Province of the
EASTERN CAPE
EDUCATION

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NATIONAL SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2024

PHYSICAL SCIENCES P2 (CHEMISTRY)

MARKS: **150**

TIME: **3 hours**

IPHSCE2

This question paper consists of 18 pages, including 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your name and surname in the appropriate space on the ANSWER BOOK.
2. This question paper consists of EIGHT 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 subquestions, 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. Show ALL formulae and substitutions in ALL calculations.
9. Round off your FINAL numerical answers to a minimum of TWO decimal places.
10. Give brief motivations, discussions, et cetera. where required.
11. You are advised to use the attached DATA SHEETS.
12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, for example 1.11 D.

1.1 Which ONE of the following bonds will have the highest bond energy?

A H – H

B C – H

C C = C

D C ≡ C (2)

1.2 Consider the following compounds and their respective boiling points.

COMPOUNDS	BOILING POINT (˚C)
He	-268,9
HBr	-66
HF	19,5

The correct arrangement for the decreasing strength of the intermolecular forces of the given compounds is …

A HF, He, HBr.

B HBr, He, HF.

C HF, HBr, He.

D He, HBr, HF. (2)

1.3 Which ONE of the following is NOT a property of the ideal gas?

A There are no forces of attraction between the molecules.

B The collisions between molecules are elastic.

C The volume occupied by the gas is equal to the total volume of the gas molecules.

D It has a low density. (2)

1.4 The molar mass of hydrated oxalic acid $(COOH)_2 \cdot \mathbf{x}H_2O$ is 126 $g \cdot mol^{-1}$.

The number of water molecules (**x**) present in the hydrated compound is …

A 1.

B 2.

C 3.

D 4. (2)

1.5 10 moles of zinc (Zn) are allowed to react with 5 moles of hydrochloric acid (HCℓ) in a test tube according to the balanced equation:

$$Zn + 2\ HC\ell \rightarrow ZnC\ell_2 + H_2$$

How many moles of hydrochloric acid (HCℓ) and zinc chloride ($ZnC\ell_2$) is in the test tube after the completion of the reaction?

	HCℓ	**$ZnC\ell_2$**
A	2,5	2,5
B	0	2,5
C	5	10
D	0	10

(2)

1.6 Which ONE of the following is the conjugate acid of HPO_4^{2-}?

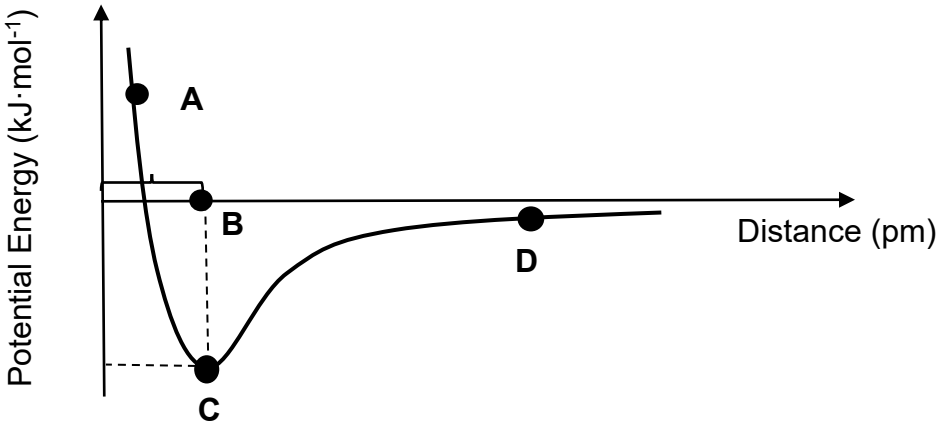
A PO_4^{3-}

B $H_2PO_4^-$

C H_3PO_4

D $H_2PO_4^{2-}$ (2)

1.7 Consider the potential energy versus distance curve below.



(I) At point **A** the repulsive forces are stronger than attractive forces

(II) Point **B** represents bond length

(III) At point **C** net attractive and repulsive forces is zero

Which of the above statement(s) regarding the above curve is CORRECT?

A **I** and **II** only

B **I** and **III** only

C **II** and **III** only

D **I, II** and **III** (2)

1.8 Which ONE of the following indicates the CORRECT colour of phenolphthalein in HCℓ and NaOH?

	HCℓ	**NaOH**
A	Yellow	Blue
B	Colourless	Pink
C	Pink	Colourless
D	Blue	Yellow

(2)

1.9 Which ONE of following solutions will have the lowest pH if all solutions have the SAME concentration?

A H_2SO_4 (aq)

B HCℓ (aq)

C NaOH (aq)

D $Ba(OH)_2$ (aq) (2)

1.10 Consider the following statements regarding a REDUCING AGENT:

(I) The substance that causes reduction.

(II) The substance that is reduced.

(III) The substance that is oxidised.

Which of the above statement(s) regarding the reducing agent is CORRECT?

A **I** only

B **I** and **II** only

C **II** and **III** only

D **I** and **III** only (2)

[20]

QUESTION 2 (Start on a new page.)

Consider the following compounds.

I_2	HOCℓ	NH_3	H_2S	KBr

2.1 Define *covalent bond.* (2)

2.2 Write down the formula of the compound from the given list that:

2.2.1 Is non-polar (1)

2.2.2 Forms a bond as a result of transferring of electrons (1)

2.2.3 Has one lone pair of electrons (1)

2.2.4 Has a pure covalent bond (1)

2.3 Draw the Lewis structure of the following compounds:

2.3.1 HOCℓ (2)

2.3.2 H_2S (2)

2.4 The ammonium ion (NH_4^+) is formed from ammonia (NH_3).

2.4.1 Identify the bond responsible for the formation of NH_4^+. (1)

2.4.2 Use the Lewis structure to show the formation of NH_4^+ from NH_3. (4)

2.5 Write down the molecular shape of:

2.5.1 HOCℓ (1)

2.5.2 NH_3 (1)

2.6 Will I_2 be soluble in $CCℓ_4$? Write down only YES or NO. (1)

2.7 Explain the answer to QUESTION 2.6 by referring to the molecular polarity and intermolecular forces involved in the compounds. (3)

2.8 The following table shows the average bond energies of atoms that are bonded to the hydrogen atom.

BONDS	AVERAGE BOND ENERGY ($kJ \cdot mol^{-1}$)
C – H	413
O – H	463
F – H	565

2.8.1 Define the term *bond energy.* (2)

2.8.2 Explain the trend observed in the bond energy in the table above. (2)
[25]

QUESTION 3 (Start on a new page.)

Learners investigated the boiling points of the compounds listed in the table below.

Compound		Boiling point (˚C)
A	CH_4	-161,5
B	SiH_4	-111,8
C	GeH_4	- 88,6
D	SnH_4	-52

3.1 Define *boiling point.* (2)

3.2 Is this a fair investigation? Write only YES or NO.

Give a reason for the answer. (2)

3.3 Write down the phase of the above compounds at room temperature. (1)

3.4 Explain the trend observed in boiling points of the compounds in the table above by referring to the molecular mass, intermolecular forces, and energy involved. (3)

3.5 Which compound in the table above has the highest vapour pressure at a given temperature? Explain the answer by referring to the data in the table above. (2)

3.6 The boiling point of HF and HCℓ is compared.

Compound		Boiling point (˚C)
E	HF	19,5
F	HCℓ	**X**

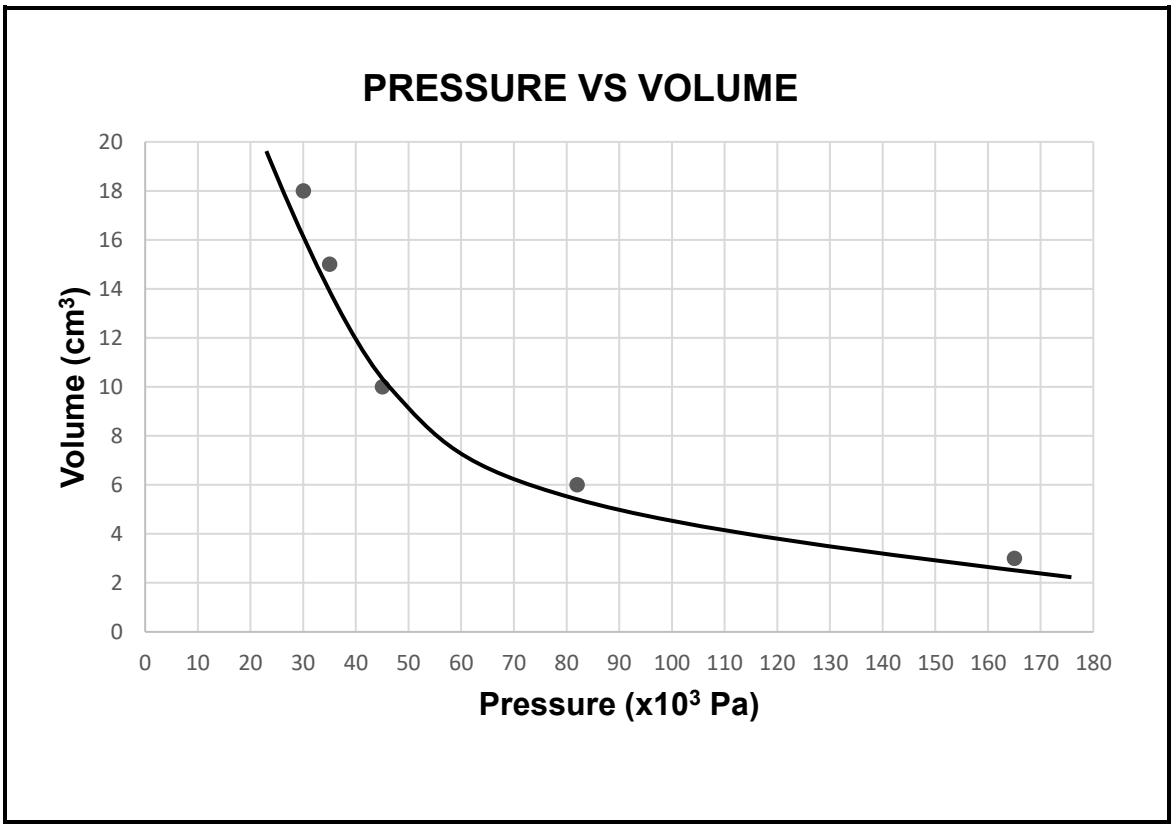
3.6.1 Will the value of **X** be HIGHER THAN, LOWER THAN or EQUAL TO 19,5 ˚C? (1)

3.6.2 Fully explain the answer to QUESTION 3.6.1. (4)

[15]

QUESTION 4 (Start on a new page.)

Learners investigated the relationship between pressure and volume of a gas. The graph below shows the results obtained during the investigation.



4.1 Name and state the law the experiment is based on. (3)

4.2 Write down a hypothesis for this investigation. (2)

4.3 Read and write down the pressure from the graph when the volume is 12 cm^3. (1)

4.4 Calculate the volume at 200 kPa. (4)

4.5 Redraw the above graph and label it **A**. On the same set of axes draw the graph to show how a real gas will deviate at a high pressure. Label this graph as **B**. (2)
[12]

QUESTION 5 (Start on a new page.)

Consider the decomposition reaction of dinitrogen pentoxide:

$$2\ N_2O_{5(g)} \rightarrow 2\ N_2O_{4(g)} + O_{2(g)}$$

The table below shows the different energies for the above reaction.

Heat the of reactants (H_r)	26,6 kJ·mol^{-1}
Activation energy (E_a)	6,73 kJ·mol^{-1}
Heat of the reaction (ΔH)	-7,28 kJ·mol^{-1}

5.1 Define the term *activation energy.* (2)

5.2 Is the above reaction ENDOTHERMIC or EXOTHERMIC?

Give a reason for the answer. (2)

5.3 Calculate the heat of the products. (2)

5.4 Draw the potential energy versus course of reaction graph for the above reaction.

On the graph indicate values for:
- Heat of reactants ($H_{reactants}$)
- Heat of products ($H_{products}$)
- Energy at the activated complex
- Heat of the reaction (ΔH) (5)

5.5 On the same graph drawn in QUESTION 5.4, use a dotted line and draw the shape of the graph when a catalyst is added to the original reaction. (2)

[13]

QUESTION 6 (Start on a new page)

6.1 Compound **Q** (C_XH_Y) reacts with oxygen according to the balanced equation:

$$\mathbf{P}\ C_XH_Y + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

The molar mass of compound **Q** is 58 g·mol^{-1}.

6.1.1 Define *empirical formula.* (2)

6.1.2 Use the principle of conservation of mass and determine the value **P**. (3)

The percentage composition of compound **Q** is:

Carbon	Hydrogen
82,76%	17,24%

6.1.3 Determine the molecular formula of compound **Q**. (5)

6.2 5 g of sodium carbonate (Na_2CO_3) reacts with 250 cm^3 of hydrochloric acid (HCℓ).

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

The percentage of hydrochloric acid (HCℓ) that reacted with sodium carbonate (Na_2CO_3) is 76%.

6.2.1 Define the term *limiting reagent*. (2)

Calculate the:

6.2.2 Amount of hydrochloric acid that reacted with sodium carbonate. (4)

6.2.3 Volume of carbon dioxide that was produced.

Take the molar volume at room temperature as 24,45 dm^3. (4)

6.2.4 The hydrochloric acid that was used in the reaction was obtained by diluting 100 cm^3 HCℓ to 250 cm^3 hydrochloric acid (HCℓ) solution.

Calculate the concentration of the concentrated hydrochloric acid (HCℓ). (4)

[24]

QUESTION 7 (Start on a new page.)

7.1 Carbonic acid ionises in water according to the following balanced equation:

$$H_2CO_3\ (aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

7.1.1 Define an *acid* according to the Arrhenius theory. (2)

Write down the:

7.1.2 FORMULAE of the TWO substances that can act as an ampholyte (2)

7.1.3 FORMULAE of TWO acids from the reaction (2)

7.1.4 Balanced equation between carbonic acid and sodium hydroxide (NaOH) (3)

7.2 2 g of NaOH is dissolved in water to make a 100 cm^3 solution.

Calculate the:

7.2.1 Concentration of NaOH (3)

7.2.2 pH of NaOH (4)

7.3 **5 g** of **impure** magnesium carbonate ($MgCO_3$), is added to 9,033 x 10^{22} molecules of hydrochloric acid ($HC\ell$).

The balanced equation for the reaction that takes place is given below:

$$MgCO_3(s) + 2\ HC\ell\ (aq) \rightarrow MgC\ell_2\ (aq) + CO_2(g) + H_2O(\ell)$$

The reaction is allowed to proceed until all the pure magnesium carbonate completely reacts. The excess hydrochloric acid is neutralised by adding 55 cm^3 of sodium hydroxide solution of concentration 0,8 $mol \cdot dm^{-3}$.

The balanced equation for the neutralisation reaction is:

$$HC\ell\ (aq) + NaOH\ (aq) \rightarrow NaC\ell\ (aq) + H_2O\ (\ell)$$

Calculate the:

7.3.1 Initial number of moles of hydrochloric acid (3)

7.3.2 Percentage purity of magnesium carbonate (8)

[27]

QUESTION 8 (Start on a new page.)

8.1 A solution of nickel (II) nitrate is placed in a zinc container. It was observed, after some time, that a chemical reaction has taken place. The net ionic equation is:

$$Zn\ (s) + Ni^{2+}(aq) \rightleftharpoons Zn^{2+}\ (aq) + Ni\ (s)$$

8.1.1 Explain the term *redox reaction*. (2)

8.1.2 Which ONE of Zn or Ni^{2+} is the oxidising agent?

Explain the answer by referring to the oxidation numbers. (3)

8.1.3 Give a reason why the nitrate ion (NO_3^-) is not written in the net ionic equation above. (1)

8.2 The reaction between dichromate ions ($Cr_2O_7^{2-}$) and tin (II) ions (Sn^{2+}) in an acid medium is given below.

$$Cr_2O_7^{2-} + Sn^{2+} + H^+ \rightarrow Cr^{3+} + Sn^{4+} + H_2O\ (\ell)$$

8.2.1 Determine the oxidation number of Cr in $Cr_2O_7^{2-}$. (2)

8.2.2 Write down the reduction half-reaction. (2)

8.2.3 Use the Table of Standard Reduction Potentials and write down the balanced net ionic equation. (4)

[14]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 11
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 11
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 teen 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 se konstante	N_A	$6{,}02 \times 10^{23}$ mol^{-1}

TABLE 2: FORMULAE/TABEL 2: FORMULES

$n = \frac{m}{M}$ **OR/OF** $n = \frac{N}{N_A}$ **OR/OF** $n = \frac{V}{V_m}$	$c = \frac{n}{V}$ or/of $c = \frac{m}{MV}$ $\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$ $K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/by 298 K

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

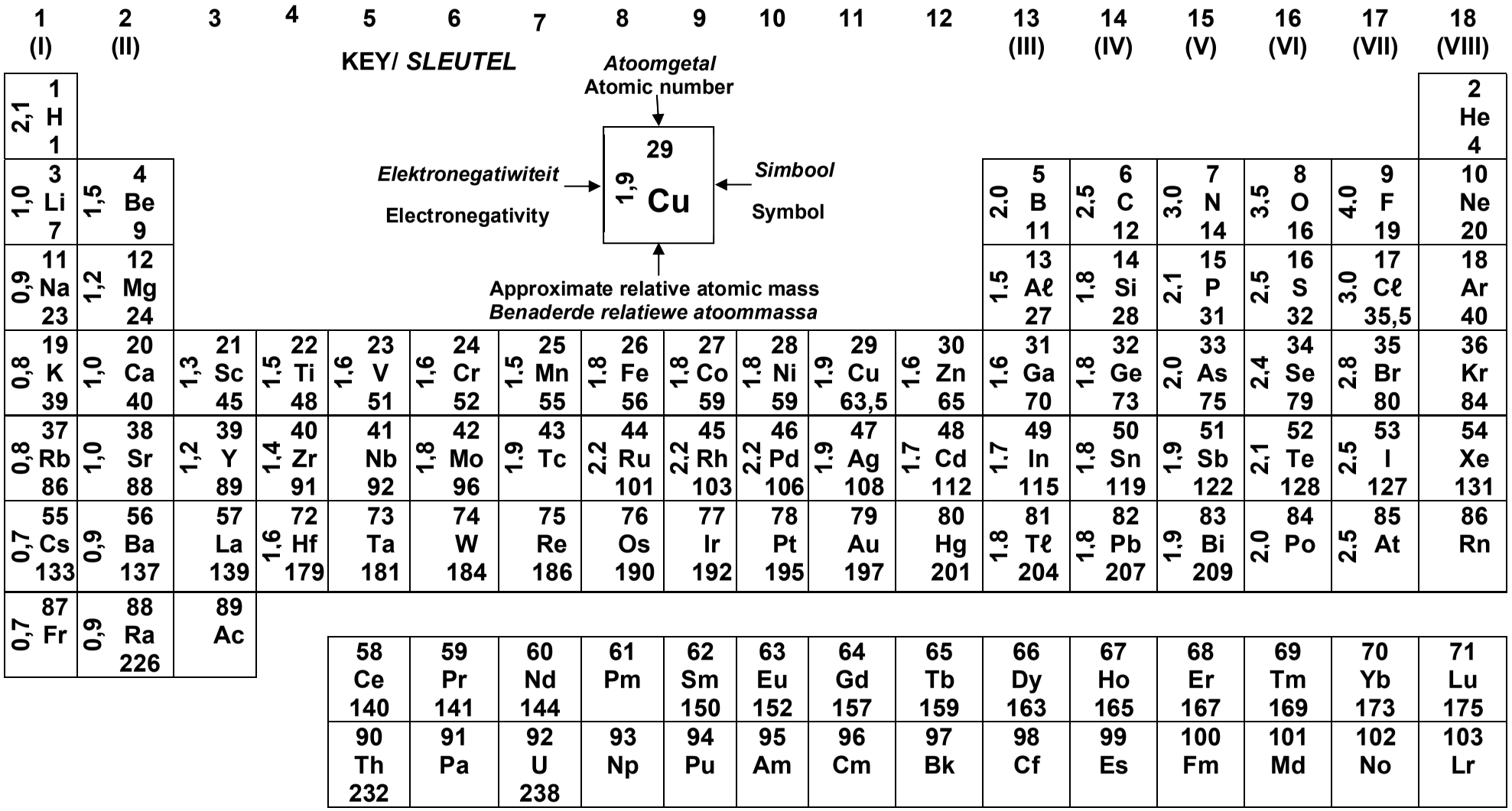


TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD REDUKSIEPOTENSIALE

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

Increasing oxidising ability/Toenemende oksiderende vermoë ↑

Increasing reducing ability/Toenemende reduserende vermoë ↓

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

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 oxidising ability/*Toenemende oksiderende vermoë* ↓

Increasing reducing ability/*Toenemende reduserende vermoë* ↑