LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

SEPTEMBER 2019

EPHSCP2

MARKS: 150

TIME: 3 hours

This question paper consists of 18 pages and 4 data sheets

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INSTRUCTIONS AND INFORMATION

1. Write your NAME in the appropriate space 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. You may use a non-programmable calculator.
5. You may use appropriate mathematical instruments.
6. YOU ARE ADVISED TO USE THE ATTACHED DATA SHEETS.
7. Number the answers correctly according to the numbering system used in this question paper.
8. Give brief motivations, discussions, et cetera where required.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your final numerical answers to a minimum of TWO decimal places.
11. 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. Write only the letter (A – D) next to the question number (1.1 – 1.10) in the ANSWER BOOK.

1.1 Which ONE of the following is an UNSATURATED organic compound?

A $CH_3CH_2CH_2OH$

B CH_2CHCH_3

C $CH_3CH(CH_3)CH_2CH_3$

D CH_3COOCH_3 (2)

1.2 The equation below represents a cracking reaction:

$$C_7H_{16} \rightarrow C_5H_{10} + Y$$

In this reaction, compound Y is:

A Ethanol

B Ethyne

C Ethene

D Ethane (2)

1.3 The IUPAC name of the monomer of polythene is:

A Ethene

B Ethane

C Ethyne

D Propene (2)

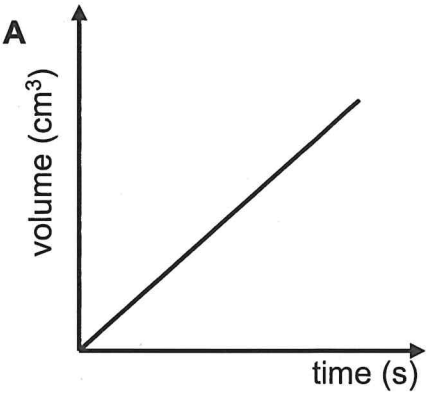
1.4 Consider the reaction represented by the following balanced reaction:

$$Zn(s) + 2HC\ell\,(aq) \rightarrow ZnC\ell_2\,(aq) + H_2\,(g)$$

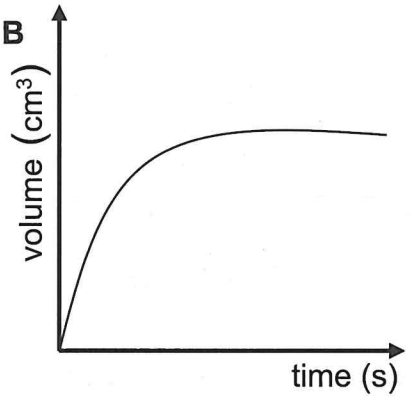
The reaction is allowed to run to completion.

Which ONE of the following graphs of volume against time best represents the formation of hydrogen gas?

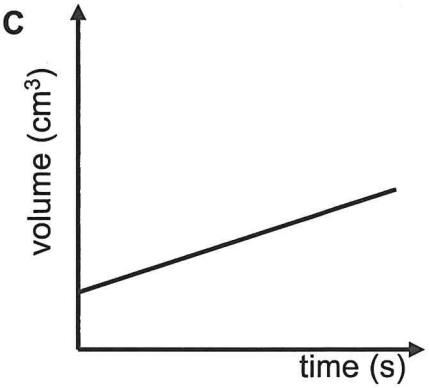
A



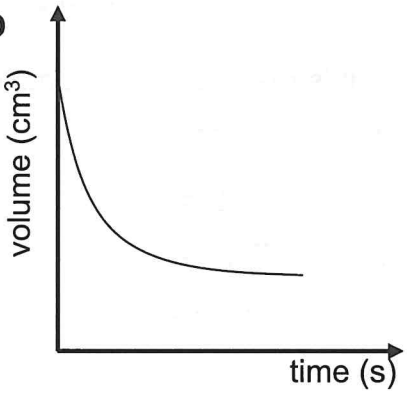
B



C



D



1.5 Consider the reaction represented by the following balanced reaction:

$$A_2(g) + B_2(g) \rightarrow 2AB(g)$$

The activation energy for the forward reaction is 180 kJ and that of the reverse reaction is 200 kJ.

The heat of reaction (ΔH) for the forward reaction is:

A -20 kJ
B +20 kJ
C -380 kJ
D +380 kJ (2)

1.6 The following reaction reaches equilibrium in a closed container at a certain temperature:

$$2\ O_3\ (g) \rightleftharpoons 3\ O_2\ (g)$$

The pressure is now increased at constant temperature.

Which ONE of the following combinations is correct when the reaction reaches a new equilibrium?

	Number of moles of O_3 (g)	**Number of moles of O_2 (g)**
A	Increases	Decreases
B	Decreases	Increases
C	Decreases	Decreases
D	Increases	Increases

(2)

1.7 Consider the reaction represented by the following reaction:

$$H_3PO_4\ (aq) + HCO_3^-(aq) \rightleftharpoons H_2PO_4^-\ (aq) + H_2CO_3\ (aq) \quad K_a > 1$$

The strongest base in this reaction is:

A $H_2PO_4^-$

B HCO_3^-

C H_3PO_4

D H_2CO_3 (2)

1.8 A beaker contains a 0,01 mol·dm^{-3} HCℓ solution. A spoonful of a soluble salt, X, is added to the solution and the pH of the solution increases.

Which ONE of the following can be salt X?

A KNO_3

B $(NH_4)_2SO_4$

C CH_3COONa

D Na_2SO_4 (2)

1.9 Which ONE of the following CANNOT act as a reducing agent?

A Mg

B Br^-

C MnO_4^-

D Fe^{2+} (2)

1.10 The main products formed during the Contact and the Haber processes are:

	Contact Process	**Haber Process**
A	SO_2	NH_3
B	N_2	H_2SO_4
C	NH_3	HNO_3
D	H_2SO_4	NH_3

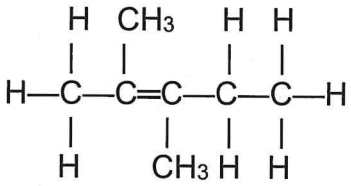
(2)

[20]

QUESTION 2 (Start on a new page.)

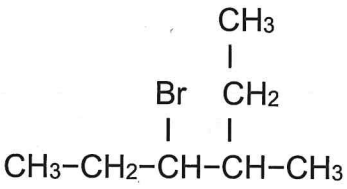
2.1 Write down the IUPAC name of each of the following compounds:

2.1.1



(2)

2.1.2



(2)

2.2 Write down the structural formula of 4 – methylpentan – 2 – ol. (2)

2.3 Use STRUCTURAL FORMULAE for all organic reactants and products to write a balanced equation for the preparation of propyl ethanoate. (4)

[10]

QUESTION 3 (Start on a new page.)

The boiling points of four organic compounds, represented by the letters **A**, **B**, **C** and **D**, are given in the table below.

	COMPOUND	BOILING POINT (°C)
A	Propane	-42
B	Pentane	36
C	2-methyl butane	27,8
D	Pentan-1-ol	137

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

3.2 Which ONE of compounds **A** or **B** has the higher vapour pressure? (1)

3.3 An unknown STRAIGHT CHAIN ALKANE has a boiling point of -0,5 °C. Use the information in the table to write down its IUPAC name. (2)

3.4 Compounds **B** and **C** are structural isomers.

3.4.1 Define the term *structural isomers.* (2)

3.4.2 What type of structural isomers are compounds **B** and **C**? (1)

3.4.3 Explain why compound **B** has a higher boiling point than compound **C**. (3)

3.5 Explain the difference in boiling points of **B** and **D**.
Refer to intermolecular forces and energy in your explanation. (4)
[15]

QUESTION 4 (Start on a new page.)

4.1 Prop-1-ene, an UNSATURATED hydrocarbon, and compound **X**, a SATURATED hydrocarbon, react with bromine, as represented by the incomplete reactions below.

Reaction I: Prop-1-ene + Br_2 →

Reaction II: **X** + Br_2 → 2-bromobutane + **Y**

4.1.1 Why is pro-1-ene classified as unsaturated? (1)

4.1.2 What type of reaction takes place in:

(a) Reaction I (1)

(b) Reaction II (1)

4.1.3 Write down the structural formula of the product which is formed in Reaction I. (2)

4.1.4 Write down the reaction condition needed in order for Reaction II to take place. (1)

4.1.5 Write down the IUPAC NAME of reactant **X**. (1)

4.1.6 Write down the NAME or FORMULA of product **Y**. (1)

4.1.7 During both reactions I and II, the colour of the solution changes from reddish brown to colourless. In which reaction (I or II) does this decolourisation occur faster? Explain briefly. (3)

4.2 2-bromobutane can undergo either ELIMINATION or SUBSTITUTION in the presence of a strong base like sodium hydroxide.

4.2.1 Which reaction will most likely take place when 2-bromo butane reacts in the presence of heated CONCENTRATED sodium hydroxide in ethanol? Choose from SUBSTITUTION or ELIMINATION. (1)

4.2.2 Write down the IUPAC name of the major organic product which is formed in QUESTION 4.2.1. (2)

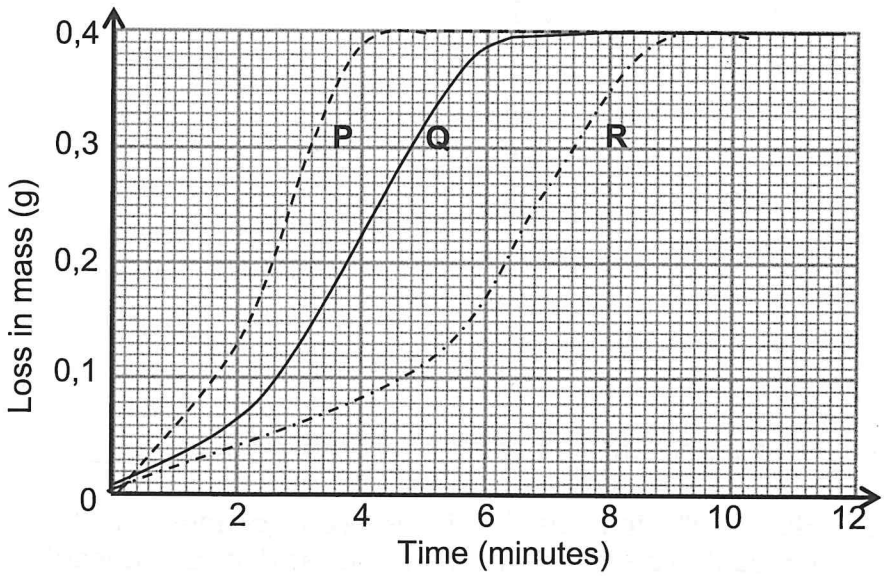
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4.2.3 Use STRUCTURAL FORMULAE for all organic reactants and products to write a balanced equation for the reaction between 2-bromobutane and DILUTED sodium hydroxide. (5)

4.2.4 Write down the name of the type of substitution reaction which occurs in QUESTION 4.2.3. (1)
[19]

QUESTION 5 (Start on a new page.)

Pieces of marble ($CaCO_3$) with a mass of 1,05 g are placed in a flask and covered with 10 cm^3 of a 2 $mol \cdot dm^{-3}$ hydrochloric acid solution at 20 °C. The flask is weighed every two minutes to determine the loss in mass due to the production of carbon dioxide. Line graph **Q** is plotted from these results.



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

5.2 Write down a balanced equation for the reaction between the marble and hydrochloric acid. (3)

Use graph **Q** to answer the following questions.

5.3 What mass of carbon dioxide gas is formed after 8 minutes? (1)

5.4 During which ONE of the following time intervals is the reaction rate the highest?
Choose from 0-2 minute, 2-4 minutes, 6-8 minutes, 8-10 minutes.
Briefly explain your choice. (2)

5.5 After how many minutes has half of the $CaCO_3$ reacted? (1)

5.6 Predict what will happen to the rate of the reaction in each of the following cases: (choose from INCREASES, DECREASES or REMAINS THE SAME)

5.6.1 The marble pieces are replaced by marble powder (1)

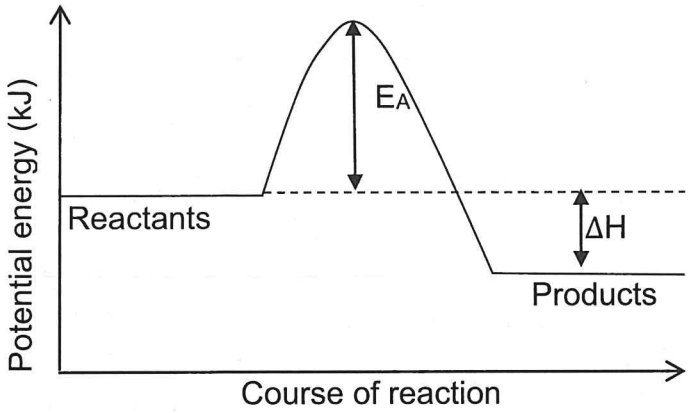
5.6.2 20 cm^3 of a 2 $mol \cdot dm^{-3}$ hydrochloric acid solution is used (1)

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The experiment is now repeated with a 1,5 mol·dm^{-3} hydrochloric acid solution. The reaction runs to completion.

5.7 Which graph, **P** or **R**, is obtained from this experiment? (1)

5.8 A potential energy diagram is drawn for the above reaction.



5.8.1 Is this reaction exothermic or endothermic? (1)

5.8.2 How will the heat of reaction change if the concentration of the hydrochloric acid is decreased? (Choose from INCREASES, DECREASES or REMAINS THE SAME) (1)

5.8.3 A suitable catalyst is added to the reaction.
WHICH quantity on the graph will change?
HOW will it change? (2)
[16]

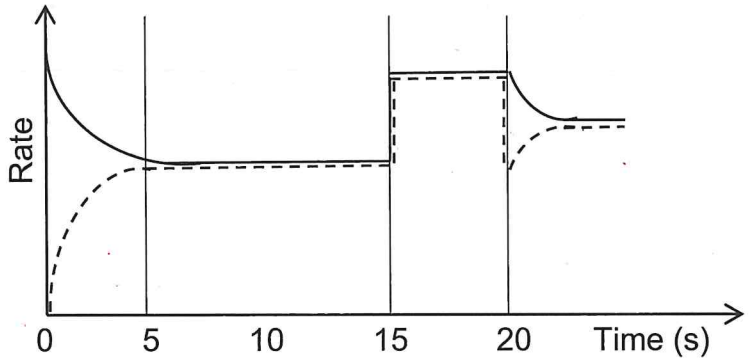
QUESTION 6 (Start on a new page.)

The following reaction reaches equilibrium at 600 K after 5s:

$$2XA_2(g) \rightleftharpoons X_2A_2(g) + A_2(g)$$

The graph below shows the changes in the rates of the forward and the reverse reactions against time.

Graph of change in reaction rate versus time



6.1 Name TWO requirements in order for a chemical reaction to reach equilibrium. (2)

6.2 Write down the balanced equation for the reaction which is represented by the dotted line. (1)

6.3 The pressure in the container is changed after 15 seconds.

6.3.1 Is the pressure increased or decreased? (1)

6.3.2 What effect does this change have on the equilibrium constant?
Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

6.4 A temperature change occurs at t = 20 s.

6.4.1 Is the temperature increased or decreased? (1)

6.4.2 Apply Le Chatelier's principle and explain whether the forward reaction is exothermic or endothermic. (3)

6.4.3 What effect does this change in temperature have on the equilibrium constant? (1)

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6.5 Initially, 5 moles of $XA_2(g)$ are placed in an empty container with a volume of 500 cm^3.
When equilibrium was reached at 600 K it was found that 2,25 moles of A2(g) were present in the container.
Calculate the equilibrium constant, Kc, at 600 K. (7)

6.6 For another reaction, Kc = 18,5 at 600 K.

6.6.1 What can you deduce about the concentration of the products and the concentration of the reactants for this reaction at 600 K? (1)

6.6.2 What is the Kc value for the reverse reaction at 600 K? (1)
[19]

QUESTION 7 (Start on a new page.)

7.1 Sulphuric acid is a diprotic acid which is used in industry.

7.1.1 Define an *acid* in terms of the Lowry-Bronsted theory. (2)

7.1.2 Give a reason why sulphuric acid is referred to as a *diprotic acid*. (1)

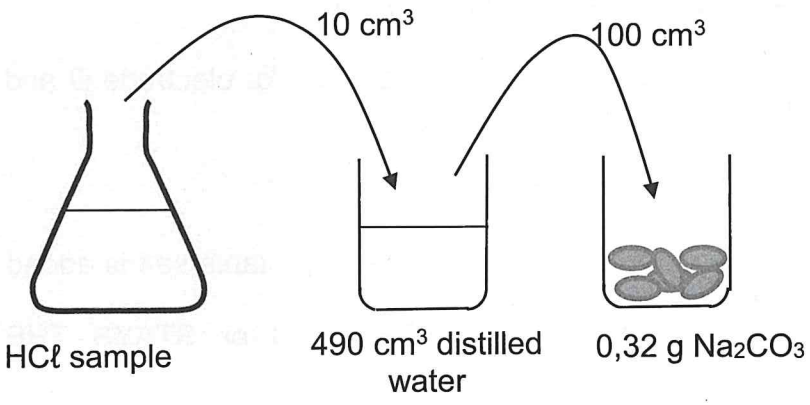
7.1.3 Give a reason why sulphuric acid is regarded as a *strong acid*. (1)

7.1.4 Write down the NAME or FORMULA of the conjugated base of sulphuric acid. (1)

7.1.5 What is the common name given to a substance which can act as both an acid or a base? (1)

7.2 A laboratory technician wants to determine the concentration of a hydrochloric acid (HCℓ) sample. He adds 10 cm^3 of the HCℓ sample to 490 cm^3 of distilled water to give 500 cm^3 of dilute hydrochloric acid.

During a reaction, 100 cm^3 of this HCℓ solution reacts completely with 0,32 g of sodium carbonate, $Na_2CO_3(s)$.



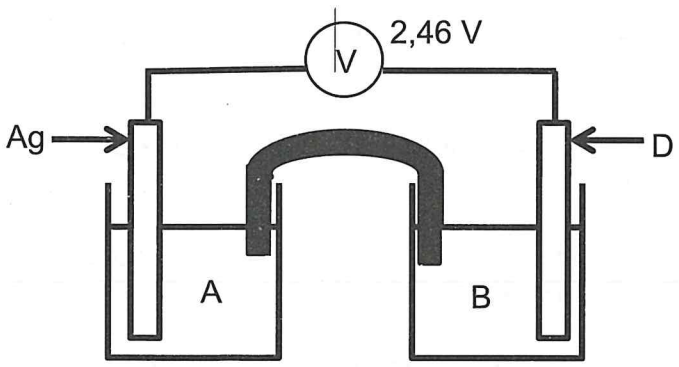
The balanced equation for this reaction is:

$$Na_2CO_3(s) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + CO_2(g) + H_2O(\ell)$$

Calculate the concentration of the original HCℓ sample. (7)
[13]

QUESTION 8 (Start on a new page.)

A standard electrochemical cell is set up, using silver and an unknown electrode, D, as shown in the sketch below,. The initial reading on the voltmeter is 2,46 V. After the cell was connected for some time, the mass of the silver electrode increased.



8.1 What process takes place at the silver electrode? Choose from OXIDATION or REDUCTION. (1)

8.2 Define an *oxidising agent* in terms of electron transfer. (2)

8.3 Write down the NAME of a solution which can be used in beaker A. (1)

8.4 Do electrons move in the external circuit from D to the silver electrode or from the silver electrode to D? (1)

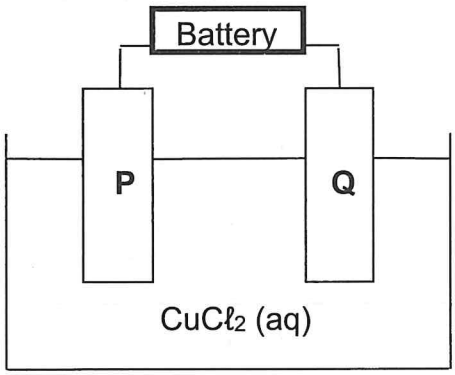
8.5 Determine the standard electrode potential for electrode D and identify D from the standard potential table. (5)

8.6 Write down the cell notation for this cell. (3)

8.7 What will happen to the voltmeter reading if table salt is added to beaker A?
Choose from INCREASES, DECREASES or STAYS THE SAME.
Give a reason for the answer. (2)
[15]

QUESTION 9 (Start on a new page.)

In the electrolytic cell below, two carbon rods are used as electrodes and a concentrated copper (II) chloride solution ($CuC\ell_2$) is used as electrolyte.



9.1 Define the term *electrolyte.* (2)

When the cell is in operation, a gas is released at electrode **P** while electrode **Q** is covered with a brown layer.

9.2 Write down a half reaction to explain the observation made at:

9.2.1 Electrode **P**. (2)

9.2.2 Electrode **Q**. (2)

9.3 Which electrode, **P** or **Q**, is the cathode? Give a reason for the answer. (2)

9.4 The carbon rods in the above cell are now replaced with COPPER RODS and the cell is allowed to operate for some time.

The following observations are made at electrode **P**:

- No gas is released.
- Its surface appears rough and corroded.

9.4.1 Refer to the RELATIVE STRENGTHS OF REDUCING AGENTS and explain these observations. (3)

9.4.2 This cell can be used for the purification of copper. Which electrode (**P** or **Q**) will be replaced with the impure copper during this purification process? (1)
[12]

QUESTION 10 (Start on a new page.)

Ammonium nitrate (NH_4NO_3) is an important fertilizer. It is prepared by reacting nitric acid with ammonia. Both nitric acid and ammonia are prepared on a large scale in industry.

10.1 Write down the name of the industrial process used for the preparation of nitric acid. (1)

10.2 The catalytic oxidation of ammonia is one of the steps in the process named in QUESTION 10.1.

Write down the FORMULAE of TWO products which are formed during the catalytic oxidation of ammonia. (2)

10.3 Write the balanced equation for the production of ammonium nitrate. (3)

10.4 Farmers often mix ammonium nitrate with potassium nitrate and ammonium phosphate. Give a reason why it is mixed with these compounds. (1)

10.5 The equation for the preparation of ammonium sulphate is:

$$2\ NH_3(g) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

Calculate the mass, in kilogram, of ammonium sulphate which can be produced from $6,8x10^4$ kg ammonia and an excess of sulphuric acid. (4)
[11]

GRAND TOTAL: 150

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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

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$c = \frac{n}{V}$
$c = \frac{m}{MV}$	$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ $E^{\theta}_{cell} = E^{\theta}_{oxidising\,agent} - E^{\theta}_{reducingagent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$

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

V

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 H 1																	2 He 4
1,0 Li 3 7	1,5 Be 4 9											2.0 B 5 11	2.5 C 6 12	3,0 N 7 14	3.5 O 8 16	4.0 F 9 19	Ne 10 20
0,9 Na 11 23	1,2 Mg 12 24											1.5 Al 13 27	1.8 Si 14 28	2.1 P 15 31	2.5 S 16 32	3.0 Cl 17 35,5	Ar 18 40
0,8 K 19 39	1,0 Ca 20 40	1,3 Sc 21 45	1.5 Ti 22 48	1,6 V 23 51	1.6 Cr 24 52	1.5 Mn 25 55	1.8 Fe 26 56	1.8 Co 27 59	1.8 Ni 28 59	1.9 Cu 29 63,5	1.6 Zn 30 65	1.6 Ga 31 70	1.8 Ge 32 73	2,0 As 33 75	2.4 Se 34 79	2.8 Br 35 80	Kr 36 84
0,8 Rb 37 86	1,0 Sr 38 88	1,2 Y 39 89	1.4 Zr 40 91	Nb 41 92	1.8 Mo 42 96	1.9 Tc 43	2.2 Ru 44 101	2.2 Rh 45 103	2.2 Pd 46 106	1.9 Ag 47 108	1.7 Cd 48 112	1.7 In 49 115	1.8 Sn 50 119	1,9 Sb 51 122	2.1 Te 52 128	2.5 I 53 127	Xe 54 131
0,7 Cs 55 133	0,9 Ba 56 137	La 57 139	1,6 Hf 72 179	Ta 73 181	W 74 184	Re 75 186	Os 76 190	Ir 77 192	Pt 78 195	Au 79 197	Hg 80 201	1.8 Tl 81 204	1.8 Pb 82 207	1,9 Bi 83 209	2.0 Po 84	2.5 At 85	Rn 86
0,7 Fr 87	0,9 Ra 88 226	Ac 89															

Ce 58 140	Pr 59 141	Nd 60 144	Pm 61	Sm 62 150	Eu 63 152	Gd 64 157	Tb 65 159	Dy 66 163	Ho 67 165	Er 68 167	Tm 69 169	Yb 70 173	Lu 71 175
Th 90 232	Pa 91	U 92 238	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103

KEY/*SLEUTEL*

Atomic number *Atoomgetal*

Electronegativity *Elektronegatiwiteit* → 29 Cu 63,5 ← Symbol *Simbool*

Approximate relative atomic mass *Benaderde relatiewe atoommassa*

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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+}	+ 1,82
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,52
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,28
$O_2(g) + 4H^+ + 3e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,06
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,78
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,78
$Fe^{3+} + e^-$	$\rightleftharpoons$	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
$SO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 4e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 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	– 0,04
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	– 0,13
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	– 0,14
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	– 0,25
$Co^{2+} + 2e^-$	$\rightleftharpoons$	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
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	– 0,74
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	– 0,76
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	– 0,83
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	– 1,18
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	– 1,66
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	– 2,37
$Na^+ + e^-$	$\rightleftharpoons$	Na	– 2,71
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	– 2,87
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	– 2,90
$K^+ + e^-$	$\rightleftharpoons$	K	– 2,92
$Li^+ + e^-$	$\rightleftharpoons$	Li	– 3,04

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TABLE 4B: STANDARD REDUCTION POTENTIALS/ *TABEL 4B: STANDAARD REDUKSIEPOTENSIALE*

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	$\rightleftharpoons$	Li	– 3,04
$K^+ + e^-$	$\rightleftharpoons$	K	– 2,92
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	– 2,90
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	– 2,87
$Na^+ + e^-$	$\rightleftharpoons$	Na	– 2,71
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	– 2,37
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	– 1,66
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	– 1,18
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	– 0,83
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	– 0,76
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	– 0,74
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	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	– 0,25
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	– 0,14
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	– 0,13
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	– 0,04
$2H^+ + 2e^-$	$\rightleftharpoons$	$H_2(g)$	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
$SO_4^{2-} + 4H^+ + 4e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 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
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,78
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,78
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,06
$O_2(g) + 4H^+ + 3e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,28
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,52
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,82
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87

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