Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2023

PHYSICAL SCIENCES P2 (CHEMISTRY)

MARKS: **150**

TIME: **3 hours**

This question paper consists of 21 pages including 4 data sheets and an answer sheet.

INSTRUCTIONS AND INFORMATION

1. Write your full NAME and SURNAME in the appropriate spaces on the ANSWER BOOK.

2. This question paper consists of NINE 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. 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 Consider the definition given below:

The high energy transition state between products and reactants.

This is the definition of …

A a catalyst.

B heat of reaction.

C activation energy.

D activated complex. (2)

1.2 Which ONE of the following ions can act as an ampholyte?

A HCO_3^-

B NH_4^+

C NO_3^-

D H_3O^+ (2)

1.3 Consider the interatomic bonds shown below:

C – H	C – O

Which ONE of the following combinations regarding the bond length and polarity of the bonds is CORRECT?

	Shortest bond length	**Most polar bond**
A	C – H	C – O
B	C – O	C – H
C	C – O	C – O
D	C – H	C – H

(2)

1.4 The conjugate base of the ion, $H_2PO_4^-$ is …

A PO_4^{3-}.

B H_2O.

C HPO_4^{2-}.

D H_3PO_4. (2)

1.5 The table below shows the melting points of water (H_2O) and hydrogen bromide (HBr).

Compounds	Melting point (K)
H_2O	273
HBr	159

Which combination below CORRECTLY lists the strongest intermolecular forces in H_2O and HBr that explain the relatively high melting points of these compounds?

	In H_2O there are:	In HBr there are:
A	Hydrogen bonds	London forces
B	Hydrogen bonds	Dipole-dipole forces
C	Dipole-dipole forces	Hydrogen bonds
D	London forces	Hydrogen bonds

(2)

1.6 A pair of electrons that is shared between two atoms in a covalent bond is called …

A lone pair.

B bond length.

C bonding pair.

D valence electrons. (2)

1.7 Air in a gas syringe is compressed to half its original volume while the temperature remains constant.

Which ONE of the following combinations are CORRECT regarding the gas pressure and the average speed of the gas particles?

	Pressure	**Average speed of gas particles**
A	Increases	Decreases
B	Decreases	Increases
C	Increases	Remain constant
D	Decreases	Remain constant

(2)

1.8 Consider the following reaction:

$$2\ H_2S(g) + SO_2(g) \rightarrow\ 3\ S(s) + 2\ H_2O$$

Which ONE of the combinations regarding the reducing agent and oxidising agent in this reaction is CORRECT?

	Reducing agent	**Oxidising agent**
A	H_2S	SO_2
B	SO_2	H_2S
C	S	H_2O
D	SO_2	S

(2)

1.9 Which ONE of the following has polar covalent bonds but has only London dispersion forces between its molecules?

A NH_3

B HBr

C CO_2

D H_2S (2)

1.10 Consider the following incomplete reactions of sulphuric acid, H_2SO_4:

(I) $CuO + H_2SO_4 \longrightarrow$

(II) $CuCO_3 + H_2SO_4 \longrightarrow$

(III) $Cu(OH)_2 + H_2SO_4 \longrightarrow$

Which reaction(s) will produce $CuSO_4$ and water as the only products of the reaction?

A **I** only

B **II** only

C Both **I** and **III**

D Both **II** and **III** (2)

[20]

QUESTION 2 (Start on a new page.)

2.1 Consider the following compounds:

NH_3	H_3O^+	$BC\ell_3$	$NaC\ell$	HCN

2.1.1 Define the term *molecule.* (2)

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

2.1.2 A dative covalent bond (1)

2.1.3 Ionic bonds (1)

2.1.4 Ion-dipole forces when dissolved in water (1)

2.2 Draw the Lewis structure for the following molecules:

2.2.1 NH_3 (2)

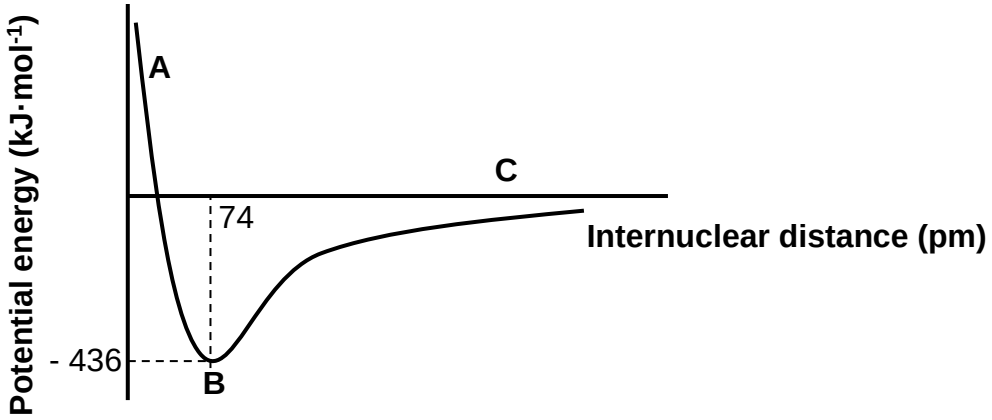
2.2.2 HCN (2)

2.3 How many lone pairs of electrons are in one molecule of NH_3? (1)

2.4 Is $BC\ell_3$ a POLAR or NON-POLAR molecule?

Explain your answer by referring to molecular shape and polarity of the bonds in the molecule. (4)

2.5 The graph below shows the relationship between potential energy and the internuclear distance between two hydrogen atoms.



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

2.5.2 Which point (**A**, **B** or **C**) on the graph represents the point of maximum force of attraction between the nuclei of the two hydrogen atoms? (1)

2.6 Consider the following table.

Bond	Bond energy (kJ·mol^{-1})
C – C	346
C = C	610
C ≡ C	835

2.6.1 Which ONE of the bonds shown in the table above will have the shortest bond length? (1)

2.6.2 Give a reason for your answer to QUESTION 2.6.1. (2)

[20]

QUESTION 3 (Start on a new page.)

The table below shows the boiling points of group 4 compounds.

Compound		Boiling point (°C)
A	CH_4	-161,6
B	SiH_4	-112,0
C	GeH_4	-88,5
D	SnH_4	-52,0
E	$HC\ell$	**X**

3.1 Define *boiling point.* (2)

3.2 Write down the phase of compounds **A** to **D** at room temperature. (1)

3.3 Explain the trend in the boiling points of compounds **A** to **D**. (3)

3.4 Which compound in the table (**A** to **D**) will have the highest vapour pressure?

Give a reason for your answer by referring to the data in the table. (2)

3.5 How will the value of **X** compare to the boiling point of CH_4?

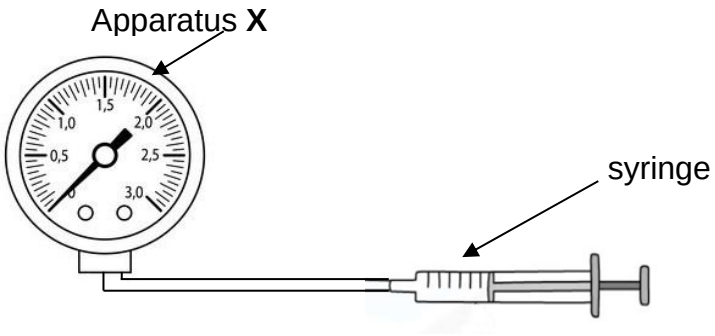
Choose from HIGHER THAN, LOWER THAN or EQUAL to. (1)

3.6 Fully explain your answer to QUESTION 3.5. (3)

[12]

QUESTION 4 (Start on a new page.)

A group of learners investigate the relationship between the pressure and the volume of a gas. The gas syringe is connected to apparatus **X** as shown below.



The learners vary the volume and record the pressure and volume. They calculated the inverse of the volume and recorded it with the pressure readings in table shown below.

	Pressure (kPa)	**1/volume (cm^{-3})**
1	92,5	0,05
2	111	0,06
3	129,5	0,07
4	148	0,08

4.1 Write down the name of the gas law that is being investigated. (1)

4.2 For this investigation, write down ONE controlled variable. (1)

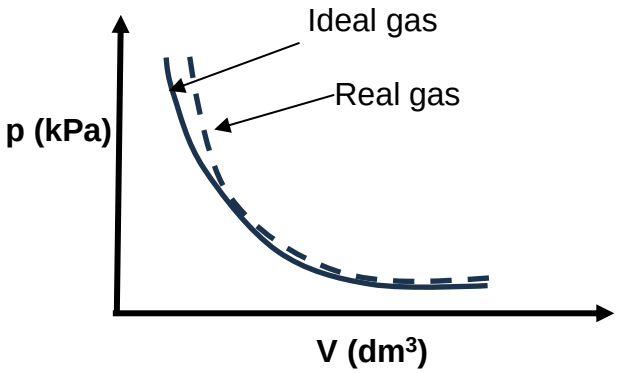
4.3 Give the name of apparatus **X**. (1)

4.4 Use the data in the table and draw a pressure against 1/ volume graph on the attached ANSWER SHEET marked ANNEXURE A. (4)

4.5 Using information from the graph write down the learners' conclusion. (2)

4.6 Calculate the volume of the gas at a pressure of 184 kPa. (4)

4.7 The graph of pressure versus volume of an enclosed gas at constant temperature for a real gas and an ideal gas is shown below.



Explain the deviation of a real gas from ideal gas behaviour as shown in the graph above. (2)

4.8 Give ONE reason in terms of the TYPE and STRENGTH of intermolecular forces why ammonia gas, NH_3 will deviate from ideal gas at low temperatures. (2)

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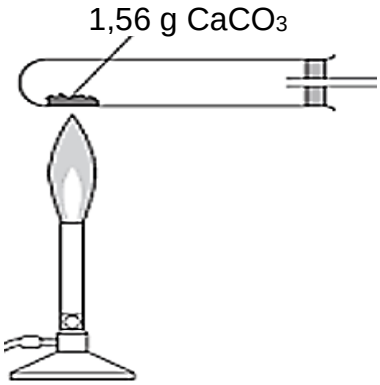
QUESTION 5 (Start on a new page.)

5.1 1,56 g of calcium carbonate is heated as shown in diagram below.



The calcium carbonate decomposes according to the balanced equation:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g) \quad \Delta H > 0$$

0,163 g of CO_2 is produced during this decomposition.

5.1.1 Is this reaction ENDOTHERMIC or EXOTHERMIC? (1)

5.1.2 Give a reason for your answer in QUESTION 5.1.1. (2)

5.1.3 Describe *Avogadro's number*. (1)

5.1.4 Calculate the:

(a) Number of CO_2 molecules produced (4)

(b) Mass of $CaCO_3$ that remains unreacted in the flask at the completion of the reaction (5)

5.2 A compound with a molar mass of 162 $g \cdot mol^{-1}$ has the following mass composition:

44,4% C	6,21% H	39,5% S	9,86% O

Determine the molecular formula of the compound. (7)

[20]

QUESTION 6 (Start on a new page.)

x grams sodium carbonate (Na_2CO_3) reacts with 0,028 mol of hydrochloric acid ($HC\ell$) at 25 °C. The balanced equation for the reaction is:

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

448 cm^3 of CO_2 gas is produced during this reaction. The molar volume at 25 °C is 24,47 $dm^3 \cdot mol^{-1}$.

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

6.2 Name the law that states that:

ONE mole of any gas occupies the same volume at the same temperature and pressure. (1)

6.3 Determine by calculation which substance is the liming reagent, Na_2CO_3 or $HC\ell$. (5)

6.4 Calculate the value of **x**. (4)

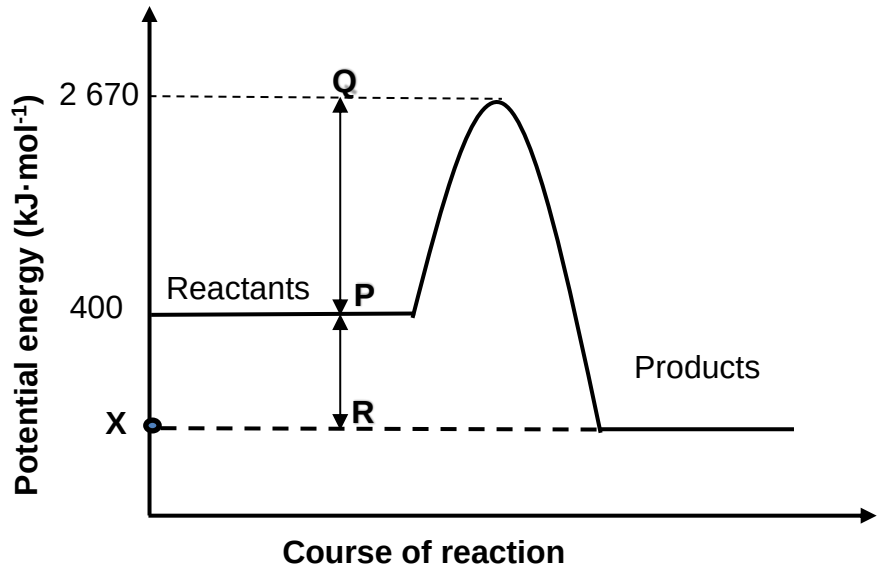
[12]

QUESTION 7 (Start on a new page.)

Consider the following reaction:

$$4\ NH_3(g) + 5\ O_2(g) \rightleftharpoons 4\ NO(g) + 6\ H_2O(g) \quad \Delta H = -216{,}7\ kJ{\cdot}mol^{-1}$$

The graph below shows the potential energy against the course of this reaction.



7.1 Define *activation energy*. (2)

7.2 What do the following sections of the graph represent?

7.2.1 **RP** (1)

7.2.2 **QP** (1)

7.3 Determine by calculation the value of **X.** (3)

7.4 What effect will the addition of suitable catalyst to the reaction mixture have on the activation energy of the reaction?

Choose from INCREASES, DECREASES or NO EFFECT. (1)

7.5 60 cm^3 of NH_3 reacts completely with 90 cm^3 of O_2 at the same temperature and pressure in a container that can expand.

Calculate the TOTAL THEORETICAL VOLUME (in dm^3) of the gases present in the container at the completion of the reaction. (5)

7.6 Will the measured TOTAL volume of the gases at the completion of the reaction be HIGHER or LOWER than the value calculated in QUESTION 7.5? (1)

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QUESTION 8 (Start on a new page.)

8.1 Consider the following acid-base reaction that occurs in an indicator, HIn:

$$HIn\ (aq) + H_2O(\ell) \rightleftharpoons In^-\ (aq) + \mathbf{X}\ (aq)$$

8.1.1 Define an *acid* according to the Lowry-Brønsted theory. (2)

8.1.2 Is the indicator (HIn) an acid or a base in the reaction?

Give a reason for your answer. (2)

8.1.3 Write down the formula of **X**. (1)

The indicator has the following colours in different solutions:

Acid	Neutral	Base
Yellow	Green	Blue

8.1.4 What will the colour of the indicator be when it is added to a sodium hydroxide (NaOH) solution?

Choose from YELLOW, GREEN or BLUE. (1)

8.2 A school laboratory has 100 cm^3 of hydrochloric acid (HCℓ) solution with a concentration of 0,9 $mol{\cdot}dm^{-3}$ available.

8.2.1 Define *concentration* in words. (2)

8.2.2 Calculate the number of moles of hydrochloric acid (HCℓ) present in 100 cm^3 of this solution. (3)

All of the 100 cm^3 hydrochloric acid solution is allowed to react with 3,5 g of an unknown metal carbonate (MCO_3) according to the balanced equation:

$$MCO_3\ (s) + 2\ HC\ell\ (aq) \rightarrow MC\ell_2\ (aq) + 2\ H_2O\ (\ell) + CO_2\ (g)$$

The hydrochloric acid solution is found to be in EXCESS.

The EXCESS hydrochloric acid (HCℓ) is neutralised by 25 cm^3 of a sodium hydroxide (NaOH) solution with a concentration 0,8 $mol{\cdot}dm^{-3}$.

The neutralisation reaction of the excess HCℓ solution is shown below:

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

8.2.3 Determine by calculation the symbol of the unknown metal, M. (7)

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QUESTION 9 (Start on a new page.)

9.1 A clean piece of copper (Cu) is placed in a solution of silver nitrate ($AgNO_3$). The balanced net ionic equation is:

$$Cu\ (s) + 2\ Ag^+\ (aq) \rightleftharpoons Cu^{2+}\ (aq) + 2\ Ag\ (s)$$

9.1.1 Define *reduction* in terms of electron transfer. (2)

9.1.2 What type of reaction does copper, Cu undergo in this equation?

Choose from OXIDATION or REDUCTION.

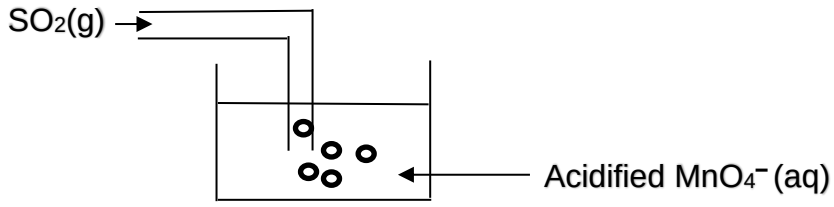
Explain your answer by referring to oxidation numbers. (3)

Write down the:

9.1.3 Formula or name of the spectator ions in the reaction (1)

9.1.4 Reduction half reaction (2)

9.2 Sulphur dioxide gas (SO_2) is bubbled into an acidified solution of potassium permanganate as shown in the diagram below.



It is observed that the solution turns from purple to colourless due to the reduction of MnO_4^- ions to Mn^{2+} ions. During the reaction SO_2 is oxidised to sulphate ions, SO_4^{2-}.

9.2.1 Determine the oxidation number of sulphur, S in SO_4^{2-}. (2)

Write down the:

9.2.2 Oxidation half reaction (2)

9.2.3 Balanced net ionic equation using the half reaction method (5)

[17]

TOTAL: 150

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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*

NAAM/*NAME*	**SIMBOOL/*SYMBOL***	**WAARDE/*VALUE***
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*** $c = \frac{m}{MV}$	$p_1V_1 = p_2V_2$

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

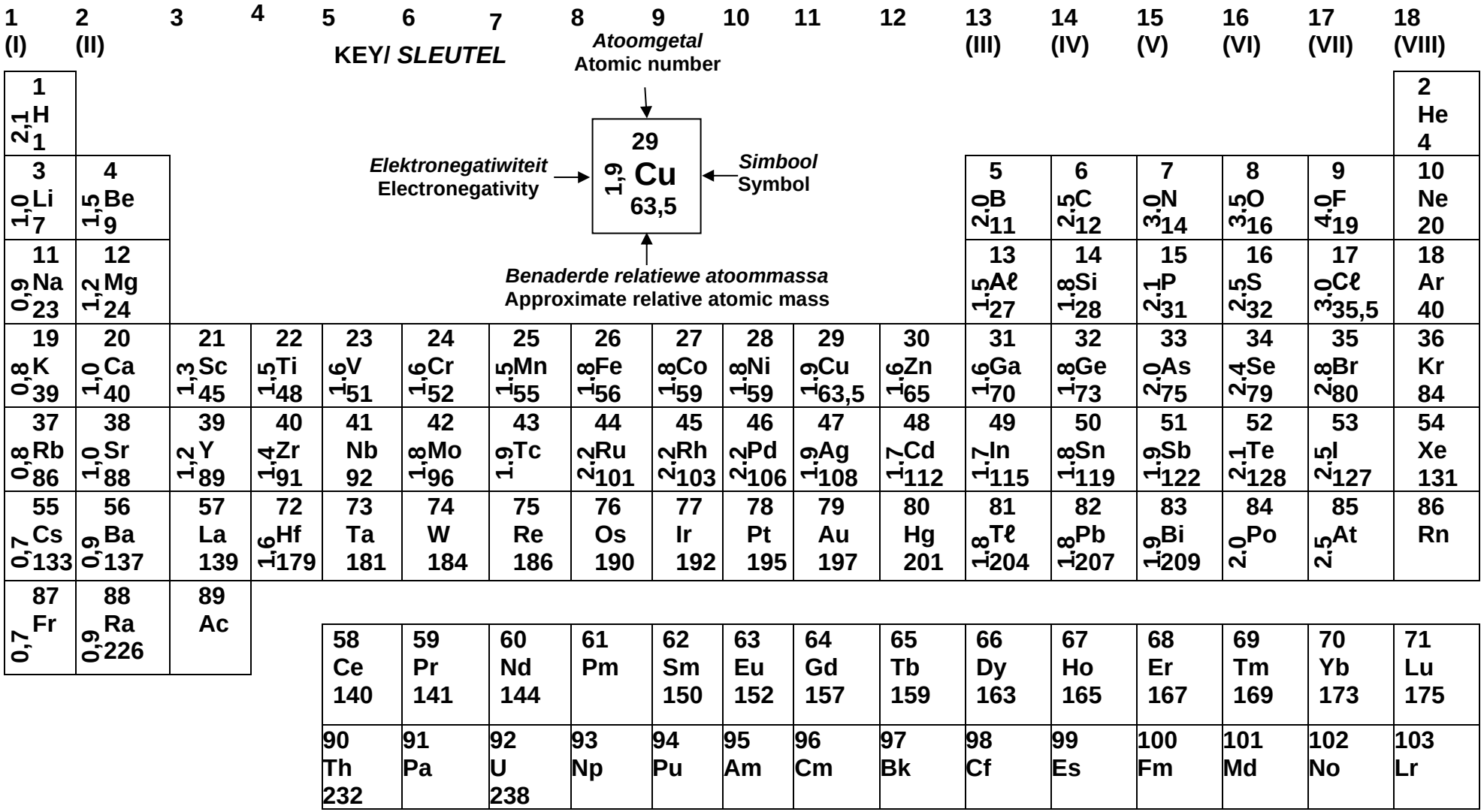

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD REDUKSIEPOTENSIALE

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
$A\ell^{3+} + 3e^-$	⇌	Aℓ	– 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(ℓ)	+ 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*

ANNEXURE A:

NAME AND SURNAME: _____

QUESTION 4.4