GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GAUTENG DEPARTMENT OF EDUCATION

PROVINCIAL EXAMINATION

NOVEMBER 2021

GRADE 11

PHYSICAL SCIENCES (CHEMISTRY)

PAPER 2

TIME: 2 hours

MARKS: 100

10 pages and 4 data sheets

INSTRUCTIONS AND INFORMATION

1. Write your name in the appropriate space on the ANSWER BOOK.
2. This question paper consists of EIGHT questions. Answer ALL 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 sub-questions, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached DATA SHEETS.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your FINAL numerical answers to a minimum of TWO decimal places.
11. Give brief motivations, discussions, et cetera, where required.
12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four 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 E. Each question has only ONE correct answer.

1.1 The intermolecular forces between two non-polar molecules are …

A ionic bonds.
B London forces.
C hydrogen bonds.
D dipole-dipole forces. (2)

1.2 Which statement best explains the formation of the dative bond between water (H_2O) and the hydrogen ion (H^+)?

A Both H_2O and H^+ are polar.
B The electronegativity of the oxygen atom is greater than the electronegativity of hydrogen.
C H^+ ion is regarded as a proton and is attracted to the electrons on the oxygen atom of the H_2O molecule.
D The H_2O molecule has two lone pairs of electrons and the H^+ ion has an empty orbital. (2)

1.3 Which of the following is NOT a property of an ideal gas?

A There are no forces of attraction between the molecules.
B The collisions between the molecules are perfectly elastic.
C The volume occupied by the gas is equal to the total volume of all the individual molecules.
D The product of the pressure and the volume of the gas is constant at constant temperature. (2)

1.4 Which of the following gases occupies the biggest volume at STP?

A 17 g ammonia
B 8 g helium
C 16 g oxygen
D 28 g nitrogen (2)

1.5 The activation energy for the forward reaction of the reaction below is 230 $kJ.mol^{-1.}$

$A_2 + B_2 \rightarrow 2C \quad \Delta H = + 150\ kJ.mol^{-1}$

What is the activation energy for the reverse reaction, in $kJ.mol^{-1}$?

A 380
B 230
C 150
D 80 (2)

1.6 The strongest oxidising agent is ...

A $KMnO_4$.
B MnO_2.
C HNO_3.
D O_2. (2)

1.7 Sodium and chlorine react together to form sodium chloride, according the following balanced reaction:

$$2Na + Cl_2 \rightarrow 2NaCl$$

Which of the following statements is correct?

A Sodium is oxidised and is the oxidising agent.
B Chlorine is reduced and is the reducing agent.
C Sodium is oxidised and is the reducing agent.
D Chlorine is oxidised and is the reducing agent. (2)

1.8 Which conjugate acid-base pair is shown in the following equation?

$H_2S(g) + H_2O(1) \rightleftharpoons HS^{-1}(aq) + H_3O+(aq)$

A H_2O & H_3O^+
B H_2S & H_3O^+
C H_2O & H_2S
D H_2S & H_2. (2)

1.9 Which of the following substances can behave as an ampholyte?

A H_2SO_4
B HSO_4^{-1}
C SO_2
D SO_4^{-2} (2)

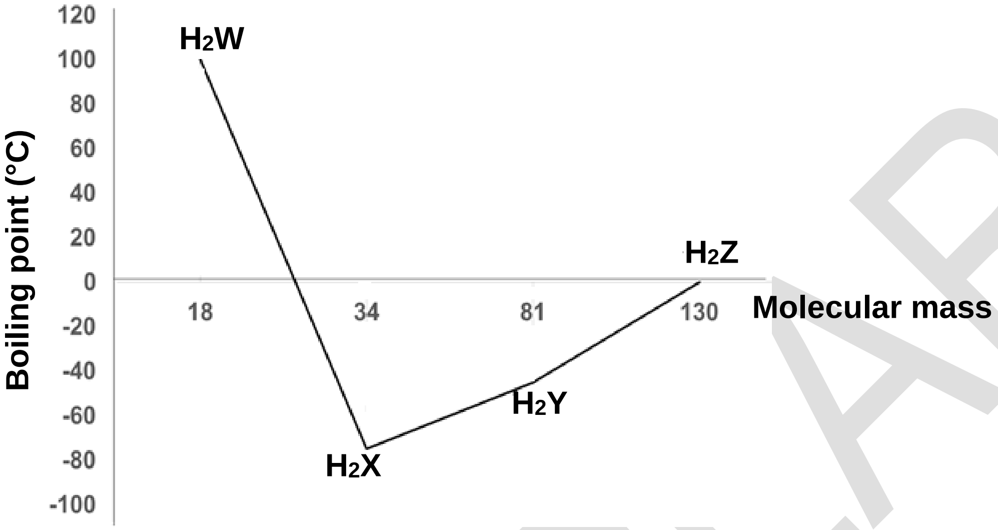
1.10 How many moles are there in 5,6 dm^3 of chlorine gas at STP?

A 2,8 mol
B 125,44 mol
C 0,25 mol
D 11,3 mol (2)

[20]

QUESTION 2 (Start on a new page.)

The graph below shows the relationship between the boiling points of the hydrides of the Group 16 elements and molecular mass.



2.1 Define the term *boiling point.* (2)

2.2 Consider the Group 16 compounds, excluding H_2W.

2.2.1 State the relationship between the molecular mass and the boiling points of the compounds. (2)

2.2.2 Explain this trend at boiling points. Refer to molecular mass, intermolecular forces and energy in your answer. (3)

2.3 H_2W does not follow the trend at boiling point for the Group 16 elements.

2.3.1 Identify the compound H_2W. (1)

2.3.2 Name the intermolecular forces present in this compound. (2)

2.3.3 Explain why the boiling point is higher than expected. (2)

[12]

QUESTION 3 (Start on a new page.)

Hydrogen fluoride (HF) is used in the manufacturing of refrigerants, herbicides, pharmaceuticals and gasoline. Hydrogen fluoride (HF) can be prepared by treating calcium fluoride with sulphuric acid, according to the following balanced equation.

$$CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$$

3.1 Draw a Lewis diagram for:

3.1.1 HF (2)

3.1.2 CaF_2 (2)

3.2 Define a *polar covalent bond.* (2)

3.3 Which of the TWO products of this reaction would most likely be:

3.3.1 A gas at room temperature? (1)

3.3.2 A crystalline solid at room temperature? (1)

3.4 Define *electronegativity.* (2)

3.5 Use electronegativity to determine the type of bond that will form in CaF_2. (2)

3.6 Will HF be a polar or non-polar molecule? (1)

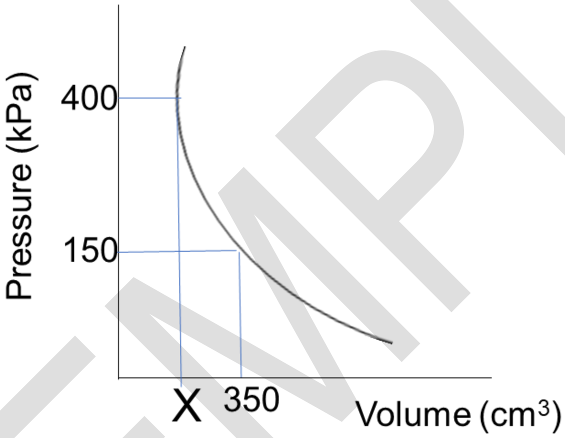
3.7 Explain the answer to QUESTION 3.6 using a calculation. (2)

[15]

QUESTION 4 (Start on a new page.)

Learners conducted an investigation to determine the relationship between the pressure and volume of a given mass of gas, while keeping the temperature constant. They changed the volume of the gas using the apparatus as shown below. The pressure gauge is used to measure the pressure of the gas in the syringe.

They plotted their results as shown in the graph below.



4.1 Write a suitable investigative question for this investigation. (2)

4.2 Write down the following:

4.2.1 Independent variable (1)

4.2.2 Controlled variable (1)

4.3 State, in words, the law that is being investigated. (2)

4.4 Calculate the value of **X** using other values given on the graph. (3)

4.5 Like all real gases, this gas will liquefy under high pressures. Explain why this happens. (2)

[11]

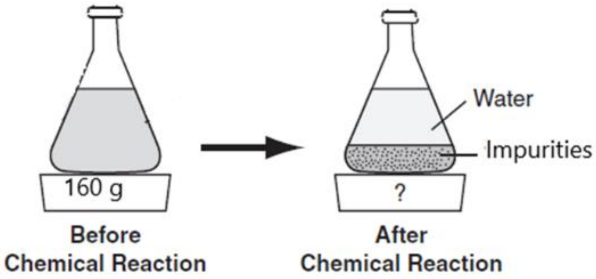
QUESTION 5 (Start on a new page.)

Sulphur dioxide has a pungent, irritating odour, similar to the smell of a just-struck match. Although its chief uses are in the preparation of sulphuric acid, sulphur trioxide and sulphites, sulphur dioxide is also used as a disinfectant, a refrigerant, a reducing agent, a bleach, and a food preservative, especially in dried fruits.

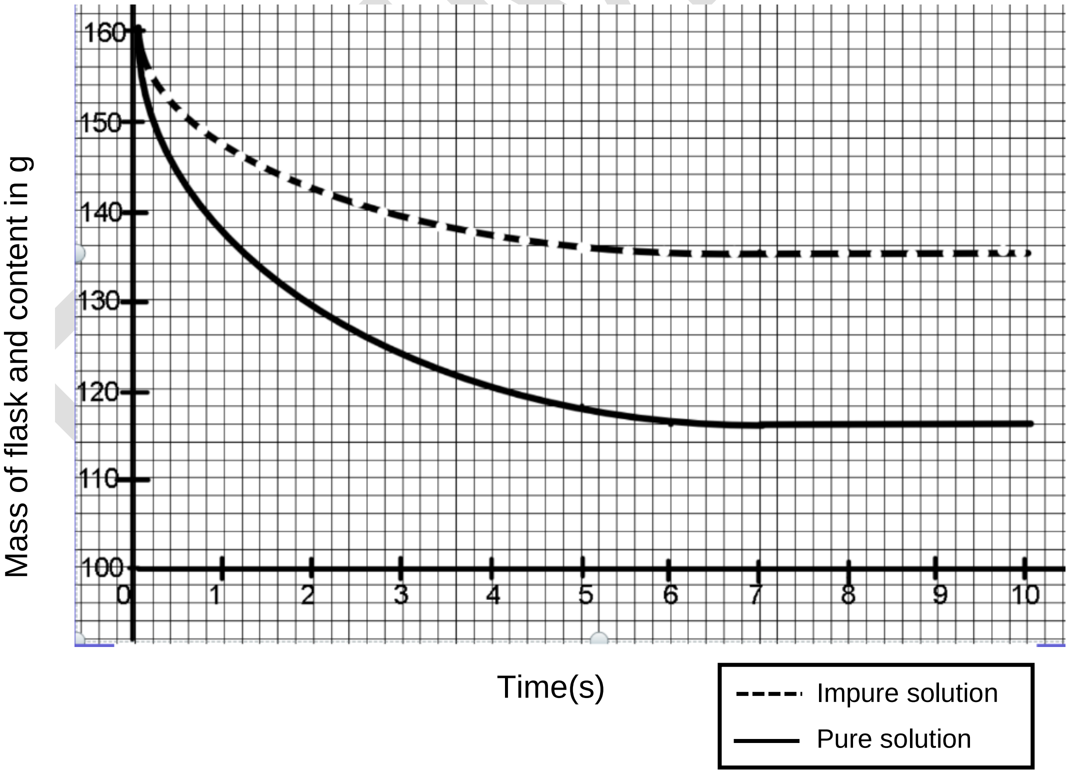
The balanced equation of the decomposition of sulphurous acid, H_2SO_3 is:

$$H_2SO_{3(aq)} \rightarrow H_2O_{(\ell)} + SO_{2(g)}$$

Two samples H_2SO_3 with equal mass of which one is pure, and one is impure, are placed in open containers on a balancing scale, as shown in the diagram below:



The graph below shows the results obtained and the graph becomes parallel to the x-axis when the reaction is complete.



5.1 Explain why the mass of the flask with its contents decreases. (2)

5.2 At which time did the reaction of the pure H_2SO_3 stop? (2)

5.3 Calculate the change in the mass of the pure sample H_2SO_3. (3)

5.4 Calculate the percentage yield of the impure sample of H_2SO_3. (4)

100 g of SO_2 has now reacted with 50 g of O_2, according to the following balanced equation:

$$2SO_2 + O_2 \rightarrow 2SO_3$$

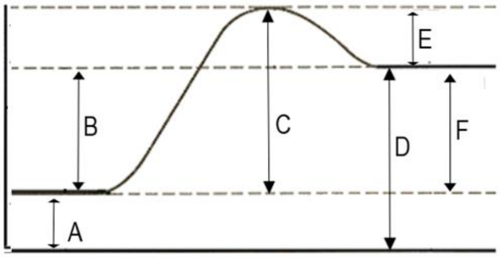
5.5 Calculate the number of moles of SO_2 and O_2. (3)

5.6 Determine which substance is the limiting reactant. (2)

5.7 Calculate the mass of SO_3 produced. (3)
[19]

QUESTION 6 (Start on a new page.)

Chemical cold packs are often used to reduce swelling after an athletic injury. A common example of a chemical ice pack is one that contains water and a packet of ammonium chloride. The cold pack is activated by breaking the barrier separating the water and ammonium chloride, allowing them to mix. The diagram below represents the potential energy changes when a cold pack is activated.



6.1 Is this an exothermic or endothermic reaction? (1)

6.2 Give ONE reason for the answer to QUESTION 6.1. (1)

6.3 Which letter on the diagram represents the activation energy of the forward reaction? (1)

6.4 Explain how a catalyst would affect the activation energy in the reaction? (2)

6.5 Explain why a "cold pack" would be effective in reducing swelling after an individual had twisted his/her ankle. Refer to the kinetic molecular theory in your answer. (2)
[7]

QUESTION 7: (Start on a new page.)

In the Haber process**,** nitrogen (extracted from the air) and hydrogen (obtained from natural gas) are pumped through pipes. The pressure of the mixture of gases is increased to 200 atmospheres. The pressurised gases are heated to 450°C and passed through a tank containing an iron catalyst, to form ammonia (NH_3), according to the following balanced equation:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

7.1 Define the term *oxidation* in terms of electron transfer. (2)

7.2 Write down the reduction half reaction. (2)

7.3 Identify the oxidising agent. (2)

7.4 Nitrogen can react in different ways. Calculate the oxidation number of nitrogen in HNO_3. (2)
[8]

QUESTION 8 (Start on a new page.)

Acids and bases play a large part in industrial chemistry and in everyday life. Almost every biological chemical process is tightly bound up with acid-base equilibria in the organism, and the acidity or alkalinity of the soil and water are of great importance for the plants or animals living in them.

8.1 Define a *Bronsted-Lowry* acid. (2)

8.2 Predict the products and write a balanced equation for the following chemical reaction:

$$H_2SO_4 + MgCO_3 \rightarrow$$ (2)

8.3 Identify the Bronsted-Lowry acid and base and their conjugate pair in the following reaction:

$$NaCN_{(aq)} + HBr_{(aq)} \rightarrow NaBr_{(aq)} + HCN_{(aq)}$$ (4)
[8]

TOTAL: 100

END

DATA FOR PHYSICAL SCIENCES GRADE 11
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 11
VRAESTEL 2 (CHEMIE)

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

NAME/*NAAM*	**SYMBOL/*SIMBOOL***	**VALUE/*WAARDE***
Avogadro's constant/ *Avogadro se konstante*	N_A	$6,02 \times 10^{23}$ mol^{-1}
Molar gas constant/ *Molêre gaskonstante*	R	8,31 J·K^{-1}·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·mol^{-1}
Standard temperature/ *Standaardtemperatuur*	T^θ	273 K

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

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

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

KEY/*SLEUTEL*

Atomic number
Atoomgetal

29
1,9 Cu
63,5

Electronegativity
Elektronegatiwiteit

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

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
$\mathbf{2H^+ + 2e^-}$	**⇌**	$\mathbf{H_2(g)}$	**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*

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
$Pt^{2+} + 2\ e^-$	$\rightleftharpoons$	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
$H_2O_2 + 2H^+ + 2\ e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,77
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87

Increasing reducing ability/*Toenemende reduserende vermoë*