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MPUMALANGA PROVINCE  
REPUBLIC OF SOUTH AFRICA

**NATIONAL  
SENIOR CERTIFICATE**

**GRADE 12**

**PHYSICAL SCIENCES: CHEMISTRY P2**

**JUNE 2025**

**MARKS: 150**

**TIME: 3 hours**

**This question paper consists of 14 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 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 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. 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 the ANSWER BOOK, for example, 1.11 E.

1.1 Which ONE of the following compounds is an alkyne?

A  $\text{C}_6\text{H}_{12}$

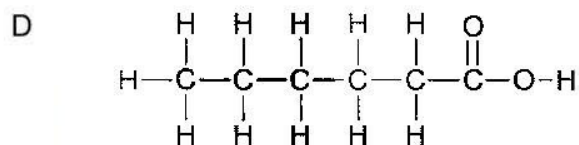
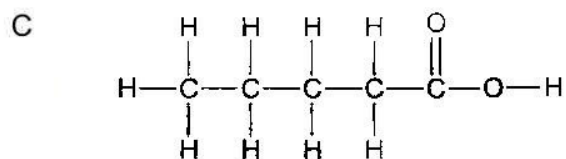
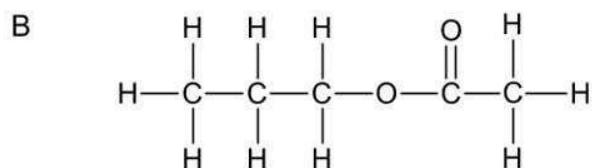
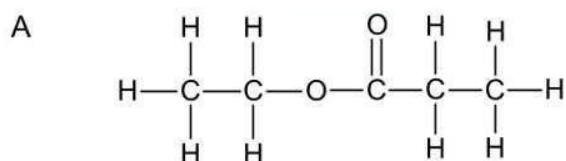
B  $\text{C}_4\text{H}_6$

C  $\text{C}_{10}\text{H}_{22}$

D  $\text{C}_4\text{H}_8\text{O}$

(2)

1.2 Which ONE of the following is a functional isomer of ethyl propanoate?



(2)

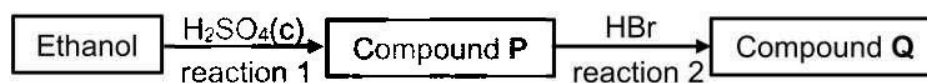


- 1.3 For which ONE of the following pairs of compounds will **X** have a higher boiling point than **Y**?

	<b>X</b>	<b>Y</b>
A	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_3$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
B	$\text{CH}_3\text{CH}_3$	$\text{CH}_3\text{CH}_2\text{CH}_3$
C	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	$\text{CH}_3\text{CH}_2\text{COCH}_3$
D	$\text{CH}_3\text{COOH}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

(2)

- 1.4 Ethanol can be converted into other carbon-containing compounds using the reactants as shown in the flow chart below.



Compounds P and Q are, respectively:

	<b>P</b>	<b>Q</b>
A	Ethene	Bromoethane
B	Ethanoic acid	Ethanol
C	Ethene	Bromoethene
D	Ethanol	Ethanoic acid

(2)

- 1.5 A piece of magnesium ribbon reacts with excess hydrochloric acid according to the following equation:



Which ONE of the following changes will NOT affect the reaction rate?

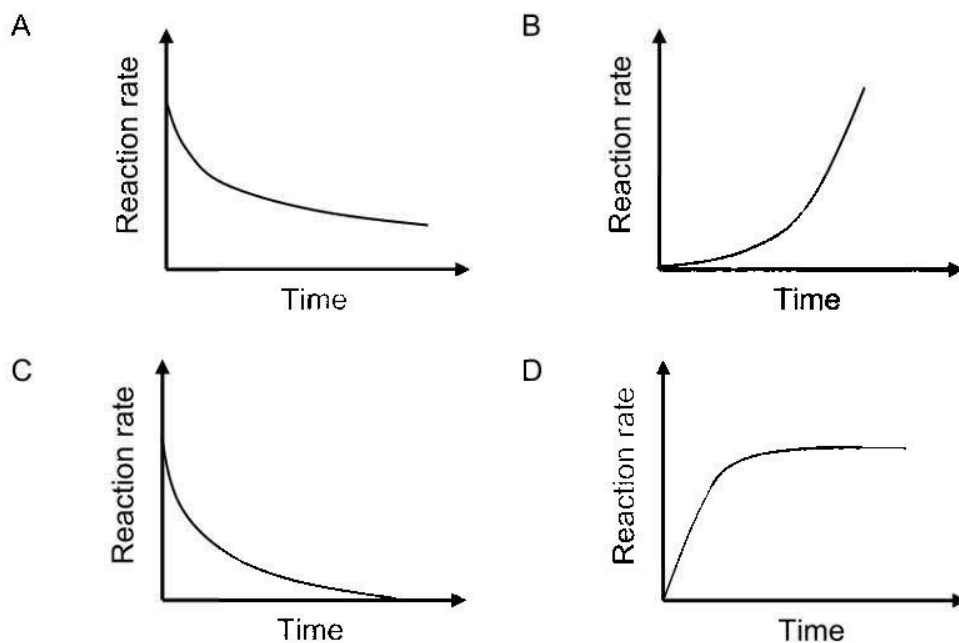
- A Putting the reaction mixture in a hot water bath
- B Using the same mass of powdered magnesium
- C Increasing the volume of the hydrochloric acid
- D Increasing the concentration of the hydrochloric acid.

(2)





- 1.6 Which ONE of the reaction rate versus time graphs below best represents the reaction between magnesium and EXCESS dilute hydrochloric acid?



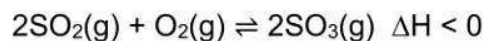
(2)

- 1.7 Which ONE of the following will NOT affect the equilibrium position of reversible chemical reactions?

- A Temperature
- B Catalyst
- C Pressure
- D Concentration

(2)

- 1.8 The reaction given below reaches equilibrium in a closed container. The  $K_c$  value is 0,04 at a certain temperature.



Which ONE of the following factors will change the  $K_c$  value to 0,4?

- A Increase in pressure
- B Decrease in pressure
- C Increase in temperature
- D Decrease in temperature

(2)



- 1.9 During a titration to determine the concentration of an acid using a standard solution of a base, a learner pipettes the base into a conical flask. The learner then uses a small amount of water to rinse the inside of the flask so that all the base is part of the solution in the flask.

How will the extra water added to the flask affect the results of this titration?

The concentration of the acid ...

- A cannot be determined.
- B will be lower than expected.
- C will be higher than expected.
- D will be the same as expected. (2)

- 1.10 Which ONE of the following statements is ALWAYS true for monoprotic acids?

- A The lower the concentration of the acid solution, the weaker the acid.
  - B There will be more  $\text{H}_3\text{O}^+$  ions in  $100\text{ cm}^3$  of a strong acid solution than in  $100\text{ cm}^3$  of a weak acid solution.
  - C The pH of a strong acid is lower than the pH of a weak acid.
  - D One mole of a strong acid will produce more  $\text{H}_3\text{O}^+$  ions in water than one mole of a weak acid. (2)
- [20]



**QUESTION 2 (Start on a new page)**

The letters **A** to **H** in the table below represent EIGHT organic compounds.

<b>A</b>	2,4-dichloro-3-ethyl-6-methyloctane	<b>B</b>	$  \begin{array}{ccccccc}  & & \text{H}_2\text{C}-\text{CH}_3 & & & & \\  & &   & & & & \\  \text{H}_2\text{C} & - & \text{CH} & - & \text{C} \equiv \text{C} & - & \text{CH} - \text{CH}_3 \\    & & & & & &   \\  \text{CH}_3 & & & & & & \text{CH}_3  \end{array}  $
<b>C</b>	$  \begin{array}{ccccccc}  & \text{H} & & \text{H} & & \text{H} & \\  &   & &   & &   & \\  \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{C} - \text{H} \\  &   & &   & &   & \\  & \text{H} & & \text{H} & & \text{H} & \\  & & & & & & \text{O} \\  & & & & & &     \end{array}  $	<b>D</b>	$\text{CH}_3\text{CH}_2\text{CHOHCH}_3$
<b>E</b>	$  \begin{array}{c}  \text{O} \\     \\  \text{H}_3\text{C} - \text{C} - \text{OH}  \end{array}  $	<b>F</b>	$\text{C}_5\text{H}_{12}$
<b>G</b>	$\text{CH}_3\text{COCH}_2\text{CH}_3$	<b>H</b>	Butan-1-ol

2.1 Write down the LETTER(S) that represents the following

2.1.1 A functional isomer of compound **G**. (1)

2.1.2 A haloalkane (1)

2.1.3 Belongs to the same homologous series as compound **H**. (1)

2.2 Write down the:

2.2.1 IUPAC name of compound **B**. (3)

2.2.2 Structural formula of compound **A**. (3)

2.2.3 Name of the homologous series to which compound **C** belongs. (1)

2.2.4 Structural formula of the FUNCTIONAL GROUP of compound **G**. (1)

2.3 Consider compound **D**

2.3.1 Define the term *positional isomer*. (2)

2.3.2 Write down the STRUCTURAL FORMULA of the positional isomer of compound **D**. (2)

2.3.3 Is compound **D** a PRIMARY, SECONDARY or TERTIARY alcohol? Give a reason for the answer. (2)





- 2.4 Compound **E** and **H** are heated together in the presence of a catalyst in a test tube to produce an ESTER.

Write down the:

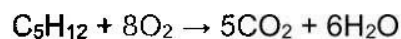
2.4.1 Name of the reaction that takes place. (1)

2.4.2 NAME or FORMULA of the catalyst used. (1)

2.4.3 STRUCTURAL FORMULA of the ester that is produced. (2)

2.4.4 IUPAC name of the ester that is produced. (2)

- 2.5 The reaction below illustrates the complete combustion of compound **F** in EXCESS oxygen.



45 g of compound **F** reacts completely with oxygen at standard temperature and pressure (STP). If the percentage yield of carbon dioxide ( $\text{CO}_2$ ) is 76%, calculate the volume of carbon dioxide formed.

(5)  
[28]



**QUESTION 3 (Start on a new page.)**

Students use alcohols **A** to **C** to investigate a factor that affects the boiling point of alcohols.

They use equal volumes of each alcohol and heat them separately in a water bath.

Compounds	Alcohols
<b>A</b>	CH <sub>3</sub> OH
<b>B</b>	CH <sub>3</sub> CH <sub>2</sub> OH
<b>C</b>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH

- 3.1 Define the term *boiling point*. (2)
- 3.2 What property of alcohols makes it necessary for them to be heated in a water bath? (1)
- 3.3 What structural requirements must the alcohols meet to make this a fair comparison? (2)
- 3.4 Write down the:
- 3.4.1 Independent variable. (1)
- 3.4.2 Name of the FUNCTIONAL GROUP of these compounds. (1)
- 3.4.3 IUPAC name of compound **B** (1)
- 3.5 Which ONE of the three compounds has the HIGHEST boiling point? (1)
- 3.6 Explain the answer to QUESTION 3.5 in full. (3)
- 3.7 The boiling point of compound **C** is now compared with that of compound **X**.

COMPOUND		BOILING POINT (°C)
<b>C</b>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH	98
<b>X</b>	CH <sub>3</sub> COOH	118

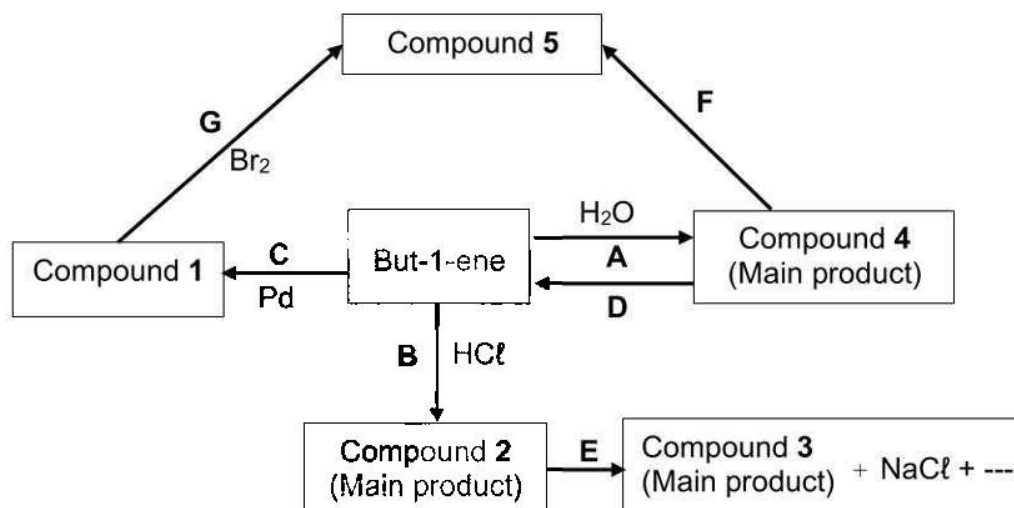
- 3.7.1 Besides the conditions used to determine boiling points, give a reason why this is a fair comparison. (1)
- 3.7.2 Fully explain the difference in the boiling points of compounds **C** and **X**. (4)

[17]



**QUESTION 4 (Start on a new page.)**

The flow chart below shows how alkenes can be used to prepare other organic compounds. The letters **A** to **G** represent different organic reactions.



4.1 Write down the type of reaction represented by:

4.1.1 C (1)

4.1.2 F (1)

4.1.3 D (1)

4.2 For reaction **A** write down the:

4.2.1 IUPAC name of compound **4**. (2)

4.2.2 NAME or FORMULA of the inorganic reactant needed for this reaction. (1)

4.2.3 Type of addition reaction. (1)

4.3 For reaction **G**, bromine water is added to compound **1**.

4.3.1 Is compound **1** a saturated or unsaturated? Give a reason for the answer. (2)

4.3.2 Write down the reaction condition for this reaction. (1)

4.4 Write down a balanced chemical equation using STRUCTURAL FORMULAE for reaction **E**. (6)

4.5 For reaction **B** write down two reaction conditions required for this reaction (2)

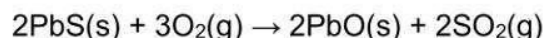
[18]



**QUESTION 5 (Start on a new page.)**

A student is asked to design an industrial process to produce sulphuric acid.

- 5.1 One of the reactions in the production of sulphuric acid is the roasting (heating in oxygen) of a metal ore that contains lead(II) sulphide:



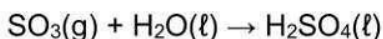
The student does a test experiment in which 36,8 g of  $\text{O}_2$  gas completely reacts with 800 g of the metal ore. All of the PbS in the ore reacts, and ONLY the PbS in the ore reacts with the oxygen.

- 5.1.1 Calculate the amount (in moles) of  $\text{O}_2$  that reacted. (3)

- 5.1.2 Calculate the mass of pure PbS in the metal ore. (3)

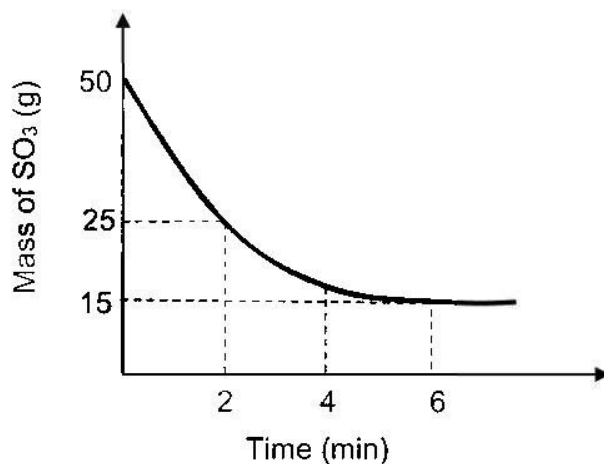
- 5.1.3 Calculate the percentage mass of the PbS in the metal ore. (2)

- 5.2 In another experiment, 50 g of sulphur trioxide reacts with water:



The amount of sulphur trioxide present in the container is monitored over time.

The following graph is plotted:



- 5.2.1 Write down the formula of the limiting reactant. (1)

- 5.2.2 At what time on the graph was the reaction rate the fastest. (1)

- 5.2.3 What happened at 6 minutes. (1)

- 5.2.4 Define the term *reaction rate*. (2)

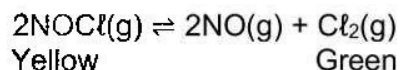




- 5.2.5 Calculate the rate of the reaction in  $(\text{g}\cdot\text{s}^{-1})$  during the first 2 minutes. (3)
- 5.2.6 Copy the above graph in your answer book. On the same set of axes, use a DOTTED LINE to show the curve that will be obtained when the temperature increases. No numerical values are required. (2)
- 5.2.7 In terms of the COLLISION THEORY, explain why the rate of a chemical reaction increases with increasing temperature. (3)
- [23]**

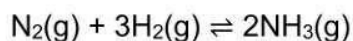
### QUESTION 6 (Start on a new page)

- 6.1 Nitrosyl chloride ( $\text{NOCl}$ ) is a yellow gas that decomposes into colourless nitrogen monoxide gas ( $\text{NO}$ ) and green chlorine gas ( $\text{Cl}_2$ ) at temperatures above  $100^\circ\text{C}$ .



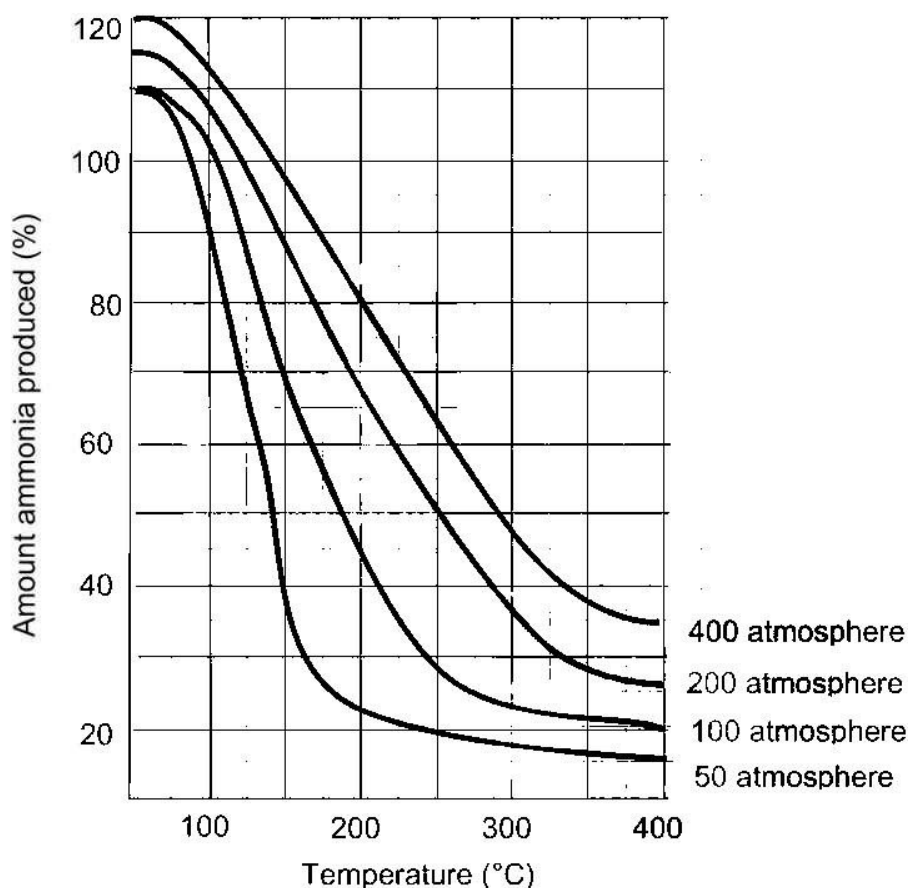
Consider an equilibrium mixture of  $\text{NOCl}$ ,  $\text{NO}$ , and  $\text{Cl}_2$ , which is initially yellow–green, in a sealed container.

- 6.1.1 Explain the term *closed system*. (1)
- 6.1.2  $\text{NO}(\text{g})$  is added to the container at constant volume. What colour change will be observed in the container. Explain the answer (4)
- 6.1.3 State *Le Chatelier's principle*. (2)
- 6.1.4 When the pressure in the container is changed, the colour becomes green. Use Le Chatelier's principle to explain whether the pressure was INCREASED or DECREASED. (4)
- 6.2 The Haber process uses nitrogen and hydrogen gases to produce ammonia gas, represented in the reversible reaction below.





The Haber process was researched. The graph (below) shows how the percentage yield of ammonia is affected by changes in temperature and pressure.



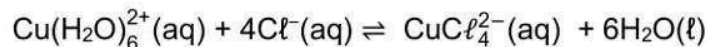
In industry, the Haber process is typically operated at a temperature of 250 °C and a pressure of 200 atmospheres (200 atm).

6.2.1 Is the forward reaction in the Haber process EXOTHERMIC or ENDOTHERMIC? (1)

6.2.2 Explain the answer to Question 6.2.1 in terms of Le Chatelier's principle by referring to the graph. (4)

6.2.3 What is the percentage yield of ammonia at 250 °C and 200 atmosphere? (1)

6.3 A solution is prepared by dissolving 4 mol of  $\text{CuCl}_4^{2-}$  completely in water to make a solution of volume 2 dm<sup>3</sup>. When equilibrium is established, there are 2,2 mol of  $\text{Cu}(\text{H}_2\text{O})_6^{2+}$  ions present at 25 °C.



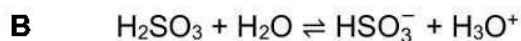
Determine the value of the equilibrium constant,  $K_c$ , for this reaction at 25 °C.

(8)  
[25]



**QUESTION 7 (Start on a new page.)**

Consider the following balanced chemical equations showing some acid-base reactions.



7.1 Define an acid according to the Lowry- Brønsted theory. (2)

7.2 Consider the chemical equations (**A** and **B**) above.

7.2.1 Describe the term *amphoteric substance*. (2)

7.2.2 Write down the **formula** of an amphoteric chemical substance (other than  $\text{H}_2\text{O}$ ). (1)

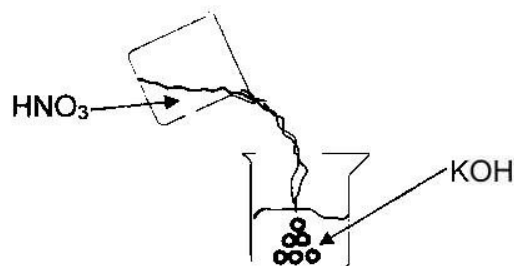
7.2.3 Write down the formulae of the conjugate acid-base pairs in reaction **B**. (2)

7.3 Which indicator must be used in reaction **A**. Choose from METHYL ORANGE, BROMOTHYMOLO BLUE or PHENOLPHTHALEIN. Give a reason for the answer (3)

7.4 Consider reactions **A** and **C**, shown below.



A 13 g, impure sample of KOH is initially dissolved in 200 cm<sup>3</sup> of a 1,2 mol·dm<sup>-3</sup> nitric acid solution. The nitric acid was in EXCESS. Assume that the volume remains constant.



50 cm<sup>3</sup> of the resulting solution was then titrated to neutralisation using 23,67 cm<sup>3</sup> of a standard 0,85 mol·dm<sup>-3</sup> sodium carbonate solution.

7.4.1 Determine the amount (in mol) of nitric acid that was added to the KOH. (2)

7.4.2 Calculate the percentage purity of the KOH sample. (9)

[21]

SA EXAM PAPERS

TOTAL [150]



**DATA FOR PHYSICAL SCIENCES GRADE 12  
PAPER 2 (CHEMISTRY)**

**GEGEWENS VIR FISIIESE WETENSKAPPE GRAAD 12  
VRAESTEL 2 (CHEMIE)**

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

NAME/NAAM	SYMBOL/SIMBOOL	VALUE/WAARDE
Standard pressure Standaarddruk	$p^\theta$	$1,013 \times 10^5 \text{ Pa}$
Molar gas volume at STP Molêre gasvolume by STD	$V_m$	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature Standaardtemperatuur	$T^\theta$	$273 \text{ K}$
Avogadro's constant	$N_A$	$6,023 \times 10^{23} \text{ mol}^{-1}$

**TABLE 2: FORMULAE/TABEL 2: FORMULES**

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ OR/OF $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{n_a}{n_b} = \frac{c_a V_a}{c_b V_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$
$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14} \text{ at/ by } 298 \text{ K}$	
$E^\theta_{\text{cell}} = E^\theta_{\text{cathode}} - E^\theta_{\text{anode}} \quad / \quad E^\theta_{\text{sel}} = E^\theta_{\text{katode}} - E^\theta_{\text{anode}}$ OR/OF $E^\theta_{\text{cell}} = E^\theta_{\text{reduction}} - E^\theta_{\text{oxidation}} \quad / \quad E^\theta_{\text{sel}} = E^\theta_{\text{reduksie}} - E^\theta_{\text{oksidasie}}$ OR/OF $E^\theta_{\text{cell}} = E^\theta_{\text{oxidising agent}} - E^\theta_{\text{reducing agent}} \quad / \quad E^\theta_{\text{sel}} = E^\theta_{\text{oksideermiddel}} - E^\theta_{\text{reduseermiddel}}$	





TABLE 3: THE PERIODIC TABLE OF ELEMENTS  
TABLE 3: THE PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
(I)	(II)											(III)	(IV)	(V)	(VI)	(VII)	(VIII)
1 H 1,0	3 Li 7	11 Na 23	19 K 39	37 Rb 85	55 Cs 133	87 Fr 226	2 He 4	10 Ne 20	18 Ar 40	36 Kr 84	54 Xe 131	86 Rn 222	102 No 259	108 Hs 277	114 Fl 289	120 Ds 304	116 Lv 293
4 Be 9	12 Mg 24	20 Ca 40	38 Sr 88	56 Ba 137	88 Ra 226	29 Cu 63,5	47 Ag 108	79 Au 197	101 Md 258	103 Nh 288	105 Db 312	107 Ts 330	109 Og 349	111 Rg 361	113 Nh 372	115 Mc 383	117 Ts 394
5 B 11	13 Al 27	21 Sc 45	39 Y 89	57 La 139	89 Ac 227	25 Mn 55	43 Tc 98	73 Ta 181	103 Rh 101	105 Ir 192	107 Au 197	109 Hg 201	111 Tl 204	113 Pb 207	115 Bi 209	117 Po 209	119 At 210
6 C 12	14 Si 28	22 Ti 48	40 Zr 91	72 Hf 179	104 Rf 261	24 Cr 52	42 Mo 96	74 W 184	106 Pd 106	108 Ag 108	110 Cd 112	112 In 115	114 Sn 119	116 Sb 122	118 Te 128	120 I 127	122 Xe 131
7 N 14	15 P 31	23 V 51	41 Nb 93	73 Ta 181	105 Re 187	26 Fe 56	44 Ru 101	76 Os 190	108 Ni 59	110 Cu 63,5	112 Zn 65	114 Ga 70	116 Ge 73	118 As 75	120 Se 79	122 Br 80	124 Kr 84
8 O 16	16 S 32	24 Cr 52	42 Mo 96	74 W 184	106 Os 190	27 Co 59	45 Rh 103	77 Ir 192	109 Pd 106	111 Ag 108	113 Cd 112	115 In 115	117 Sn 119	119 Sb 122	121 Te 128	123 I 127	125 Xe 131
9 F 19	17 Cl 35,5	25 Mn 55	43 Tc 98	75 Re 186	107 Ta 181	28 Ni 59	46 Ru 101	78 Pt 195	110 Cu 63,5	112 Zn 65	114 Ga 70	116 Ge 73	118 As 75	120 Se 79	122 Br 80	124 Kr 84	126 Xe 131
10 Ne 20	18 Ar 40	26 Fe 56	44 Ru 101	76 Os 190	108 Ir 192	29 Cu 63,5	47 Rh 103	79 Au 197	111 Pd 106	113 Ag 108	115 Cd 112	117 In 115	119 Sn 119	121 Sb 122	123 Te 128	125 I 127	127 Xe 131
11 Na 23	19 K 39	27 Co 59	45 Rh 103	77 Ir 192	109 Pt 195	30 Zn 65	48 Pd 106	80 Hg 201	112 Cu 63,5	114 Ag 108	116 Cd 112	118 In 115	120 Sn 119	122 Sb 122	124 Te 128	126 I 127	128 Xe 131
12 Mg 24	20 Ca 40	28 Ni 59	46 Ru 101	78 Pt 195	110 Au 197	31 Ga 70	49 Rh 103	81 Tl 204	113 Cu 63,5	115 Ag 108	117 Cd 112	119 In 115	121 Sn 119	123 Sb 122	125 Te 128	127 I 127	129 Xe 131
13 Al 27	21 Sc 45	29 Cu 63,5	47 Rh 103	79 Au 197	111 Pt 195	32 Ge 73	50 Pd 106	82 Hg 201	114 Cu 63,5	116 Ag 108	118 Cd 112	120 In 115	122 Sn 119	124 Sb 122	126 Te 128	128 I 127	130 Xe 131
14 Si 28	22 Ti 48	30 Zn 65	48 Pd 106	80 Pt 195	112 Au 197	33 As 75	51 Rh 103	83 Tl 204	115 Cu 63,5	117 Ag 108	119 Cd 112	121 In 115	123 Sn 119	125 Sb 122	127 Te 128	129 I 127	131 Xe 131
15 P 31	23 V 51	31 Ga 70	49 Rh 103	77 Ir 192	109 Pt 195	34 Se 79	52 Pd 106	84 Hg 201	116 Cu 63,5	118 Ag 108	120 Cd 112	122 In 115	124 Sn 119	126 Sb 122	128 Te 128	130 I 127	132 Xe 131
16 S 32	24 Cr 52	32 Ge 73	50 Pd 106	78 Pt 195	110 Au 197	35 Br 80	53 Rh 103	85 Tl 204	117 Cu 63,5	119 Ag 108	121 Cd 112	123 In 115	125 Sn 119	127 Sb 122	129 Te 128	131 I 127	133 Xe 131
17 Cl 35,5	25 Mn 55	33 As 75	51 Rh 103	79 Au 197	111 Pt 195	36 Kr 84	54 Pd 106	86 Tl 204	118 Cu 63,5	120 Ag 108	122 Cd 112	124 In 115	126 Sn 119	128 Sb 122	130 Te 128	132 I 127	134 Xe 131
18 Ar 40	26 Fe 56	34 Se 79	52 Pd 106	80 Pt 195	112 Au 197	37 Rb 85	55 Rh 103	87 Tl 204	119 Cu 63,5	121 Ag 108	123 Cd 112	125 In 115	127 Sn 119	129 Sb 122	131 Te 128	133 I 127	135 Xe 131
19 K 39	27 Co 59	35 Br 80	53 Rh 103	81 Pt 195	113 Au 197	38 Sr 88	56 Pd 106	88 Tl 204	120 Cu 63,5	122 Ag 108	124 Cd 112	126 In 115	128 Sn 119	130 Sb 122	132 Te 128	134 I 127	136 Xe 131
20 Ca 40	28 Ni 59	36 Kr 84	54 Pd 106	82 Pt 195	114 Au 197	39 Y 89	57 Rh 103	89 Tl 204	121 Cu 63,5	123 Ag 108	125 Cd 112	127 In 115	129 Sn 119	131 Sb 122	133 Te 128	135 I 127	137 Xe 131
21 Sc 45	29 Cu 63,5	37 Rb 85	55 Pd 106	83 Pt 195	115 Au 197	40 Zr 91	58 Rh 103	90 Tl 204	122 Cu 63,5	124 Ag 108	126 Cd 112	128 In 115	130 Sn 119	132 Sb 122	134 Te 128	136 I 127	138 Xe 131
22 Ti 48	30 Zn 65	38 Sr 88	56 Pd 106	84 Pt 195	116 Au 197	41 Nb 93	59 Rh 103	91 Tl 204	123 Cu 63,5	125 Ag 108	127 Cd 112	129 In 115	131 Sn 119	133 Sb 122	135 Te 128	137 I 127	139 Xe 131
23 V 51	31 Ga 70	39 Y 89	57 Pd 106	85 Pt 195	117 Au 197	42 Mo 96	60 Rh 103	92 Tl 204	124 Cu 63,5	126 Ag 108	128 Cd 112	130 In 115	132 Sn 119	134 Sb 122	136 Te 128	138 I 127	140 Xe 131
24 Cr 52	32 Ge 73	40 Zr 91	58 Pd 106	86 Pt 195	118 Au 197	43 Tc 98	61 Rh 103	93 Tl 204	125 Cu 63,5	127 Ag 108	129 Cd 112	131 In 115	133 Sn 119	135 Sb 122	137 Te 128	139 I 127	141 Xe 131
25 Mn 55	33 As 75	41 Nb 93	59 Pd 106	87 Pt 195	119 Au 197	44 Ru 101	62 Rh 103	94 Tl 204	126 Cu 63,5	128 Ag 108	130 Cd 112	132 In 115	134 Sn 119	136 Sb 122	138 Te 128	140 I 127	142 Xe 131
26 Fe 56	34 Se 79	42 Mo 96	60 Pd 106	88 Pt 195	120 Au 197	45 Rh 103	63 Rh 103	95 Tl 204	127 Cu 63,5	129 Ag 108	131 Cd 112	133 In 115	135 Sn 119	137 Sb 122	139 Te 128	141 I 127	143 Xe 131
27 Co 59	35 Br 80	43 Tc 98	61 Pd 106	89 Pt 195	121 Au 197	46 Ru 101	64 Rh 103	96 Tl 204	128 Cu 63,5	130 Ag 108	132 Cd 112	134 In 115	136 Sn 119	138 Sb 122	140 Te 128	142 I 127	144 Xe 131
28 Ni 59	36 Kr 84	44 Ru 101	62 Pd 106	90 Pt 195	122 Au 197	47 Rh 103	65 Rh 103	97 Tl 204	129 Cu 63,5	131 Ag 108	133 Cd 112	135 In 115	137 Sn 119	139 Sb 122	141 Te 128	143 I 127	145 Xe 131
29 Cu 63,5	37 Rb 85	45 Rh 103	63 Pd 106	91 Pt 195	123 Au 197	48 Pd 106	66 Rh 103	98 Tl 204	130 Cu 63,5	132 Ag 108	134 Cd 112	136 In 115	138 Sn 119	140 Sb 122	142 Te 128	144 I 127	146 Xe 131
30 Zn 65	38 Sr 88	46 Ru 101	64 Pd 106	92 Pt 195	124 Au 197	49 Rh 103	67 Rh 103	99 Tl 204	131 Cu 63,5	133 Ag 108	135 Cd 112	137 In 115	139 Sn 119	141 Sb 122	143 Te 128	145 I 127	147 Xe 131
31 Ga 70	39 Y 89	47 Rh 103	65 Pd 106	93 Pt 195	125 Au 197	50 Pd 106	68 Rh 103	100 Tl 204	132 Cu 63,5	134 Ag 108	136 Cd 112	138 In 115	140 Sn 119	142 Sb 122	144 Te 128	146 I 127	148 Xe 131
32 Ge 73	40 Zr 91	48 Pd 106	66 Pd 106	94 Pt 195	126 Au 197	51 Rh 103	69 Rh 103	101 Tl 204	133 Cu 63,5	135 Ag 108	137 Cd 112	139 In 115	141 Sn 119	143 Sb 122	145 Te 128	147 I 127	149 Xe 131
33 As 75	41 Nb 93	49 Rh 103	67 Pd 106	95 Pt 195	127 Au 197	52 Pd 106	70 Rh 103	102 Tl 204	134 Cu 63,5	136 Ag 108	138 Cd 112	140 In 115	142 Sn 119	144 Sb 122	146 Te 128	148 I 127	150 Xe 131
34 Se 79	42 Mo 96	50 Pd 106	68 Pd 106	96 Pt 195	128 Au 197	53 Rh 103	71 Rh 103	103 Tl 204	135 Cu 63,5	137 Ag 108	139 Cd 112	141 In 115	143 Sn 119	145 Sb 122	147 Te 128	149 I 127	151 Xe 131
35 Br 80	43 Tc 98	51 Rh 103	69 Pd 106	97 Pt 195	129 Au 197	54 Pd 106	72 Rh 103	104 Tl 204	136 Cu 63,5	138 Ag 108	140 Cd 112	142 In 115	144 Sn 119	146 Sb 122	148 Te 128	150 I 127	152 Xe 131
36 Kr 84	44 Ru 101	52 Pd 106	70 Pd 106	98 Pt 195	130 Au 197	55 Rh 103	73 Rh 103	105 Tl 204	137 Cu 63,5	139 Ag 108	141 Cd 112	143 In 115	145 Sn 119	147 Sb 122	149 Te 128	151 I 127	153 Xe 131
37 Rb 85	45 Rh 103	53 Pd 106	71 Pd 106	99 Pt 195	131 Au 197	56 Pd 106	74 Rh 103	106 Tl 204	138 Cu 63,5	140 Ag 108	142 Cd 112	144 In 115	146 Sn 119	148 Sb 122	150 Te 128	152 I 127	154 Xe 131
38 Sr 88	46 Ru 101	54 Rh 103	72 Pd 106	100 Pt 195	132 Au 197	57 Pd 106	75 Rh 103	107 Tl 204	139 Cu 63,5	141 Ag 108	143 Cd 112	145 In 115	147 Sn 119	149 Sb 122	151 Te 128	153 I 127	155 Xe 131
39 Y 89	47 Rh 103	55 Pd 106	73 Pd 106	101 Pt 195	133 Au 197	58 Rh 103	76 Rh 103	108 Tl 204	140 Cu 63,5	142 Ag 108	144 Cd 112	146 In 115	148 Sn 119	150 Sb 122	152 Te 128	154 I 127	156 Xe 131
40 Zr 91	48 Pd 106	56 Pd 106	74 Pd 106	102 Pt 195	134 Au 197	59 Rh 103	77 Rh 103	109 Tl 204	141 Cu 63,5	143 Ag 108	145 Cd 112	147 In 115	149 Sn 119	151 Sb 122	153 Te 128	155 I 127	157 Xe 131
41 Nb 93	49 Rh 103	57 Pd 106	75 Pd 106	103 Pt 195	135 Au 197	60 Rh 103	78 Rh 103	110 Tl 204	142 Cu 63,5	144 Ag 108	146 Cd 112	148 In 115	150 Sn 119	152 Sb 122	154 Te 128	156 I 127	158 Xe 131
42 Mo 96	50 Pd 106	58 Rh 103	76 Pd 106	104 Pt 195	136 Au 197	61 Pd 106	79 Rh 103	111 Tl 204	143 Cu 63,5	145 Ag 108	147 Cd 112	149 In 115	151 Sn 119	153 Sb 122	155 Te 128	157 I 127	159 Xe 131
43 Tc 98	51 Rh 103	59 Pd 106	77 Pd 106	105 Pt 195	137 Au 197	62 Rh 103	80 Rh 103	112 Tl 204	144 Cu 63,5	146 Ag 108	148 Cd 112	150 In 115	152 Sn 119	154 Sb 122	156 Te 128	158 I 127	160 Xe 131
44 Ru 101	52 Pd 106	60 Rh 103	78 Pd 106	106 Pt 195	138 Au 197	63 Pd 106	81 Rh 103	113 Tl 204	145 Cu 63,5	147 Ag 108	149 Cd 112	151 In 115	153 Sn 119	155 Sb 122	157 Te 128	15	

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

Half-reactions/Halfreaksies	E° (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
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 4e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+ 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
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^- \rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^- \rightleftharpoons Hg(l)$	+ 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
$Al^{3+} + 3e^- \rightleftharpoons Al$	- 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

Increasing strength of oxidising agents/Toenemende sterkte van oksideermiddels

Increasing strength of reducing agents/Toenemende sterkte van reduseermiddels





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

Increasing strength of oxidising agents/Toenemende sterkte van oksideermiddels

Half-reactions/Halfreaksies		$E^{\ominus}$ (V)
$\text{Li}^+ + \text{e}^-$	$\rightleftharpoons$ Li	-3,05
$\text{K}^+ + \text{e}^-$	$\rightleftharpoons$ K	-2,93
$\text{Cs}^+ + \text{e}^-$	$\rightleftharpoons$ Cs	-2,92
$\text{Ba}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Ba	-2,90
$\text{Sr}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Sr	-2,89
$\text{Ca}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Ca	-2,87
$\text{Na}^+ + \text{e}^-$	$\rightleftharpoons$ Na	-2,71
$\text{Mg}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Mg	-2,36
$\text{Al}^{3+} + 3\text{e}^-$	$\rightleftharpoons$ Al	-1,66
$\text{Mn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Mn	-1,18
$\text{Cr}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Cr	-0,91
$2\text{H}_2\text{O} + 2\text{e}^-$	$\rightleftharpoons$ $\text{H}_2(\text{g}) + 2\text{OH}^-$	-0,83
$\text{Zn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Zn	-0,76
$\text{Cr}^{3+} + 3\text{e}^-$	$\rightleftharpoons$ Cr	-0,74
$\text{Fe}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Fe	-0,44
$\text{Cr}^{3+} + \text{e}^-$	$\rightleftharpoons$ $\text{Cr}^{2+}$	-0,41
$\text{Cd}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Cd	-0,40
$\text{Co}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Co	-0,28
$\text{Ni}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Ni	-0,27
$\text{Sn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Sn	-0,14
$\text{Pb}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Pb	-0,13
$\text{Fe}^{3+} + 3\text{e}^-$	$\rightleftharpoons$ Fe	-0,06
$2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$ $\text{H}_2(\text{g})$	0,00
$\text{S} + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$ $\text{H}_2\text{S}(\text{g})$	+0,14
$\text{Sn}^{4+} + 2\text{e}^-$	$\rightleftharpoons$ $\text{Sn}^{2+}$	+0,15
$\text{Cu}^{2+} + \text{e}^-$	$\rightleftharpoons$ $\text{Cu}^+$	+0,16
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$ $\text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+0,17
$\text{Cu}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Cu	+0,34
$2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-$	$\rightleftharpoons$ $4\text{OH}^-$	+0,40
$\text{SO}_2 + 4\text{H}^+ + 4\text{e}^-$	$\rightleftharpoons$ $\text{S} + 2\text{H}_2\text{O}$	+0,45
$\text{Cu}^+ + \text{e}^-$	$\rightleftharpoons$ Cu	+0,52
$\text{I}_2 + 2\text{e}^-$	$\rightleftharpoons$ $2\text{I}^-$	+0,54
$\text{O}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$ $\text{H}_2\text{O}_2$	+0,68
$\text{Fe}^{3+} + \text{e}^-$	$\rightleftharpoons$ $\text{Fe}^{2+}$	+0,77
$\text{NO}_3^- + 2\text{H}^+ + \text{e}^-$	$\rightleftharpoons$ $\text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+0,80
$\text{Ag}^+ + \text{e}^-$	$\rightleftharpoons$ Ag	+0,80
$\text{Hg}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ $\text{Hg}(\ell)$	+0,85
$\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^-$	$\rightleftharpoons$ $\text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+0,96
$\text{Br}_2(\ell) + 2\text{e}^-$	$\rightleftharpoons$ $2\text{Br}^-$	+1,07
$\text{Pt}^{2+} + 2\text{e}^-$	$\rightleftharpoons$ Pt	+1,20
$\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$ $\text{Mn}^{2+} + 2\text{H}_2\text{O}$	+1,23
$\text{O}_2(\text{g}) + 4\text{H}^+ + 4\text{e}^-$	$\rightleftharpoons$ $2\text{H}_2\text{O}$	+1,23
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 4\text{e}^-$	$\rightleftharpoons$ $2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1,33
$\text{Cl}_2(\text{g}) + 2\text{e}^-$	$\rightleftharpoons$ $2\text{Cl}^-$	+1,36
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$	$\rightleftharpoons$ $\text{Mn}^{2+} + 4\text{H}_2\text{O}$	+1,51
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$ $2\text{H}_2\text{O}$	+1,77
$\text{Co}^{3+} + \text{e}^-$	$\rightleftharpoons$ $\text{Co}^{2+}$	+1,81
$\text{F}_2(\text{g}) + 2\text{e}^-$	$\rightleftharpoons$ $2\text{F}^-$	+2,87

Increasing strength of reducing agents/Toenemende sterkte van reduseermiddels

