Education

KwaZulu-Natal Department of Education

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES P2 (CHEMISTRY)

PREPARATORY EXAMINATION

SEPTEMBER 2018

MARKS : 150

TIME : 3 Hours

This question paper consists of 22 pages including data sheets.

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INSTRUCTIONS AND INFORMATION TO CANDIDATES

1. Write your name and other information in the appropriate spaces on the ANSWER BOOK.
2. The 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 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 where applicable.
11. Give brief motivations, discussions, et cetera where required.
12. Write neatly and legibly.

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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 number (1.1-1.10) in The ANSWER BOOK, for example 1.11 D.

1.1 Which ONE of the following equations represents the **incomplete** combustion of pentane?

A $2\ CH_3CH_2CH_2CH_2CH_3 + 11\ O_2 \rightarrow 10\ CO_2 + 12\ H_2O$

B $2\ CH_3CH_2CH_2CH_2CH_3 + 11\ O_2 \rightarrow 10\ CO + 12\ H_2O$

C $CH_3CH_2CH_2CH_2CH_3 + 8\ O_2 \rightarrow 5\ CO_2 + 6\ H_2O$

D $CH_3CH_2CH_2CH_2CH_3 + 8\ O_2 \rightarrow 5\ CO + 6\ H_2O$ (2)

1.2 A polymer formed as a result of addition polymerisation is most likely to be derived from a monomer that is …

A An ester.
B An alcohol.
C A hydrocarbon.
D A carboxylic acid. (2)

1.3 The IUPAC name of an organic compound with the molecular formula $C_5H_{10}O$ can be:

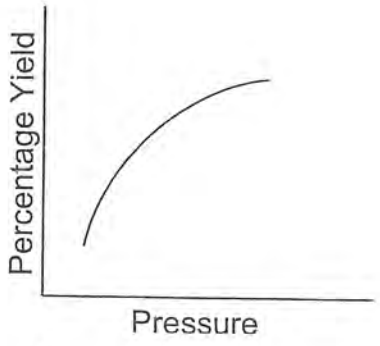
A pentan-1-ol
B pentanoic acid
C 3-methylbutanal
D 3-methylbutan-1-one (2)

1.4 The following reaction reaches equilibrium in a sealed container.

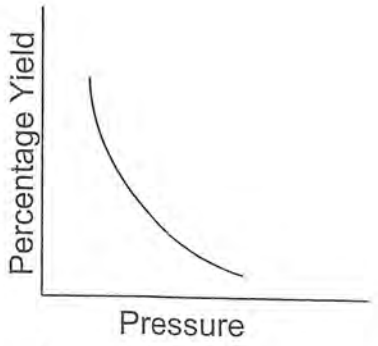
$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$$

Which ONE of the following graphs correctly illustrates the relationship between percentage yield of $SO_3(g)$ and pressure for the above reaction, at constant temperature.

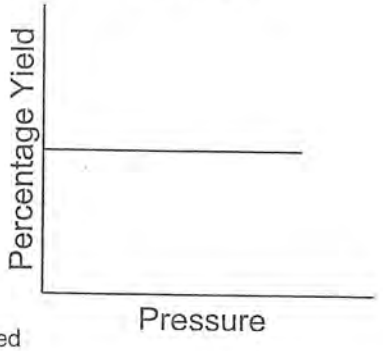
A



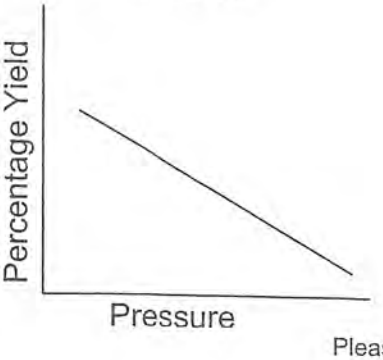
B



C



D



(2)

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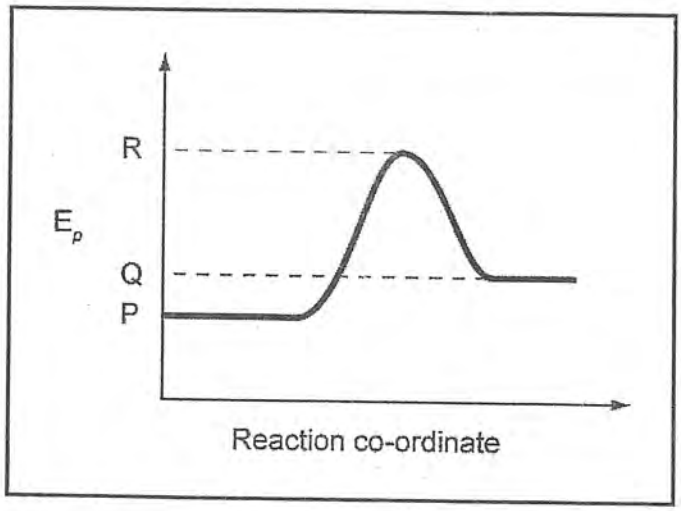
1.5 The graph below represents the change in potential energy against time for the following reaction:

$$A_2(g) + 2B_2(g) \rightleftharpoons 2AB_2(g)$$



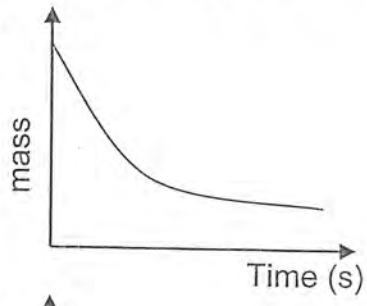
Which ONE of the following statements is correct?

A The forward reaction is exothermic.
B The heat of reaction for the forward reaction is Q – P.
C The activation energy for the forward reaction is R – Q.
D The activation energy for the reverse reaction is R – P. (2)

1.6 A mixture of sulphur dioxide and oxygen gases, together with a suitable catalyst, are placed in an evacuated, sealed container.
The following reaction takes place in the container at constant temperature:

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

The mass of the catalyst is measured over time.
Which ONE of the following graphs correctly illustrates the relationship between the mass of the catalyst and time?

A


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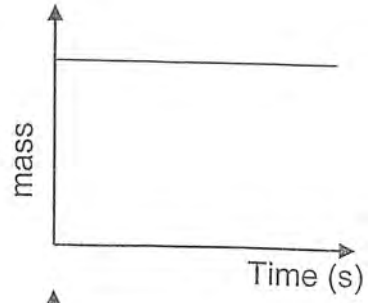

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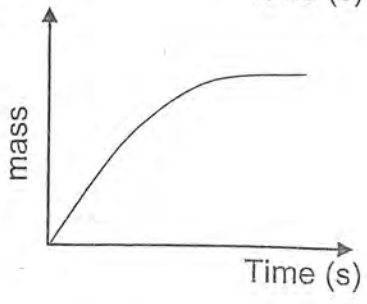

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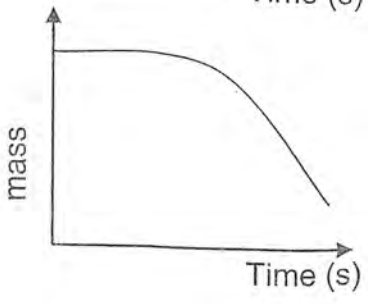

(2)

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1.7 The balanced equation below represents the first step in the ionization of sulphuric acid in water:

$$H_2SO_4(\ell) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + HSO_4^-(aq)$$

The TWO Bronsted bases in the equation above are:

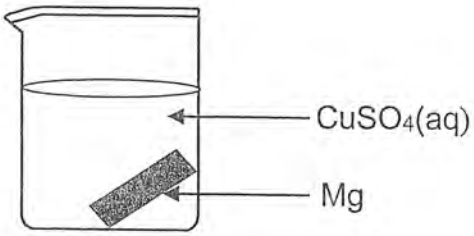
A H_2SO_4 and H_2O

B H_3O^+ and HSO_4^-

C H_2SO_4 and H_3O^+

D H_2O and HSO_4^- (2)

1.8 A piece of magnesium ribbon is placed in a beaker containing a blue solution of copper(II)sulphate.



After a while, it is observed that the solution becomes colourless. The reason that the solution becomes colourless is:

A The Cu^{2+} is a stronger oxidising agent than Mg^{2+} and is reduced to Cu.
B The Mg^{2+} is a stronger oxidising agent than Cu^{2+} and is reduced to Mg.
C Mg is a weaker reducing agent than Cu and will reduce Cu^{2+} to Cu.
D Cu is a stronger reducing agent than Mg and will oxidise Mg to Mg^{2+}. (2)

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

A Aluminium oxide is dissolved in molten cryolite.
B The ore of aluminium oxide is called cryolite.
C When the cell is in operation, aluminium forms at the anode.
D When the cell is in operation, carbon dioxide gas forms at the cathode. (2)

1.10 Which ONE of the following is a primary nutrient for plants?

A Carbon
B Oxygen
C Potassium
D Magnesium

(2)
[20]

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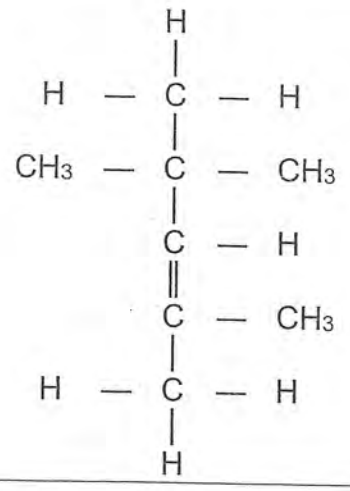
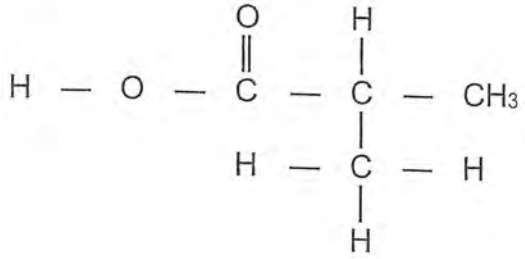
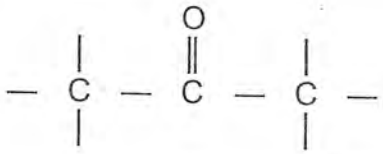
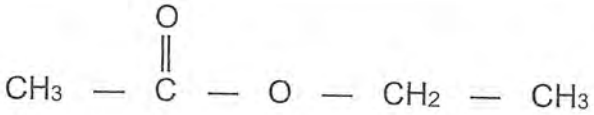
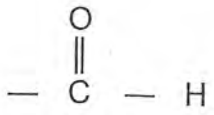
QUESTION 2 (Start on a new page.)

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

A		**B**	
C		**D**	$CH_3CH_2CH(CH_3)CH_2CH(CH_3)CH_3$
E		**F**	
G	Ethene		

2.1 Write down the LETTER that represents EACH of the following:

2.1.1 A functional isomer of butanoic acid. (1)

2.1.2 The compound that has a carboxyl group. (1)

2.1.3 A saturated hydrocarbon. (1)

2.1.4 The structural formula of the functional group of an aldehyde. (1)

2.1.5 The smallest organic molecule that can be covalently bonded to each other in a repeating pattern. (1)

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2.2 For compound A, write down the:

2.2.1 IUPAC name. (2)

2.2.2 General formula of the homologous series to which it belongs. (1)

2.3 Consider compound E:

2.3.1 Write down the IUPAC name of the alcohol required to prepare compound E. (1)

2.3.2 The name of the catalyst that is used in the reaction that produces Compound E. (1)
[10]

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QUESTION 3 (Start on a new page.)

The boiling points of organic compounds from 3 different homologous series are given in the table below:

COMPOUND	BOILING POINT
A	78,40 °C
B	-89,00 °C
C	118,50 °C

3.1 Define each of the following terms:

3.1.1 homologous series. (2)

3.1.2 boiling point. (2)

3.2 Which compound A, B or C will have the lowest vapour pressure? Explain the answer. (3)

3.3 Which compound A, B or C is a gas at room temperature? (1)

3.4 The homologous series to which the three compounds A, B and C belong, were identified in random order as : ***ETHANOIC ACID, ETHANOL AND ETHANE.***

3.4.1 What is the boiling point of ethanoic acid? (1)

3.4.2 Explain the answer to question 3.4.1 by referring to the type of intermolecular forces and the energy involved in the compound from each homologous series. (4)

[13]

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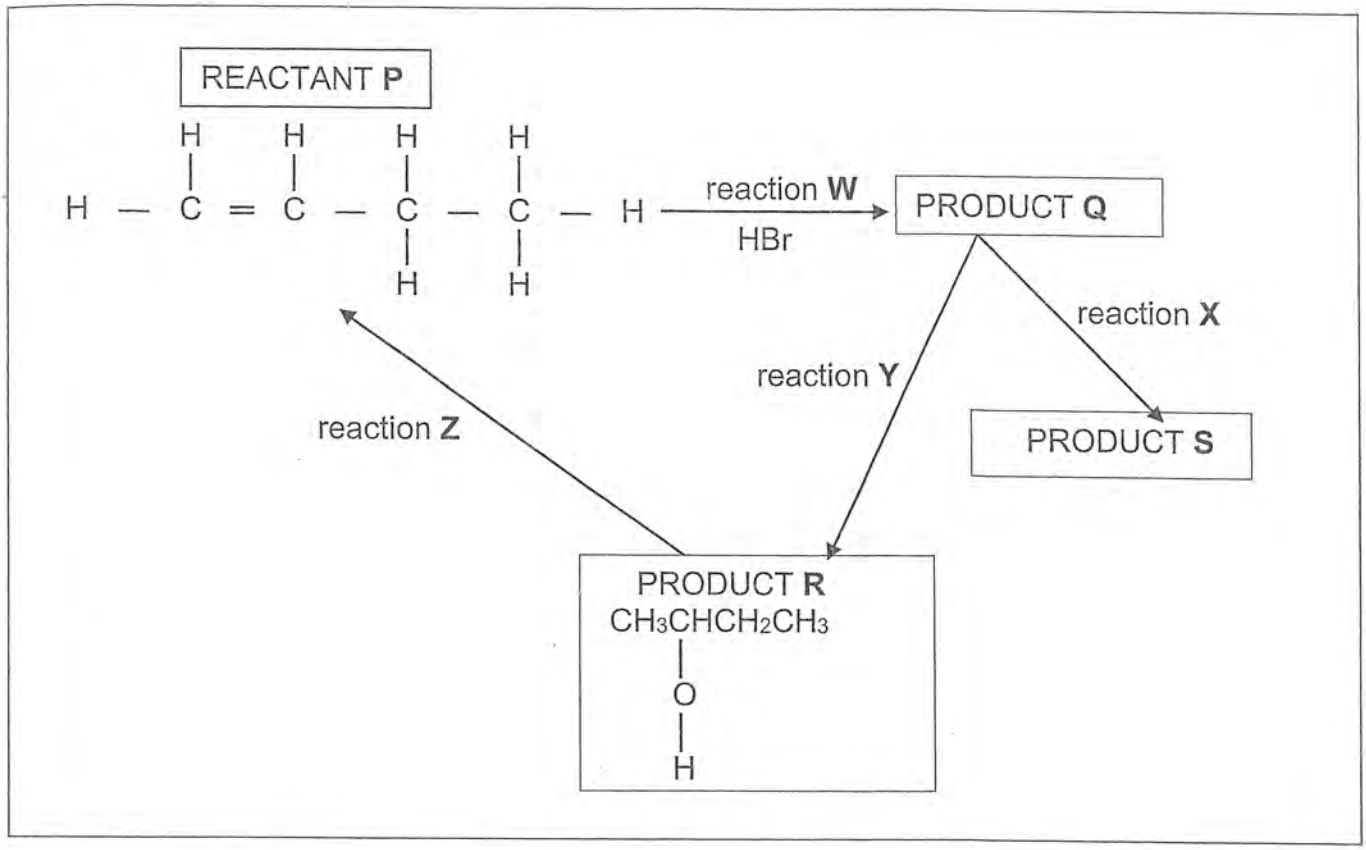
QUESTION 4 (Start on a new page.)

In the flow diagram below, **W**, **X**, **Y** and **Z** represent organic reactions. **Q**, **S** and **R** represents organic compounds. **Q** is the major product.



4.1 Name the type of reaction that is represented by . . .

4.1.1. **W**. (1)

4.1.2 **Y**. (1)

4.2 Write down the structural formula and IUPAC name for the product **Q**. (3)

4.3 Is product R a primary, secondary or tertiary alcohol? Give a reason for the answer. (3)

4.4 Name the type of elimination reaction represented by **Z**. (1)

4.5 State TWO reaction conditions that must be satisfied for reaction **Y** to take place. (2)

4.6 Product **S** is a positional isomer of reactant **P**.

4.6.1 Define the term positional isomer. (2)

4.6.2 Classify reaction **X** as, substitution, addition or elimination. (1)

4.6.3 Use structural formulae to write a balanced equation for the formation of product S from product **Q**. (3)

[17]

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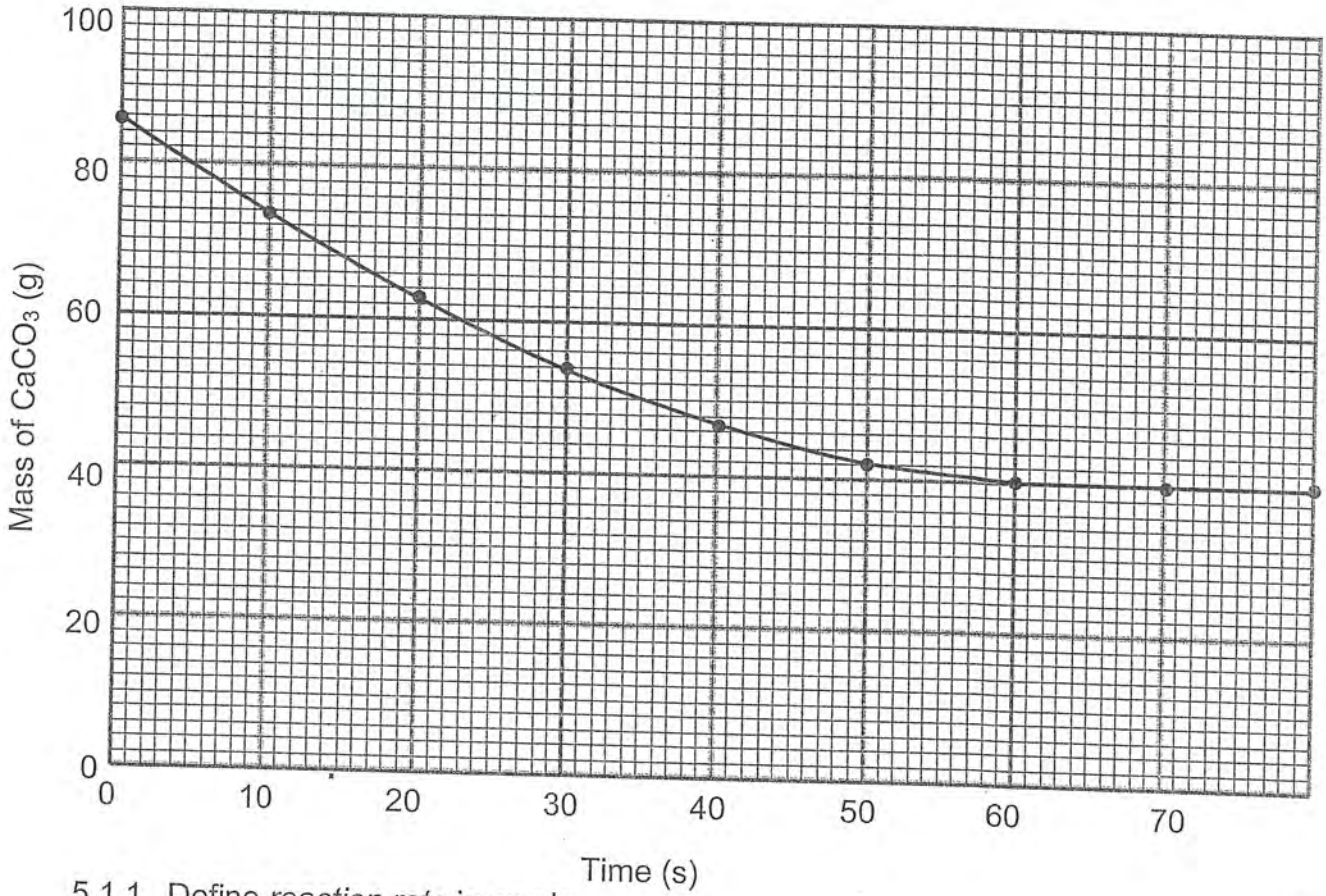
QUESTION 5 (Start on a new page)

5.1 The graph drawn below shows how the mass of powdered calcium carbonate changes with time when the powdered calcium carbonate reacts with a specific volume of hydrochloric acid of known concentration at conditions of standard temperature and pressure.
The balanced equation for the reaction that takes place is given below:

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



5.1.1 Define *reaction rate* in words. (2)

5.1.2 After how many seconds does the reaction between calcium carbonate and hydrochloric acid stop? (1)

5.1.3 Calculate the volume of hydrochloric acid that was required at conditions of standard temperature and pressure for the above reaction to reach completion. (5)

The above reaction is repeated under the same conditions but the powdered calcium carbonate is replaced by the same initial mass of lumps of calcium carbonate.

5.1.4 Write down the mass in grams of calcium carbonate at the end of the reaction. (1)

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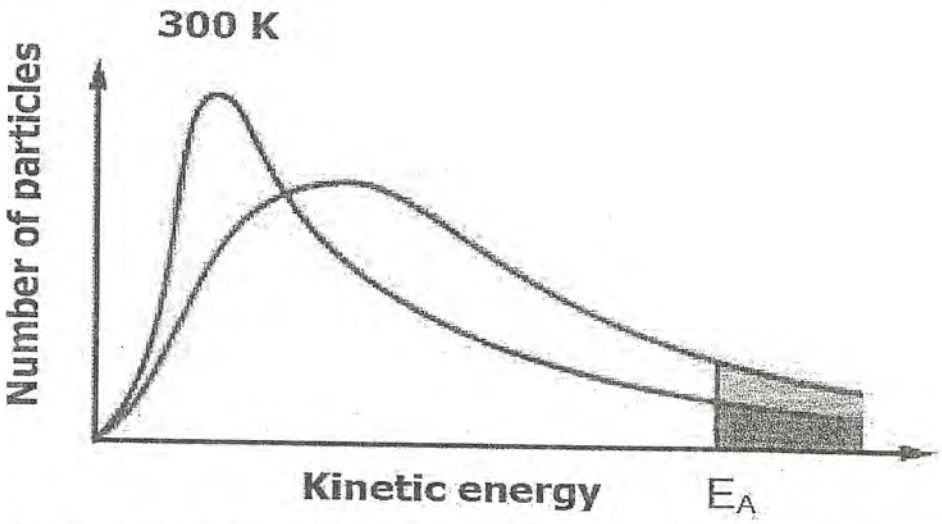
5.1.5 How will the time for the reaction to reach completion be affected? (Write down only, INCREASES, DECREASES or REMAINS THE SAME) (1)

5.1.6 Use the attached copy of the above graph and on the same set of axes sketch a graph to show how the rate of the reverse reaction changes with time for the same reaction. Label this graph lumps. (3)

5.2 The figure below shows the Maxwell-Boltzmann distribution curves for the above reaction at two different temperatures. The activation energy for this reaction is indicated on the graph by the vertical line and labelled as EA.



5.2.1 Write down the name of the theory used to explain how reactions occur at the molecular level. (1)

5.2.2 Referring to the shaded areas in the distribution curves provided, use the theory named in QUESTION 5.2.1 to explain why an increase in temperature causes an increase in reaction rate. (3)
[17]

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QUESTION 6 (Start on a new page)

A mixture of 2 moles of hydrogen and 2 moles of iodine is sealed in a 4 dm^3 flask at 180 °C. The reaction reaches equilibrium according to the balanced equation below:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The information in the table below also applies to the reaction above.

T °C	Kc
180	49
450	48

6.1 State Le Chatelier's Principle. (2)

6.2 What effect will the following changes have on the concentration of HI(g) at equilibrium?

Choose from INCREASES,DECREASES or REMAINS THE SAME

6.2.1 The pressure on the system is increased without changing the volume. (1)

6.2.2 More $H_2(g)$ is added to the system, without a change in pressure. (1)

6.2.3 A catalyst is added. (1)

6.2.4 The temperature is decreased. (1)

6.3 Explain the answer to question 6.2.4, by referring to Le Chatlier's Principle. (3)

6.4 Calculate the mass of HI present in the container when equilibrium is reached at 180 °C. (10)

[19]

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QUESTION 7 (Start on a new page.)

A learner prepares a standard solution of barium hydroxide at 25 °C. She completely dissolves an unknown mass of pure barium hydroxide in enough distilled water to make a solution of volume 250 cm^3. The prepared solution of barium hydroxide has a pH of 13,45.

7.1 Give a reason why barium hydroxide is regarded as a STRONG base. (1)

The barium hydroxide solution prepared by the learner is dilute.

7.2 Explain what is meant by the above statement. (2)

Barium hydroxide dissociates as follows:

$$Ba(OH)_2\,(aq) \rightleftharpoons Ba^{2+}\,(aq) + 2\,OH^-\,(aq)$$

7.3 Calculate the mass of the barium hydroxide that was completely dissolved to make the above solution. (7)

7.4 Calculate the volume of a 0,5 $mol.dm^{-3}$ hydrochloric acid solution, needed to completely neutralize 60 cm^3 of the barium hydroxide solution prepared by the learner. The balanced equation below represents the reaction that takes place.

$$2HC\ell\,(aq) + Ba(OH)_2\,(aq) \rightleftharpoons BaC\ell_2\,(aq) + 2H_2O(aq)$$ (4)

[14]

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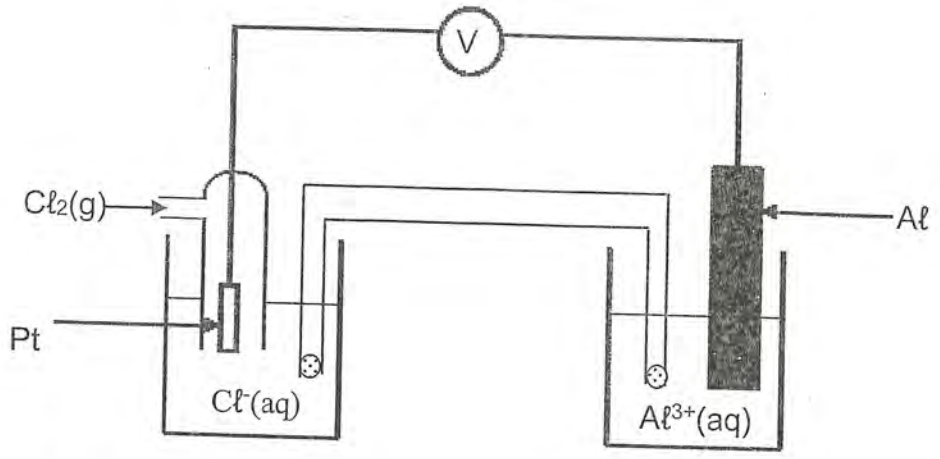
QUESTION 8 (Start on a new page.)

The electrochemical cell shown below consists of a chlorine half cell and an aluminium half cell at standard conditions.



8.1 Does the above electrochemical cell represent and ELECTROLYTIC or GALVANIC cell? Give a reason for the answer. (2)

8.2 Write down three standard conditions needed for the above cell to function. (3)

8.3 Write down the name of the oxidising agent in the above cell. (2)

8.4 Calculate the initial emf of the above cell under standard conditions. (4)

8.5 Write down the balanced NET (overall) cell reaction that takes place in this cell. No spectator ions are required. (3)

8.6 How will the initial voltmeter reading change if the:
(Write down only INCREASES, DECREASES or REMAINS THE SAME)

8.6.1 Size of the platinum electrode is increased. (1)

8.6.2 Initial concentration of the electrolyte in the CATHODE HALF-CELL is increased. (1)

[16]

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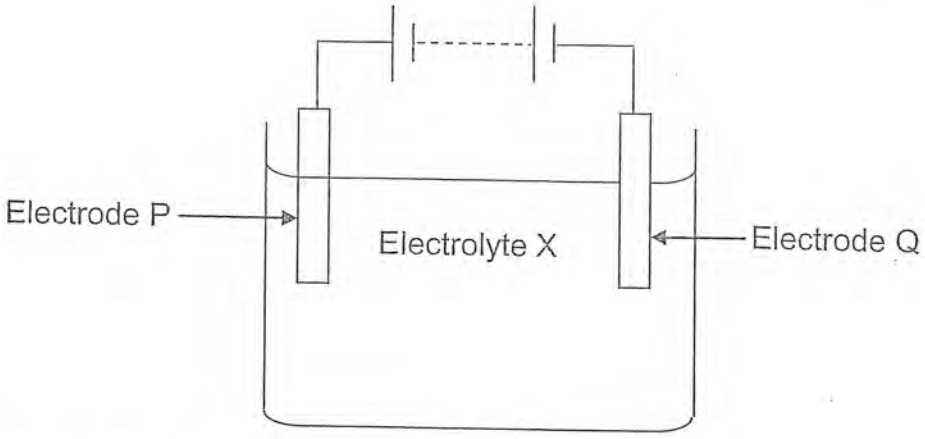
QUESTION 9 (Start on a new page.)

The simplified diagram below shows an electrochemical cell used in refining copper.



9.1 Define an *electrolyte*. (1)

9.2 Write down the formula of the cation in the electrolyte X in the above electrochemical cell. (1)

9.3 When an electric current passes through the electrolyte the masses of the electrodes change.

9.3.1 Does the mass of electrode P increase or decrease? (1)

9.3.2 Write down the relevant half reaction to support the answer to question 9.3.1 (2)

9.4 During the process illustrated by the above cell, a total of $2,259 \times 10^{24}$ cations are reduced.
Calculate the mass by which the cathode should change. (4)
[9]

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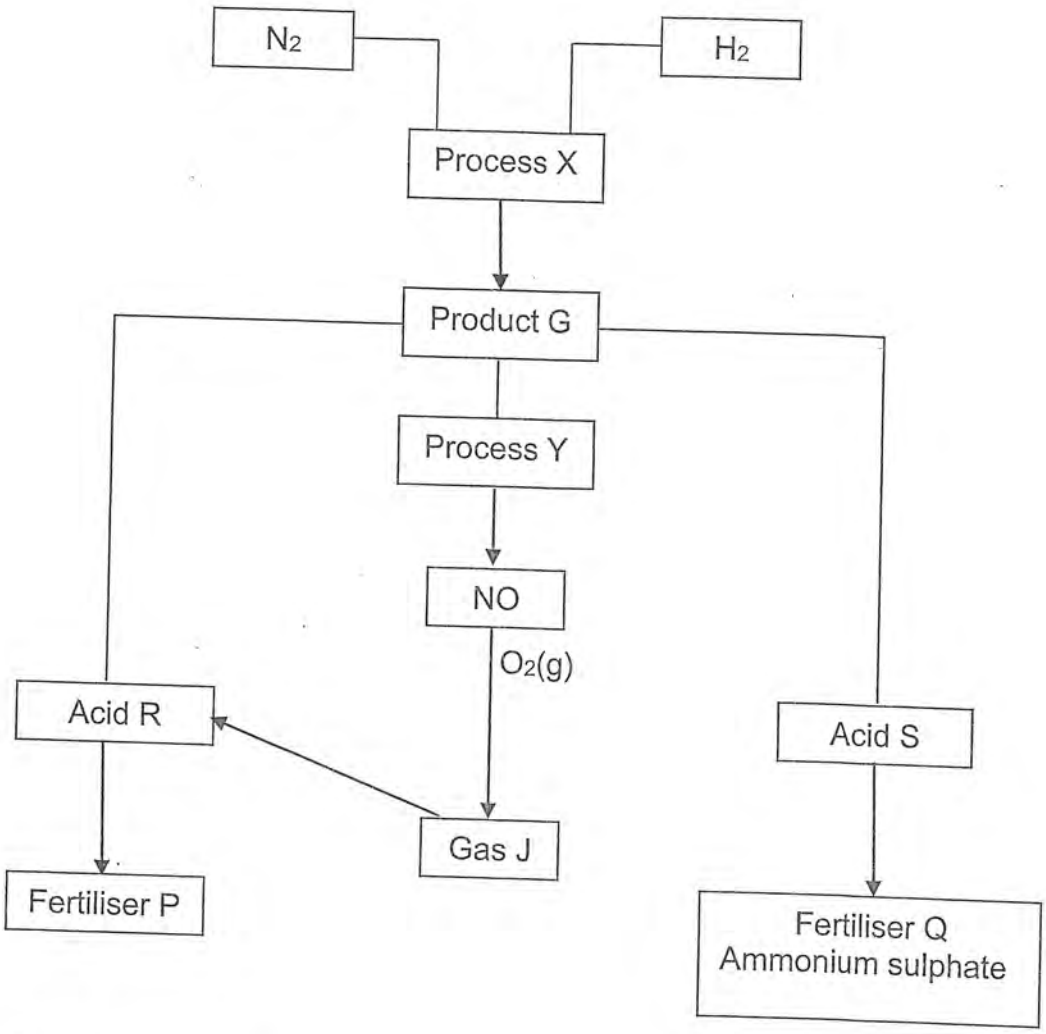
QUESTION 10 (Start on a new page.)

The different processes used in the preparation of fertilisers P and Q are represented in the flow diagram below:



10.1 Write down the name of:

10.1.1 Process X. (1)

10.1.2 Process Y. (1)

10.1.3 Gas J. (1)

10.1.4 Fertiliser P. (1)

10.2 Product G reacts with acid S to form fertiliser Q. Write down:

10.2.1 The name or formula of acid S. (1)

10.2.2 A balanced equation for the preparation of ammonium sulphate as shown the flow diagram above. (3)

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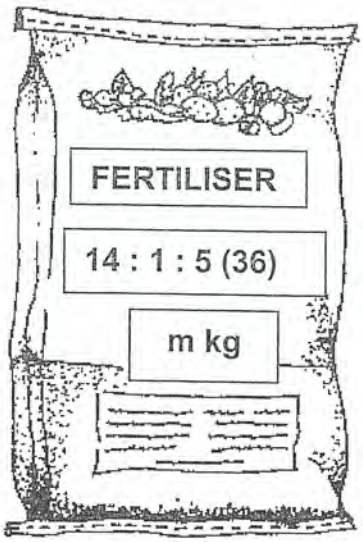
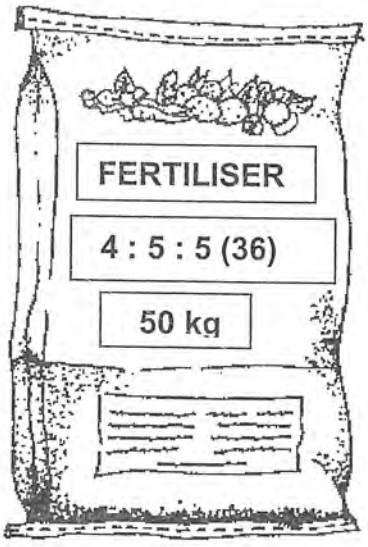
10.3 A bag of a certain brand of fertiliser, is labelled as shown in the diagram below:

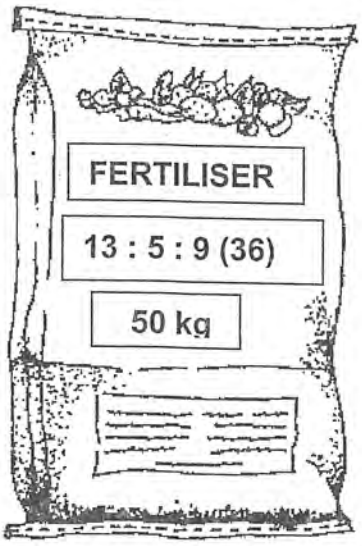


The total mass of nitrogen in the bag of fertiliser shown above is 12,60 kg. Calculate the value **m**, in kilograms indicated on the bag. (4)

10.4 A farm wants to improve the quality of fruit produced on his farm. He has available TWO bags of fertiliser as shown below:



FERTILISER A



FERTILISER B

Explain with reasons whether the farmer should apply fertiliser A or fertiliser B to improve the quality of fruit produced on his farm. (3)

[15]

TOTAL MARKS: 150

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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* $E^\theta_{cell} = E^\theta_{oxidising\ agent} - E^\theta_{reducing\ agent}$ / $E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	

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TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/SLEUTEL

Electronegativity / *Elektronegatiwiteit*

Atomic number / *Atoomgetal*

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)
																	2 He 4
2,1 1 H 1																	
1,0 3 Li 7	1,5 4 Be 9																
0,9 11 Na 23	1,2 12 Mg 24																
0,8 19 K 39	1,0 20 Ca 40	1,3 21 Sc 45	1,5 22 Ti 48	1,6 23 V 51	1,6 24 Cr 52	1,5 25 Mn 55	1,8 26 Fe 56	1,8 27 Co 59	1,8 28 Ni 59	1,9 29 Cu 63,5	1,6 30 Zn 65	1,5 31 Ga 70	1,8 32 Ge 73	2,0 33 As 75	2,4 34 Se 79	2,8 35 Br 80	3,0 36 Kr 84
0,8 37 Rb 86	1,0 38 Sr 88	1,2 39 Y 89	1,4 40 Zr 91	1,8 41 Nb 92	1,8 42 Mo 96	1,9 43 Tc 101	2,2 44 Ru 101	2,2 45 Rh 103	2,2 46 Pd 106	1,9 47 Ag 108	1,7 48 Cd 112	1,7 49 In 115	1,8 50 Sn 119	1,9 51 Sb 122	2,1 52 Te 128	2,5 53 I 127	2,5 54 Xe 131
0,7 55 Cs 133	0,9 56 Ba 137	1,6 57 La 139	1,6 72 Hf 179	1,6 73 Ta 181	1,8 74 W 184	1,9 75 Re 186	2,2 76 Os 190	2,2 77 Ir 192	2,2 78 Pt 195	1,9 79 Au 197	1,7 80 Hg 201	1,8 81 Tℓ 204	1,8 82 Pb 207	1,9 83 Bi 209	2,0 84 Po	2,5 85 At	86 Rn
0,7 87 Fr	0,9 88 Ra 226	89 Ac															

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce 140	Pr 141	Nd 144	Pm	Sm 150	Eu 152	Gd 157	Tb 159	Dy 163	Ho 165	Er 167	Tm 169	Yb 173	Lu 175
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th 232	Pa	U 238	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

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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
$2H^+ + 2e^- \rightleftharpoons H_2(g)$	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

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Half-reactions/*Halfreaksies*			$E^{\ominus}$ (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
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	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

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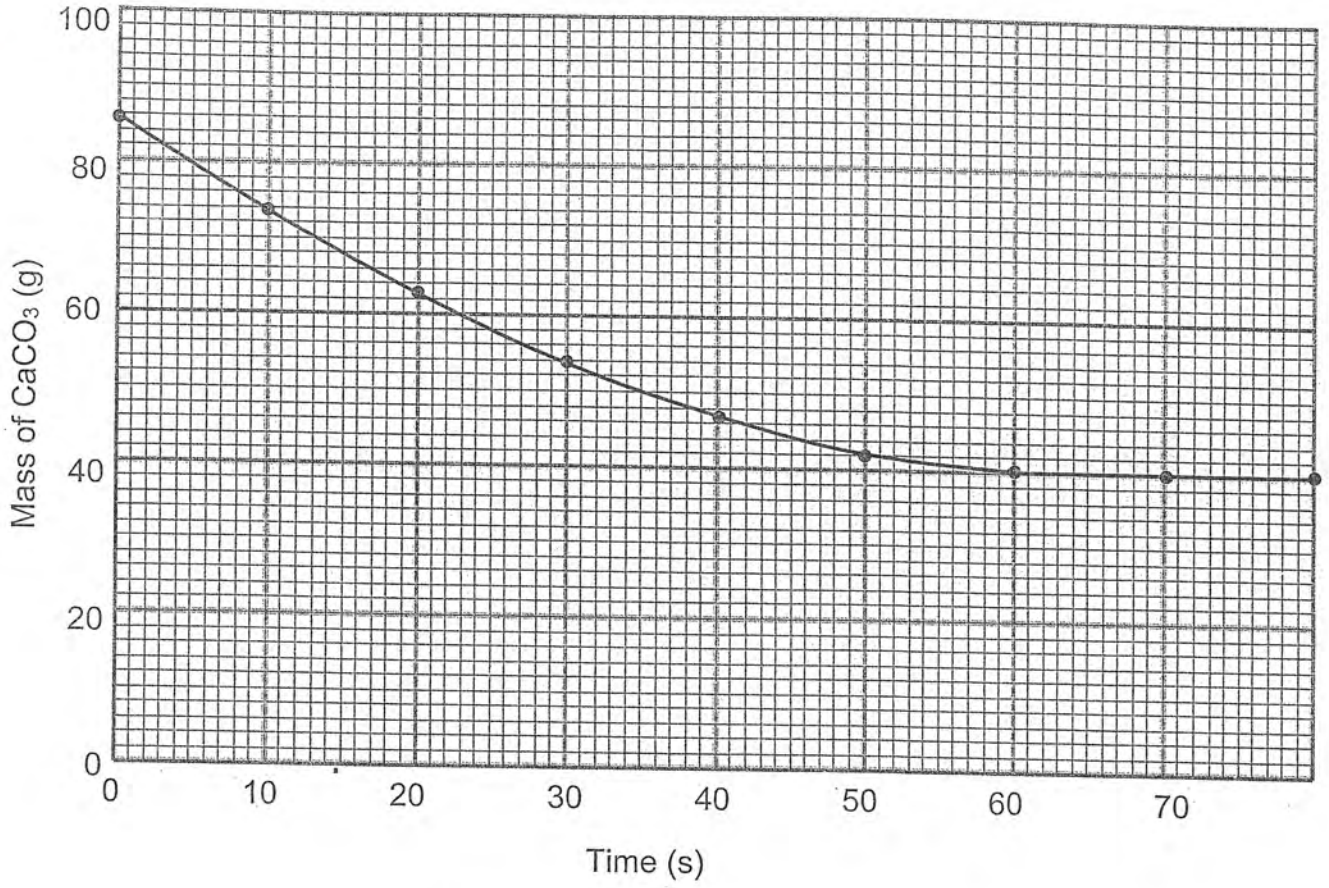
QUESTION 5.1.6



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