HILLCREST HIGH SCHOOL

PHYSICAL SCIENCE

GRADE 11

PAPER 2- Chemistry

NOVEMBER 2022

EXAMINER: J. KNOX-WHITEHEAD

TIME: 3 HRS

Total 100

Instructions

1. Answer ALL the questions.
2. This question paper consists of TWO sections:
3. SECTION A (10)
   SECTION B (90)

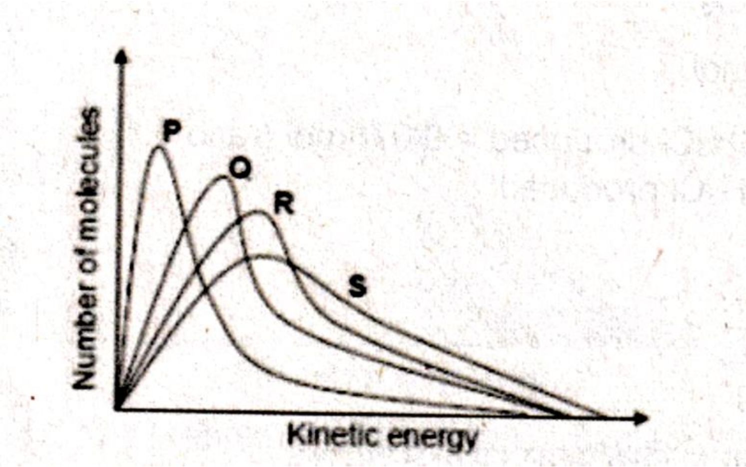
   Answer SECTIONS A and B in the ANSWER BOOK.
4. Non-programmable calculators may be used.
5. Appropriate mathematical instruments may be used.
6. Number the answers correctly according to the numbering system used in this question paper.
7. Data sheets and a periodic table are attached for your use.
8. 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 The graphs below represent the molecular distribution for a reaction at different temperatures. Which ONE of the graphs represents the reaction at the lowest temperature?



A. P
B. Q
C. R
D. S (2)

1.2 The oxidation number of chromium (Cr) in $Cr_2O_7{}^{-2}$ is…

A. -2
B. -6
C. +6
D. +7 (2)

1.3 Substance **A** is <u>insoluble</u> in substance **B**. Which ONE of the following most likely represents **A** and **B**?

	A	**B**
A	HCℓ	H_2O
B	NaCℓ	H_2O
C	NH_3	CCℓ$_4$
D	I_2	CCℓ$_4$

(2)

1.4 The balanced equation below represents the second step in the ionisation of phosphoric acid in water:

$$H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+{}_{(aq)} + HPO_4^{-2}{}_{(aq)}$$

The two BASES in the above reaction are:

A $H_2PO_4^-{}_{(aq)}$ + $H_2O_{(l)}$

B $H_2PO_4^-{}_{(aq)}$ + $H_3O^+{}_{(l)}$

C $H_2O_{(l)}$ + $HPO_4^{-2}{}_{(aq)}$

D $H_3O^+{}_{(l)}$ + $HPO_4^{-2}{}_{(aq)}$

(2)

1.5 Consider the following TWO statements regarding a galvanic cell:

I. A reduction half reaction takes place at the anode of the cell.
II. Negative ions move from the salt bridge to the anode of the cell.

Which of the following is TRUE for a galvanic cell?

A I only

B II only

C Neither I nor II

D Both I and II (2)

[2 X 5 = 10]

Section B

Question 2

2.1 When heated in a crucible, blue copper sulphate pentahydrate crystals release water as shown in the balanced equation below:

$$CuSO_4.5H_2O_{(s)} \rightarrow CuSO_4{}_{(s)} + 5H_2O_{(g)}$$

2.1.1 Calculate the percentage of water in copper sulphate pentahydrate. (3)

2.1.2 If 55 g of anhydrous, white copper sulphate powder remains in the crucible after the water has been removed, calculate the volume of water vapour that was released if the molar gas volume (V_m) at the temperature of heating was 30,6 $dm^3.mol^{-1}$. (5)

2.2 Aerobic cellular respiration is the opposite process of photosynthesis in that glucose molecules are combined with the oxygen we breathe to release the energy needed by our cells plus carbon dioxide and water. The balanced equation for aerobic cellular respiration is given below:

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + \text{energy}$$

Suppose that 2,65 g glucose reacts with 6×10^{22} molecules of oxygen.

2.2.1 Is this reaction ENDOTHERMIC or EXOTHERMIC? (1)

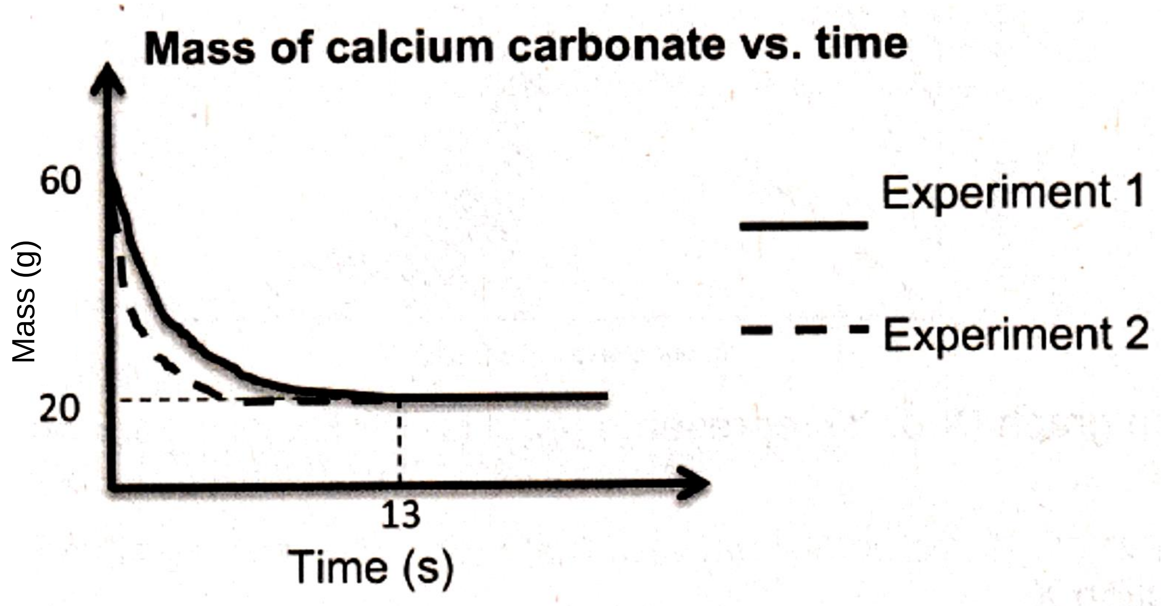
2.2.2 Determine by calculation which substance is the limiting reagent. (6)

2.2.3 Calculate the mass of carbon dioxide that will be produced from this process if the yield of this reaction is typically 97%. (4)

[19]

Question 3

The reaction of calcium carbonate ($CaCO_3$) and hydrochloric acid was used to investigate the factors that affect the rate of reaction. In one experiment, powdered calcium carbonate was used, and in another, lumps of calcium carbonate were used. The graph below shows the change in mass of calcium carbonate with time.



3.1 Which experiment (**1** or **2**) used powdered calcium carbonate?
Explain by referring to the Collision Theory. (4)

3.2 Calculate the rate of reaction for experiment 1 during the first 13 seconds. (3)

3.3 Define the term *catalyst*. (2)

3.4 If a catalyst were to be added to the above reaction, explain how it would increase the rate of reaction. (3)

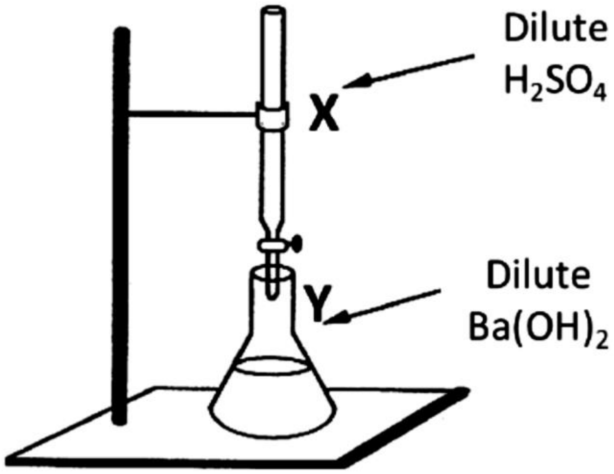
3.5 Suggest another method that could be used to increase the rate of this reaction, other than the two already discussed in this question. (1)

[13]

Question 4

The following apparatus is used for the titration of a dilute alkali ($Ba(OH)_2$) with a dilute acid (H_2SO_4). The balanced equation is given below:

$$H_2SO_4\,(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2H_2O(\ell)$$



4.1 Define a *strong base*. (2)

4.2 Name the piece of apparatus labelled **X**, and explain TWO important guidelines that must be followed when reading volumes using this apparatus. (3)

4.3 Methyl orange is used as an indicator for the above reaction. State the colour change that would be observed in **Y** as the end point of the titration is reached. (1)

4.4 State whether each of the following INCREASES, DECREASES or REMAINS CONSTANT while the acid is being added to **Y** <u>before</u> the end point is reached:

4.4.1 $[Ba^{2+}]$ (1)

4.4.2 $[OH^-]$ (1)

4.4.3 pH (1)

4.5 The concentration of the $Ba(OH)_2$ is 0,1 $mol.dm^{-3}$.

4.5.1 Calculate the pH of this solution before the titration is started. (4)

4.5.2 If 30 cm^3 of the sulfuric acid reacts with 50 cm^3 of the dilute alkali, calculate the mass of $BaSO_4$ that will form in **Y** during the reaction. (5)

4.5.3 Calculate the concentration of the H_2SO_4. (4)

[22]

Question 5

In the table below the melting points and boiling points of different substances at standard pressure are given. Use this information to answer the following questions.

Substance	Melting point °C	Boiling point °C
He	-272	-269
HBr	−86.9	−66.8
CCl_4	-23	77
CO_2	Sublimes at -79	
CH_4	-184	-162
H_2O	0	100

5.1 Define a *covalent bond*. (2)

5.2 Covalent bonds can be represented with Lewis structures. Draw the Lewis structure for CO_2. (2)

5.3 With reference to intermolecular forces, explain the difference in melting and boiling points of HBr and H_2O. (4)

5.4 In which ONE of the substances will the weakest intermolecular forces exist in the solid phase? (1)

5.5 State whether the CH_4 molecule is POLAR or NON-POLAR, and explain your answer making reference to bond polarity, electronegativity difference and molecular shape. (4)

[13]

Question 6

Consider the following chemical equation which represents a redox reaction:

$$\mathbf{H_2\,(g) + F_2\,(g) \rightarrow 2HF\,(g)}$$

6.1 Give the NAME of the reducing agent in the above reaction. (1)

6.2 Write down the balanced equation for the OXIDATION half-reaction. (2)

[3]

Question 7

A pupil sets up a galvanic cell based on the following reaction:

$$Ni(s) + Fe^{3+}(aq) \rightarrow Ni^{2+}(aq) + Fe(s)$$

7.1 State the energy conversion that occurs in this cell. (1)

7.2 Represent this cell using cell notation. (3)

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

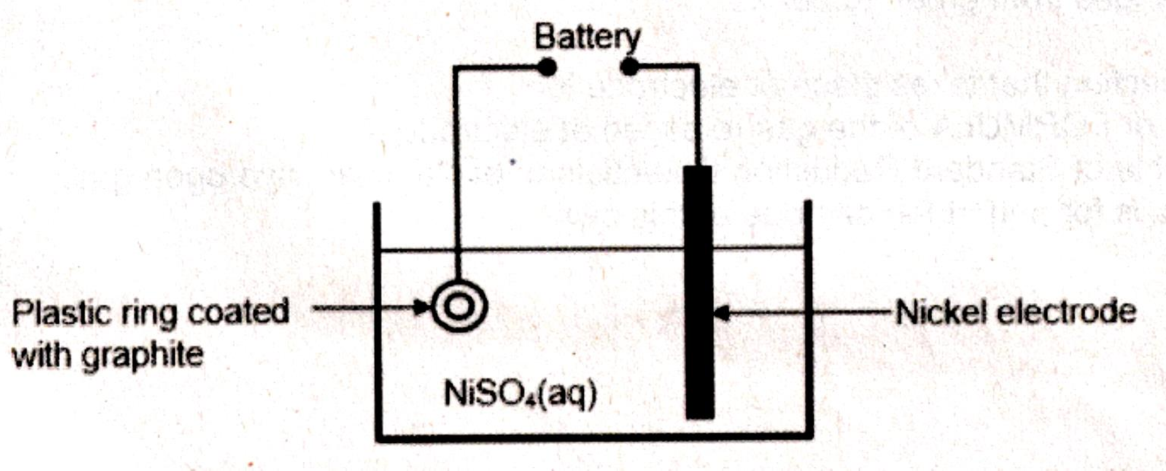
7.4 A learner sets up this cell in the classroom and immediately connects a voltmeter. She finds the emf reading to be different to the value calculated in QUESTION 7.3. Give ONE possible explanation for this incorrect reading. (1)

7.5 If 0,87 g mass is gained at the cathode, calculate the maximum mass that can be lost from the anode. (4)

[13]

Question 8

The diagram below shows a simplified electrolytic cell that can be used to electroplate a plastic ring with nickel. Prior to electroplating, the ring is covered with a graphite layer to allow it to conduct electricity.



8.1 Write down the half-reaction that occurs at the plastic ring. (2)

8.2 Which electrode, the RING or the NICKEL, is the cathode? (1)

8.3 Define the term *electrolyte*. (2)

8.4 How will the concentration of the electrolyte change during electroplating? Choose from INCREASES, DECREASES or NO CHANGE. Give a reason for your answer. (2)

[7]

Total 100

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	$6{,}02 \times 10^{23}\ mol^{-1}$

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ 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 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD- REDUKSIEPOTENSIALE

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

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 reducing ability/*Toenemende reduserende vermoë* (↑)

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

KEY/*SLEUTEL*

Atomic number / *Atoomgetal*	29
Symbol / *Simbool*	Cu
Electronegativity / *Elektronegatiwiteit*	1,9
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)
2,1 1 **H** 1																	2 **He** 4
1,0 3 **Li** 7	1,5 4 **Be** 9											2,0 5 **B** 11	2,5 6 **C** 12	3,0 7 **N** 14	3,5 8 **O** 16	4,0 9 **F** 19	10 **Ne** 20
0,9 11 **Na** 23	1,2 12 **Mg** 24											1,5 13 **Aℓ** 27	1,8 14 **Si** 28	2,1 15 **P** 31	2,5 16 **S** 32	3,0 17 **Cℓ** 35,5	18 **Ar** 40
0,8 19 **K** 39	1,0 20 **Ca** 40	1,3 21 **Sc** 45	1,5 22 **Ti** 48	1,6 23 **V** 51	1,6 24 **Cr** 52	1,5 25 **Mn** 55	1,8 26 **Fe** 56	1,8 27 **Co** 59	1,8 28 **Ni** 59	1,9 29 **Cu** 63,5	1,6 30 **Zn** 65	1,6 31 **Ga** 70	1,8 32 **Ge** 73	2,0 33 **As** 75	2,4 34 **Se** 79	2,8 35 **Br** 80	36 **Kr** 84
0,8 37 **Rb** 86	1,0 38 **Sr** 88	1,2 39 **Y** 89	1,4 40 **Zr** 91	41 **Nb** 92	1,8 42 **Mo** 96	1,9 43 **Tc**	2,2 44 **Ru** 101	2,2 45 **Rh** 103	2,2 46 **Pd** 106	1,9 47 **Ag** 108	1,7 48 **Cd** 112	1,7 49 **In** 115	1,8 50 **Sn** 119	1,9 51 **Sb** 122	2,1 52 **Te** 128	2,5 53 **I** 127	54 **Xe** 131
0,7 55 **Cs** 133	0,9 56 **Ba** 137	57 **La** 139	1,6 72 **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 81 **Tℓ** 204	1,8 82 **Pb** 207	1,9 83 **Bi** 209	2,0 84 **Po**	2,5 85 **At**	86 **Rn**
0,7 87 **Fr**	0,9 88 **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**