Hillcrest High School

PHYSICAL SCIENCE P2
NOVEMBER 2025

Grade 11

MARKS: 125 | **EXAMINER:** Mrs J. Knox-Whitehead
TIME: 2½ hours | **MODERATOR:** Ms N. Badenhorst

Instructions

1. Answer ALL the questions.

2. This question paper consists of TWO sections:

3. SECTION A (16)
   SECTION B (109)

   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 – 1.8) in the ANSWER BOOK.

1.1 Nitrogen gas, N_2(g), is cooled until it turns into liquid nitrogen, N_2(l). What type of intermolecular forces exist between nitrogen molecules in the liquid phase?

A covalent bonds

B ionic bonds

C dipole-dipole forces

D London forces

1.2 When NaCl dissolves in water, aqueous Na^+ and Cl^- ions result. The force of attraction that exists between Na^+ and H_2O is called a/an … interaction.

A ion-ion

B ion-dipole

C dipole-dipole

D hydrogen bonding

1.3 The percentage oxygen in $CuSO_4.5H_2O$ is …

A 25,65%

B 40,13%

C 43,13%

D 57,72%

1.4 Consider the reaction represented by the following balanced equation:

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

The activation energy for the forward reaction is 180 kJ and that of the reverse reaction is 200 kJ. The heat of reaction, △H, for the reverse reaction is …

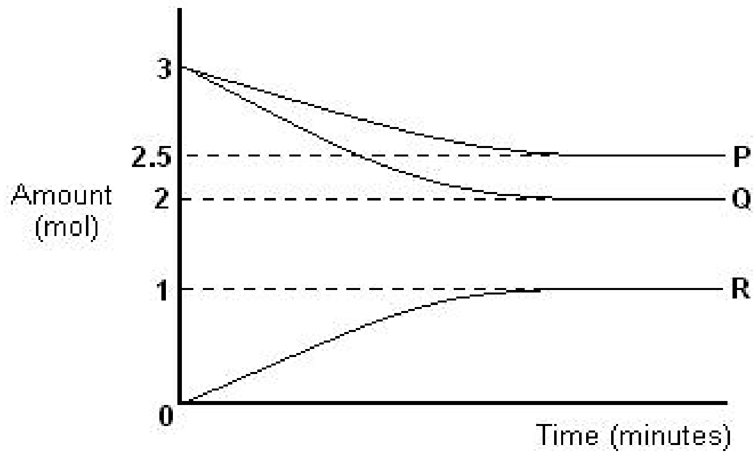
A - 20 kJ

B + 20 kJ

C - 380 kJ

D + 380 kJ

1.5 The accompanying graph shows the change in amounts of substances **P**, **Q** and **R** over time during a reaction.



The equation for the reaction can be represented as …

A P + 2Q → 2R

B 3P + 2Q → R

C R → 3P + 2Q

D 2R → 5P + 4Q

1.6 In the titration of acid **A** and base **B**, the pH at the end point is 8,72. The most suitable indicator for this titration will be …

A methyl orange

B phenolphthalein

C bromothymol blue

D universal indicator

1.7 In the reaction:

$$2\,Al_2O_3 \rightarrow 4Al + 3O_2$$

the reducing agent is …

A Al^{3+}

B Al

C O^{2-}

D O_2

1.8 Which ONE of the following represents an unbalanced equation for a reaction that can take place spontaneously?

A $Fe^{2+} + Pb \rightarrow Fe^{3+} + Pb^{2+}$

B $Fe + Pb^{2+} \rightarrow Fe^{3+} + Pb$

C $Fe^{2+} + Fe^{3+} \rightarrow Fe + Fe^{3+}$

D $Fe^{3+} + Fe \rightarrow Fe^{3+} + Fe^{2+}$

[2 x 8 = 16]

SECTION B

Question 2

To investigate the reaction between a metal carbonate and a strong acid, some Grade 11 learners placed 0,05 moles of calcium carbonate in a reaction vessel containing 25,00 cm^3 of HCl solution of concentration 0,2 $mol.dm^{-3}$. Carbon dioxide gas was produced and collected in a syringe.

$$CaCO_3(s) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

2.1 What is meant by *reagent in excess*? (2)

2.2 Calculate which reagent will be in excess. (5)

2.3 What is the maximum mass of $CaCl_2$ that can be produced in this reaction? (4)

2.4 If the volume of $CO_2(g)$ collected in the syringe was 0,023 dm^3 at STP, calculate the percentage yield of the calcium chloride. (5)

[16]

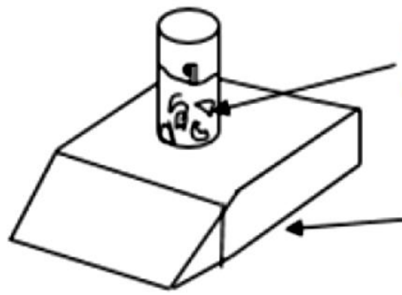
Question 3

To further investigate the rate of the reaction between calcium carbonate and hydrochloric acid, the Grade 11 learners then added a certain mass of calcium carbonate chunks to EXCESS hydrochloric acid solution in an open beaker as shown below. The equation for the reaction is:

$$CaCO_3(s) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The data in the table below was obtained for this reaction.

Time (minutes)	Mass of beaker and contents (g)
0	192,4
1	188,8
2	188,0
3	187,4
4	187,1
5	186,7
6	186,7



3.1 How long (in minutes) did the reaction take to reach completion? (1)

3.2 Calculate the average rate of reaction during the interval 0 to 1 minute in grams per minute. (3)

3.3 The table shows that the mass of the contents of the beaker decreases over time. Write the NAME or FORMULA of TWO substances that are not present in the beaker after 6 minutes. (2)

3.4 Calculate the mass of calcium carbonate consumed after completion of the reaction. (5)

3.5 Draw a sketch graph showing the concentration of hydrochloric acid in the beaker from 0 until 6 minutes. (No values required.) (2)

3.6 Use the collision theory to explain how the rate of the above reaction would have changed when the learners repeated the experiment after crushing the calcium carbonate into powder. (3)

[16]

Question 4

4.1 A monoprotic acid, HY, ionises completely when dissolved in water. The hydroxide ion concentration $[OH^-]$ in the solution is 1×10^{-11} $mol.dm^{-3}$.

4.1.1 Define the term *monoprotic acid*. (2)

4.1.2 Would the acid, HY, be considered a STRONG or WEAK acid? (1)

4.1.3 Calculate the pH of the above solution. (3)

4.2 7,5 g IMPURE sodium hydroxide pellets are added to a flask containing 700 cm^3 of a 0,15 $mol.dm^{-3}$ sulphuric acid solution. The balanced equation for the reaction is:

$$H_2SO_4(aq) + 2\ NaOH \rightarrow Na_2SO_4(aq) + 2\ H_2O(l)$$

4.2.1 Write down the FORMULA of a substance in the above reaction that is an ampholyte. (1)

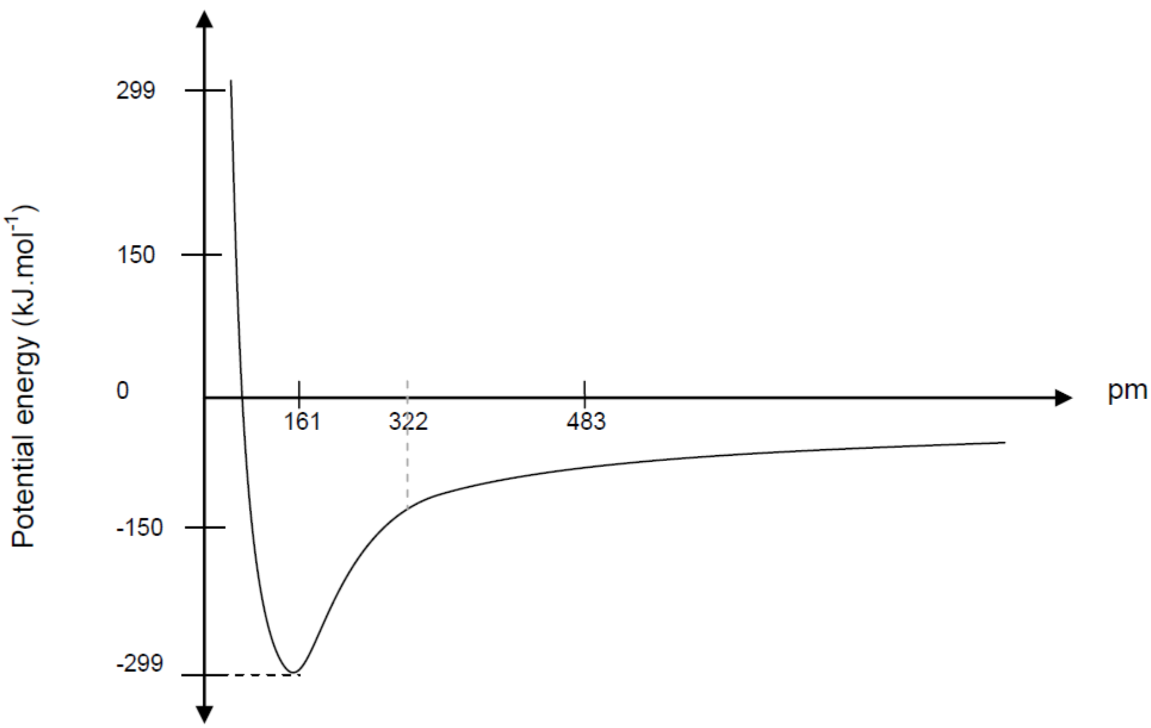
4.2.2 Calculate the number of moles of sulphuric acid in the flask. (3)

4.2.3 The percentage purity of the solution of the sodium hydroxide pellets used is 80%. Calculate the pH of the solution in the flask after the addition of the NaOH(s). (9)

[19]

Question 5

The graph below shows how the potential energy changes as two atoms (H and I) approach each other (pm = picometer).



5.1 Define the term *bond length*. (2)

5.2 From the graph, write down the value of the bond length. (1)

5.3 How will the bond length of the H-Cl bond compare to that of the HI bond? Write down SHORTER THAN, EQUAL TO or LONGER THAN. Explain your answer. (2)

[5]

Question 6

Consider the following molecules and answer the questions which follow:

H_2S CO_2 BF_3 NH_3

6.1 BF_3 and NH_3 both contain 3 bonds around the central atom. The BF_3 molecule is non-polar while the NH_3 molecule is polar. Account for this difference between the two compounds using the VSEPR theory. Identify the shape of each molecule in your answer. (4)

6.2 Determine with the aid of a calculation, whether the bond between C and O in the CO_2 molecule is POLAR or NON-POLAR. (2)

6.3 The boiling point of H_2S is –60°C and that of CO_2 is –78°C. Explain why the boiling point of H_2S is higher than that of CO_2 by referring to the types of intermolecular forces and energy. (4)

6.4 NH_3 forms a bond with the H^+ ion to form NH_4^+.

6.4.1 Name the type of bond mentioned above. (1)

6.4.2 Use Lewis dot structure to show the bonding in the NH_4^+ ion. (2)

[13]

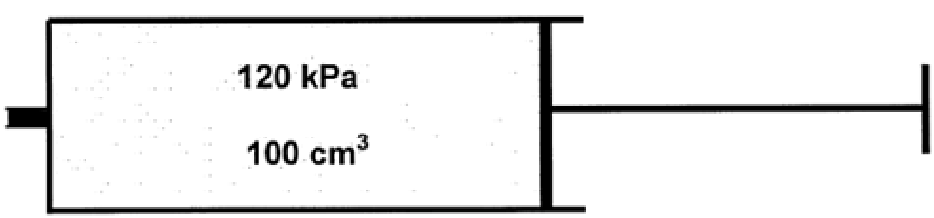
Question 7

7.1 A quantity of carbon dioxide is at STP.

7.1.1 What does STP stand for? (2)

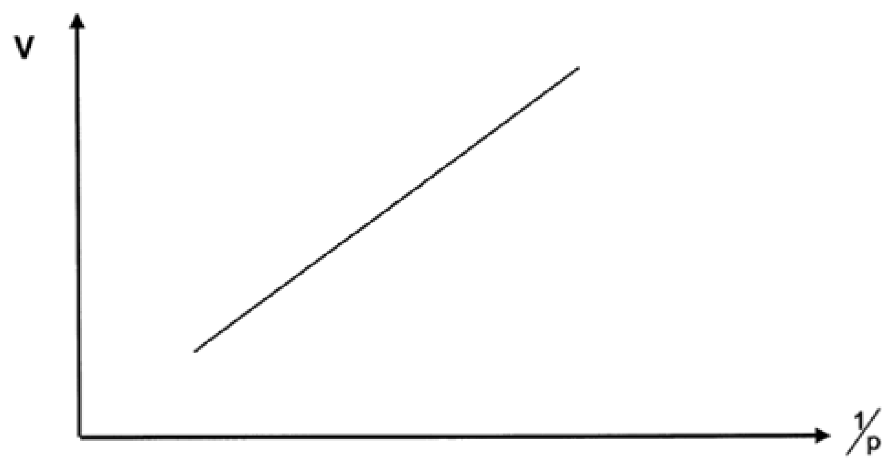
7.1.2 Calculate the volume of 5,4 moles of this CO_2 gas. (3)

7.2 The gas syringe in the sketch below is filled with chlorine gas (Cl_2), occupying a volume of 100 cm^3 and a pressure of 120 kPa.



7.2.1 The plunger is now pressed in until the volume is reduced to 40 cm^3. Assuming that the gas behaves like an ideal gas, calculate the pressure experienced by the gas under these new conditions. (3)

7.2.2 The relationship between the volume (V) and the reciprocal (inverse) of the pressure $\left(\frac{1}{p}\right)$ for the $C\ell_2(g)$ is investigated. The result is shown in the graph below.



Name and state the <u>gas law</u> represented by the relationship in this graph. (3)

[11]

Question 8

When Cu(s) is reacted with dilute nitric acid (HNO_3), the copper is oxidised to Cu^{2+} ions and the nitrate ion (NO_3^-) is reduced to NO(g).

8.1 Define a *redox reaction*. (2)

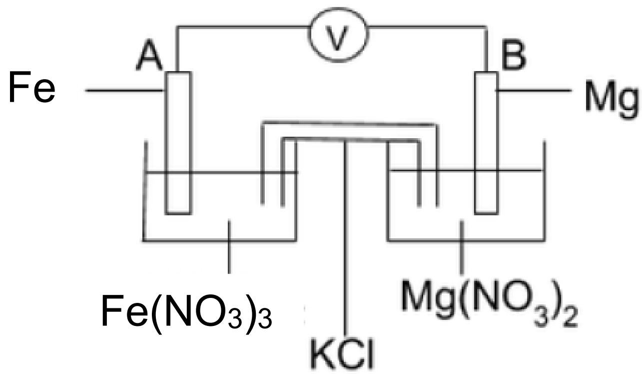
8.2 Determine the oxidation number of N in the NO_3^- ion. (1)

8.3 Write down the reduction half reaction that takes place. (2)

[5]

Question 9

In the cell below, an iron electrode is connected to a magnesium electrode. The cell is set up under standard conditions. Both electrodes are placed in electrolytes, connected with a salt bridge.



9.1 Write down the energy conversion that occurs in this cell. (1)

9.2 Define the term **electrolyte**. (2)

9.3 Which electrode, **A** or **B**, is the anode? (1)

9.4 Write down the reduction half-reaction that occurs in this cell. (2)

9.5 Calculate the reading on the voltmeter for this cell. (4)

The voltmeter is now replaced with an ammeter.

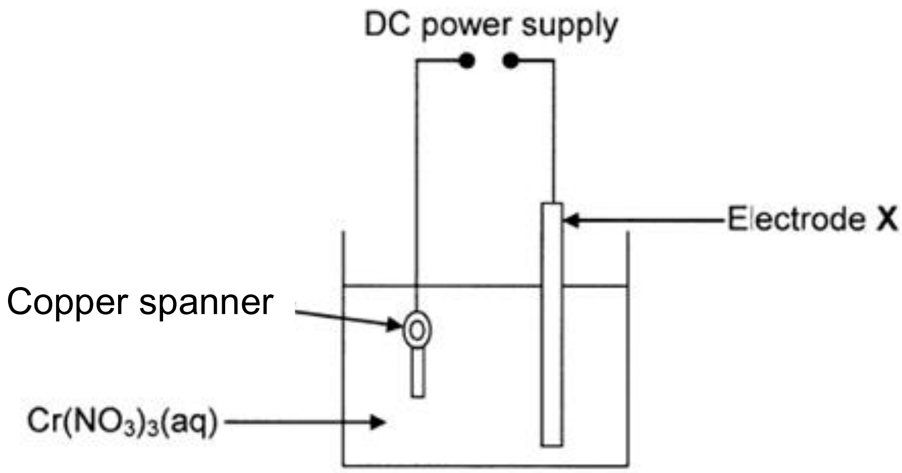
9.6 In which direction do the electrons flow in the external circuit? Write down ONLY from **A to B** or from **B to A**? (1)

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

[14]

Question 10

The diagram below represents a simplified electrolytic cell used to electroplate a copper spanner with chromium. The spanner is continuously rotated during the process of electroplating.



A constant current passes through the solution and the concentration of $Cr(NO_3)_3(aq)$ remains constant during the process. In the process, a total of 2880 C of charge is transferred in the electrolytic cell.

10.1 Define the term *electrolysis*. (2)

10.2 Write down the:

10.2.1 Half-reaction that occurs at the spanner (2)

10.2.2 NAME or FORMULA of the oxidising agent (1)

10.3 Calculate the gain in mass of the spanner. (5)

[10]

Total 125 marks

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* (↑)

Increasing reducing ability/*Toenemende reduserende vermoë* (↓)

Half-reactions/*Halfreaksies*			E^θ (V)
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	⇌	**$H_2(g)$**	**0,00**
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$Na^+ + e^-$	⇌	Na	− 2,71
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Cs^+ + e^-$	⇌	Cs	- 2,92
$K^+ + e^-$	⇌	K	− 2,93
$Li^+ + e^-$	⇌	Li	− 3,05

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* (↓)

Half-reactions/*Halfreaksies*			E^θ (V)
$Li^+ + e^-$	⇌	Li	− 3,05
$K^+ + e^-$	⇌	K	− 2,93
$Cs^+ + e^-$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$2H^+ + 2e^-$	⇌	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

Increasing reducing ability/*Toenemende reduserende vermoë* (↑)

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Avogadro's constant *Avogadro-konstante*	N_A	$6,02 \times 10^{23}$ mol^{-1}
Molar gas constant *Molêre gaskonstante*	R	$8,31 J \cdot K^{-1} \cdot mol^{-1}$
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	e^-	$-1,6 \times 10^{-19}$ C

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$	$n = \frac{Q}{e^-}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$	$Q = I\Delta t$
$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$	
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K		
$E_{cell}^\theta = E_{cathode}^\theta - E_{anode}^\theta$ / $E_{sel}^\theta = E_{katode}^\theta - E_{anode}^\theta$ or/*of* $E_{cell}^\theta = E_{reduction}^\theta - E_{oxidation}^\theta$ / $E_{sel}^\theta = E_{reduksie}^\theta - E_{oksidasie}^\theta$ or/*of* $E_{cell}^\theta = E_{oxidising\ agent}^\theta - E_{reducing\ agent}^\theta$ / $E_{sel}^\theta = E_{oksideermiddel}^\theta - E_{reduseermiddel}^\theta$		
$p_1V_1 = p_2V_2$		

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

KEY/*SLEUTEL*

Atomic number / *Atoomgetal*: 29
Symbol / *Simbool*: Cu
Approximate relative atomic mass / *Benaderde relatiewe atoommassa*: 63,5
Electronegativity / *Elektronegatiwiteit*: 1,9

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