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TRINITYHOUSE HIGH SCHOOL PHYSICAL SCIENCES GRADE 12

PRELIM EXAMINATION 2024 PAPER 2 - CHEMISTRY

MARKS: 200

TIME: 3 HOURS

EXAMINERS: MRS MILLETT-CLAY; MR TAM

MODERATORS: MRS SHEPPARD; MR ZINZOMBE

NAME: _____ KEY: _____

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of 31 pages, and a Data Sheet.
2. Please make sure that your question paper is complete.
3. Write your name in the space above.
4. Read the questions carefully.
5. ALL of the questions in this paper must be answered on the question paper.
6. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions must be answered on the grid provided. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	B	☒ C	D
---	---	---------------------------------------	---

7. Use data and formulae whenever necessary.
8. You may use approved, non-programmable and non-graphical calculators, unless otherwise stated.
9. Show the necessary steps in calculations.
10. Where appropriate take your final answer to 2 decimal places.
11. It is in your own interest to write legibly and to set out your work neatly.

QUESTION	1	2	3	4	5	6	7	8	9	TOT	%
MAXIMUM	20	19	24	21	45	21	18	15	17	200	
MARK											

QUESTION 1: MULTIPLE CHOICE**[20 marks]**

Answer the following multiple choice questions **on the grid provided below**, and indicate your choice of answer as follows:

A	~~B~~	C	D
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(Here **B** is indicated as the correct answer)

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

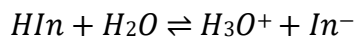
1.1 Which of the following IS a condition for hydrogen bonding?

- A. Hydrogen bonded to elements in Group 15, 16 and 17 and in Period 3.
- B. Hydrogen bonded to any small atom.
- C. Hydrogen bonded to an atom of low electronegativity.
- D. Hydrogen bonded to an atom with at least one lone pair of electrons.

1.2 Identify the ampholyte below:

- A. HNO_3
- B. $Mg(HCO_3)_2$
- C. H_2O
- D. $(COOH)_2$

1.3 Consider the generic indicator reaction below showing the reaction of bromothymol blue.

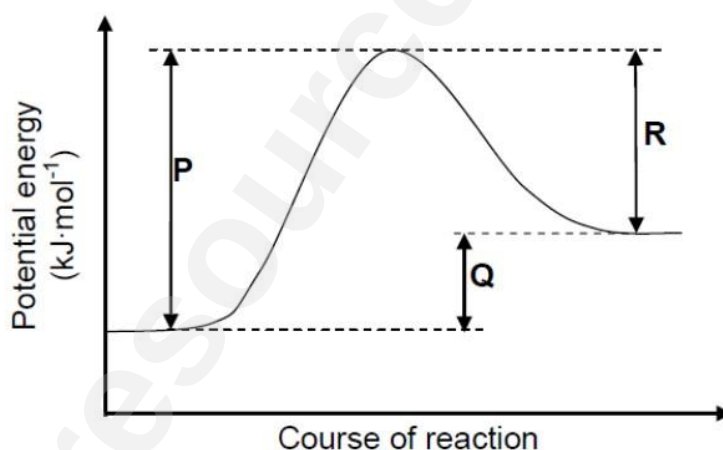


The salt $(COONa)_2$ is added into the solution. Which of the following is/are true?

- I The solution will go blue.
- II The pH will reduce.
- III The concentration of HIn will increase.

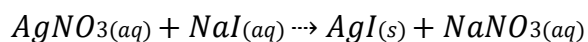
- A. I only
- B. I and III
- C. I and II
- D. II and III

1.4 The energy change represented by the letter **Q** is...



- A. Activation energy
- B. Energy released
- C. Activated complex
- D. Enthalpy of reaction

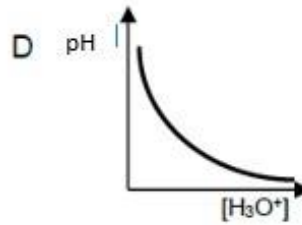
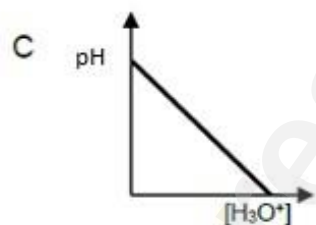
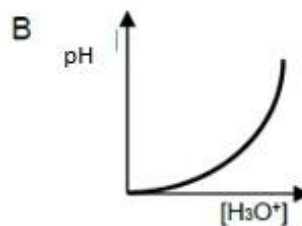
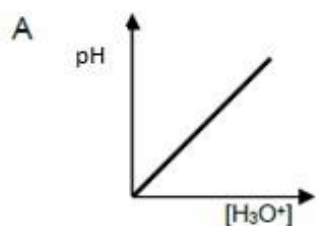
1.5 The following reaction is also known as a...



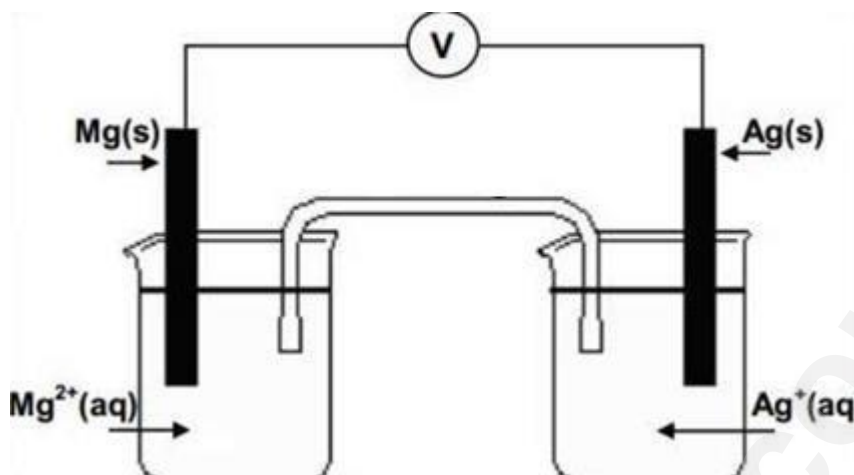
- I Proton exchange.
- II Ion exchange.
- III Electron exchange

- A. I, II and III
- B. I only
- C. II only
- D. III and I

1.6 Identify the graph that most accurately depicts the relationship between pH and $[\text{H}_3\text{O}^+]$



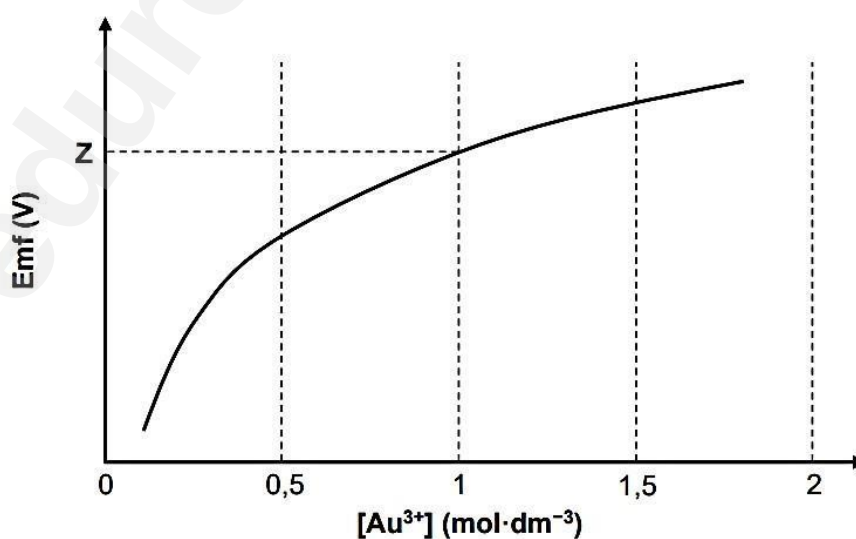
1.7 Refer to the cell given below:



How will the emf of the cell be affected if the salt bridge were to be filled with KCl?

- A. No effect
- B. Increase
- C. Decrease
- D. Go immediately to zero

1.8 The graph below shows how the emf of a H₂-Au galvanic cell is affected by the concentration of Au³⁺ at 25 °C.



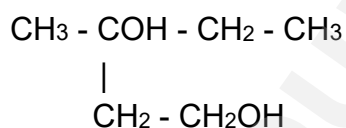
Which of the following statements is INCORRECT?

- A. The Emf is directly proportional to the concentration of Au^{3+} .
- B. The pressure in the H_2 half cell at point Z is 101,3 kPa.
- C. The Emf at point Z = +1,42 V.
- D. The Au half cell is the cathode as the concentration of Au^{3+} ions is increasing.

1.9 If only two products are obtained from the cracking of $\text{C}_{14}\text{H}_{30}$ they could be:

- A. heptane and heptene
- B. two heptane molecules
- C. octane and hexane
- D. octene and hexene

1.10 Which is the correct IUPAC name for the following organic compound?

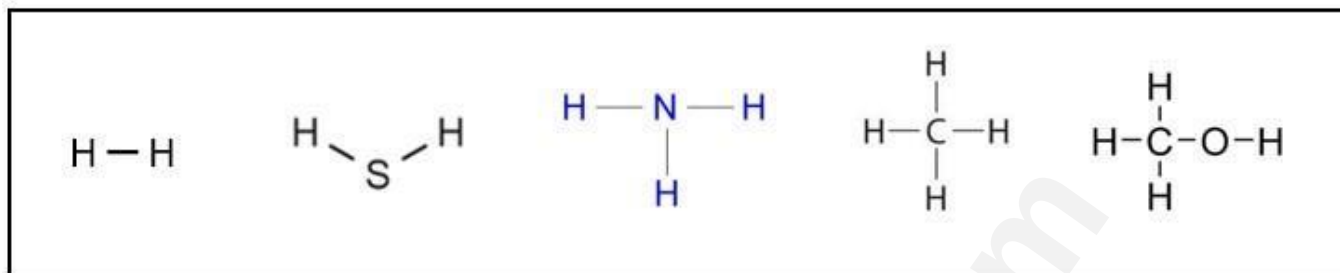


- A. 3-methylpentan-2,4-diol
- B. 3-methylpentane-1,3-diol
- C. 2-ethylbuta-2,4-diol
- D. hexa-1,3-diol

[10 x 2 = 20]

QUESTION 2 : BONDING**[19 marks]**

2.1 Given the following substances, answer the questions that follow:



2.1.1 **NAME** the substance which will have the lowest boiling point. (1)

2.1.2 Which intermolecular forces are responsible for the low boiling point in **QUESTION 2.1.1**? (1)

2.1.3 Classify the specific type of bond between the hydrogen and sulfur atoms in hydrogen sulfide. (2)

2.1.4 Which substance/s form non-polar molecules? (2)

2.2 Study the substances below and select **ONE** which meets the criteria of each statement.

You can use any of the substances more than once. (5)

Mg	C	KCl	CH ₄	Ar
----	---	-----	-----------------	----

2.2.1 It has a sea of delocalised electrons surrounding positive kernels.

2.2.2 It has London forces between its atoms.

2.2.3 It dissociates into ions in water.

2.2.4 It has a solid allotrope (different structural forms of a single chemical element) comprised of an atomic lattice of covalently bonded atoms.

2.2.5 It conducts electricity when melted into a liquid, but cannot conduct as a solid.

2.3 Magnesium and oxygen react to form magnesium oxide, which has a high melting point.

2.3.1 Write a balanced equation to represent the reaction that takes place. (3)
State/ phase symbols are not required.

2.3.2 Explain, in terms of its bonding and structure, why magnesium oxide ...

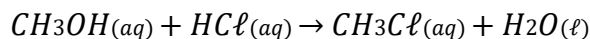
a) has a high melting point. (3)

b) does not conduct electricity when solid. (2)

[19]

QUESTION 3: ENERGY AND RATES OF REACTION**[24 marks]**

Drs Gravette and Rodriques are investigating a reaction for industrial use. Methanol and hydrochloric acid react according to the following balanced equation:



3.1 State TWO factors that can increase the rate of this reaction. (2)

3.2 Define the following:

3.2.1 *Reaction rate*. (2)

3.2.2 *Heat of reaction*. (2)

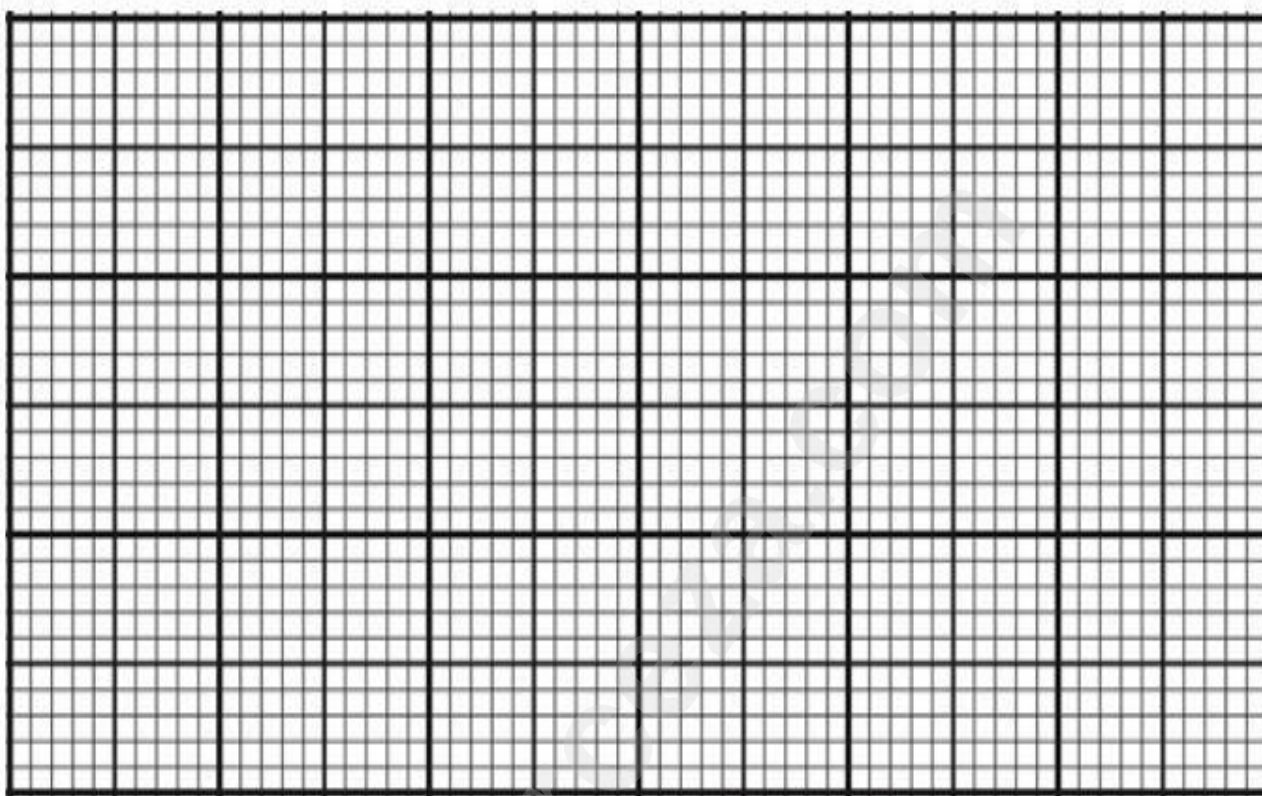
The rate of reaction between methanol and hydrochloric acid is investigated. The concentration of $\text{HCl}_{(\text{aq})}$ was measured at different time intervals.

The following results were obtained.

Time (minutes)	Concentration of HCl ($\text{mol}\cdot\text{dm}^{-3}$)
0	1,90
15	1,45
55	1,10
100	0,85
215	0,60

3.3 From the table calculate the average reaction rate, in $\text{mol}\cdot\text{dm}^{-3}\cdot\text{min}^{-1}$, during the first 15 minutes. (3)

- 3.4 Use the data in the table to draw a graph of concentration versus time on the graph paper. NOTE: the graph is not a straight line. NO HEADING REQUIRED. (6)



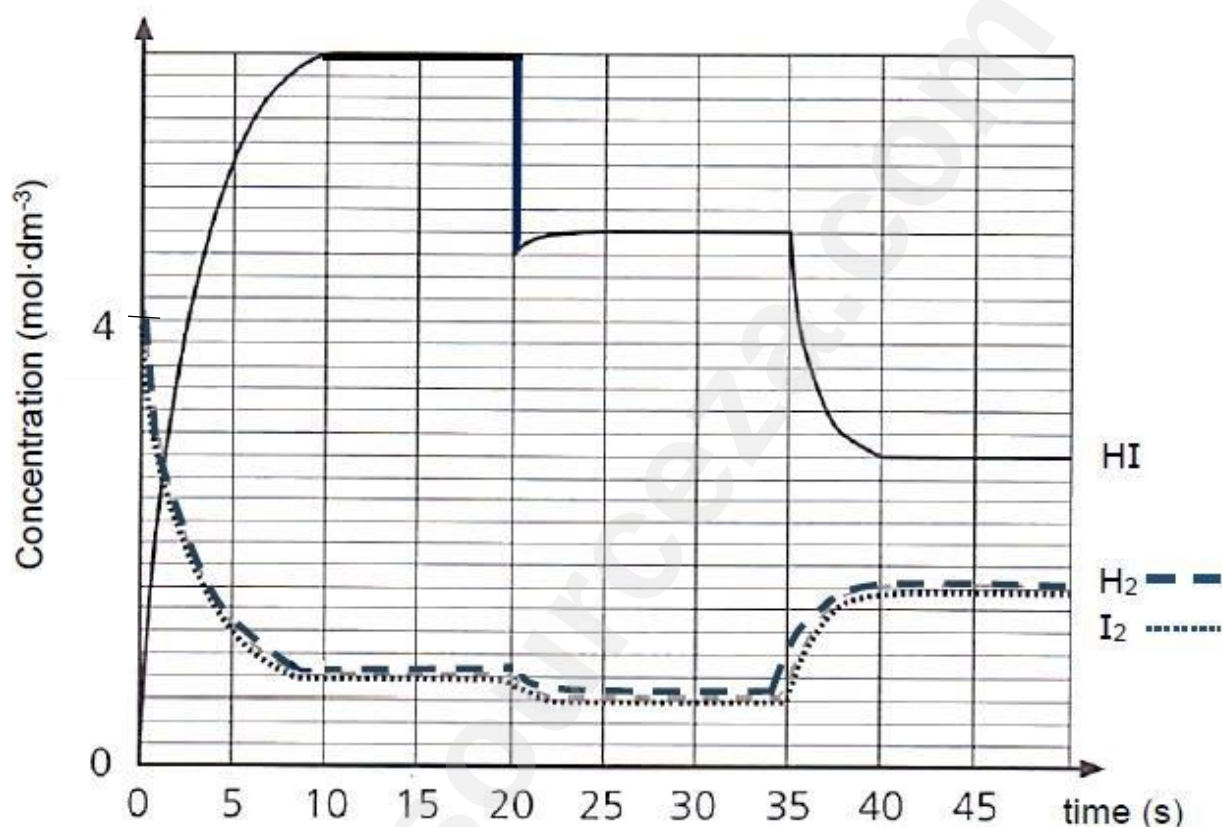
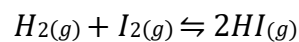
- 3.5 From the graph, determine the concentration of HCl at the 40th minute. (1)
- 3.6 Use the collision theory to explain why the reaction rate decreases with time. Temperature remains constant. (3)

- 3.7 Calculate the mass of CH_3Cl in the flask at the 215th minute. The volume of the reagents remains 60 cm^3 during the reaction. (5)

[24]

QUESTION 4 : CHEMICAL EQUILIBRIUM**[21 marks]**

The following equilibrium graph shows the changes in concentration versus time of all three species in the following reaction.



4.1 State the time when the reaction reaches equilibrium for the first time. (1)

4.2 Refer to the disturbance at t=20 s.

4.2.1 Identify the stress that occurs at 20 seconds. (1)

4.2.2 Explain your answer in **QUESTION 4.2.1**. Use *Le Chatelier's principle* to substantiate your answer. (4)

4.2.3 Define *molar concentration*. (2)

4.3 Calculate the K_c of the reaction at 10 seconds, if the volume of the container is 3 dm^3 . The concentration of HI at equilibrium is $6,4 \text{ mol} \cdot \text{dm}^{-3}$. (7)

4.4 State the disturbance at 35 seconds. Explain your answer. (2)

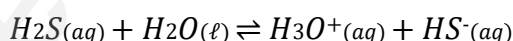
- 4.5 At the equilibrium after 35 seconds, would the K_c be HIGHER THAN, LOWER THAN or EQUAL TO the calculated K_c in **QUESTION 4.3**? (1)
- 4.6 Calculate the mass of HI in the reaction container after 40 seconds, if the volume of the container stays the same and the concentration of HI is $2,8 \text{ mol.dm}^{-3}$. (3)

[21]

QUESTION 5 : ACIDS AND BASES AND STOICHIOMETRY**[45 marks]**

Prof R. Burrows, the resident scientist and water quality officer of Rand Water, is tasked with determining the danger of acids in the environment. The first study she does is to study the effect of hydrogen sulfide in solutions.

- 5.1 Consider the balanced equation below showing how hydrogen sulfide (H_2S) reacts in water.



- 5.1.1 Rewrite the equation above, label each of the substances as either an acid or a base and link the conjugate acid-base pairs. (4)

5.1.2 Write the K_a expression for the reaction above. (2)

5.1.3 When 0,1 mol of hydrogen sulfide is dissolved in 1 litre of water, the concentration of the H_2S solution is $0,0998 \text{ mol}\cdot\text{dm}^{-3}$ at equilibrium.

Calculate the following:

a) The concentrations of H_3O^+ and HS^- at equilibrium using a RICE table. (3)

b) The value of K_a for the ionisation of H_2S . (3)

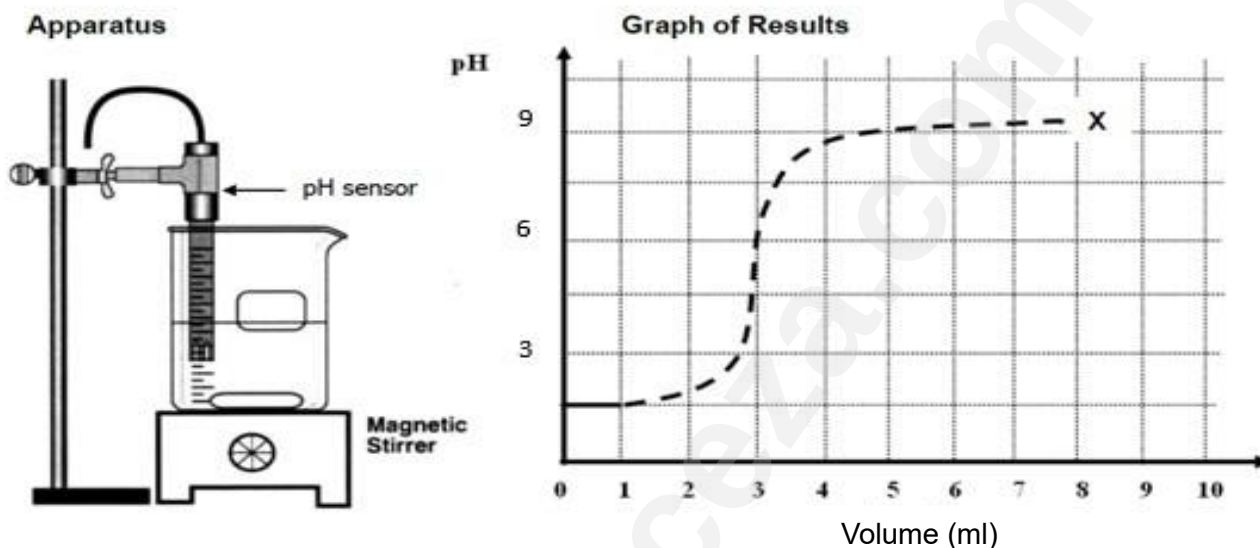
c) State whether H_2S ionises or dissociates in water. (1)

5.1.4 Define *le Chatelier's principle*. (2)

- 5.1.5 Show the steps, and substitutions required to determine the hydroxide ion concentration of this solution at equilibrium. (Use the K_w value). (3)
- 5.1.6 Explain what the answer to **QUESTION 5.1.3 b)** indicates about this solution. Refer to strengths and concentrations. (3)
- 5.1.7 Explain how we can lower the probability that H_2S will ionize in water. Refer to *le Chatelier's* principle. (3)

Indigestion is a common and painful condition which affects many people. The use of antacids is common to reduce the effect of indigestion. Antacids rely on neutralization reactions.

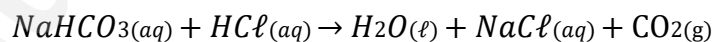
Prof Meerholz is investigating the neutralization of 15 ml of a $0,1 \text{ mol.dm}^{-3}$ hydrochloric acid using sodium bicarbonate (NaHCO_3). She tracks the reaction using a pH meter and plots the following graph:



5.2 Refer to the study mentioned above to answer the following questions.

- 5.2.1 a) Mark the equivalence point with a "**B**" on the graph above. (1)
- b) State what volume of base would be needed to reach the equivalence point in dm^3 . (1)

The balanced equation of NaHCO_3 with HCl is given below.



- 5.2.2 Calculate concentration of NaHCO_3 needed to neutralize the HCl . (4)

5.2.3 Calculate the number of sodium ions that are present in solution. (3)

5.2.4 State the NAME of the conjugate acid for the base shown in the reaction above. (1)

5.2.5 If **the hydrochloric acid is the limiting reactant**, calculate the mass lost in the beaker due to the formation of $\text{CO}_{2(g)}$. (3)

Sodium bicarbonate is a basic salt. The salt undergoes hydrolysis and reacts with water.

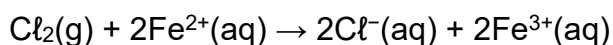
5.2.6 Define *Hydrolysis*. (2)

5.2.7 Explain why the resulting solution of NaHCO_3 is basic. Use bullet points and the appropriate dissociation and hydrolysis reaction equation to substantiate your answer. (6)

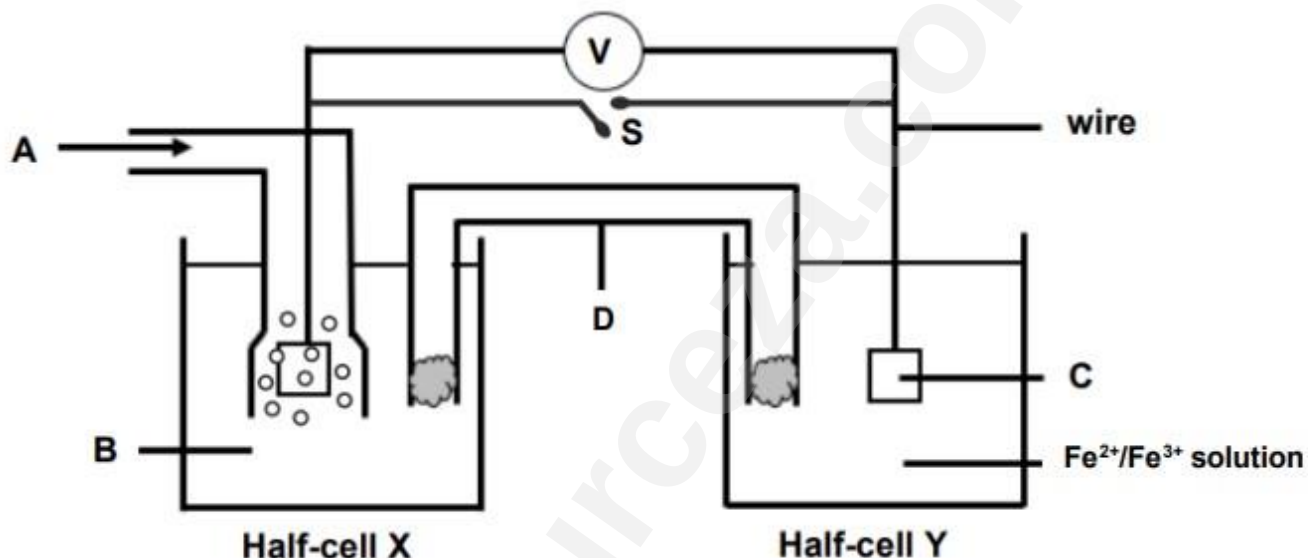
[45]

QUESTION 6: GALVANIC CELL**[21 marks]**

Chlorine gas and iron(II) ions react in aqueous solution as follows:



The diagram below shows a galvanic cell used to determine the cell potential (E^{θ}_{cell}) for the above reaction under standard conditions.



6.1 Give the **chemical formulae** of the substances represented by the letters: (3)

A: _____

B: _____

C: _____

6.2.1 What does **D** represent? (1)

6.2.2 If **D** is replaced by a shorter, wider version, what effect would it have on the maximum current the cell can provide? (State only INCREASES, DECREASES, or NO EFFECT.) (2)

- 6.3 Write down the anode half-reaction. (2)

- 6.4 Identify the reducing agent in this cell. (1)

- 6.5 Write down the cell notation of this cell, including phase symbols and standard conditions. (5)

- 6.6 Calculate the initial cell potential (E^θ_{cell}) for this cell under standard conditions. (3)

- 6.7 Iron(III) hydroxide is **far less soluble** than iron(II) hydroxide. Make use of this fact and Le Châtelier's principle to explain how the emf of the cell will be affected if some NaOH is added to the $\text{Fe}^{2+}/\text{Fe}^{3+}$ half-cell. (4)

[21]

QUESTION 7: ELECTROLYTIC CELLS**[18 marks]**

The entire world has watched the 2024 Olympics and marvelled at the beautifully designed medals that the French have designed.

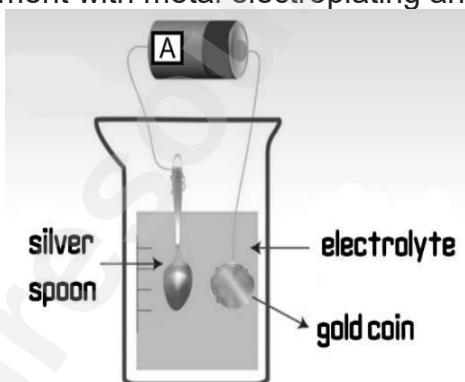


The three types of medals have different metals.

The makeup of the most highly-coveted of the three medal types – the gold medal – largely includes silver with 6 grams of gold plating, [according to NPR](#). Meanwhile, the silver medal contains the precious metal it derives its name from, the outlet reported.

Copper, tin and zinc are reportedly the metals used for the Paris Olympics' third-place bronze medal.

Mr Tam decides to experiment with metal electroplating and tests it out on a silver spoon.



- 7.1 In order for the spoon to be electroplated, should **A** be the positive or negative terminal of the cell?

(1)

- 7.2 Write the equation for the half-reaction taking place at the anode.

(1)

- 7.3 Mr Tam runs this cell for 3 hours and notices that 4 g of gold has been plated onto the spoon. Calculate the current in Mr Tam's cell. (7)

Mr Tam knows that in order to have made the medal from solid gold, impure gold would have needed to be purified by an electrorefining process.

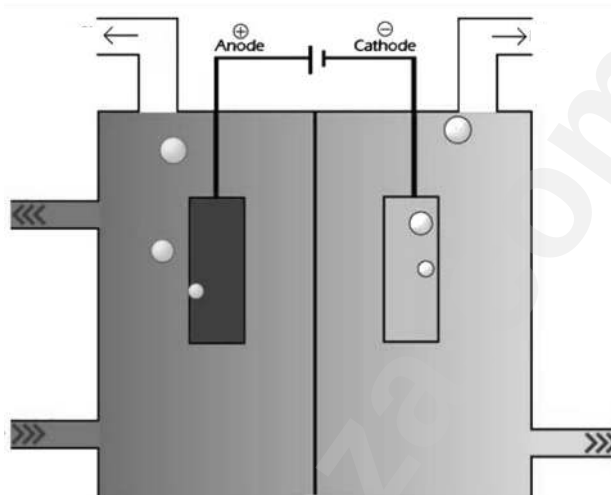
- 7.4 Must the impure gold be attached to the anode or the cathode in this process? (1)
-

- 7.5 If silver was one of the impurities in the gold, explain, with reasons, what would happen to it during the refining process. (2)

Dr Rhys Feldman is proud of the fact that our water purification system is of such a high standard that drinking straight from the tap is perfectly safe.

This is thanks to the chlor-alkali plant (NCP) in Kempton Park where chlorine is produced.

NCP makes use of the membrane cell as depicted below:



- 7.6 Which gas is produced at the positive electrode? (1)
- _____
- 7.7 Write the overall (net) chemical reaction for this cell. (1)
- _____
- 7.8 List and explain TWO disadvantages associated with the products of this cell. (2)
- _____
- _____
- _____
- 7.9 Give the equation for the reaction that takes place at the cathode in the membrane cell. (1)
- _____
- 7.10 Give the name of the electrolyte that is found in this cell. (1)
- _____

[18]

QUESTION 8 : ORGANIC CHEMISTRY**[15 marks]**

Consider the various carbon compounds and their boiling points given in the table below and answer the questions that follow:

Compound	Name or structural formulae	Boiling point (°C)
A	Pentanoic acid	187
B	<pre> H H H H H - C - C - C - C - H H H H H - C - H H </pre>	-161
C	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	138
D	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_3$	102
E	<pre> H Br H H H H - C - C - C - C - C - H H H H H H - C - H H - C - H H </pre>	154
F	<pre> H H H H H H - C - C - C - C - C - H H H H H H </pre>	-130

G	<pre> H H H H O H H - C - C - C - C - C - H H H H H H </pre>	119
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8.1 Describe an organic molecule. (2)

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

8.3 Give the IUPAC name of compound **E**. (2)

8.4 From the compounds in the table above, name all the positional isomers of compound **G**. Give only the letter/s of the correct compound/s and their name/s. (1)

8.5 Give the IUPAC name of compound **D**. (2)

- 8.6 Explain why compound **B** has a lower boiling point than compound **F**. Include reference to specific intermolecular forces in your answer. (3)

- 8.7 Explain why compound **D** has a lower boiling point than compound **G**. Include reference to specific intermolecular forces in your answer. (4)

[15]

QUESTION 9 : ORGANIC CHEMISTRY CONTD**[17 marks]**

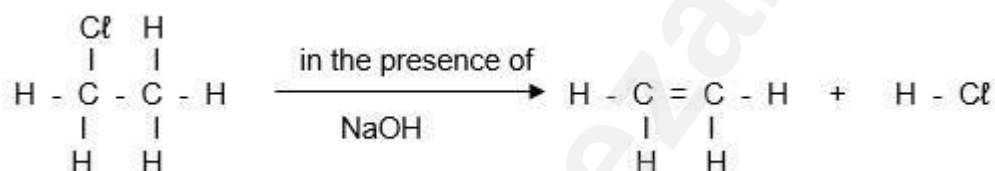
Consider the following reactions. Unidentified compounds are labelled with letters **W**, **X** and **Y** within boxes. Not all of the relevant conditions have been included in the reactions.

Reactions A and B:

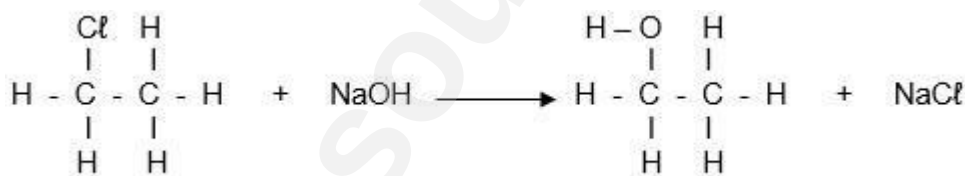
Under different conditions, a haloalkane will either react to form an alkene or an alcohol. Both reactions require the presence of a strong base such as sodium hydroxide to allow each reaction to take place.

Reaction A:

A haloalkane can be converted into ethene according to the following reaction:

**Reaction B:**

A haloalkane can alternatively be converted into an alcohol according to the following reaction:



9.1 What type of general reaction is Reaction **A**? (1)

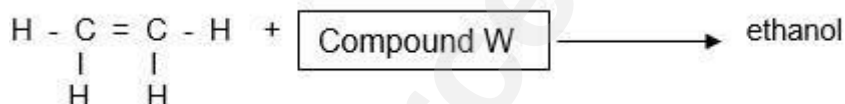
9.2 What type of specific reaction is Reaction **B**? (1)

- 9.3 Reaction **A** produces two gaseous products, ethene and hydrogen chloride. Suggest a practical way to separate these two products from each other and explain why this is a suitable method. (2)

- 9.4 Which reaction (**Reaction A** or **Reaction B**) will take place when the sodium hydroxide is present in the form of a dilute aqueous solution? (1)

Reaction C:

Ethene further reacts in a hydration reaction to form ethanol according to the following chemical reaction equation:

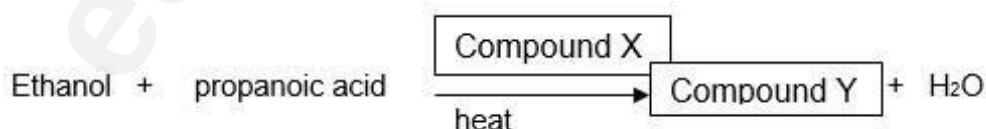


- 9.5 Reaction **C** is a hydration reaction. What general type of reaction is this? (1)

- 9.6 Give the formula for compound **W**. (1)

Reaction D:

Ethanol further reacts with propanoic acid forming compound **Y** according to the following chemical reaction equation:

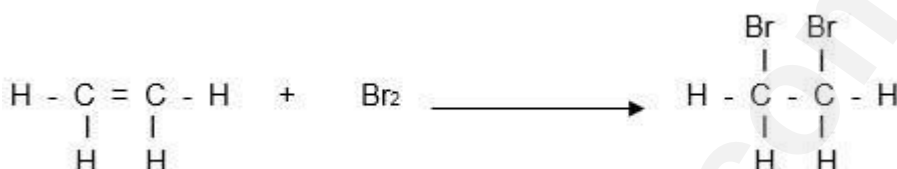


- 9.7 Give the IUPAC name of compound **Y**. (2)

- 9.8 Identify compound **X** which is needed for **Reaction D** to form compound **Y**. (1)

Reaction E:

In another reaction, ethene is bubbled through liquid bromine and a reaction takes place according to the following chemical reaction equation:



- 9.9 What observation can be made when **Reaction E** takes place? (2)

- 9.10 Give the IUPAC name for the product of **Reaction E**. (2)

Reaction F:

Ethene will also burn in the presence of oxygen. It is made from a fossil fuel.

- 9.11 Give the balanced chemical equation for the complete combustion of ethene. Use molecular formulae for all substances in the reaction. Phases need not be shown. (3)

[17]

END OF EXAM

ADDITIONAL SPACE (ALL questions)

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

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