higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

PHYSICAL SCIENCE

(Second paper)

NQF LEVEL 3

(10021003)

26 November 2024 (X-paper)
09:00–12:00

REQUIREMENTS: Graph paper

Non-programmable calculators may be used.

This question paper consists of 8 pages, 1 data sheet,
1 periodic table and 2 information sheets.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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NATIONAL CERTIFICATE (VOCATIONAL)
PHYSICAL SCIENCE
NQF LEVEL 3
(Second paper)
TIME: 3 HOURS
MARKS: 150

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Write your EXAMINATION NUMBER (and centre number if applicable) in the space provided in the ANSWER BOOK.
5. Start each section on a NEW page.
6. Cross out any work that you do not want to be marked.
7. Use only a blue or black pen.
8. All final answers must be accurately approximated to TWO decimal places.
9. Write neatly and legibly.

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SECTION A

QUESTION 1

Give ONE word/term for each of the following descriptions. Write only the word/term next to the question number (1.1–1.5) in the ANSWER BOOK

1.1 The volume occupied by 22,4 dm^3 of any gas at STP.

1.2 Energy absorbed or released at constant pressure when a chemical reaction has taken place.

1.3 A reaction in which two or more substances combine to form one product.

1.4 Ability to stretch without permanent deformation.

1.5 The heating up of the earth's atmosphere.

(5 × 1) **[5]**

QUESTION 2

Choose a word/term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–I) next to the question number (2.1–2.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
2.1	Hydrogen bonding	A	displacement reaction
2.2	$F = k\Delta \ell$	B	CO
2.3	$Cl_2 + 2NaI \longrightarrow 2NaCl + I_2$	C	intramolecular forces
2.4	Speeds up the rate of a chemical reaction	D	catalyst
2.5	Binds very strongly to iron in haemoglobin in the blood	E	tensile stress
		F	O_2
		G	intermolecular forces
		H	combination reaction
		I	Hooke's law

(5 × 1) **[5]**

QUESTION 3

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (3.1–3.5) in the ANSWER BOOK.

3.1 The more greenhouse gases there are (as a result of air pollution) in the atmosphere, the warmer the air near the earth's surface becomes.

3.2 The average kinetic energy of gas particles is not affected by the temperature of the gas molecules.

3.3 When there are three pairs of bonding electrons, they arrange themselves in a triangular shape.

3.4 The following reaction will occur spontaneously.
$Br_2 + NaCl \longrightarrow Cl_2 + NaBr$

3.5 The hydrogen bonds are stronger than covalent bonds and weaker than ionic bonds.

(5 × 2) **[10]**

QUESTION 4

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (4.1–4.5) in the ANSWER BOOK.

4.1 Polar substances are those substances that have polar molecules or are ionic. Which ONE of the following molecules is non-polar?

A CH_4
B NH_3
C H_2O
D HF

4.2 Hydrogen bonding is one of the strong intermolecular forces that exist between certain molecules. Which ONE of the following hydrogen halides will have a strong hydrogen bonding?

A HI
B HBr
C HCl
D HF

4.3 During displacement reactions, a more reactive element displaces a lesser reactive element. which reaction equation represents a non-spontaneous reaction.

A $Zn + CuSO_4 \longrightarrow Cu + ZnSO_4$
B $Mg + CuSO_4 \longrightarrow Cu + MgSO_4$
C $Cu + FeSO_4 \longrightarrow Fe + CuSO_4$
D $Fe + CuSO_4 \longrightarrow Cu + FeSO_4$

4.4 Catalysts are introduced in chemical reactions to speed up the rate at which products are formed or reactants are consumed. They achieve this by …

A increasing the energy of the reactants.
B lowering the activation energy.
C increasing the activation energy.
D changing the dimension of the activated complex.

4.5 Which ONE of the following gases does NOT contribute to the formation of acid rain?

A CO_2
B CH_4
C NO_2
D SO_2

(5 × 3) **[15]**

TOTAL SECTION A: 35

SECTION B

QUESTION 5

5.1 Describe the following mechanical properties of matter:

5.1.1 Ductility

5.1.2 Brittleness

(2 × 2) (4)

5.2 Differentiate between *elasticity* and *plasticity*. (2)

5.3 Answer the following questions about the sulphide ion:

5.3.1 Write down the chemical symbol for the sulphide ion. (1)

5.3.2 Write down the electron configuration of the sulphide ion in sp notation. (2)

5.3.3 Does the sulphide ion above obey the octet rule? Explain. (2)

5.3.4 Which noble gas does this configuration of sulphide ion resemble? (1)

5.4 Both methane (CH_4) and ammonia (NH_3) are covalent hydrides, but they behave differently.

5.4.1 Name the intermolecular forces found in each molecule.

5.4.2 Which one of these hydrides has a highest boiling point and why?

5.4.3 Explain why methane is non-polar.

5.4.4 Explain why ammonia is polar.

5.4.5 What is the shape of each molecule?

(5 × 2) (10)

5.5 A tank holds 100 dm^3 of water. The tank is full, and the temperature of water is increased from 22 ^oC to 49 ^oC. The coefficient of volume expansion of water is 7,5 × 10 $^oC^{-1}$.

5.5.1 Explain why liquids expand more rapidly than solids. (2)

5.5.2 Calculate the change in volume of water in the tank. (4)

5.5.3 State the relationship between *viscosity* and *temperature*. (2)

[30]

QUESTION 6

6.1 State THREE properties of an ideal gas. (3)

6.2 How does the pressure of an enclosed gas and its volume compare? (2)

6.3 The following values were obtained during the demonstration of a gas law, which states the relationship between volume and temperature of a gas at a constant pressure (1 atm).

Volume in dm^3	Temperature in ^0C	Temperature in kelvin (K)
70	-179	
140	-87	
210	6	
280	99	

6.3.1 Redraw and complete the table in your ANSWER BOOK. (2)

6.3.2 State Charles' Law. (2)

6.3.3 Plot a graph of volume versus temperature in kelvin. (4)

6.3.4 If the temperature were increased to 120 ^oC, calculate the new volume of the gas by using Charles' Law equation. (4)

6.4 Explain the following statement:

The specific heat capacity of water is 4 200 J.kg^{-1} $^oC^{-1}$. (2)

6.5 A piece of aluminium of mass 2 kg is heated to 100 ^oC and then placed in 1,6 kg of water with a temperature of 10 ^oC. If the resulting temperature of the mixture is 30 ^oC, what is the specific heat capacity of aluminium if that of water is 4 200 J.kg^{-1} $^oC^{-1}$? (5)

[24]

QUESTION 7

7.1 Draw a fully labelled potential energy diagram for the reaction represented by the following equation: $CaO + H_2O \longrightarrow Ca(OH)_2 \quad \Delta H < 0$ (8)

7.2 When 10 g of carbon dioxide gas is bubbled through a solution of $Ca(OH)_2$, a precipitate is formed as shown by the following reaction equation:
$Ca(OH)_2 + CO_2 \longrightarrow \downarrow CaCO_3 + H_2O$

7.2.1 Name the precipitate formed. (2)

7.2.2 Balance this chemical equation. (2)

7.2.3 Show that the mass is conserved in this reaction. (5)

7.2.4 Calculate the mass of $CaCO_3$ produced in this reaction if all of the 10 g of CO_2 is used in the reaction. (5)

7.3 Researchers have found that 1 mol of any gas occupies 22,4 dm^3 at STP. SO gas reacts with oxygen gas according to the following balanced chemical equation: $2SO_{2(g)} + O_{2(g)} \longrightarrow 2SO_3$

7.3.1 What is the molar gas volume? (2)

7.3.2 If 268,8 dm^3 of SO_3 was produced at STP, what was the total volume of the reactants used for the reaction? (6)

[30]

QUESTION 8

8.1 Balance the following chemical equations, and in each case indicate the type of reaction that is taking place.

8.1.1 $KC\ell O_3 + \text{heat} \longrightarrow KC\ell + O_2$

8.1.2 $kBr + C\ell_2 \longrightarrow kC\ell + Br_2$

8.1.3 $NO + O_2 \longrightarrow NO_2$

(3 × 3) (9)

8.2 A group of L3 students are investigating the reaction between magnesium and oxygen. They put magnesium ribbon over flame and observed, without directly looking at the magnesium ribbon while it burns.

8.2.1 What is the colour of the flame produced when magnesium burns in flame? (1)

8.2.2 What type of a reaction is this, decomposition or combination? (1)

8.2.3 Is the product formed basic or acidic oxide? Explain. (2)

8.2.4 Would we regard this reaction as exothermic or endothermic? (2)

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8.2.5 Provide a chemical name for the product formed. (1)

8.2.6 Arrange the following metals in order of increasing reactivity: Mg, Ca and Zn (3)

8.3 Indicate which are reactants and which are the products by redrawing the table below and filling in the missing information:

Reaction	Reactants	Products
$N_2 + 3H_2 \longrightarrow 2NH_3$		NH_3
$Cl_2 + NaBr \longrightarrow Br_2 + NaCl$		
$CuCO_3 \longrightarrow CuO + CO_2$	$CuCO_3$	

(4)
[23]

QUESTION 9

9.1 State TWO uses of each of the following industrial gases:

9.1.1 Methane

9.1.2 Hydrogen chloride

9.1.3 Carbon dioxide

(3 × 2) (6)

9.2 In the chemical industry a wide range of gases like methane, nitrogen, oxygen, ammonia and carbon dioxide are used in their industrial productions.

Identify the gas in each of the following applications:

9.2.1 The gas that supports life during respiration

9.2.2 The gas that is used in the manufacture of fertilizers

(2 × 1) (2)
[8]

TOTAL SECTION B: 115
GRAND TOTAL: 150

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DATA FOR PHYSICAL SCIENCES
PAPER 2 (CHEMISTRY)

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Avogadro's constant	N_A	$6{,}02 \times 10^{23}$ mol^{-1}
Molar gas constant	R	8,31 J·K^{-1}·mol^{-1}
Standard pressure	p^{θ}	$1{,}013 \times 10^{5}$ Pa
Molar gas volume at STP	V_m	22,4 dm^3·mol^{-1}
Standard temperature	T^{θ}	273 K

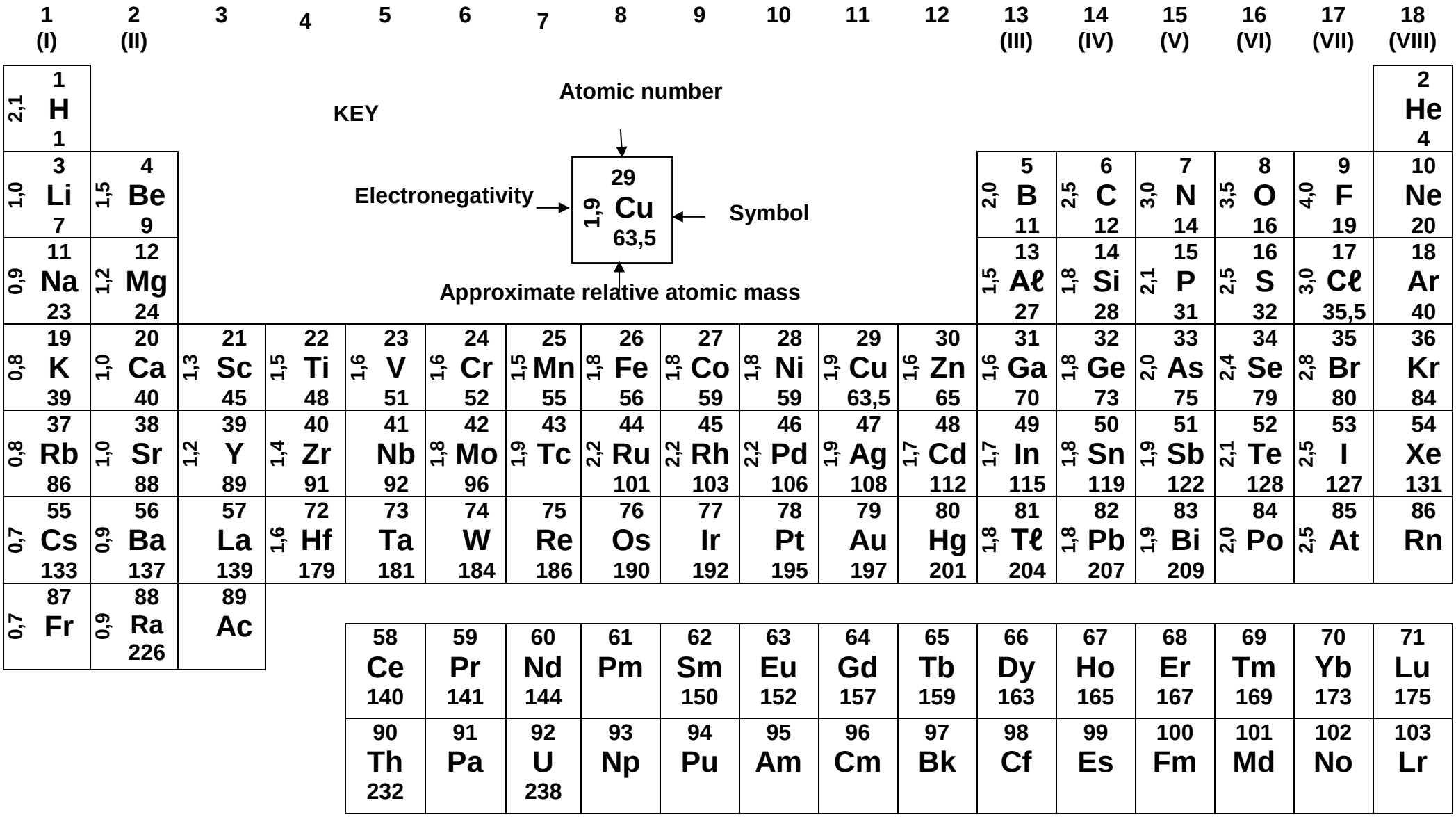
TABLE 2: FORMULAE

$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$	$pV = nRT$
$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$n = \frac{V}{V_m}$	$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$

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TABLE 3: THE PERIODIC TABLE OF THE ELEMENTS



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TABLE 4A: STANDARD REDUCTION POTENTIALS

*Toenemende oksiderende vermoë/*Increasing oxidising ability ↑

***Halfreaksies/*Half-reactions**			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

*Toenemende reduserende vermoë/*Increasing reducing ability ↓

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TABLE 4B: STANDARD REDUCTION POTENTIALS

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	− 2,37
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	− 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* ↑

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