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NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2026

PHYSICAL SCIENCES: PAPER II

EXAMINATION NUMBER

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Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 26 pages as well as a Data Sheet of 3 pages (i–iii). Please make sure that your question paper is complete.
2. Read the questions carefully.
3. Answer all the questions.
4. Unless instructed otherwise, you do NOT have to give state symbols (phase indicators) when asked to write a balanced chemical equation.
5. Use the data and formulae whenever necessary.
6. Show all the necessary steps in calculations.
7. Where appropriate, take your answers to two decimal places.
8. It is in your interest to write legibly and to present your work neatly.
9. Two blank pages (pages 25–26) are included at the end of the question paper. Use these pages if you run out of space for a question. Clearly indicate the number of the question you are answering, should you use this additional space.

FOR OFFICE USE ONLY: MARKERS TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total
Mark									
Marker Initials									
Moderated Mark									
Moderator Initials									
Question Total	20	19	25	19	28	29	25	35	200
Re-mark									
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QUESTION 1 MULTIPLE CHOICE

Every question has only one correct answer. You may use the space provided to solve the questions, BUT YOU MUST INDICATE YOUR CHOSEN ANSWER FOR EACH QUESTION IN THE GRID BELOW. Make a clear cross (X) in the box corresponding to the letter you consider correct.

A	B	C	D
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Here, option C has been marked as an example.

1.1	A	B	C	D
1.2	A	B	C	D
1.3	A	B	C	D
1.4	A	B	C	D
1.5	A	B	C	D
1.6	A	B	C	D
1.7	A	B	C	D
1.8	A	B	C	D
1.9	A	B	C	D
1.10	A	B	C	D

1.1 Which compound has a cation with a charge of +2?

- A $\text{Cr}(\text{PO}_4)_2$
- B PbS_2
- C $\text{Na}_2\text{Cr}_2\text{O}_7$
- D Fe_3N_2

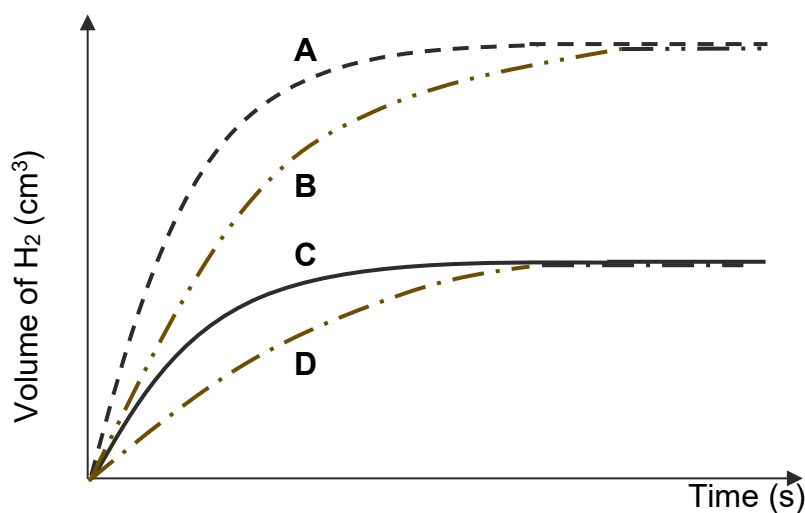
1.2 How many ions are present in 1 mole of aluminium chlorate, $\text{Al}(\text{ClO}_3)_3$?

- A 4
- B 13
- C $4 \times N_A$
- D $13 \times N_A$

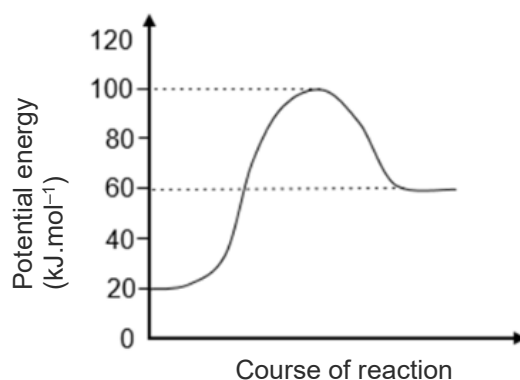
- 1.3 The table gives the results of four experiments in which hydrochloric acid reacts with excess zinc.

Experiment	1	2	3	4
Volume acid (cm ³)	60	30	30	60
Volume water (cm ³)	60	30	30	60
Temperature of solution (°C)	40	20	40	40
Zinc	whole	whole	whole	crushed

Which graph below corresponds to **Experiment 2**?



- 1.4 Use the given potential energy profile to answer the questions that follow.

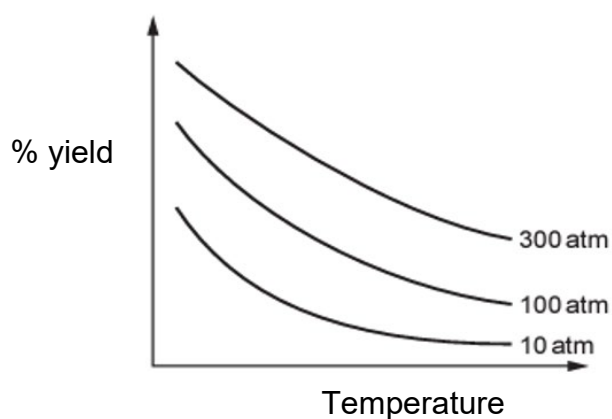


For the forward reaction:

- Which are the stronger bonds, the reactant bonds or the product bonds?
- What is the energy of the activated complex?

	Stronger bonds	Energy of the activated complex (kJ.mol ⁻¹)
A	Reactants	100
B	Reactants	80
C	Products	100
D	Products	80

- 1.5 The graph below shows how the percentage yield varies with temperature and pressure for an equilibrium process.



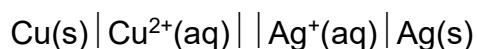
Choose the correct option in the table below.

	The forward reaction is ...	More moles of gas are produced by the ... reaction.
A	exothermic	forward
B	exothermic	reverse
C	endothermic	forward
D	endothermic	reverse

- 1.6 Which one of the substances below will oxidise Zn to Zn^{2+} but not Sn to Sn^{2+} ?

- A Mg^{2+}
- B Co
- C Br_2
- D Cd^{2+}

- 1.7 The following cell is set up:



What is the standard cell emf, E_{cell}^{θ} ?

- A +0,46 V
- B -0,46 V
- C +1,14 V
- D -1,14 V

- 1.8 Which statement is **incorrect** regarding the membrane in a cell used in the chlor-alkali process?

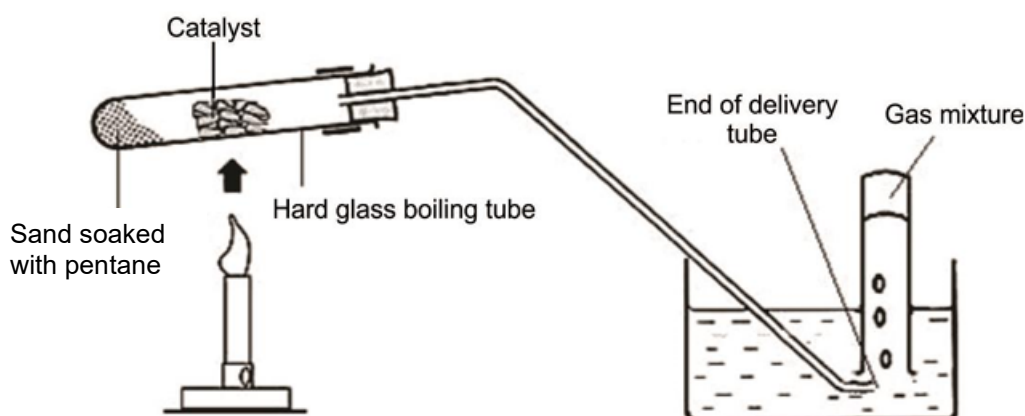
The membrane ...

- A prevents the oxidation of hydroxide ions.
- B minimises the contamination of the NaOH product by NaCl.
- C prevents the formation of hydroxide ions.
- D prevents the reaction of hydroxide ions with chlorine gas.

- 1.9 Which option shows the organic compounds arranged in order of **increasing** boiling point?

- A butane; methylpropane; methyl propanoate; butanoic acid
- B methylpropane; butane; methyl propanoate; butanoic acid
- C methylpropane; butane; butanoic acid; methyl propanoate
- D butane; methylpropane; butanoic acid; methyl propanoate

1.10



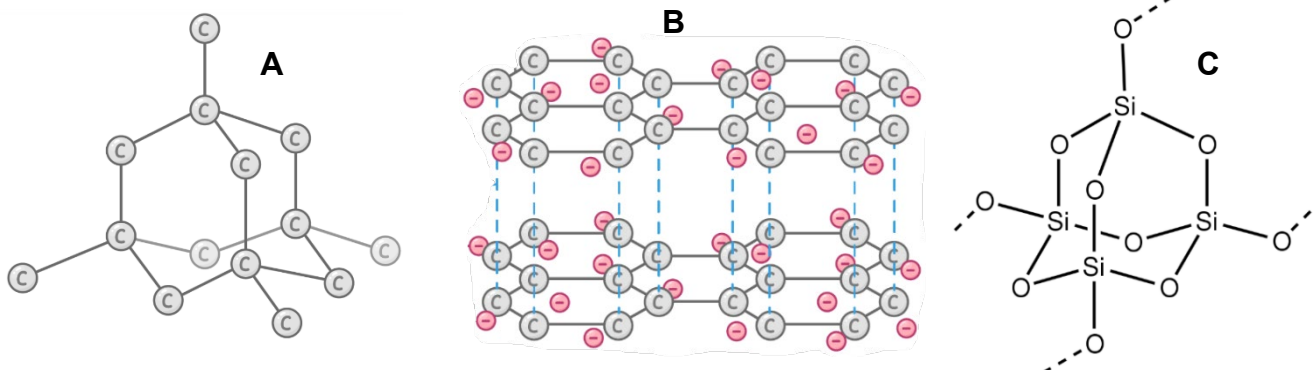
Which gas **cannot** be a product of the reaction of pentane depicted above?

- A butane
- B propene
- C ethene
- D methane

[20]

QUESTION 2

2.1 Diagrams of three giant solids are shown below.



2.1.1 Name the three solids.

(3)

A

B

C

2.1.2 Explain why all three solids require large amounts of energy to melt.

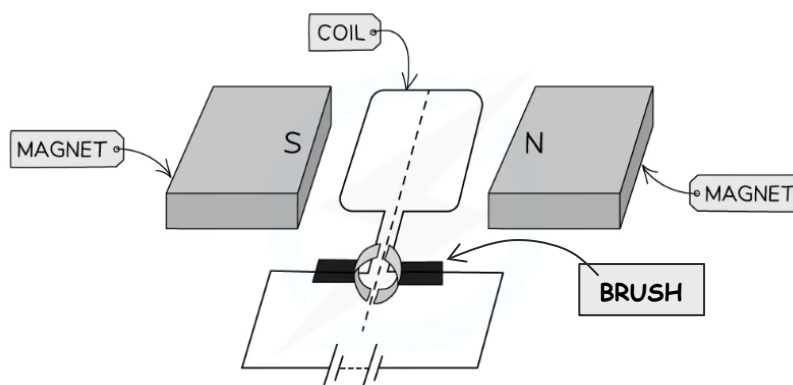
(2)

2.1.3 Which one of the solids has polar intramolecular bonds? Give a reason.

(2)

2.1.4 Which one of the solids can be used to make the brushes in a motor, as shown in the diagram below?

(1)



- 2.1.5 What **two** properties of the solid named in Question 2.1.4 enable it to function appropriately as a brush in a motor? (2)

- 2.2 Water boils at 100 °C while hydrogen sulfide boils at –60 °C.

- 2.2.1 Explain the origin of dipole-dipole intermolecular forces. (3)

- 2.2.2 State the two differences between sulfur and oxygen atoms that account for the large difference in the boiling points of H₂O and H₂S. (2)

- 2.2.3 By referring to the bonding in these two compounds, explain how the differences mentioned in Question 2.2.2 influence the strength of the predominant intermolecular forces in H₂O and H₂S. (4)

[19]

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QUESTION 3

3.1 State one requirement for an effective collision between reacting particles. (1)

3.2 A small amount of an inert gas is added to a gaseous reaction mixture, thus increasing the total pressure. How will this affect the rate of the reaction?

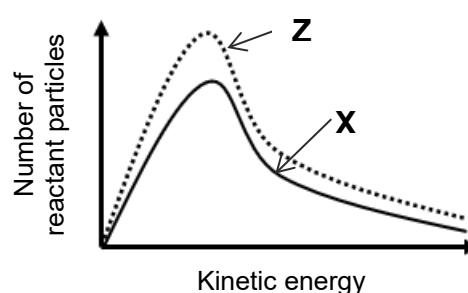
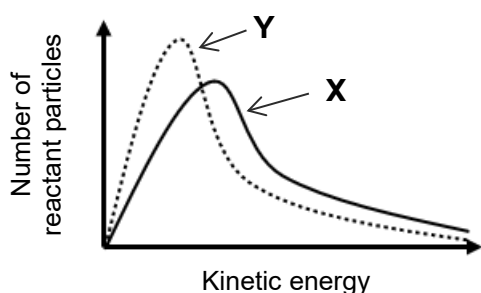
Circle the answer:

INCREASE	DECREASE	NO EFFECT
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Explain.

(3)

3.3 Consider the Maxwell-Boltzmann distribution curves **X**, **Y**, and **Z** shown below.



In comparison to Graph **X**:

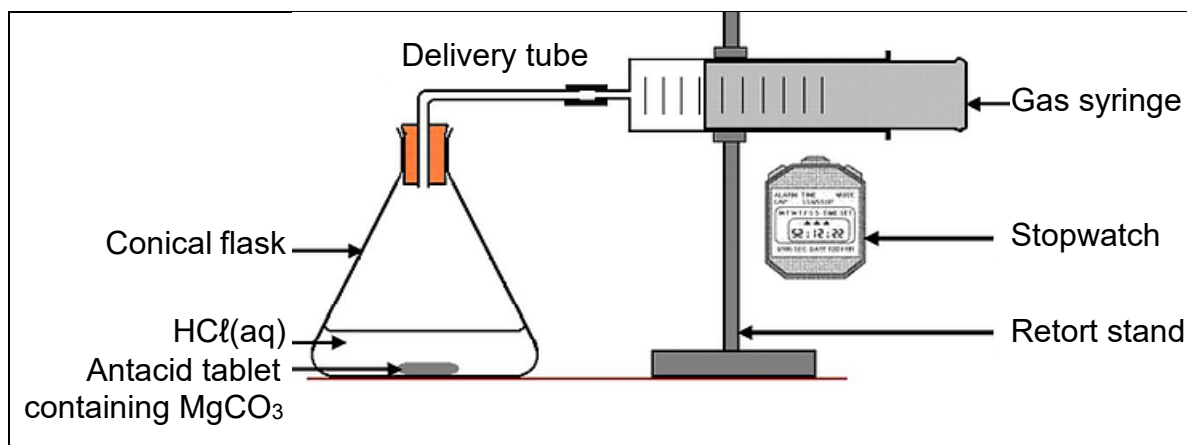
3.3.1 What condition changed to produce Graph **Y**? (2)

3.3.2 What condition changed to produce Graph **Z**? (2)

- 3.4 Magnesium carbonate is used in antacid tablets for the relief of indigestion. It reacts spontaneously with the hydrochloric acid in the stomach as follows:

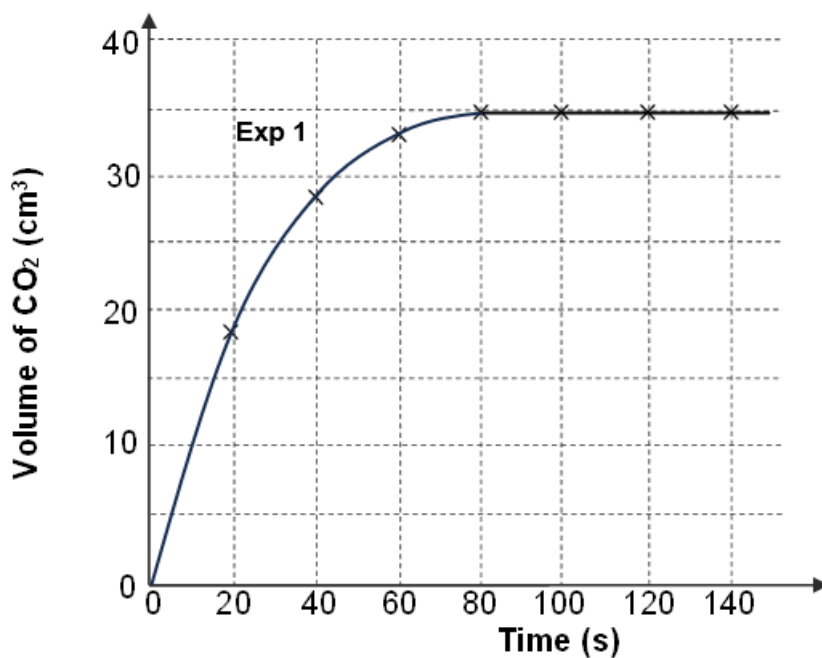


The effect of crushing the tablet on the reaction rate was investigated. The apparatus shown below was used to record the volume of CO_2 gas every 20 seconds.



The results for the whole tablet and the crushed tablet were as follows:

	Time (s)	20	40	60	80	100	120	140
Volume CO_2 (cm^3)	Exp 1	18	28	33	35	35	35	35
	Exp 2	9	18	24	29	33	35	35



- 3.4.1 Plot the graph for Experiment 2 on the axes provided above.

(3)

- 3.4.2 State which experiment made use of the crushed tablet. Explain the answer with reference to the collision theory. (5)

Exp 1	Exp 2
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used the crushed tablet.

At the temperature of the experiment, the molar gas volume, $V_m = 24 \text{ dm}^3$.

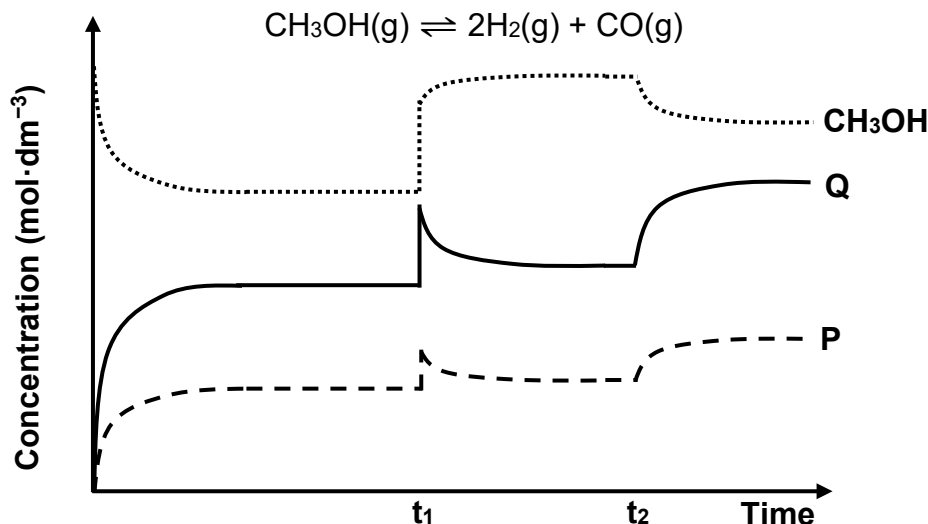
- 3.4.3 For **Experiment 1**, calculate the average rate of the reaction in units of $\text{mol} \cdot \text{s}^{-1}$. (5)

- 3.4.4 The mass of the tablet used was 0,2 g. The hydrochloric acid was in excess. Calculate the percentage of the tablet's mass that is MgCO_3 . (4)

[25]

QUESTION 4

Consider the concentration vs time graph for the gaseous equilibrium reaction between methanol, hydrogen, and carbon monoxide. The equation follows below.



Methanol gas is placed in the reaction vessel, which is then sealed and allowed to reach equilibrium at a certain temperature.

- 4.1 Identify the products **P** and **Q**. (2)

P		Q	
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- 4.2 The volume of the container was changed at **t₁**. Circle the correct option.

The volume of the container was

INCREASED

DECREASED

Use a suitable formula to explain the answer.

(3)

- 4.3 Apply Le Châtelier's Principle to explain the changes in the graph between **t₁** and **t₂**. (5)

- 4.4 The temperature of the equilibrium mixture was **decreased** at t_2 . Circle the correct option.

The forward reaction is

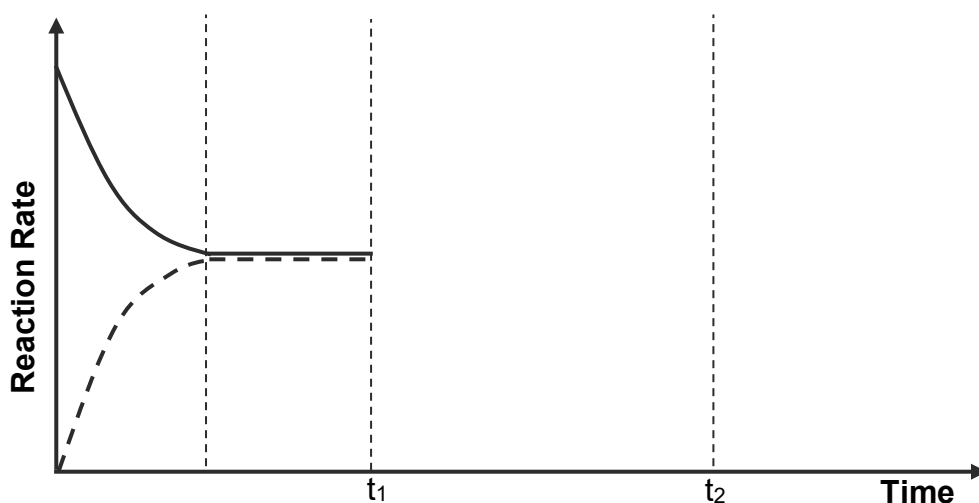
EXOTHERMIC

ENDOTHERMIC

Explain the answer in terms of Le Châtelier's Principle.

(3)

- 4.5 On the axes below, show how the reaction rates will be affected by the changes at t_1 (change in volume) and t_2 (decrease in temperature). (6)



[19]

QUESTION 5

5.1 Consider the two acid solutions given below.

- **Solution A:** $3,0 \text{ mol}\cdot\text{dm}^{-3}$ HCOOH , $K_a = 1,8 \times 10^{-4}$ at 25°C
- **Solution B:** $1,0 \times 10^{-4} \text{ mol}\cdot\text{dm}^{-3}$ HBr , $K_a = 1,0 \times 10^9$ at 25°C

5.1.1 Define *strong acid*. (2)

5.1.2 Which of the above two acids is stronger? Give a reason for your choice. (2)

5.1.3 Define *ionisation*. (2)

5.1.4 Write the equation for the ionisation reaction of HCOOH . (2)

5.1.5 Write the expression for the acid ionisation constant, K_a , for HCOOH . (2)

5.1.6 Calculate the H_3O^+ concentration in the $3,0 \text{ mol}\cdot\text{dm}^{-3}$ HCOOH solution at 25°C . (5)

5.1.7 Write down the H_3O^+ concentration in the HBr solution. (1)

5.1.8 State which solution will have the lower pH. Explain your answer. (2)

5.2 Consider the following three salts of the acids in Question 5.1.

CsHCOO	KBr	NH_4Br
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5.2.1 Define *salt*. (2)

5.2.2 Name the chemical bonds responsible for the high melting points of salts. (1)

5.2.3 Define *dissociation*. (2)

5.2.4 Name the salt CsHCOO . (2)

5.2.5 Which one of the above salts will form an acidic aqueous solution? (1)

5.2.6 Write an appropriate hydrolysis equation that explains the answer to Question 5.2.5. (2)

[28]

QUESTION 6

6.1 The reaction of hot, concentrated sulfuric acid with copper metal will produce SO_2 gas.

6.1.1 Why is this classified as a *redox reaction*? (2)

6.1.2 Write equations for the following:

(a) The oxidation half-reaction (1)

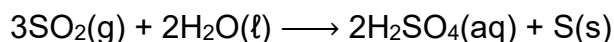
(b) The reduction half-reaction (1)

6.1.3 Define *oxidising agent*. (2)

6.1.4 Refer to the relative strengths of the oxidising agents to explain why the reaction only occurs if **hot, concentrated** sulfuric acid is used. (5)

6.2 SO_2 gas is also one of the three products of the reaction between hydrochloric acid and sodium sulfite. Write a balanced equation for this reaction. (3)

6.3 Under certain conditions, SO₂ gas can react with water as follows:



Under these conditions, 0,96 mol of SO₂ gas was bubbled through 1,50 dm³ of water.

6.3.1 Show by calculation that the water was in excess. The mass of 1,50 dm³ of water is 1 500 g. (4)

6.3.2 Assume that the final volume of the solution remains 1,50 dm³. Calculate the molar concentration of the H₂SO₄ when the reaction goes to completion. (4)

6.3.3 Under these specific conditions, the sulfuric acid does not ionise fully, and the hydronium ion concentration in the solution is found to be 0,493 mol·dm⁻³. Calculate the concentration of the **hydroxide ions** in the solution at 25 °C. (3)

6.3.4 The resulting solution was filtered, and the yellow sulfur powder was rinsed and dried. The yield was 9,52 g of sulfur. What was the percentage yield of sulfur achieved? (4)

[29]

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QUESTION 7

7.1 Describe an *electrolytic cell*. (2)

7.2 During the electrolysis of water, some potassium sulfate is dissolved in the water, and a few drops of bromothymol blue indicator are added. Hydrogen gas and oxygen gas form at the electrodes.

7.2.1 Give a reason that the potassium ions are not reduced. (2)

7.2.2 Bromothymol blue indicator is yellow in acidic solution and blue in alkaline solution. What colour will be observed in the solution around the **anode** after a while? (2)

Circle the answer in the table:

BLUE	YELLOW
------	--------

7.2.3 Write down the balanced equation for the electrolysis of water. (2)

7.2.4 Refer to the value of K_w at 25 °C to explain why pure water cannot easily be electrolysed. (3)

- 7.3 Parents sometimes copper-plate baby shoes to keep as a memento. An acidified copper(II) sulfate solution is used as the electrolyte.



- 7.3.1 Define *electrolyte*. (2)

- 7.3.2 The shoes are coated with metallic paint before immersion into the electrolyte. Give a reason for this. (1)

- 7.3.3 Why is it necessary to use a DC (not AC) power source for electrolysis? (2)

- 7.3.4 To which terminal of the DC power source should the shoe be connected?

Circle one:

POSITIVE TERMINAL

NEGATIVE TERMINAL

- Give a reason. (2)

7.3.5 In a certain time interval, 15,9 g of copper is deposited on the shoe.

- (a) Calculate the number of moles of electrons that must be supplied to produce 15,9 g of copper from the copper(II) sulfate electrolyte. (3)

- (b) Given that a constant current of 20 A was used, calculate the time taken for the copper to be deposited. (4)

[25]

QUESTION 8

Consider the organic compounds given below.

A	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$	B	$\text{CH}_2\text{ClCH}_2\text{CH}_3$	C	$\text{CH}_3\text{CH}_2\text{CH}_3$
D	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	E	$\text{CH}_3\text{CH}=\text{CH}_2$	F	$\text{CH}_3(\text{CH}_2)_3\text{COOH}$

8.1 Give the IUPAC names of:

8.1.1 Compound **A** (2)

8.1.2 Compound **F** (2)

8.2 Define a *homologous series*. (3)

8.3 Name the homologous series to which compound **D** belongs. (1)

8.4 Diabo says that compounds **A** and **B** are chain isomers. State why he is incorrect. (1)

8.5 Explain what is meant by the term *functional isomer*. (2)

8.6 Give the IUPAC name of a functional isomer of compound **F**. (2)

8.7 Circle the correct word in the table and complete the sentence: (3)

Compound **F** is

SATURATED	UNSATURATED
-----------	-------------

 because ...

8.8 A simple laboratory test uses bromine to distinguish between compounds **C** and **E**.

8.8.1 Use condensed structural formulae to complete the reaction equations for compounds **C** and **E** with bromine. (3)



8.8.2 Explain the results of the test. (2)

8.9 Name the **specific** reaction type when ...

8.9.1 compound **D** forms compound **E**. (1)

8.9.2 compound **B** forms compound **D**. (1)

8.9.3 compound **E** forms compound **C**. (1)

8.9.4 compound **C** forms compound **A**. (1)

The list of compounds is repeated below for ease of reference.

A	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$	B	$\text{CH}_2\text{ClCH}_2\text{CH}_3$	C	$\text{CH}_3\text{CH}_2\text{CH}_3$
D	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	E	$\text{CH}_3\text{CH}=\text{CH}_2$	F	$\text{CH}_3(\text{CH}_2)_3\text{COOH}$

8.10 One of the above compounds is treated with a **hot, concentrated solution of NaOH in an ethanol solvent**.

8.10.1 Choose the appropriate letters from the table above to complete the sentence: (2)

Under these reaction conditions, compound _____ forms compound _____.

8.10.2 Give the **general** type of this reaction. (1)

8.11 Compounds **D** and **F** are gently heated together with a few drops of concentrated sulfuric acid.

8.11.1 Name the homologous series of the organic product. (1)

8.11.2 Draw the **structural** formula of the organic product. (2)

8.11.3 Write down the IUPAC name of the organic product formed. (2)

8.11.4 Identify the other (inorganic) product of this reaction. (1)

8.11.5 What is the function of the sulfuric acid? (1)

[35]

Total: 200 marks

ADDITIONAL SPACE (ALL QUESTIONS)

**REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE
ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.**

[illegible]

[illegible]