Western Cape Government
Education
FOR YOU

WEST COAST EDUCATION DISTRICT

PHYSICAL SCIENCES PAPER 2
GRADE 12

COMMON EXAMINATION
SEPTEMBER 2026

MARKS: 150

TIME: 3 hours

This paper consists of 18 pages.

EXAM INSTRUCTIONS:

1. Write your **NAME** on your answer sheet.
2. Answer all questions on your **ANSWER SHEET**.
3. **NEATNESS** and **ACCURACY** will count in your favour.
4. **START EACH QUESTION ON A NEW PAGE**.
5. **FORMULA SHEETS** are attached to the back of the paper.
6. **NUMBER** the answers correctly according to the numbering system in this paper.
7. Leave **ONE LINE** open between two sub-questions, e.g. between QUESTION 2.1 and 2.2
8. You may use a non-programmable **CALCULATOR**.
9. Show **ALL FORMULAS** and substitutions in **ALL CALCULATIONS**.
10. Round all FINAL numeric answers to a minimum of **TWO DECIMAL PLACES**.
11. Give short (concise) **MOTIVATIONS** where necessary.
12. Attach all **GRAPHS** and extra **ANSWER SHEETS** to your answer sheet.

QUESTION 1

Four options are given as possible answers to the following questions.
Each question has only ONE correct answer. Select the answer and write only the letter (A-D) next to the question number (1.1 to 1.10) in your ANSWER BOOK, e.g.: 1.11 E.

1.1 Which ONE of the following organic compounds is a possible product when a carboxylic acid and an alcohol react with each other?

A Propan-1-ol

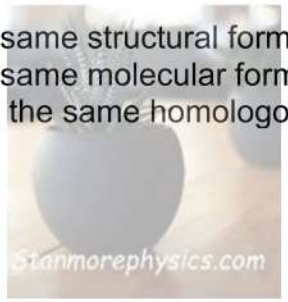
B Propanoic acid

C Propyl propanoate

D Propanal (2)

1.2 Which of the following statements is TRUE for compounds that are structural isomers of each other?

Statement **I**: Compounds have the same structural formula.
Statement **II**: Compounds have the same molecular formula.
Statement **III**: Compounds belong to the same homologous series.



A **I**, **II** and **III**

B **I** and **II**

C **I** and **III**

D **II** and **III** (2)

1.3 Which organic compound is represented by **X** in the following reaction?

$$2\mathbf{X} + 19O_2 \rightarrow 12CO_2 + 14H_2O \quad \triangle H < 0$$

A Hexane

B Hex-2-ene

C Propane

D Hexanoic acid (2)

1.4 A learner carries out two separate experiments at 25 °C.

An excess of zinc powder (Zn) reacts with the following acids:

- Experiment **I**: 100 cm^3 of 0,1mol·dm^{-3} HCℓ(aq)
- Experiment **II**: 50 cm^3 of 0,1mol·dm^{-3} H_2SO_4(aq)

Which ONE of the following options describes the fastest initial reaction rate (RR) and the largest volume of H_2(g) formed?

	Fastest initial RR	Volume H_2(g) formed
A	**I**	H_2(g) in **I** > H_2(g) in **II**
B	**II**	H_2(g) in **I** > H_2(g) in **II**
C	**I**	H_2(g) in **I** = H_2(g) in **II**
D	**II**	H_2(g) in **I** = H_2(g) in **II**

(2)

1.5 The following reaction is initially in equilibrium in a closed container:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The volume of the container is reduced at constant temperature.

How will the amount and concentration of HI(g) change?

	Amount of HI(g)	Concentration of HI (g)
A	Stay the same	Stay the same
B	Stay the same	Increase
C	Increase	Stay the same
D	Increase	Increase

(2)

1.6 Ammonium chloride ($NH_4C\ell$) dissolves in water. Which ONE of the following statements describes the pH of the solution and the correct hydrolysis reaction?

A pH < 7, because $NH4^+$ reacts with water to form H_3O^+ ions.

B pH > 7, because $C\ell^-$ reacts with water to form OH^- ions.

C pH < 7, because $C\ell^-$ reacts with water to form OH^- ions.

D pH > 7, because $NH4^+$ reacts with water to form H_3O^+ ions. (2)

1.7 Three acid solutions P, Q and R each have a concentration of 0,1 $mol \cdot dm^{-3}$.

- Solution **P**: $HNO_3(aq)$
- Solution **Q**: $CH_3COOH(aq)$
- Solution **R**: $H_2SO_4(aq)$

Which ONE of the following arrangements shows the solutions in order of increasing electrical conductivity?

A Q, P, R

B R, P, Q

C Q, R, P

D P, Q, R (2)

1.8 Sodium carbonate (Na_2CO_3) is dissolved in water. Which ONE of the following options gives the correct approximate pH of the solution and the hydrolysis equation of the ion that reacts with water?

	Approximate pH	Hydrolysis equation
A	pH < 7	$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$
B	pH < 7	$Na^+ + H_2O \rightleftharpoons NaOH + H^+$
C	pH > 7	$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$
D	pH > 7	$Na^+ + H_2O \rightleftharpoons NaOH + H^+$

(2)

1.9 The following half-reactions and standard electrode potentials are given.

$$X^{2+} + 2e^- \rightleftharpoons X \quad (E^\theta = +0,3)$$

$$Y^{2+} + 2e^- \rightleftharpoons Y \quad (E^\theta = -0,9)$$

$$Z^{2+} + 2e^- \rightleftharpoons Z \quad (E^\theta = -0,3)$$

Which ONE of the following combinations will form a galvanic cell with an initial cell potential of 1,2 V?

	Anode	Cathode
A	Y	X
B	Y	Z
C	X	Y
D	X	Z

(2)

1.10 Molten zinc chloride ($ZnC\ell_2$) is decomposed during electrolysis.

Which ONE of the following statements correctly describes the flow of electrons in the external circuit and the change in the oxidation number of chlorine?

	Flow of electrons in the external circuit:	Change in oxidation number of chlorine:
A	Electrons flow from the anode to the cathode.	–1 to 0
B	Electrons flow from the cathode to the anode.	–1 to 0
C	Electrons flow from the anode to the cathode.	0 to –1
D	Electrons flow from the cathode to the anode.	0 to –1

(2)

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QUESTION 2 (Start on a new page)

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

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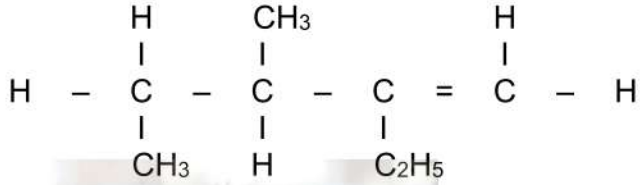
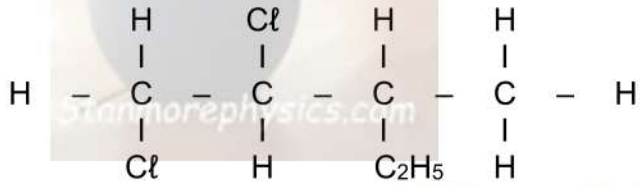
<tr><td>A)</td><td colspan="3">  </td></tr>
<tr><td>B)</td><td>Pentan-2-one</td><td>C)</td><td>2,2-dimethylpropane</td></tr>
<tr><td>D)</td><td>C_3H_8O</td><td>E)</td><td>$C_3H_6O_2$</td></tr>
<tr><td>F)</td><td colspan="3">  </td></tr>
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2.1 Write down the letter of a compound that is an example of:

2.1.1 An unsaturated hydrocarbon (1)

2.1.2 A haloalkane (1)

2.1.3 A ketone (1)

2.2 Define the term: HOMOLOGOUS SERIES (2)

2.3 Name the homologous series to which the following compounds belong:

2.3.1 D (1)

2.3.2 E (1)

2.4 Write down the IUPAC name of:

2.4.1 A (3)

2.4.2 F (3)

2.5 Define the term: STRUCTURAL ISOMER (2)

2.6 Write down the IUPAC name of the following type of isomers of B:

2.6.1 Position isomer (1)

2.6.2 Functional isomer (1)

2.7 Draw the structural formula of a chain isomer of C. (2)

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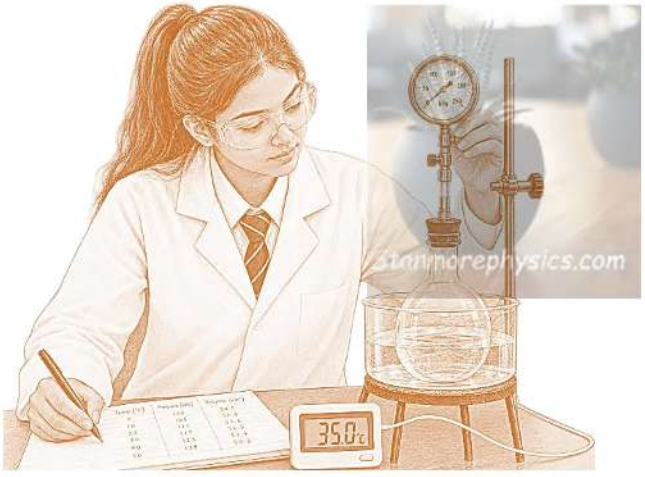
QUESTION 3 (Start on a new page)

A matriculant is determining the vapour pressure of three organic compounds at a temperature of 35 °C. She heats each compound in a round-bottomed flask in a water bath to ensure more control over the even distribution of heat.



The results of the investigation are summarized in the following table:

Compound	IUPAC name	Molar mass	Vapour pressure
A	Propanone	58 g·mol^{-1}	48 kPa
B	Propan-1-ol	60 g·mol^{-1}	5 kPa
C	Ethanoic acid	60 g·mol^{-1}	4 kPa

Source: https://www.inchem.org (Values have been rounded for the question paper.)

3.1 Define the term: VAPOUR PRESSURE (2)

3.2 Identify the following variables for this investigation:

3.2.1 Constant variable (1)

3.2.2 Independent variable (1)

3.2.3 Dependent variable (1)

3.3 Is this an example of a FAIR investigation? (2)

Answer only YES or NO and give a reason for your answer.

3.4 Explain the difference in vapour pressure between the following compounds by referring to the strength of the intermolecular forces.

3.4.1 **A** and **B** (4)

3.4.2 **B** and **C** (4)

3.5 Which ONE of the compounds (**A**, **B** or **C**) will have the lowest boiling point? Give a reason for your answer. (2)

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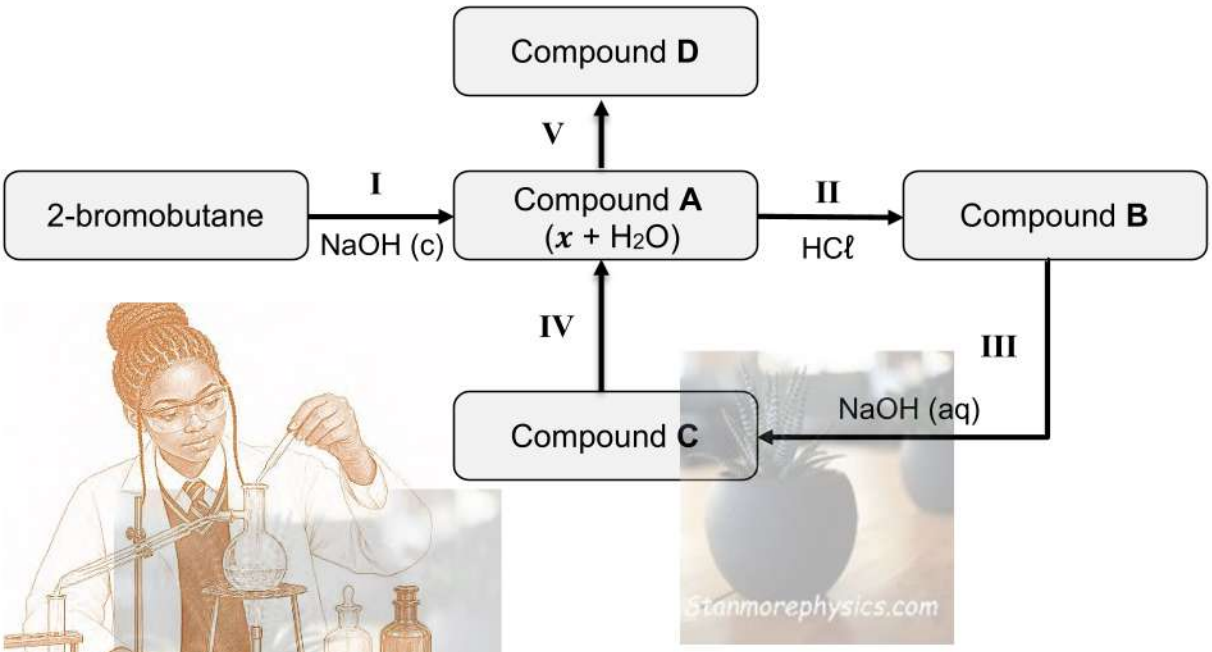
QUESTION 4 (Start on a new page)

Consider the following flow diagram representing organic reactions with 2-bromobutane as the original compound.

The alphabetical letters (**A** to **D**) represent organic compounds and the Roman numerals (**I** to **IV**) represent the types of organic reactions.

If a chemical substance is shown next to a reaction arrow, it means that the substance is a reactant. If a chemical substance is shown inside a box, it means that the substance is a product of the reaction.



The products x and H_2O are two inorganic products that are formed together with Compound **A** during reaction I.

4.1 Reaction **I** is an ELIMINATION REACTION.

4.1.1 Name the type of elimination reaction that occurs here. (1)

4.1.2 Give the IUPAC names of two possible products (the major product and the minor product) that can be represented by compound **A**. (2)

4.1.3 Write the NAME or the FORMULA of the inorganic product, x, which is also formed during the reaction. (1)

For the rest of this question, assume that compound **A** is the MAIN PRODUCT formed during reaction **I**.

4.2 Reaction **II** is an ADDITION REACTION.

4.2.1 Write the IUPAC name of compound **B**. (1)

4.2.2 Name a reaction condition necessary for this reaction to occur. (1)

4.3 In reaction **III**, compound **B** is heated in dilute sodium hydroxide, NaOH (aq), to form compound **C**.

4.3.1 Is this an example of an ADDITION, SUBSTITUTION or an ELIMINATION reaction? (1)

4.3.2 Name the specific **type** of reaction that occurs here. (1)

Do not refer to the reaction again in your answer as an ADDITION, ELIMINATION or SUBSTITUTION REACTION.

4.3.3 Draw the STRUCTURAL FORMULA of compound **C** and give the IUPAC name of the compound. (3)

4.4 Compound **D** is a saturated hydrocarbon. (2)

Name the two SPECIFIC TYPES OF REACTIONS, **IV** and **V**, that are needed to get from compound **C** to compound **D** on the flow diagram.

Do not refer to the reactions as ADDITION, ELIMINATION or SUBSTITUTION REACTIONS in your answer.

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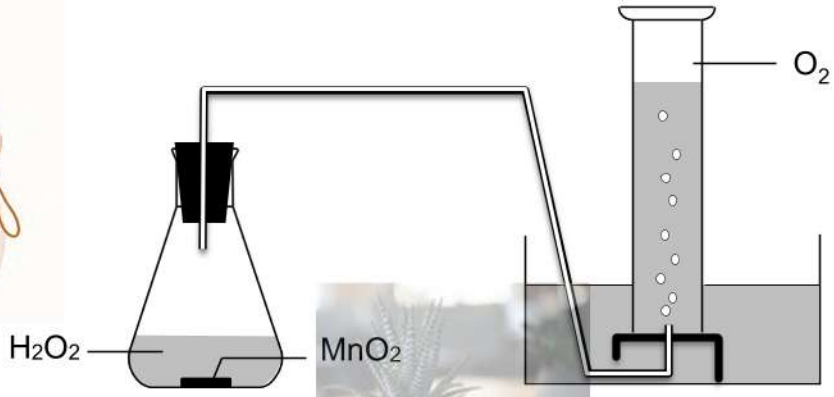
QUESTION 5 (Start on a new page)

Manganese dioxide with a mass of 0,1 g is placed in a flask with 200 cm^3 of a solution of hydrogen peroxide (H_2O_2) with a concentration of 0,2 $mol \cdot dm^{-3}$.

The oxygen gas formed is recorded every minute. The reaction occurs at STP. The reaction stops before all the hydrogen peroxide has decomposed.

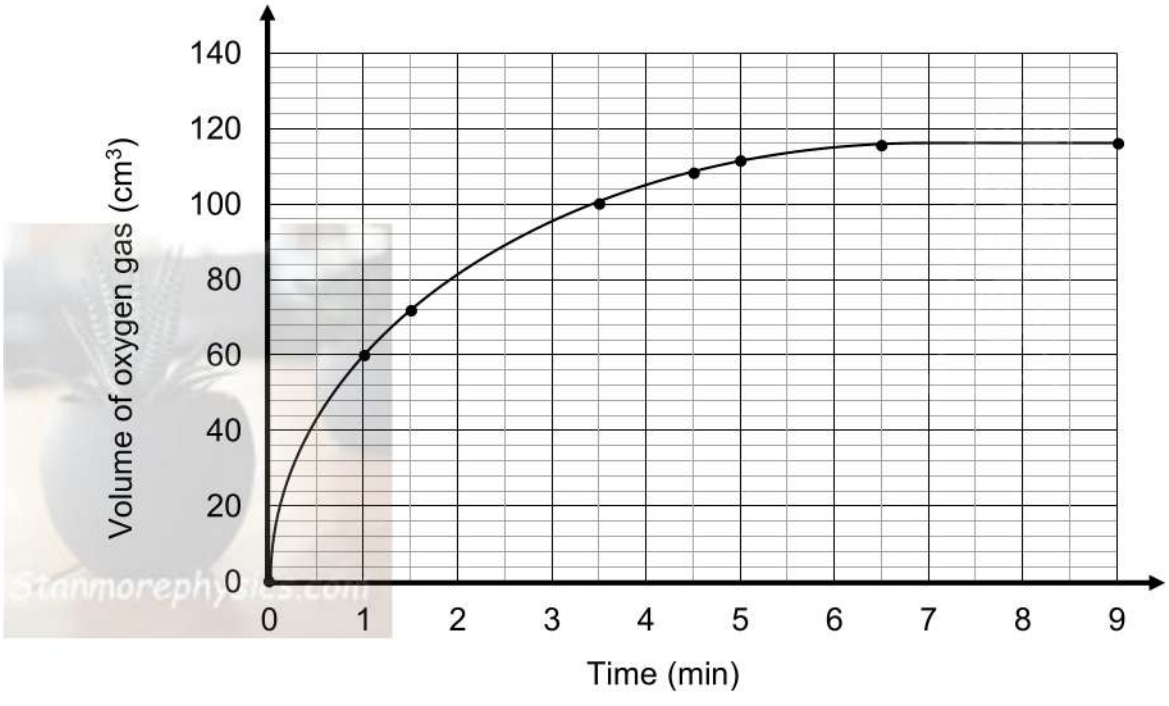
Assume that the volume of the reaction mixture (200 cm^3) remains constant during the reaction.

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$$



The following graph is obtained:

Graph of VOLUME of oxygen gas formed versus TIME.



5.1 Define the term: REACTION RATE (2)

5.2 How long did it take for the reaction to stop? (1)

5.3 How can you see on the graph that the reaction rate decreased over time? (1)

5.4 Calculate:

5.4.1 The average reaction rate from the time the reaction starts until it stops. Let the unit be in $cm^3.min^{-1}$. (2)

5.4.2 The number of moles of oxygen gas formed during the reaction. Write the answer to **four** decimal places. (3)

5.4.3 The concentration of hydrogen peroxide in the flask after the reaction has ended (c_f). (6)

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QUESTION 6 (Start on a new page)

Consider the following reaction that reaches equilibrium in a 2 dm^3 container at a temperature of 700 °C.

$$NO_2(g) + SO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

Initially, 2 mol $NO_2(g)$ and 2 mol $SO_2(g)$ were placed in the container.

After equilibrium is reached, there are 60 g $SO_3(g)$ in the container.

6.1 Define the term: CHEMICAL EQUILIBRIUM (2)

6.2 Calculate the value of the equilibrium constant (K_C). (7)

The colours of the gases in the reaction are as follows:

$$NO_2(g) + SO_2(g) \rightleftharpoons SO_3(g) + NO(g) \quad \triangle H < 0$$

(Reddish brown) (Colourless) (Colourless) (Colourless)

At equilibrium, the reaction mixture appears **light** reddish brown.

If the forward reaction is favoured, the reaction mixture becomes completely colourless and if the reverse reaction is favoured, the reaction mixture appears **dark** reddish brown.

6.3 State Le Chatelier's principle in words. (2)

6.4 Name ONE change that can be made to the reaction mixture so that it appears **dark** reddish brown, without changing the K_c value. (4)

Explain your answer using Le Chatelier's principle.

6.5 Why would a change in the volume of the container have no effect on the colour of the reaction mixture? (2)

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QUESTION 7 (Start on a new page)

A matriculant is diluting sulfuric acid (H_2SO_4) in distilled water. He adds the acid carefully using a stirrer. The balanced net reaction that occurs is:

$$H_2SO_4 + 2H_2O \rightleftharpoons 2H_3O^+ + SO_4^{2-} \qquad K_a = 10$$

7.1 Define the term: STRONG ACID (2)

7.2 Calculate the pH value of the diluted acid if its concentration, $H_2SO_4(aq)$, is 0,25 mol·dm^{-3}. (3)

Sulfuric acid (H_2SO_4) ionizes in water according to the following half-reactions:

Reaction 1: $H_2SO_4 + H_2O \rightleftharpoons H_3O^+ + HSO_4^-$ $K_a = 1 \times 10^3$

Reaction 2: $HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$ $K_a = 1 \times 10^{-2}$

The two acids (H_2SO_4 and HSO_4^-) in the half-reactions are compared with each other.

7.3 Answer each of the following questions by writing down the correct acid's FORMULA or NAME **and** give a reason for your answer.

Which acid is an example of a:

7.3.1 Weak acid (2)

7.3.2 Ampholyte (2)

7.4 How does the concentration of the H_3O^+ ions compare to the concentration of the acid in each of the following reactions?

Write only LOWER, HIGHER or THE SAME.

7.4.1 Reaction 1 (1)

7.4.2 Reaction 2 (1)

7.5 Sodium hydroxide (NaOH) granules with a mass of x grams are diluted in 25 cm^3 of distilled water.

12 cm^3 of sulfuric acid (H_2SO_4) with a concentration of 0,1 $mol \cdot dm^{-3}$ is placed in the same flask with the NaOH(aq).

Assume that the volumes can be added together if the acid and base are poured together and that the volume then remains constant for the rest of the question. The reaction takes place at 25 °C.

The pH of the final mixture is 12,56.

7.5.1 How does the concentration of hydronium ions (H_3O^+) compare to the concentration of hydroxide ions (OH^-) in the final mixture? (1)

Choose between HIGHER, LOWER or THE SAME.

7.5.2 Calculate the value of x. (8)

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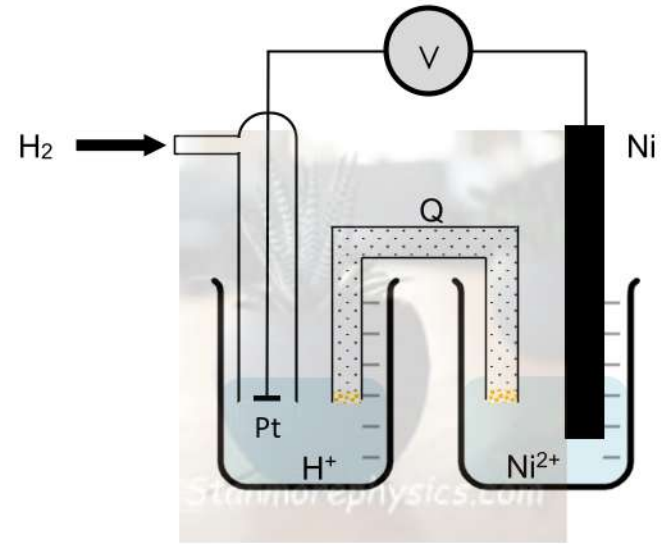
QUESTION 8 (Start on a new page)

The following cell is set up under standard conditions in a laboratory:



8.1 Name the three standard conditions under which this cell should be set up. (3)

8.2 Write down the half-reaction that occurs at the following electrode:

8.2.1 Anode (2)

8.2.2 Cathode (2)

8.3 Calculate the initial reading on the voltmeter. (3)

8.4 Write down the CELL NOTATION for this cell. (3)

8.5 Briefly explain how component Q keeps the electrolyte in the ANODE neutral. (2)

8.6 Over time, the voltmeter reading decreases to 0,1 V.

How will the voltmeter reading change if more nickel nitrate, $Ni(NO_3)_2$, is added to the electrolyte in the nickel half-cell?

Write only INCREASE, DECREASE or STAY THE SAME. (2)

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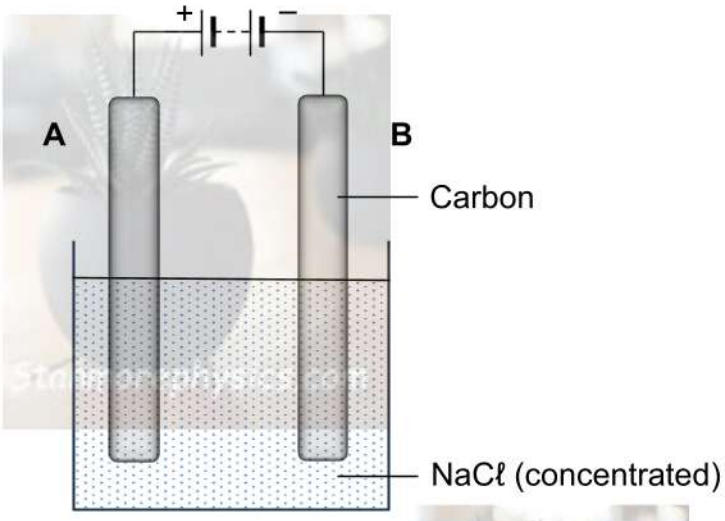
QUESTION 9 (Start on a new page)

The electrolysis of brine (salt water) is used in the chemical industry to produce chlorine gas and sodium hydroxide.

Consider the following diagram of an electrolytic cell. Two carbon electrodes are placed in an electrolyte of concentrated sodium chloride, NaCℓ.



9.1 Define the term: ELECTROLYSIS (2)

9.2 Is the redox reaction that occurs in this cell an example of:

9.2.1 A SPONTANEOUS or a NON-SPONTANEOUS reaction? (1)

9.2.2 An ENDOTHERMIC or an EXOTHERMIC reaction? (1)

9.3 Since this is an aqueous solution, two different substances can be oxidized at electrode A. Write down the two possible oxidation half-reactions. (4)

9.4 Write down the **net** reaction if the following salt is used as the electrolyte:

9.4.1 Concentrated NaCℓ (2)

9.4.2 Concentrated $NaNO_3$ (2)

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Western Cape Government
Education
FOR YOU

WEST COAST EDUCATION DISTRICT

PHYSICAL SCIENCES PAPER 2
GRADE 12

MARKING GUIDELINES: SEPTEMBER 2026

MARKS: 150

TIME: 3 hours

These marking guidelines consist of 20 pages.

Please pay attention to the correct application of the following **MARKING RULES**:

1. Marks will be awarded for: correct formula, correct substitution, correct answer with unit.

2. No marks will be awarded where an incorrect or inappropriate formula is used, even if there are relevant symbols and relevant substitutions.

3. When an error is made during substitution in a correct formula, a mark will be awarded for the correct formula and for the correct substitutions, but no further marks will be awarded.

4. If no formula is given, but all the substitutions are correct, the candidate loses one mark.

5. Marks are only awarded for a formula if an attempt at a calculation has been made, i.e. substitutions have been made or a numerical answer has been given.

6. Marks can only be awarded for substitutions when values are entered into formulas and not for values listed before a calculation.

7. The final answer to all calculations, when not specified in the question, must be rounded to a minimum of TWO decimal places.

8. If a final answer to a calculation is correct, full marks will not be automatically awarded. Markers will always ensure that the correct/appropriate formula has been used and that operations, including substitutions, are correct.

9. Mathematical manipulations and changing the subject of applicable formulas do not count for any marks, but if a candidate starts with the correct formula and then incorrectly changes the subject of the formula, marks will be awarded for the formula and the correct substitutions. The mark for the incorrect numerical answer is forfeited.

10. Candidates will only be penalized once for repeatedly using an incorrect unit in a question.

11. Units are only required in the final answer to a question.

12. Marks are awarded only for an answer and not for a unit per se. Candidates will therefore forfeit the mark awarded for the answer in each of the following cases: (i) Correct answer + incorrect unit, (ii) Incorrect answer + correct unit, (iii) Correct answer + no unit.

13. Separate compound units with a multiplication point and not a period, e.g. $mol{\cdot}dm^{-3}$. Accept $mol.dm^{-3}$ (or mol/dm^3) for marking purposes.

14. If one answer or calculation is required, but two are given by the candidate, only the first one will be marked, regardless of which one is correct. If two answers are required, only the first two will be marked, etc.

15. When a chemical FORMULA is asked, and the NAME is given as an answer, the candidate will forfeit the marks. The same rule applies when the NAME is asked and the FORMULA is given.

16. When writing redox half-reactions, the correct arrow must be used.

17. When candidates are required to provide an explanation about the relative strengths of oxidizing and reducing agents, the following are not accepted:

    - Only state the position of a substance on Table 4 (e.g. Cu is above Mg).
    - Only use relative reactivity (e.g. Mg is more reactive than Cu).
    - For example, the correct answer would be: Mg is a stronger reducing agent than Cu and therefore Mg will be able to reduce Cu^{2+} ions to Cu. The answer can also be given in terms of the relative strength as electron acceptors or donors.

18. One point will be forfeited when the charge of an ion is omitted from an equation (not for the charge on an electron).

19. The "mark-with-the-error" principle does not apply to chemical equations or half-reactions. For example, if a learner writes the wrong oxidation/reduction half-reaction for a sub-question and transfers the answer to another sub-question (balancing an equation or calculating E^{θ}_{sel}), then the learner will not be credited for this substitution.

20. In the structural formula of an organic molecule, all hydrogen atoms must be shown. Marks must be deducted for the omission of hydrogen atoms.

21. When a structural formula is asked, marks must be deducted if the candidate writes the condensed formula.

22. When an IUPAC name is asked and the candidate omits the hyphen(s) (e.g. instead of pent-1-ene or 1-pentene the candidate writes pent 1 one or 1 penten), marks will be forfeited.

23. When a chemical reaction is asked, marks are awarded for correct reactants, correct products and correct balancing. If only a reactant(s) followed by an arrow, or only a product(s) preceded by an arrow, is written, marks are given for the reactant(s) or product(s). If only reactant(s) or only product(s) are written, without an arrow, no marks are given for the reactant(s) or product(s).

Positive marking with regard to calculations will apply in the following cases:

24. Sub-question after sub-question: When a certain variable is calculated in one sub-question (e.g. (QUESTION 3.1) and then has to be replaced in another (QUESTION 3.2 or QUESTION 3.3), e.g. if the answer for QUESTION 3.1 is incorrect and is replaced correctly in QUESTION 3.2 or QUESTION 3.3, full marks are awarded for the subsequent sub-questions.

25. A question with multiple steps in a sub-question: If a candidate, for example, incorrectly calculates the number of moles of a chemical substance in the first step due to a substitution error, the candidate forfeits the mark for the substitution as well as the final answer.

26. An incorrect answer, if it is based on a conceptual error, cannot normally be correctly motivated. If the candidate is asked to motivate the answer to QUESTION 3.1 in QUESTION 3.2 and QUESTION 3.1 is incorrect, no marks can be awarded for QUESTION 3.2. However, if the answer to, for example, QUESTION 3.1 is based on a calculation, the motivation for the incorrect answer in QUESTION 3.2 can be considered.

27. This Examination Guidelines document is intended to articulate the assessment aspirations advocated in the CAPS document. It is therefore not a substitute for the CAPS document, which teachers should use for teaching.

QUESTION 1

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

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Explanation of answers to **QUESTION 1**:

1.1	**C**	When a carboxylic acid and an alcohol react with each other in the presence of an acid catalyst, an esterification reaction occurs. The organic product formed during this condensation reaction is an ester along with water. Propyl propanoate is the only ester among the given options, as its name ends in the characteristic suffix. The other choices represent an alcohol, a carboxylic acid, and an aldehyde, which are not the expected organic products of this reaction.
1.2	**D**	• **Statement I (False):** Structural isomers have **different** structural formulas because the atoms are arranged or bonded differently. If they had the same structural formula, they would be the same compound. Because Statement I is incorrect, options A, B, and C are eliminated. • **Statement II (True):** By definition, structural isomers always have the same molecular formula. • **Statement III (True):** Structural isomers (such as chain isomers and position isomers) often belong to the same homologous series (e.g., two different alkanes or alcohols).
1.3	**A**	• **Carbon chain**: The total number of carbon atoms on the product side corresponds to the prefix hex-, indicating a longer carbon chain. This eliminates propane. • **No oxygen atoms**: All the oxygen atoms in the products are already completely supplied by the oxygen gas on the reactant side. The organic compound itself therefore contains no oxygen atoms, eliminating hexanoic acid. • **Saturated hydrocarbon**: The ratio of hydrogen atoms to carbon atoms shows that the molecule is completely saturated and contains only single bonds. This confirms that it is an alkane and eliminates hex-2-ene (an alkene with a double bond). Therefore, the organic compound is **hexane**.
1.4	**D**	**Initial reaction rate:** • Sulfuric acid is a diprotic acid and releases two hydrogen ions per molecule, while hydrochloric acid is a monoprotic acid and releases only one hydrogen ion per molecule. • At the same concentration, the sulfuric acid solution therefore contains a higher concentration of reactive hydrogen ions than the hydrochloric acid solution. • This higher concentration results in a faster initial reaction rate in **Experiment II**. **Volume of hydrogen gas formed:** • The volume of the hydrochloric acid solution is double the volume of the sulfuric acid solution. • Since sulfuric acid produces twice as many hydrogen ions per unit volume, but only half the volume is used, both experiments end up containing the same total amount of hydrogen ions. • Because the total amount of hydrogen ions is equal, the final volume of hydrogen gas formed in both experiments will be exactly the same.
1.5	**B**	**Amount of product:** • The number of gas particles on the reactant side and the product side of the reaction are equal. • A decrease in the volume of the container therefore does not cause any shift in the equilibrium position. • Because the equilibrium does not shift to either side, the total amount of product remains unchanged. **Concentration of the product:** • Concentration represents the amount of substance relative to the available volume of the container. • When the volume is made smaller, the same amount of particles are compressed into a smaller space. • This compaction of the particles causes the concentration of the gas to increase.
1.6	**A**	• **Nature of the salt**: Ammonium chloride is a salt of a weak base and a strong acid. • **Hydrolysis**: When the salt dissolves in water, the ammonium ion reacts with water molecules to release hydronium ions. The chloride ion does not react with water because it comes from a strong acid. • **Acidity**: The formation of additional hydronium ions increases the acidity of the solution, causing the pH to drop to a value less than seven (acidic solution).

1.7	**A**	• **Electrical conductivity**: The ability of a solution to conduct electricity depends on the concentration of freely charged ions in the solution. • **Solution Q**: Ethanoic acid is a weak acid that only partially ionizes. It contains the lowest concentration of ions and therefore has the weakest conductivity. • **Solution P**: Nitric acid is a strong monoprotic acid that ionizes completely to release two ions per molecule. • **Solution R**: Sulfuric acid is a strong diprotic acid that ionizes completely to release three ions per molecule. It has the highest concentration of ions and therefore the strongest conductivity. The order of increasing conductivity (from weakest to strongest) is therefore **Q**, **P**, **R**.
1.8	**C**	• **Nature of the solution:** Sodium carbonate is a salt formed from a strong base and a weak acid. When this salt dissolves in water, it forms a basic or alkaline solution with a pH greater than the neutral point. • **Hydrolysis reaction:** The sodium ion does not react with water. The carbonate ion does react with water by absorbing a proton from a water molecule. This reaction forms a hydrogen carbonate ion and a hydroxide ion. The release of these hydroxide ions causes the alkaline character of the solution.
1.9	**A**	• **Anode:** The anode is the electrode where oxidation occurs and represents the half-cell with the most negative reduction potential. Element **Y** has the most negative value of the three options and therefore serves as the anode. • **Cathode:** The cathode is the electrode where reduction occurs and represents the half-cell with the most positive reduction potential. Element X has the most positive value of the three options and therefore serves as the cathode. • **Cell potential:** The total cell potential is determined by the difference between the reduction potential of the cathode and that of the anode. The distance between the values of **X** and **Y** yields exactly the required cell potential.
1.10	**A**	**Flow of electrons in the external circuit:** • In any electrochemical cell (including an electrolytic cell), electrons always flow from the anode to the cathode through the external circuit. • Oxidation occurs at the anode where electrons are released, while reduction occurs at the cathode where electrons are absorbed. **Change in oxidation number of chlorine:** • In molten zinc chloride, chlorine exists as negatively charged chloride ions with an oxidation number of -1. • During the reaction at the anode, the chloride ions lose electrons (oxidation) to form neutral chlorine gas. • Since the most stable elemental form of an element has an oxidation number of 0, the oxidation number of chlorine changes from -1 to 0.

QUESTION 2

2.1.1 A ✓ (1)

2.1.2 F ✓ (1)

2.1.3 B ✓ (1)

2.2 **HOMOLOGOUS SERIES:** A series of organic compounds that can be described by the same general formula. ✓✓ (2)

OR

A series of organic compounds in which each successive molecule differs from the previous molecule by a CH_2 group. ✓✓

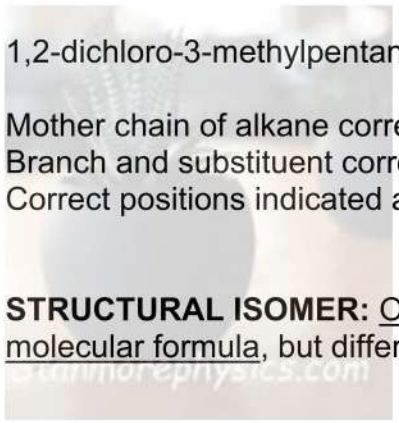
If any ONE of the underlined phrases is omitted = 1 mark If MORE than one of the underlined phrases is omitted = 0 marks

2.3.1 Alcohol ✓ (1)

2.3.2 Carboxylic acid / Ester ✓ (1)

2.4.1 2-ethyl-3-methylpent-1-ene (3)

Mother chain of alkene correctly named: "pentene" ✓
Two branches are correctly named: "ethyl" and "methyl" ✓
Correct positions indicated and all IUPAC conventions adhered to. ✓



2.4.2 1,2-dichloro-3-methylpentane (3)

Mother chain of alkane correctly named: "pentane" ✓
Branch and substituent correctly named: "dichloro" and "methyl" ✓
Correct positions indicated and all IUPAC conventions adhered to. ✓

2.5 **STRUCTURAL ISOMER:** Organic molecules with the same molecular formula, but different structural formulas. ✓✓ (2)

If any ONE of the underlined phrases is omitted = 1 mark If MORE than one of the underlined phrases is omitted = 0 marks

2.6.1 Pentan-3-one ✓ (1)

2.6.2 Any ONE of the following options: ✓ (1)

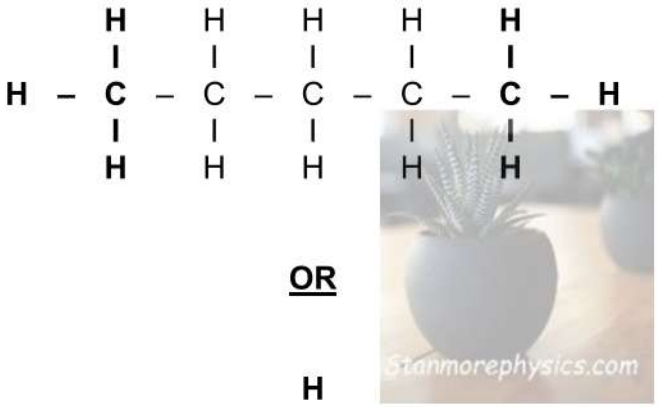
- Pentanal
- 2-methylbutanal
- 3-methylbutanal
- 2,2-dimethylpropanal

2.7 Any ONE of the following structural formulas. (2)

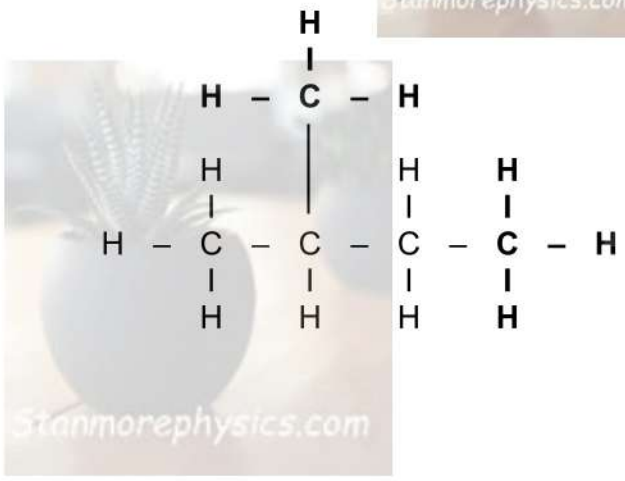
The structure represents a CHAIN ISOMER with 5 x C. ✓

<u>All IUPAC conventions adhered to</u>: ✓

- All hydrogens indicated.
- All covalent bonds indicated.
- Four covalents per carbon.



OR



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QUESTION 3

3.1 **VAPOUR PRESSURE:** The pressure exerted by a vapour in equilibrium with its liquid in a closed system. ✓✓ (2)

If any ONE of the underlined phrases is omitted = 1 mark
If MORE than one of the underlined phrases is omitted = 0 marks

3.2.1 Temperature (35 °C) / Molar mass ✓ (1)

3.2.2 Type of intermolecular forces / Functional groups / Homologous series ✓ (1)

3.2.3 Vapour pressure ✓ (1)

3.3 YES. ✓ (2)

Reason: There is only one independent variable, namely the strength of the **intermolecular forces** involved. ✓

The **vapour pressure** is the dependent variable and **molar mass** is a constant variable.

3.4.1 ❶ Identify the TYPE of intermolecular forces for two marks: ✓✓ (4)

Compound **A** (propanone) is a ketone and has **dipole-dipole** forces.

Compound **B** (propan-1-ol) is an alcohol and has **hydrogen bonds**.

❷ Compare the intermolecular forces for one mark: ✓

Dipole-dipole forces are weaker than hydrogen bonds.
Hydrogen bonds are stronger than dipole-dipole forces.

B has stronger intermolecular forces than **A.**
A has weaker intermolecular forces than **B.**

❸ Compare the energy required to overcome IMF for one mark: ✓

Compound **B** therefore requires **more energy** to overcome the intermolecular forces and will therefore have a lower vapour pressure.

Compound **A** therefore requires **less energy** to overcome the intermolecular forces and will therefore have a higher vapour pressure.

NOTE: The candidate will NOT receive a mark for a statement that the vapour pressure of compound B is lower than the vapour pressure of compound A, or vice versa, because this is already indicated on the question paper.

3.4.2 (4)

❶ Candidate gets one mark for the fact that both compounds, B and C, have the same type of intermolecular force: ✓

Compound **B** (propan-1-ol) is an alcohol with **hydrogen bonds** and compound **C** (ethanoic acid) is a carboxylic acid with **hydrogen bonds**.

❷ Candidate gets two marks for the fact that the number of points where a hydrogen bond can be formed differs:

Compound **C** has **two sites** for hydrogen bonds. ✓
Compound **B** has **one site** for a hydrogen bond. ✓

Compound **C** has **two sites** where hydrogen bonds can form.
Compound **B** has **one site** where hydrogen bonds can form.

The number of hydrogen bonds that must be overcome at **C** is more than that which must be overcome at **B**.

❸ Compare the energy required to overcome IMF for one mark: ✓

Compound **C** therefore requires **more energy** to overcome the intermolecular forces and will therefore have a lower vapour pressure.

Compound **B** therefore requires **less energy** to overcome the intermolecular forces and will therefore have a higher vapoor pressure.

NOTE: The candidate will NOT receive a mark for a statement that the vapour pressure of compound C is lower than the vapour pressure of compound B, or vice versa, because this is already indicated on the question paper.

3.5 **A** / Propanone ✓ (2)

Any acceptable and correctly worded reason: ✓

- Compound A has the highest vapour pressure.
- The vapour pressure is inversely proportional to the boiling point.
- Compound A has the weakest intermolecular forces and therefore requires the least amount of energy to overcome the intermolecular forces.

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QUESTION 4

4.1.1 Dehydrohalogenation / Dehydrobromination ✓ (1)

4.1.2 Major product: But-2-ene ✓ (2)
Minor product: But-1-ene ✓

4.1.3 Sodium bromide / NaBr ✓ (1)

Reason: $C_4H_9Br + NaOH(c) \rightarrow C_4H_8 + \mathbf{H}Br + Na\mathbf{OH}$
$C_4H_9Br + NaOH(c) \rightarrow C_4H_8 + NaBr + \mathbf{H_2O}$

HBr is a strong acid and NaOH is a strong base.

4.2.1 2-chlorobutane ✓ (1)

NOTE: Only one mark because the "bromo" was replaced with "chloro"

4.2.2 Any ONE of the following reaction conditions: ✓ (1)
No water should be present. Room temperature.

4.3.1 SUBSTITUTION ✓ (1)

4.3.2 Hydrolysis ✓ (1)

4.3.3 (3)

Hydroxyl group (OH) on C_2: ✓

Length of parent chain and all IUPAC conventions adhered to: ✓

IUPAC name: Butan-2-ol / 2-butanol ✓

4.4 **IV** = Dehydration ✓ (2)

V = Hydrogenation ✓

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QUESTION 5

5.1 **REACTION RATE:** The change in concentration of reactants or products per unit time. ✓✓ (2)

Definition counts 2 or 0

5.2 6,5 minutes / 6½ minutes / 390 s ✓ (1)

5.3 Any ONE of the following explanations: ✓ (1)

- The gradient of the tangent to the curve decreases over time.
- The average gradient between any two points decreases over time.
- The volume of oxygen formed per minute decreases.
- The time it takes to form 20 cm^3 of oxygen increases.

5.4.1 Reaction Rate = $\frac{\Delta V}{\Delta t} = \frac{116}{6,5}$ ✓ = 17,85 $cm^3.min^{-1}$ ✓ (2)

5.4.2 $n = \frac{V}{V_m}$ ✓ $= \frac{0,116}{22,4}$ ✓ $= 0,0052$ mol ✓ (3)

5.4.3 (6)

	$2H_2O_2(aq)$	$2H_2O(\ell)$	$O_2(g)$
n_i	0,04	0	0
$\triangle n$	– 0,010357 ❶		+ 0,0051785
n_f	0,029643 ❸		0,0051785
	$V = 0,2\ dm^3$ $c_i = 0,2\ mol{\cdot}dm^{-3}$ $n = cV$ $n_i = (0,2)(0,2)$ ❷ $n_i = 0,04$ mol		

❶ $\triangle n(H_2O_2):\triangle n(O_2) = 2:1$ ✓

$\therefore \triangle n(H_2O_2) = 2(0,0051785) = 0,010357$ mole

❷ $n_i(H_2O_2) = cV$ ✓ $= (0,2)(0,2)$ ✓ $= 0,04$ mole

❸ $n_f(H_2O_2) = n_i - \triangle n = (0,04) - (0,010357)$ ✓ $= 0,029643$ mole

❹ $c_f = \frac{n_f}{V} = \frac{0,029643}{0,2}$ ✓ $= 0,148\ mol.dm^{-3} \approx 0,15\ mol{\cdot}dm^{-3}$ ✓

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QUESTION 6

6.1 **CHEMICAL EQUILIBRIUM:** A dynamic equilibrium when the rate of the forward reaction is equal to the rate of the reverse reaction. ✓✓ (2)

OR

CHEMICAL EQUILIBRIUM: A dynamic equilibrium when the concentration of the reactants and the concentration of the products remain constant. ✓✓

If any ONE of the underlined phrases is omitted = 1 mark If MORE than one of the underlined phrases is omitted = 0 marks

6.2 (7)

	$NO_2(g)$	$SO_2(g)$	$SO_3(g)$	$NO(g)$	
n_i	**2**	**2**	**0**	**0**	
$\triangle n$	-0,75	-0,75	+0,75	+0,75	❶
n_f	1,25	1,25	**0,75**	0,75	❷
$c_{Equilibrium}$	0,625	0,625	0,375	0,375	❸
			m = 60 g $n = \frac{m}{M} = \frac{60}{80}$ n = 0,75 ✓		

❶ The correct ratio (1:1:1:1) is indicated in the $\triangle n$. ✓

❷ n_f for each gas is correctly determined by $n_i \pm \triangle n$ ✓

❸ $c_{Equilibrium}$ correctly calculated by $n_f \div 2$ ✓

$$K_C = \frac{[SO_3][NO]}{[NO_2][SO_2]}$$ ✓

$$K_C = \frac{(0,375)(0,375)}{(0,625)(0,625)}$$ ✓

$$K_C = 0,36$$ ✓

6.3 **LE CHATELIER'S PRINCIPLE:** When the equilibrium in a closed system is disturbed, the system establishes a new equilibrium by favouring the reaction that counteracts the disturbance. ✓✓ (2)

If any ONE of the underlined phrases is omitted = 1 mark If MORE than one of the underlined phrases is omitted = 0 marks

6.4 **OPTION 1:** (4)

- **Increase the concentration** of any one of the **products**. ✓
- According to Le Chatelier, the reaction that will **remove** the excess substance will be favored. ✓
- The **reverse reaction** is favored. ✓
- If the reverse reaction is favored, the **concentration of the NO_2 increases** ✓ and the reaction mixture appears reddish brown.

OPTION 2:

- **Decrease the concentration** of any one of the **reactants**. ✓
- According to Le Chatelier, the reaction that will **replenish** the deficiency will be favored. ✓
- The **reverse reaction** is favored. ✓
- If the reverse reaction is favored, **the concentration of the NO_2 increases** ✓ and the reaction mixture appears reddish brown.

6.5 (2)

- **Any ONE of the following references to Le Chatelier's principle:** ✓

According to Le Chatelier, the reaction will be favored in the direction of the largest number of moles if the volume of the container is increased and the concentration of the particles decreases.

OR

According to Le Chatelier, the reaction will be favored in the direction of the least number of moles if the volume of the container is reduced and the concentration of the particles increases.

- **One mark for the references to the fact that the reactants and the products have the same number of moles of particles:** ✓

Because the number of particles of the reactants and the products is the same number of moles, a change in the volume of the container will have no effect on the concentrations of the gases.

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QUESTION 7

7.1 **STRONG ACID:** Acid that ionizes completely in water to form a high concentration of hydronium ions. ✓✓ (2)

Definition counts 2 or 0

7.2 $pH = -\log[H_3O^+]$ ✓ (3)

$pH = -\log(0,5)$ ✓

$pH = 0,3$ ✓

7.3.1 HSO_4^- / Hydrogen sulfate **ion** ✓ (2)

Reason: It has the smallest K_a value ✓

7.3.2 HSO_4^- / Hydrogen sulfate **ion** ✓ (2)

Reason: It can donate a proton or accept a proton. ✓
It can act as both an acid or a base.

7.4.1 THE SAME ✓ (1)

7.4.2 LOWER ✓ (1)

7.5.1 LOWER ✓ (1)

Reason: The pH of the mixture is 12,56 which indicates that the mixture is a base and therefore contains more hydroxide ions (OH^-).

7.5.2 (8)

	$H_2SO_4(aq)$	$2NaOH(aq)$	$Na_2SO_4(aq)$	$2H_2O(\ell)$
n_i	0,0012	0,00374 ❻		
$\triangle n$	– 0,0012 ❹	– 0,0024		
n_f	**0**	0,00134		
	V = 0,012 c = 0,1 ❸ $c_i = \frac{n_i}{V}$ $(0,1) = \frac{n_i}{(0,012)}$ $n_i = 0,0012$	m = x g V = 0,025 ❺ $c_f = \frac{n_f}{V}$ $(0,0363) = \frac{n_i}{(0,037)}$ $n_f = 0,00134$		

❶ $pH = -\log[H_3O^+]$

$12,56 = -\log[H_3O^+]$ ✓

$\therefore [H_3O^+] = 10^{-12,56} = 2,75 \times 10^{-13}\ mol \cdot dm^{-3}$

❷ $[H_3O^+][OH^-] = 1 \times 10^{-14}$

$(2,75 \times 10^{-13})[OH^-] = 1 \times 10^{-14}$ ✓

$\therefore [OH^-] = 0,0363\ mol \cdot dm^{-3}$

❸ $c_i(H_2SO_4) = \frac{n_i}{V}$

$(0,1) = \frac{n_i}{(0,012)}$ ✓

$n_i = 0,0012$

❹ $\triangle n(H_2SO_4) : \triangle n(NaOH) = 1:2$ ✓

$\therefore \triangle n(NaOH) = 0,0024\ mol$ ✓

❺ $c_f\ (NaOH) = \frac{n_f}{V}$

$(0,0363) = \frac{n_i}{(0,037)}$ ✓

$n_f = 0,00134$

❻ $n_i(NaOH) = n_f + \triangle n = 0,00134 + 0,0024$ ✓ $= 0,00374\ mol$

❼ $n_i(NaOH) = \frac{m}{M}$

$\therefore m = nM = (0,00374)(40)$ ✓ $= 0,1496\ g \approx 0,15\ g$ ✓

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QUESTION 8

8.1 Temperature = 25 °C / 298 K ✓ (3)
Consentrations = 1 mol·dm^{-3} ✓
Pressure = 1,013 x 10^5 Pa / 101,3 x 10^3 Pa / 101,3 kPa / 1 atm ✓

8.2.1 $Ni \rightarrow Ni^{2+} + 2e^-$ ✓✓ (2)

8.2.2 $2H^+ + 2e^- \rightarrow H_2$ ✓✓ (2)

8.3 Any version of the equation: ✓ (3)

$$E^\theta_{sel} = E^\theta_{cathode} - E^\theta_{anode}$$
$$E^\theta_{sel} = E^\theta_{reduction} - E^\theta_{oxidation}$$
$$E^\theta_{sel} = E^\theta_{oxidizing\ agent} - E^\theta_{reducing\ agent}$$

$E^\theta_{sel} = (0) - (-0,27)$ ✓
$E^\theta_{sel} = 0,27\ V$ ✓

8.4 $Ni(s) / Ni^{2+}(aq) // 2H^+(aq) / H_2(g) / Pt(s)$ (3)

OR

$Ni / Ni^{2+} // 2H^+ / H_2 / Pt$

Anode is described first and in the correct order with phase boundaries: ✓
Cathode is described second and in the correct order with phase boundaries: ✓
All conventions are followed (Salt Bridge): ✓

8.5 The electrolyte at the anode becomes more positive over time because the concentration of nickel cations increases. [Ni^{2+}] ✓ (2)

Negative ions (anions) move from the salt bridge through the membrane to the electrolyte to keep it neutral. ✓

8.6 DECREASE ✓✓ (2)

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QUESTION 9

9.1 **ELECTROLYSIS:** The chemical process in which electrical energy is converted into chemical energy. ✓✓ (2)

OR

ELECTROLYSIS: The chemical process in which electrical energy is used to bring about a chemical change. ✓✓

Definition counts 2 or 0

9.2.1 NON-SPONTANEOUS reaction ✓ (1)

9.2.2 ENDOTHERMIC reaction ✓ (1)

9.3 $2C\ell^- \rightarrow C\ell_2 + 2e^-$ ✓✓ (2)

$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ ✓✓ (2)

9.4.1 $2C\ell^- + 2H_2O \rightarrow C\ell_2 + H_2 + 2OH^-$ ✓✓ (2)

9.4.2 **One mark** if candidate writes down: (2)
$2H_2O + 4H_2O \rightarrow O_2 + 4H^+ + 2H_2 + 4OH^-$.

Two marks if candidate writes down **$2H_2O \rightarrow O_2 + 2H_2$**

Reason: $2H_2O + 4H_2O \rightarrow O_2 + 4H^+ + 2H_2 + 4OH^-$

$2H_2O + 4H_2O \rightarrow O_2 + \mathbf{4H^+} + 2H_2 + \mathbf{4OH^-}$

$\mathbf{6H_2O} \rightarrow O_2 + \mathbf{4H_2O} + 2H_2 + 4OH^-$

$2H_2O \rightarrow O_2 + 2H_2$

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