education
DEPARTMENT: EDUCATION
MPUMALANGA PROVINCE

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY P2

SEPTEMBER 2020

MARKS: 150

TIME: 3 hours

This question paper consists of 15 pages and 4 data sheets.

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. 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. 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. Each question has only ONE correct answer. Choose the answer and write only the letter (A – D) next to the question number (1.1 – 1.10) in the ANSWER BOOK , for example, 1.11 E.

1.1 Which ONE of the following organic compounds is an UNSATURATED HYDROCARBON?

A C_2H_6

B C_3H_6

C CH_3COOH

D CH_4 (2)

1.2 An organic compound was mistakenly named as 4,5-diethylpentan-3-ol. What is the correct IUPAC name for this compound?

A 1,2-diethylpentan-3-ol

B 4-ethylheptan-5-ol

C 4-ethylheptan-3-ol

D 4-ethylhexan-5-ol (2)

1.3 The following reaction reaches equilibrium in a closed container

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +206 \text{ kJ·mol}^{-1}$$

Which ONE of the following changes in temperature and pressure would lead to the greatest yield in the products?

	Pressure	Temperature
A	Decreases	Increases
B	Increases	Decreases
C	Increases	Increases
D	Decreases	Decreases

(2)

1.4 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·mol^{-1}. At a temperature of 90°C, the heat of reaction (ΔH), in kJ·mol^{-1}, is:

A -30

B -10

C +50

D -50 (2)

1.5 Consider the reaction represented by the following equation:

$$Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(s) + 3CO_2(g)$$

The Kc expression for this reaction is:

A $Kc = [Fe_2O_3][CO]^2$

B $Kc = \dfrac{[Fe]^2[CO_2]}{[Fe_2O_3][CO]^2}$

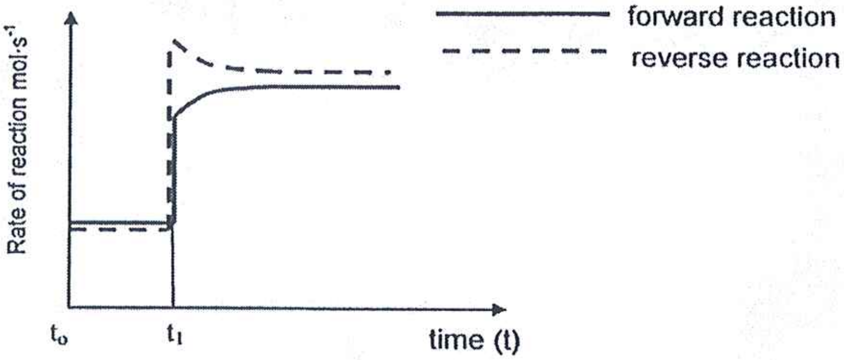
C $Kc = \dfrac{[Fe]^2[CO_2]^3}{[Fe_2O_3][CO]^3}$

D $Kc = \dfrac{[CO_2]^3}{[CO]^3}$

1.6 The reaction represented by the equation below reaches equilibrium in a closed container at time t_0

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -198kJ$$

A change is made to the equilibrium system at time t_1, as shown in the graph below.



Which ONE of the following describes the change to the equilibrium at t_1 as indicated on the graph?

A Increase the concentration of $O_2(g)$

B Increase the temperature.

C Increase in the pressure by decreasing the volume.

D Increase in the concentration of $SO_2(g)$ (2)

1.7 Which ONE of the following species CANNOT act as a Brønsted-Lowry acid and a Brønsted-Lowry base?

A $H_2PO_4^-$

B H_2O

C HSO_4^-

D CH_3COOH (2)

1.8 The process used to deposit a metal onto a conductive object is called:

A Electrorefining

B Electroextraction

C Electroplating

D Neutralisation (2)

1.9 Which ONE of the following pairs will react spontaneously?

A Mg^{2+} (aq) + Zn (s)

B Mg^{2+} (aq) + Cu (s)

C Cu^{2+} (aq) + Ag (s) (2)

D Ag^{+} (aq) + Pb (s

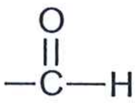
1.10 Which ONE of the following is correct for the industrial preparation of nitric acid?

	PROCESS	**CATALYST**
A	Haber	Platinum
B	Ostwald	Platinum
C	Contact	Iron
D	Contact	Vanadium pentoxide

(2)
[20]

QUESTION 2 (Start on a new page.)

2.1 The structural formula of a functional group of a certain organic compound is given below.



$$-\overset{\overset{O}{||}}{C}-H$$

2.1.1 Define the term *functional group*. (2)

Write down the

2.1.2 Name of this functional group (1)

2.1.3 General formula of the homologous series to which this functional group belongs. (1)

2.2 Consider the condensed structural formula of the organic compound below.

$$CH_3CH_2COOCH_2CH_3$$

The above-mentioned organic compound has one functional isomer.

2.2.1 Define the term *functional isomer.* (2)

2.2.2 Draw the structural formula of the FUNCTIONAL ISOMER of this compound (2)

The same compound can be prepared in a laboratory.

2.2.3 Write down the name for this type of reaction. (1)

2.2.4 Write down the IUPAC name of the alcohol needed to prepare this compound. (1)

2.2.5 Write down two reaction conditions for this reaction. (2)

2.2.6 How can one easily identify whether this compound is being formed (1)

2.3 A sample of impure butane (C_4H_{10}) of mass 26 g burns in excess oxygen, 34 g of CO_2 forms. The balanced equation for this reaction is given below:

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

Calculate the percentage purity of the sample of butane. (5)

[18]

QUESTION 3 (Start on a new page.)

Two separate experiments are conducted to determine the boiling points of organic compounds from different homologous series, under the same conditions. The results obtained are shown in the table below.

Experiment	**Organic compound**		**Boiling point (°C)**
I	**A**	2,2-dimethylpropane	9
	B	2-methylbutane	27
	C	Pentane	36
II	**P**	$CH_3CH_2CH_2CH_2OH$	117,7
	Q	CH_3CH_2COOH	141,2

3.1 Define the term *homologous series*. (2)

3.2 Consider the boiling points of the compounds in Experiment **I**.

3.2.1 Write down the dependent variable for this investigation. (1)

3.2.2 Fully explain why the boiling points increases from compound **A** to compound **C**. (3)

3.3 Use the data in Experiment **II** to answer the following questions.

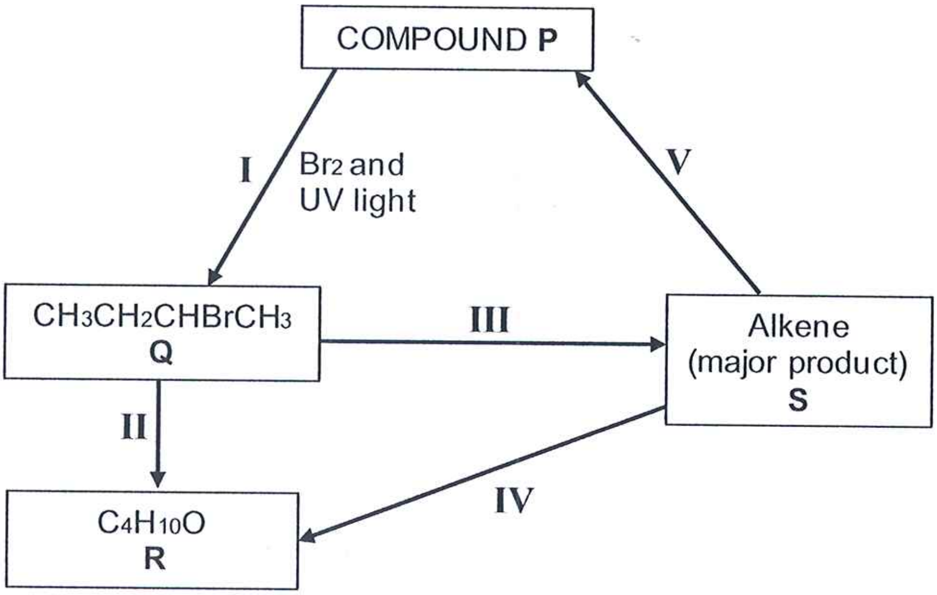
3.3.1 Formulate an investigative question for this experiment. (2)

3.3.2 Explain why compound **Q** has a higher boiling point than compound **P**. (4)

[12]

QUESTION 4 (Start on a new page.)

Consider the following series of organic reactions and answer the questions that follow.



4.1 Write down the TYPE of reaction represented by:

4.1.1 **I** (1)

4.1.2 **II** (1)

4.1.3 **V** (1)

4.2 During reaction **III**, compound **Q** reacts with a base to form compound **S**. Write down:

4.2.1 Two reaction conditions for this reaction. (2)

4.2.2 The IUPAC name of compound **Q**. (2)

4.2.3 The STRUCTURAL FORMULA of the major product **S** formed. (2)

4.3 Consider reaction **IV**. Write down

4.3.1 The TYPE of addition reaction that take place. (1)

4.3.2 The NAME or FORMULA of the catalyst that is used. (1)

4.4 Write down the FORMULA of the INORGANIC product that is formed in reaction **II**. (1)

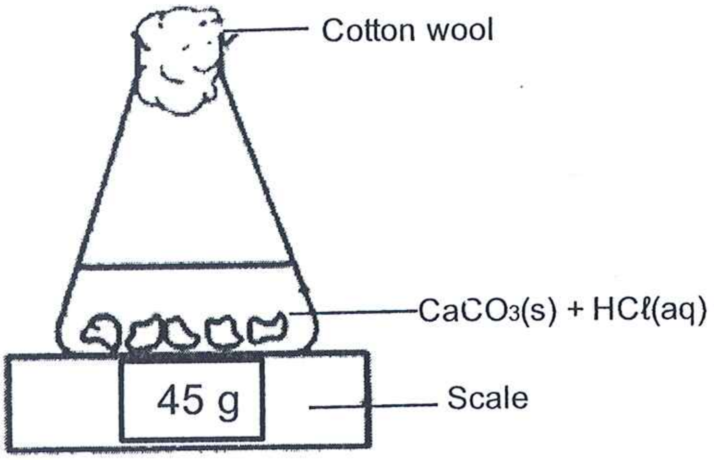
[12]

QUESTION 5 (Start on a new page.)

A series of experiments are conducted to investigate the effect of changing temperature, concentration and surface area on the rate of reaction between hydrochloric acid and calcium carbonate. The balanced chemical equation for the reaction taking place is:

$$CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g)$$

Each experiment is carried out in a conical flask, which is placed on top of a sensitive digital balance as shown in the diagram below.



The reading on the scale decreases over a period of time.

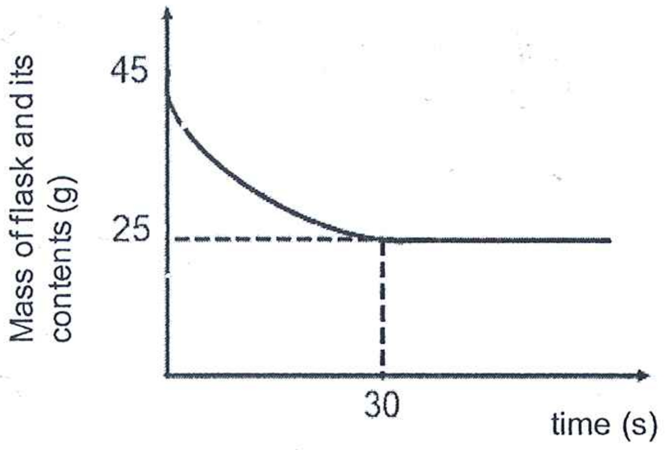
5.1 What is the reason for the decrease in the mass of the flask? (1)

5.2 Define the term *rate of reaction*. (2)

Four different experiments are carried out using the conditions indicated in the table below.

Experiment	**Temperature (°C)**	**Concentration of HCℓ (mol·dm^{-3})**	**State of $CaCO_3$**
1	20	0,1	large pieces
2	15	0,1	large pieces
3	20	0,1	powder
4	20	0,2	large pieces

The results of EXPERIMENT 1 were used to sketch the graph shown below:

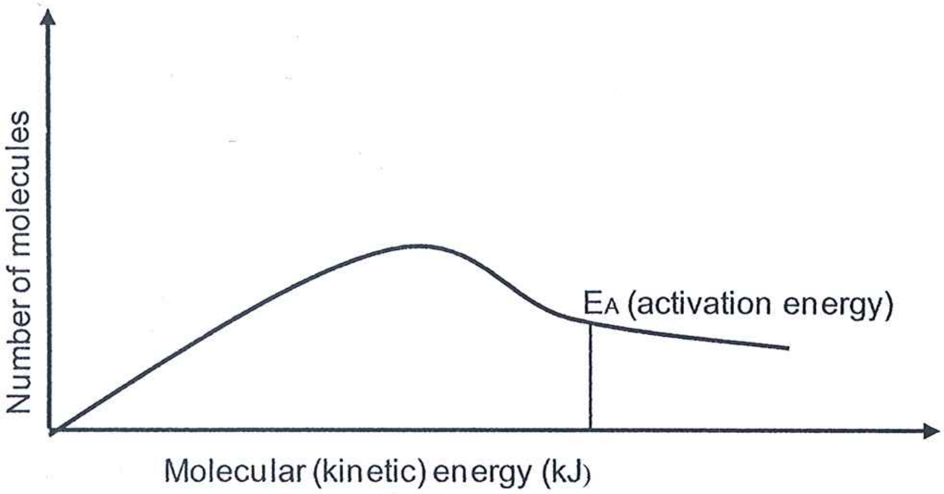


5.3 Using the graph, calculate the rate of reaction for experiment 1. (3)

5.4 Redraw the graph in your answerbook. On the same set of axes draw sketch graphs to represent the results of EXPERIMENT 2 and 3. CLEARLY LABEL EACH GRAPH USING 2 AND 3. (4)

5.5 Use the collition theory to explain the difference in rate of reactions between EXPERIMENTS 1 and 4. (4)

5.6 The Maxwell-Boltzman curve below shows the distribution of molecular energies of reacting molecules in the chemical reaction of experiment 1.



Redraw the graph in your answerbook and draw a new curve that represents experiment 2 (2)

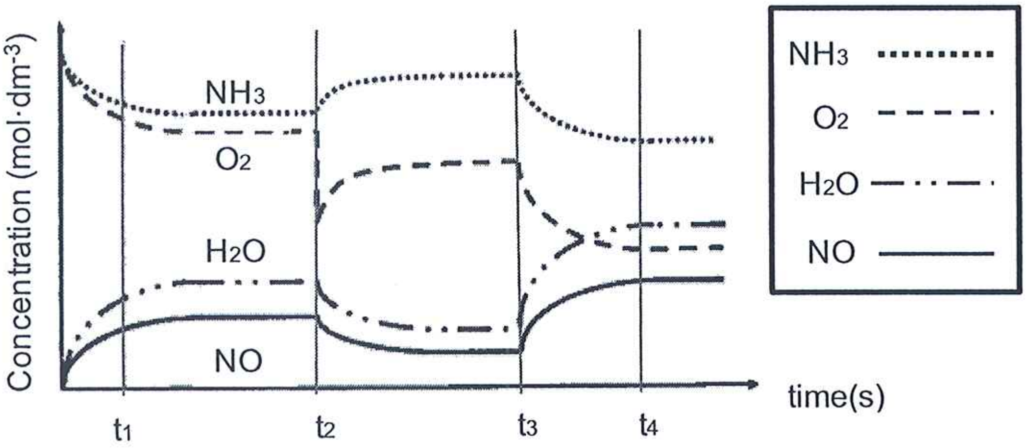
[16]

QUESTION 6 (Start on a new page.)

6.1 In an experiment, ammonia gas and oxygen gas are introduced into a container at a certain temperature. The container is sealed and the reaction taking place reaches equilibrium, according to the following balanced chemical equation.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

The graph below shows the change in consentration of $NH_3(g)$, $O_2(g)$, $NO(g)$ and $H_2O(g)$ with time.



6.1.1 If numerical values were given for concentration on the y-axis, would it be possible to calculate the equilibrium constant (Kc) for this reaction at time t_1 ? Explain the answer. (2)

6.1.2 Identify the change (stress) which was introduced to the reaction at time t_2 and explain the subsequent changes in concentrations of all substances immediately after time t_2. (4)

6.1.3 At time t_3 the temperature of the container is decreased. Is the forward reaction EXOTHERMIC or ENDOTHERMIC? (2)

6.2 Phosphorus pentachloride decomposes into phosphorous trichloride and chlorine gas. When gaseous phosphorous pentachloride is sealed in a closed container the following equilibrium is established.

$$PC\ell_5(g) \rightleftharpoons PC\ell_3(g) + C\ell_2(g)$$

6.2.1 An unknown mass of phosphorous pentachloride is sealed in an empty 2000 cm^3 container. The system is allowed to reach equilibrium at 250°C.
When the equilibrium mixture was analysed the concentrations of $PC\ell_5$ and $C\ell_2$ were 0,7 $mol\cdot dm^{-3}$ and 0,5 $mol\cdot dm^{-3}$ respectively.
Calculate the Kc value at 250°C. (5)

6.2.2 Calculate the mass of phosphorous pentchloride that was originally placed in the container. (4)

[17]

QUESTION 7 (Start on a new page)

7.1 Barium hydroxide ($Ba(OH)_2$), is defined as a strong base.

7.1.1 Define a *strong base.* (2)

7.1.2 Calculate the pH of a solution of a barium hydroxide solution, $Ba(OH)_2$ (aq), with a concentration of 0,1 mol·dm^{-3}. (5)

7.2 A standard solution of oxalic acid, $(COOH)_2$ (aq), with concentration 0,2 mol·dm^{-3} is prepared by dissolving a certain amount of oxalic acid crystals, $(COOH)_2 \cdot 2H_2O$, in water. The flask is then filled with distilled water up to the 250 cm^3 mark.

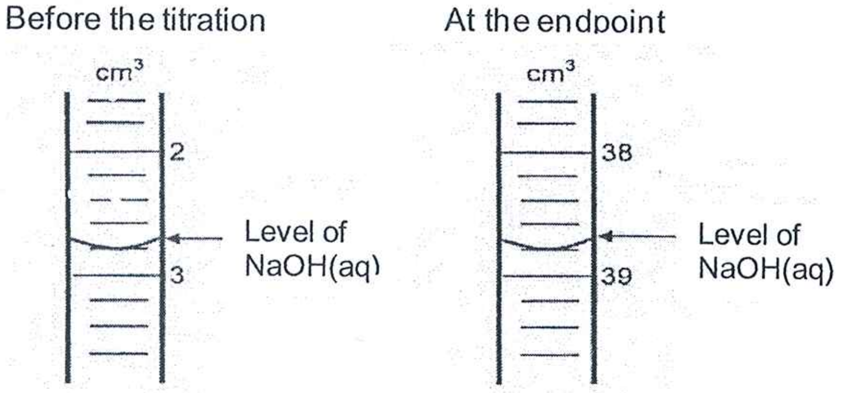
7.2.1 Define the term *standard solution.* (2)

7.2.2 Calculate the mass of oxalic acid needed to prepare the standard solution. (4)

7.3 During a titration, 25 cm^3 of the standard oxalic acid solution, $(COCH)_2$ (aq), prepared in QUESTION 7.2, is neutralised by a sodium hydroxide solution, NaOH(aq), from a burette.
The balanced equation for the reaction is given below.

$$(COOH)_2(aq) + 2NaOH(aq) \rightarrow (COO)_2Na_2(aq) + 2H_2O(\ell)$$

The diagrams below show the burette readings before the titration commenced and at the endpoint respectively.


Before the titration

At the endpoint

7.3.1 Define the term *endpoint.* (2)

7.3.2 What will the pH at the endpoint be? Choose from: GREATER THAN 7, EQUAL TO 7 or LESS THAN 7. (1)

7.3.3 Determine the volume of NaOH(aq) that was added to the $(COOH)_2$(aq) to reach the endpoint of the titration from the diagrams above.. (1)

7.3.4 Calculate the concentration of the sodium hydroxide solution, NaOH(aq). (5)

[22]

QUESTION 8 (Start on a new page)

Consider the following galvanic cell at 25 °C.

$$Cu(s)\ |\ Cu^{2+}(1\ mol\cdot dm^{-3})\ ||\ C\ell_2\ (1\ atm)\ |\ C\ell^-\ (1\ mol\cdot dm^{-3})$$

8.1 Write down the balanced chemical equation for the net cell reaction that takes place. (3)

8.2 Calculate the initial cell potential at 25 °C. (4)

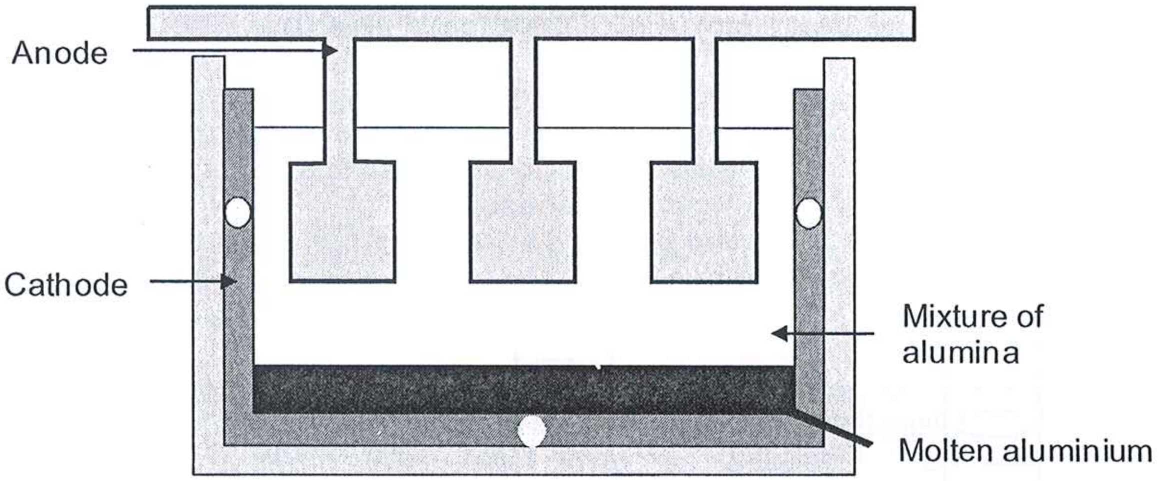
8.3 Write down the FORMULA of the cathode. (1)

8.4 Fully explain how the salt bridge functions to maintain electrical neutrality by referring to the movement of the ions. (2)

[10]

QUESTION 9 (Start on a new page)

Aluminium metal is extracted from pure aluminium oxide ($A\ell_2O_3$) in an electrolytic cell represented in the diagram below.



9.1 What is the NAME of the ore which contains aluminium oxide ($A\ell_2O_3$)? (1)

9.2 Define the term *electrolytic cell.* (2)

9.3 Write down the FORMULA of the ions present in the molten alumina ($A\ell_2O_3$). (2)

9.4 What is the advantage of adding cryolite to the alumina? (1)

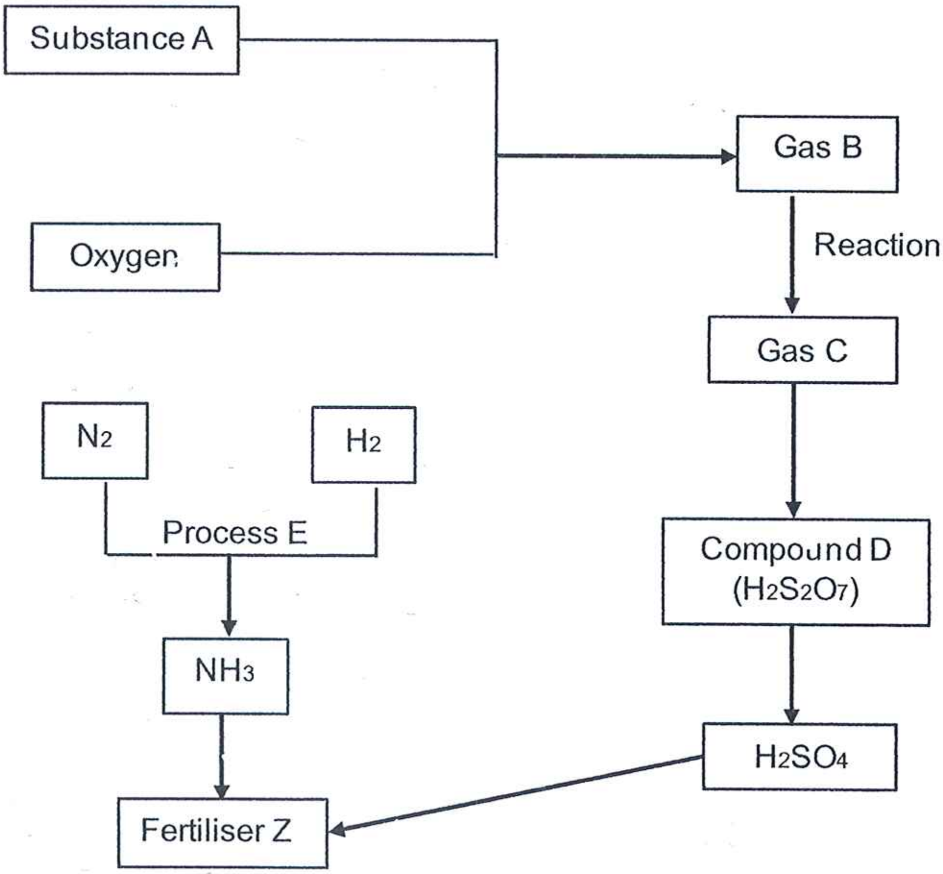
9.5 Write down the half reaction that takes place at the cathode. (2)

9.6 Explain why the carbon anode should be replaced regularly. Make use of a chemical equation to support the answer. (3)

[11]

QUESTION 10 (Start on a new page)

The fertiliser industry can be summarised as follows:



10.1 Write down the NAME or FORMULA for Substance A. (1)

10.2 Write down the NAME of the catalyst used in Reaction 1. (1)

10.3 Gas C is diluted with a small amount of sulphuric acid to form Compound D.

10.3.1 Write down the NAME for compound D. (1)

10.3.2 Why is gas C not added directly to water to form sulphuric acid? (2)

10.4 Write down a balanced equation for the formation of fertiliser Z. (3)

10.5 A farmer bought a 40 kg bag of fertiliser with a ratio of 3:2:1(22) for his crops. Calculate the mass of the primary nutrient required for healthy strong roots. (3)

[11]

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^0	$1,013 \times 10^5$ Pa
Molar gas volume at STP Molêre gasvolume by STD	V_m	$22,4\ dm^3 \cdot mol^{-1}$
Standard temperature Standaardtemperatuur	T^0	273 K
Avogadro's constant	N_A	$6,023 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ OR/OF $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{n_a}{n_b} = \frac{c_a V_a}{c_b V_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ 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 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
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

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
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**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
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	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
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87

Increasing reducing ability/*Toenemende reduserende vermoë*

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

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KEY/*SLEUTEL*

Atomic number
Atoomgetal

29
1,9 Cu
63,5

Electronegativity
Elektronegatiwiteit

Symbol
Simbool

Approximate relative atomic mass
Benaderde relatiewe atoommassa

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