



HILLCREST HIGH SCHOOL
PHYSICAL SCIENCE
GRADE 11
PAPER 2- Chemistry



NOVEMBER 2021

EXAMINER: J. KNOX-WHITEHEAD

TIME: 2 HRS

Total 100

Instructions

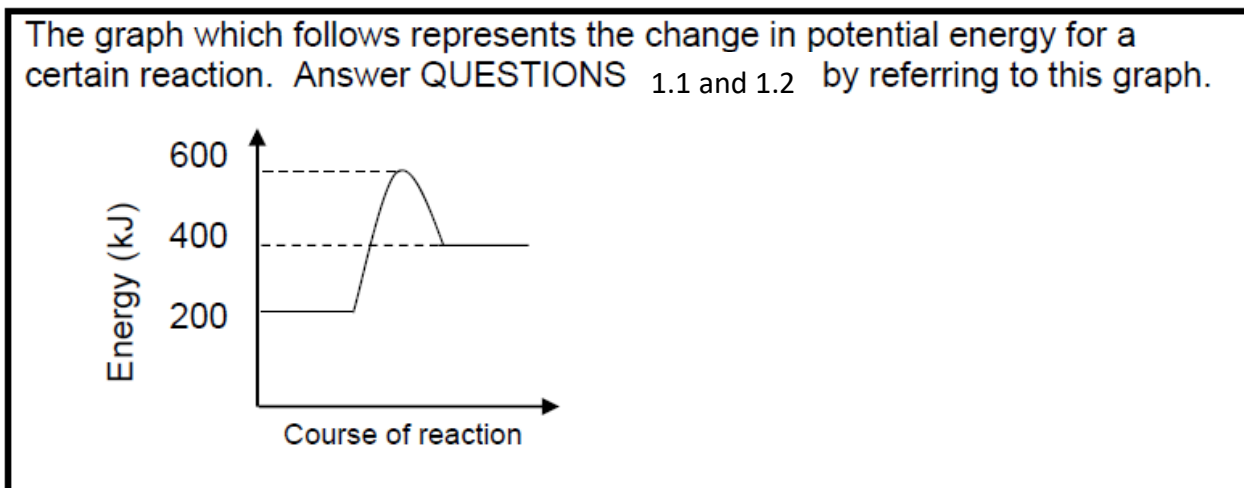
1. Answer ALL the questions.
2. This question paper consists of TWO sections:
3. SECTION A (12)
SECTION B (88)

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 Which of the following statements concerning this graph is INCORRECT?

- A More energy is absorbed than released.
- B More energy is released than absorbed.
- C The reactants have less energy than the products.
- D The products have more energy than the reactants.

(2)

1.2 Which combination is CORRECT for this reaction?

	Type of reaction	Activation energy (kJ)
A	Endothermic	200
B	Exothermic	400
C	Endothermic	400
D	Exothermic	200

(2)

1.3 Substance **A** is soluble in substance **B**. Which ONE of the following most likely represents **A** and **B**?

	A	B
A	HCl	CCl ₄
B	HCl	H ₂ O
C	NaCl	CCl ₄
D	I ₂	H ₂ O

(2)

1.4 The oxidation number of manganese (Mn) in MnO₄⁻¹ is...

- A. -1
- B. +8
- C. +7
- D. +2

(2)

1.5 In an **electrolytic** cell which statement is INCORRECT?

- A. The anode is negatively charged
- B. There is no salt bridge
- C. The cathode is negatively charged
- D. Electrical energy is converted to chemical energy

(2)

1.6 1 g of hydrogen gas at STP occupies a volume of:

- A. 5,6 dm³
- B. 11,2 dm³
- C. 22,4 dm³
- D. 44,8 dm³

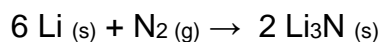
(2)

[2 X 6 = 12]

SECTION B

Question 2

When heated, lithium reacts with nitrogen to form Li₃N. The balanced equation is shown below:



12,3 g of lithium is heated with 33,6 g N₂.

2.1 Define the term *limiting reagent*.

(2)

2.2 Name the PRODUCT formed in this reaction.

(1)

2.3 Determine by calculation which substance is the limiting reagent. (6)

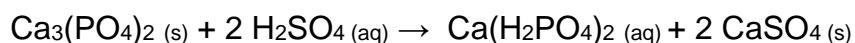
The actual yield of Li_3N in the above reaction is 5,89 g.

2.4 Calculate the percentage yield of Li_3N . (5)

[14]

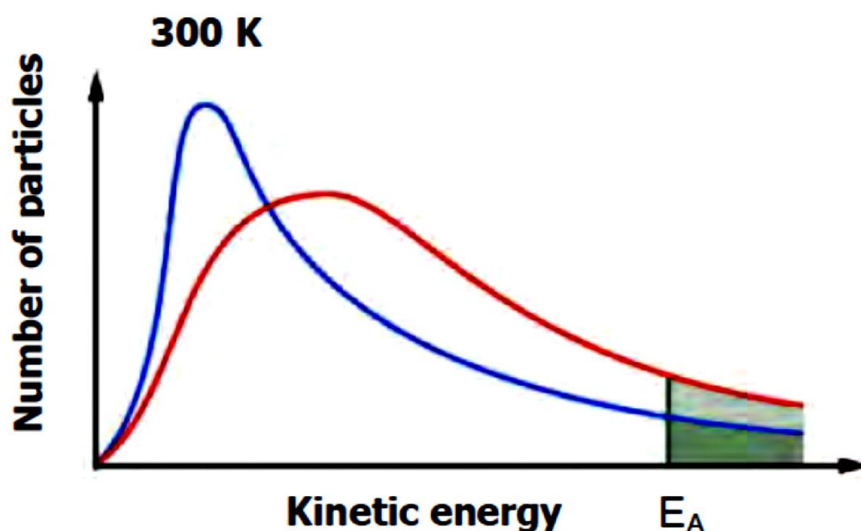
Question 3

The mining of phosphate rock and its conversion to superphosphate is carried out in South Africa at Phalaborwa in the Limpopo province, and can be represented by the equation below:



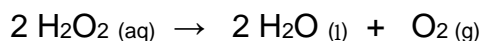
3.1 An increase in temperature will increase the rate of the above reaction. List ONE other factor that will INCREASE the rate of this reaction. (1)

3.2 The figure below shows the Maxwell-Boltzmann distributions curves for the above reaction at two different temperatures. The activation energy for this reaction is indicated on the graph by the vertical line and labelled as E_A .



Referring to the shaded areas in the distribution curves above, use the Collision Theory to explain why an increase in the temperature causes an increase in reaction rate. (2)

3.3 In another experiment, learners obtained the following results for the decomposition of hydrogen peroxide:



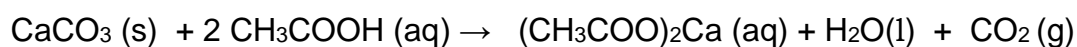
TIME (s)	H_2O_2 CONCENTRATION ($\text{mol}\cdot\text{dm}^{-3}$)
0	0,0200
200	0,0160
400	0,0131
600	0,0106
800	0,0086

- 3.3.1 Define *reaction rate*. (2)
- 3.3.2 Calculate the AVERAGE rate of decomposition (in mol.dm⁻³.s⁻¹) of H₂O₂ (aq) in the first 400 s. (3)
- 3.3.3 Calculate the mass of oxygen produced after the first 600 s if 50 cm³ of hydrogen peroxide decomposes in this time interval. (5)

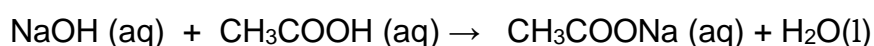
[13]

Question 4

- 4.1 Olwethu and Hannah carried out a titration in the laboratory where 10 ml of nitric acid was titrated against a standard solution of sodium carbonate that has a concentration of 0,5 mol.dm⁻³. It was found that 25 ml of the base just neutralised the acid.
- 4.1.1 Write a balanced equation for the reaction. (4)
- 4.1.2 What is the name given to the stage of the reaction when the base has **just neutralised the acid**? (1)
- 4.1.3 Suggest an indicator which could be used for this titration. (1)
- 4.2 Sulphuric acid can react with water through a multistep reaction as shown below:
- I: $\text{H}_2\text{SO}_4 (\text{aq}) + \text{H}_2\text{O} (\text{l}) \rightleftharpoons \text{HSO}_4^- (\text{aq}) + \text{H}_3\text{O}^+ (\text{aq})$
- II: $\text{HSO}_4^- (\text{aq}) + \text{H}_2\text{O} (\text{l}) \rightleftharpoons \text{SO}_4^{2-} (\text{aq}) + \text{H}_3\text{O}^+ (\text{aq})$
- 4.2.1 Is water acting as a base or an acid in reactions I and II? (1)
- 4.2.2 Write down the chemical formula of the substance that acts as an ampholyte in the above reactions. (1)
- 4.3 An eggshell contains calcium carbonate (CaCO₃) and impurities. An EXCESS amount of a standard dilute acetic acid solution (CH₃COOH) of concentration 0,5 mol.dm⁻³ and volume 250 cm³ is allowed to react COMPLETELY with an eggshell of mass 56 g. The reaction is represented by the balanced equation shown below:



The acetic acid that remained UNREACTED is then neutralised by 25 cm³ of sodium hydroxide (NaOH) with a concentration of 0,968 mol.dm⁻³. The equation for this reaction is shown below:



- 4.3.1 Define a *standard solution*. (2)
- 4.3.2 Calculate the percentage of calcium carbonate in the egg shell. (10)

[20]

Question 5

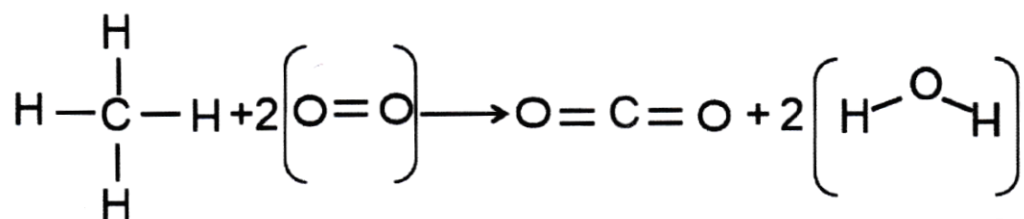
Consider the substances below and answer the questions which follow:



- 5.1 Give the Lewis structure for **CCl₄**. (2)
- 5.2 According to the VSEPR theory, what shapes will **CCl₄** molecules have? (1)
- 5.3 Name the intermolecular force found between the **CH₄** molecules. (1)
- 5.4 Identify the gaseous substance/s which have polar covalent bonds between the atoms, but the molecule as a whole is non-polar. (2)
- 5.5 Which substance has the strongest intermolecular forces? (1)
- 5.6 A group of learners investigate how bond energy changes with increasing bond length. The data collected theoretically is shown in the table below:

BOND	BOND LENGTH (pm)	BOND ENERGY (kJ.mol ⁻¹)
C≡C	120	839
C=O	123	804
O=O	121	498
C-C	154	348
H-O	96	463
H-C	109	413

- 5.6.1 In a combustion reaction methane burns in oxygen to form carbon dioxide and water. The balanced reaction, showing the bonds, is given below:



Using the table above, determine whether there is a net release or a net absorption of energy in this reaction. Show all your workings. (6)

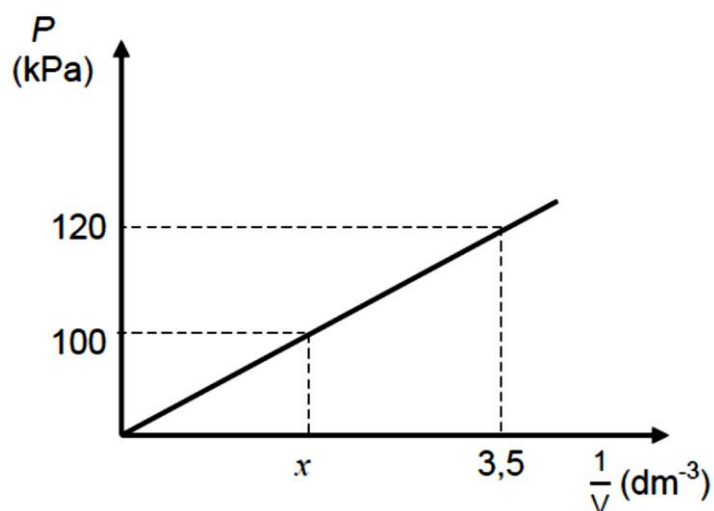
- 5.6.2 Use the values given in the table to decide which ONE of the following bond energies would be correct for the C=C bond?

Choose from: **880 kJ.mol⁻¹** OR **540 kJ.mol⁻¹** OR **320 kJ.mol⁻¹** (1)

[14]

Question 6

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 volume was obtained from the results:

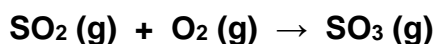


- 6.1 Use the graph above to express the relationship between pressure and volume mathematically. (1)
- 6.2 Name ONE variable which must be kept constant during this investigation. (1)
- 6.3 Calculate the value of x on the graph. (6)

[8]

Question 7

Consider the following chemical equation which represents a reaction between sulfur dioxide and oxygen:

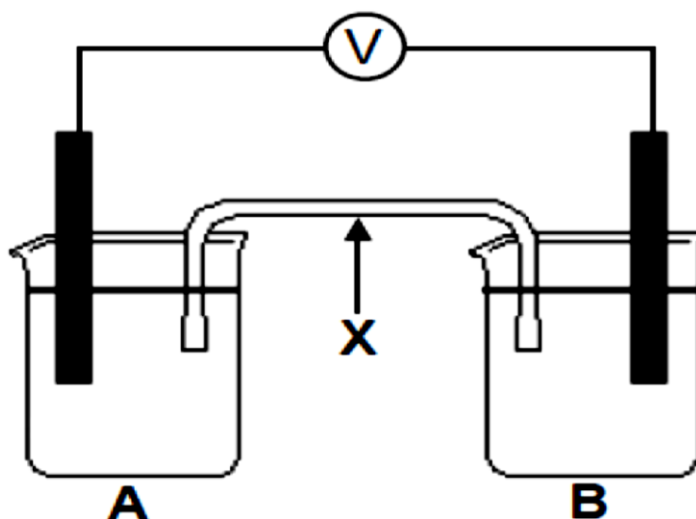


- 7.1 Define *oxidation* in terms of electron transfer. (1)
- 7.2 Give the oxidation number for sulfur in SO_2 and SO_3 . (2)
- 7.3 Is sulfur the OXIDISING AGENT or REDUCING AGENT? (1)

[4]

Question 8

A group of learners set up a galvanic cell using half-cells **A** (Mg/Mg^{2+}) and **B** (Pb/Pb^{2+}) as shown in the diagram below.



- 8.1 State which substance will be formed at the anode. Write only **Mg** or **Mg²⁺**. (1)
- 8.2 Write down the reduction half reaction for the above cell. (2)
- 8.3 Calculate the initial emf of this cell. (4)
- 8.4 Give the FUNCTION of component **X**. (1)
- 8.5 State the type of energy conversion that occurs in this cell. (1)

[9]

Question 9

A group of learners would like to plate a teaspoon with silver. They set up an electrolytic cell for this purpose.

- 9.1 Name TWO differences in the setting up of an electrolytic cell compared to a galvanic cell. (2)
- 9.2 Which terminal of the battery should the teaspoon be connected to? Write down only POSITIVE or NEGATIVE. (1)
- 9.3 Define the term *electrolyte*. (2)
- 9.4 Write down the FORMULA of the substance which is oxidised during the electroplating process. (1)

[6]

Total 100

NAME/NAAM	SYMBOL/SIMBOOL	VALUE/WAARDE
Avogadro's constant <i>Avogadro-konstante</i>	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$
Molar gas constant <i>Molêre gaskonstante</i>	R	$8,31 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$
Standard pressure <i>Standaarddruk</i>	p^θ	$1,013 \times 10^5 \text{ Pa}$
Molar gas volume at STP <i>Molêre gasvolume by STD</i>	V_m	$22,4 \text{ dm}^3\cdot\text{mol}^{-1}$
Standard temperature <i>Standaardtemperatuur</i>	T^θ	273 K
Charge on electron <i>Lading op elektron</i>	e	$-1,6 \times 10^{-19} \text{ C}$

TABLE 2: FORMULAE/TABEL 2: FORMULES

$\frac{m}{n} = M$	$\frac{N}{n} = N_A$
$c = \frac{n}{V}$ or/of $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$
$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$ at/by 298 K	
$E_{\text{cell}}^\theta = E_{\text{cathode}}^\theta - E_{\text{anode}}^\theta / E_{\text{sel}}^\theta = E_{\text{katode}}^\theta - E_{\text{anode}}^\theta$ <p>or/of</p> $E_{\text{cell}}^\theta = E_{\text{reduction}}^\theta - E_{\text{oxidation}}^\theta / E_{\text{sel}}^\theta = E_{\text{reduksie}}^\theta - E_{\text{oksidasie}}^\theta$ <p>or/of</p> $E_{\text{cell}}^\theta = E_{\text{oxidising agent}}^\theta - E_{\text{reducing agent}}^\theta / E_{\text{sel}}^\theta = E_{\text{oksideermiddel}}^\theta - E_{\text{reduseermiddel}}^\theta$	
$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$	$pV = nRT$

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

Half-reactions/Halfreaksies	E^{\ominus} (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
$Cl_2(g) + 2e^- = 2Cl^-$	+ 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
$Br_2(l) + 2e^- = 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^- = NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^- = Hg(l)$	+ 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
$Al^{3+} + 3e^- = Al$	- 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° (V)
$\text{Li}^+ + e^- = \text{Li}$	-3,05
$\text{K}^+ + e^- = \text{K}$	-2,93
$\text{Cs}^+ + e^- = \text{Cs}$	-2,92
$\text{Ba}^{2+} + 2e^- = \text{Ba}$	-2,90
$\text{Sr}^{2+} + 2e^- = \text{Sr}$	-2,89
$\text{Ca}^{2+} + 2e^- = \text{Ca}$	-2,87
$\text{Na}^+ + e^- = \text{Na}$	-2,71
$\text{Mg}^{2+} + 2e^- = \text{Mg}$	-2,36
$\text{Al}^{3+} + 3e^- = \text{Al}$	-1,66
$\text{Mn}^{2+} + 2e^- = \text{Mn}$	-1,18
$\text{Cr}^{2+} + 2e^- = \text{Cr}$	-0,91
$2\text{H}_2\text{O} + 2e^- = \text{H}_2(\text{g}) + 2\text{OH}^-$	-0,83
$\text{Zn}^{2+} + 2e^- = \text{Zn}$	-0,76
$\text{Cr}^{3+} + 3e^- = \text{Cr}$	-0,74
$\text{Fe}^{2+} + 2e^- = \text{Fe}$	-0,44
$\text{Cr}^{3+} + e^- = \text{Cr}^{2+}$	-0,41
$\text{Cd}^{2+} + 2e^- = \text{Cd}$	-0,40
$\text{Co}^{2+} + 2e^- = \text{Co}$	-0,28
$\text{Ni}^{2+} + 2e^- = \text{Ni}$	-0,27
$\text{Sn}^{2+} + 2e^- = \text{Sn}$	-0,14
$\text{Pb}^{2+} + 2e^- = \text{Pb}$	-0,13
$\text{Fe}^{3+} + 3e^- = \text{Fe}$	-0,06
$2\text{H}^+ + 2e^- = \text{H}_2(\text{g})$	0,00
$\text{S} + 2\text{H}^+ + 2e^- = \text{H}_2\text{S}(\text{g})$	+0,14
$\text{Sn}^{4+} + 2e^- = \text{Sn}^{2+}$	+0,15
$\text{Cu}^{2+} + e^- = \text{Cu}^+$	+0,16
$\text{SO}_4^{2-} + 4\text{H}^+ + 2e^- = \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+0,17
$\text{Cu}^{2+} + 2e^- = \text{Cu}$	+0,34
$2\text{H}_2\text{O} + \text{O}_2 + 4e^- = 4\text{OH}^-$	+0,40
$\text{SO}_2 + 4\text{H}^+ + 4e^- = \text{S} + 2\text{H}_2\text{O}$	+0,45
$\text{Cu}^+ + e^- = \text{Cu}$	+0,52
$\text{I}_2 + 2e^- = 2\text{I}^-$	+0,54
$\text{O}_2(\text{g}) + 2\text{H}^+ + 2e^- = \text{H}_2\text{O}_2$	+0,68
$\text{Fe}^{3+} + e^- = \text{Fe}^{2+}$	+0,77
$\text{NO}_3^- + 2\text{H}^+ + e^- = \text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+0,80
$\text{Ag}^+ + e^- = \text{Ag}$	+0,80
$\text{Hg}^{2+} + 2e^- = \text{Hg}(\ell)$	+0,85
$\text{NO}_3^- + 4\text{H}^+ + 3e^- = \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+0,96
$\text{Br}_2(\ell) + 2e^- = 2\text{Br}^-$	+1,07
$\text{Pt}^{2+} + 2e^- = \text{Pt}$	+1,20
$\text{MnO}_2 + 4\text{H}^+ + 2e^- = \text{Mn}^{2+} + 2\text{H}_2\text{O}$	+1,23
$\text{O}_2(\text{g}) + 4\text{H}^+ + 4e^- = 2\text{H}_2\text{O}$	+1,23
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6e^- = 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1,33
$\text{Cl}_2(\text{g}) + 2e^- = 2\text{Cl}^-$	+1,36
$\text{MnO}_4^- + 8\text{H}^+ + 5e^- = \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+1,51
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2e^- = 2\text{H}_2\text{O}$	+1,77
$\text{Co}^{3+} + e^- = \text{Co}^{2+}$	+1,81
$\text{F}_2(\text{g}) + 2e^- = 2\text{F}^-$	+2,87

Increasing reducing ability/Toenemende reduserende vermoë

