HILLCREST HIGH SCHOOL
PHYSICAL SCIENCE
GRADE 12
PAPER 2- CHEMISTRY

TRIALS 2022
EXAMINER: J. KNOX-WHITEHEAD **TIME: 3 HRS**
TOTAL 150

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 given 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 $C_nH_{2n}O_2$ is the general formula for both …

A A ketone and an aldehyde

B An ester and an aldehyde

C A ketone and a carboxylic acid

D An ester and a carboxylic acid (2)

1.2 When butane is subjected to high temperatures and pressures, the following reaction takes place:

Butane → methane + **Y**

Which ONE of the following represents **Y**?

A $CHCCH_3$

B CH_2CHCH_3

C $CH_3CH_2CH_3$

D $CH_3CHCHCH_3$ (2)

1.3 Which of the following has the highest vapour pressure?

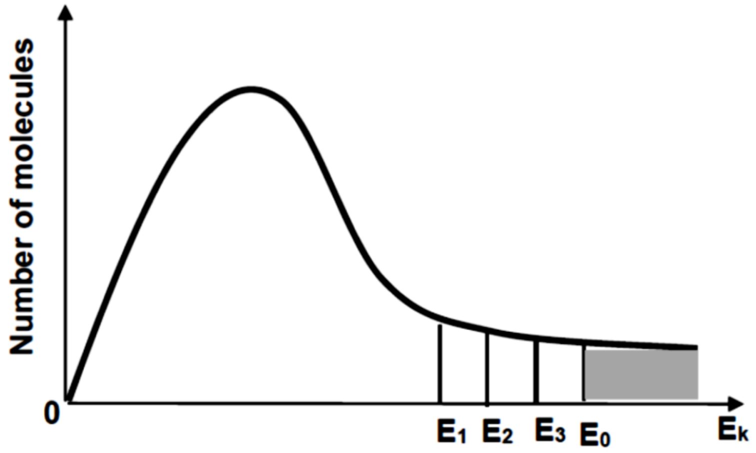
A hexane

B butane

C propane

D ethane (2)

1.4 Three catalysts are used separately to change the rate of a hypothetical reaction. In the diagram below, $\mathbf{E_1}$, $\mathbf{E_2}$ and $\mathbf{E_3}$ represent the effect of each catalyst on the activation energy ($\mathbf{E_0}$) for the reaction.



Which of the following is the activation energy for the reaction with the HIGHEST rate?

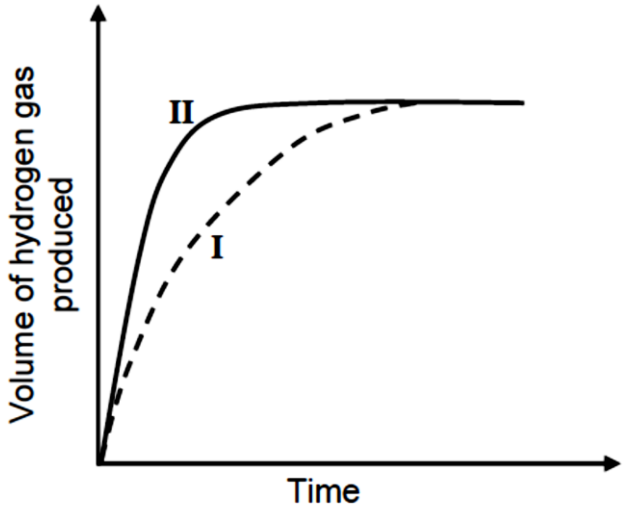
A **E_0**

B **E_1**

C **E_2**

D **E_3** (2)

1.5 A hydrochloric acid solution, HCℓ(aq),of concentration 1 mol.dm^{-3} is added to EXCESS POWDERED magnesium at 25°C. Curve **I** below represents the volume of hydrogen gas produced during this reaction. Curve **II** was obtained under different conditions using the SAME VOLUME of hydrochloric acid solution.



Which ONE of the following represents the conditions used to obtain curve **II**?

	STATE OF DIVISION OF Mg	**CONCENTRATION OF ACID (mol·dm^{-3})**	**TEMPERATURE (°C)**
A	Ribbon	0,5	25
B	Ribbon	2	25
C	Powder	1	20
D	Powder	1	30

(2)

1.6 Chromate ions, CrO_4^{2-} (aq), and dichromate ions, $Cr_2O_7^{2-}$ (aq), are in equilibrium in an aqueous solution according to the following balanced equation:

$$\underset{\text{yellow}}{CrO_4^{2-}(aq)} + 2H^+(aq) \leftrightarrows \underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(\ell)$$

Which ONE of the following concentrated solutions should be added to make the colour of the solution orange?

A NaOH

B NH_3

C $Cr_2O_7^{2-}$

D $HC\ell$ (2)

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

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

The two BASES in the above reaction are:

A $H_2SO_4(\ell)$ + $H_2O(\ell)$

B $H_3O^+(\ell)$ + $HSO_4^-(aq)$

C $H_2O(\ell)$ + $HSO_4^-(aq)$

D $H_2SO_4(\ell)$ + $H_3O^+(\ell)$ (2)

1.8 The following equations represent two hypothetical half-reactions. The reduction potentials are also provided:

$$X_2 + 2e^- \leftrightarrows 2X^- \qquad +1{,}09\ V$$

$$Y^+ + e^- \leftrightarrows Y \qquad -2{,}8\ V$$

Which one of the following substances from these hypothetical half-reactions will be the strongest oxidising agent?

A X^-

B X_2

C Y^+

D Y (2)

1.9 Consider the following TWO statements regarding a galvanic cell:

I. An oxidation half reaction takes place at the cathode of the cell.

II. Positive ions move from the salt bridge to the anode of the cell.

Which of the following is TRUE for a galvanic cell?

A I only

B II only

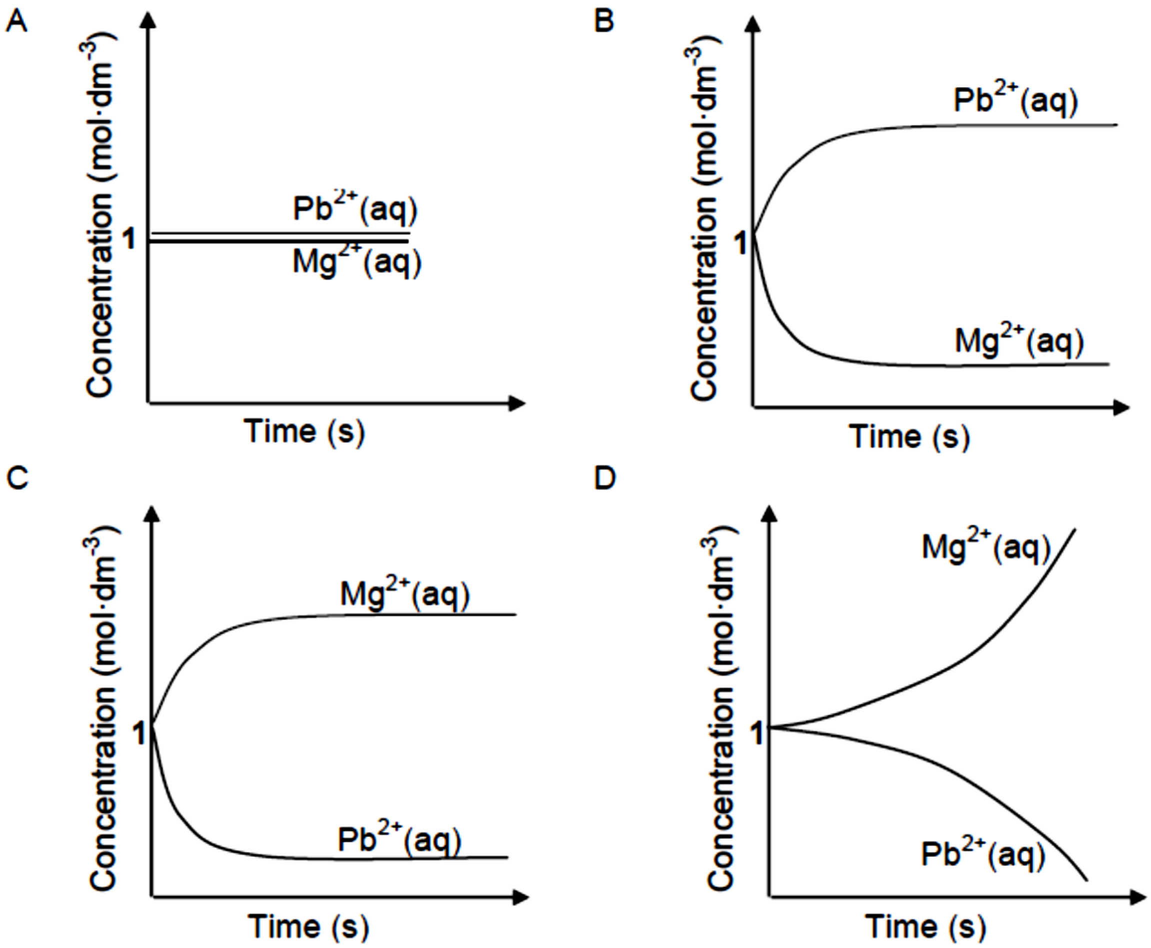
C Neither I nor II

D Both I and II (2)

1.10 An electrochemical cell is set up at standard conditions. The cell notation for the cell is given below:

$$Mg\ (s)\ |\ Mg^{2+}(aq)\ \|\ Pb^{2+}\ (aq)\ |\ Pb\ (s)$$

The cell is now connected in a circuit. Which ONE of the graphs below BEST represents the concentrations of the electrolytes after a long time.



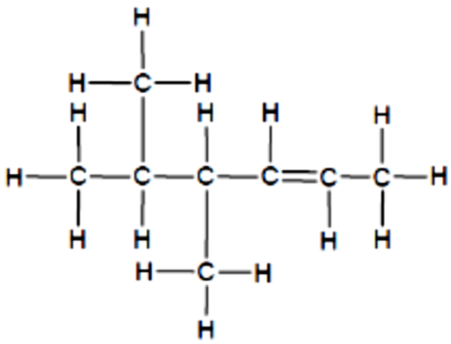
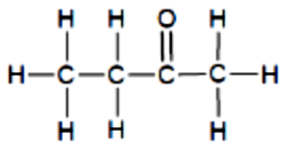
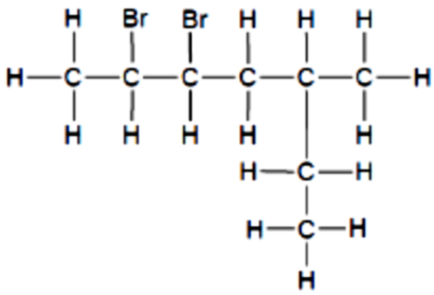
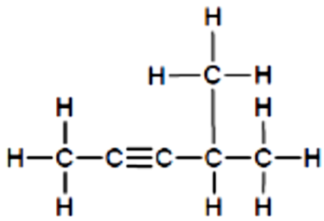
(2)

[20]

<u>SECTION B</u>

QUESTION 2

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

A		**B**	
C	$CH_3CH{=}CHCH_2CH_2CH_3$	**D**	Pentyl propanoate
E		**F**	

2.1 Write down the letter/s that represent/s the following:

- 2.1.1 Alkene (1)
- 2.1.2 A ketone (1)
- 2.1.3 A compound with the general formula C_nH_{2n-2} (1)
- 2.1.4 A structural isomer of octanoic acid (1)

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

2.2.2 Write down the NAME of the functional group of compound **B**. (1)

2.2.3 Give the IUPAC name of a FUNCTIONAL ISOMER of compound **B**. (1)

2.3 Write down the IUPAC name of the compound:

- 2.3.1 **A** (2)
- 2.3.2 **E** (2)
- 2.3.3 **F** (2)

2.4 Compound **D** is prepared by heating two organic compounds in the presence of a catalyst.

2.4.1 Why is it necessary for the heating to be done in a water bath for this reaction? (1)

2.4.2 Define the term *catalyst*. (2)

Write down the:

2.4.3 Structural formula of compound **D** (2)

2.4.4 IUPAC name of the organic acid used to prepare compound **D** (1)

2.4.5 FORMULA of the catalyst used in this reaction (1)

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QUESTION 3

The boiling points of TWO organic compounds, **A** and **B**, were investigated.

	FORMULA	MOLECULAR MASS ($g.mol^{-1}$)
A	$CH_3(CH_2)_2COOH$	88,1
B	$CH_3(CH_2)_3CH_2OH$	88,1

3.1 State the definition of *boiling point*. (2)

3.2 State the INDEPENDENT variable for this investigation. (1)

The following boiling points were obtained from this investigation:

137 °C	163 °C

3.3.1 Write down the boiling point that is most likely to be that of compound **A**. (1)

3.3.2 Explain FULLY how you arrived at the answer to QUESTION 3.3.1. (4)

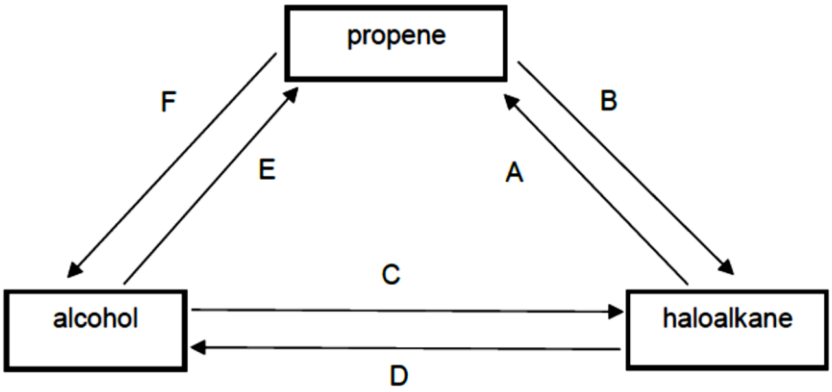
3.4.1 The boiling point of another compound, $CH_3(CH_2)_2CH_2OH$, was also determined. How will the boiling point of this compound compare to that of compound B?
Choose from GREATER THAN, LESS THAN or EQUAL TO. (1)

3.4.2 Explain FULLY how you arrived at the answer to QUESTION 3.4.1. (3)

[12]

QUESTION 4

The flow diagram below shows the interconversion between alcohols, alkenes and haloalkanes. The letters **A** – **F** represent the reactions required to convert from one compound to the other.



4.1.1 What type of reaction is represented by **F**? (1)

4.1.2 Use structural formulae to write a balanced chemical equation for reaction **F** to show the formation of the major product. (3)

4.1.3 Is the major product formed in reaction **F** a PRIMARY, SECONDARY or TERTIARY alcohol? (1)

4.2 Reaction **E** is sometimes referred to as dehydration. Write down the FORMULA of the substance eliminated during dehydration. (1)

4.3 Letter **C** represents the reaction of the alcohol with HBr.

4.3.1 Write down the structural formula for the organic product of this reaction. (1)

4.3.2 What type of reaction is represented by **C**? (1)

4.4 The haloalkane can be converted to an alcohol through reaction **D**, or to propene through reaction **A**.

4.4.1 What type of reaction is represented by **B**? (1)

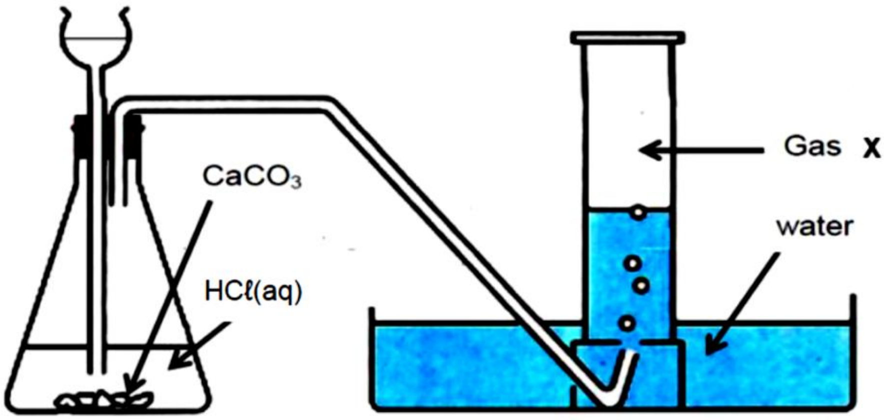
4.4.2 What type of reaction is represented by **D**? (1)

4.4.3 What condition is important for reaction **B** to take place successfully? (1)

[11]

QUESTION 5

A group of Grade 12 learners uses the reaction between calcium carbonate and hydrochloric acid to investigate one of the factors that influence reaction rate. They use the apparatus shown below.



The reaction that takes place is represented by the following chemical equation:

$CaCO_3(s)$ + $2HC\ell(aq)$ → $CaC\ell_2(aq)$ + **X**(g) + $H_2O(\ell)$ $\Delta H < 0$

5.1 Identify the gas **X**. (1)

Two experiments were conducted using the apparatus shown above. The conditions for each experiment are given in the table below.

Experiment	Mass of $CaCO_3(s)$(g)	State of division of $CaCO_3(s)$	Concentration of HCl ($mol{\cdot}dm^{-3}$)	Temperature of HCl(aq)(°C)
1	4	lumps	0,2	40
2	4	lumps	0,4	40

5.2 Define, in words, the term *reaction rate* in terms of THIS investigation. (2)

5.3 From the table above, write down the independent variable for this investigation. (1)

5.4 In which reaction would you expect the learners to have observed a HIGHER reaction rate? Choose from EXPERIMENT 1 or EXPERIMENT 2. (1)

5.5 Use the Collision Theory to explain your answer to QUESTION 5.4. (3)

5.6 Assume that $CaCO_3$ is the LIMITING REAGENT.

5.6.1 Refer to **experiment 2** and calculate the volume of hydrochloric acid (in cm^3) that reacts with $CaCO_3(s)$. (4)

5.6.2 After 14,8 minutes no more bubbles of gas **X** are observed in the water. Calculate the average rate of reaction in $\mathbf{g.min^{-1}}$. (3)

[15]

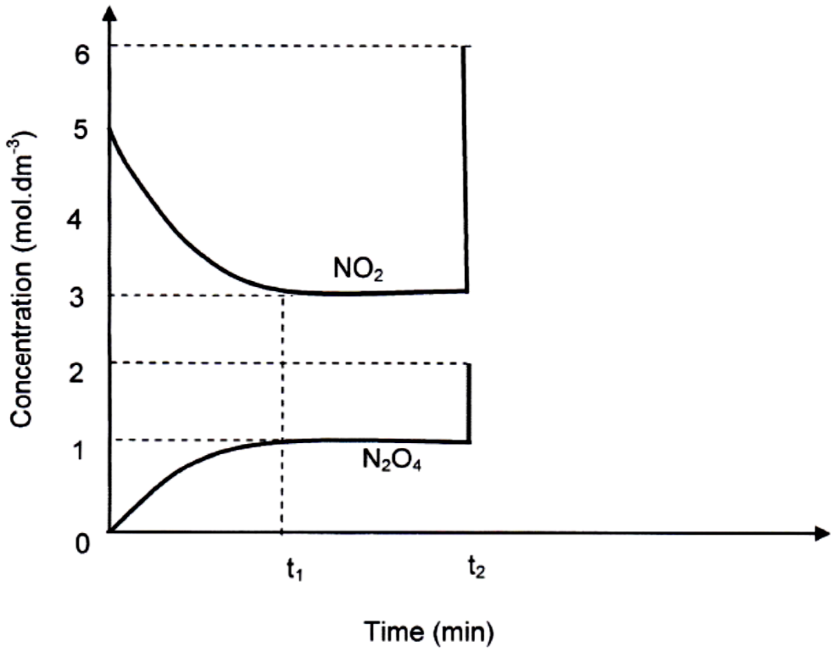
QUESTION 6

6.1 State *Le Chatelier's principle*. (2)

6.2 10 moles of $NO_2(g)$ is injected into a 2 dm^3 container at 330 K. The container is then sealed. The following reaction takes place:

$$\underset{\text{brown}}{2NO_2(g)} \leftrightarrows \underset{\text{colourless}}{N_2O_4(g)}$$

The concentration-time graph for the two gases is drawn below.



6.2.1 Explain what happened at time t_1. (1)

6.2.2 Identify the external change that was made at time t_2. (1)

6.2.3 State what colour change will occur in the container after t_2. (1)

6.2.4 Use Le Chatelier's Principle to explain the colour change in QUESTION 6.2.3. (3)

6.3 Initially excess NH_4HS (s) is placed in a 5 dm^3 container at 218°C. The container is sealed and the reaction is allowed to reach equilibrium according to the following balanced equation:

$$NH_4HS(s) \leftrightarrows NH_3(g) + H_2S(g) \qquad \Delta H > 0$$

6.3.1 What effect will each of the following changes have on the amount of $NH_3(g)$ at equilibrium? Write down only INCREASES, DECREASES or REMAINS THE SAME.

6.3.1.1 More $NH_4HS(s)$ is added (1)

6.3.1.2 The temperature is increased (1)

6.3.2 The equilibrium constant, K_c, for this reaction at 218°C is $1{,}2\text{x}10^{-4}$. Calculate the minimum mass of $NH_4HS(s)$ that must be sealed in the container to obtain equilibrium. (6)

[16]

QUESTION 7

7.1.1 Define a *weak acid*. (2)

7.1.2 What can be said about the value of the equilibrium constant, Ka, for a weak acid? Choose from Ka = 1 <u>OR</u> Ka < 1 <u>OR</u> Ka > 1. (1)

7.2 Ammonium chloride, $NH_4C\ell$, is an example of a salt that can undergo hydrolysis.

7.2.1 Use chemical equations to show the hydrolysis of ammonium chloride. (3)

7.2.2 Methyl orange is red in an acidic medium and yellow in an alkaline medium. What will the colour of methyl orange be in an ammonium chloride solution? (1)

7.3 Milk of Magnesia has been used over the ages to relieve acid indigestion caused by excess stomach acid. The active ingredient in Milk of Magnesia is magnesium hydroxide, $Mg(OH)_2$. A group of learners prepare a solution of magnesium hydroxide.

7.3.1 What mass of $Mg(OH)_2$ must be dissolved in distilled water to prepare 500 cm^3 of a solution with a concentration of 0,20 $mol.dm^{-3}$? (4)

7.3.2 The pH of any medicine safe for human consumption must lie between pH = 4 and pH = 9. Will the solution that the learners prepared in QUESTION 7.3.1 be safe for human consumption? Assume 100% dissociation of magnesium hydroxide in water. Show all calculations. (5)

7.4 A learner adds a sample of calcium carbonate to 50,0 cm^3 of sulphuric acid. The sulphuric acid is in **excess** and has a concentration of 1,0 $mol.dm^{-3}$. The reaction is allowed to proceed until all the $CaCO_3$ is used up, as shown in the balanced equation:

Reaction 1: $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$

The H_2SO_4 **left over** from this reaction is now neutralised by 28,0 cm^3 of a 0,5 $mol.dm^{-3}$ sodium hydroxide solution. The balanced equation for this reaction is:

Reaction 2: $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Calculate the initial mass of calcium carbonate in the sample in **Reaction 1**. (9)

[25]

QUESTION 8

A pupil sets up an electrochemical cell based on the following reaction:

$$A\ell(s) + Cu^{2+}(aq) \rightarrow A\ell^{3+}(aq) + Cu(s)$$

8.1 Identify the type of electrochemical cell represented by this reaction. (1)

8.2 Represent this cell using cell notation. (3)

8.3 Do the electrons in the external circuit flow from the Aℓ to the Cu electrode or from the Cu to the Aℓ electrode? (1)

8.4 Write down the half reaction that takes place at the ANODE. (2)

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

8.6 Give the standard conditions relevant to this electrochemical cell. (2)

8.7 If 1,05 g mass is lost from the anode, calculate the maximum mass that will be gained by the cathode. (4)

8.8 5 g of $AlCl_3$ is now dissolved in the aluminium half-cell of the standard cell.

8.8.1 What will be the effect on the cell potential? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

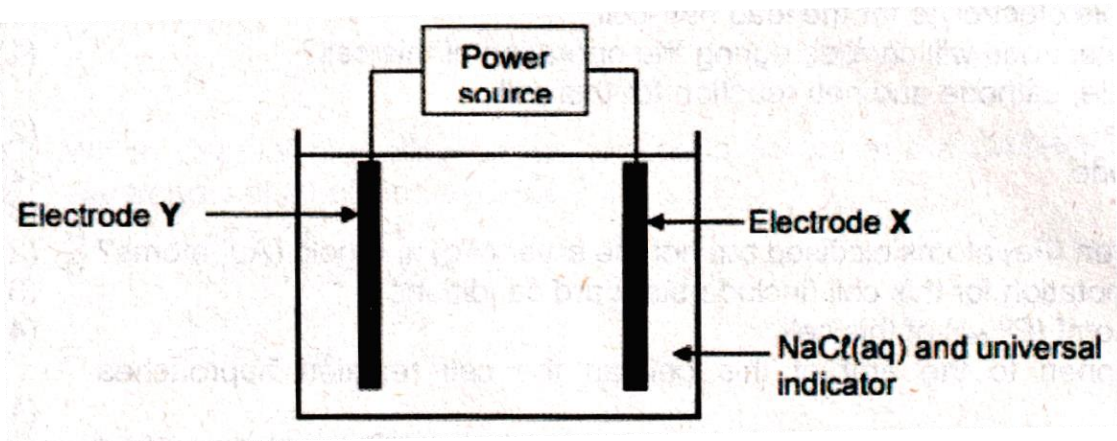
8.8.2 Explain your answer to QUESTION 8.8.1. (3)

[21]

QUESTION 9

The apparatus below is used to demonstrate the electrolysis of a concentrated sodium chloride solution. Both electrodes are made of carbon. A few drops of universal indicator are added to the electrolyte. The equation for the net cell reaction is:

$$2NaCl(aq) + 2H_2O(l) \rightarrow Cl_2(g) + H_2(g) + 2NaOH(aq)$$



Initially the solution has a green colour. Universal indicator becomes **red in acidic solutions** and **purple in alkaline solutions**.

9.1 Write down the energy conversion that takes place in this cell. (1)

9.2 Is this reaction ENDOTHERMIC or EXOTHERMIC? (1)

9.3 Define the term *electrolyte*. (2)

When the power source is switched on, the colour of the electrolyte around electrode **Y changes from green to purple**.

9.4 Write down the:

9.4.1 Half-reaction that takes place at electrode **Y**. (2)

9.4.2 NAME of the gas released at electrode **X**. (1)

9.5 Refer to the relative strengths of the oxidising agents to explain why hydrogen gas, and not sodium metal, is formed at the cathode of this cell. (2)

[9]

TOTAL 150

CAPS

INFORMATION FOR PHYSICAL SCIENCES GR 12
PAPER 2 (CHEMISTRY)

TABLE 1: PHYSICAL CONSTANTS

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

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

KEY/*SLEUTEL*

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

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TABLE 4A: STANDARD REDUCTION POTENTIALS

Increasing oxidising ability (↑)

Half-reactions			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
$Cl_2(g) + 2e^-$	⇌	$2Cl^-$	+ 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
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 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
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**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 reducing ability/ (↓)

CAPS

TABLE 4B: STANDARD REDUCTION POTENTIALS

Increasing oxidising ability

Increasing reducing ability

Half-reactions			E° (V)
$Li^+ + e^-$	$\rightleftharpoons$	Li	$-3,05$
$K^+ + e^-$	$\rightleftharpoons$	K	$-2,93$
$Cs^+ + e^-$	$\rightleftharpoons$	Cs	$-2,92$
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	$-2,90$
$Sr^{2+} + 2e^-$	$\rightleftharpoons$	Sr	$-2,89$
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	$-2,87$
$Na^+ + e^-$	$\rightleftharpoons$	Na	$-2,71$
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	$-2,36$
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	$-1,66$
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	$-1,18$
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	$-0,91$
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	$-0,83$
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	$-0,76$
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	$-0,74$
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	$-0,44$
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	$-0,41$
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	$-0,40$
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	$-0,28$
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	$-0,27$
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	$-0,14$
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	$-0,13$
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	$-0,06$
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**0,00**
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	$+0,14$
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	$+0,15$
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	$+0,16$
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	$+0,17$
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	$+0,34$
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	$+0,40$
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$S + 2H_2O$	$+0,45$
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	$+0,52$
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	$+0,54$
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	$+0,68$
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	$+0,77$
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	$+0,80$
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	$+0,80$
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	$+0,85$
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	$+0,96$
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	$+1,07$
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	Pt	$+1,20$
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	$+1,23$
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	$+1,23$
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	$+1,33$
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	$+1,36$
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	$+1,51$
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	$+1,77$
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	$+1,81$
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	$+2,87$