Hillcrest
High School

PHYSICAL SCIENCE P2

NOVEMBER 2024

Grade 11

MARKS: 125
TIME: 2½ hours

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

Instructions

1. Answer ALL the questions.
2. This question paper consists of TWO sections:
3. SECTION A (12)
   SECTION B (113)

   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 – 1.6) in the ANSWER BOOK.

1.1 The bond energy of a C—Cℓ bond is 338 kJ.mol^{-1} whereas the bond energy of a C—I bond is 238 kJ.mol^{-1}. The difference in bond energy exists because…

A the bond length of the C—Cℓ bond is greater than that of the C—I bond
B chlorine is less electronegative than iodine
C the bond length of the C—I bond is greater than that of the C—Cℓ bond
D the chlorine atom is bigger than the iodine atom

1.2 The intermolecular forces in methane (CH_4) are …

A ion-induced dipole forces
B hydrogen bonding
C dipole-dipole forces
D London forces

1.3 The shape of the molecule in which the central atom is surrounded by two lone pairs and two bonding pairs is…

A bent
B trigonal planar
C trigonal pyramidal
D tetrahedral

1.4 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 68 $kJ.mol^{-1}$

C 111 $kJ.mol^{-1}$

D 154 $kJ.mol^{-1}$

1.5 Consider the following reversible reaction:

$$HSO_3^-(aq) + H_2O(\ell) \leftrightarrows H_2SO_3(aq) + OH^-(aq)$$

The compounds HSO_3^- and OH^- in this reaction can be described as…

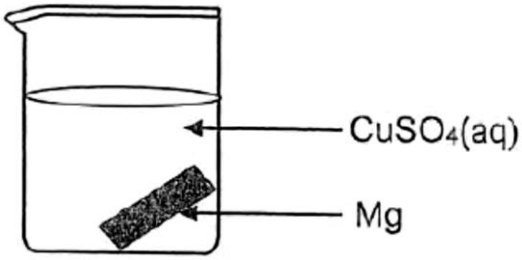
A a conjugate acid – base pair

B Lowry – Bronsted bases

C Lowry – Bronsted acids

D ampholytes

1.6 A piece of magnesium ribbon is placed in a beaker containing a blue solution of copper (II) sulphate.



After a while, it is observed that the solution becomes colourless. The reason for this is…

A Cu^{2+} is a stronger oxidising agent than Mg^{2+} and is reduced to Cu.

B Mg^{2+} is a stronger oxidising agent than Cu^{2+} and is reduced to Mg.

C Mg is a weaker reducing agent than Cu and will reduce Cu^{2+} to Cu.

D Cu is a stronger reducing agent than Mg and will oxidise Mg to Mg^{2+}.

[2 x 6 = 12]

SECTION B

Question 2

2.1 A 10 g sample of a compound contains 2,66 g of potassium, 3,54 g of chromium and 3,81 g of oxygen.

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

2.1.2 Determine the empirical formula of this compound. (6)

2.2 0,448 dm^3 of hydrochloric acid reacts with 0,5 g of calcium carbonate at STP according to the following balanced equation:

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

2.2.1 Determine the limiting reagent for this reaction. (6)

2.2.2 Calculate the total volume of gas that would be in the container after the reaction is completed. (4)

[18]

Question 3

3.1 Consider the hypothetical reaction below and the data given:

$$X_2 + Y_2 \longrightarrow 2\,XY$$

Energy of reactants = 15 $kJ.mol^{-1}$
Energy of products = 40 $kJ.mol^{-1}$
Energy of activated complex = 65 $kJ.mol^{-1}$

3.1.1 Calculate the activation energy for this reaction. (2)

3.1.2 Calculate the heat of reaction (enthalpy change). (2)

3.1.3 Is this reaction ENDOTHERMIC or EXOTHERMIC? Give a reason for your answer. (2)

3.2 A group of learners use the reaction of the decomposition of hydrogen peroxide to investigate one of the factors that affect the rate of a chemical reaction. The balanced equation for the reaction is given below:

$$2H_2O_2(aq) \rightarrow H_2O(\ell) + O_2(g)$$

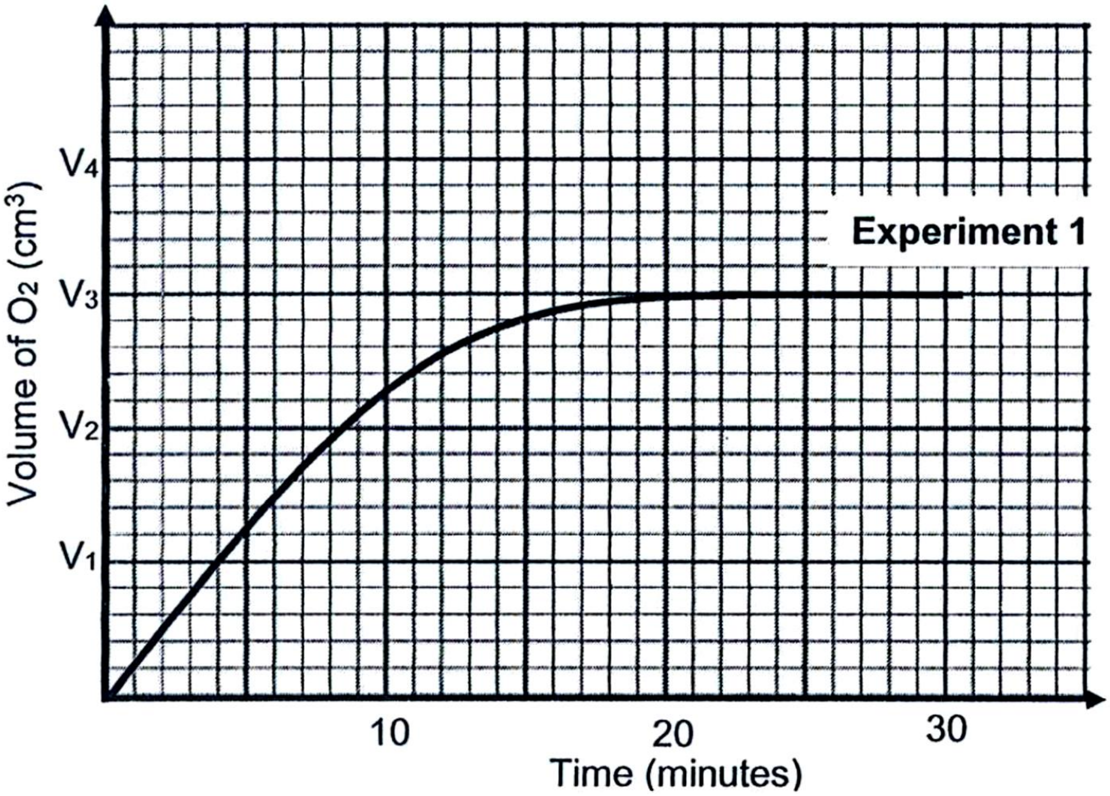
The learners collect the oxygen gas produced in a gas syringe. Two different experiments are carried out.

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

The reaction conditions for experiment **1** and **2** are summarised in the table below:

	Volume of H_2O_2 (cm^3)	Concentration of H_2O_2 ($mol{\cdot}dm^{-3}$)	Temperature (°C)
Experiment 1	40	x	25
Experiment 2	40	x	40

The results of experiment **1** are shown in the graph below:



3.2.2 Write down the INDEPENDENT variable for this investigation. (1)

3.2.3 What can be deduced from the graph regarding the rate of reaction during the time interval:

(a) 10 to 17 minutes (1)

(b) 20 – 30 minutes (1)

3.2.4 The average rate of production of oxygen gas in experiment **1** is 10 $cm^3.min^{-1}$. Use the information on the graph to calculate the initial concentration of the hydrogen peroxide used. Take the molar gas volume at 25°C to be 24 000 cm^3. (5)

3.2.5 Use the Collision Theory to explain how the change in conditions for experiment **2** will affect the rate of the reaction for this experiment. (3)

[19]

Question 4

4.1 Define a *base* in terms of the Lowry-Bronsted theory. (1)

4.2 Consider the following acid-base reaction:

$$H_2PO_4^- + NH_3 \leftrightarrows HPO_4^{2-} + NH_4^+$$

4.2.1 Identify the conjugate acid-base pairs in the above reaction. (2)

4.2.2 Write down the formula of a substance in the above reaction that is an ampholyte. (1)

4.3 A grade 11 learner dissolves 13,995 g of $Cu(NO_3)_2$ in water to make up a standard solution with a concentration of 0,15 $mol.dm^{-3}$. The learner then transfers some of this solution into a volumetric flask and adds 150 cm^3 of water to dilute it to a concentration of 0,05 $mol.dm^{-3}$.

Calculate the volume of the original solution that must be transferred to the volumetric flask to prepare the diluted solution. (4)

4.4 A flask contains 300 cm^3 of dilute sodium hydroxide, NaOH(aq), of concentration 0,167 $mol \cdot dm^{-3}$.

4.4.1 Calculate the number of moles of sodium hydroxide in the flask. (3)

Ethanoic acid of volume 500 cm^3 and of unknown concentration. **X**, is now added to this flask to give a solution **with a total volume of 800 cm^3.**

It is found that the pH of the mixture is 11,4.

The balanced equation for the reaction is:

$$NaOH(aq) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + H_2O(\ell)$$

Calculate the:

4.4.2 Concentration of the $OH^-(aq)$ in the mixture (4)
Write your answer in scientific notation.

4.4.3 Initial concentration, **X**, of the ethanoic acid solution (6)

[21]

Question 5

Electronegativity of atoms may be used to explain the polarity of bonds.

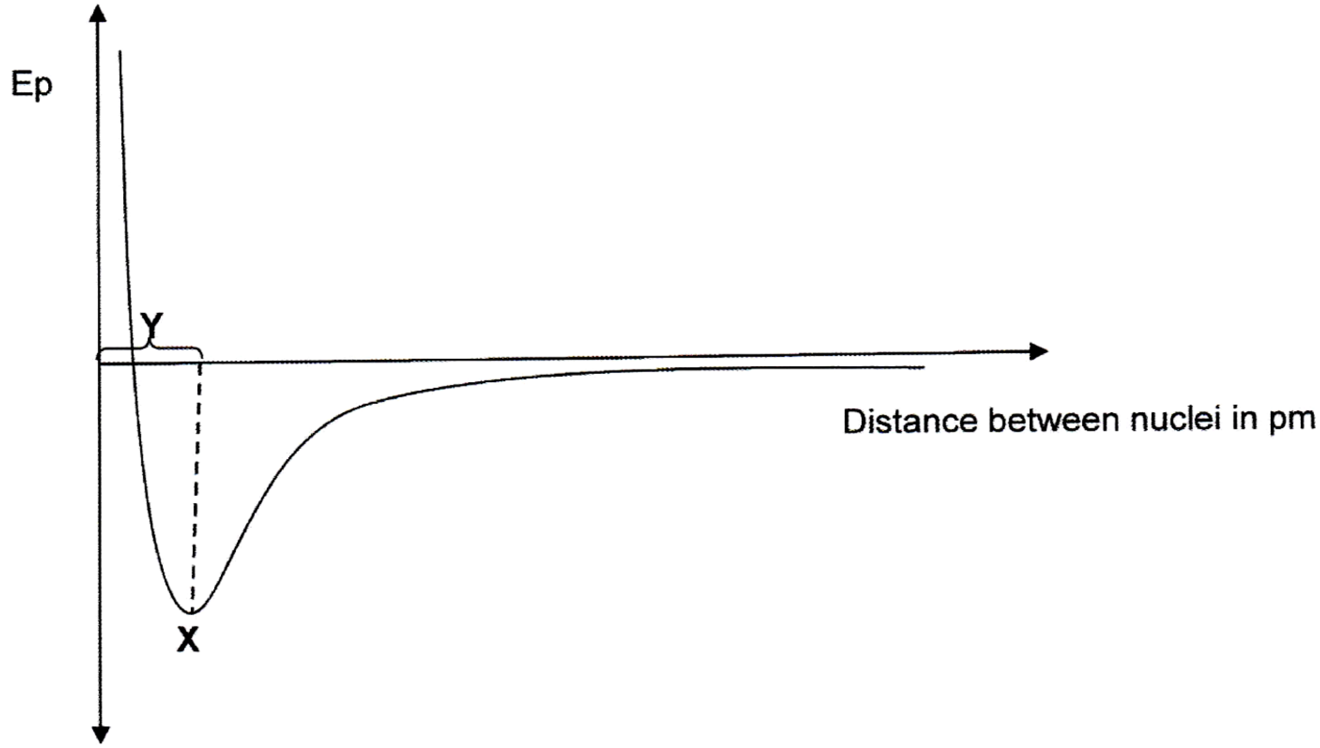
5.1 Define the term *electronegativity*. (2)

5.2 Draw the Lewis diagram of an oxygen difluoride molecule. (2)

5.3 A polar bond does not always lead to a polar molecule.

Explain this statement by referring to OF_2 and CO_2 molecules. In your explanation, refer to electronegativity difference, polarity of the bonds and shape of the molecules. (4)

5.4 The diagram below shows the energy change that takes place when two atoms move towards each other.



5.4.1 Write down what **X** and **Y** represent. (2)

5.4.2 Define the concept represented by **X**. (2)

[12]

Question 6

The table below shows the relative molecular masses, melting points and boiling points of a few substances:

Substance	Formula	Relative molecular mass ($g \cdot mol^{-1}$)	Melting point (°C)	Boiling point (°C)
Propane	C_3H_8	44	–188	–42
Butane	C_4H_{10}	58	–138	–1
Pentane	C_5H_{12}	72	–130	36
Heptane	C_7H_{16}	100	–90,5	98,4

6.1 From the substances in the table, write down the NAME of:

6.1.1 one substance that is a LIQUID at room temperature. (1)

6.1.2 The substance with the HIGHEST vapour pressure. (1)

6.2 Propane, butane, pentane and heptane are non-polar molecules.

6.2.1 Name the type of intermolecular forces present between molecules of these substances. (1)

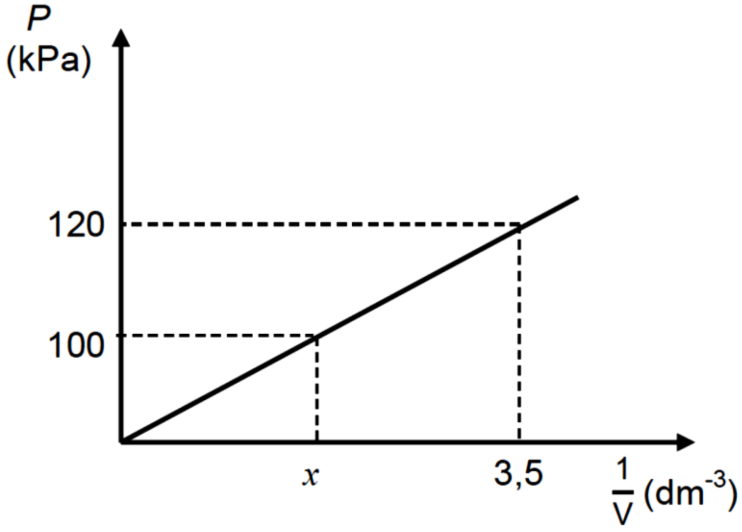
6.2.2 State the trend with respect to the boiling points of these compounds as shown in the table. (1)

6.2.3 Explain the answer to QUESTION 6.2.2 by referring to the strengths of the forces and the energies involved. (2)

[6]

Question 7

A group of learners investigated the relationship between the pressure and volume of an enclosed gas. The graph below of the pressure against the reciprocal of volume was obtained from the results:



7.1 Write a conclusion for this investigation. (2)

7.2 Name ONE variables which must be kept constant during this investigation. (1)

7.3 Calculate the value of x on the graph. (6)

7.4 Name the law that is being investigated here. (1)

[10]

Question 8

A silver Christmas tree can be made by placing copper wire, shaped in the form of a tree, into a silver nitrate solution. The unbalanced equation for the reaction is:

$$\mathbf{Cu(s) \quad + \quad AgNO_3(aq) \quad \rightarrow \; Cu(NO_3)_2(aq) \; + \; Ag(s)}$$

8.1 Define the term *oxidation* in terms of oxidation number. (1)

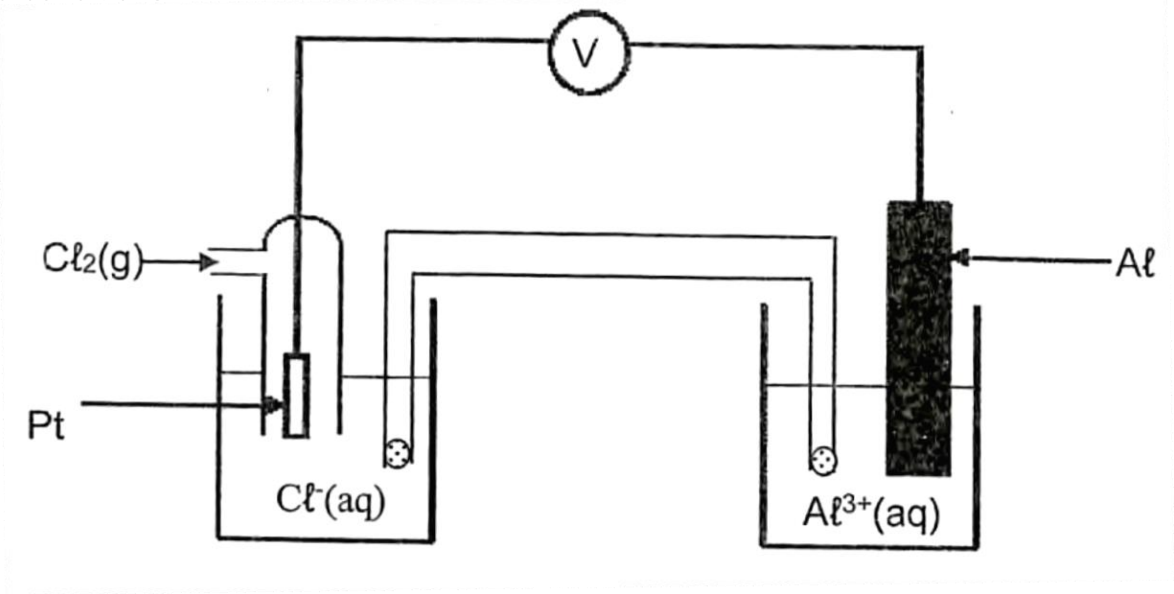
8.2 Write down the following for the reaction above:

- 8.2.1 Name of the reducing agent (1)
- 8.2.2 Formula of the oxidising agent (1)
- 8.2.3 Reduction half-reaction (2)

[5]

Question 9

The electrochemical cell shown below consists of a chlorine half cell and an aluminium half cell at standard conditions.



9.1 Write down all of the standard conditions needed for the above cell to function correctly. (3)

9.2 Write down the name of the oxidising agent in the above cell. (1)

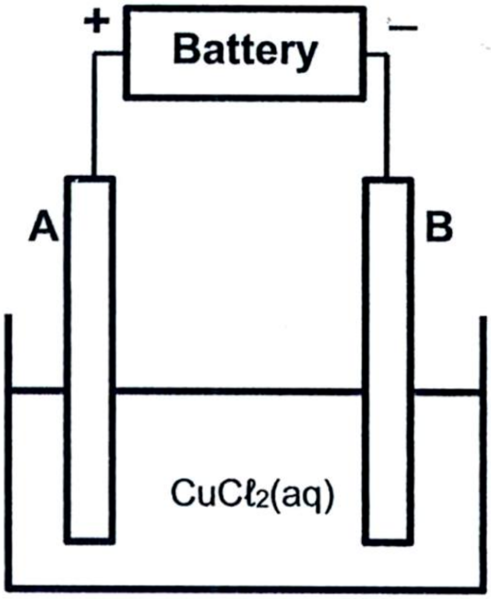
9.3 Calculate the initial emf of the above cell under standard conditions. (4)

9.4 Write down the cell notation that represents the reaction that takes place in this cell. (3)

[11]

Question 10

The simplified diagram below shows an electrolytic cell used in the purification of copper.



10.1 Define the term *electrolyte*. (2)

10.2 Which electrode, **A** or **B**, will increase in mass? (1)

10.3 Write down the equation for the half reaction that takes place at the cathode. (2)

10.4 If electrons are transferred at a rate of 7,22 x 10^{22} electrons per second when the cell is in operation, calculate the mass of pure copper that will be recovered from the ore in 1 hour. (6)

[11]

Total 125

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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

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 reducing ability/*Toenemende reduserende vermoë*

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
$2H^+ + 2e^-$	$\rightleftharpoons$	**$H_2(g)$**	**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

NAME/*NAAM*	**SYMBOL/*SIMBOOL***	**VALUE/*WAARDE***
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}\ mol^{-1}$
Molar gas constant *Molêre gaskonstante*	R	$8{,}31\ J{\cdot}K^{-1}{\cdot}mol^{-1}$
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	$273\ K$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$	$pH = -log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ 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* $E^\theta_{cell} = E^\theta_{oxidising\ agent} - E^\theta_{reducing\ agent}$ / $E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	

$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$	$pV = nRT$

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

KEY/*SLEUTEL*

Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit

29
1,9 Cu
63,5

Symbol
Simbool

Approximate relative atomic mass
Benaderde relatiewe atoommassa

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																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											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											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