education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

FEBRUARY/MARCH 2010

MARKS: 150

TIME: 3 hours

This question paper consists of 14 pages and 4 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the spaces on the ANSWER BOOK.

2. Answer ALL the questions in the ANSWER BOOK.

3. This paper consists of TWO sections:

   SECTION A (25)
   SECTION B (125)

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.

SECTION A

QUESTION 1: ONE-WORD ITEMS

Give ONE word/term for each of the following descriptions. Write only the word/term next to the question number (1.1 – 1.5) in the ANSWER BOOK.

1.1 The minimum energy needed for a reaction to take place (1)

1.2 A reaction in which all reactants and products are in the same phase (1)

1.3 A substance whose oxidation number decreases during a chemical reaction (1)

1.4 Cells that can be recharged (1)

1.5 The type of elimination reaction during which a hydrogen halide is removed from a haloalkane (1)
[5]

QUESTION 2: FALSE ITEMS

Each of the five statements below is FALSE. Correct each statement so that it is TRUE. Write down only the correct statement next to the question number (2.1 – 2.5) in the ANSWER BOOK.

NOTE: Correction by using the negative of the statement, for example "… IS NOT …", will not be accepted.

2.1 The arenes is the homologous series to which cyclohexane belongs. (2)

2.2 The temperature of an enclosed gas is a measure of the kinetic energy of the individual gas molecules. (2)

2.3 If the equilibrium constant for the reaction $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$ is equal to K, then the equilibrium constant for the reverse reaction $2AB(g) \rightleftharpoons A_2(g) + B_2(g)$ is also equal to K. (2)

2.4 Electrons flow through the salt bridge of a galvanic cell. (2)

2.5 A battery with a capacity of 100 A·h can deliver a maximum charge of 100 C. (2)
[10]

QUESTION 3: 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) of the answer next to the question number (3.1 – 3.5) in the ANSWER BOOK.

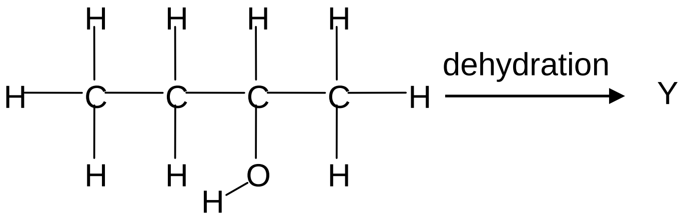
3.1 Consider the flow diagram below:

$$\boxed{\text{propene}} \xrightarrow[\text{Pt}]{H_2} \boxed{\text{compound X}}$$

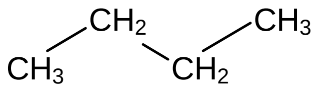
The IUPAC name for compound X is:

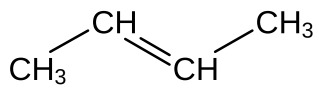
A propyne
B propan-1-ol
C propane
D propan-2-ol (2)

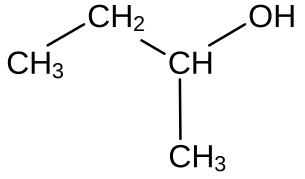
3.2 During the dehydration of butan-2-ol, represented below, compound Y forms as one of the products.

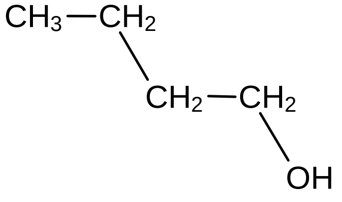


Which ONE of the following is the correct condensed structural formula for compound Y?

A


B


C


D


(2)

3.3 Consider the following hypothetical reaction that reached equilibrium in a closed container at 450 °C:

$$XY(s) \rightleftharpoons X(g) + Y(s) \qquad \Delta H > 0$$

Which ONE of the following changes will NOT affect the equilibrium position?

A Increase in temperature

B Increase in the amount of Y(s)

C Decrease in pressure at constant volume

D Increase in the volume of the container (2)

3.4 The following characteristics may be used to describe an electrochemical cell (electrolytic or galvanic):

I The chemical reaction is self-sustaining.
II The reaction requires energy from an electrical source.
III The anode is the positive electrode of the cell.

Which of these characteristics are specific to an electrolytic cell?

A Only I

B Only II

C I and III

D II and III (2)

3.5 Which ONE of the following statements about the extraction of aluminium is TRUE?

A The ore of aluminium oxide is called cryolite.

B When the cell is in operation, aluminium forms at the anode.

C Aluminium oxide is dissolved in cryolite.

D When the cell is in operation, carbon dioxide gas forms at the cathode. (2)
[10]

TOTAL SECTION A: 25

SECTION B

INSTRUCTIONS

1. Start each question on a NEW page.
2. Leave one line between two sub-questions, for example between QUESTION 4.1 and QUESTION 4.2.
3. The formulae and substitutions must be shown in ALL calculations.
4. Round off your answers to TWO decimal places where applicable.

QUESTION 4 (Start on a new page.)

Consider the following terms/compounds in organic chemistry.

aldehydes ketones oxidation haloalkane hydrolysis

ethyne hydrohalogenation but-1-ene water amines

hydration chlorine butane potassium hydroxide alkynes

Choosefrom the above terms/compounds: (Write down the question number only and next to each the correct term/compound.)

4.1 The homologous series that has a carbonyl group as functional group (1)

4.2 A saturated hydrocarbon (1)

4.3 The product formed when an alkane reacts with a halogen (1)

4.4 The homologous series to which propanal belongs (1)

4.5 The homologous series to which 2-bromobutane belongs (1)

4.6 The reaction of 2-bromobutane with water (1)

4.7 The homologous series with a $–NH_2$ group as functional group (1)

4.8 An unsaturated compound that has isomers (1)

4.9 A compound which belongs to the homologous series with the general formula $C_nH_{2n - 2}$ (1)

4.10 The type of organic reaction during which hydrogen chloride reacts with ethene (1)

[10]

QUESTION 5 (Start on a new page.)

Petrol is a complex mixture of hydrocarbons such as hexane. Compounds such as 2,2,4-trimethylpentane are added to petrol to change its combustion properties.

5.1 Explain the term *hydrocarbon.* (2)

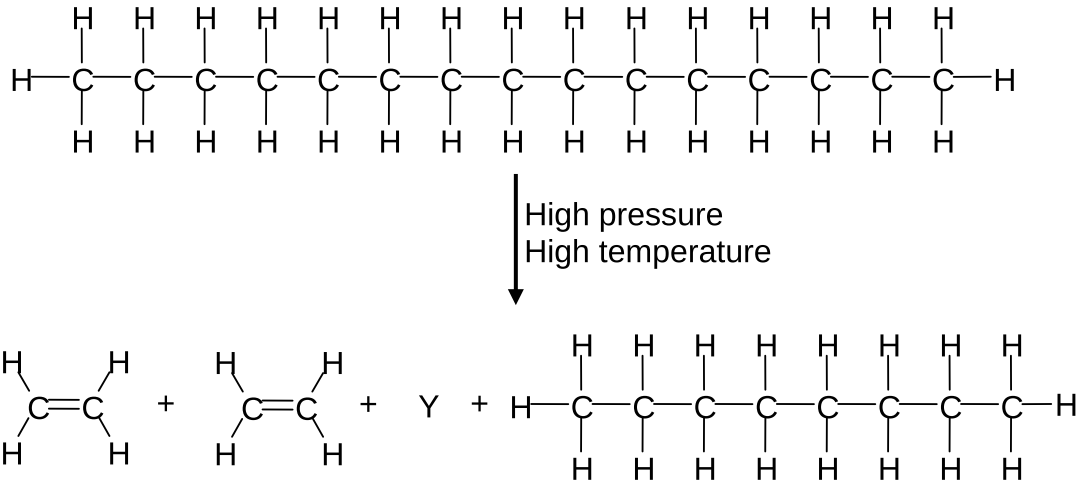
5.2 Complete the following equation that represents the complete combustion of hexane in a car engine. (Balancing of the equation is not required.)

$C_6H_{14} + O_2 \rightarrow ... + ...$ (2)

5.3 Write down the structural formula for 2,2,4-trimethylpentane. (2)

5.4 Petrol requires alkanes in the range from C_5 to C_{10}. Cracking is the process that is used to convert longer chains into shorter chains.

The diagram below illustrates one of the possible cracking reactions of $C_{15}H_{32}$.



Write down the STRUCTURAL FORMULA and NAME for the hydrocarbon represented by Y. (3)

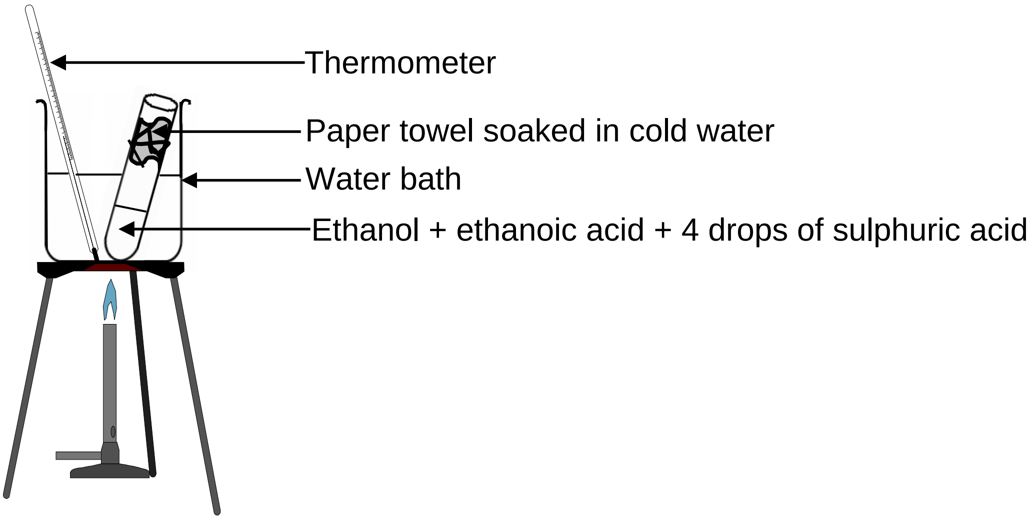
[9]

QUESTION 6 (Start on a new page.)

Many of the flavours and odours of fruits are esters. Ethyl ethanoate is the most common ester found in wines and contributes to the perception of the fruitiness of wine.

A learner wants to prepare ethyl ethanoate in the school laboratory. She follows the instructions below.

- Mix 1 cm^3 ethanoic acid and 1 cm^3 ethanol thoroughly in a test tube.
- Slowly add 4 drops of concentrated sulphuric acid while swirling the test tube.
- Soak a paper towel in cold water and fasten it around the test tube close to its mouth with an elastic band.
- Place the test tube in a water bath and heat the water with a flame to a temperature of about 60 °C.
- Leave the test tube in the hot water bath for about 15 minutes.
- Cool the test tube by placing it in a beaker of cold water.
- Smell the vapour in the test tube after 10 minutes.



6.1 To which homologous series does ethanol belong? (1)

6.2 Use structural formulae to write a balanced equation for the reaction taking place in the test tube. (5)

6.3 What is the function of the sulphuric acid in the above reaction? (1)

6.4 Why does the method use a water bath instead of direct heating over an open flame? (1)

6.5 State ONE function of the wet paper towel at the top of the test tube. (1)

6.6 The learner finds it difficult to detect the smell of the ester due to the presence of sulphuric acid and unreacted ethanoic acid. A friend suggests that she add 10 drops of a diluted sodium carbonate solution to the contents of the test tube. Briefly explain why this suggestion might be a solution to the problem. (2)

6.7 Whilst several esters may be present in wine, the observed aroma is generally that of the smallest ester present in wine, namely ethyl ethanoate. State a physical property of ethyl ethanoate which is responsible for this. (1)
[12]

QUESTION 7 (Start on a new page.)

Amides are nitrogen containing organic compounds. Two examples of amides are ethanamide and *N*-methylethanamide.

7.1 Write down the structural formula for:

7.1.1 The functional group of an amide (2)

7.1.2 Ethanamide (2)

7.2 Give a reason why *N*-methylethanamide is a secondary amide. (1)

7.3 A group of learners know that the boiling points of straight chain hydrocarbons increase with an increase in their molecular mass.

7.3.1 Refer to intermolecular forces to explain why the boiling points of straight chain hydrocarbons increase with an increase in their molecular mass. (2)

The learners want to investigate the relationship between boiling point and molecular mass of the amides. Based on their knowledge of the relationship in QUESTION 7.3.1, they hypothesise that:

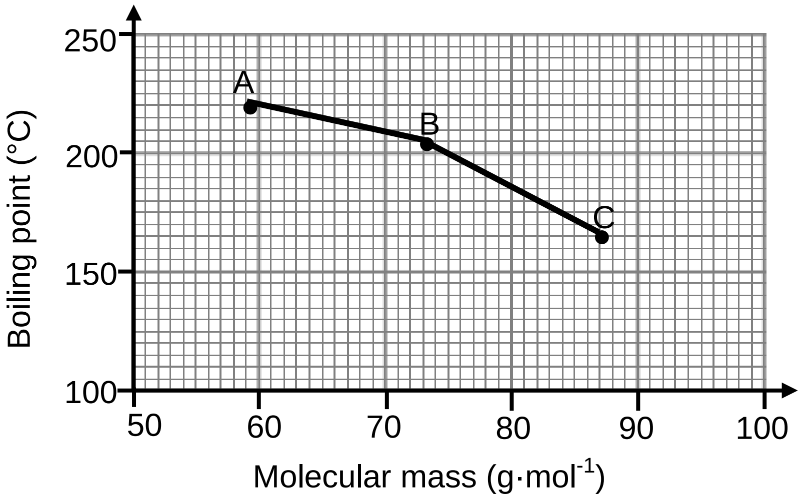
Boiling points of amides increase with an increase in molecular mass.

The learners then determined the boiling points of the following amides:

A: Ethanamide
B: *N*-methylethanamide
C: *N,N*-dimethylethanamide

The graph on page 10 represents their results.

Graph of boiling points of amides versus molecular mass



7.3.2 What conclusion can the learners draw from the graph? (2)

7.3.3 Use your knowledge of structural formulae and the intermolecular forces in each of the three amides to explain the results obtained. (3)

7.3.4 One of the learners feels that the experiment is not a fair test. He suggests that they must rather compare the boiling points of methanamide, ethanamide and propanamide.

Explain why this suggestion makes the experiment a fair test. (2)
[14]

QUESTION 8 (Start on a new page.)

Combustion in air at high temperatures produces oxides of nitrogen of which nitrogen dioxide ($NO_2(g)$), is the most common. Natural sources of nitrogen dioxide include lightning and the activity of some soil bacteria. These natural sources are small compared to emissions caused by human activity.

NO_2 can irritate the lungs and cause respiratory infection. When $NO_2(g)$ dissolves in rainwater in air it forms nitric acid which contributes to acid rain.

8.1 State TWO human activities that contribute to high nitrogen dioxide levels in the atmosphere. (2)

8.2 Write a balanced equation to show how nitric acid forms from nitrogen dioxide in air. (3)

8.3 High levels of nitrogen dioxide in the atmosphere can result in damage to crops and eventually food shortages. Briefly state how high levels of nitrogen dioxide can damage crops. (1)

8.4 Nitric acid can cause corrosion of copper cables whilst hydrochloric acid does no harm to copper cables. Refer to the relative strengths of the oxidising agents involved to explain this phenomenon. (3)

8.5 2 mol of $NO_2(g)$ and an unknown amount of $N_2O_4(g)$ are sealed in a 2 dm^3 container, that is fitted with a plunger, at a certain temperature. The following reaction takes place:

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

At equilibrium it is found that the NO_2 concentration is 0,4 $mol{\cdot}dm^{-3}$. The equilibrium constant at this temperature is 2.

8.5.1 Calculate the initial amount (in mol) of $N_2O_4(g)$ that was sealed in the container. (9)

The plunger is now pushed into the container causing the pressure of the enclosed gas to increase by decreasing the volume.

8.5.2 How will this change influence the amount of nitrogen dioxide at equilibrium? Only write down INCREASES, DECREASES or REMAINS THE SAME. (1)

8.5.3 Use Le Chatelier's principle to explain your answer to QUESTION 8.5.2. (2)
[21]

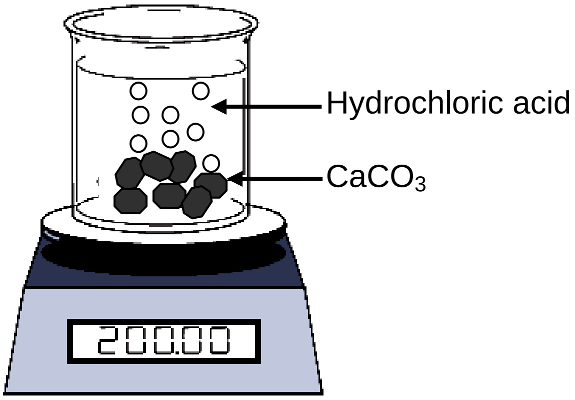
QUESTION 9 (Start on a new page.)

A certain mass of calcium carbonate chunks is added to a hydrochloric acid solution in an open beaker on a scale as shown below. The equation for the reaction is as follows:

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

$CO_2(g)$ is allowed to escape from the beaker. The data in the table below was obtained for a time interval of 8 minutes.

Time (min)	Mass of beaker and contents (g)
0	200,00
1	197,50
2	195,45
3	193,55
4	191,70
5	189,90
6	188,15
7	186,45
8	184,80



9.1 'Rate' in science refers to something that happens in a certain time. Explain the term *reaction rate*. (2)

9.2 Calculate the change in mass of the beaker and its contents during the 8 minutes. (1)

9.3 Use your answer in QUESTION 9.2 to show that the average reaction rate during the 8 minutes is 1,9 $g \cdot min^{-1}$. (2)

9.4 Calculate the mass of calcium carbonate consumed during the 8 minutes. (5)

9.5 Use the collision theory to explain how the rate of the above reaction will change when powdered calcium carbonate is used instead of calcium carbonate chunks. (3)

[13]

QUESTION 10 (Start on a new page.)

Batteries consist of one or more galvanic cells. A galvanic cell is a combination of two half-cells.

John wants to determine which one of Options A or B, shown below, can be used to assemble a galvanic cell with the highest potential difference.

Option	**Combination of half-cells**
A	Ag(s) in $AgNO_3$(aq) & Ni(s) in $Ni(NO_3)_2$(aq)
B	Mg(s) in $Mg(NO_3)_2$(aq) & Ag(s) in $AgNO_3$(aq)

10.1 Draw a fully labelled diagram of the galvanic cell that John can use to measure the potential difference for the cell in **Option B**. Use a positive (+) and negative (-) sign to indicate the positive and negative electrodes respectively. (5)

10.2 Write a balanced chemical equation, excluding spectator ions, for the net (overall) cell reaction for the galvanic cell in **Option B.** (3)

10.3 Calculate the initial potential difference that can be obtained under standard conditions for the galvanic cell in **Option B.** (4)

10.4 State TWO standard conditions that John must adhere to during the experiment, to ensure that the measured potential difference is the same as the calculated potential difference. (2)

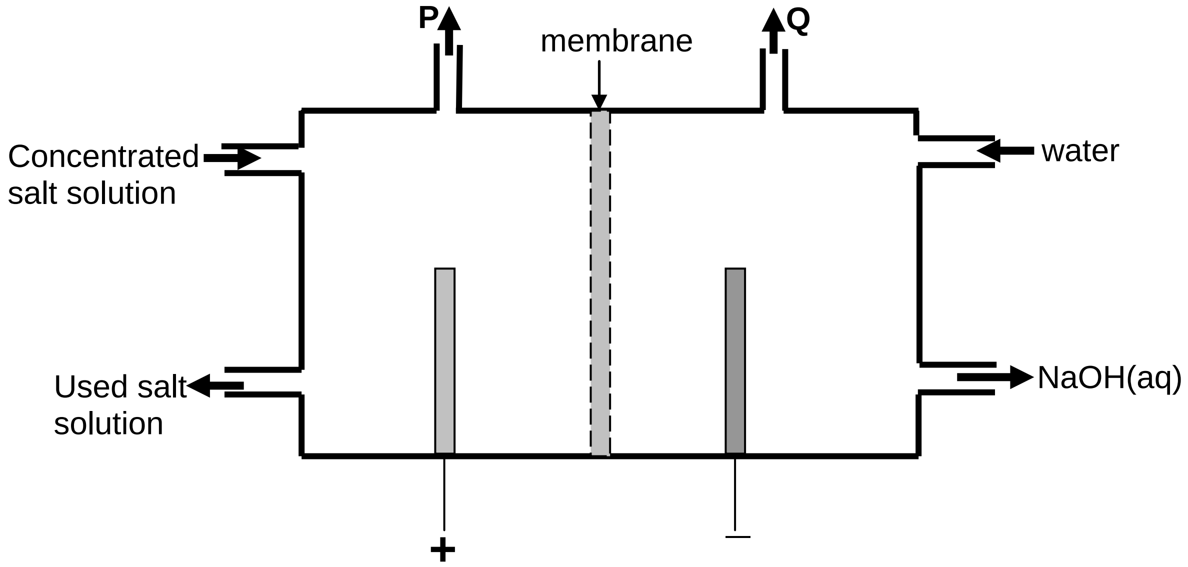
10.5 Write down the cell notation (symbolic notation) for the galvanic cell in **Option A**. (3)

10.6 WITHOUT ANY CALCULATIONS, determine which one of Option A or Option B should result in the galvanic cell with the highest potential difference. Refer to the relative strengths of the two reducing agents involved, as well as the relative strengths of the two oxidising agents involved, to explain your answer. (3)

[20]

QUESTION 11 (Start on a new page.)

The diagram below is a simplified version of a membrane cell, one of the electrolytic cells used in the chlor-alkali industry. The letters P and Q represent the two gases formed during this process.



11.1 Write down the letters P and Q in your answer book. Next to each, write down the half-reaction that shows how gas P and gas Q are respectively formed. (4)

11.2 Water ($H_2O(\ell)$) and sodium ions ($Na^+(aq)$) are both present in the cathode side of the membrane cell. Explain why hydrogen gas, and not sodium metal, is formed in the membrane cell. Refer to the relative strengths of oxidising agents to explain your answer. (2)

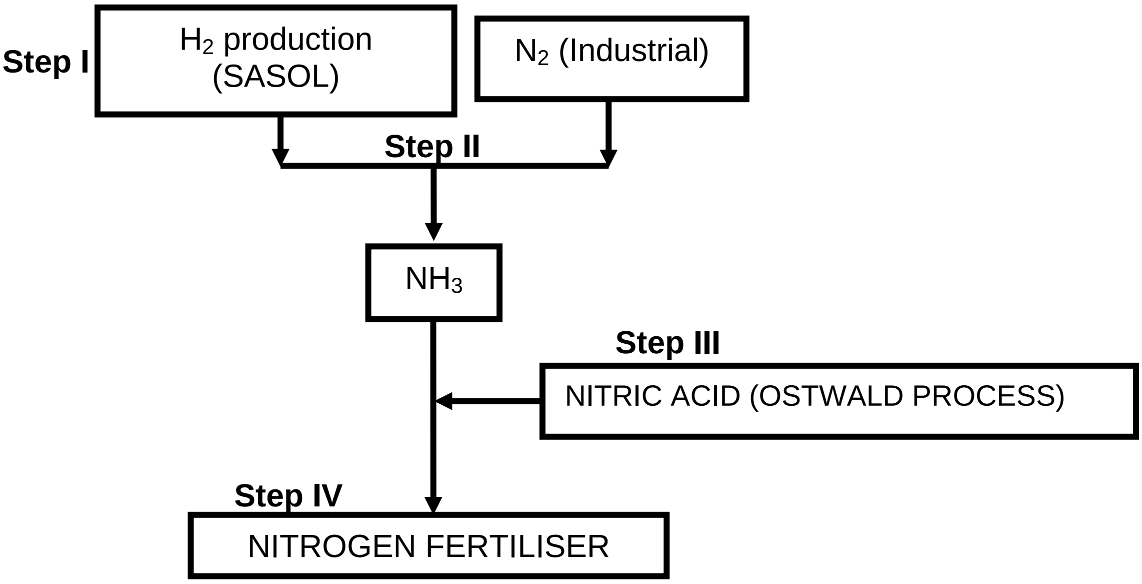
11.3 State ONE function of the membrane. (1)

11.4 State TWO uses of chlorine. (2)

[9]

QUESTION 12 (Start on a new page.)

A learner who is revising for a test on fertilisers, summarises her notes as follows:



12.1 Write down the NAME of the industrial process in **Step I** used to extract nitrogen gas from the atmosphere. (1)

12.2 The Haber process, indicated in **Step II**, is represented by the following equation:

$$3H_2(g) + N_2 \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0$$

In this process, high temperatures of approximately 450 °C are used.

Explain in terms of reaction rate, equilibrium and temperature why such a high temperature, and not a lower temperature, is used. (4)

12.3 Write a balanced chemical equation for the reaction that produces the nitrogen fertiliser in **Step IV.** (3)

12.4 The learner decides to educate the community about the possible negative effects of the overuse of nitrogen fertilisers on the environment.

Write down the main arguments that she will raise to convince the community to avoid excessive use of nitrogen fertilisers. (4)

12.5 The learner notes that fertiliser with an NPK ratio of 7:1:1 is needed for the growth of maize plants.

12.5.1 State what the term *NPK ratio* means. (2)

12.5.2 Will the fertiliser with this NPK ratio lead to a good crop yield? Explain the answer. (3)
[17]

TOTAL SECTION B: 125

GRAND TOTAL: 150

DATA FOR PHYSICAL SCIENCES
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE
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

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$c = \frac{n}{V}$
$c = \frac{m}{MV}$	$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$

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

KEY/*SLEUTEL*

Atomic number / ***Atoomgetal***: 29

Electronegativity / ***Elektronegatiwiteit***: 1,9

Symbol / ***Simbool***: Cu

Approximate relative atomic mass / ***Benaderde relatiewe atoommassa***: 63,5

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

Increasing oxidising ability/*Toenemende oksiderende vermoë*

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 reducing ability/*Toenemende reduserende vermoë*

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Increasing reducing ability/*Toenemende reduserende 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