Western Cape Government
Education

METRO CENTRAL EDUCATION DISTRICT

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

SEPTEMBER 2024

MARKS	**:**	**150**
TIME	**:**	**3 hours**
DATE	**:**	**11 SEPTEMBER 2024**

This question paper consists of 17 pages and 2 data sheets

INSTRUCTIONS AND INFORMATION

1. Write your Name and Surname on the first page of your ANSWER BOOK.

2. This question paper consists of **10 QUESTIONS**. Answer ALL the questions in the ANSWER BOOK.

3. Start EACH question on a NEW PAGE of your RULED A4 PAPER. Use BOTH sides of the page to avoid wasting paper.

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 or 2.1.1 and 2.1.2

6. You may use a non-programmable 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**. In multi-step calculations, intermediate steps, round of to four decimal places.

11. Give brief motivations, discussions, et cetera where required.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A – D) next to the question number (1.1 – 1.10) on your RULED A4 PAPER, for example 1.11 D.

1.1 The name of the functional group of propanoic acid is ....

A formyl.

B carboxyl.

C carbonyl.

D hydroxyl. (2)

1.2 Which ONE of the following compounds of comparable molecular mass, has the highest boiling point?

A Pentane

B Butan-2-one

C Propanoic acid

D Ethyl methanoate (2)

1.3 To which homologous series does a compound with molecular formula $C_6H_{12}O_2$ belong?

A Ketones

B Alcohols

C Aldehydes

D Esters (2)

1.4 Which ONE of the following is the CORRECT name for the addition reaction of water to an alkene?

A hydration

B hydrolysis

C dehydration

D hydrohalogenation (2)

1.5 Which of the following changes will take place if the temperature of a reaction mixture is increased?

I The rate of the reaction increases.
II The frequency of collisions increases.
III The average kinetic energy of the particles remains constant.

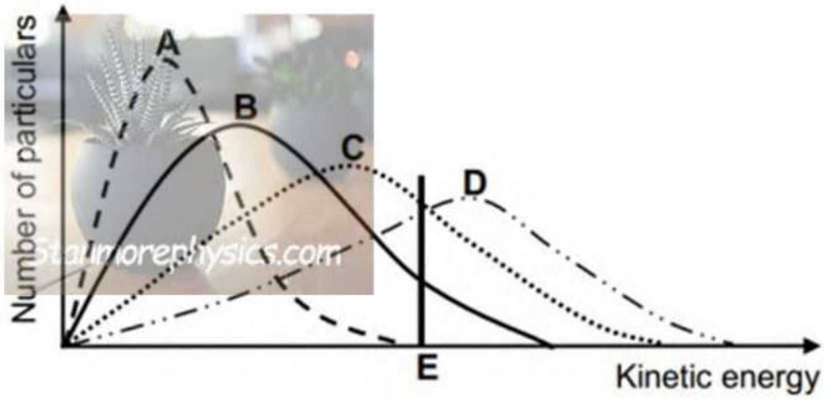
A I and II only

B I, II and III

C II and III only

D none the above (2)

1.6 The Maxwell-Boltzman energy distribution curves (**A**,**B**,**C** and **D**) below show the number of particles versus kinetic energy for a reaction at four different temperatures. The minimum kinetic energy needed for effective collisions to take place is represented by **E**.



Which ONE of the curves represents the reaction that will take place the fastest?

A Curve A

B Curve B

C Curve C

D Curve D (2)

1.7 Which ONE of the following is true regarding the concentration of products, for a chemical reaction that is already at equilibrium, assuming no disruptions to the equilibrium?

A The concentrations of products will not change because there are no more reactants.

B The concentrations of products will not change because the limiting reagent is used up completely.

C The concentrations of products will not change because the forward and reverse rates are equal.

D The concentrations of products will change continually because of reversibility. (2)

1.8 Consider the reactant **Z** in the following reaction:

$$\mathbf{Z} + H_2O \rightleftharpoons H_3O^+ + HPO_4^{2-}$$

The formula of **Z** is:

A PO_4^{3-}

B HPO_4^-

C $H_2PO_4^-$

D H_3PO_4 (2)

1.9 Which ONE of the following salt solutions can be stored in an aluminium Container without a chemical reaction taking place?

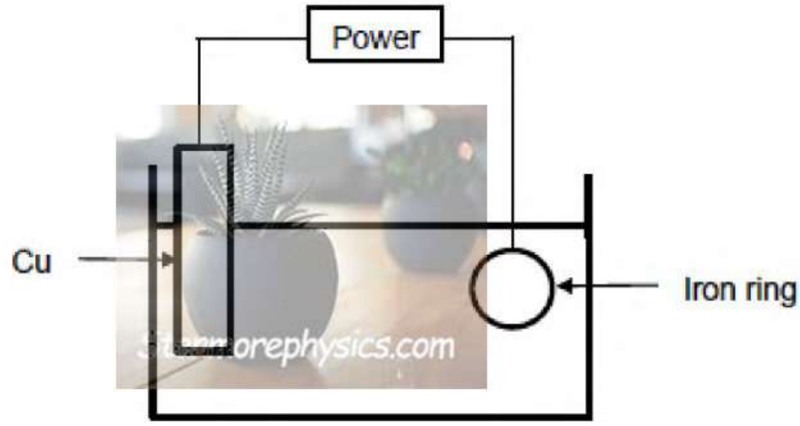
A $CuSO_4(aq)$

B $ZnSO_4(aq)$

C $NaC\ell(aq)$

D $Pb(NO_3)_2(aq)$ (2)

1.10 The electrolytic cell shown below is used during the electroplating of an iron ring with copper.



Which ONE of the following combinations is CORRECT regarding the CONCENTRATION of the electrolyte and the type of POSITIVE ION in the electrolyte when the cell is operating?

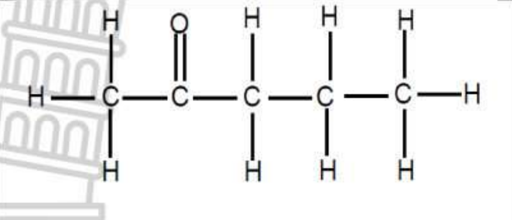
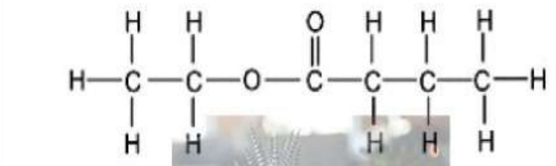
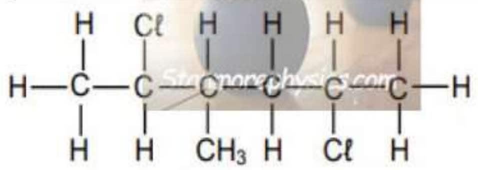
	CONCENTRATION OF ELECTROLYTE	POSITIVE IONS
A	Remains the same	Cu^{2+}
B	Remains the same	Fe^{2+}
C	Increases	Fe^{2+}
D	Increases	Cu^{2+}

(2)

[20]

QUESTION 2 **(Start on a NEW page)**

The letters **A** to **F** in the table below represent SIX (6) organic compounds:

A		**B**	
C	4,4-dimethylpent-2-yne	**D**	
E	$CH_3CH_2C(CH_3)CH_3$ | OH	**F**	$C_{10}H_{22}$

Use the information in the table (where applicable) to answer the questions that follow.

2.1 Define the term *positional isomer*. (2)

2.2 Write down the IUPAC name of the POSITIONAL isomer of compound **A**. (2)

2.3 Draw the structural formula of:

2.3.1 The FUNCTIONAL ISOMER of compound **B**. (2)

2.3.2 Compound **C**. (3)

2.4 Write down the IUPAC name of compound **D**. (3)

2.5 Compound **F** ($C_{10}H_{22}$) reacts at high temperatures and pressures to form a 2-carbon alkene **X** and an alkane **Y**, as shown below:

$$C_{10}H_{22} \rightarrow \mathbf{X} + \mathbf{Y}$$

Write down the:

2.5.1 Type of reaction that takes place (1)

2.5.2 MOLECULAR FORMULA of compound **Y** (2)

[15]

QUESTION 3 **(Start on a NEW page)**

Grade 12 learners investigate one of the factors that influence the vapour pressure of straight chain alkanes. They use equal amounts of each of the alkanes and the results of their investigation are shown below.

Compound	Relative Molecular Mass (amu)	Vapour Pressure at 25 °C (kPa)
X	58	207
Y	86	16
Z	114	2

3.1 Define the term *vapour pressure*. (2)

3.2 For the above investigation, write down:

3.2.1 An investigative question. (2)

3.2.2 The conclusion that can be made from the recorded data. (1)

3.3 Explain fully the trend shown in the table above by referring to the STRUCTURE, STRENGTH OF INTERMOLECULAR FORCE and the ENERGY needed. (3)

3.4 The molecular mass of propanal is 58 amu and is comparable to that of compound **X**. Which compound between propanal and compound **X** will have a higher vapour pressure?

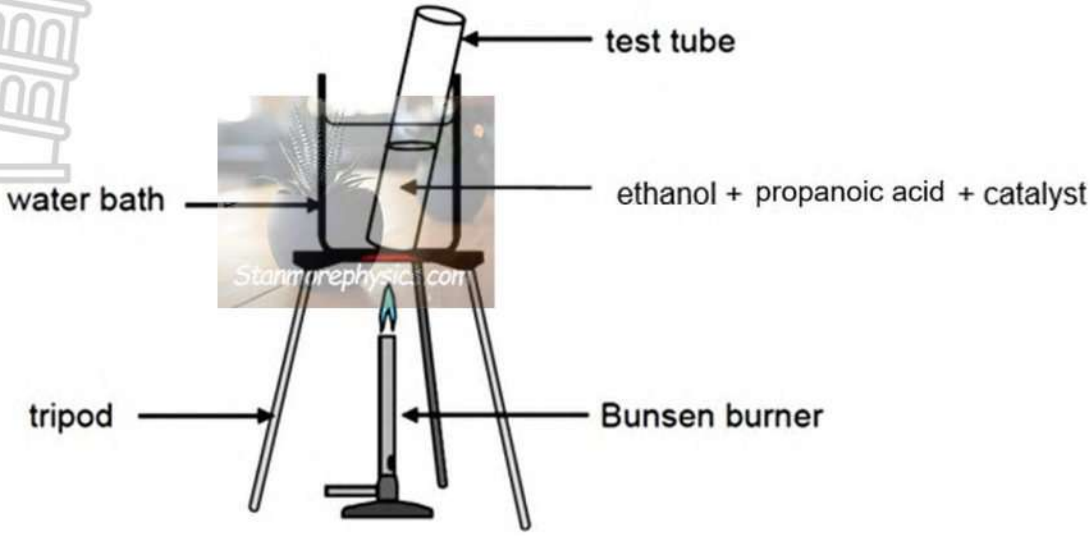
Fully explain the answer by referring to the STRUCTURE, STRENGTH of INTERMOLECULAR FORCES and the ENERGY needed. (4)

3.5 The empirical formula for compound **Z** is C_4H_9. Determine the molecular formula of compound **Z**. Show all calculations. (2)

[14]

QUESTION 4 (Start on a NEW page)

4.1 In an experiment, a test tube containing propanoic acid, ethanol and a catalyst is heated in a water bath as shown below:



Write down:

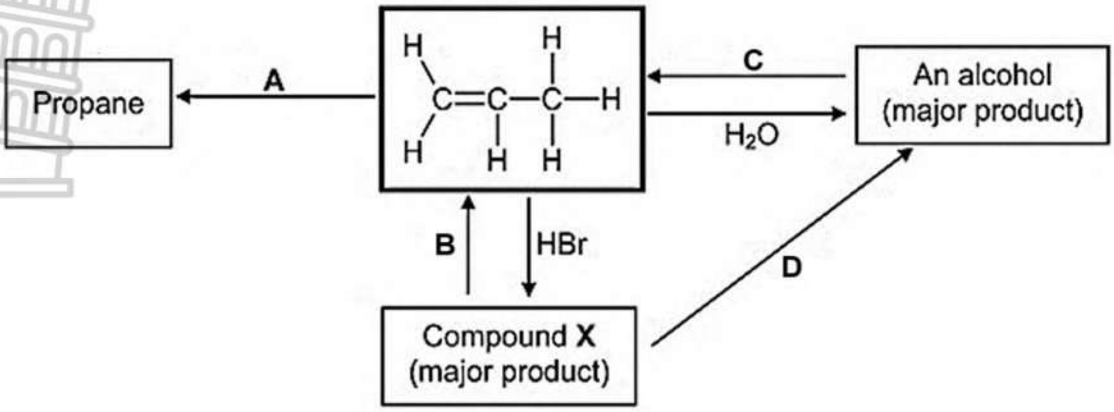
4.1.1 The NAME or FORMULA of the catalyst. (1)

4.1.2 The type of reaction taking place. Choose from ESTERIFICATION or COMBUSTION. (1)

4.1.3 ONE reason why the use of a water bath is preferred in this experiment. (1)

4.1.4 The balanced chemical equation for this reaction using STRUCTURAL FORMULAE (5)

4.2 Consider the flow diagram below showing the interconversion of organic molecules through organic reactions and answer the questions that follow. **X** is an organic compound and **A** – **D** are organic reactions.



Write down:

4.2.1 The NAME or FORMULA of the inorganic reactant in reaction **A** (2)

4.2.2 The IUPAC name of compound **X** (2)

4.2.3 The type of reaction represented by reaction **B** (1)

4.2.4 The NAME or FORMULA of the catalyst used in reaction **C** (1)

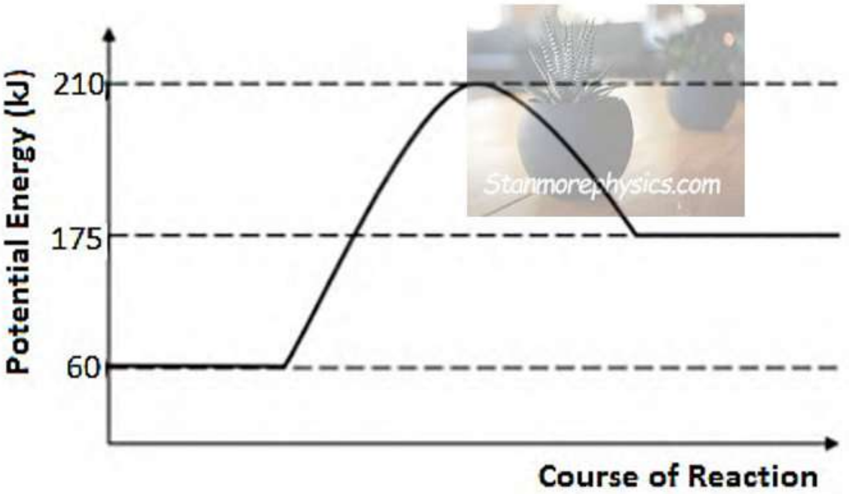
4.2.5 The type of SUBSTITUTION reaction represented by reaction **D** (1)

4.2.6 The type of haloalkane represented by compound **X**
(Choose from PRIMARY, SECONDARY or TERTIARY) (1)

[16]

QUESTION 5 **(Start on a NEW page)**

A learner conducts a practical investigation to test whether the dissolution of solid sodium chloride is **exothermic** or **endothermic**. The apparatus used includes a beaker, a salt and a certain measuring instrument. The graph below shows the energy changes that occur when sodium chloride dissolves in water:



5.1 For this reaction, calculate:

5.1.1 The heat of the reaction of the forward reaction (1)

5.1.2 Activation energy of the REVERSE reaction (1)

5.2 In another experiment, a learner adds a suitable catalyst. On addition of the catalyst, state whether the following will INCREASE, DECREASE or REMAIN THE SAME:

5.2.1 Potential energy of the products (1)

5.2.2 Activation energy (1)

5.3 Explain how the addition of a suitable catalyst will affect the rate of a chemical reaction. (2)

[6]

QUESTION 6 **(Start on a NEW page)**

One of the reactions in the production of sulphuric acid is the roasting (heating in oxygen) of a metal ore that contains lead (II) sulphide according to the equation below. The $SO_2(g)$ produced, is then reacted further to produce sulphuric acid.

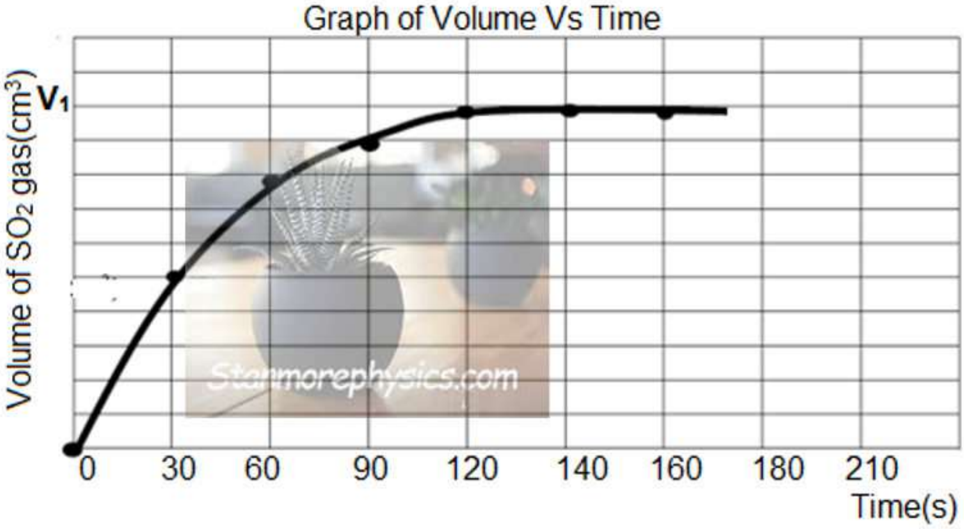
$$2PbS(s) + 3O_2(g) \rightarrow 2PbO(s) + 2SO_2(g) \;\ldots\ldots\ldots\ldots\; \Delta H < 0$$

6.1 When particles collide, state TWO conditions that need to be met for the collisions to be effective collisions. (2)

6.2 Define *reaction rate*. (2)

6.3 State THREE ways in which the rate of this reaction could be increased. (3)

6.4 The reaction is simulated in a laboratory using EXCESS $O_2(g)$ and a graph showing the volume of SO_2 produced versus time is drawn.



6.4.1 Suggest a reason, why the graph flattens at t =120 s. (1)

6.4.2 If the average rate of production of SO_2 is 600 $cm^3 \cdot s^{-1}$, calculate the value of $\mathbf{V_1}$ (3)

6.4.3 If 1,7 kg PbS ore is used and the molar volume of gas at this reaction temperature is 26 490 $cm^3 \cdot mol^{-1}$, calculate the percentage purity of the ore. (6)

[17]

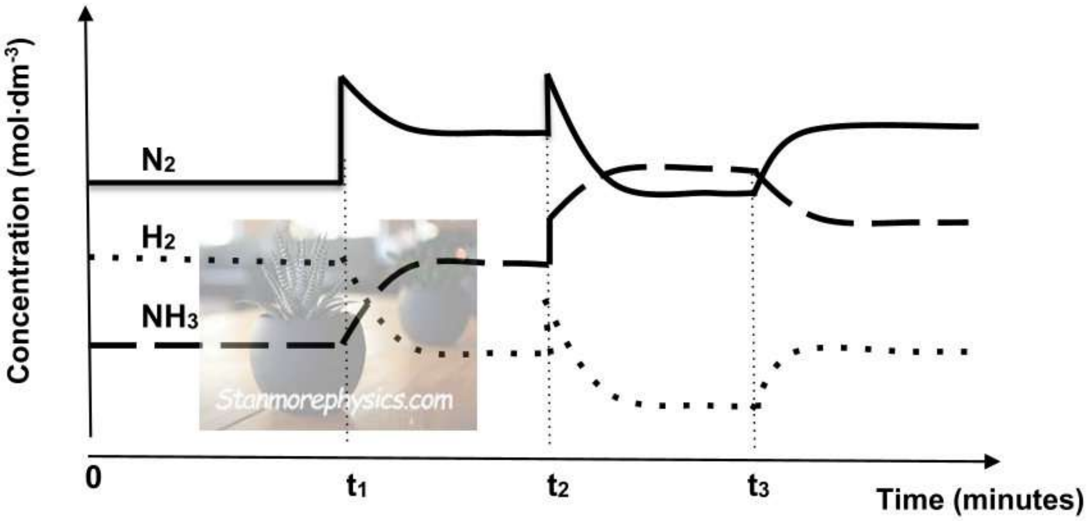
QUESTION 7 (Start on a NEW page.)

A fertiliser company produces ammonia on a large scale at a temperature of 450°C. The balanced equation below represents the reaction that takes place in a sealed container. The reaction below occurs in the presence of Iron as a *catalyst*.

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

7.1 Explain what a *catalyst* is. (1)

To increase the yield of ammonia, engineers make adjustments to the TEMPERATURE, PRESSURE and CONCENTRATION of the equilibrium mixture. The graph below of concentration vs time (not drawn to scale) represents the results obtained.



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

7.3 Identify the FACTOR which affects the equilibrium mixture at each of the following times AND then state whether that factor was INCREASED or DECREASED.

7.3.1 t_1 (2)

7.3.2 t_2 (2)

7.3.3 t_3 (2)

7.4 A chemist in a laboratory injects an **unknown mass** of N_2 and 11 mol H_2 into a 5 dm^3 sealed empty container at temperature **T**. Upon analysis of the equilibrium mixture, they find that the number of moles of NH_3 is 1,2 mol. The equilibrium constant (Kc) at temperature **T** for this reaction is $9,45 \times 10^{-3}$.

Calculate the initial mass of N_2 that was added to the container. (8)

[17]

QUESTION 8 (Start on a NEW page.)

8.1 NH_3 reacts with $HC\ell$ to form a salt as shown below:

$$NH_3(g) + HC\ell(g) \rightarrow NH_4C\ell\ (s)$$

8.1.1 Identify the base in the above equation (1)

8.1.2 Give a reason for your answer in QUESTION 8.1.1 (1)

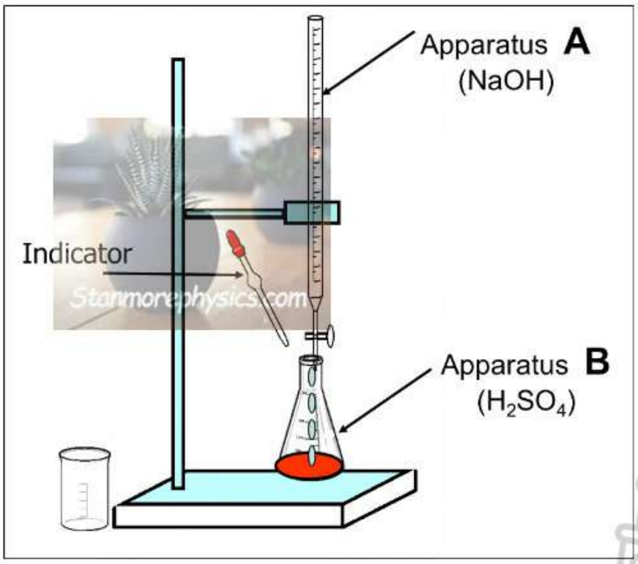
8.1.3 Write down the name of the salt formed. (1)

8.2 $NH_4C\ell$ can undergo hydrolysis.

8.2.1 Define the term *hydrolysis*. (2)

8.2.2 Write down a balanced equation for the hydrolysis of $NH_4C\ell$ and indicate whether the solution will be ACIDIC, ALKALINE or NEUTRAL. (3)

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



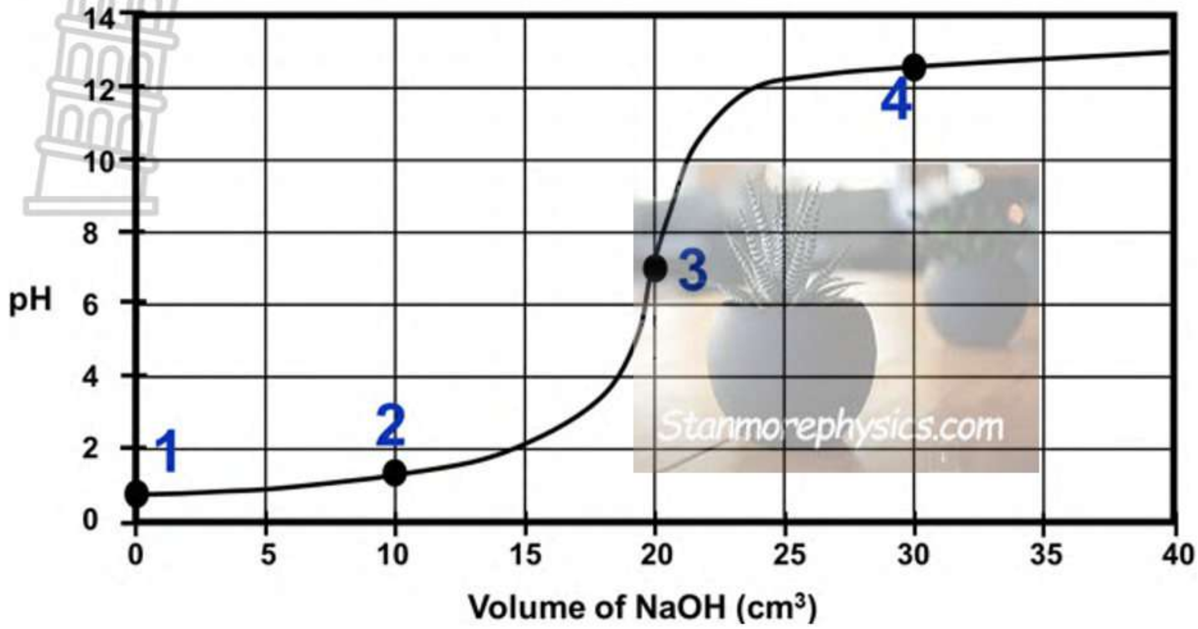
The balanced equation for the reaction is:

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(\ell)$$

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

8.3.2 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.



8.3.3 Give the name of the position labelled **3** on the graph Choose from EQUIVALENCE POINT or END POINT. (1)

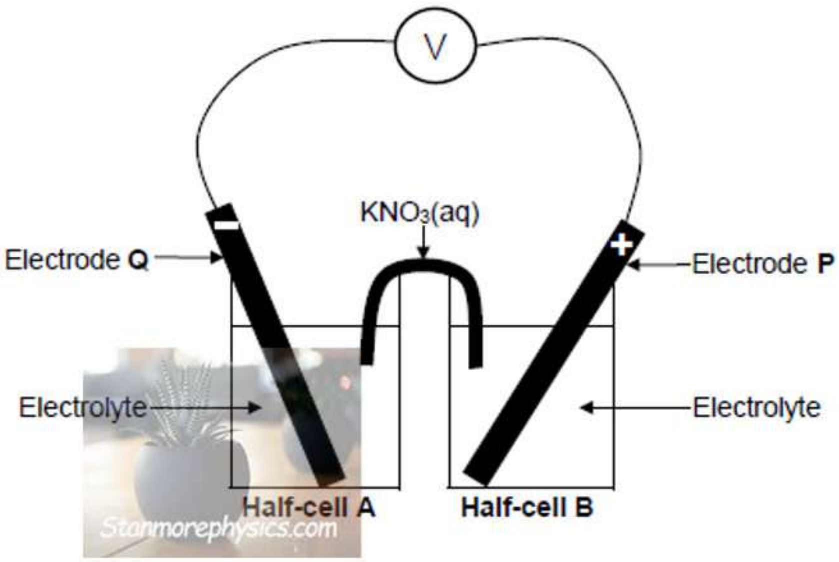
Use the graph and the information provided earlier to calculate:

8.3.4 The original concentration of the sulphuric acid (5)

8.3.5 The pH of the solution at the point labelled **4** on the graph (7)
[23]

QUESTION 9 **(Start on a NEW page.)**

Learners set up an electrochemical cell, shown in the simplified diagram below, using Calcium (Ca) and tin (Sn) as electrodes. Nitrate ion solutions are used as electrolytes in both half-cells and the cell is under standard conditions.



9.1. Define a *redox reaction*. (2)

9.2. Which electrode, **P** or **Q**, is tin? (1)

9.3. Write down:

9.3.1. ONE standard condition under which this cell functions, besides concentration. (1)

9.3.2. The cell notation for this cell. (3)

9.3.3. The NAME or FORMULA of the reducing agent in the cell. (1)

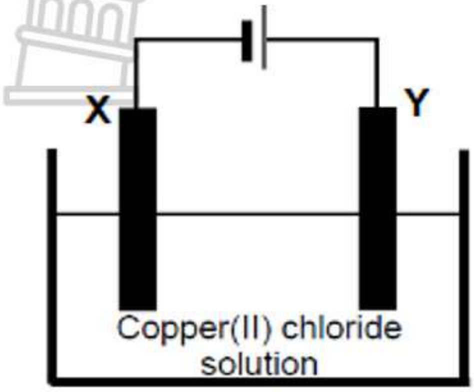
9.4. Calculate the initial EMF of the cell above under standard conditions. (3)

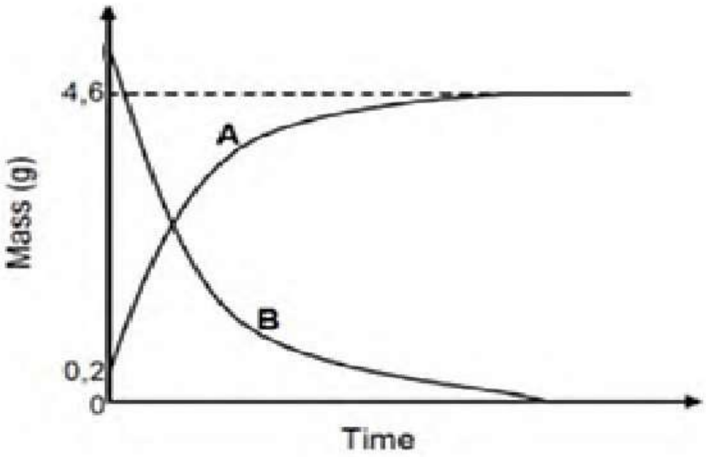
9.5. How will the voltmeter reading change if the initial concentration of the electrolyte in half-cell **B** is increased?
(Write down only INCREASES, DECREASES or REMAINS THE SAME.) (1)

[12]

QUESTION 10 **(Start on a NEW page.)**

The electrochemical cell below is set up to demonstrate the purification of copper. The graphs below show the change in mass of the electrodes whilst the cell is in operation.





10.1 Define the term *electrolyte*. (2)

10.2 Which graph, **A** or **B**, represents a change in mass of the cathode? (1)

10.3 Write down the half-reaction taking place at the anode. (2)

10.4 If the process takes 5 minutes to reach completion, determine the rate of formation of copper in $mol \cdot s^{-1}$. (5)

[10]

TOTAL 150 MARKS

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 Molêregasvolume 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* $E^{\theta}_{cell} = E^{\theta}_{oxidising agent} - E^{\theta}_{reducing agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	
$I=\frac{Q}{\Delta t}$	$n=\frac{Q}{q_e}$ where n is the number of electrons/ *waar n die aantal elektrone is*

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

KEY/*SLEUTEL*

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

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

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

TABLE 4A: STANDARD REDUCTION POTENTIALS

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↑

Increasing reducing ability/*Toenemende reduserende 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

TABLE 4B: STANDARD REDUCTION POTENTIALS

Increasing oxidising ability/*Toenemende oksiderende 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
$\mathbf{2H^+ + 2e^-}$	⇌	$\mathbf{H_2(g)}$	**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

Increasing reducing ability/*Toenemende reduserende vermoë* ↑

METRO CENTRAL EDUCATION DISTRICT

PHYSICAL SCIENCES P2 MARKING GUIDELINES

SEPTEMBER 2024

QUESTION 1

1.1	B	✓✓	(2)
1.2	C	✓✓	(2)
1.3	D	✓✓	(2)
1.4	A	✓✓	(2)
1.5	A	✓✓	(2)
1.6	D	✓✓	(2)
1.7	C	✓✓	(2)
1.8	C	✓✓	(2)
1.9	C	✓✓	(2)
1.10	A	✓✓	(2)

QUESTION 2

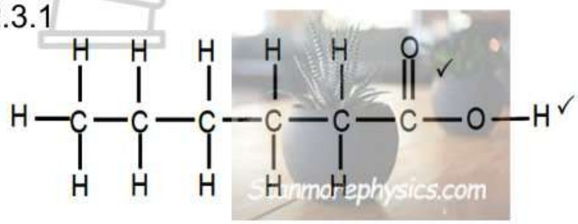
2.1 Compounds with the same molecular formula✓ but different POSITIONS of the functional group / side chain / substituents (Any one) ✓on parent chain. (2)

2.2 Pentan-3-one ✓✓
[accept: 3-pentanone]

✓ pentan
✓ -3-one

(2)

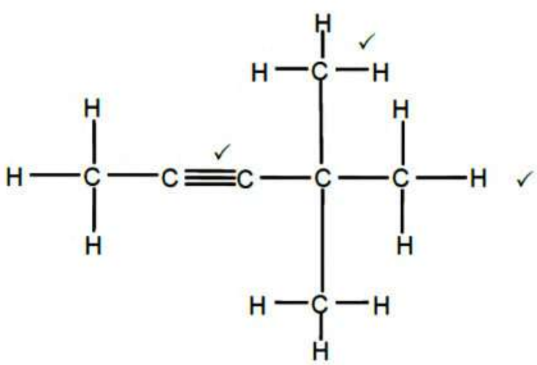
2.3.1



✓ 6 C chain with all bonds and **11** H
✓ functional group: Must show bond from O to H.

(2)

2.3.2



✓ alkyne functional group on carbon 2
✓ 5 C chain with all bonds and **12** H
✓ 2 methyl groups on carbon 4

(3)

2.4 2,5-dichloro-3-methylhexane ✓ ✓ ✓ (3)

✓ Correct stem i.e. hexane.
✓ All substituents (chloro and methyl) correctly identified.
✓ IUPAC name completely correct including numbering, sequence, hyphens and commas.

2.5.1 Cracking/Elimination ✓ (1)

2.5.2 C_8H_{18} (2 or zero) ✓✓ (2)

[15]

QUESTION 3

3.1 The pressure exerted by a vapour at equilibrium with its liquid ✓in a closed system ✓ [accept Isolated system] (2)

3.2

3.2.1 What is the relationship between the (relative) molecular mass / (chain length / number of C-atoms) and the vapour pressure of (straight chain) alkanes?
OR
What effect does an increase / decrease in (relative) molecular mass have on the vapour pressure of (straight chain) alkanes? ✓✓(2 or 0)

(2)

Criteria for Investigative question
A question is asked concerning the relationship of the dependent and independent variables✓✓

3.2.2 The higher the molecular mass, the lower the vapour pressure ✓ **OR** Vapour pressure decreases with increasing molecular mass / chain length / number of C-atoms ✓ (1)

3.3 **FROM X TO Z**

- Molecular mass / Chain length / surface area increases ✓
- The number of London forces increases
  OR
  Increasing strength of the Intermolecular forces. ✓
- More energy needed to overcome *(not to break)* the intermolecular forces. ✓
  ∴ Vapour pressure decreases (3)

3.4 **X** / butane / alkane (will have a *higher* vapour pressure than propanal.) ✓

- **X** (butane / alkane) has London/dispersion/induced dipole forces only
- Propanal (aldehydes) has dipole dipole forces (in addition to London/dispersion) between its molecules ✓
- London forces are *weaker* intermolecular forces than dipole dipole forces ✓
- Less energy needed to overcome intermolecular forces in **X** / alkanes ✓

∴ X (alkane) has higher vapour pressure

(4)

OR

Propanal will have a lower vapour pressure than X. ✓

- **X** / Alkane / butane) has London/dispersion/induced dipole forces only
- Propanal (aldehydes) has dipole-dipole forces (in addition to London/dispersion) between its molecules) ✓
- Dipole dipole forces are stronger intermolecular forces than London forces/dispersion/induced dipole. ✓
- More energy needed to overcome intermolecular forces in propanal ✓
- ∴ Propanal (aldehydes) has a lower vapour pressure than X.

3.5 (a) Empirical mass: C + H: (4x12 + 9x1) = 57 $g{\cdot}mol^{-1}$

(b) Ratio $= \frac{114}{57} = 2$ ✓ (2)

(c) Molecular formula: C_8H_{18} ✓ (If Answer only given: 2 marks).

[14]

QUESTION 4

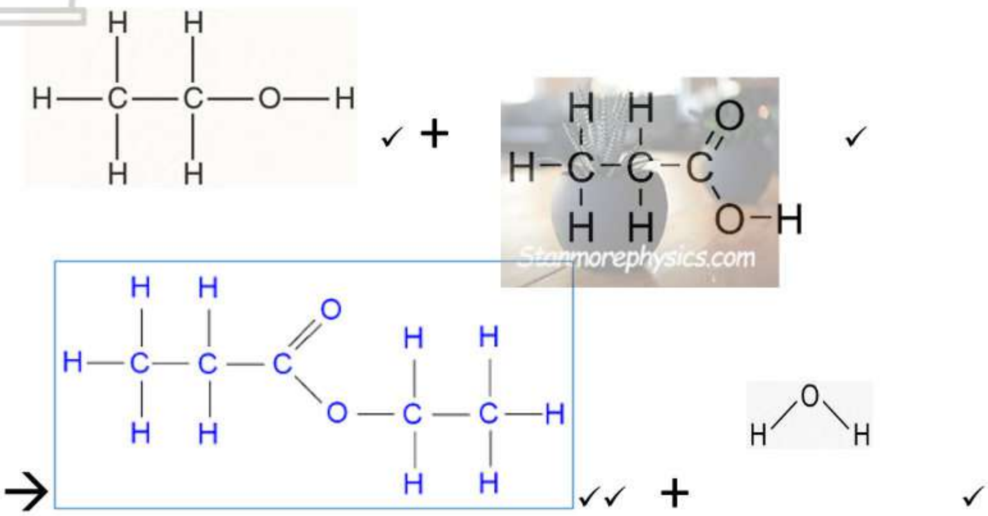
4.1.1 Sulphuric acid / H_2SO_4 ✓ [ACCEPT: phosphoric acid / H_3PO_4] (1)

4.1.2 Esterification ✓ (1)

4.1.3 Reactants are flammable under direct heat. ✓

ACCEPT: Reactants evaporate (1)

4.1.4



(Only penalize once for -OH.)

(For water: must show the bent shape.)

(If hydrogens missing in all: penalize once.) (5)

4.2.1 Hydrogen gas / H_2 ✓✓ (Hydrogen: 1 mark ✓. H: zero marks.) (2)

4.2.2 2-bromopropane ✓✓ [2-bromo ✓ propane ✓] (2)

4.2.3 Elimination / dehydrohalogenation / dehydrobromination ✓ (1)

4.2.4 Sulphuric acid / Hydrogen sulphate / H_2SO_4 / phosphoric acid / H_3PO_4 ✓ (1)

4.2.5 Hydrolysis ✓ (1)

4.2.6 Secondary ✓ (1)

[16]

QUESTION 5

5.1.1 $\Delta H = H_{Products} - H_{reactants}$
$= 175 - 60$
$= 115$ kJ ✓ (1)

5.1.2 $E_a = 210 - 175$
$= 35$ kJ ✓ (1)

(In the above, penalize only once for units.)

5.2.1 Remain the same ✓ (1)

5.2.2 Decrease ✓ (1)

5.3 The addition of a suitable catalyst decreases the activation energy. ✓
Therefore there will be more effective collisions per unit time which increases rate of reaction. ✓

OR

Provides an alternative pathway for reacting molecules ✓
Therefore there will be more effective collisions per unit time which increases rate of reaction. ✓

OR

There will be more particles having kinetic energy greater than the activation energy / sufficient kinetic energy. ✓
Therefore there will be more effective collisions per unit time which increases rate of reaction. ✓ (2)

[6]

QUESTION 6

6.1 Correct orientation ✓ and sufficient kinetic energy ✓(to overcome activation energy) (2)

6.2 Change in concentration of reactant or product ✓ per unit time. ✓ (2)

6.3 ANY 3 BELOW:
- Increase surface area of PbS / break up the PbS into smaller pieces
- Increase concentration of O_2 / Add more O_2
- Increase temperature
- Add a suitable catalyst
- Increase in pressure of O_2 ✓✓✓ (3)

6.4.1 Reaction has stopped / Reaction run to completion / PbS(s) is used up / Limiting reagent is used up / One of the reactants is used up. ✓ (1)

6.4.2 $\text{rate} = \frac{\Delta\text{volume}}{\Delta\text{time}}$ ✓

$600 = \frac{V_1 - 0}{120 - 0}$ ✓ (Accept any time until 130 s).

$V_1 = (600)(120)$

$= 72\ 000\ (cm^3)\ /\ 7{,}2 \times 10^4\ (cm^3)$ [Range: 72 000 cm^3 - 78 000 cm^3] ✓(3)

6.4.3 **POSITIVE MARKING FROM 6.4.2**

(a) $n(SO_2) = \frac{V}{V_M}$ ✓ (Or second formula: $n(\text{PbS}) = \frac{m}{M_r}$)

$= \frac{72000}{26490}$ ✓ **OR** $= \frac{72}{26{,}490}$ ✓

$= 2{,}718$ moles of $SO_2(g)$

(b) $n(SO_2) : n(PbS)$

2 : 2 ✓

$n(PbS) = 2{,}718$ mol of PbS

(c) $n(\text{PbS}) = \frac{m}{M_r}$

$2{,}718 = \frac{m}{207+32}$ ✓

$\therefore m_{PbS} = 649{,}603$ g [Range 649,60 – 650,08 g]

(d) Percentage purity $= \frac{649{,}603}{1700} \times \frac{100}{1}$ **OR** $\frac{0{,}649603}{1{,}7} \times \frac{100}{1}$ ✓

$= 38{,}21\%$ ✓ [Range: 38,21% - 38,24%]

OR

OR

(a) $n(PbS) = \frac{V}{V_M}$ ✓ (Or second formula: $n(PbS) = \frac{m}{M_r}$)

$= \frac{1700}{239}$ ✓

= 7,1129 moles of PbS(s)

(b) n(PbS) : n(SO_2)

2 : 2 ✓

n(PbS) = 7,1129 mol of SO_2

(c) $n(SO_2) = \frac{V}{V_m}$

$7{,}1129 = \frac{V}{26490}$ ✓

$\therefore V_{SO2}$ = 188 420,721 cm^3 [Range 188 343,9 – 188 423,37 g]

(d) Percentage purity $= \frac{72\,000}{188\,420{,}721} \times \frac{100}{1}$ ✓

= 38,21% ✓ [Range: 38,21% - 38,24%] (6)

[17]

QUESTION 7

7.1 It is a substance that increases the rate of a chemical reaction without itself undergoing a permanent change.
OR
A catalyst increases the rate of a reaction by providing an alternative path of lower activation energy ✓ (1)

7.2 <u>When the equilibrium</u> in a <u>closed system is disturbed</u>, the system will <u>re-instate a new equilibrium</u> ✓ by favouring the reaction that will <u>oppose the disturbance</u>. ✓ (2)

In 7.3: First part must be correct in order to get the second mark.

7.3.1 Concentration of N_2 ✓ was increased ✓ (2)

7.3.2 Pressure ✓ was increased ✓ (2)

7.3.3 Temperature ✓ was increased ✓ (2)

7.4 Marking criteria:

- Use of n = m/M ✓
- $n(NH_3)$ at equilibrium = 1,2 mol✓
- Using molar ratio 1:3:2✓
- $n(N_2)$ at equilibrium (initial – change)✓
- $n(H_2)$ at equilibrium (initial – change)✓
- Divide by volume✓ (5 dm^3)
- K_c expression✓
- Substitution into K_c expression✓
- Final answer✓

	N_2	H_2	NH_3	
Ratio	1	3	2	
Initial moles(n_i)	x	11	0	
Change in moles (Δn)	**0,6**	**1,8**	1,2	Use ratio ✓
Eq moles (n_i)	**x-0,6**	**9,2**	**1,2**	Entire row ✓
Eq conc C=n/v ($mol \cdot dm^{-3}$)	$\frac{x-0,6}{5}$	**1,84**	**0,24**	Divide by 5 ✓

(a) $Kc = \frac{[NH_3]^2}{[N_2][H_2]^3}$ ✓ Kc expression

$9,45 \times 10^{-3}$ ✓ = $\frac{(0,24)^2}{(\frac{x-0,6}{5})(1,84)^3}$ ✓ Sub left and Sub right

x = 5,4922 moles of N_2

(b) $m(N_2)$ = n x M

= (5,4922)(28) ✓ Sub. mark

= 153,782 g ✓ [Range: 153,782 g – 153,783 g]

OR

OR

	N_2	H_2	NH_3	
Ratio	1	3	2	
Initial moles(n_i)	5,4922	11	0	
Change in moles (Δn)	**0,6**	**1,8**	**1,2**	Use ratio ✓
Eq moles (n_i)	4,8922	**9,2**	**1,2**	9,2 and 1,2 ✓
Eq conc C=n/v ($mol \cdot dm^{-3}$)	0,9784	1,84	0,24	Divide by 5 ✓

(a) $Kc = \frac{[NH_3]^2}{[N_2][H_2]^3}$ ✓

$9,45 \times 10^{-3}$ ✓ $= \frac{(0,24)^2}{[N_2](1,84)^3}$ ✓

$[N_2] = 0,9784$ ($mol \cdot dm^{-3}$)

(b) $m(N_2) = n \times M$

$= (5,4922)(28)$ ✓

$= 153,782$ g ✓ [Range: 153,782 g – 153,783 g] (8)

[17]

QUESTION 8

8.1

8.1.1 NH_3 / Ammonia ✓ (1)

8.1.2 It's a proton / H^+ / Hydrogen ion acceptor ✓ (1)

8.1.3 Ammonium chloride ✓ (1)

8.2 8.2.1 Hydrolysis is the reaction of a salt with water. (2 or 0) ✓✓ (2)

8.2.2 $NH_4^+ (aq) + H_2O (\ell)$ ✓ $\rightarrow H_3O^+ (aq) + NH_3 (aq)$ ✓
Due to the formation of hydronium ions (H_3O^+) the solution is acidic ✓ (3)

8.3.1 Burette. ✓ (1)

8.3.2 Yellow to Blue ✓ (1)

8.3.3 Equivalence point ✓ (1)

What is the endpoint and equivalence point in titration?
Equivalence point refers to the point at which the chemical reaction comes to a stop, whereas **endpoint** refers to the point at which the colour change in a system or solution occurs.

As an example, take a strong acid solution as an analyte that is titrated with a strong base. In this case, the pH of the analyte starts out very low (as the analyte solution is a strong acid). As strong base is titrated into the solution, the pH increases slightly but in general will not change much. However, at some point the number of moles of base that have been added to the solution will be equal to the number of moles of acid in the original analyte. At this point the pH will change very dramatically as the solution will now be neutral. After this adding any more of the strong base will rapidly make the solution basic. It is the very large change in pH over a small range of the added titrate volume that is the reason to perform a titration. The point at which the number of moles of added base are equal to the number of moles of acid in the analyte solution is called the *equivalence point*. It is easy to identify this point in a titration because it is the volume at which the pH is rapidly changing. Technically, the equivalence point is where the titration curve exhibits an inflection point. At this point the curve has the steepest slope. The volume at the equivalence point can be used with the known concentration of the titrant to determine how many moles have been added to the solution. At the equivalence point the moles of added base will be equal to the moles of original acid, this allows the determination of the number of moles of original acid. This can then be combined with the original volume of the analyte solution to determine its concentration. In practice it is very important to use small aliquots to accurately determine the exact volume at the equivalence point.

8.3.4

Marking criteria:

- $c = \frac{n}{V}$ OR $\frac{c_a \times V_a}{c_b \times V_b} = \frac{n_a}{n_b}$ ✓
- Correct substitution ✓
- Ratio of moles ✓
- Substitution of 25 ml (0,025 dm^3)
- Final answer: 0,08 mol ✓

OPTION 1

(a) $c(NaOH) = \frac{n}{V}$ ✓

$0{,}2 = \frac{n}{0{,}02}$ ✓

$= 0{,}004$ mol NaOH

(b) $n(H_2SO_4) = \frac{1}{2} n(NaOH)$

$= \frac{1}{2} \times 0{,}004$ ✓

$= 0{,}002$ mol

(c) $c(H_2SO_4) = \frac{0{,}002}{0{,}025}$ ✓

$= 0{,}08\ mol \cdot dm^{-3}$ ✓

OPTION 2

$\frac{c_a \times V_a}{c_b \times V_b} = \frac{n_a}{n_b}$ ✓

$\frac{c_a \times 25 ✓}{0{,}2 \times 20 ✓} = \frac{1}{2}$ ✓

$c(H_2SO_4) = 0{,}08\ mol \cdot dm^{-3}$ ✓

<u>OPTION 3</u>

Value read from graph: [Range for pH: 0,7 – 0,9]

(a) $pH = -\log[H_3O^+]$ ✓

$0{,}8 = -\log[H_3O^+]$ ✓

$[H_3O^+] = 0{,}1585\ mol.dm^{-3}$ ✓

(b) $[H_3O^+] : [H_2SO_4]$

2 : 1 ✓

(c) $[H_2SO_4] = 0{,}079\ mol.dm^{-3}$ ✓

[Range: 0,063 $mol \cdot dm^{-3}$ - 0,0998 $mol \cdot dm^{-3}$] (5)

8.3.5

Marking Guideline

- Formula $c = \frac{n}{V}$ / $c_1V_1 = c_2V_2$ ✓
- Substitution of (30 – 20) = 10 ml (0,01) ✓
- Substitution of (30+25) = 55 ml (0,055) ✓
- Using K_w to find $[H_3O^+]$ ✓
- Formula pH = -log$[H_3O^+]$ ✓
- Substitution of $[H_3O^+]$ ✓
- Final answer: 12.56 ✓

<table>
<tr><th>OPTION 1</th><th>OPTION 2</th><th>OPTION 3</th></tr>
<tr>
<td>(a)
$c(NaOH) = \frac{n}{V}$ ✓
$0,2 = \frac{n}{(0.03-0,02)}$ ✓
n = 0,002 mol
$c(NaOH) = \frac{0,002}{(0,03+0,025)}$ ✓
= 0,03636 mol·dm^{-3}</td>
<td>(a)
$c_1V_1 = c_2V_2$ ✓
(0,2)(0,03 – 0,02) ✓ =
c_2(0,055) ✓
c_2 = 0,03636 mol·dm^{-3}</td>
<td>$n_{initial} = c.V$ ✓
= (0,2)(0,03)
=0,006 mol
$n_{reacted} = c.V$
= (0,2)(0,02)
= 0,004 mol
$n_{excess} = n_{initial} - n_{re}$
= 0,006 – 0,004 ✓
= 0,002 mol
$C = \frac{n}{v}$
$= \frac{0,002}{0,055}$ ✓
=0,03636 mol·dm^{-3}</td>
</tr>
<tr>
<td colspan="2">(b) NaOH → Na^+ + OH^- (Ratio 1: 1)
$[OH^-]$ = 0,03636 mol·dm^{-3}

(c) $K_w = [H_3O^+][OH^-]$ = 1x10^{-14}
$[H_3O^+] = \frac{1x10^{-14}}{0,03636}$ ✓
= 2,75 x 10^{-13} mol·dm^{-3}

(d) pH = - log$[H_3O^+]$ ✓
= - log(2,75 x 10^{-13}) ✓
= 12,56 ✓</td>
<td></td>
</tr>
</table>

(7)

Accept if pOH is calculated **[23]**

QUESTION 9

9.1 Redox reaction is where there is a transference/movement of electrons. ✓✓ (2)

OR

A type of chemical reaction in which the oxidation numbers of atoms are changed ✓✓

9.2 Electrode P ✓ (1)

9.3.1 Temperature: 25 ºC or 298K ✓ [Must give value of temperature]. (1)
[**No mark for pressure]**

9.3.2 $Ca(s) \mid \underset{(1\ mol.dm^{-3})}{Ca^{2+}(aq)} \parallel \underset{(1\ mol.dm^{-3})}{Sn^{2+}(aq)} \mid Sn(s)$

NOTE: no deductions if 1 mol.dm^{-3} or state of matter omitted
Marking Criteria
✓ anode (reducing agent I oxidised species)
✓ salt bridge ||
✓ cathode (II oxidising agent I reduced species) (3)

(1)

9.3.3 Ca or Calcium ✓

9.4 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$

$E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ any formula ✓

$E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$

$= (-0,14) - (-2,87)$ ✓

$= 2,73V$ ✓ (3)

9.5 Increase ✓ (1)

[12]

QUESTION 10

10.1 A substance of which the aqueous solution contains ions ✓ which conducts electricity ✓
OR
A substance that dissolves in water ✓ to give a solution that conducts electricity ✓
OR
A solution that conducts electricity ✓ through the movement of ions. ✓ (2)

10.2 A. ✓ (1)

10.3 $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ ✓✓ (2)

10.4

OPTION 1

(a) $n = \frac{m}{M}$ ✓

$= \frac{(4,6-0,2)}{63,5}$ ✓

$= 0,06929$ mol

(b) $\text{rate} = \frac{\triangle n}{\triangle t}$ ✓ $= \frac{n_f - n_i}{t_f - t_i}$

$= \frac{(0,06929-0)}{(300-0)}$ ✓

$= 0,00023 \text{ mol·s}^{-1}$ $(2,3 \times 10^{-4} \text{ mol·s}^{-1})$ ✓

OPTION 2

(a) $n_i = \frac{m}{M_R}$ ✓ $n_i = \frac{m}{M_R}$

$= \frac{(0,2)}{63,5}$ (both subst) ✓ $= \frac{(0,46)}{63,5}$

$= 0,00315$ mol $= 0,07244$

(b) $\text{rate} = \frac{\triangle n}{\triangle t}$ ✓ $= \frac{n_f - n_i}{t_f - t_i}$

$= \frac{(0,07244-0,00315)}{(300-0)}$ ✓

$= 0,00023 \text{ mol·s}^{-1}$ $(2,3 \times 10^{-4} \text{ mol·s}^{-1})$ ✓

OPTION 3

(a) $\text{Rate} = \frac{\Delta m}{\Delta t}$ ✓

$= \frac{(4{,}6 - 0{,}2)}{300 - 0}$ ✓

$= 0{,}01467\ g \cdot s^{-1}$ ✓

(b) $\text{rate} = \frac{0{,}01467}{63{,}5}$ ✓

$= 0{,}00023\ mol \cdot s^{-1}$ ($2{,}3 \times 10^{-4}\ mol \cdot s^{-1}$) ✓

(5)

[10]

TOTAL 150 MARKS