



HILLCREST HIGH SCHOOL PHYSICAL SCIENCE P2

JUNE 2025

Grade 11

MARKS: 150

EXAMINER: Ms N. Badenhorst

TIME: 3 Hours

MODERATOR: Mrs J. Knox-Whitehead

Instructions

1. Answer ALL the questions.
2. This question paper consists of TWO sections:
3. SECTION A (20)
SECTION B (130)

Answer SECTIONS A and B in the ANSWER BOOK.
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.
9. Numbers must be rounded off to **two decimal** places.

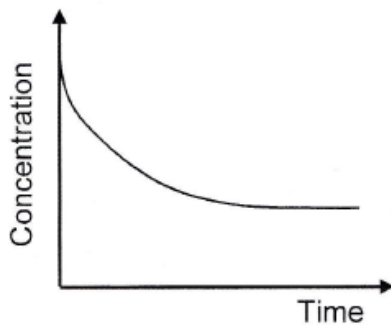
SECTION A**QUESTION 1: MULTIPLE CHOICE QUESTIONS**

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A – D) next to the question number (1.1 – 1.10) in the ANSWER BOOK.

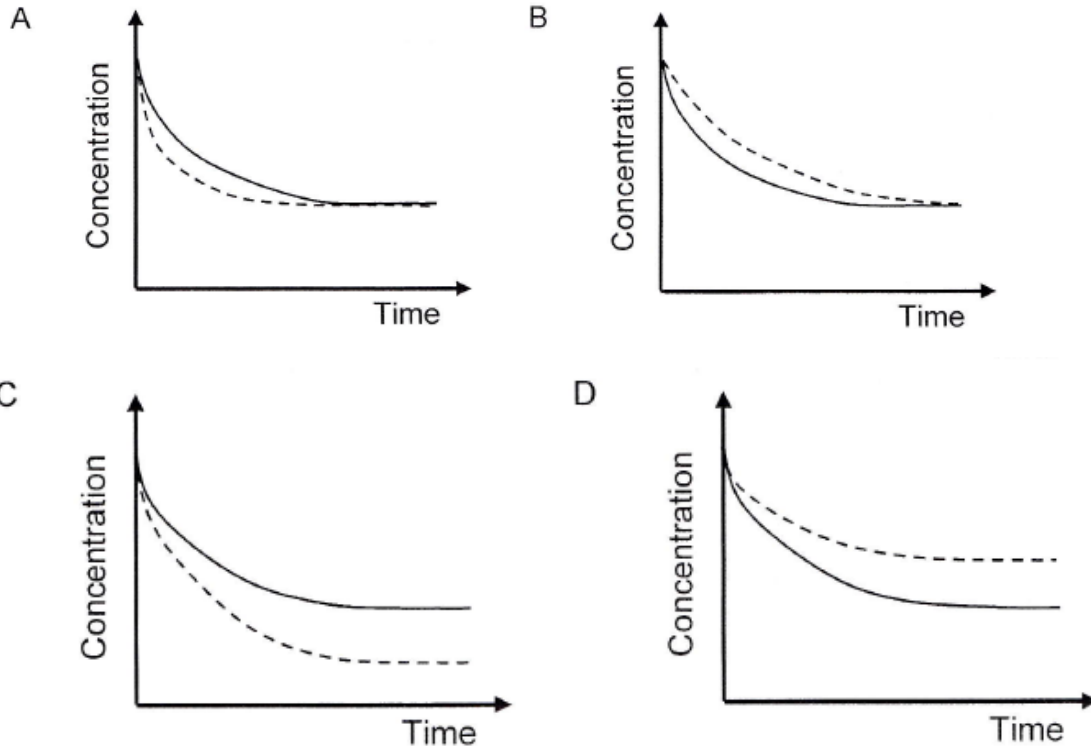
1.1 The number of ions present in 3 moles of MgCl_2 is ...

- A $3 \times 6,02 \times 10^{23}$
- B $6 \times 6,02 \times 10^{23}$
- C $9 \times 6,02 \times 10^{23}$
- D $12 \times 6,02 \times 10^{23}$

1.2 The graph below represents the change in concentration of a reactant against time for a chemical reaction.

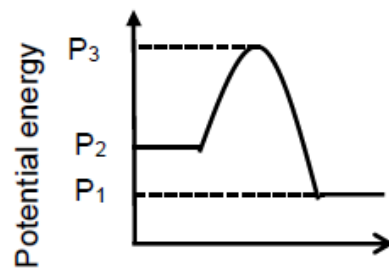


In which ONE of the following graphs does the dotted line show the effect of a catalyst on this reactant?



1.3 When sulphuric acid reacts with water, the temperature of the reaction mixture increases.

Which ONE of the following correctly describes the heat of the reaction (ΔH) between sulphuric acid and water from the graph below?



- A $P_3 - P_2$
- B $P_1 - P_2$
- C $P_3 - P_1$
- D $P_2 - P_1$

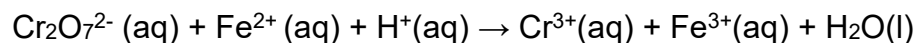
- 1.4 Which ONE of the following pairs represents the conjugate acid and conjugate base of HPO_4^{2-} ?

	CONJUGATE ACID	CONJUGATE BASE
A	PO_4^{3-}	H_2PO_4^-
B	H_2PO_4^-	PO_4^{3-}
C	H_2PO_4^-	H_3PO_4
D	$\text{H}_2\text{PO}_4^{2-}$	PO_4^{2-}

- 1.5 The oxidation number of sulphur (S) in HSO_4^- ...

- A -2
- B +6
- C +1
- D +4

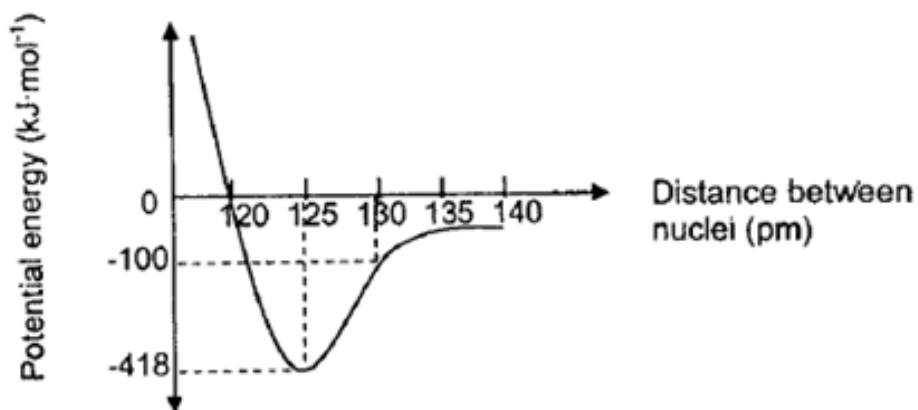
- 1.6 Consider the following redox reaction:



The product of the reduction half reaction in the equation is...

- A Fe^{3+}
- B Cr^{3+}
- C H_2O
- D H^+

1.7



The bond energy and bond length are:

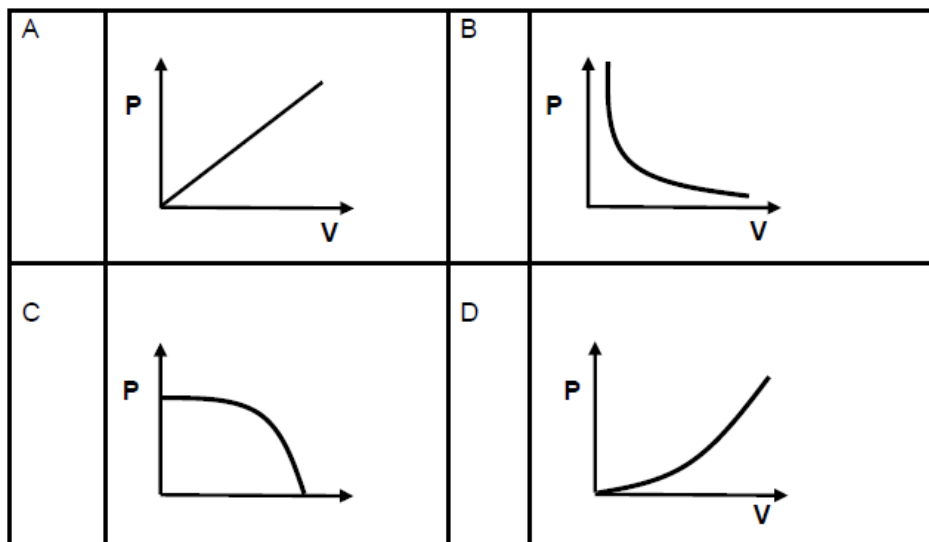
	Bond energy (kJ·mol ⁻¹)	Bond length (pm)
A	0	120
B	-100	130
C	-418	125
D	-50	140

1.8 Substance **P** is soluble in substance **R**.

Which ONE of the following most likely represents **P** and **R**?

	P	R
A	HCl	CCl ₄
B	HCl	H ₂ O
C	NaCl	CCl ₄
D	I ₂	H ₂ O

- 1.9 The relationship between pressure and volume for a fixed amount of gas at constant temperature is BEST described by...



- 1.10 A fixed amount of gas exerts a pressure of 50 Pa. If the volume of the container decreases by 20%, what will the new pressure be?

- A 40 Pa
 B 62,5 Pa
 C 60 Pa
 D 50 Pa

[2 x 10 = 20]

SECTION B

Question 2

- 2.1 Methyl propanoate is an organic compound with the following percentage composition:

54,55% C: 9,09% H: 36,36% O

The molar mass of the compound is $88 \text{ g}\cdot\text{mol}^{-1}$.

- 2.1.1 Define the term empirical formula. (2)
 2.1.2 Determine, by calculation, the empirical formula. (5)
 2.1.3 Determine the molecular formula. (2)

2.2 Sodium azide (NaN_3) is used in car airbags. For the airbag to inflate the following reaction must take place:



Calculate the volume of nitrogen gas (N_2) that would be produced at STP if 55 g of sodium azide reacts completely. (5)

[14]

Question 3

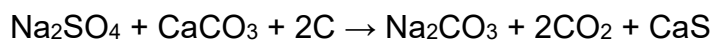
Na_2CO_3 is well known domestically for its everyday use as a water softener.

3.1 Define the term concentration. (2)

3.2 What mass of Na_2CO_3 is needed to prepare 500cm^3 of a $0,25 \text{ mol}\cdot\text{dm}^{-3}$ solution? (4)

3.3 The above solution is then diluted by adding 100 cm^3 of water to 40 cm^3 of the above solution. Calculate the new concentration of the solution. (3)

3.4 The Leblanc process includes the following reaction.



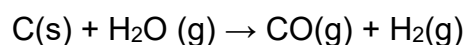
3.4.1 Define the term *limiting reactant*. (2)

3.4.2 In a closed container 52,54 g of Na_2SO_4 is allowed to react with 45 g of CaCO_3 in the presence of enough C. Determine the *limiting reactant*. (6)

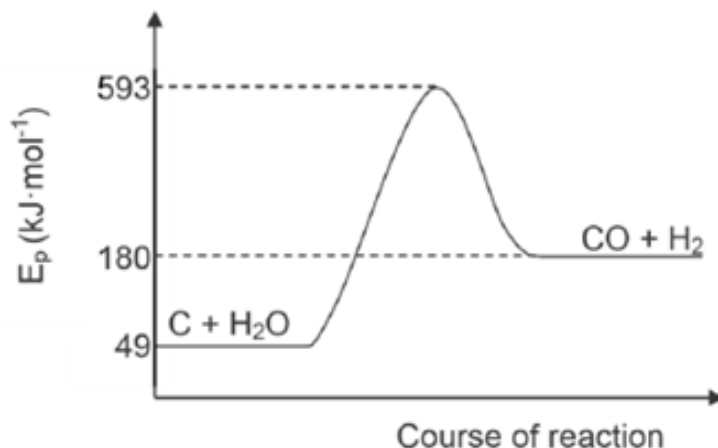
[17]

Question 4

The balanced equation for the reaction of carbon with steam is as follows:



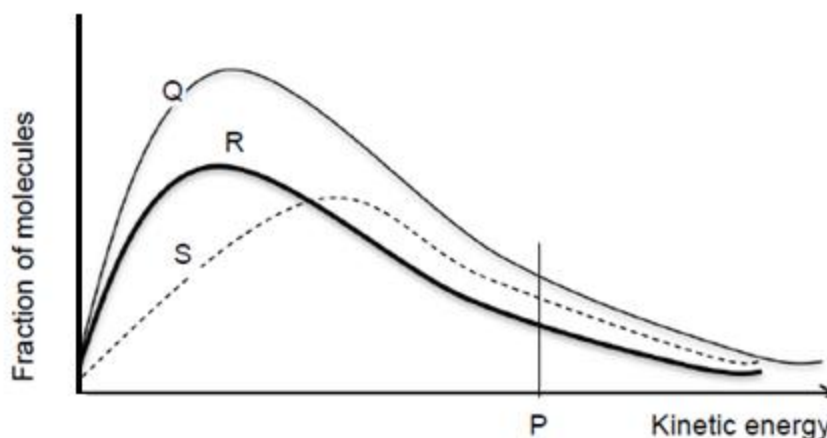
The graph below, NOT drawn to scale, represents the change in potential energy of the substances during the reaction.



- 4.1 Define the term heat of reaction. (2)
- 4.2 Is the reaction ENDOTHERMIC or EXOTHERMIC? Give a reason for the answer. (2)
- 4.3 Use the information on the graph and write down the value of the:
- 4.3.1 Activation energy. (2)
- 4.3.2 Heat of reaction. (2)
- 4.3.3 Heat of reaction for the reverse reaction. (1)

[9]**Question 5**

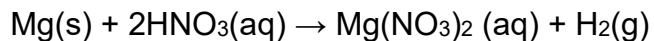
- 5.1 The collision theory can be used to explain how different factors affect the rate of a chemical reaction.
- 5.1.1 Name TWO conditions that determine whether a collision between two molecules will lead to a chemical reaction. (2)
- 5.1.2 In terms of the collision theory, explain why the rate of a chemical reaction increases with increasing temperature. (2)
- 5.2 Curve **R** represents the Maxwell-Boltzmann distribution curve for gas in a closed container at a certain temperature. Curve **Q** and **S** represents the curves of the same molecules at different conditions.



- 5.2.1 Write down the NAME of the energy represented by **P**. (1)
- 5.2.2 Write down the change in the condition(s) which results in:
- (a) Curve Q. (1)
- (b) Curve S. (1)

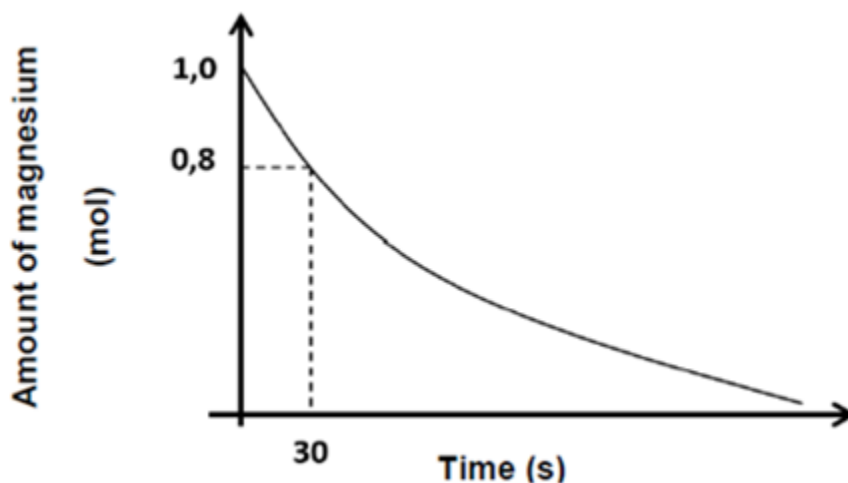
5.3 A teacher uses the reaction between magnesium ribbon, Mg(s) and nitric acid, HNO₃ (aq), to investigate ONE of the factors that influence reaction rate.

The balanced equation of the reaction between Mg(s) and HNO₃ (aq) is given below.



5.3.1 Write down an investigative question for this investigation. (2)

The results obtained when using DILUTED nitric acid are shown on the graph below.

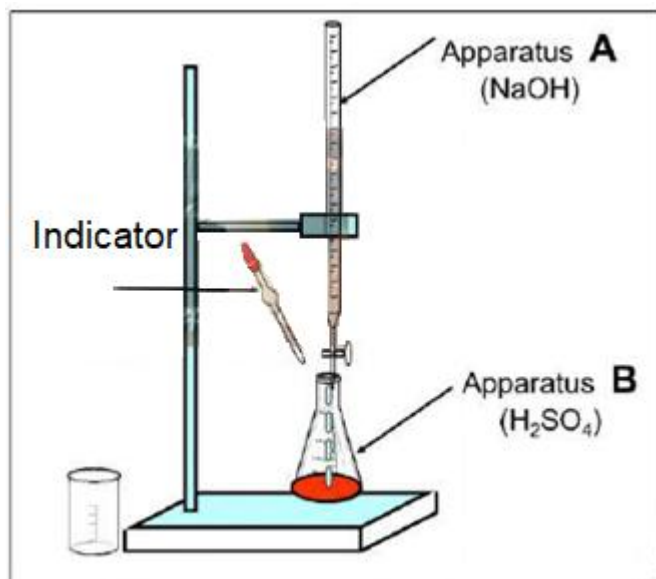


5.3.2 Calculate the average reaction rate (in grams per second) during the first 30 s. (5)

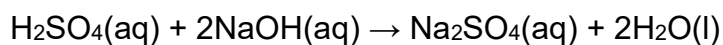
[14]

Question 6

6.1 The diagram below shows the titration of 25 ml of sulphuric acid of unknown concentration with $0,2 \text{ mol.dm}^{-3}$ sodium hydroxide.



The balanced equation for the reaction is:



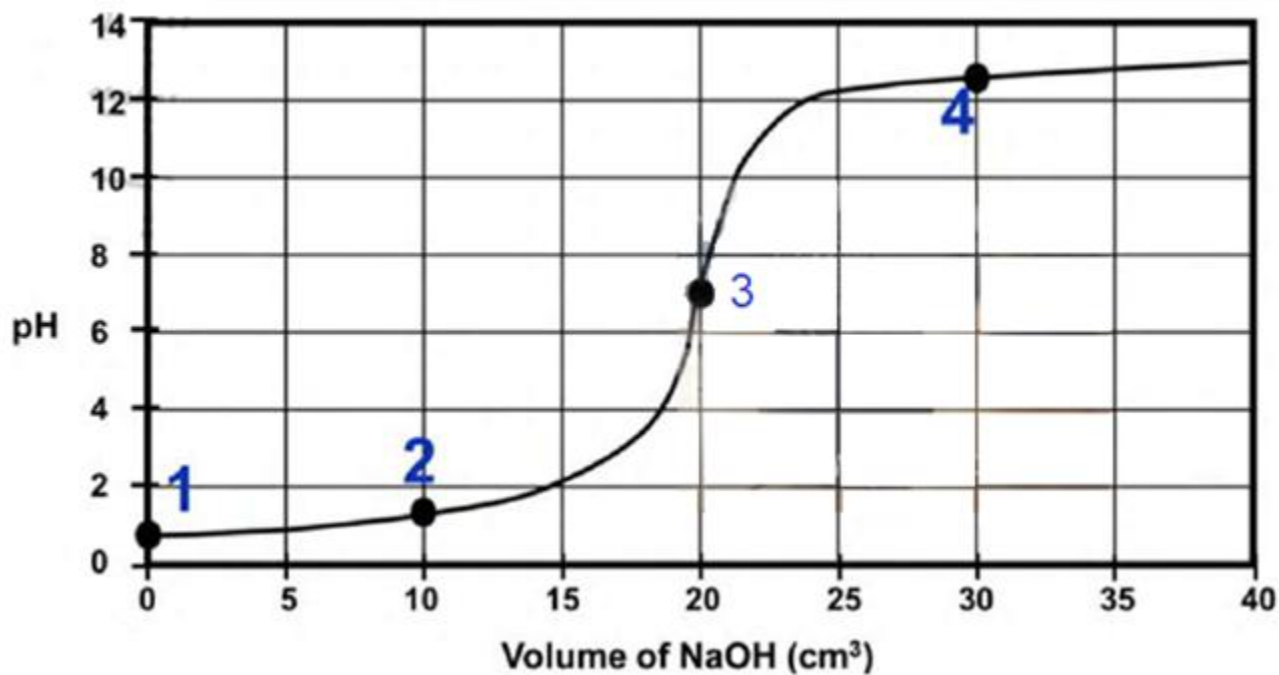
6.1.1 Identify apparatus **A**. (1)

6.1.2 Bromothymol blue was used as the indicator in the titration above.

Write down the colour change observed.

Choose between BLUE TO YELLOW or YELLOW TO BLUE. (1)

During this titration, the pH of the solution was measured as the volume of the base increased. The following graph was produced.



6.1.3 Give the name of the position labelled 3 on the graph

Choose from EQUIVALENCE POINT or END POINT.

(1)

Use the graph and the information provided earlier to calculate:

6.1.4 The original concentration of the sulphuric acid.

(5)

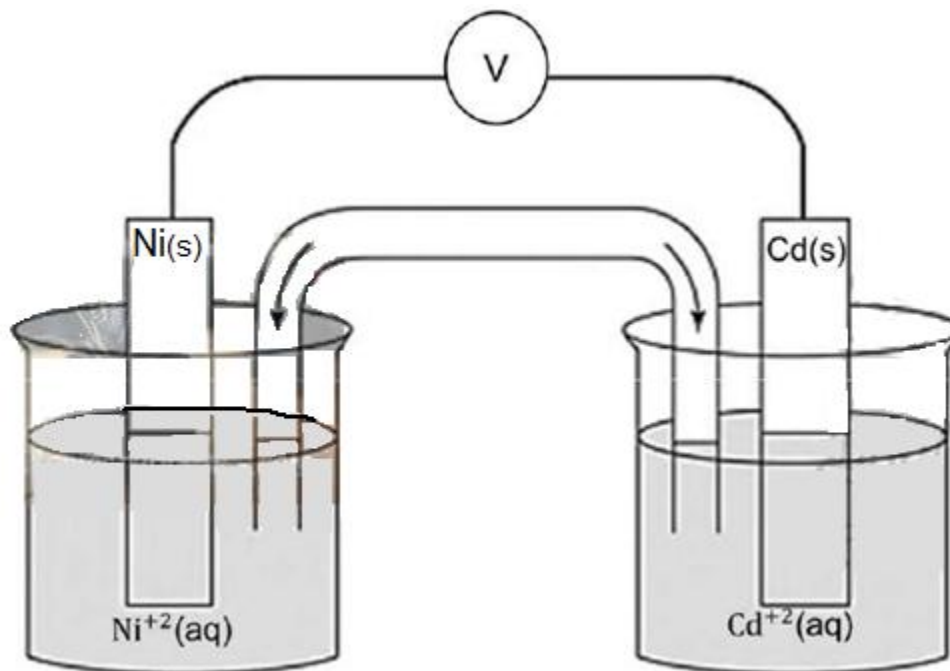
6.1.5 The pH of the solution at the point labelled 4 on the graph.

(7)

[15]

Question 7

7.1 A galvanic cell is constructed as shown in the diagram below.

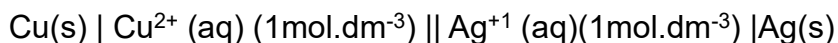


7.1.1 Which electrode is cathode? Write only NICKEL or CADMIUM. (1)

7.1.2 Write down the equation for the oxidation half-reaction of this cell. (2)

7.1.3 Calculate the emf of the cell. (4)

7.2 Consider the following standard electrochemical cell:



Initially each half cell contains 200 cm^3 electrolyte.

The cell is connected to a circuit and allowed to produce current until the concentration of the electrolyte in the cathode half-cell is reduced to $0,5 \text{ mol} \cdot \text{dm}^{-3}$.

The cell is then disconnected.

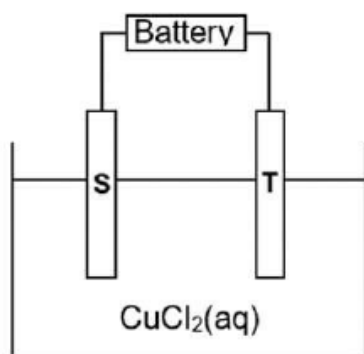
7.2.1 Write a balanced equation for the net ionic cell reaction. (3)

- 7.2.2 Calculate the concentration of the electrolyte in the anode half-cell when the cell is disconnected. (7)

[17]

Question 8

In the electrolytic cell below, two carbon rods are used as electrodes and a concentrated copper (II) chloride solution (CuCl_2) is used as an *electrolyte*.



When the cell is in operation, a gas is released at electrode S while electrode T is covered with a brown layer.

8.1 Write down a half reaction to explain the observation made at:

8.1.1 Electrode **S**. (2)

8.1.2 Electrode **T**. (2)

8.2 Which electrode, S or T, is the anode? Give a reason for the answer. (2)

8.3 A current of 2,5 A passes through the cell for 5 hours.

Calculate the:

8.3.1 Total charge that flows through the cell during this time. (2)

8.3.2 Increase in mass of the cathode. (5)

8.4 The carbon rods in the above cell are now replaced with COPPER RODS and the cell is allowed to operate for some time.

The following observations are made at electrode **S**:

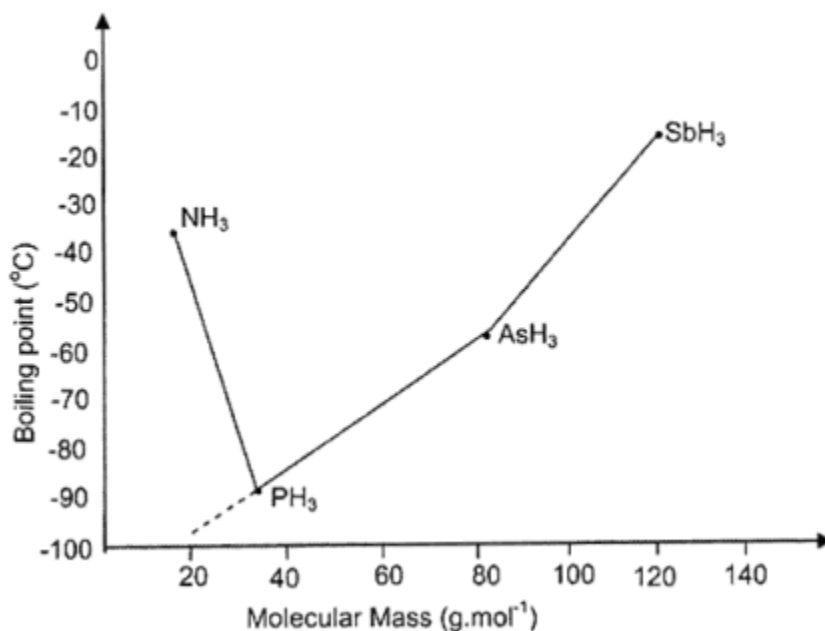
- No gas is released
- Its surface appears rough and corroded.

8.4.1 Refer to the RELATIVE STRENGTHS OF REDUCING AGENTS and explain these observations. (3)

[16]

Question 9

The graph below shows the results obtained during an investigation to determine the boiling points of substances formed when hydrogen is bonded to atoms from group V of the periodic table.



9.1 Define *boiling point*. (2)

9.2 Write down an investigative question for this investigation. (2)

9.3 Consider PH₃, AsH₃ and SbH₃.

9.3.1 Name the type of van der Waals force that exist between molecules of PH₃. Explain the answer by referring to the shape and polarity of the molecule. (3)

9.3.2 Which of the three substances has the highest vapor pressure?

Give a reason for your answer. (2)

9.3.3 Fully explain why SbH_3 has a higher boiling point than AsH_3 . (3)

9.4 It is expected that from the trend shown in the above graph, the boiling point of NH_3 should fall along the dotted line.

Explain, with reference to the TYPE OF INTERMOLECULAR FORCES AND ENERGY why the boiling point of NH_3 does not fall along the dotted line. (4)

9.5 The SAME INVESTIGATION is now conducted when the atmospheric pressure is LOWERED.

What effect will this have on:

9.5.1 The vapour pressure of NH_3 ? (1)

9.5.2 The boiling point of NH_3 ? (1)

(Choose from INCREASES, DECREASES or REMAINS THE SAME in each case):

[18]

Question 10

Study the molecules given below and answer the questions that follow.

CCl_4 , NH_3 , HCN , H_2S and OF_2

10.1 Define the term molecule. (2)

10.2 Use the VSEPR model to predict the molecular geometry of the following:

10.2.1 CCl_4 . (1)

10.2.2 H_2S (1)

10.3 Draw the Lewis structures for the following molecules:

10.3.1 OF_2 . (2)

10.3.2 HCN . (2)

10.4 Explain why it is possible for NH_3 to form a dative covalent bond with H^+ but it is not possible for CCl_4 to form a dative covalent bond with H^+ (2)

[10]

Total 150

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

Half-reactions/Halfreaksies	E^{\ominus} (V)
$F_2(g) + 2e^- = 2F^-$	+ 2,87
$Co^{3+} + e^- = Co^{2+}$	+ 1,81
$H_2O_2 + 2H^+ + 2e^- = 2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^- = Mn^{2+} + 4H_2O$	+ 1,51
$Cl_2(g) + 2e^- = 2Cl^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^- = 2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^- = 2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^- = Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^- = Pt$	+ 1,20
$Br_2(l) + 2e^- = 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^- = NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^- = Hg(l)$	+ 0,85
$Ag^+ + e^- = Ag$	+ 0,80
$NO_3^- + 2H^+ + e^- = NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^- = Fe^{2+}$	+ 0,77
$O_2(g) + 2H^+ + 2e^- = H_2O_2$	+ 0,68
$I_2 + 2e^- = 2I^-$	+ 0,54
$Cu^+ + e^- = Cu$	+ 0,52
$SO_2 + 4H^+ + 4e^- = S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^- = 4OH^-$	+ 0,40
$Cu^{2+} + 2e^- = Cu$	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^- = SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^- = Cu^+$	+ 0,16
$Sn^{4+} + 2e^- = Sn^{2+}$	+ 0,15
$S + 2H^+ + 2e^- = H_2S(g)$	+ 0,14
$2H^+ + 2e^- = H_2(g)$	0,00
$Fe^{3+} + 3e^- = Fe$	- 0,06
$Pb^{2+} + 2e^- = Pb$	- 0,13
$Sn^{2+} + 2e^- = Sn$	- 0,14
$Ni^{2+} + 2e^- = Ni$	- 0,27
$Co^{2+} + 2e^- = Co$	- 0,28
$Cd^{2+} + 2e^- = Cd$	- 0,40
$Cr^{3+} + e^- = Cr^{2+}$	- 0,41
$Fe^{2+} + 2e^- = Fe$	- 0,44
$Cr^{3+} + 3e^- = Cr$	- 0,74
$Zn^{2+} + 2e^- = Zn$	- 0,76
$2H_2O + 2e^- = H_2(g) + 2OH^-$	- 0,83
$Cr^{2+} + 2e^- = Cr$	- 0,91
$Mn^{2+} + 2e^- = Mn$	- 1,18
$Al^{3+} + 3e^- = Al$	- 1,66
$Mg^{2+} + 2e^- = Mg$	- 2,36
$Na^+ + e^- = Na$	- 2,71
$Ca^{2+} + 2e^- = Ca$	- 2,87
$Sr^{2+} + 2e^- = Sr$	- 2,89
$Ba^{2+} + 2e^- = Ba$	- 2,90
$Cs^+ + e^- = Cs$	- 2,92
$K^+ + e^- = K$	- 2,93
$Li^+ + e^- = Li$	- 3,05

Increasing oxidising ability/Toenemende oksiderende vermoë

Increasing reducing ability/Toenemende reduserende vermoë

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

Half-reactions/Halfreaksies	E^{\ominus} (V)
$\text{Li}^+ + e^- = \text{Li}$	-3,05
$\text{K}^+ + e^- = \text{K}$	-2,93
$\text{Cs}^+ + e^- = \text{Cs}$	-2,92
$\text{Ba}^{2+} + 2e^- = \text{Ba}$	-2,90
$\text{Sr}^{2+} + 2e^- = \text{Sr}$	-2,89
$\text{Ca}^{2+} + 2e^- = \text{Ca}$	-2,87
$\text{Na}^+ + e^- = \text{Na}$	-2,71
$\text{Mg}^{2+} + 2e^- = \text{Mg}$	-2,36
$\text{Al}^{3+} + 3e^- = \text{Al}$	-1,66
$\text{Mn}^{2+} + 2e^- = \text{Mn}$	-1,18
$\text{Cr}^{2+} + 2e^- = \text{Cr}$	-0,91
$2\text{H}_2\text{O} + 2e^- = \text{H}_2(\text{g}) + 2\text{OH}^-$	-0,83
$\text{Zn}^{2+} + 2e^- = \text{Zn}$	-0,76
$\text{Cr}^{3+} + 3e^- = \text{Cr}$	-0,74
$\text{Fe}^{2+} + 2e^- = \text{Fe}$	-0,44
$\text{Cr}^{3+} + e^- = \text{Cr}^{2+}$	-0,41
$\text{Cd}^{2+} + 2e^- = \text{Cd}$	-0,40
$\text{Co}^{2+} + 2e^- = \text{Co}$	-0,28
$\text{Ni}^{2+} + 2e^- = \text{Ni}$	-0,27
$\text{Sn}^{2+} + 2e^- = \text{Sn}$	-0,14
$\text{Pb}^{2+} + 2e^- = \text{Pb}$	-0,13
$\text{Fe}^{3+} + 3e^- = \text{Fe}$	-0,06
$2\text{H}^+ + 2e^- = \text{H}_2(\text{g})$	0,00
$\text{S} + 2\text{H}^+ + 2e^- = \text{H}_2\text{S}(\text{g})$	+0,14
$\text{Sn}^{4+} + 2e^- = \text{Sn}^{2+}$	+0,15
$\text{Cu}^{2+} + e^- = \text{Cu}^+$	+0,16
$\text{SO}_4^{2-} + 4\text{H}^+ + 2e^- = \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+0,17
$\text{Cu}^{2+} + 2e^- = \text{Cu}$	+0,34
$2\text{H}_2\text{O} + \text{O}_2 + 4e^- = 4\text{OH}^-$	+0,40
$\text{SO}_2 + 4\text{H}^+ + 4e^- = \text{S} + 2\text{H}_2\text{O}$	+0,45
$\text{Cu}^+ + e^- = \text{Cu}$	+0,52
$\text{I}_2 + 2e^- = 2\text{I}^-$	+0,54
$\text{O}_2(\text{g}) + 2\text{H}^+ + 2e^- = \text{H}_2\text{O}_2$	+0,68
$\text{Fe}^{3+} + e^- = \text{Fe}^{2+}$	+0,77
$\text{NO}_3^- + 2\text{H}^+ + e^- = \text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+0,80
$\text{Ag}^+ + e^- = \text{Ag}$	+0,80
$\text{Hg}^{2+} + 2e^- = \text{Hg}(\text{l})$	+0,85
$\text{NO}_3^- + 4\text{H}^+ + 3e^- = \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+0,96
$\text{Br}_2(\text{l}) + 2e^- = 2\text{Br}^-$	+1,07
$\text{Pt}^{2+} + 2e^- = \text{Pt}$	+1,20
$\text{MnO}_2 + 4\text{H}^+ + 2e^- = \text{Mn}^{2+} + 2\text{H}_2\text{O}$	+1,23
$\text{O}_2(\text{g}) + 4\text{H}^+ + 4e^- = 2\text{H}_2\text{O}$	+1,23
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6e^- = 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1,33
$\text{Cl}_2(\text{g}) + 2e^- = 2\text{Cl}^-$	+1,36
$\text{MnO}_4^- + 8\text{H}^+ + 5e^- = \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+1,51
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2e^- = 2\text{H}_2\text{O}$	+1,77
$\text{Co}^{3+} + e^- = \text{Co}^{2+}$	+1,81
$\text{F}_2(\text{g}) + 2e^- = 2\text{F}^-$	+2,87

Increasing oxidising ability/Toenemende oksiderende vermoë

Increasing reducing ability/Toenemende reduserende vermoë

NAME/NAAM	SYMBOL/SIMBOOL	VALUE/WAARDE
Avogadro's constant <i>Avogadro-konstante</i>	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$
Molar gas constant <i>Molêre gaskonstante</i>	R	$8,31 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
Standard pressure <i>Standaarddruk</i>	p^θ	$1,013 \times 10^5 \text{ Pa}$
Molar gas volume at STP <i>Molêre gasvolume by STD</i>	V_m	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature <i>Standaardtemperatuur</i>	T^θ	273 K

Charge on an electron e^- $-1,6 \times 10^{-19} \text{ C}$

TABLE 2: FORMULAE/TABEL 2: FORMULES

$\frac{m}{n} = M$	$\frac{N}{n} = N_A$
$\frac{n}{c} = V$ or/of $\frac{m}{c} = MV$	$\frac{V}{n} = V_m$
$\frac{C_a V_a}{C_b V_b} = \frac{n_a}{n_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$
$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$ at/by 298 K	
$E_{\text{cell}}^\theta = E_{\text{cathode}}^\theta - E_{\text{anode}}^\theta / E_{\text{sel}}^\theta = E_{\text{katode}}^\theta - E_{\text{anode}}^\theta$	
or/of $E_{\text{cell}}^\theta = E_{\text{reduction}}^\theta - E_{\text{oxidation}}^\theta / E_{\text{sel}}^\theta = E_{\text{reduksie}}^\theta - E_{\text{oksidasie}}^\theta$	
or/of $E_{\text{cell}}^\theta = E_{\text{oxidising agent}}^\theta - E_{\text{reducing agent}}^\theta / E_{\text{sel}}^\theta = E_{\text{oksideermiddel}}^\theta - E_{\text{reduseermiddel}}^\theta$	

$I = \frac{Q}{\Delta t}$	$n = \frac{Q}{e}$ where n is the number of electrons/ waar n die aantal elektrone is
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$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$	$pV = nRT$
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e-

