education
MPUMALANGA PROVINCE
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12



PHYSICAL SCIENCES: CHEMISTRY P2

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SEPTEMBER 2024

MARKS: 150

TIME: 3 ure

This question paper consists of 16 pages and 4 data sheets.

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INSTRUCTIONS AND INFORMATION

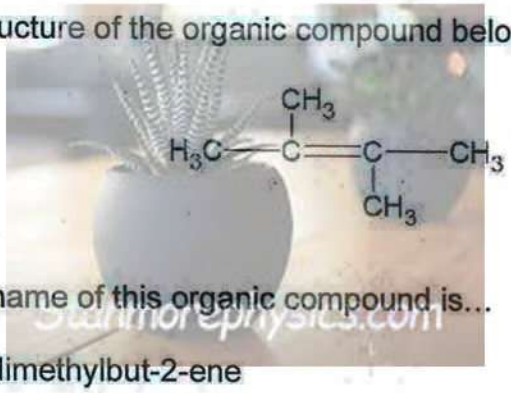
1. Write your name in the appropriate space on the ANSWER BOOK.
2. This question paper consists of NINE questions. Answer ALL the questions in the ANSWER BOOK.
3. Start EACH question on a NEW page in the ANSWER BOOK.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Leave ONE line between two sub questions, for example between QUESTION 2.1 and QUESTION 2.2.
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.
11. Give brief motivations, discussions, et cetera where required.
12. Write neatly and legibly.

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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) in the ANSWER BOOK, for example, 1.11 E.

1.1 Study the structure of the organic compound below.



The IUPAC name of this organic compound is...

A 2,3-dimethylbut-2-ene

B 2,2-dimethylbut-2-ene

C 1,1,2-trimethylprop-1-ene

D 1,1,2,2-trimethylethene (2)

1.2 Which ONE of the following organic reactions will take place when exposed to light.

A $CH_2CH_2 + H_2 \rightarrow CH_3CH_3$

B $CH_3CH_3 \rightarrow CH_2CH_2 + H_2$

C $CH_2CH_2 + C\ell_2 \rightarrow CH_2C\ell CH_2C\ell$

D $CH_3CH_3 + C\ell_2 \rightarrow CH_3CH_2C\ell + HC\ell$ (2)

1.3 Consider the reaction given below.

$$CH_3(CH_2)_3CH_3 \rightarrow CH_3CHCH_2 + \mathbf{X}$$

Which ONE of the following combinations correctly identifies the type of reaction that takes place and the IUPAC name of product **X**?

	TYPE OF REACTION	Product X
A	Elimination	Ethane
B	Elimination	Ethene
C	Addition	Ethane
D	Addition	Ethene

(2)

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1.4 Which ONE of the following isomers has the lowest boiling point?

A $CH_3CH_2CH_2CH_2CH_2CH_3$

B $CH_3CH_2C(CH_3)_2CH_3$

C $CH_3CH(CH_3)CH_2CH_2CH_3$

D $CH_3CH_2CH(CH_3)CH_2CH_3$ (2)

1.5 A potential energy diagram can be used to show the activation energy (E_A) and the heat of reaction (ΔH) of a reaction.

Which ONE of the following combinations of values of E_A and ΔH CANNOT be obtained for any reaction?

	E_A (kJ·mol^{-1})	ΔH (kJ·mol^{-1})
A	50	-100
B	50	+100
C	100	+50
D	100	-50

(2)

1.6 The reaction represented by the balanced equation below reaches equilibrium in a closed container at 400 K and standard pressure.

$$4HC\ell(g) + O_2(g) \rightleftharpoons 2C\ell_2(g) + 2H_2O\,(g) \qquad \Delta H > 0$$

Which ONE of the following is CORRECT when the temperature is changed to 350 K?

	YIELD OF $O_2(g)$	RATE OF FORWARD REACTION	EQUILIBRIUM CONSTANT
A	Decreases	Increases	Remains the same
B	Increases	Decreases	Decreases
C	Decreases	Increases	Increases
D	Increases	Decreases	Remains the same

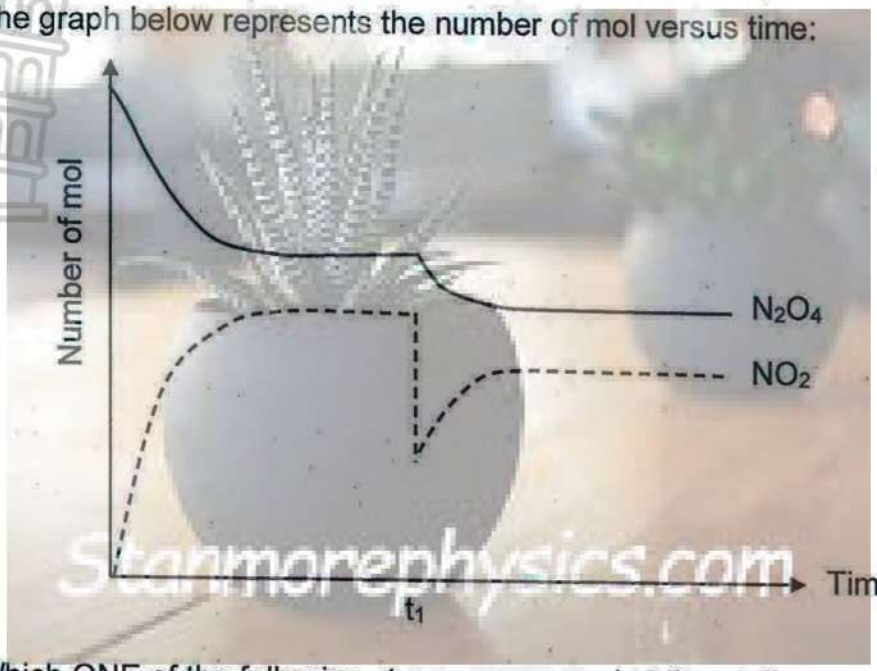
(2)

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1.7 The following reversible reaction reached equilibrium in a closed container:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H > 0$$

The graph below represents the number of mol versus time:



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Which ONE of the following stresses occurred at time t_1?

A NO_2 was removed from the system

B N_2O_4 was removed from the system

C The temperature was decreased

D The pressure was increased (2)

1.8 Ammonium sulphate is dissolved in water at 25 °C. Which ONE of the following options gives the best description of the solution?

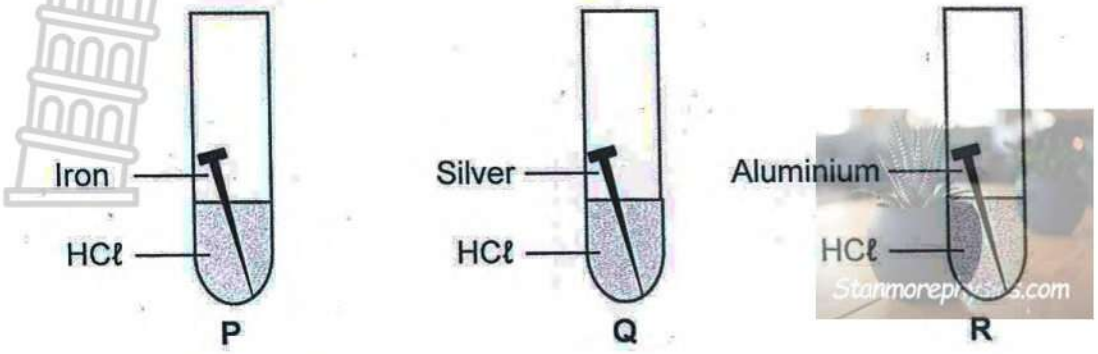
A $[OH^-] = 10^{-7}$ mol·dm^{-3}

B $[OH^-] = [H_3O^+]$

C $[OH^-] > [H_3O^+]$

D pH < 7 (2)

1.9 Three nails made of different metals are placed in separate test tubes, **P**, **Q** and **R**. Each of the test tubes contain 1 mol·dm^{-3} hydrochloric acid (HCℓ) at 25 °C



In which tubes will hydrogen gas be produced?

A **P** and **Q** only

B **P** and **R** only

C **Q** and **R** only

D **P**, **Q** and **R** (2)

1.10 Which ONE of the following represents the oxidation half-reaction in the electrolysis of concentrated sodium chloride solution?

A $Na(s) \rightarrow Na^+(aq) + e^-$

B $2Cl^-(aq) \rightarrow 2Cl_2(g) + 2e^-$

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

D $2H_2O + 2e^- \rightarrow H_2(g) + 2OH^-$ (2)

[20]

QUESTION 2 (Start on a new page.)

2.1 Study the organic compound below:

$$CH_3COOCH_3$$

For this compound, write down the:

2.1.1 IUPAC name (2)

2.1.2 Structural formula for the functional group (1)

2.1.3 IUPAC name of the alcohol used in the preparation of this compound. (1)

2.1.4 Define the term *functional isomer* (2)

2.1.5 Structural formula of this compound's functional isomer (2)

2.2 The IUPAC name of an organic compound is:

2,4-dimethylhexan-3-one

For this compound, write down the:

2.2.1 Homologous series to which it belongs (1)

2.2.2 Structural formula (3)

2.2.3 Structural formula of its positional isomer (2)

2.3 Study the following chemical reaction:

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

2.3.1 Name the type of reaction represented above. (1)

2.3.2 Write down the IUPAC name of the gas that reacted with oxygen in the reaction above. (1)

2.3.3 60,2 g of the gas named in QUESTION 2.3.2 reacts completely with an excess of oxygen gas. All the carbon dioxide that is formed during the reaction is bubbled through a solution of calcium hydroxide to form calcium carbonate as a product. As shown in the reaction below.

$$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O$$

Calculate the mass of calcium carbonate that will form. (5)

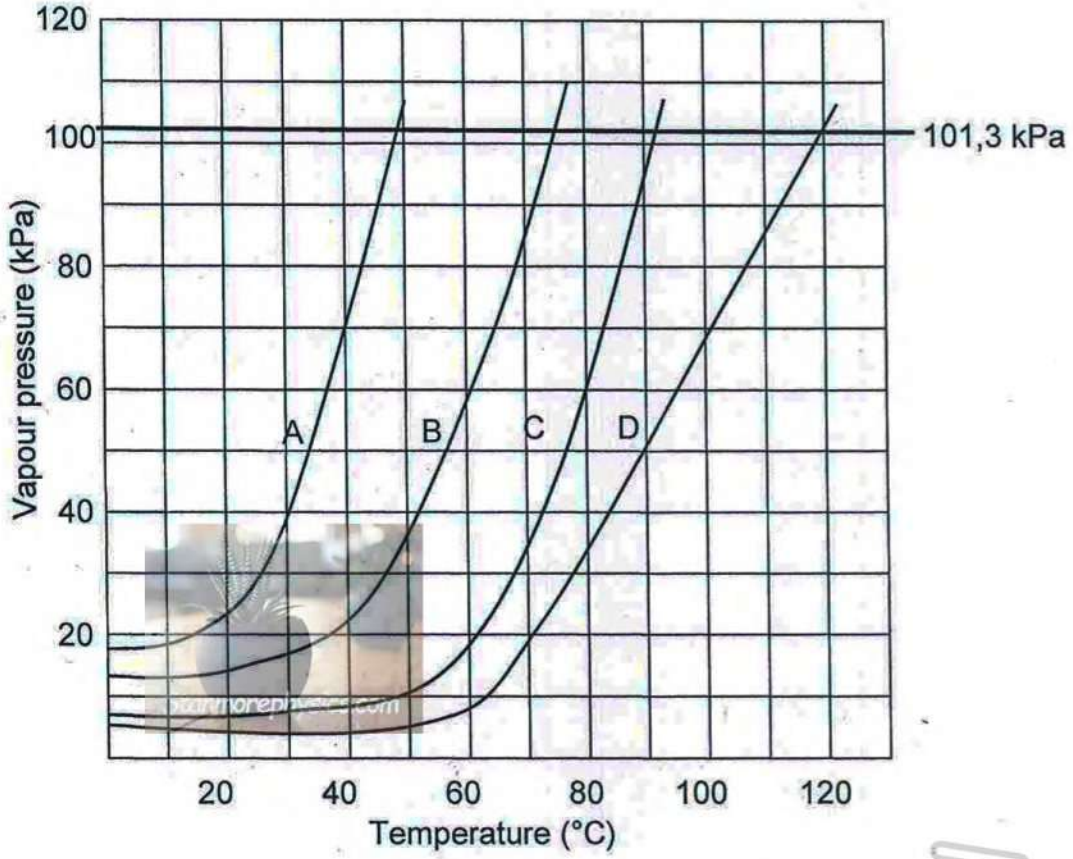
[21]

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QUESTION 3 (Start on a new page.)

The graph below shows how the vapour pressure of different organic molecules change as the temperature changes. The line at 101,3 kPa, on the graph, indicates the external atmospheric pressure.

The vapour pressure of four different organic substances, which are similar in molecular mass, versus temperature are indicated. The four curves (**A**, **B**, **C** and **D**) represent organic compounds belonging to the following homologous series. A STRAIGHT CHAIN ALKANE, a BRANCHED ALKANE, a PRIMARY ALCOHOL and an ALDEHYDE.



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

3.2 The vapour pressure of compounds **A** and **B** are compared.

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

3.2.2 Explain the difference in the vapour pressure of these two compounds. (4)

3.3 Write down the boiling point of compound **D** (1)

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3.4 Which ONE of the compounds **C** or **D** is the alcohol?

Give a reason for the answer (2)

3.5 The vapour pressure of compounds **C** and **D** are now compared.

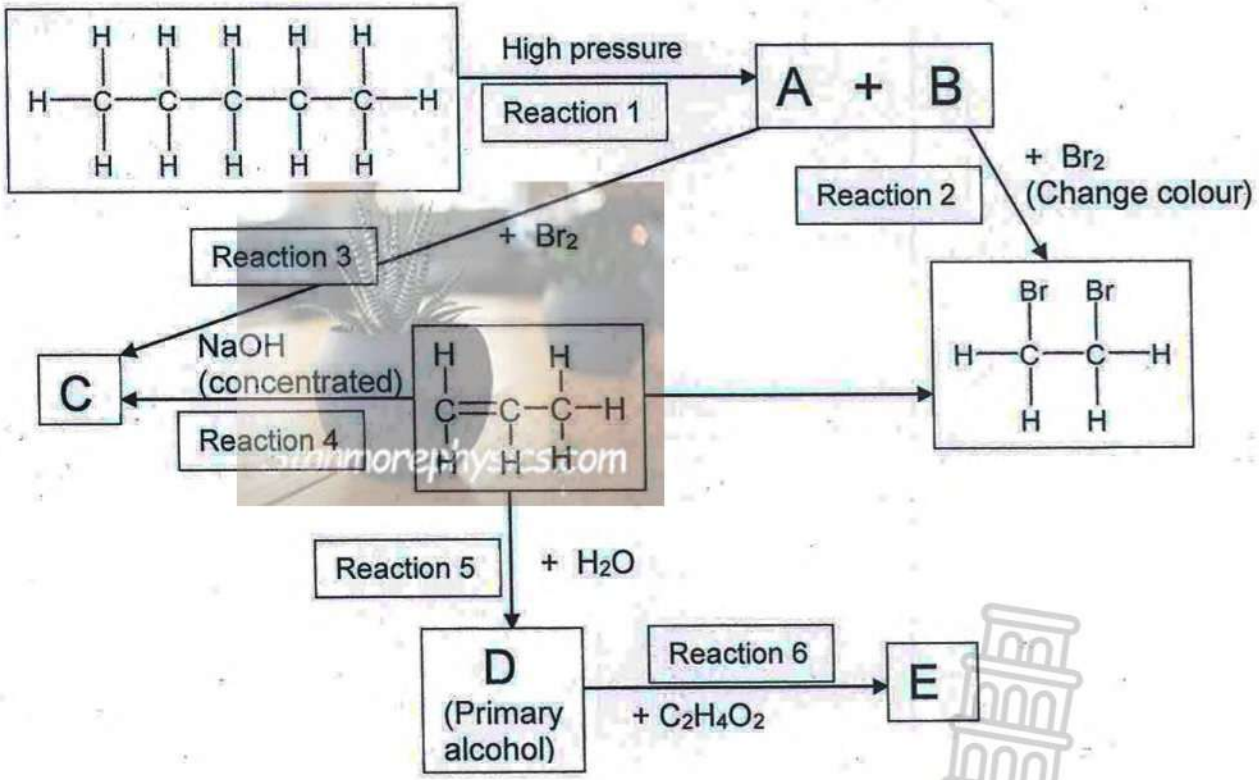
3.5.1 Which variable must be kept constant in this experiment? (1)

3.5.2 Refer to the TYPES of intermolecular forces to explain the difference in vapour pressure between compound **C** and **D**. (3)

[14]

QUESTION 4 (Start on a new page.)

Study the flow diagram of organic reactions below and answer the questions that follow. The letters **A**, **B**, **C**, **D** and **E** represent organic compounds.



4.1 For reaction **1** write down:

4.1.1 The type of reaction that takes place (1)

4.1.2 The structural formula for compound **B** (2)

4.2 For reaction **2**:

4.2.1 Write down the type of reaction that takes place. (1)

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4.2.2 Explain the colour change as indicated in this reaction. (2)

4.3 For reaction **3** write down:

4.3.1 The type of reaction that takes place (1)

4.3.2 The NAME or FORMULA of the inorganic product for reaction **3** (1)

4.4 Write down a balanced chemical equation using CONDENSED STRUCTURAL FORMULAE for reaction **4**. (2)

4.5 Define the term *primary alcohol* (2)

4.6 Write down a balanced chemical equation using STRUCTURAL FORMULAE for reaction **6**. (3)
[15]

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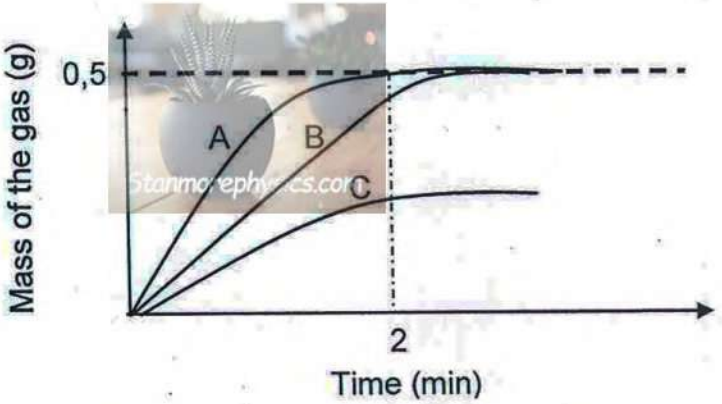
QUESTION 5 (Start on a new page.)

Learners use the reaction of a sodium thiosulphate solution with dilute hydrochloric acid to investigate several factors that affect the rate of a chemical reaction. The balanced equation for the reaction is:

$$Na_2S_2O_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + SO_2(g) + S(s) + H_2O(\ell)$$

Three investigations (**A**, **B** and **C**) are carried out.

The graph below shows the results of three investigations in which the same concentration of diluted hydrochloric acid ($HC\ell$) reacts with 1,3 g impure sodium thiosulphate ($Na_2S_2O_3$). Details of the experiment are given in the table below.



	Investigation 1	Investigation 2	Investigation 3
Volume of ($HC\ell$) (cm^3)	60	15	60
Temperature (°C)	40	20	40
Catalyst added	No	No	Yes

5.1 Match each curve **(A,B,C)** to its corresponding investigation **(1,2,3)** in the table. (3)

5.2 Use the information given on the graph and table to determine the rate of reaction of investigation **A** in ($mol \cdot s^{-1}$) (4)

5.3 Write down the factor that remains constant in all three investigations. (1)

5.4 A catalyst is used in investigation 3. State the effect that a catalyst has on each of the following. Write only INCREASE, DECREASE or REMAIN THE SAME.

5.4.1 Concentration of the products. (1)

5.4.2 Heat of the reaction. (1)

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5.5 Use the collision theory to explain the difference in rate of reaction between investigation **A** and **B**. (4)

5.6 Sketch the Maxwell-Boltzman distribution curve for **Investigation 1**. Label this curve as **1**. On the same set of axis, draw the curve that will be obtained for **Investigation 3**. (4)
[18]

QUESTION 6 (Start on a new page.)

Carbon monoxide gas, CO(g), and oxygen gas, $O_2(g)$, are sealed in a 2 dm^3 container and allowed to react to form carbon dioxide, $CO_2(g)$. The reversible reaction reaches equilibrium at 600 K according to the following balanced equation:

$$2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$$

6.1 Explain what is meant by the term *reversible* reaction. (1)

6.2 How will each of the following changes affect the yield of $CO_2(g)$?

Write down only INCREASES, DECREASES or REMAINS THE SAME.

6.2.1 A catalyst is added to the reaction mixture. (1)

6.2.2 The pressure is lowered by increasing the volume of the container at constant temperature. (1)

6.2.3 Explain the answer in QUESTION 6.2.2 using Le Chateliers' principle. (2)

6.3 Initially, 0,35 mol of CO(g) and an unknown amount of $O_2(g)$ were placed in the container. At equilibrium, the number of particles CO(g) present is $9,03 \times 10^{22}$. The equilibrium constant K_c for the reaction is 51 at 600 K

Calculate the initial mass of $O_2(g)$, in grams, sealed in the container. (9)

6.4 The equilibrium constant (K_c) at 400 K for the reaction above is 45. Is the forward reaction EXOTHERMIC or ENDOTHERMIC? Explain the answer fully. (3)
[17]

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QUESTION 7 (Start on a new page.)

7.1 The hydrogens carbonate ion (HCO_3^-) can act as an ampholyte.

7.1.1 Explain what is meant by the underlined term. (2)

7.1.2 Consider the following reaction:

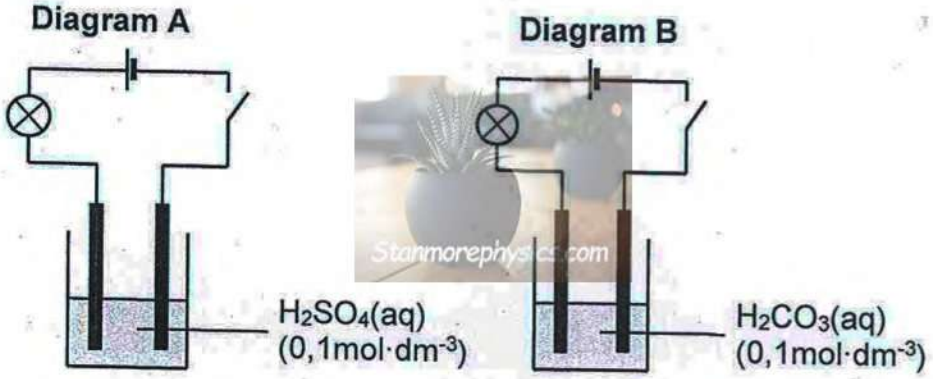
$$HCO_3^-(aq) + H_2O(\ell) \rightleftharpoons CO_3^{2-}(aq) + H_3O^+(aq)$$

Is the HCO_3^- ion in this reaction acting as a Brønsted-Lowry acid or a base? Give a reason for the answer. (2)

7.1.3 Write down the FORMULA of the substance which forms a conjugate acid base pair with the HCO_3^- ion. (1)

7.2 Two identical electrolytic cells are set up as follows to determine the conductivity of sulphuric acid (H_2SO_4) and carbonic acid (H_2CO_3)

The concentration of both solutions is 0,1 mol·dm^{-3}



Which diagram's bulb will burn the brightest? Give a reason for the answer by referring to the acids. (2)

7.3 The concentration of the sulphuric acid (H_2SO_4) in a solution is $0,25 \times 10^{-3}$ mol·dm^{-3}. Calculate the pH of the solution. (3)

7.4 Na_2CO_3 is a salt that forms when NaOH reacts with H_2CO_3. This salt reacts with water.

7.4.1 Write down one word for the underlined part. (1)

7.4.2 Is the aqeous solution of sodium carbonate (Na_2CO_3), ACIDIC, BASIC, or NEUTRAL? (1)

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7.5 A standard solution was prepared by adding an unknown amount of $Ba(OH)_2$ to 250 cm^3 water. $Ba(OH)_2$ now reacts with $HC\ell(aq)$ according to the following balanced equation.

$$Ba(OH)_2(aq) + 2HC\ell(aq) \rightarrow BaC\ell_2(aq) + 2H_2O(\ell)$$

25 cm^3 of the standard solution of $Ba(OH)_2$ reacts with 100 cm^3 of the diluted $HC\ell$ which has a concentration of 0,15 $mol \cdot dm^{-3}$.

The EXCESS $Ba(OH)_2$ is neutralised by adding 50 cm^3 of a 0,05 $mol \cdot dm^{-3}$ H_2SO_4. The reaction is as follows:

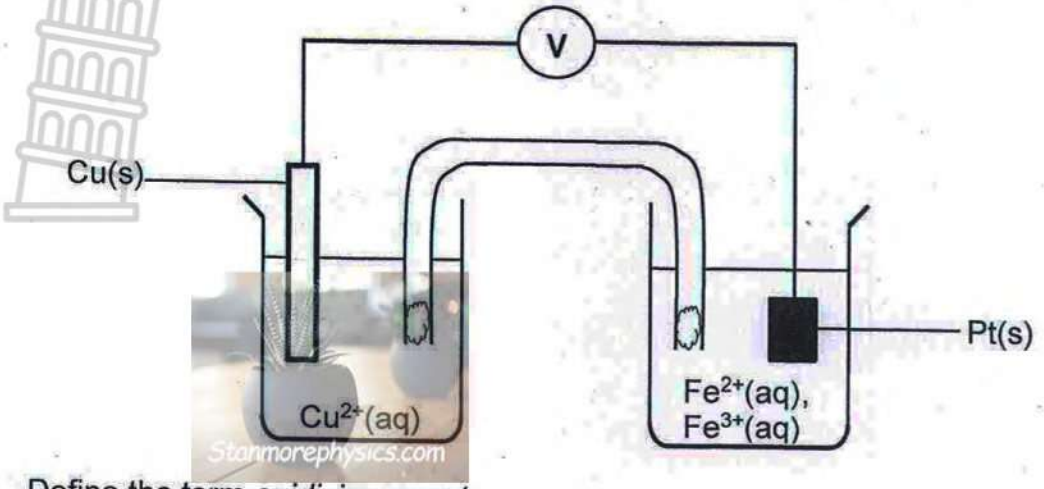
$$Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(aq) + 2H_2O(\ell)$$

Calculate the initial mass of $Ba(OH)_2$ used to prepare the standard solution. (8)
[20]

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QUESTION 8 (Start on a new page.)

The electrochemical cell illustrated below was set up under standard conditions.



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8.1 Define the term *oxidising agent*. (2)

8.2 Identify the oxidising agent in the cell above. (1)

8.3 Write down the:

8.3.1 Cell notation of this cell. (3)

8.3.2 Oxidation half-reaction that takes place. (2)

8.4 Iron(II)chloride solution, $FeC\ell_2$ is added to the Fe^{3+}/Fe^{2+}-half cell.

8.4.1 How will the reading on the voltmeter on the voltmeter be affected? (Choose from INCREASES, DECREASES or REMAINS THE SAME). (1)

8.4.2 Use Le Chatelier's principle to explain the answer to QUESTION 8.4.1. (2)

8.5 The $Fe^{3+}|Fe^{2+}$ half-cell is now replaced by a $Sn^{4+}|Sn^{2+}$-half-cell. It is found that the direction of the electron flow changes.

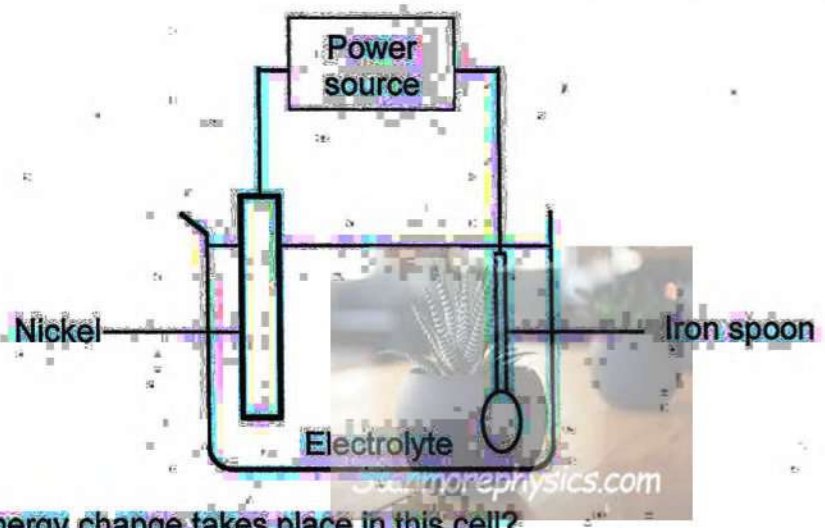
Fully explain why there is a change in direction of electron flow by referring to the relative strengths of the reducing agents involved. (3)

[14]

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QUESTION 9 (Start on a new page.)

The diagram below shown a simplified cell used to electroplate an iron spoon with nickel.



9.1 What energy change takes place in this cell? (1)

9.2 Write down the:

9.2.1 NAME or FORMULA of a substance that can be used as an electrolyte in this cell. (1)

9.2.2 NAME or FORMULA of the substance which is oxidised. (1)

9.2.3 Half-reaction that takes place at the cathode. (2)

9.3 How will the concentration of the electrolyte change during electroplating? Choose from INCREASE, DECREASE or STAY THE SAME.

Give a reason for the answer. (2)

9.4 Calculate the number of electrons transferred if 2,5 g of nickel is plated on the spoon. (4)
[11]

TOTAL [150]

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