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TOTAL
MARKS

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INTERNATIONAL SECONDARY CERTIFICATE EXAMINATION
NOVEMBER 2024

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 28 pages and a Data Sheet of 3 pages (i–iii). Please check that your question paper is complete.
2. Read the questions carefully.
3. **Answer ALL the questions on the question paper and hand this in at the end of the examination. Remember to write your examination number in the space above.**
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
7. Answers must be expressed in decimal format, not left as proper fractions.
8. Where appropriate, express answers to TWO decimal places.
9. It is in your own interest to write legibly and to present your work neatly.
10. Two blank pages (page 27 and 28) are included at the end of the paper. If you run out of space for an answer, use these pages. Clearly indicate the number of your answer should you use this extra space.

FOR MARKERS' USE ONLY

Question	1	2	3	4	5	6	7	8	9	Total
Marks	20	17	22	23	36	36	11	17	18	200
Marked										
Moderated										

QUESTION 1 MULTIPLE-CHOICE QUESTIONS

Answer these multiple-choice questions on the grid below. Make a clear cross (X) in the box corresponding to the letter that you consider to be correct. Every question has only one correct answer.

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

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

1.1 What is the correct formula for Iron (III) sulfite?

- A Fe_3SO_3
- B $\text{Fe}_2(\text{SO}_3)_3$
- C Fe_3SO_4
- D $\text{Fe}_2(\text{SO}_4)_3$

1.2 Which quantity represents 2 mol of particles?

- A 28 g nitrogen gas
- B $44,8 \text{ dm}^3 \text{ H}_2\text{O} (\ell)$
- C 80 g calcium
- D 18 g water

1.3 The amount of solute per unit volume of solution is known as ...

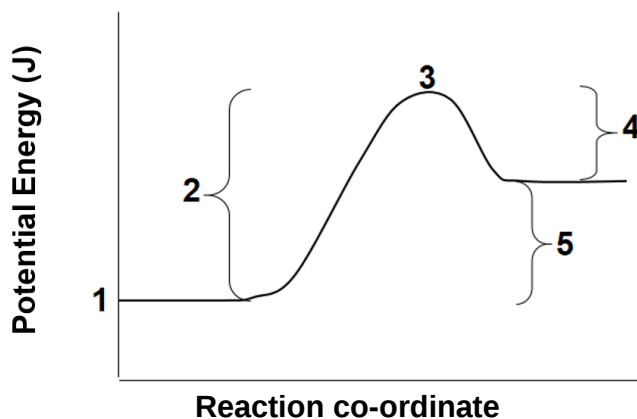
- A volume.
- B moles.
- C molar mass.
- D concentration.

1.4 Which statement is TRUE regarding the bond that forms between the following elements?



- A Electrons will be shared unequally.
- B Electrons will be shared equally.
- C A sea of delocalised electrons will form between the positive kernels.
- D An electron will be transferred leading to an electrostatic attraction.

- 1.5 In the following energy profile graph, which set of numbers correctly corresponds to the headings in the table?



	Energy absorbed to break bonds	Heat of reaction	Activation energy
A	3	5	2
B	2	5	2
C	4	2	3
D	2	4	3

- 1.6 For the following equilibrium reaction:



Which system stress will increase the K_c value?

- A Increase in temperature.
- B Increase in pressure.
- C Increases in concentration of H_2S .
- D Increase in volume of water.

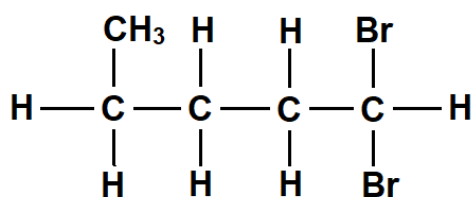
- 1.7 Sodium carbonate dissolves in water. State which of the following is correct.

	Ion that undergoes hydrolysis	Approximate pH of salt solution
A	Na^+	Basic
B	Na^+	Acidic
C	CO_3^{2-}	Basic
D	CO_3^{2-}	Acidic

- 1.8 Which of the following reactions will occur spontaneously?

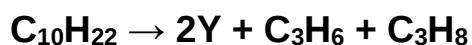
- A $\text{NaCl} + \text{Ni} \rightarrow$
- B $\text{SrCl}_2 + \text{Cu} \rightarrow$
- C $\text{PbCl}_2 + \text{Al} \rightarrow$
- D $\text{PbCl}_2 + \text{Ag} \rightarrow$

1.9 The correct IUPAC name for the compound below is ...



- A 1,1-dibromo-4-methylbutane
- B 1-methyl-4,4-dibromobutane
- C 1,1-dibromopentane
- D 1-bromo-1-methylbutane

1.10 In the following cracking reaction, the product Y is ...

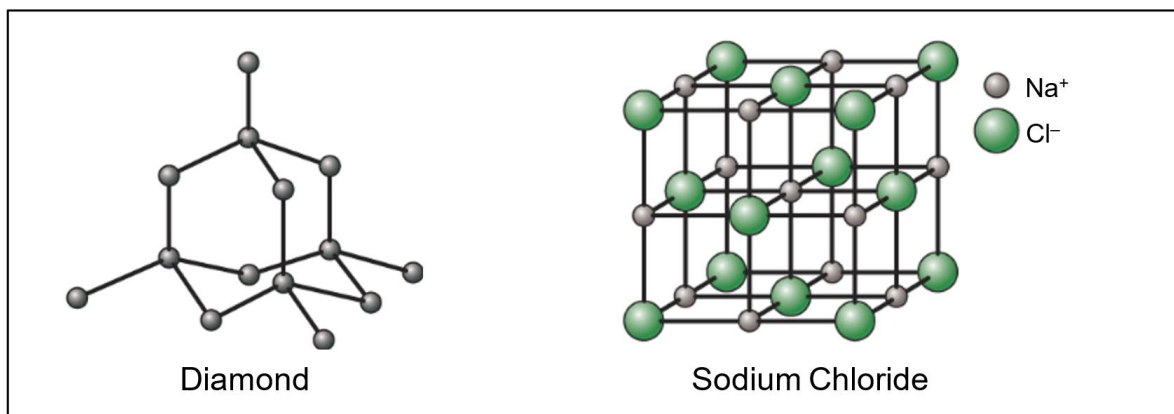


- A butane
- B butene
- C ethane
- D ethene

[20]

QUESTION 2

2.1 Consider the following lattice structures.



[Images sourced from: <<https://igcseandialchemistry.com>>]

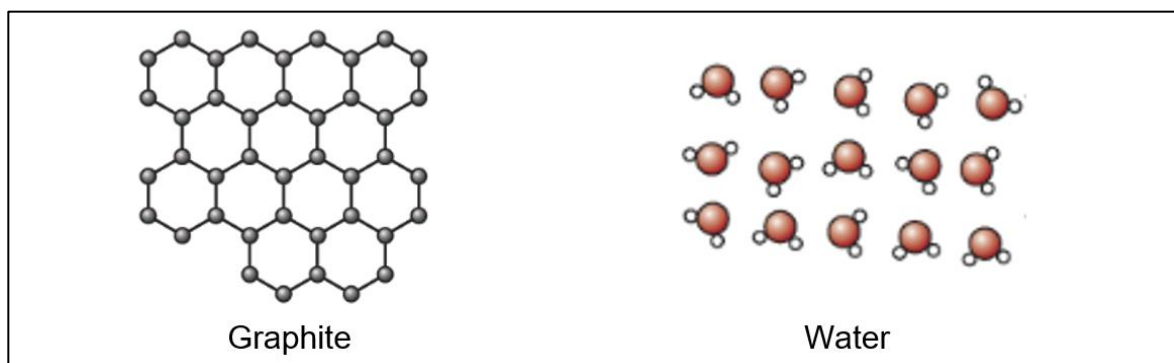
2.1.1 Define an *intramolecular bond*. (2)

2.1.2 Explain how a covalent bond forms. (2)

2.1.3 Classify the bonds in diamond as polar or non-polar covalent and give a reason for your answer. (2)

2.1.4 What kind of bonding is found in sodium chloride? (1)

2.2 Consider the following covalent compounds.

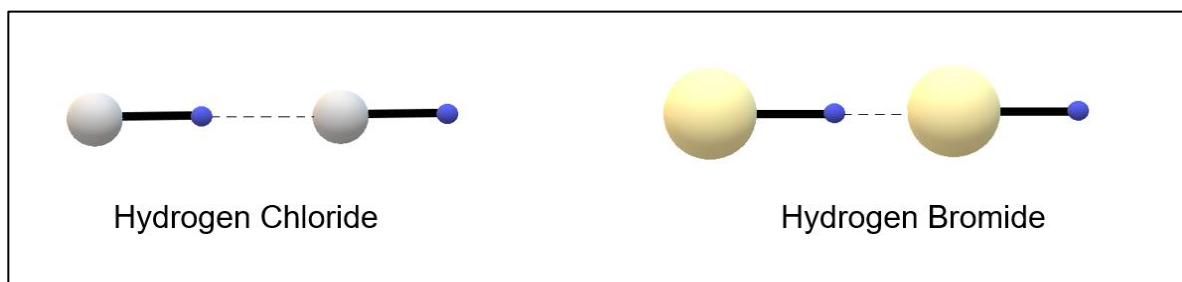


[Images sourced from: <<https://igcseandialchemistry.com>>]

2.2.1 Both of these compounds contain covalent bonds. Explain why water is a liquid at room temperature, while graphite is a solid at room temperature. (4)

2.2.2 Why is graphite able to conduct electricity, while pure water cannot? (2)

2.3 Consider the following simple molecular compounds.

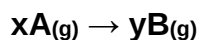


Which of these compounds has a higher boiling point? Give a reason for your answer. (4)

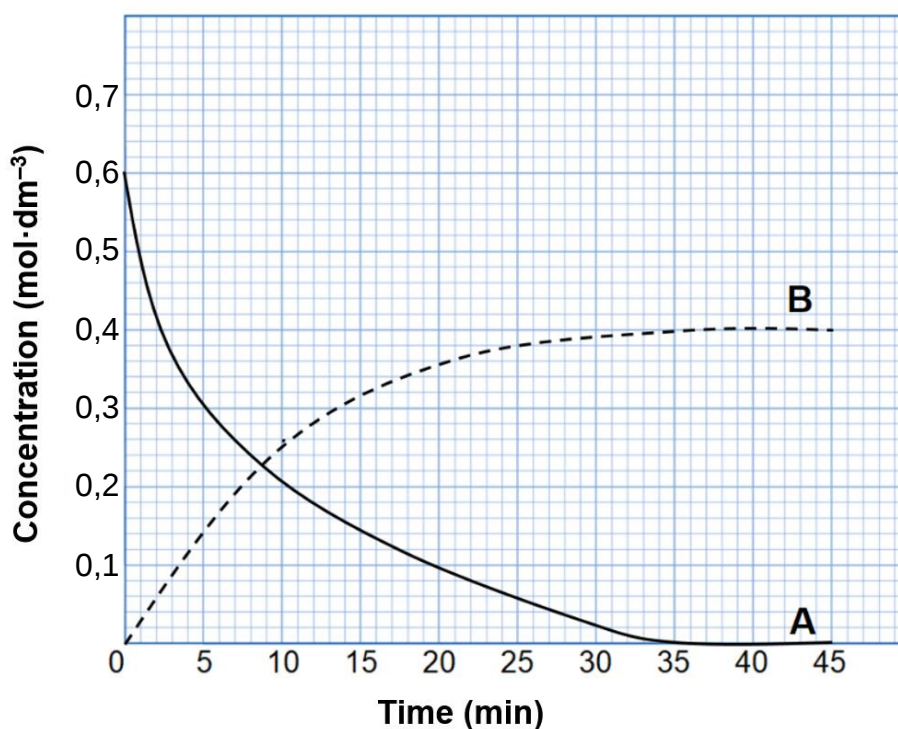
[17]

QUESTION 3

In the following hypothetical reaction, compound **A** is decomposed into compound **B** in a 0,5-litre container at 30 °C. The following, unbalanced, reaction equation is obtained:



The change in concentration vs time graph for the reaction is given below.



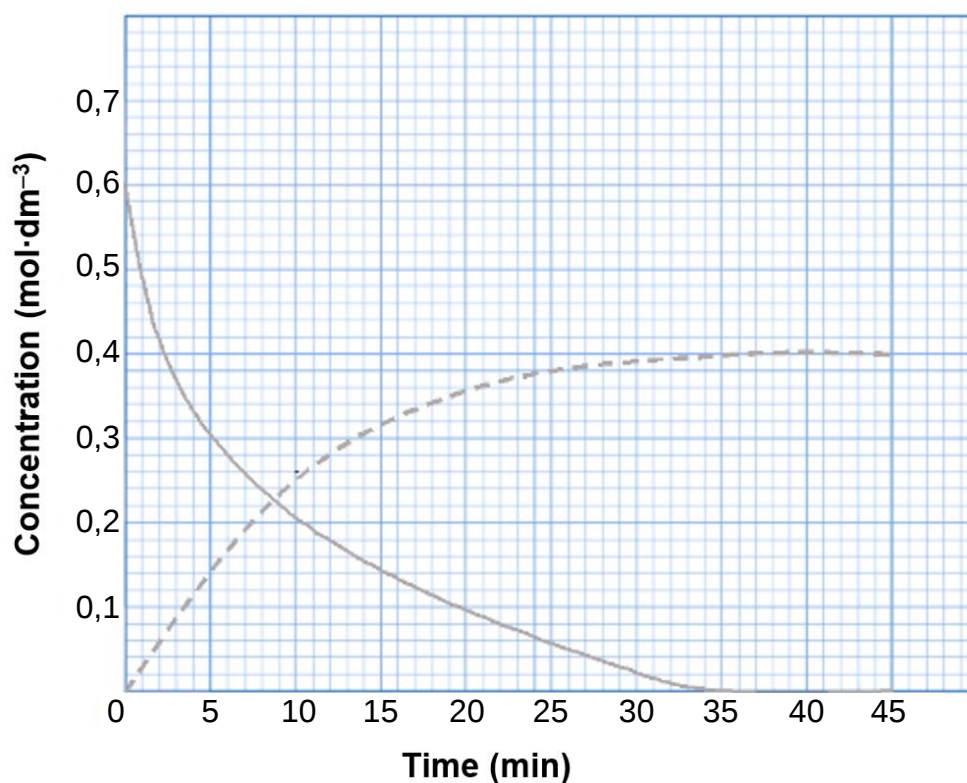
- 3.1 Define the *rate of reaction*. (2)

- 3.2 Use the graph to calculate the average rate of change of **reactant** for the 35 minutes. Give your answer to three decimal places. (4)

3.3 Calculate the moles of reactant initially present in the container. (3)

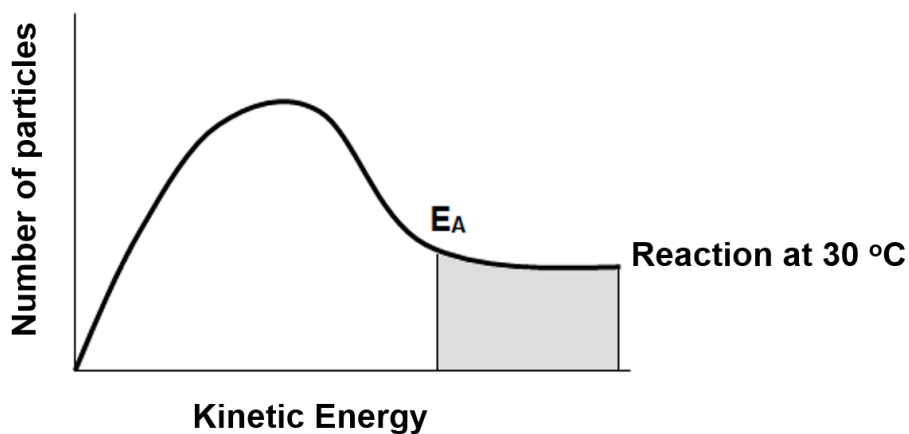
3.4 Use the graph to determine the coefficients **x** and **y** in the equation. (2)

3.5 On the graph below, sketch the curves that would be obtained if the same reaction occurred in a 1-litre container at 30 °C. (4)



- 3.6 Use the collision theory to explain how the reaction rate would be affected if the reaction occurred at 15 °C. (4)

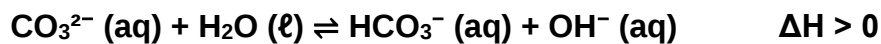
- 3.7 On the Maxwell-Boltzmann distribution curve below, draw a new graph for the reaction occurring at 15 °C. The reaction occurring at 30 °C has been drawn in for you. (3)



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QUESTION 4

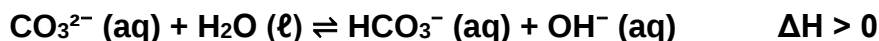
The following equilibrium occurs in the blood and plays an important role in maintaining the correct pH levels in the blood.



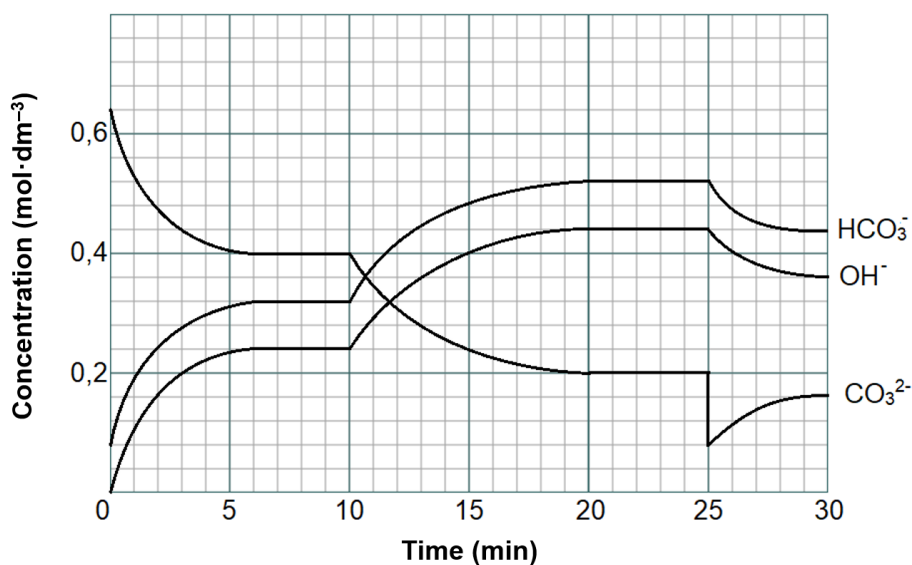
- 4.1 State *Le Châtelier's Principle*. (2)

- 4.2 If the blood were to become more acidic, explain how this equilibrium would maintain the alkalinity of the blood. (4)

To investigate this equilibrium, aqueous solutions of carbonate and hydrogen carbonate were sealed in a container and allowed to reach equilibrium. The reaction equation is given again for ease of reference.



The graph below shows how the concentrations change over time.



4.3 Write an equilibrium expression for this reaction. (2)

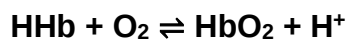
4.4 Calculate the equilibrium constant at 7 minutes. (2)

4.5 Identify the external stress that was placed on the system at 10 minutes. (2)

- 4.6 Use *Le Châtelier's Principle* to explain the changes in concentration observed from 10 to 20 minutes. (4)

- 4.7 How will the K_c value at 23 minutes compare to the K_c at 7 minutes? (Only write HIGHER THAN, LOWER THAN, or EQUAL TO.) (1)

The haemoglobin-oxygen complex is part of another equilibrium in the blood and it regulates how haemoglobin (Hb) binds to oxygen for transport in the body. The equilibrium is given by the following equation:



- 4.8 At 25 minutes, the concentration of carbonate ions drastically decreases. In the body, this can be caused by the overconsumption of refined sugars. Use **both** equilibrium reactions in the blood to explain how this might impact oxygen transport in the blood. (6)

[23]

QUESTION 5

- 5.1 Bees release methanoic acid in their sting, which is responsible for pain and irritation experienced. To ease this, sodium bicarbonate can be applied to neutralise the acid.

5.1.1 Define an *acid* according to Lowry-Brønsted. (1)

5.1.2 Define *neutralisation*. (2)

5.1.3 Complete the equation below for the reaction between methanoic acid and sodium bicarbonate. (2)



5.1.4 Classify methanoic acid as a *strong* or *weak* acid and give a reason for your answer. (3)

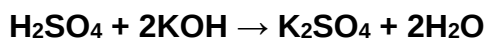
An ammonia solution could be an alternative base that would be suitable to ease the pain caused by a bee sting.

5.1.5 Write down the ionisation reaction of ammonia when added to water and indicate the conjugate acid base pairs. (4)

- 5.1.6 Give a reason why the use of a sodium hydroxide solution would not be advised for the neutralisation of a bee sting. (3)

- 5.1.7 Wasp stings are alkaline in nature. Suggest an appropriate household product that could be applied to neutralise the sting. (1)

- 5.2 A titration has been set up to determine the concentration of a sulfuric acid solution. A potassium hydroxide standard solution is made up with a concentration of $0,5 \text{ mol} \cdot \text{dm}^{-3}$. The reaction equation is given below.



- 5.2.1 Define a *standard solution*. (1)

- 5.2.2 Calculate the mass of potassium hydroxide needed to prepare 250 ml of a $0,5 \text{ mol} \cdot \text{dm}^{-3}$ standard solution. (4)

The following steps were recorded in the method for preparing the standard solution:

- (1) Measure 250 ml water in a beaker.
- (2) Add the calculated mass of potassium hydroxide.
- (3) Swirl until dissolved.

5.2.3 Suggest two improvements to this method to ensure accuracy of the titration. (2)

5.2.4 In the table below, circle the letter of a suitable indicator for this titration. (1)

Indicator	End-point pH range
A	3,4–5
B	6,8–7,2
C	8,5–10
D	5–9

The following steps in the method for a titration were carried out:

- (1) Transfer 0,025 dm³ of the standard solution to a conical flask using a pipette.
- (2) Add a few drops of indicator.
- (3) Titrate with the acid until the *endpoint* is reached.
- (4) Repeat 3–4 times to collect reliable data.

It was determined that an average volume of 6,5 cm³ of sulfuric acid neutralised the base.

5.2.5 What is the meaning of the term *endpoint* as used in step 3? (2)

5.2.6 Calculate the concentration of the sulfuric acid solution. (5)

5.3 Limestone is a substance that can exist in various forms, including chalk, marble, and limestone rock. While calcium carbonate is the primary component, limestone may also contain other impurities such as magnesium carbonate, clay and silica.

700 g of limestone reacts with excess HCl to form 140 dm^3 of CO_2 measured at STP. The balanced chemical reaction is given below:

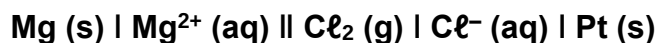


Determine the percentage purity of the CaCO_3 in the limestone sample. (5)

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QUESTION 6

6.1 The following cell notation for a galvanic cell is given:



6.1.1 Define a *redox reaction*. (2)

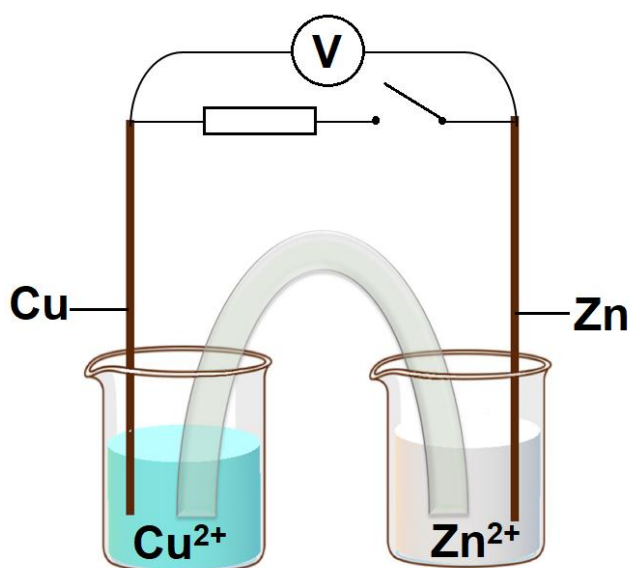
6.1.2 Write down the reduction half-reaction for this cell. (2)

6.1.3 Write down the oxidizing agent for this cell. (1)

6.1.4 Rewrite the cell notation and include the standard conditions. (3)

6.1.5 What is the function of the platinum electrode? (2)

6.2 The following galvanic cell is set up under standard conditions.



6.2.1 Define *electrolyte*. (2)

6.2.2 List TWO functions of the salt bridge. (2)

6.2.3 Which electrode is the cathode in this cell? (Only write Zn or Cu.) (1)

6.2.4 Calculate the emf of this cell when it operates under standard conditions. (3)

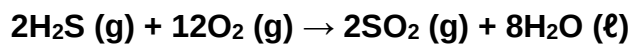
6.2.5 How would the emf change if the Zn^{2+} solution was changed to $3,5 \text{ mol} \cdot \text{dm}^{-3}$?
(Only write INCREASE, DECREASE or STAYS THE SAME.) (1)

6.2.6 Give an explanation for your answer in **Question 6.2.5**. (3)

6.2.7 The cell has significant internal resistance. **Explain** what would be observed on the voltmeter when the switch is closed. (3)

6.2.8 Describe TWO ways in which the internal resistance can be decreased. (2)

- 6.3 In the redox reaction between H_2S and O_2 , 170 g of H_2S is placed in a container to react with 800 g of O_2 .

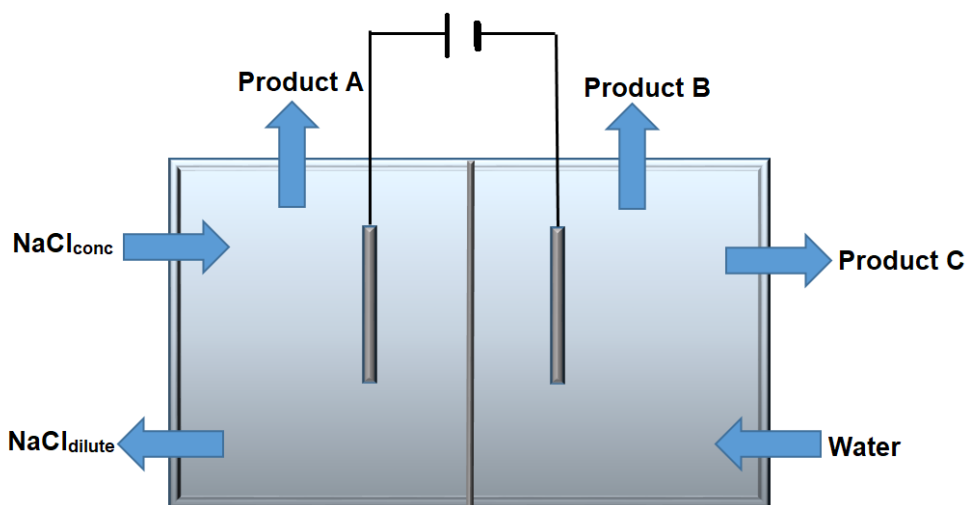


- 6.3.1 Show by calculation that O_2 is the limiting reagent. (5)

- 6.3.2 Determine the volume of SO_2 that will form if the experiment is performed at STP. (4)

QUESTION 7

The following diagram is a simple illustration of the membrane cell used in the chloro-alkali industry.



7.1 Write down the half-reaction that takes place at the anode. (2)

7.2 Write down the half-reaction that takes place at the cathode. (2)

7.3 Identify the products labelled **A**, **B** and **C**. (3)

A: _____

B: _____

C: _____

7.4 Explain why sodium ions are not reduced at the cathode. (1)

7.5 What is the purpose of the membrane in this cell? In your explanation, refer to two undesirable results if the membrane was not there. (3)

[11]

QUESTION 8

Consider the following compounds and answer the questions that follow.

A	CH_2CHCH_3	C	CH_3COOH
B	$\text{CH}_2\text{OHCH}_2\text{CH}_3$	D	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$

- 8.1 Write down the **letter** of the compound from the list above that is a saturated hydrocarbon. (1)

- 8.2 Define a *homologous series*. (2)

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

- 8.4 **Compound A** undergoes a chemical reaction to form **compound B**. Using IUPAC names, write down a word equation for the reaction that takes place. (3)

- 8.5 Provide the IUPAC name for the organic product that forms when **compound B** and **compound C** are heated in the presence of concentrated sulfuric acid. (2)

- 8.6 Define a *structural isomer*. (2)

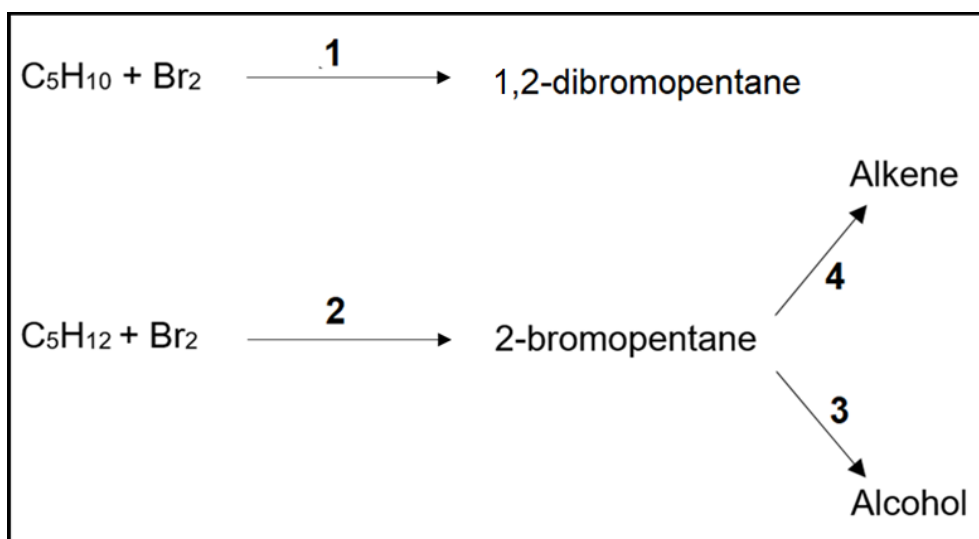
- 8.7 Provide the STRUCTURAL formula for a *chain isomer* of **compound D**. (2)

- 8.8 Using MOLECULAR formulas, write down a balanced chemical reaction for the complete combustion of **compound B**. (4)

[17]

QUESTION 9

Consider the four reactions shown in the diagram below, and answer the questions that follow.



9.1 Name the GENERAL type of reaction for **reaction 1**. (1)

9.2 **Compare** what will be observed when the bromine is added to the reactants in **reactions 1** and **2**. (2)

9.3 Which reaction condition is needed for **reaction 2** to take place? (1)

9.4 Give the name of the SPECIFIC type of substitution that takes place in **reaction 3**. (1)

9.5 Use STRUCTURAL formula to write an equation for **reaction 3**. (4)

9.6 Which GENERAL reaction takes place in **reaction 4**? (1)

9.7 Give the IUPAC name of the alkene that forms in **reaction 4**. (2)

9.8 Compare **reactions 3** and **4**. How can you ensure that **reaction 4** will take place instead of **reaction 3**. (1)

9.9 Consider the alkene formed in **reaction 4** and the alcohol formed in **reaction 3**. Which product will have the highest boiling point? Refer to intermolecular forces and energies to explain your answer. (5)

[18]

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.**

