KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

PROVINCIAL STANDARDISED ASSESSMENT

GRADE 12

PHYSICAL SCIENCES P2 (CHEMISTRY)

JUNE 2026

MARKS: 150

TIME: 3 hours

This question paper consists of 16 pages and an 2 data sheets.

INSTRUCTIONS AND INFORMATION

1 Write your name in the appropriate spaces on the ANSWER BOOK.

2 This question paper consists of SEVEN questions. Answer ALL the questions in the ANSWER BOOK.

3 Start EACH question on a NEW page in the ANSWER BOOK.

4 Number the answers correctly according to the numbering system used in this question paper.

5 Leave ONE line between two sub-questions, for example between QUESTION 2.1 and 2.2.

6 You may use a non-programmable calculator.

7 You may use appropriate mathematical instruments.

8 Show ALL formulae and substitutions in ALL calculations.

9 Round off your final numerical answers to a minimum of TWO decimal places.

10 Give brief motivations, discussions et cetera where required.

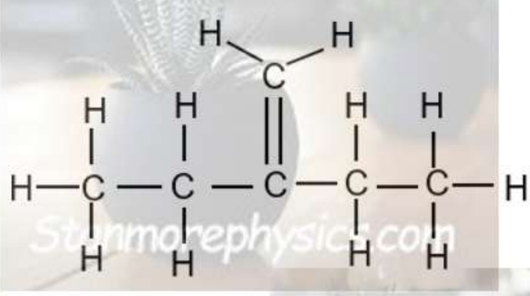
11 You are advised to use the attached DATA SHEETS.

12 Write neatly and legibly.

QUESTION 1

Four possible options are provided as answers to the following questions. Each question has only one correct answer. Choose the correct answer and write the letter (A – D) next to the relevant question number (1.1 – 1.10) on the answer sheet.

1.1 The IUPAC name of the following organic compound is ...



A 3-methylpent-3-ene
B 3-ethylpent-3-ene
C 2-ethylbut-1-ene
D 2-ethylbut-2-ene (2)

1.2 Which ONE of the following is the EMPIRICAL formula of ethyl ethanoate?

A C_2H_4O
B C_2H_2O
C C_4H_4O
D $C_4H_8O_2$ (2)

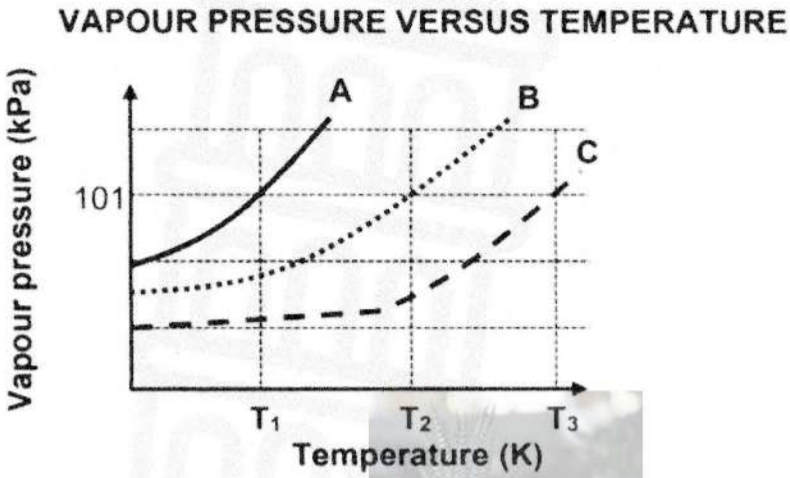
1.3 Consider the reaction represented below:

$$C_{12}H_{26} \rightarrow 2C_5H_{10} + C_2H_6$$

The term that describes this reaction is ...

A Hydrolysis
B Hydrogenation
C Combustion
D Cracking (2)

1.4 Consider the vapour pressure against temperature curves for THREE STRAIGHT- CHAIN ISOMERS under standard atmospheric pressure.



Consider the statements regarding the curves for the THREE CHAIN ISOMERS.

- **I** Compound A has the strongest intermolecular forces
- **II** Compound B has a higher boiling point than compound C.
- **III** Compound B is in the gaseous phase at temperature T_3.

Which of the above statement(s) is/are true?

A **I** only
B **II** only
C **III** only
D **I** and **II** only (2)

1.5 Consider the DEHYDRATION reaction below:

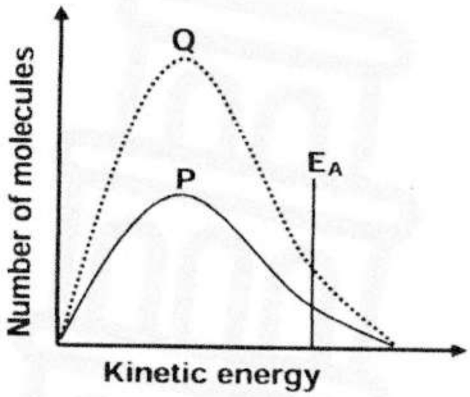
4-methylhexan-3-ol → Alkene + H_2O

The IUPAC names of the MAJOR and MINOR products of this reaction are …

	MAJOR	**MINOR**
A	4-methylhex-3-ene	4-methylhex-2-ene
B	3-methylhex-3-ene	3-methylhex-4-ene
C	3-methylhex-3-ene	4-methylhex-2-ene
D	4-methylhex-2-ene	3-methylhex-3-ene

(2)

1.6 The Maxwell-Boltzmann distribution curve **P** represents the number of molecules against kinetic energy for a certain reaction.



Curve **Q** is obtained after a change was made to one reaction condition. Which ONE of the following changes resulted in curve **Q**?

A Increase in activation energy
B Increase in the concentration of the reactants
C Increase in temperature
D Addition of a catalyst (2)

1.7 Which ONE of the following statements concerning equilibrium is NOT correct?

A Equilibrium is reached in a closed system.
B At equilibrium, the concentrations of reactants and products are constant.
C At equilibrium, the concentration of reactants is equal to concentration of products.
D At equilibrium, the concentration of reactants and products is not necessarily the same. (2)

1.8 Consider the equation below for a hypothetical reaction.

A(aq) + B(s) ⇌ C(aq) + D(aq)

If the equilibrium constant Kc = 1×10^{-4}, then ...

A [A] > [C][D]
B [A] < [C][D]
C [A] = [C][D]
D 0 = [C][D] (2)

1.9 The following values represents the ionisation constant, **k_b**, for four different bases, that were obtained at a temperature of 25 °C:

65×10^{-8}	**40×10^{-1}**	**28×10^{-5}**	**30×10^{-7}**

Which ONE of these values represents the STRONGEST base?

A 40×10^{-1}
B 28×10^{-5}
C 30×10^{-7}
D 65×10^{-8} (2)

1.10 The endpoint in a titration is the exact point where ...

A equal number of moles of acid and base have reacted.
B the indicator changes colour.
C equal masses of base and acid have reacted.
D neutralisation occurs. (2)

[20]

QUESTION 2 (Start on a new page)

2.1 A certain compound **A**, has the following condensed structural formula**:**

$CH_3CH = CHCH_3$

Another compound **B** is a POSITIONAL ISOMER of compound **A,** while compound **C** is a CHAIN ISOMER of compound **A**.

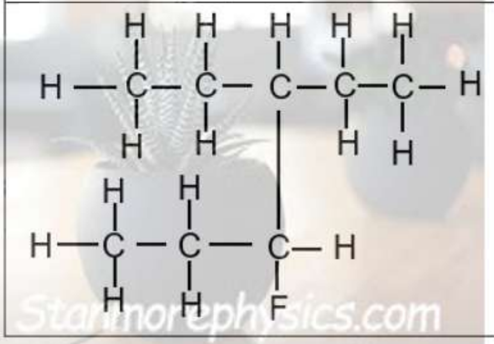
2.1.1 Define the term *structural isomers*. (2)

2.1.2 Is compound **A** SATURATED or UNSATURATED?
Give a reason for your answer.Stanmorephysics.com (2)

2.1.3 Write down the IUPAC name of compound **B**. (2)

2.1.4 Draw the structural formula of compound **C**. (3)

2.2 Consider TWO organic compounds, **1** and **2**, shown in the table below.

Compound 1	Compound 2
	$C_XH_YO_Z$

2.2.1 To which homologous series does compound **1** belong? (1)

2.2.2 Write down the IUPAC name of compound **1.** (3)

Compound **2** is a **carboxylic acid** with a relative molecular mass of 74.

2.2.3 Determine, by means of calculations, the values of X, Y, and Z. (5)

2.2.4 Draw the structural formula of compound **2**. (3)

[21]

QUESTION 3 (Start on a new page)

Two parallel investigations were conducted to investigate the effect of relative molecular mass on the boiling point of organic compounds. In one investigation, straight-chain alkanes were used; in the other, straight-chain primary alcohols. The results obtained are shown in the tables below.

ALKANES		
Compound	**Relative Molecular mass**	**Boiling point (°C)**
C_2H_6	30	-89
C_3H_8	44	-42
C_4H_{10}	58	0
C_5H_{12}	72	36

ALCOHOLS		
Compound	**Relative Molecular mass**	**Boiling point (°C)**
CH_4O	32	65
C_2H_6O	46	78
C_3H_8O	60	97
$C_4H_{10}O$	74	117

3.1 Write down a suitable conclusion for these investigations based on the data provided in the above tables. Stanmorephysics.com (2)

3.2 Consider the table containing Alkanes above:

3.2.1 Define the term *hydrocarbon*. (2)

3.2.2 Which ONE of these alkanes is a LIQUID at room temperature? Give a reason for your answer. (2)

3.2.3 Write down the balanced equation for the complete combustion of Propane. (3)

3.3 Consider the table containing Alcohols above.

3.3.1 Define the term *Primary alcohol*. (2)

3.3.2 Explain, by referring to the TYPE and STRENGTH of intermolecular forces involved, WHY the boiling point of $C_4H_{10}O$ is higher than that of the other alcohols in the table. (3)

3.4 It is observed that, although C_5H_{12} and $C_4H_{10}O$ have comparable molecular masses, the boiling point of $C_4H_{10}O$ is much higher than that of C_5H_{12}. Fully explain this observation. Refer to the TYPE and STRENGTH of the intermolecular forces present. (4)

[18]

QUESTION 4 (Start on a new page)

4.1 2-Bromobutane is mixed with NaOH in two different reactions, as shown below:

Reaction 1: 2-Bromobutane + **dilute** NaOH → **G** + **M**

Reaction 2: 2-bromobutane + **concentrated** NaOH → **Q** + **M** + H_2O

G and **Q** are organic compounds, and **M** is an inorganic compound.

4.1.1 Distinguish between concentrated base and dilute base. (2)

For **Reaction 1**, write down:

4.1.2 The type of reaction that takes place. (1)

4.1.3 The homologous series to which compound **G** belongs. (1)

4.1.4 The IUPAC name of compound **G**. (2)

Compound **Q** is the major product of **Reaction 2**:

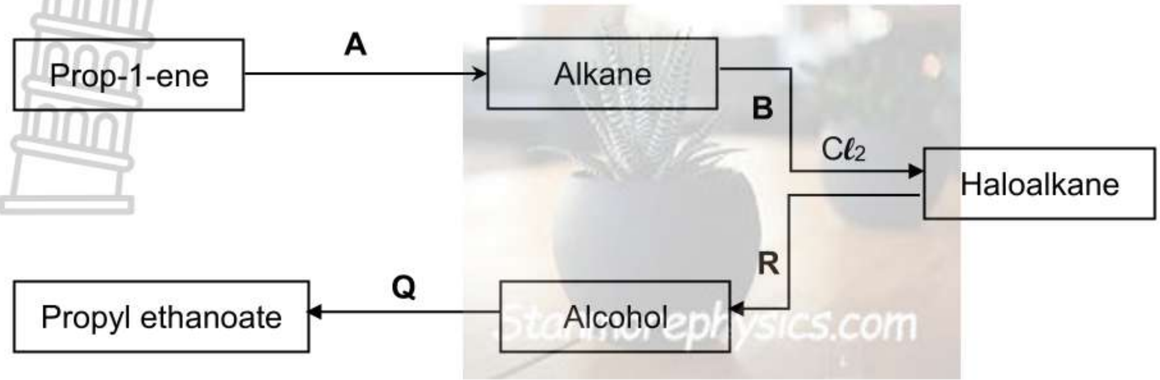
4.1.5 Name the type of reaction that takes place in **Reaction 2**. (1)

4.1.6 Besides heat and concentrated NaOH, write down ONE other condition necessary for **Reaction 2**. (1)

4.1.7 Draw the structural formula of compound **Q**. (2)

4.1.8 Write down the chemical NAME or FORMULA of compound **M**. (1)

4.2 Propyl ethanoate can be prepared from prop-1-ene by a four-step process as shown in the flow diagram below.



Refer to the diagram above and write down: (1)

4.2.1 The NAME or FORMULA of the catalyst needed for reaction **A**.

4.2.2 The letter(s) that represent(s) Substitution reaction(s)? (2)

4.2.3 The IUPAC name of the Alcohol used in reaction **Q**. (2)

4.2.4 TWO reaction conditions for reaction **Q**. (2)

4.2.5 The NAME of the function group of Propyl ethanoate. (1)

4.2.6 The balanced equation of reaction **Q**, using MOLECULAR FORMULAE. (3)

[22]

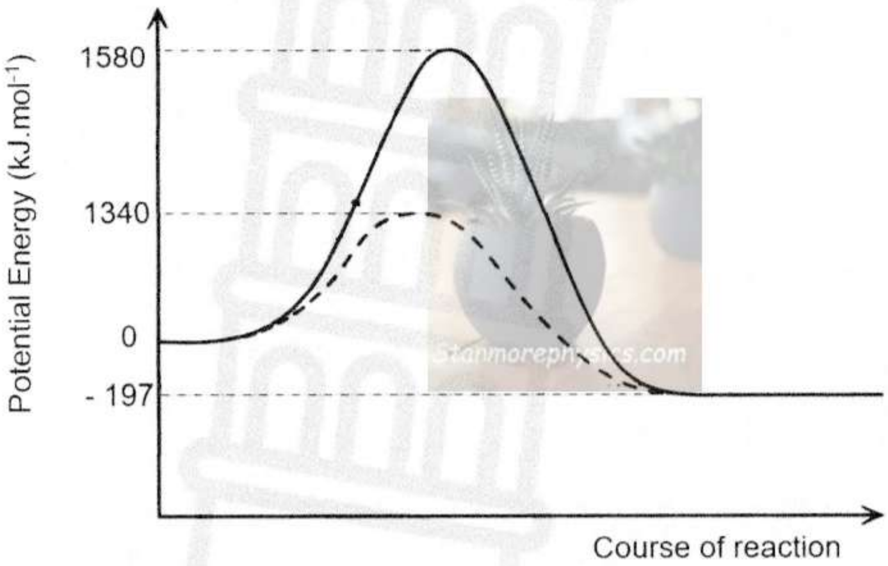
QUESTION 5 (Start on a new page)

5.1 During the contact process, Sulphur dioxide reacts with Oxygen, in the presence of Vanadium oxide (V_2O_5), to form Sulphur trioxide.

The balanced chemical equation and the potential energy versus the course of reaction graph are given below.

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

Graph of Potential energy versus the course of the reaction.



5.1.1 Define the term *Activation energy*. (2)

5.1.2 Write down the value of the activation energy for the forward reaction in the PRESENCE of vanadium oxide. (1)

5.1.3 Calculate the energy (in kilojoules) released to make 24 g of SO_3. (4)

5.2 Two investigations, **I** and **II**, have been performed to investigate factors that affect the rate of chemical reactions.

The balanced chemical equation for the reaction between Aluminium (Aℓ) and sulfuric acid (H_2SO_4) solution is shown below.

$2A\ell(s) + 3H_2SO_4(aq) \rightarrow A\ell_2(SO_4)_3(aq) + 3H_2(g)$

In both investigations, 8 g of Aluminium and EXCESS dilute Sulphuric acid are used, while ensuring that the Aluminium is completely covered by the acid.

INVESTIGATION I

Two experiments are conducted using the conditions as shown in the table below.

	Mass of Aℓ (g)	State of division of Aℓ	Concentration of H_2SO_4 (mol.dm^{-3})	Temperature (°C)
Experiment 1	8	Lumps	0, 1	30
Experiment 2	8	Powder	0, 1	30

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

5.2.2 Which experiment, **1** or **2**, will reach completion within a shorter period of time? Give a reason. (2)

INVESTIGATION II

Two other experiments, **3** and **4**, are conducted using different conditions as shown in the table below.

	Mass of Aℓ (g)	State of division of Aℓ	Concentration of H_2SO_4 (mol.dm^{-3})	Temperature (°C)
Experiment 3	8	Powder	0, 1	30
Experiment 4	8	Powder	0, 1	40

As the reactions progress, it is observed that **Experiment 4** has a higher reaction rate than **Experiment 3**.

5.2.3 Write down the independent variable for this investigation. (1)

5.2.4 Use the collision theory to explain this observation. (3)

5.3 5 g of a sample of IMPURE Sodium carbonate (Na_2CO_3) is reacted with EXCESS dilute hydrochloric acid (HCℓ) according to the balanced equation below.

$2HC\ell\,(aq) + Na_2CO_3\,(s) \rightarrow 2NaC\ell\,(aq) + CO_2\,(g) + H_2O\,(\ell)$

The average rate of CO_2 produced, at room temperature, is 0,005 dm^3.s^{-1}. Take the molar volume of gas as 24 dm^3.mol^{-1}, and assume that no impurities react. Calculate the percentage purity of Na_2CO_3 if the time for this reaction to reach completion is 3 minutes. (7)

[22]

QUESTION 6 (Start on a new page)

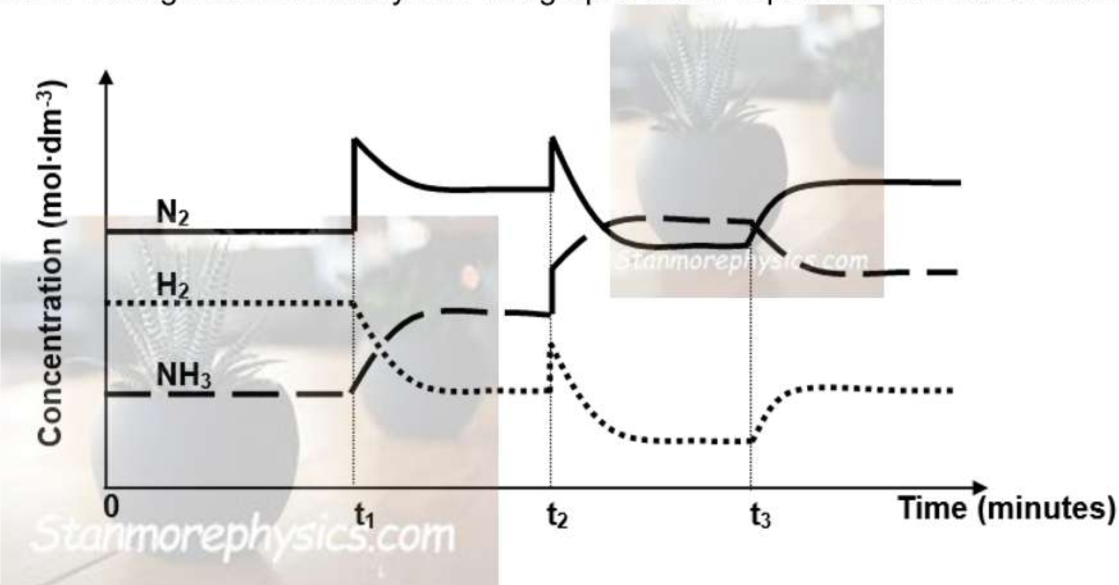
Ammonia (NH_3) is an important product in the fertiliser industry. The balanced equation below shows the reaction between Nitrogen and Hydrogen to produce Ammonia.

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

This reaction is reversible, and it will eventually reach a stage where the rate of the forward reaction equals the rate of the reverse reaction.

6.1 Write down the term that is described by the underlined sentence. (1)

Adjustments to the equilibrium mixture conditions are made to determine which condition results in the highest Ammonia yield. The graphs below represent the results obtained.

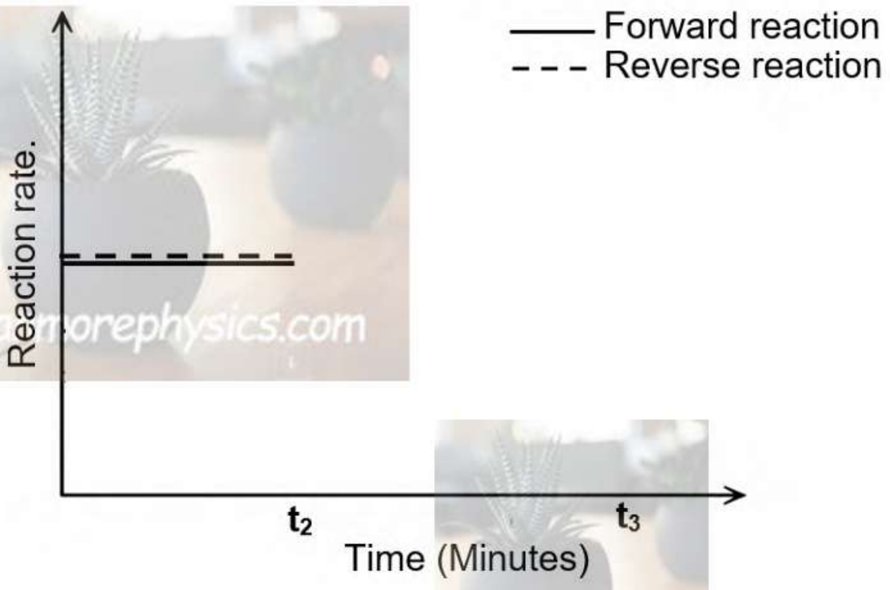


6.2 State *Le Chatelier's principle*. (2)

6.3 At time **t₃**, the temperature was adjusted.

Use Le Chatelier's principle to explain whether the temperature was INCREASED or DECREASED. (4)

6.4 At time t_2, the pressure of the system was increased by decreasing the volume of the container. The INCOMPLETE graph, starting from the equilibrium after t_1, of the reaction rate versus time is shown below.



6.4.1 Will the increase in pressure favour the FORWARD or the REVERSE reaction? Give a reason (2)

6.4.2 Sketch the reaction rate vs time graph showing:

- Immediate effect at t_2
- New equilibrium after t_3. (4)

6.5 In a different experiment, Nitrogen monoxide is reacted with oxygen in a closed container at 100°C. The reaction reaches equilibrium according to the following chemical equation:

$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

Initially 8 mol of NO and 8 mol of O_2 were placed in the reaction container. When equilibrium was established, it was found that 65% of oxygen was still present in the container. The equilibrium constant, K_c, for the reaction at 100 °C is 3,15. Calculate the volume of the container used for this reaction. (9)

[22]

QUESTION 7 (Start on a new page)

7.1 Sulphuric acid, H_2SO_4, is a strong acid used in car batteries.

The equations below represent the ionisation of sulphuric acid.

Equation I: $H_2SO_4\,(aq) + H_2O\,(l) \rightleftharpoons H_3O^+\,(aq) + HSO_4^-\,(aq)$

Equation II: $HSO_4^-\,(aq) + H_2O\,(l) \rightleftharpoons H_3O^+\,(aq) + SO_4^{2-}\,(aq)$

7.1.1 Is Sulphuric acid a MONOPROTIC or DIPROTIC acid? Give a reason for your answer. (2)

7.1.2 Write down the FORMULA of a species that acts as ampholyte in the above reactions. (1)

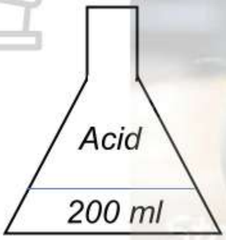
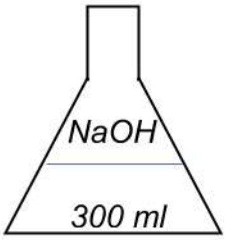
7.1.3 Write down the NAME of the conjugate base of hydrogen sulphate ion. (1)

7.2 Sodium hydrogen carbonate, **$NaHCO_3$**, is a salt with a pH slightly greater than 7.

7.2.1 Define the term *Hydrolysis*. (2)

7.2.2 Write down a balanced equation that explains why a sodium hydrogen carbonate solution has a pH greater than 7. (3)

7.3 During a Chemistry practical lesson, a group of Grade 12 learners notices three conical flasks, **A**, **B**, and **C**, labelled as shown below.
The learners mix the contents of conical flasks **A** and **B**, assuming that both are sulphuric acid solutions. The total volume of the mixture obtained is now 500 ml.

Conical flask A	**Conical flask B**	**Conical flask C**
 c = Unknown	 c = 0,12 mol•dm^{-3}	 c = 0,305 mol•dm^{-3}

7.3.1 Calculate the pH of the H_2SO_4 solution in conical flask **B**, before the learners mixed it with the acid in conical flask A. (4)

Learners are now told that conical flask **A** contained a hydrochloric acid (HCl) solution of unknown concentration and are consequently tasked with performing a titration to neutralise the 500 ml acidic solution with the NaOH solution in conical flask **C**.

7.3.2 What indicator would be suitable for this titration?

Choose from METHYL ORANGE, PHENOLPHTHALEIN, or BROMOTHYMOL BLUE.

Give a reason for your choice. (2)

After performing the titration, they find that 20 ml of the acidic solution is completely neutralised by 16 ml of the Sodium hydroxide solution (NaOH) of concentration 0, 305 mol•dm^{-3}.

7.3.3 Calculate the concentration of the HCl solution that was initially present in conical flask **A** before it was mixed with the content of conical flask **B**. Conical flask **B** contained 0,12 mol•dm^{-3} H_2SO_4. (10)

[25]

TOTAL MARKS: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1,013 \times 10^{5}$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22,4\ dm^{3}\cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Charge on electron *Lading op elektron*	e	$-1,6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6,02 \times 10^{23}\ mol^{-1}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

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

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

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

FINAL

KWAZULU-NATAL PROVINCE

EDUCATION
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PROVINCIAL STANDARDISED ASSESSMENT

GRADE 12

PHYSICAL SCIENCES P2 (CHEMISTRY)

MARKING GUIDELINES

JUNE 2026

MARKS: 150

These marking guidelines consist of 10 pages.

QUESTION 1

1.1	C ✓✓	(2)
1.2	A ✓✓	(2)
1.3	D ✓✓	(2)
1.4	C ✓✓	(2)
1.5	C ✓✓	(2)
1.6	B ✓✓	(2)
1.7	C ✓✓	(2)
1.8	A ✓✓	(2)
1.9	A ✓✓	(2)
1.10	B ✓✓	(2)
		[20]

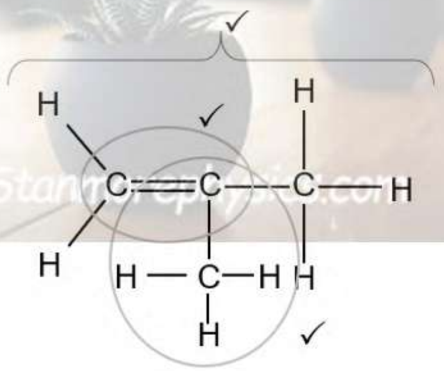
QUESTION 2

2.1.1 Compounds with the same molecular formula, but different structural formula. ✓✓ (2/0) (2)

2.1.2 Unsaturated. ✓
It has a <u>double bond between carbon</u> ✓ atoms.
(Accept: It has a general formula C_nH_{2n}) (2)

2.1.3 But-2-ene ✓✓ (2 or 0) (2)

2.1.4



Marking criteria

- Functional group (double bond): ✓
- Side chain (methyl) on carbon 2: ✓
- Whole structure correct: ✓

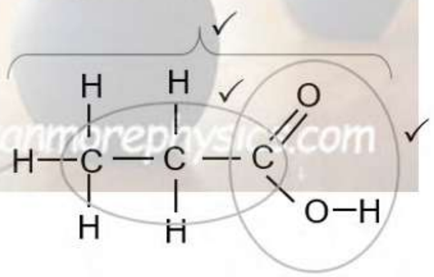
(3)

2.2.1 Haloalkanes ✓ (1)

2.2.2 3-ethyl✓-4-fluoro✓hexane✓
Note:
If: 4-fluoro-3-ethylhexane: 2/3 (3)

2.2.3 General formula for carboxylic acid: $C_nH_{2n}O_2$.
(12 x n) + (1 x 2n) + (16 x 2) ✓= 74 ✓
n = 3
∴ X = 3 ✓
Y = 6 ✓
Z = 2 ✓ (5)

2.2.4



Positive marking from 2.2.3
Marking criteria

- Functional group: ✓
- Chain of 3 carbon atoms: ✓
- Whole structure correct: ✓

(3)
[21]

QUESTION 3

3.1 The greater the molecular mass/chain length the higher the boiling point. ✓✓(2/0)
(Boiling point increases with an increase in molecular mass) (2)

3.2.1 An organic compound made of Carbon and Hydrogen atoms only. ✓✓(2/0) (2)

3.2.2 C_5H_{12} ✓ (Accept: Pentane)
Its boiling point is higher than the room temperature. ✓ (2)

3.2.3 <u>$C_3H_8 + 5O_2$</u> ✓→ <u>$3CO_2 + 4H_2O$</u> ✓ Bal. ✓ (3)

3.3.1 An alcohol in which the carbon bonded to OH is directly bonded to one carbon ✓✓(2/0) (2)

3.3.2
- Alcohols have <u>Hydrogen bonds, dipole-dipole and London forces</u> ✓ between their molecules.
- <u>London forces in $C_4H_{10}O$ are the strongest</u> ✓ compared to the other compounds.
- <u>More energy is required to overcome the intermolecular forces in $C_4H_{10}O$</u> ✓ than the other alcohols. (3)

3.4
- C_5H_{12} (Alkanes) have London forces ✓ between their molecules.
- $C_4H_{10}O$ (Alcohols) have Hydrogen bonds, ✓ dipole-dipole, and London forces between their molecules.
- Intermolecular forces of $C_4H_{10}O$ are stronger than that of C_5H_{12}. ✓
- More energy is required to overcome Intermolecular forces of $C_4H_{10}O$ ✓ (4)

[18]

QUESTION 4

4.1.1 A concentrated base contains a large amount of base in proportion to the volume of water. ✓
A dilute base contains a small amount of base in proportion to the volume of water. ✓ (2)

4.1.2 Substitution ✓ (Hydrolysis). (1)

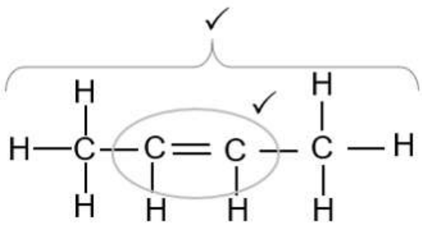
4.1.3 Alcohols. ✓ (1)

4.1.4 Butan-2-ol ✓✓
Note
(If: Butanol / Butan-1-ol: 1/2) (2)

4.1.5 Elimination✓ (Dehydrohalogenation) (1)

4.1.6 Dissolve 2-Bromobutane in Ethanol.(alcohol) ✓ (1)

4.1.7



Marking criteria
- Functional group (double bond): ✓
- Whole structure correct: ✓

(2)

4.1.8 Sodium bromide/NaBr. ✓ (1)

4.2.1 Platinum/Pt ✓ (Palladium/Pd/Nickel/Ni) (3)

4.2.2 Q ✓ and R ✓ (2)

4.2.3 Propan-1-ol/1 - propanol. ✓✓ (2 or 0) (2)

4.2.4 - Heat ✓
- Concentrated H_2SO_4 ✓ (2)

4.2.5 Ester ✓ (group) (1)

4.2.6 $\underline{C_3H_8O + C_2H_4O_2}$ ✓→ $\underline{C_5H_{10}O_2 + H_2O}$ ✓ Bal. ✓ (3)
NB: If they use correct structural formulae 2/3

[22]

QUESTION 5

5.1.1 The minimum energy required for a reaction to take place. ✓✓ (2)

5.1.2 1340 ($kJ.mol^{-1}$). ✓ (1)

5.1.3 According to the balanced equation, 197 kJ is released for 2 mol SO_3.
Energy released for 1 mol of SO_3:
$\frac{197}{2}$ ✓= 98, 5 kJ per mol
Energy released to make 24 g of SO_3:
$n = \frac{m}{M} = \frac{24}{80}$ ✓= 0, 3 mol
Energy = 0, 3 x 98, 5 ✓= 29, 55 kJ. ✓ (4)

5.2.1 What is the relationship between surface area and reaction rate? ✓✓
(How does the surface area affect the reaction rate?) (2)

5.2.2 Experiment 2. ✓
Aluminium has a greater surface area. ✓ (2)

5.2.3 Temperature ✓ (1)

5.2.4
- Increase in temperature increases the average kinetic energy of particles. ✓
- More particles collide with sufficient kinetic energy. ✓
- More effective collisions per unit time/ Higher frequency of effective collisions. . ✓ (3)

5.3 **Volume of CO_2 formed:**

Reaction rate = $\frac{\Delta Volume}{\Delta time}$: 0, 05 ✓= $\frac{V - 0}{180 - 0}$ ✓

V = 0, 9 dm^3

Number of moles of CO_2 formed:

n = $\frac{V}{V_m}$ = $\frac{0,9}{24}$ ✓= 0, 0375 mol

Number of moles of Na_2CO_3 used (Ratio CO_2: Na_2CO_3):

$n_{(Na2CO3)}$ = $n_{(CO2)}$ = 0, 0375 mol. ✓

Mass of Na_2CO_3 used:

m = n x M = 0, 0375 x 106 ✓= 3, 975 g

Percentage purity of Na_2CO_3:

% purity = $\frac{3,975}{5}$ x 100 ✓

= 79, 5 % ✓ (7)

[22]

QUESTION 6

6.1 Chemical equilibrium. ✓ (1)

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

Marking criteria
If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark. Stanmorephysics.com

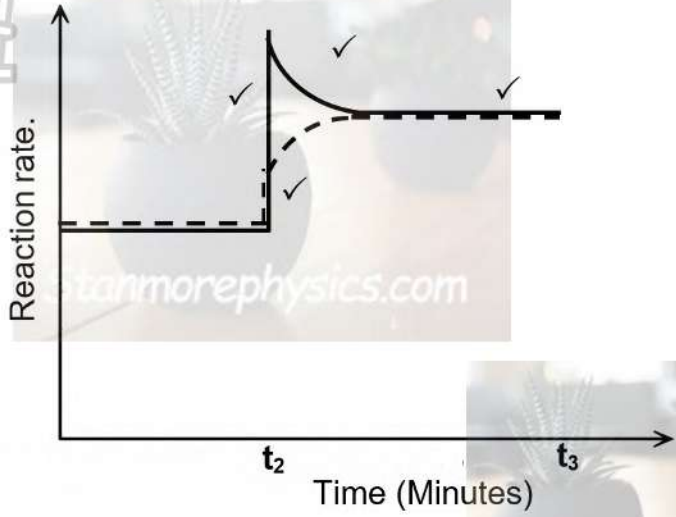
6.3
- Temperature was increased. ✓
- Concentrations of N_2 and H_2 increase while concentration of NH_3 decreases. ✓
- Reverse reaction is favoured. ✓
- Endothermic reaction is favoured. ✓ (4)

6.4.1
- Forward reaction. ✓
- An increase in pressure favours the reaction that proceeds towards the fewer number of moles. ✓

(2)

-

6.4.2



Marking criteria
- Both rates increase at t_2: ✓
- Rate of forward increases more than rate of reverse at t_2: ✓
- After t_2, Rate of forward decreases while rate of reverse increases: ✓
- Both rates become equal and remain constant (horizontal) before t_3: ✓

(4)

6.5 **Marking criteria**

- Percentage O_2: 0, 65 x 8 = 5, 2 mol ✓
- Number of moles of O_2 used: 8 – ✓5, 2 = 2, 8 mol
- Ratio n(NO):n(O_2):n(NO_2) = 2:1:2 ✓
- Number of moles at equilibrium:
  $n_{initial}$-n_{used} for NO and O_2 and $n_{initial}$+n_{formed} for NO_2:
  2, 4 (NO): 5, 2 (O_2): 5, 6 (NO_2) ✓
- Concentration at equilibrium: Dividing all number of moles by unknown volume. ✓
- Correct Kc expression. ✓
- Substitution of Kc value. ✓
- Substitution of concentration values in terms of unknown volume. ✓
- Correct volume: 3, 01 dm^3. ✓

	NO (g)	O_2 (g)	NO_2 (g)	
Ratio	2	1	2	
Initial n (mol)	8	8	-	
Change (mol)	-5, 6	-2, 8✓	+5, 6	✓
Equilibrium (mol)	2, 4	5, 2✓	5, 6	✓
$c = \frac{n}{V}$ (mol.dm^{-1})	$\frac{2,4}{x}$	$\frac{5,2}{x}$	$\frac{5,6}{x}$	✓

$Kc = \frac{[NO_2]^2}{[NO]^2.[O_2]}$ ✓

$3,15$✓ $= \frac{(\frac{5,6}{x})^2}{(\frac{2,4}{x})^2.(\frac{5,2}{x})}$ ✓

x = 3, 01

V= 3, 01 dm^3 ✓

(9)

[22]

QUESTION 7

7.1.1 Diprotic✓
The acid can donate two hydrogen ions. ✓ (2)

7.1.2 HSO_4^-✓ (1)

7.1.3 Sulphate ion. ✓ (1)

7.2.1 Reaction between salt and water. ✓ ✓ (2)

7.2.2 <u>$HCO_3^- + H_2O$</u> ✓→ <u>$H_2CO_3 + OH^-$</u> ✓Balancing✓

Marking criteria
• Left side correct: HCO_3^-+H_2O ✓
• Right side correct: H_2CO_3 + OH^-✓
• Balancing: ✓

(3)

7.3.1 $[H_3O^+] = 2 \times [H_2SO_4] = 2 \times 0,12$ ✓ $= 0,24\ mol.dm^{-3}$.

pH = - log $[H_3O^+]$ ✓

= - log (0, 24) ✓

= 0, 62 ✓ (4)

7.3.2
- Bromothymol blue ✓
- Reaction between a strong base and strong acid✓ (2)

7.3.3 **Marking criteria**

- Number of moles of NaOH in 16 ml. ✓
- Number of moles of H^+ in 20 ml. ✓
- n of H^+ in 500 ml: 0, 00488 x 25 ✓
- Number of moles of H_2SO_4: 0, 12 x 0, 3 ✓= 0, 036 mol.
- Number of moles of H^+ in 0, 036 mol of H_2SO_4:
  Ratio: $n(H^+) = 2 \times n(H_2SO_4)$ = 2 x 0, 036 ✓= 0, 072 mol.
- Number of moles of H^+ from HCl:
  Total $n_{(entire\ solution)} - n_{(H2SO4)}$ = 0, 122 – 0, 072 ✓= 0, 05 mol.
- Number of moles of HCl:
  Ratio HCl:H^+ = 1:1, $n_{(HCl)}$ = 0, 05 mol. ✓
- Formula for concentration: c=n/v ✓
- Substitution into formula c = n/v = 0,05/0,2. ✓
- Concentration of HCl: 0, 25 $mol.dm^{-3}$.✓

Number of moles of NaOH in 16 ml.

n = c.v = 0, 305 x 0, 016 ✓= 0, 00488 mol.

Number of moles of H^+ in 20 ml of acidic solution.

Ratio OH^-:H^+ = 1:1

$n_{(H+)} = n_{(OH-)}$ = 0, 00488 mol. ✓

Number of moles of H^+ in 500 ml

$n(H^+)$ = 0, 00488 x 25 ✓= 0, 122 mol.

Number of moles of H_2SO_4 in 500 ml.

n = c.v = 0, 12 x 0, 3 ✓= 0, 036 mol.

Number of moles of H^+ in 0, 036 mol of H_2SO_4 present in 500 ml.

Ratio H^+:H_2SO_4 = 2:1

$n(H^+) = 2 \times n(H_2SO_4)$ = 2 x 0, 036 ✓ = 0, 072 mol.

Number of moles of H^+ of HCl in 500 ml.

$n_{(H+)} = n_{(total\ H+)} - n_{(H+\ of\ H2SO4)}$ = 0, 122 – 0, 072 ✓= 0, 05 mol.

Number of moles of HCl in 500 ml.

Ratio HCl:H^+ = 1:1

$n(HCl) = n(H^+)$ = 0, 05 mol. ✓

Concentration of HCl in 200 ml.

$c = \frac{n}{V}$ ✓ $= \frac{0,05}{0,2}$ ✓

c = 0, 25 $mol.dm^{-3}$. ✓ (10)

[25]

TOTAL 150