LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

NATIONAL
SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY P2
JUNE 2024

TOTAL: 150

TIME: 3 HOURS

INSTRUCTIONS AND INFORMATION

1. Write your name and other applicable information in the appropriate spaces on the ANSWER BOOK.
2. The question paper consists of SEVEN 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 sub-questions, for example between QUESTION 3.1 and QUESTION 3.2.
6. Non-programmable pocket calculators may be used.
7. Appropriate mathematical instruments may be used.
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 where necessary.
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. Each question has only ONE correct answer. Choose the answer and write only the letter (A – D) next to the question number (1.1 – 1.10) in your ANSWER BOOK, for example 1.11 E.

1.1 $C_nH_{2n+1}OH$ is the GENERAL FORMULA for:

A Alkanes

B Aldehydes

C Alcohols

D Alkenes (2)

1.2 The functional group of carboxylic acids is:

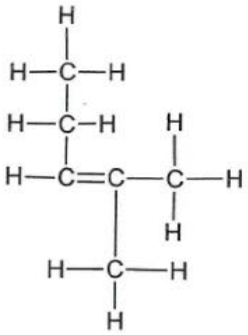
A – COO –

B – COOH

C – OH

D – CHO (2)

1.3 Consider the following structural formula of an organic compound.



The IUPAC name of this compound is:

A 2-methyl-3-ethylprop-1-ene

B 2-methyl-1-ethylprop-1-ene

C 4-methylpent-3-ene

D 2-methylpent-2-ene (2)

1.4 Which ONE of the following represents an acid-catalysed condensation reaction?

A Hydration

B Esterification

C Hydrolysis

D Dehydration (2)

1.5 50 cm^3 of a 0,1 $mol.dm^{-3}$ solution of hydrochloric acid is poured on to 5 g of granulated zinc which is inside a glass beaker at room temperature. Which one of the following factors will **not** increase the initial rate of the reaction?

A Grinding the granulated zinc into powder.

B Using 30 cm^3 of a 0,2 $mol.dm^{-3}$ hydrochloric acid at room temperature.

C Increasing the temperature of the acid solution to 50 °C

D Using 100 cm^3 of a 0,1 $mol.dm^{-3}$ solution of hydrochloric acid at room temperature. (2)

1.6 The reaction represented below reaches equilibrium in a closed container.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H > 0$$

Which ONE of the following changes will increase the yield of $H_2(g)$?

A Add a catalyst.

B Decrease pressure by increasing the volume.

C Decrease the temperature.

D Increase pressure by decreasing the volume. (2)

1.7 Consider the reaction:

$$2H_2O(\ell) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

The equilibrium constant for this reaction at 25 °C is 10^{-14}. At 60 °C the equilibrium constant for this reaction is 10^{-13}. From the above information one can conclude that this reaction at 60 °C …

A is an exothermic reaction.

B has a high product yield.

C the concentration of H_3O^+ decreases.

D the concentration of products does not change. (2)

1.8 A saturated solution of NaCℓ in water is prepared at 50 °C. The equation for this equilibrium is:

$$NaC\ell(s) \rightleftharpoons Na^+(aq) + C\ell^-(aq) \qquad \triangle H > 0$$

Which ONE of the following changes will cause more NaCℓ(s) to form?

A Add dilute hydrochloric acid.

B Add a catalyst at constant temperature.

C Increase the pressure on the solution.

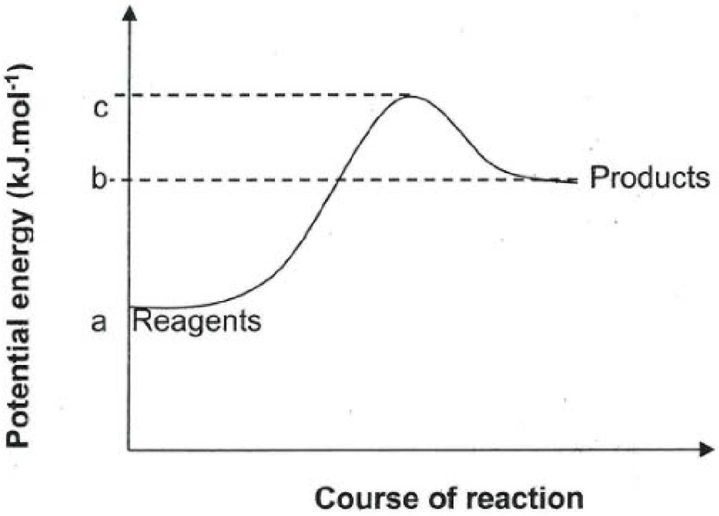
D Decrease the temperature. (2)

1.9 Which ONE of the following is TRUE if the ACIDITY of a solutions increases.

	$[H_3O^+]$	pH
A	Increase	Increase
B	Increase	Decrease
C	Decrease	Increase
D	Decrease	Decrease

(2)

1.10 The potential energy graph for a hypothetical chemical reaction is shown below.



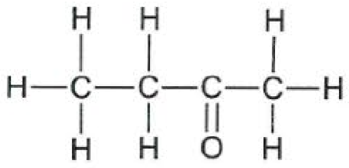
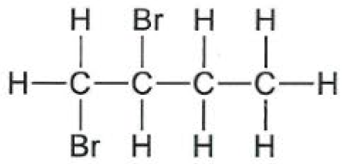
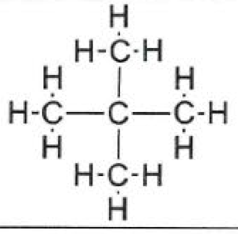
What type of reaction takes place and what are the correct methods to calculate ∆H and Ea?

	TYPE OF REACTION	∆H	Ea
A	Exothermic	b – a	c – b
B	Endothermic	b – a	c – a
C	Endothermic	a – b	a – c
D	Exothermic	a – b	b – c

(2)
[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **F** in the table below represent six organic compounds.

A	Butanal	**B**	CH_2CH_2
C		**D**	
E		**F**	Ethyl ethanoate

Use the information in the table to answer the questions that follow.

2.1 Write down the letter(s) representing:

2.1.1 A compound with the general formula C_nH_{2n+2} (1)

2.1.2 A ketone (1)

2.1.3 An aldehyde (1)

2.1.4 An unsaturated hydrocarbon (1)

2.2 For compound **F**, write down the:

2.2.1 Structure of the functional group to which it belongs. (2)

2.2.2 IUPAC name of the acid and an alcohol needed to prepare **F**. (2)

2.2.3 Balanced equation, using structural formulas, for the formation of **F**. (5)

2.3 Write down the IUPAC name of:

2.3.1 Compound **C** (2)

2.3.2 Compound **D** (2)

2.4 Write down the condensed structural formula for **C**. (2)

2.5 Write down the structural formula of:

2.5.1 A chain isomer of compound **E** (2)

2.5.2 Compound **F** (2)

2.6 Write down the NAME or FORMULA of each product formed during the complete combustion of compound **E**. (2)

2.7 A few drops of fresh reddish-brown bromine water are added to compound B in a test tube.

2.7.1 Describe what will be observed in the test tube. (1)

2.7.2 Use structural formulas to write a balanced equation for the reaction that takes place in the test tube. (4)

[30]

QUESTION 3 (Start on a new page.)

Two different experiments are performed to determine the boiling points of organic compounds of different homologous series under the same conditions. The results obtained are shown in the table below.

Experiment	**Organic compound**		**Relative Molecular Mass**	**Boiling Point (°C)**
I	P	CH_3F		-78,3
	Q	$CH_3C\ell$		-24,1
	R	CH_3Br		3,7
II	X	$CH_3(CH_2)_2COOH$	88,1	163
	Y	$CH_3(CH_2)_3CH_2OH$	88,1	137
	Z	$CH_3(CH_2)_3CHO$	88,1	103

3.1 Define the term *homologous series*. (2)

3.2 Give one word for: *The temperature at which the vapour pressure of a substance equals the atmospheric pressure.* (1)

3.3 Write down the independent variable for **Experiment I**. (1)

3.4 From the table, write down the IUPAC names of TWO compounds that would be gases at –20°C. (2)

3.5 Describe the trend in the boiling points of the compounds in **Experiment I**. (2)

3.6 Explain the trend in QUESTION 3.5 above.
Refers to INTERMOLECULAR FORCES and ENERGY needed in you explanation. (3)

Use the data for Experiment II to answer QUESTIONS 3.7 – 3.9.

3.7 Formulate an investigative question for the experiment. (2)

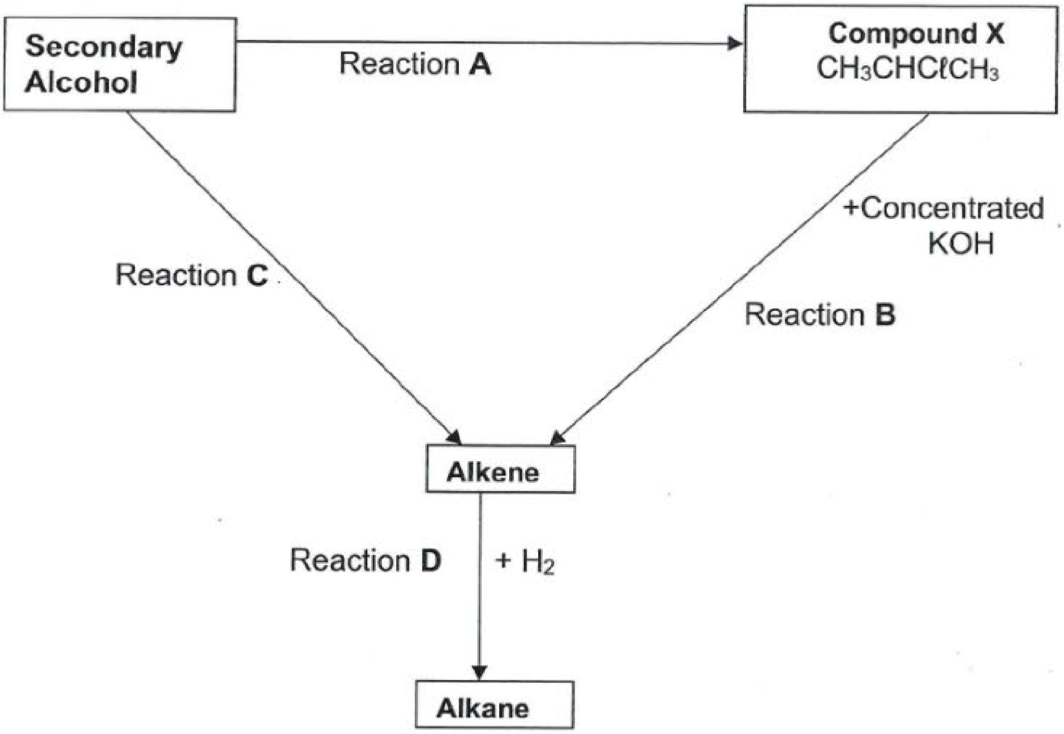
3.8 NAME a variable that must be kept constant in this experiment. (1)

3.9 State the conclusion that can be drawn from the results of this experiment. (2)

[16]

QUESTION 4 (Start on a new page.)

The flow diagram below shows how alcohols can react to form other organic compounds.



4.1 Write down the type of reaction represented by reaction:

4.1.1 **A** (1)

4.1.2 **B** (1)

4.1.3 **D** (1)

4.2 In reaction **B**, compound **X** is converted to an alkene. Write down the:

4.2.1 IUPAC name of compound **X.** (2)

4.2.2 Balanced equation for the reaction **B**, using structural formulae. (4)

4.3 Reaction **C** takes place in the presence of a strong acid.

4.3.1 Explain the term *secondary alcohol.* (2)

4.3.2 Write down the IUPAC name of the alcohol used. (2)

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QUESTION 5 (Start on a new page.)

NOTE: The graph for QUESTION 5.3.2 must be drawn on the GRAPH SHEET attached at the end of the QUESTION PAPER.

Methanol and hydrochloric acid react according to the following balanced equation:

$$CH_3OH\,(aq) + HC\ell\,(aq) \rightarrow CH_3C\ell\,(aq) + H_2O\,(\ell)$$

5.1 Give two ways how the rate of this reaction can be increased. (2)

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

5.3 The rate of the reaction between methanol and hydrochloric acid is investigated.
The concentration of HCℓ (aq) was measured at different time intervals.
The following results were obtained:

TIME (minutes)	**HCℓ consentration (mol.dm^{-3})**
0	1,90
15	1,45
55	1,10
100	0,85
215	0,60

5.3.1 Calculate the average reaction rate, in (mol·dm^{-3})·min^{-1} during the first 15 minutes. (3)

5.3.2 Use the data in the table to draw a graph of concentration versus time on the attached graph sheet.
NOTE: The graph is not a straight line.
(ATTACH THIS GRAPH SHEET TO YOUR ANSWER BOOK.) (3)

5.3.3 From the graph, determine the concentration of HCℓ (aq) at the 40th minute. (2)

5.3.4 Use the collision theory to explain why the reaction rate decreases with time. Assume that the temperature remains constant. (3)

5.3.5 Calculate the mass of $CH_3C\ell$ (aq) in the flask at the 215th minute. The volume of the reagents remains 60 cm^3 during the reaction. (5)

[20]

QUESTION 6 (Start on a new page.)

Many industries in South Africa rely on sulphuric acid and the compounds it is used to produce. The large-scale production of sulphuric acid involves the following equilibrium:

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g) \qquad \Delta H < 0$$

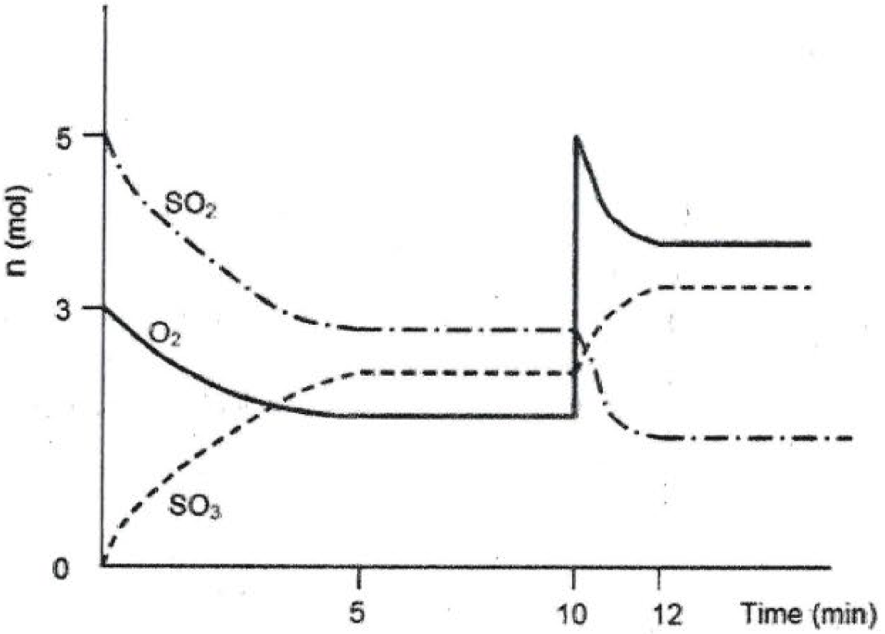
6.1 State *Le Chatelier's Principle.* (2)

6.2 How will each of the following changes affect the yield of SO_3 (g) at equilibrium?
Choose from INCREASES, DECREASES and REMAINS THE SAME.
Explain by using Le Chatelier's Principle.

6.2.1 An increase in pressure by decreasing the volume. (3)

6.2.2 An increase in temperature. (3)

6.3 In a laboratory experiment, 5 mol SO_2 and 3 mol O_2 are sealed in a 2 dm^3 container. The graph below shows how the number of moles of reactants and products change over a 15 minute period.

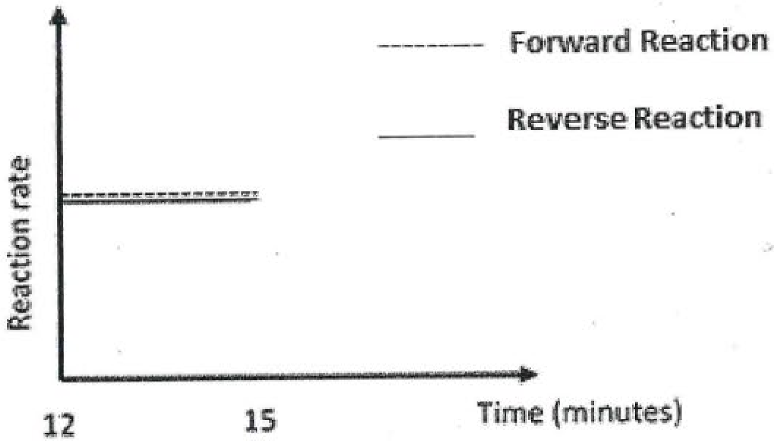


6.3.1 After 5 minutes, the concentration of oxygen gas in the container was found to be 0,9 mol.dm^{-3}. Calculate the value of Kc between 5 and 10 minutes. (7)

6.3.2 What disturbance occurred at t = 10 minutes? (2)

6.3.3 How does the disturbance at t = 10 minutes affect the value of Kc? Write down only INCREASES or DECREASES or NO CHANGE. (2)

After 12 minutes the following sketch graph of reaction rate against time is obtained for the equilibrium mixture.



6.3.4 Explain the term *dynamic equilibrium*. (2)

6.3.5 A catalyst is added to the equilibrium mixture at time 15 minutes. Redraw the graph above in your ANSWER BOOK. On the same set of axes, complete the graph showing the effect of the catalyst on the reaction rates. (2)

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QUESTION 7 (Start on a new page.)

7.1 Hydrochloric acid is a highly corrosive strong acid with many industrial uses. When 0,02 dm^3 of sodium hydroxide is added to 0,15 dm^3 of diluted hydrochloric acid of concentration 0,03 $mol.dm^{-3}$, the pH of the mixture changes to 4.

7.1.1 Give a reason why hydrochloric acid is classified as a strong acid. (2)

7.1.2 Write down a balanced chemical equation to show the dissociation of $HC\ell$ in water. (3)

7.1.3 Will the final mixture be acidic or basic? Give a reason for your answer by referring to the pH of the mixture. (2)

7.1.4 Calculate the final concentration of the H^+ ion in the mixture. (3)

7.1.5 Calculate the original concentration of the sodium hydroxide solution. (6)

7.2 Calcium carbonate solutions provide living organisms with the substance they need to grow their protective shells and skeletons. For example, eggshells are composed of calcium carbonate. Grade 12 learners decide to calculate the percentage calcium carbonate in eggshells at STP.

They take 5 g of crushed eggshells and react it with excess hydrochloric acid according to the following equation:

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

The carbon dioxide gas produced is collected and found to be 1,06 dm^3 after all the calcium carbonate has reacted.

7.2.1 Define the term *diluted acid.* (2)

7.2.2 Calculate the percentage calcium carbonate in the 5 g eggshells. Show all the calculations. (6)

7.3 Sulphuric acid ionises in two steps as shown below:

		K_a at 25 °C
Step 1	$H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$	Very large
Step 2	$HSO_4^- + H_2O \rightarrow H_3O^+ + SO_4^{2-}$	$1{,}2 \times 10^{-2}$

7.3.1 Explain why the Ka value for Step 1 is a very large number. (1)

7.3.2 H_2O is acting as a base in both reactions. Give the definition of a base according to Lowry-Bronsted. (1)

7.3.3 Write down the FORMULA of a substance that acts as an ampholyte in these reactions. (1)

7.3.4 Write down the NAME for the conjugate base of HSO_4^-. (1)

[28]

GRAND TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

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

TABLE 2: FORMULAE / *TABEL 2: FORMULES*

$n=\frac{m}{M}$	$n=\frac{N}{N_A}$
$c=\frac{n}{V}$ or/*of* $c=\frac{m}{MV}$	$n=\frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b}=\frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ 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 3: THE PERIODIC OF ELEMENTS

KEY/*SLEUTEL*

Atomic number / *Atoomgetal* → 29
Electronegativity / *Elektronegatiwiteit* → 1,9
Symbol / *Simbool* → Cu
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)
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

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

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