Hillcrest High School

PHYSICAL SCIENCE P2

JUNE 2023

Grade 11

MARKS: 150
TIME: 3 Hours

EXAMINER: Ms N. Badenhorst
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 ONE mole of water (H_2O) and ONE mole of carbon dioxide (CO_2) will have the same…

A Mass
B Molar mass
C Number of molecules
D Density

1.2 Which ONE of the following substances has ION-DIPOLE forces?

A H_2O (l)
B CO_2 (g)
C NaCl (aq)
D NaCl (s)

1.3 Consider the reaction:

$$\mathbf{Mg(s) + 2HCl(aq) \rightarrow MgCl_2 + H_2(g)}$$

The rate of production of $MgCl_2$, can be increased by

A Decreasing the concentration of HCl (aq)
B Increasing the volume of H_2(g)
C Increase the temperature
D Decreasing the surface area of Mg

1.4 Which ONE of the solutions has the LOWEST pH?

A $100cm^3$ of a 0,2 $mol.dm^{-3}$ H_2SO_4

B $100cm^3$ of a 0,2 $mol.dm^{-3}$ CH_3COOH

C $100cm^3$ of a 0,2 $mol.dm^{-3}$ HCl

D $100cm^3$ of a 0,2 $mol.dm^{-3}$ $(COOH)_2$

1.5 Which indicator will be most suitable to use for the titration of sodium hydroxide (NaOH) with ethanoic acid (CH_3COOH)?

A Methyl red

B Phenolphthalein

C Bromothymol blue

D Universal indicator

1.6 Consider the following redox reaction:

$$\mathbf{Cr_2O_7^{2-}(aq) + Fe^{2+}(aq) + H^+(aq) \rightarrow Cr^{3+}(aq) + Fe^{3+}(aq) + H_2O(l)}$$

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

A Fe^{3+}

B Cr^{3+}

C H_2O

D H^+

1.7 Which ONE OF the following will reduce Sn^{2+} to Sn?

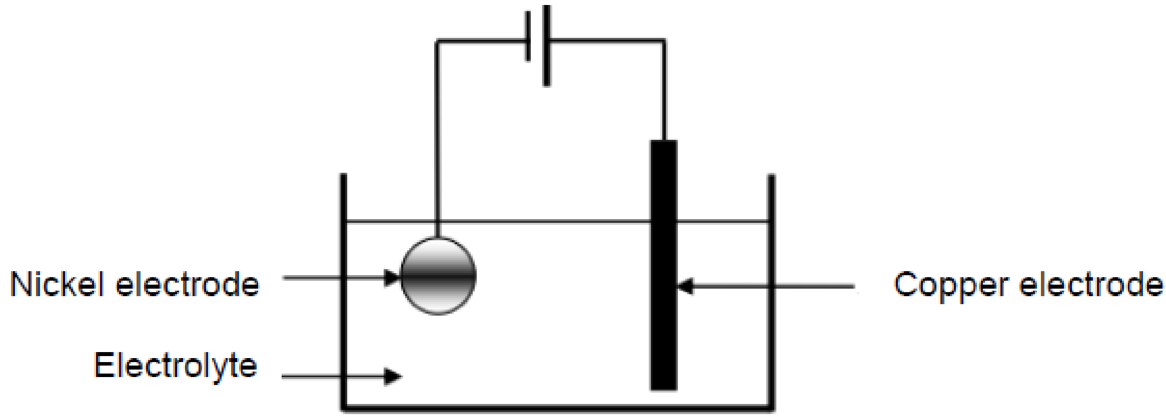
A Zn

B Ag

C Hg

D Pb

1.8 The simplified diagram below represents an electrolytic cell used to electroplate a nickel (Ni) coin with copper (Cu).



Which ONE of the following reactions takes place at the anode?

A $Ni^{2+} + 2e^- \rightarrow Ni$

B $Ni \rightarrow Ni^{2+} + 2e^-$

C $Cu^{2+} + 2e^- \rightarrow Cu$

D $Cu \rightarrow Cu^{2+} + 2e^-$

1.9 A fixed amount of gas occupies a volume of 12 dm^3 at a pressure of 2 kPa.
If the pressure increases by 15%, the new volume of the gas will be:

A 100 dm^3

B 13,64 dm^3

C 11 dm^3

D 10,43 dm^3

1.10 According to Boyle's law…

A $p \propto \frac{1}{V}$ if T is constant.

B $V \propto T$ if p is constant.

C $V \propto \frac{1}{T}$ if p is constant.

D $p \propto V$ if n is constant.

[2 x 10 = 20]

SECTION B

Question 2

2.1 *The chemical composition of a particular compound is:

11,79% Carbon
69,57% Chlorine
18,64% Fluorine

The molar mass of the compound is 204 $g \cdot mol^{-1}$.

Determine, by calculations, the molecular formula of the compound. (7)

2.2 When heated, lithium reacts with nitrogen to form lithium nitride.

The balanced equation: $6\ Li_{(s)} + N_{2\ (g)} \rightarrow 2\ Li_3N_{(s)}$

12,3 g of lithium is heated with 33,6 g of N_2.

2.2.1 Define the term *limiting reagent*. (2)

2.2.2 Determine by calculation which substance is the limiting reagent. (6)

[15]

Question 3

3.1 An eggshell contains calcium carbonate ($CaCO_3$) and impurities.

An **EXCESS** amount of a standard dilute acetic acid solution (CH_3COOH) of concentration 0,5 mol·dm^{-3} and volume 250 cm^3 is allowed to react COMPLETELY with an eggshell of mass 56 g.

The equation for the reaction is given by the balanced equation shown below:

$$2\,CH_3COOH_{(aq)} + CaCO_{3\,(s)} \rightarrow Ca(CH_3COO)_{2\,(aq)} + H_2O_{(\ell)} + CO_{2\,(g)} \text{.........(1)}$$

The **acetic acid that remained unreacted** is neutralised by 25 cm^3 of sodium hydroxide (NaOH) with a concentration of 0,968 mol·dm^{-3}.

The equation for the reaction is given by the balanced equation below:

$$CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow CH_3COONa_{(aq)} + H_2O_{(\ell)} \text{..........(2)}$$

3.1.1 Calculate the **given** number of moles of CH_3COOH in reaction 1. (3)

3.1.2 Calculate the **reacted** number of moles of CH_3COOH in reaction 1. (5)

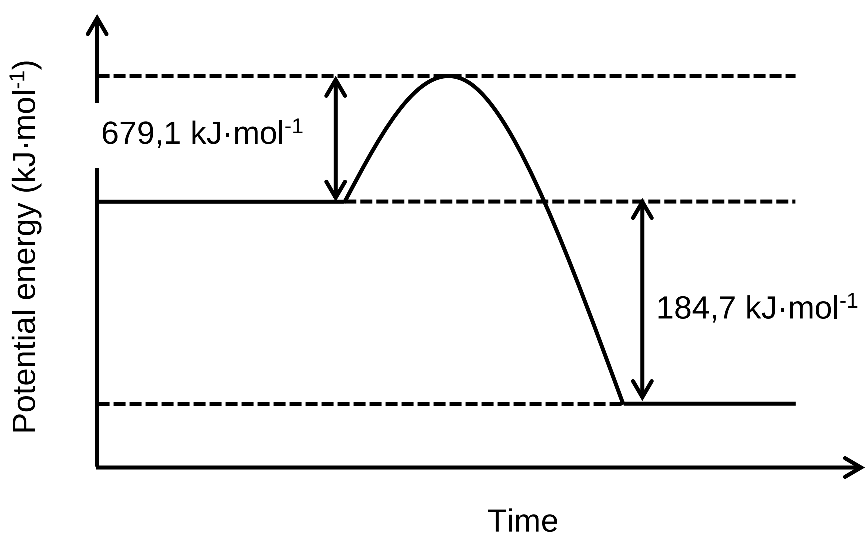
3.1.3 Calculate the percentage of $CaCO_3$ in the eggshell (% purity) (4)

[12]

Question 4

The diagram shows the potential energy changes during the following chemical reaction:

$$2\,H_{2\,(g)} + C\ell_{2\,(g)} \rightarrow 2\,HC\ell_{(g)}$$



4.1 Define *activation energy.* (2)

4.2 Is the reaction EXOTHERMIC or ENDOTHERMIC?

Give a reason for the answer. (2)

4.3 Calculate the activation energy for the reverse reaction. (3)

4.4 Determine the energy released by the bond formation of the HCℓ molecule. (3)

4.5 What effect will the addition of a catalyst have on the value 184,7 kJ·mol^{-1}?

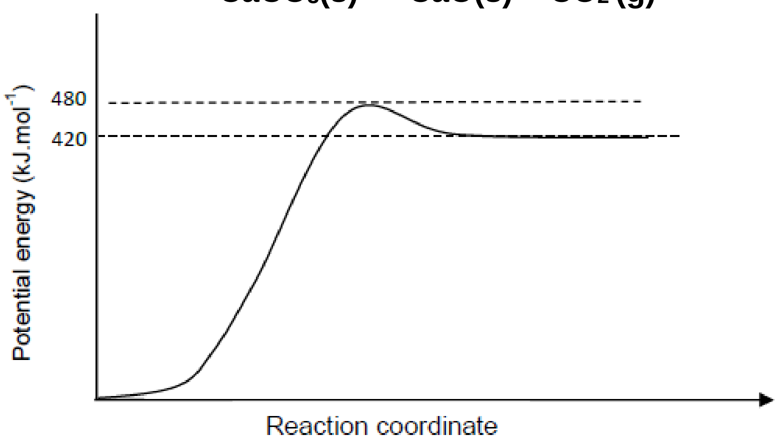
Write down only INCREASE, DECREASE or NO EFFECT.

Give a reason for the answer. (2)
[12]

Question 5

5.1 The graph below shows the change in potential energy for the reaction where limestone is changed into lime. The balanced equation for this reaction is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

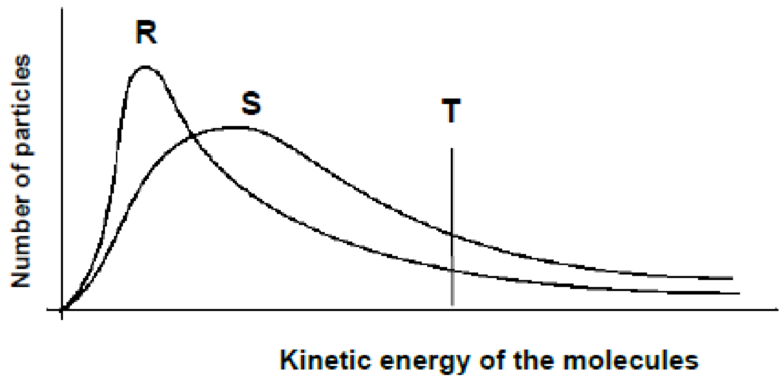


5.1.1 Is the forward reaction exothermic or endothermic? (1)

5.1.2 Calculate the heat of reaction for the forward reaction. (2)

5.1.3 Calculate the activation energy for the reverse reaction. (1)

5.2 The following graph represents the number of particles against a specific amount of kinetic energy of the molecules. The data for samples **R** and **S** was obtained at different temperatures which affects the rate of reaction.



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

5.2.2 What does the area to the right of line **T** represent? (1)

5.2.3 Which sample was at a higher temperature? Write down on SAMPLE **R** or SAMPLE **S**. (1)

5.2.4 Explain the answer to QUESTION 5.2.3 by using the collision theory. (3)

5.3 11 g of magnesium ribbon reacts with a 0,25 mol.dm^{-3} hydrochloric acid solution at a temperature of 25 °C according to the following balanced reaction:

$$\mathbf{Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)}$$

A table of the results is given below:

Time elapsed (minutes)	Volume of $H_{2(g)}$ (cm^3)
0	0
0,5	17
1,0	25
1,5	30
2,0	33
2,5	35
3,0	35

5.3.1 Plot a graph of these results in your answer booklet. (2)

5.3.2 Use the graph and explain what happened with the reaction between 2 minutes and 3 minutes. (1)

5.3.3 In a second experiment, the concentration of the hydrochloric acid changed from 0,25 mol.dm^{-3} to 1 mol.dm^{-3}.
Draw a new curve on the same graph paper to show what effect it will have. Label the new curve **X.** (2)

5.3.4 Assume molar gas volume at 25°C is 24,47 dm^3. Calculate the volume of acid that was used in the experiment when the reaction was completed. (4)

[20]

Question 6

Carbonic acid (H_2CO_3) ionises according to the following equation:

$$H_2CO_3(aq) + H_2O(l) \rightarrow H_3O^+(aq) + HCO_3^-(aq)$$

6.1 Is carbonic acid, H_2CO_3(aq), *a strong acid or a weak acid*?
Give a reason for your answer. (2)

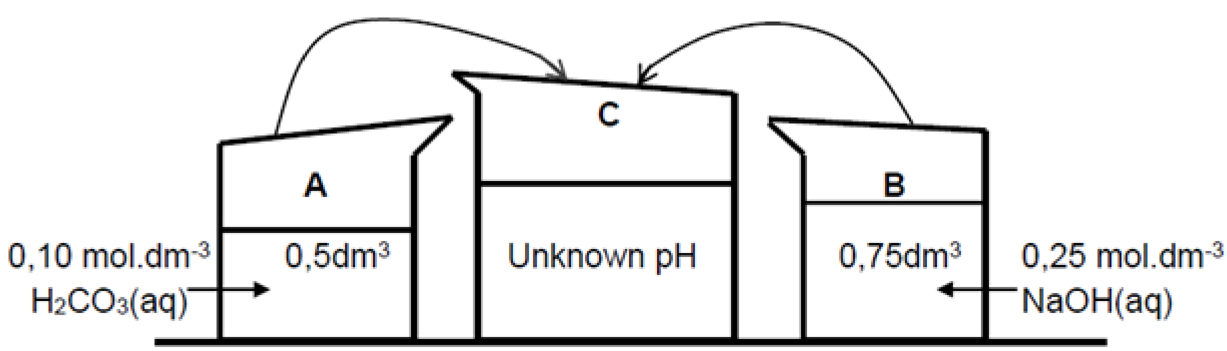
Two beakers **A** and **B** contain the acid and a strong base respectively.

Beaker **A**: 0,5 dm^3 of carbonic acid, H_2CO_3(aq) of concentration 0,10 $mol.dm^{-3}$
Beaker **B**: 0,75 dm^3 of sodium hydroxide, NaOH (aq) of concentration 0,25 $mol.dm^{-3}$

When a 0,10 mol.dm-3 solution of H_2CO_3 is prepared, it is found that the concentration of H_3O^+ ions is 0,012 $mol.dm^{-3}$ at 25℃

6.2 Calculate the number of moles of H_3O^+(aq) ions present in H_2CO_3 solution in beaker **A**. (3)

The contents of beakers **A** and **B** are added together in beaker **C**. The solution in beaker **C** has an unknown pH.



The balanced equation for the reaction is:

$$H_2CO_3(aq) + NaOH(aq) \rightarrow NaHCO_3(aq) + H_2O(l)$$

6.3 Calculate the

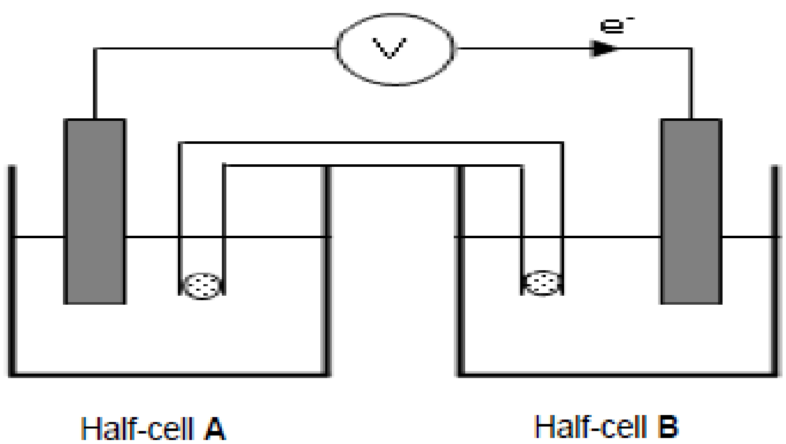
6.3.1 Number of moles of hydroxide (OH^-) ions in beaker **B.** (3)

6.3.2 pH of the solution at the completion of the reaction in beaker **C.** (7)

[15]

Question 7

The galvanic cell represented in the diagram below consists of a Ba electrode dipped into a Ba $(NO_3)_2$ solution, and a Cu electrode dipped into a Cu $(NO_3)_2$ solution. Assume that the cell operates under standard conditions.



7.1 State TWO standard conditions under which this cell operates. (2)

7.2 Which half-cell, A or B is the cathode? Write only A or B. (1)

7.3 Write down the half-reaction that takes place in half-cell A. (2)

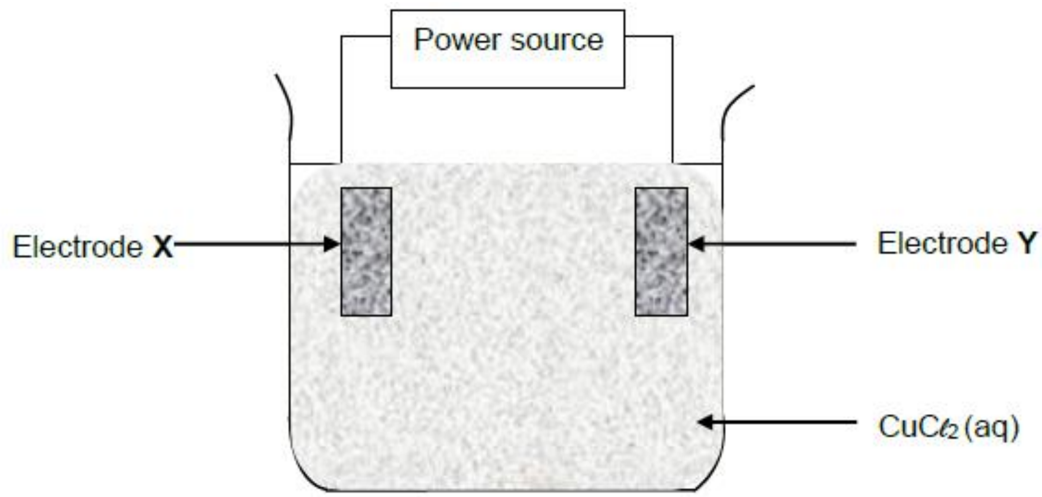
7.4 Write down the cell notation for this cell. (3)

7.5 Calculate the emf of this cell. (4)

7.6 The volume of the electrolyte in each **standard** half-cell is 40 cm^3.
Calculate the maximum mass loss that can occur at the anode. (5)
[17]

Question 8

The diagram below represents an electrochemical cell that is used for the refining of copper.



One of the electrodes consists of *pure copper* and the other of *impure copper*.

8.1 When the cell is allowed to operate, it is found that the mass of electrode **X increases** over time.

8.1.1 Define the term *electrolyte*. (2)

8.1.2 Is electrode X the CATHODE or ANODE of the cell? (1)

8.1.3 Write down a half-reaction to justify the answer to QUESTION 8.1.2 above. (2)

8.2 State whether electrode Y is connected to the POSITIVE terminal or the NEGATIVE terminal of the power source. (1)

8.3 The impure copper contains zinc and silver. State what will happen to the:

8.3.1 *Silver* that is in the impure copper. (1)

8.3.2 *Zinc* that is in the impure copper. (1)

8.4 Refer to the relative strength of oxidising agents to explain why zinc in the impure copper will not be deposited on the pure copper electrode. (2)

8.5 After the purification of the impure copper was completed, it was found that $3,75\times10^{-2}$ mol of copper was formed. Calculate the percentage of copper that was present in the impure sample if the initial mass of the impure copper was 4 g. (4)

Electrode **X** and **Y** are now replaced with *graphite* (C) electrodes.

8.6 State what will be observed at electrode Y (now graphite). (1)

8.7 Describe what will happen to the blue colour of the electrolyte as the reaction proceeds/progresses. (2)

[17]

Question 9

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

$CC\ell_4$, NH_3, HCN, H_2S and OF_2

9.1 Define the term *molecule*. (2)

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

9.2.1 $CC\ell_4$ (1)

9.2.2 NH_3 (1)

9.3 Draw the Lewis structures for the following molecules:

9.3.1 OF_2 (2)

9.3.2 HCN (2)

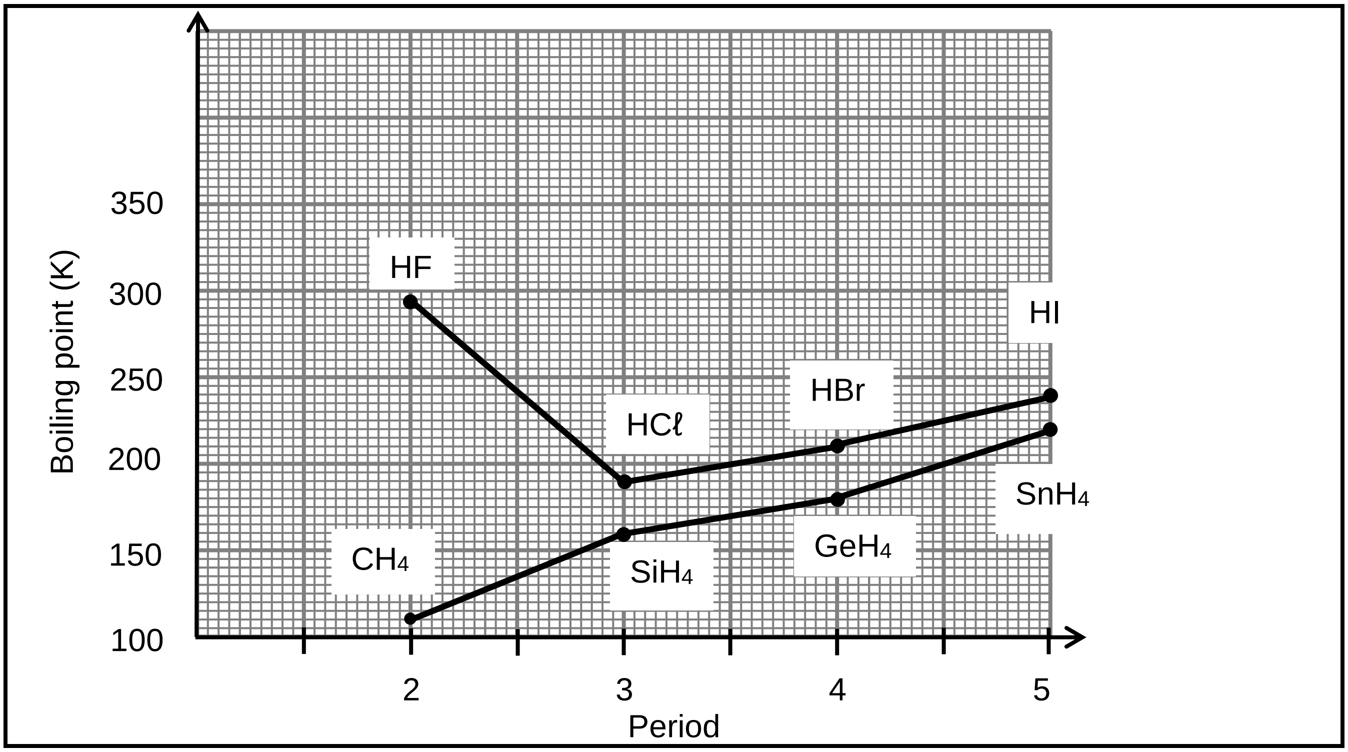
9.4 Explain why it is possible for NH_3 to form a dative covalent bond with H^+ but it is not possible for $CC\ell_4$ to form a dative covalent bond with H^+. (2)

9.5 Is the H_2S molecule POLAR or NON-POLAR? Explain the answer. (4)

[14]

Question 10

The boiling points of the hydrogen halides and group 4 hydrogen compounds are compared in the graph below.



10.1 Define *boiling point*. (2)

10.2 Explain why the boiling points of the hydrogen halides are higher than those of corresponding group 4 hydrides from period 3 to 5, by referring to the type of intermolecular forces present in these compounds and energy involved. (4)

HF is the halide with the HIGHEST boiling point.

10.3 Write down the name of the intermolecular force present in HF responsible for the high boiling point. (2)

[8]

Total 150

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

Increasing oxidising ability/*Toenemende oksiderende vermoë* (↑)

Increasing reducing ability/*Toenemende reduserende vermoë* (↓)

Half-reactions/*Halfreaksies*			E^θ (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
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 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
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 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
$\mathbf{2H^+ + 2e^-}$	⇌	$\mathbf{H_2(g)}$	**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
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 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

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

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}$ mol^{-1}
Molar gas constant *Molêre gaskonstante*	R	8,31 J·K^{-1}·mol^{-1}
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·mol^{-1}
Standard temperature *Standaardtemperatuur*	T^θ	273 K

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_aV_a}{c_bV_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ 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* $E^\theta_{cell} = E^\theta_{oxidising\ agent} - E^\theta_{reducing\ agent}$ / $E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	

$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$	$pV = nRT$

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Atomic number / *Atoomgetal*	29
Symbol / *Simbool*	Cu
Approximate relative atomic mass / *Benaderde relatiewe atoommassa*	63,5
Electronegativity / *Elektronegatiwiteit*	1,9

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 H 1 (2,1)																	2 He 4
3 Li 7 (1,0)	4 Be 9 (1,5)											5 B 11 (2,0)	6 C 12 (2,5)	7 N 14 (3,0)	8 O 16 (3,5)	9 F 19 (4,0)	10 Ne 20
11 Na 23 (0,9)	12 Mg 24 (1,2)											13 Aℓ 27 (1,5)	14 Si 28 (1,8)	15 P 31 (2,1)	16 S 32 (2,5)	17 Cℓ 35,5 (3,0)	18 Ar 40
19 K 39 (0,8)	20 Ca 40 (1,0)	21 Sc 45 (1,3)	22 Ti 48 (1,5)	23 V 51 (1,6)	24 Cr 52 (1,6)	25 Mn 55 (1,5)	26 Fe 56 (1,8)	27 Co 59 (1,8)	28 Ni 59 (1,8)	29 Cu 63,5 (1,9)	30 Zn 65 (1,6)	31 Ga 70 (1,6)	32 Ge 73 (1,8)	33 As 75 (2,0)	34 Se 79 (2,4)	35 Br 80 (2,8)	36 Kr 84
37 Rb 86 (0,8)	38 Sr 88 (1,0)	39 Y 89 (1,2)	40 Zr 91 (1,4)	41 Nb 92	42 Mo 96 (1,8)	43 Tc (1,9)	44 Ru 101 (2,2)	45 Rh 103 (2,2)	46 Pd 106 (2,2)	47 Ag 108 (1,9)	48 Cd 112 (1,7)	49 In 115 (1,7)	50 Sn 119 (1,8)	51 Sb 122 (1,9)	52 Te 128 (2,1)	53 I 127 (2,5)	54 Xe 131
55 Cs 133 (0,7)	56 Ba 137 (0,9)	57 La 139	72 Hf 179 (1,6)	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 Tℓ 204 (1,8)	82 Pb 207 (1,8)	83 Bi 209 (1,9)	84 Po (2,0)	85 At (2,5)	86 Rn
87 Fr (0,7)	88 Ra 226 (0,9)	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