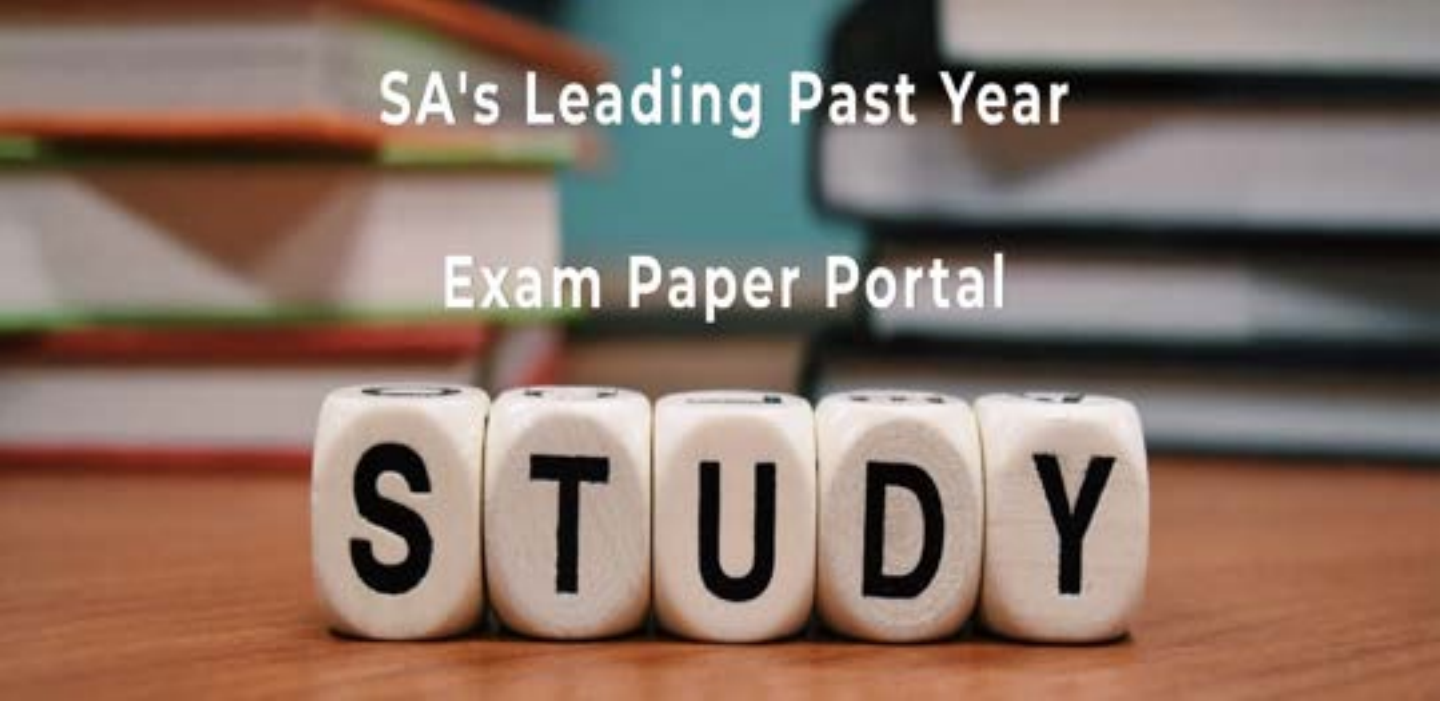

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PREPARATORY EXAMINATION

GRADE 12

PHYSICAL SCIENCES PAPER 2 (CHEMISTRY)

SEPTEMBER 2018

MARKS: 150

TIME: 3 HOURS

This question paper consists of 17 pages, 4 data sheets and a graph sheet.

INSTRUCTIONS AND INFORMATION

1. Write your name and other applicable information in the appropriate spaces on the ANSWER BOOK and on the attached GRAPH SHEET. Place the GRAPH SHEET in your ANSWER BOOK and hand it in with your ANSWER BOOK.

2. The question paper consists of TEN questions. Answer ALL the questions in the ANSWER BOOK. Answer QUESTION 5.1.2 on the attached GRAPH SHEET.

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 pocket 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.

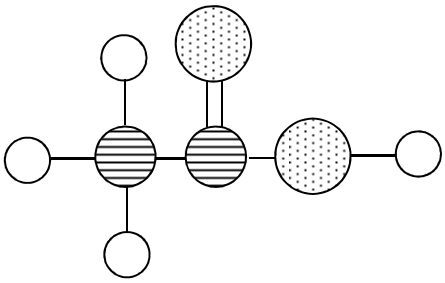
11. Give brief motivations, discussions, et cetera where required.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

1.1 The diagram below represents an organic compound consisting of three different elements.



The IUPAC name of this compound is ...

A ethanol.

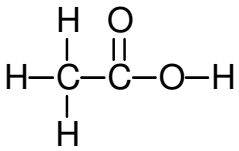
B propanal.

C ethanoic acid.

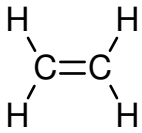
D propan-2-one. . (2)

1.2 The structures of four organic compounds are shown below.

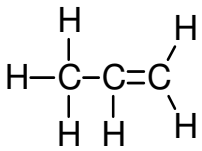
Compound 1



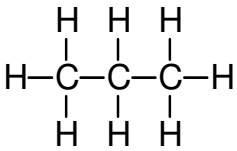
Compound 2



Compound 3



Compound 4



Which of the above compounds will decolourise bromine water in a darkened room?

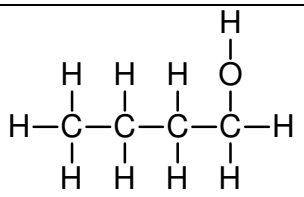
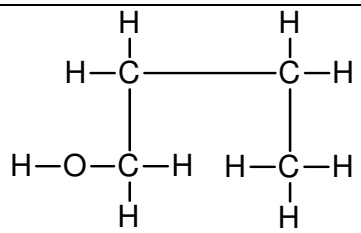
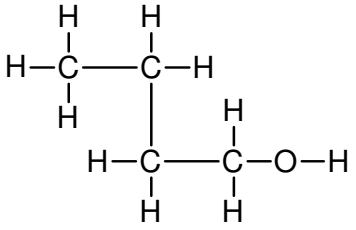
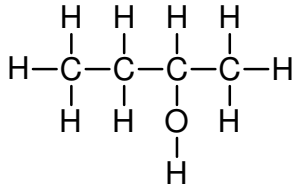
A 2 and 3

B 1 and 2

C 3 and 4

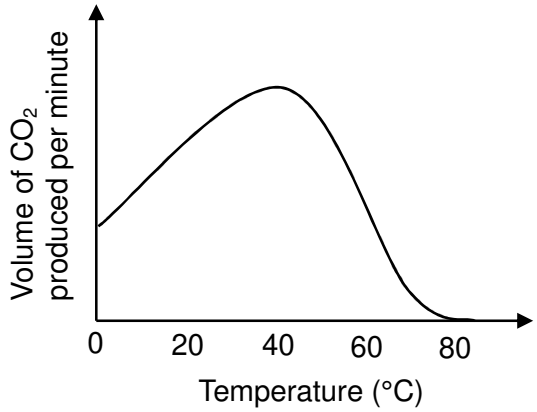
D 2, 3 and 4 (2)

1.3 Which ONE of the following is a positional isomer of butan-1-ol?

A		B	
C		D	

(2)

1.4 The graph below shows how the volume of carbon dioxide produced per minute varies with temperature during the fermentation of sugar.



Which ONE of the following statements is TRUE for this reaction?

A The reaction rate is the lowest at 0 °C.

B The reaction rate is the highest at 0 °C.

C The rate of the reaction increases with temperature.

D The rate of reaction reaches a maximum at about 40 °C. (2)

1.5 Consider the equation for a hypothetical reaction below.

$$A(g) + B(g) \rightleftharpoons AB(g)$$

At 70 °C, the heat of reaction (ΔH) for this reaction is - 30 $kJ \cdot mol^{-1}$.
At a temperature of 90 °C, the heat of reaction (ΔH), in $kJ \cdot mol^{-1}$, is:

A - 30

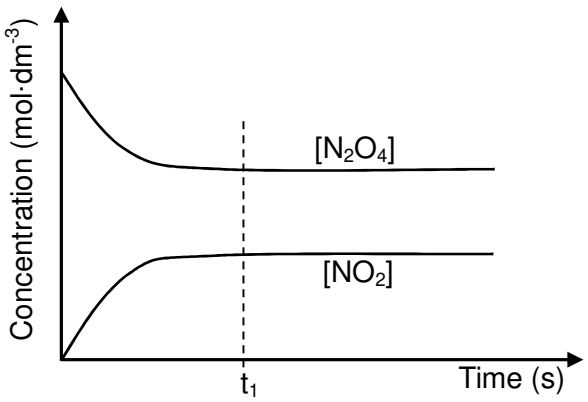
B - 10

C + 50

D - 50 (2)

1.6 The graph below represents the decomposition of $N_2O_4(g)$ in a closed container according to the following equation:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$



Which ONE of the following correctly describes the situation at t_1?

A The N_2O_4 gas is used up.

B The NO_2 gas is used up.

C The rate of the forward reaction equals the rate of the reverse reaction.

D The concentrations of the reactant and the product are equal. (2)

1.7 According to the Arrhenius theory, an acid ...

A is a proton donor.

B is a proton acceptor.

C forms hydroxide ions in water.

D forms hydronium ions in water. (2)

1.8 The reactions below occur in two different electrochemical cells **X** and **Y**.

Cell **X**: $CuC\ell_2(aq) \rightarrow Cu(s) + C\ell_2(g)$

Cell **Y**: $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$

Which ONE of the following CORRECTLY gives the products formed at the CATHODE in each of these cells?

	Cell X	**Cell Y**
A	$C\ell_2(g)$	Cu(s)
B	Cu(s)	Cu(s)
C	$C\ell_2(g)$	$ZnSO_4(aq)$
D	Cu(s)	$ZnSO_4(aq)$

(2)

1.9 Which ONE of the reactions below occurs when ammonium nitrate is prepared from nitric acid?

A Oxidation

B Acid-base

C Decomposition

D Condensation (2)

1.10 The information appearing on a 50 kg bag of fertiliser is shown below:

3 : 2 : 3 (21)

Which ONE of the following can be deduced from the above information?

The bag contains ...

A 21% filler.

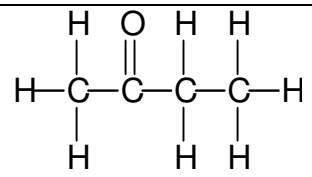
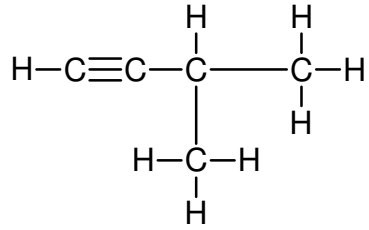
B 3 kg nitrogen.

C 79% fertiliser.

D 21% fertiliser. (2)
[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **G** in the table below represent seven organic compounds.

A	Butane	**B**	
C	Methyl propanoate	**D**	Ethanol
E	$CH_2CHCH_2CH_3$	**F**	
G	Ethene		

Use the table to answer the questions that follow.

2.1 Write down the letter(s) representing the following:

2.1.1 A saturated hydrocarbon (1)

2.1.2 TWO compounds with dipole-dipole forces between molecules (1)

2.2 Compound **A** has a chain isomer.

2.2.1 Define a *chain isomer*. (2)

2.2.2 Write down the structural formula of a chain isomer of compound **A**. (2)

2.3 Compound **E** is one of the products formed during a cracking reaction of compound **A**. Write down the molecular formula of the other product formed during this reaction. (1)

2.4 Write down the IUPAC name of:

2.4.1 A functional isomer of compound **B** (1)

2.4.2 Compound **F** (2)

2.5 Use structural formulae to write a balanced equation for the preparation of compound **C** from an alcohol and another organic compound. (4)

2.6 Draw TWO structural formulae of compound **D**. Use a dotted line to represent the hydrogen bonding between the two structural formulae. (2)

2.7 Compound **G** is used in the preparation of polyethene.

2.7.1 Name the type of reaction that takes place. (1)

2.7.2 Using structural formulae, write down a balanced equation for this preparation. (3)
[20]

QUESTION 3 (Start on a new page.)

The boiling points of five (5) organic compounds (**A** to **E**) are determined and the results are shown in the table below.

	IUPAC NAME	**MOLAR MASS ($g \cdot mol^{-1}$)**	**BOILING POINT (°C)**
A	1-chloropropane	78,5	47
B	1-chlorobutane	92,5	78
C	2-chlorobutane	92,5	70
D	1-chloro-2-methylpropane	92,5	**N**
E	2-chloro-2-methylpropane	92,5	51

3.1 Write down the homologous series to which compounds **A** to **E** belong. (1)

3.2 Compound **B** has a higher boiling point than compound **A**.

3.2.1 Name the intermolecular force responsible for this difference. (1)

3.2.2 Fully explain this difference in boiling point. (3)

3.3 Compounds **B** and **C** are structural isomers. Name the type of structural isomer of which they are an example. (1)

3.4 Compound **D** has an unknown boiling point indicated as **N**.

3.4.1 Predict the boiling point of compound **D**. Choose from the boiling points listed below.

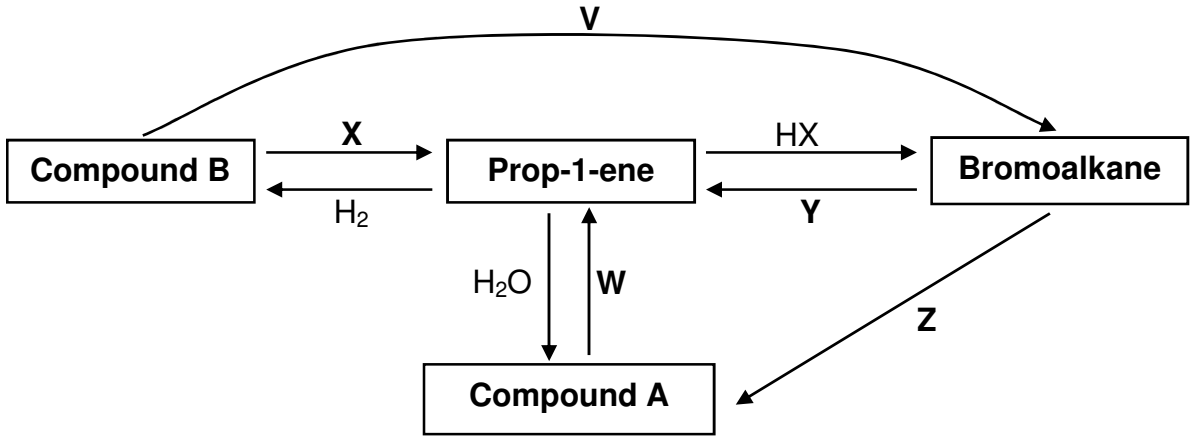
45 °C	69 °C	80 °C

(1)

3.4.2 Fully explain how you arrived at the answer to QUESTION 3.4.1. (4)
[11]

QUESTION 4 (Start on a new page.)

The flow diagram below shows how prop-1-ene can be used to prepare other organic compounds. **V**, **W**, **X**, **Y** and **Z** represent organic reactions.



4.1 Write down the letter (**V**, **W**, **X**, **Y** or **Z**) that represents each of the following reactions:

4.1.1 Hydrolysis (1)

4.1.2 Dehydrogenation (1)

4.1.3 Halogenation (1)

4.1.4 Dehydrobromination (1)

4.2 Write down the IUPAC name of:

4.2.1 Compound **A** (major product) (1)

4.2.2 Compound **B** (1)

4.3 Compare the reaction conditions for reaction **Y** and reaction **Z** by stating the following:

4.3.1 ONE similarity (1)

4.3.2 TWO differences (2)

4.4 Using structural formulae, write down a balanced equation for the preparation of the bromoalkane from prop-1-ene. (3)
[12]

QUESTION 5 (Start on a new page.)

ANSWER QUESTION 5.1.2 ON THE ATTACHED GRAPH SHEET.

5.1 The reaction of sodium thiosulphate ($Na_2S_2O_3$) and hydrochloric acid ($HC\ell$) is used to investigate one of the factors that influences reaction rate. The balanced equation for the reaction is:

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

In the first experiment, 25 cm^3 of the sodium thiosulphate solution is added to 10 cm^3 of a dilute hydrochloric acid solution in a flask that is placed over a cross drawn on a sheet of white paper.

The time taken for the cross to become invisible, when viewed from the top, is determined to calculate the reaction rate as $\frac{1}{reaction\ time}$.

The experiment is then repeated five times with different volumes of the sodium thiosulphate solution. The conditions used and results obtained are shown in the table below.

Experiment	Volume of $HC\ell$ (cm^3)	Volume of $Na_2S_2O_3$ (cm^3)	Volume of H_2O (cm^3)	Reaction time (s)	$\frac{1}{reaction\ time}$ (s^{-1})
1	10	25	0	7,7	0,130
2	10	20	5	9,5	0,104
3	10	15	10	12,8	0,078
4	10	10	15	20,0	0,052
5	10	5	20	42,6	0,026

5.1.1 For this investigation, write down the:

(a) The independent variable without referring to volume (1)

(b) Purpose of the water used in the investigation (1)

5.1.2 Draw a graph of volume of $Na_2S_2O_3(aq)$ versus reaction rate, in s^{-1}, on the attached GRAPH SHEET. (ATTACH THIS GRAPH SHEET TO YOUR ASNWER BOOK.) (3)

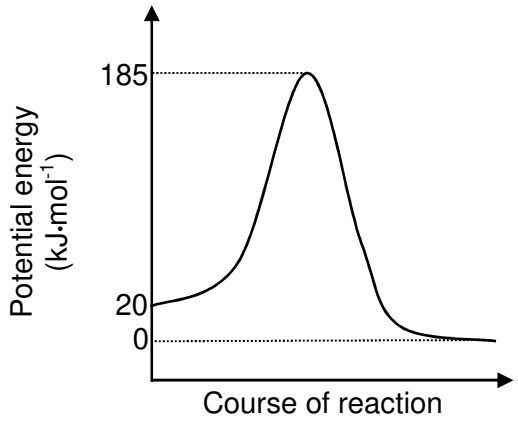
5.1.3 Use the graph in QUESTION 5.1.2 to determine the volume of $Na_2S_2O_3(aq)$ that should be used to obtain a reaction time of 11 s. USE A DOTTED LINE ON THE GRAPH AND A CALCULATION TO SHOW HOW YOU ARRIVED AT THE ANSWER. (3)

5.1.4 How does the rate of reaction in **experiment 1** compare to that in **experiment 5**. Write down HIGHER THAN, LOWER THAN or EQUAL TO. Use the collision theory to explain the answer. (3)

5.2 Consider a hypothetical reaction below:

$$A(aq) + BC(aq) \rightleftharpoons AB(aq) + C(aq)$$

The sketch graph, not drawn to scale, of potential energy versus course of reaction was obtained for the reaction.



5.2.1 Define *activation energy*. (2)

5.2.2 Write down the:

(a) Heat of reaction for the forward reaction (1)

(b) Activation energy for the reverse reaction (1)

5.2.3 Is the FORWARD or the REVERSE reaction an endothermic reaction? (1)
[16]

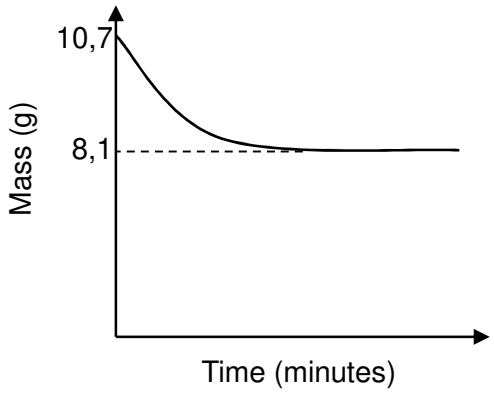
QUESTION 6 (Start on a new page.)

Ammonium chloride ($NH_4C\ell$) decomposes in a closed container at 340 °C according to the following balanced equation:

$$NH_4C\ell(s) \rightleftharpoons NH_3(g) + HC\ell(g)$$

6.1 What is the meaning of the double arrow in the above equation? (1)

6.2 The graph below, not drawn to scale, shows how the amount of $NH_4C\ell(s)$ in the container changes with time at 340 °C.



Equilibrium is reached at 340 °C. Calculate the equilibrium constant, K_c, at this temperature. The volume of the container is 500 cm^3. (8)

6.3 It is found that the K_c value increases when the temperature is increased. Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Fully explain the answer. (3)

6.4 The pressure is now increased, by decreasing the volume at constant temperature. How will each of the following be affected?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

6.4.1 The K_c value (1)

6.4.2 The number of moles of $NH_4C\ell(s)$ present in the equilibrium mixture (1)

6.4.3 The concentration of $NH_3(g)$ at equilibrium (1)

[15]

QUESTION 7 (Start on a new page.)

7.1 A learner determines the pH of a number of dilute solutions of acids and bases. The following results are obtained at 25 °C:

Solution	pH
Phosphoric acid	2
Orange juice	3,3
Potassium hydroxide	12

7.1.1 Explain the difference between a DILUTE base and a CONCENTRATED base. (2)

7.1.2 Which ONE of the above solutions contains the highest concentration of hydronium ions? (1)

7.1.3 Will the pH of the orange juice at 25 °C INCREASE, DECREASE or REMAIN THE SAME when:

(a) Distilled water is added to it (1)

(b) Some of the potassium hydroxide is added to it (1)

7.2 The learner adds 0,12 g of magnesium hydroxide, $Mg(OH)_2(s)$, to 500 cm^3 of the phosphoric acid solution, $H_3PO_4(aq)$ of pH = 2. The phosphoric acid solution is in excess.

The balanced equation for the reaction is:

$$3Mg(OH)_2 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6H_2O$$

7.2.1 Calculate the initial number of moles of phosphoric acid in the solution. (5)

7.2.2 The excess H_3PO_4 is how titrated with a sodium hydroxide solution, NaOH(aq), of unknown concentration. It is found that 25 cm^3 of the NaOH(aq) neutralises 14 cm^3 of the $H_3PO_4(aq)$.

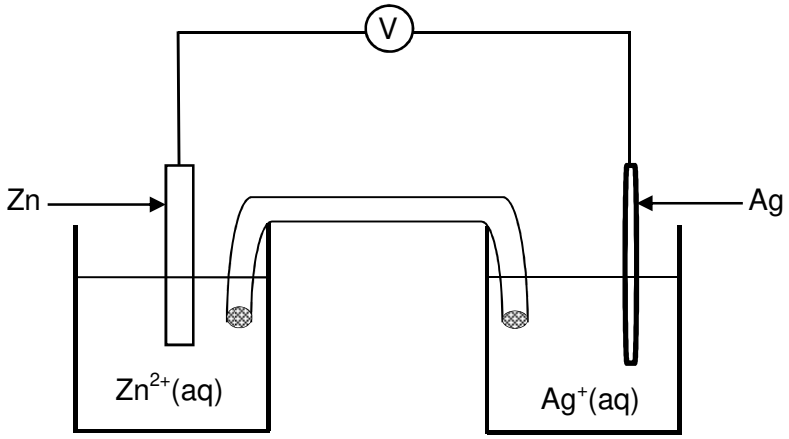
The balanced equation for the reaction is:

$$3NaOH(aq) + H_3PO_4(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(\ell)$$

Calculate the concentration of the NaOH(aq). (7)
[17]

QUESTION 8 (Start on a new page.)

The diagram below represents an electrochemical cell which functions under standard conditions.



8.1 Which type of electrochemical cell, ELECTROLYTIC or GALVANIC, is represented above? (1)

8.2 Which electrode, **Zn** or **Ag**, is the cathode? (1)

8.3 Write down the half-reaction that takes place in the zinc half-cell. (2)

8.4 How will the concentration of Zn^{2+} ions be affected when the cell is functioning? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

8.5 After the cell has been operating for a period of time, the gain in mass at the cathode is 2,16 g. Calculate the loss in mass at the anode. (4)

8.6 The Ag^{+}I Ag half-cell is now replaced by a H^{+} I H_2 half-cell.

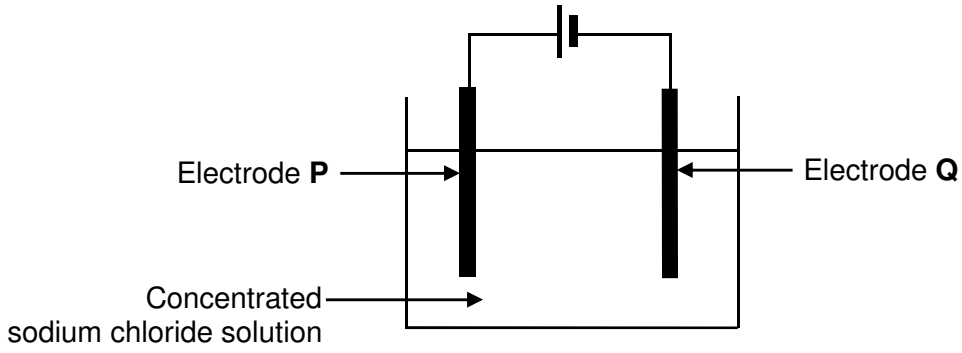
8.6.1 Which standard condition, not applicable to the zinc-silver cell, is applicable to this cell? (1)

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

8.6.3 Calculate the initial emf of this cell under standard conditions. (4)
[17]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents a cell used for the electrolysis of a concentrated sodium chloride solution. Both **P** and **Q** are inactive electrodes.



9.1 Define *electrolysis*. (2)

9.2 Which half-reaction (OXIDATION or REDUCTION) takes place at electrode **P**? (1)

9.3 Define a *reducing agent* in terms of electron transfer. (2)

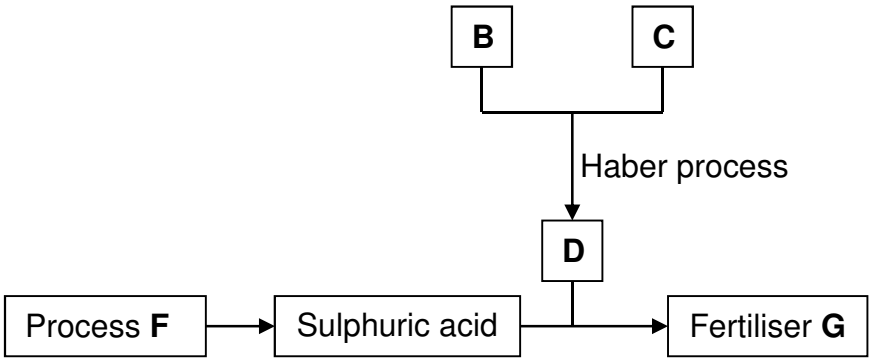
9.4 Write down the NAME or FORMULA of the reducing agent in the above cell. (1)

9.5 Write down the half-reaction that takes place at electrode **Q**. (2)

9.6 Write down the NAME or FORMULA of a substance that can be used as electrodes **P** and **Q**. (1)
[9]

QUESTION 10 (Start on a new page.)

10.1 The flow diagram below shows the processes involved in the industrial preparation of fertiliser **G**.



Write down the:

10.1.1 Balanced equation for the preparation of substance **D** (3)

10.1.2 Name of process **F** (1)

10.1.3 Balanced equation for the preparation of fertiliser **G** (3)

10.2 A park owner stores 2 kg bags of fertiliser **R** with ratio 4:6:8 (30) and fertiliser **S** with ratio 13:5:8 (30). He wants to grow shade trees.

10.2.1 Which ONE of the above fertilisers, **R** or **S**, must he use to obtain trees with enough shade? (1)

10.2.2 Give a reason for the answer to QUESTION 10.2.1. (2)

10.2.3 Calculate the mass of filler in fertiliser **R**. (3)
[13]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

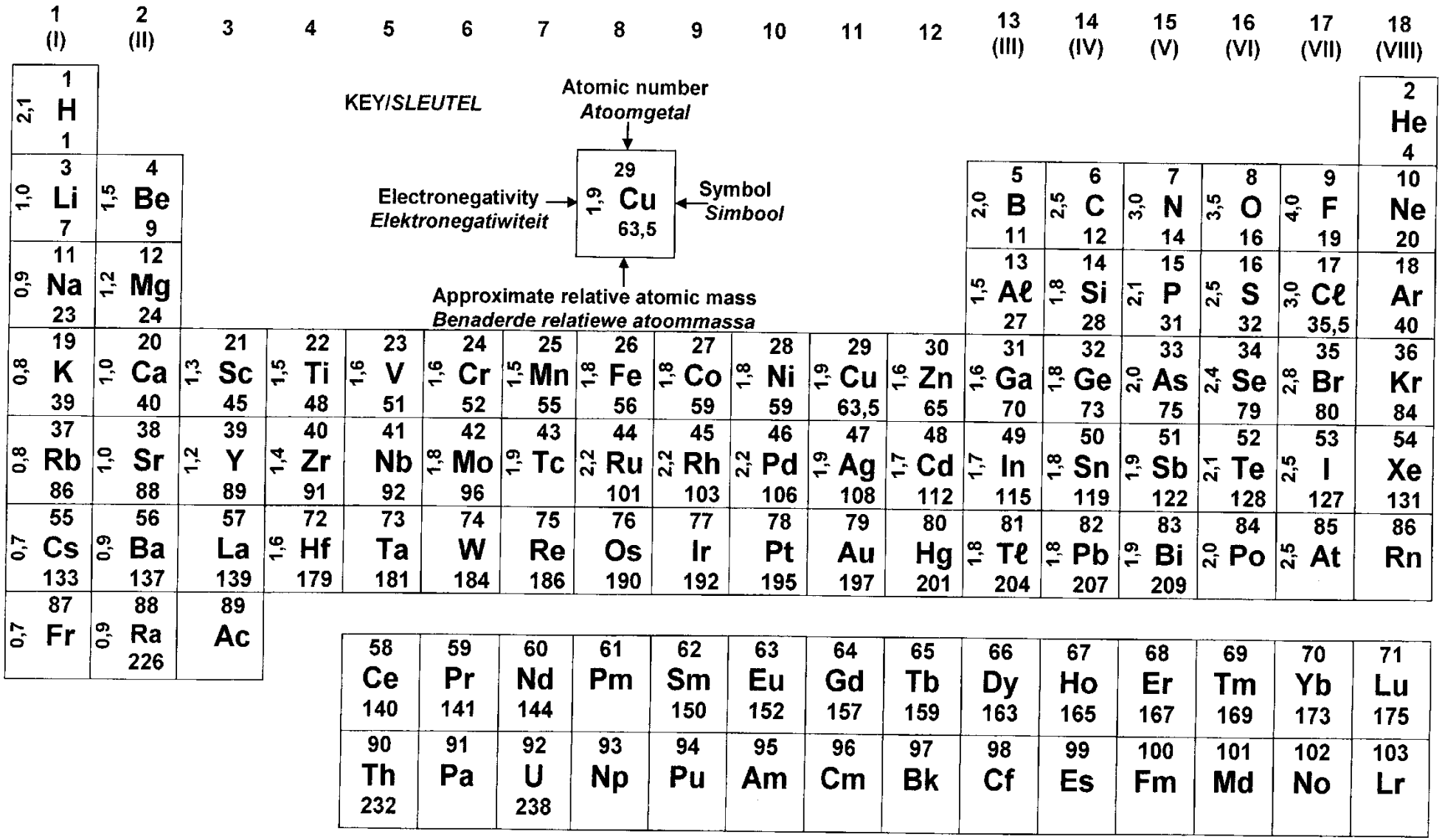
TABLE 1: PHYSICAL CONSTANTS / *TABEL 1: FISIESE KONSTANTES*

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

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

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
$Pt^{2+} + 2\ e^-$	$\rightleftharpoons$	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
$H_2O_2 + 2H^+ + 2\ e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87

Increasing oxidising ability / *Toenemende oksiderende vermoë* ↓

Increasing reducing ability / *Toenemende reduserende vermoë* ↑

ANSWER SHEET

NAME & SURNAME: _____

CLASS: _____

QUESTION 5.1.2: PLACE THIS GRAPH SHEET IN YOUR ANSWER BOOK

Graph of volume of $Na_2S_2O_3(aq)$ versus reaction rate