education

Department of Education
FREE STATE PROVINCE

PREPARATORY EXAMINATION

GRADE 12

PHYSICAL SCIENCES P2 (CHEMISTRY)

SEPTEMBER 2017

MARKS: 150

TIME: 3 HOURS

This question paper consists of 18 pages, 1 graph paper and 4 data sheets.

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INSTRUCTIONS AND INFORMATION

1. Write your name on the ANSWER BOOK.

2. This question paper consists of TEN 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.

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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 SHEET, for example 1.11 E.

1.1 Which ONE of the following pairs of compounds belong to the same homologous series?

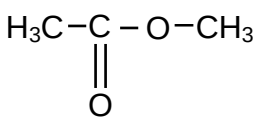
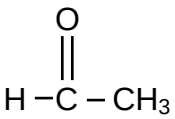
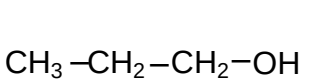
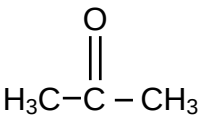
A C_2H_6 and C_4H_{12}

B C_3H_6 and C_5H_8

C CH_4O and $C_2H_4O_2$

D C_2H_2 and C_3H_4 (2)

1.2 Which ONE of the following compounds is an isomer of CH_3CH_2COOH?

A		B	
C		D	

(2)

1.3 The hydrogenation of sunflower oil results in the production of margarine. During this process the ...

A number of double bonds increases.

B carbon chain increases.

C number of double bonds decreases.

D compound becomes less saturated. (2)

1.4 Consider the following reversible reaction:

$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \quad \Delta H > 0$

The temperature is now lowered. Which ONE of the following statements is correct?

A The rate of the forward reaction is increased.

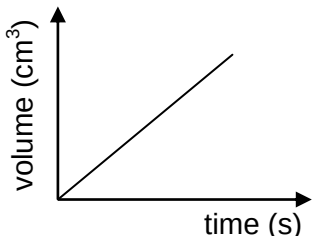
B The rate of both the forward and the reverse reactions decreased.

C The rate of the reverse reaction is decreased.

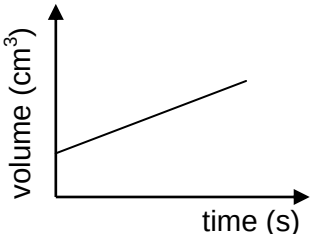
D The rate of both the forward and the reverse reactions increased. (2)

1.5 Hydrogen gas is produced in the reaction between hydrochloric acid and magnesium. Which ONE of the following graphs of volume versus time best represents the formation of hydrogen gas until the reactants are used up?

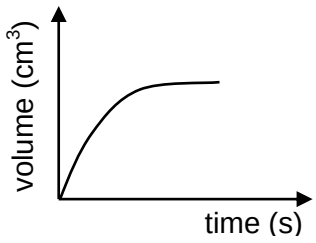
A



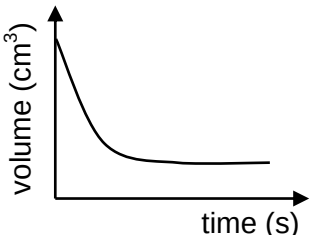
B



C



D



(2)

1.6 The addition of a catalyst to a reversible reaction at equilibrium increases the …

A equilibrium constant of the forward reaction.

B product produced at equilibrium.

C the rate of both the forward and reverse reactions.

D rate of only the forward reaction. (2)

1.7 Consider the reaction $CaO(s) + SO_2(g) \rightleftharpoons CaSO_3(s)$ at equilibrium in a closed container.

If the equilibrium concentration of $SO_2(g)$ at 25°C is x mol.dm^{-3}, the value of the equilibrium constant at this temperature is ...

A x

B x^2

C $\frac{1}{x^2}$

D $\frac{1}{x}$ (2)

1.8 A 0,5 mol·dm^{-3} solution of each of the following acids is prepared. Which acid has the greatest electrical conductivity?

A H_2SO_4

B HCℓ

C CH_3COOH

D HNO_3 (2)

1.9 Which ONE of the following solutions will react spontaneously with copper?

A NaCℓ (aq)

B $AgNO_3$ (aq)

C $ZnSO_4$ (aq)

D $Pb(NO_3)_2$ (aq) (2)

1.10 Which ONE of the following nutrients is responsible for the growth of green leaves in plants?

A Phosphorous

B Nitrogen

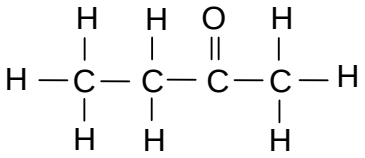
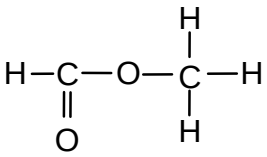
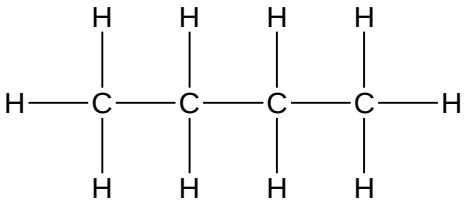
C Potassium

D Magnesium (2)

[20]

QUESTION 2 (Start on a new page.)

Study the organic compounds represented by the letters **A** to **F** in the table below and answer the following questions.

A	propanal	**B**	
C		**D**	
E	$CH_3CH_2CH_2COOH$	**F**	$CH_2\,CH_2$

2.1 Name the homologous series to which each of the following compounds belong:

2.1.1 **A** (1)

2.1.2 **B** (1)

2.2 Write down the IUPAC name of the alcohol needed for the preparation of compound **C**. (2)

2.3 Write down the letter for the compound that represents a carboxylic acid. (1)

2.4 Polymers are organic compounds with a wide range of applications in everyday life.

2.4.1 Define an *addition polymer.* (2)

2.4.2 Write down the letter that represents a monomer of an addition polymer. (1)

2.5 Give the STRUCTURAL FORMULA for the functional group of compoun **A**. (1)

2.6 Give the general formula for the homologous series to which compound **F** belong. (1)

2.7 Is compound **D** a saturated or unsaturated hydrocarbon? Give a reason for your answer. (2)

2.8 Using molecular formulae write down a balanced chemical equation for the combustion of compound **D**. (3)

[15]

QUESTION 3 (Start on a new page.)

A group of learners were investigating the intermolecular forces and physical properties of various organic compounds. As part of their research they determined the boiling point of eight different compounds represented by letters **A** to **H** in the table below:

	Compound	**Molecular mass (M) ($g \cdot mol^{-1}$)**	**Boiling point (^oC)**
A	methyl propane	58	-12
B	butane	58	-0,5
C	pentane	72	36
D	propan-1-ol	60	97
E	butan-1-ol	74	117
F	pentan-1-ol	88	138
G	ethanoic acid	60	118
H	ethyl ethanoate	58	77,1

3.1 Give the STRUCTURAL FORMULA for compound **H**. (2)

3.2 Explain why compounds **D** and **G** have different boiling points despite the fact that they have the same molecular mass. In your explanation refer to the MOLECULAR STRUCTURE, the INTERMOLECULAR FORCES and the ENERGY needed. (3)

3.3 Compounds **A** to **C** have different boiling points even though they belong to the same homologous series. Explain the reason for the difference in their boiling points. (2)

3.4 How will the vapour pressure of compound **G** compare to that of compound **H**? Write only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

3.5 Compounds **A** and **B** are structural isomers

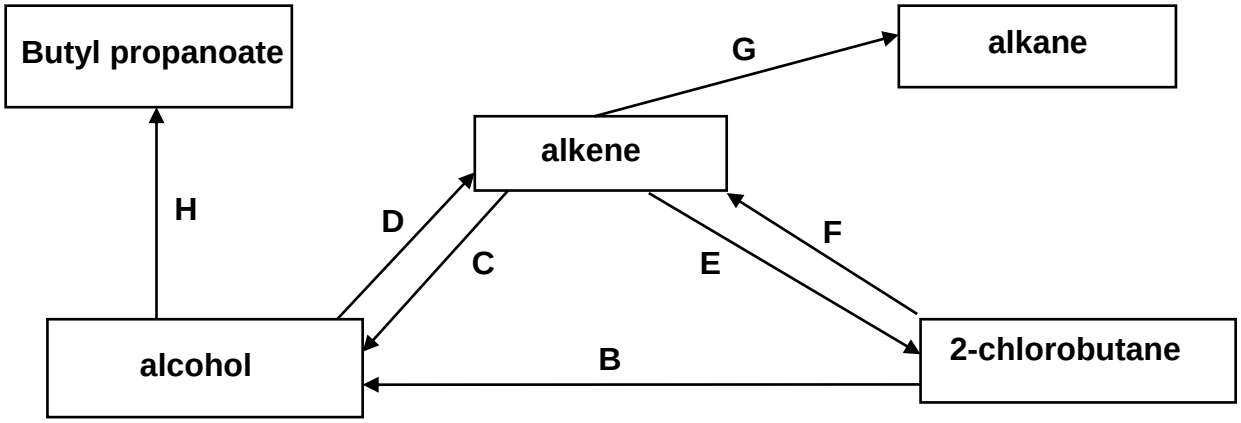
3.5.1 Define the term *structural isomer.* (2)

3.5.2 Name the type of structural isomerism shown by compounds **A** and **B**. (1)

[11]

QUESTION 4 (Start on a new page.)

The letters **B** to **H** in the flow diagram represent different reactions.



4.1 Which type of reaction is represented by EACH of the following? Write only ADDITION, SUBSTITUTION or ELIMINATION.

4.1.1 Reaction **D** (1)

4.1.2 Reaction **E** (1)

4.2 2-chlorobutane is converted into an alkene through reaction **F**. Write down the structural formula of the MAJOR PRODUCT formed in this reaction. (2)

4.3 Using structural formulae write down a balanced chemical equation for reaction **C**. (4)

4.4 Write down TWO reaction conditions for the reaction **B**. (2)

4.5 Reaction **G** is an addition reaction. Write down the:

4.5.1 IUPAC name of the alkane formed in this reaction (1)

4.5.2 Type of the addition reaction (1)

4.6 Reaction **H** represents the reaction between an alcohol and a carboxylic acid in the presence of a catalyst. Write down the:

4.6.1 IUPAC name of the carboxylic acid used in this reaction (1)

4.6.2 NAME of the catalyst (1)

4.6.3 The name of the process that takes place in QUESTION 4.6. (1)

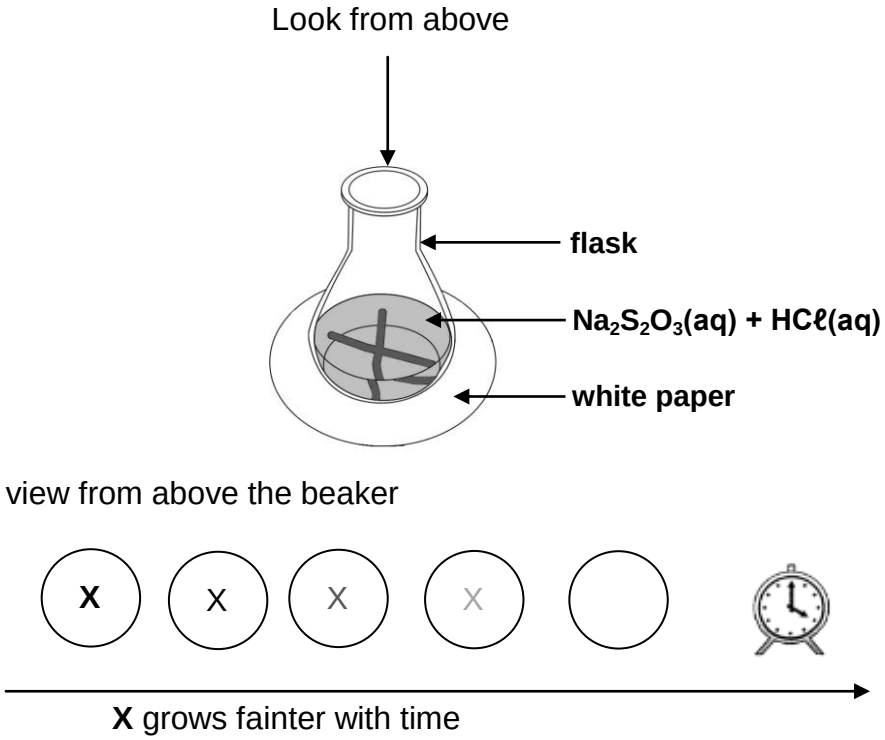
[15]

QUESTION 5 (Start on a new page.)

A group of learners were investigating the factors affecting the reaction rate. In one of their reactions sodium thiosulphate ($Na_2S_2O_3$) and hydrochloric acid (HCℓ) are reacted according to the balanced equation given below:

$$\mathbf{Na_2S_2O_3(aq) + 2HC\ell\,(aq) \rightarrow 2NaC\ell\,(aq) + S(s) + H_2O(\ell) + SO_2(g)}$$

During the reaction one of the products formed causes the solution to turn cloudy. Due to this, the mark **X** drawn on paper, on which the reaction mixture is placed, were not visible after the reaction is completed. Refer the sketch below.



In the investigation the learners took sodium thiosulphate of different concentration and reacted it with hydrochloric acid of constant concentration. They recorded the time taken for the mark **X** on the paper to disappear. Their result is tabulated below.

Trial	1	2	3	4
Concentration $Na_2S_2O_3$(mol.dm^{-3})	0,15	0,09	0,06	0,03
Time taken for the X to disappear in (s)	43	66	100	240

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

5.2 For the experiment described above, name the:

5.2.1 Independent variable (1)

5.2.2 ONE control variable (1)

5.3 Write down the NAME or FORMULA of the substance responsible for the cloudiness. (1)

5.4 Consider the table of results and write down which trial (1, 2, 3 or 4) occurred at the highest reaction rate? (1)

5.5 Draw a graph of concentration of sodium thiosulphate against time for the mark **X** to disappear in the ATTACHED GRAPH SHEET. (4)

5.6 Use the graph to make a conclusion for the above investigation. (2)

5.7 Name TWO other ways in which the rate of this reaction can be increased. (2)

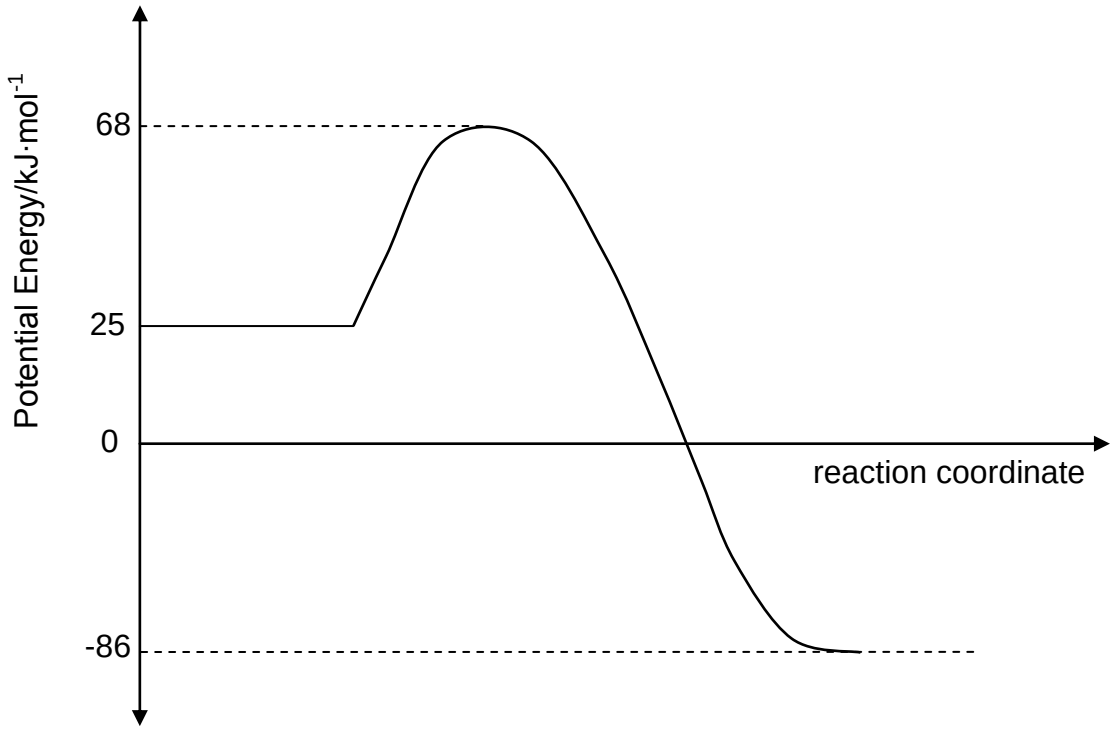
[14]

QUESTION 6 (Start on a new page.)

One of the steps in the preparation of sulphuric acid in the industry is represented by the following reversible reaction:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The graph below shows the energy change during this reaction.



6.1 Write down the type of reaction represented by above graph. Choose from EXOTHERMIC or ENDOTHERMIC. Explain your answer. (2)

6.2 According to collision theory, give TWO conditions necessary for the reaction to take place. (2)

Vanadium pentoxide is added as a catalyst in the above reaction.

6.3 Explain how the presence of a vanadium pentoxide as a catalyst affect the rate of above reaction. (2)

6.4 Calculate the enthalpy change of this reaction. (3)

At 68 $kJ \cdot mol^{-1}$ an activated complex is formed.

6.5 Define the term *activated complex.* (2)

6.6 Calculate the activation energy for the reverse reaction. (2)

[13]

QUESTION 7 (Start on a new page.)

Consider the reversible reaction represented by the following balanced equation.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

During this reaction 4 mole of nitrogen monoxide gas, 2,5 mole of oxygen and ***x*** mole of nitrogen dioxide gas is placed in an 500 cm^3 container at a temperature of 450 K. At equilibrium there is 3 mole of nitrogen oxide present in the container. The equilibrium constant (K_c) at this temperature is 0,25.

7.1 Calculate the initial mole of nitrogen dioxide placed in the container. (7)

7.2 Is the given equilibrium system an example of a heterogeneous or homogeneous equilibrium? Explain your answer. (2)

7.3 State Le Chatelier's principle. (2)

Now the pressure is increased.

7.4 Use Le Chatelier's principle to explain how this change affects the concentration of NO_2 at the new equilibrium. (2)

[13]

QUESTION 8 (Start on a new page.)

A learner takes 20 cm^3 of sodium hydrogen carbonate ($NaHCO_3$) solution of unknown concentration and titrate it against a standard solution of sulphuric acid with a pH of 1.

8.1 Define a *standard solution*. (2)

8.2 Write down the formula of the conjugate base for sulphuric acid. (1)

The balanced chemical equation for the titration is given below:

$$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2CO_2 + 2H_2O$$

8.3 Calculate the concentration of the sodium hydrogen carbonate solution if it neutralizes 12 cm^3 of the sulphuric acid solution. (7)

8.4 What mass of the sodium hydrogen carbonate is needed to prepare a 250 cm^3 solution that the learner used in the titration? (3)

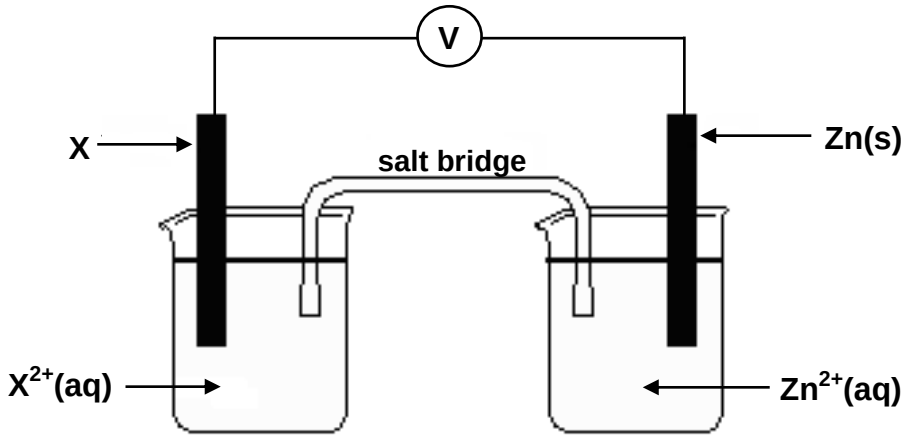
8.5 Which indicator would be best to use during this titration? Explain your choice. (2)

[15]

QUESTION 9 (Start on a new page.)

9.1 The cell notation of a standard galvanic cell that contains an unkown metal electrode **X**, is as follows:

$$Zn(s) \mid Zn^{2+}(1\ mol{\cdot}dm^{-3}) \parallel \mathbf{X}^{2+}(1\ mol{\cdot}dm^{-3}) \mid \mathbf{X}(s)$$



9.1.1 Name the component of the cell that is represented by the double vertical lines (||) in the cell notation. (1)

9.1.2 Name TWO standard conditions that is applicable to the $Zn^{2+}|Zn$-half cell. (2)

9.1.3 Identify the reducing agent in the above mentioned cell. (1)

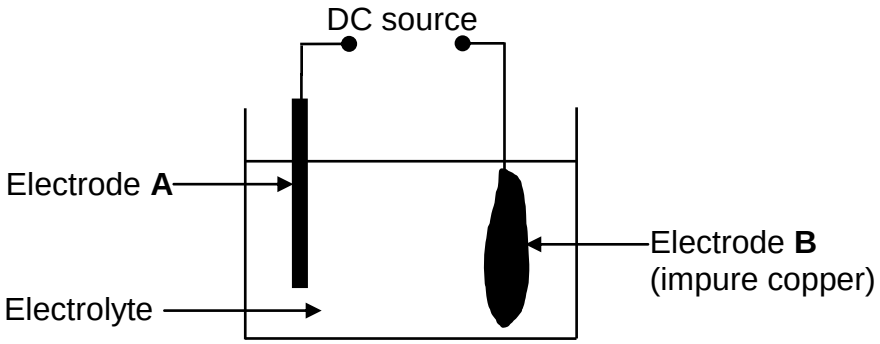
9.1.4 The initial reading on the volt meter connected to the electrodes of the above given cell is 0,49 V. Identify metal **X** by calculating the standard reduction potential of the unkown metal **X**. (5)

9.1.5 Write a balanced chemical equation for the net reaction that takes place in this cell. Leave out the spectator ions. (3)

9.1.6 How will the initial voltmeter reading be influenced if the two metal plates are replaced by metal plates that have a larger surface? Write only INCREASES, DECREASES or STAYS THE SAME (1)

9.1.7 Write down the value of the reading on the volt meter when the cell reaction reaches equilibrium. (1)

9.2 The simplified diagram below represents an electrochemical cell used for the purification of copper.



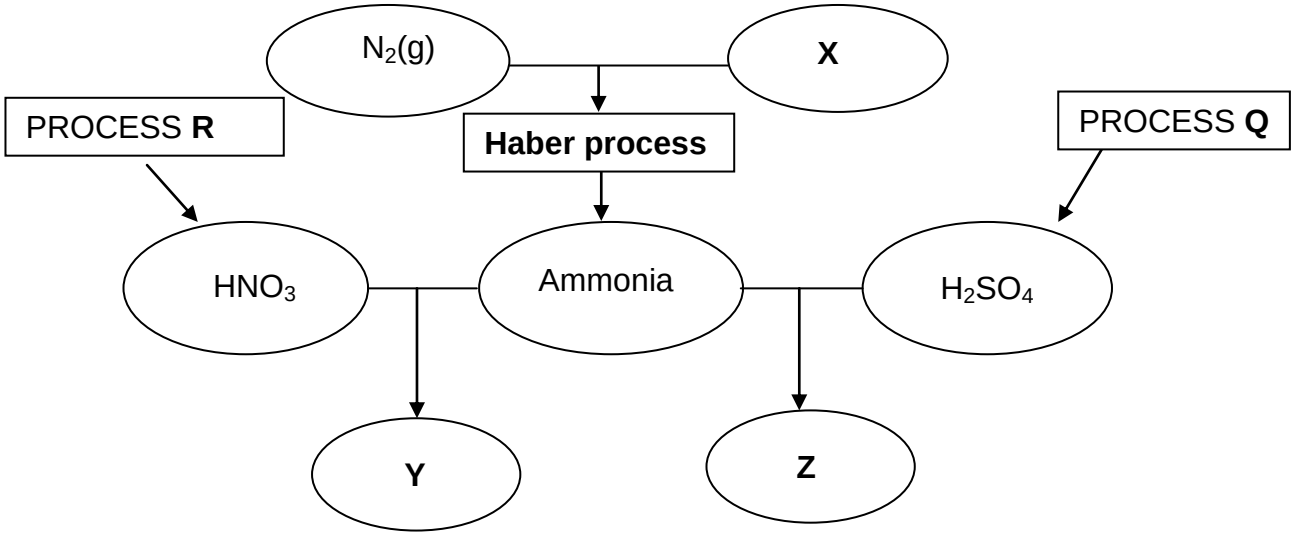
9.2.1 Write down the energy conversion that takes place in the above cell in QUESTION 9.2. (1)

9.2.2 Write down the NAME or FORMULA of the electrolyte that can be used in the above cell. (1)

9.2.3 Write down the half-reaction which takes place at electrode **A**. (2)
[18]

QUESTION 10 (Start on a new page.)

Ammonia is the main reactant in the production of various fertilizers. The following flow diagram illustrates the process of the manufacturing of some fertilizers.



10.1 Write down the NAME of the industrial process used to manufacture nitrogen gas. (1)

10.2 Write a balanced chemical equation for the preparation of ammonia. (3)

10.3 Identify the following in the flow diagram:

10.3.1 PROCESS **R** (1)

10.3.2 Compound **Z** (1)

10.4 Write down the balanced equation for the oxidation of sulphur dioxide in PROCESS **Q**. (3)

10.5 Write down the FORMULA of compound **Y**. (1)

10.6 A farmer find a old bag of fertilizer weighing 50 kg. The label of the bag is partly damaged. One number in the N:P:K ratio was missing (see diagram).



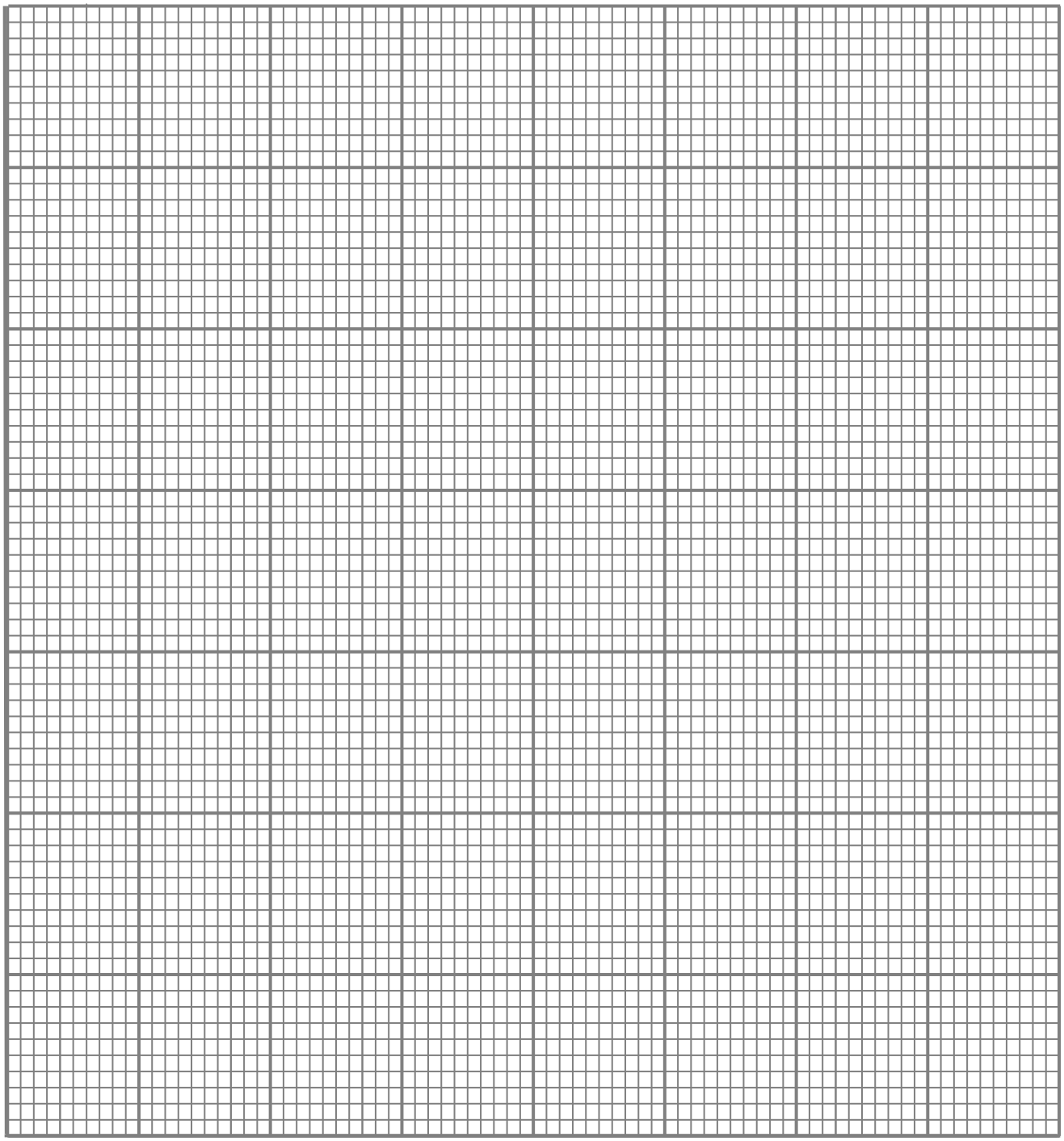
The farmer analysed the content of the fertilizer and found that the nitrogen content in the bag is 15%. Determine the number that is missing on the label of the fertiliser bag regarding the N:P:K ratio. Assume that no content is lost due to aging. (4)

10.7 Eutrofication is the result of excessive use of inorganic fertilizers.
Explain what is meant by *eutrofication.* (2)
[16]

TOTAL: 150

QUESTION 5.5

SURNAME AND NAME **CLASS**



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 *Avogadro-konstante*	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* $E^{\theta}_{cell} = E^{\theta}_{oxidisingagent} - E^{\theta}_{reducingagent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

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

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)
2,1 **1** **H** 1																	**2** **He** 4
1,0 **3** **Li** 7	1,5 **4** **Be** 9											2,0 **5** **B** 11	2,5 **6** **C** 12	3,0 **7** **N** 14	3,5 **8** **O** 16	4,0 **9** **F** 19	**10** **Ne** 20
0,9 **11** **Na** 23	1,2 **12** **Mg** 24											1,5 **13** **Aℓ** 27	1,8 **14** **Si** 28	2,1 **15** **P** 31	2,5 **16** **S** 32	3,0 **17** **Cℓ** 35,5	**18** **Ar** 40
0,8 **19** **K** 39	1,0 **20** **Ca** 40	1,3 **21** **Sc** 45	1,5 **22** **Ti** 48	1,6 **23** **V** 51	1,6 **24** **Cr** 52	1,5 **25** **Mn** 55	1,8 **26** **Fe** 56	1,8 **27** **Co** 59	1,8 **28** **Ni** 59	1,9 **29** **Cu** 63,5	1,6 **30** **Zn** 65	1,6 **31** **Ga** 70	1,8 **32** **Ge** 73	2,0 **33** **As** 75	2,4 **34** **Se** 79	2,8 **35** **Br** 80	**36** **Kr** 84
0,8 **37** **Rb** 86	1,0 **38** **Sr** 88	1,2 **39** **Y** 89	1,4 **40** **Zr** 91	**41** **Nb** 92	1,8 **42** **Mo** 96	1,9 **43** **Tc**	2,2 **44** **Ru** 101	2,2 **45** **Rh** 103	2,2 **46** **Pd** 106	1,9 **47** **Ag** 108	1,7 **48** **Cd** 112	1,7 **49** **In** 115	1,8 **50** **Sn** 119	1,9 **51** **Sb** 122	2,1 **52** **Te** 128	2,5 **53** **I** 127	**54** **Xe** 131
0,7 **55** **Cs** 133	0,9 **56** **Ba** 137	**57** **La** 139	1,6 **72** **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	1,8 **81** **Tℓ** 204	1,8 **82** **Pb** 207	1,9 **83** **Bi** 209	2,0 **84** **Po**	2,5 **85** **At**	**86** **Rn**
0,7 **87** **Fr**	0,9 **88** **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**

KEY/*SLEUTEL*

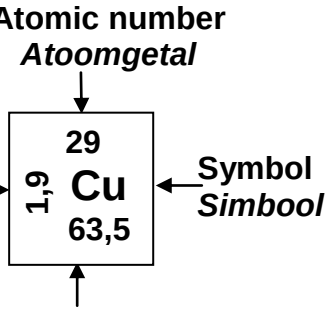


TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Half-reactions/*Halfreaksies*	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

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