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

TABLE 5: THE PERIODIC TABLE OF ELEMENTS/*TABEL 5: 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)
1 $_{2,1}$ **H** 1					**KEY/SLEUTEL**		Atomic number *Atoomgetal*										2 **He** 4
3 $_{1,0}$ **Li** 7	4 $_{1,5}$ **Be** 9		Electronegativity *Elektronegatiwiteit* →			29 $_{1,9}$ **Cu** 63,5	← Symbol *Simbool*					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					Approximate relative atomic mass *Benaderde relatiewe atoommassa*						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**