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HILTON COLLEGE
GRADE 12 TRIAL EXAMINATIONS
SEPTEMBER 2020

PHYSICAL SCIENCES: PAPER II

Examiner: Mr MJ van Wyk
Moderator: Mr NC Robert

Time: 3 hours
200 Marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 18 pages, a yellow ANSWER SHEET of 1 page (i) and a green DATA SHEET of 3 pages (i–iii). Please make sure that your question paper is complete.
 2. Answer ALL the questions.
 3. Read the questions carefully.
 4. Use the data and formulae whenever necessary.
 5. **START EACH QUESTION ON A NEW PAGE.**
 6. Please ensure that you number your answers as the questions are numbered.
 7. Unless instructed otherwise, it is NOT necessary to give state symbols (phase indicators) when asked to write a balanced chemical equation.
 8. Show all necessary steps in calculations.
 9. Where appropriate, express final answers correct to TWO decimal places.
 10. It is in your own interest to write legibly and to set your work out neatly.
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QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice Answer Sheet on the inside front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter of the option that you consider to be most correct. Every question has only one correct answer.

A	B	☒	D
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Here the answer C has been marked.

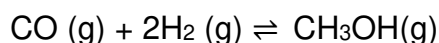
1.1 The correct formula for potassium phosphate is ...

- A KPO_4
- B KPO_3
- C K_3PO_4
- D $\text{K}(\text{PO}_4)_3$

1.2 The rate of the reaction between zinc **granules** and **dilute** sulphuric acid can be increased by adding a solution of **copper sulphate**. The reason for this is that the ...

- A zinc displaces the copper from the copper sulphate.
- B sulphuric acid reacts more vigorously with the copper.
- C concentration of the sulphate ions increases.
- D copper ions act as a catalyst.

1.3 Initially, 2 mol CO(g) and 2 mol $\text{H}_2\text{(g)}$ are sealed in a container. The reaction reaches equilibrium according to the following balanced equation:

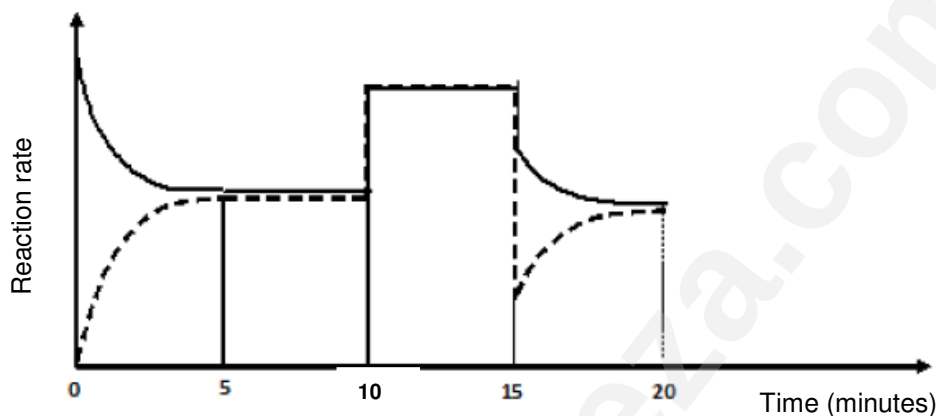
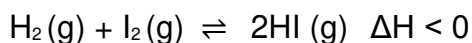


At equilibrium the amount of $\text{CH}_3\text{OH (g)}$ in the mixture will be ...

- A 1 mol.
- B 2 mol.
- C less than 1 mol.
- D greater than 1 mol.

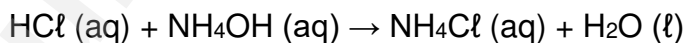
- 1.4 The graph represents the change in the reaction rate against time for the reversible reaction that takes place when hydrogen gas (H_2) and iodine gas (I_2) is placed in a closed container. Equilibrium was established after 5 minutes.

The balanced equation for the reaction is:



What change was made at **10 minutes** to the reaction rate as indicated on the graph?

- A A catalyst was added.
 - B An increase in temperature.
 - C A decrease in temperature.
 - D A decrease in the external pressure of the reaction mixture.
- 1.5 A hydrochloric acid solution is titrated with an ammonium solution. The balanced equation for the reaction is:



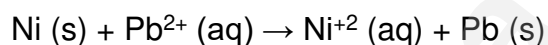
Which **ONE** of the following gives the pH of the solution at the end point and the reason for the pH?

	pH	REASON
A	3	$\text{H}_3\text{O}^+(\text{aq})$ forms during the ionization of $\text{HCl}(\text{aq})$.
B	5	$\text{H}_3\text{O}^+(\text{aq})$ forms during the hydrolysis of $\text{NH}_4^+(\text{aq})$.
C	7	Neutralisation will take place at the end-point.
D	9	$\text{OH}^-(\text{aq})$ forms during the hydrolysis of $\text{NH}_4^+(\text{aq})$.

- 1.6 Which **ONE** of the following acids, each with a concentration of $0,1 \text{ mol.dm}^{-3}$, will have the highest pH value?

	Acid	K_a
A	$\text{H}_2\text{S (aq)}$	$1,0 \times 10^{-7}$
B	$\text{H}_2\text{CO}_3 \text{ (aq)}$	$4,2 \times 10^{-7}$
C	$\text{H}_2\text{SO}_4 \text{ (aq)}$	$1,2 \times 10^{-2}$
D	$(\text{COOH})_2 \text{ (aq)}$	$5,6 \times 10^{-2}$

- 1.7 The following equation represents the reaction taking place in an electrochemical cell:

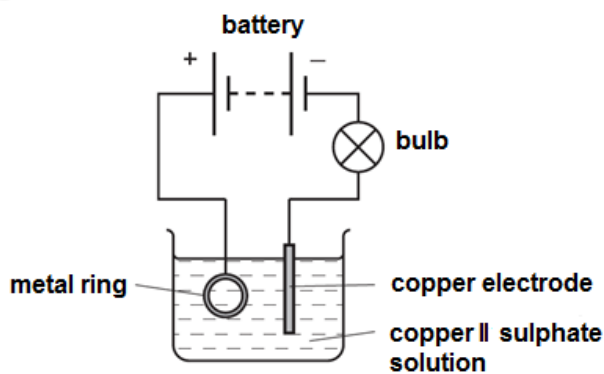


The flow of electrons through the external circuit of this cell is from ...

- A Pb at the anode to Ni at the cathode.
 B Pb at the cathode to Ni at the anode.
 C Ni at the cathode to Pb at the anode.
 D Ni at the anode to Pb at the cathode.
- 1.8 The diagram shows apparatus used in an attempt to electroplate a metal ring with copper.

The experiment did not work.

Which change is needed to make the experiment work?

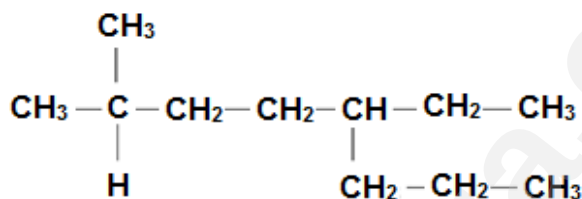


- A Replace the metal ring with a different metal ring.
 B Reverse the connection on the battery.
 C Add solid copper sulphate to the electrolyte.
 D Add more cells to the battery.

1.9 Which **ONE** of the following organic compounds will have the **LOWEST** boiling point?

- A Propanoic acid
- B Propan-1-ol
- C Propan-2-ol
- D Propane

1.10 Consider the formula of the compound below:



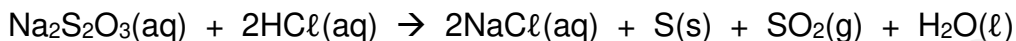
The correct IUPAC name of this compound is ...

- A 2-methyl-5-propylheptane.
- B 4-ethyl-7,7-dimethylheptane.
- C 4-ethyl-7-methyloctane.
- D 5-ethyl-2-methyloctane

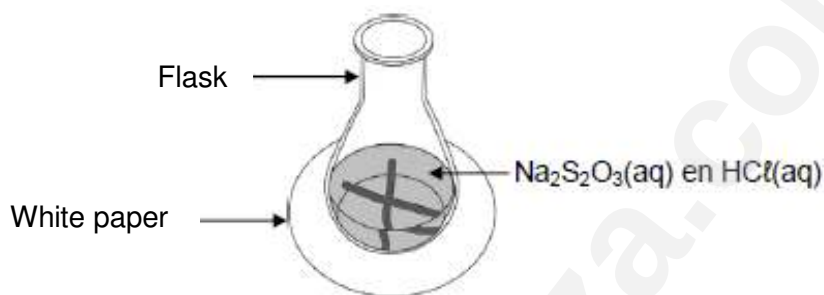
[20]

QUESTION 2

Ethan wants to investigate the reaction between sodium thiosulphate solution and dilute hydrochloric acid to investigate one of the factors that affect the reaction rate. The balanced equation for the reaction is:



The diagram below shows the experimental set-up:



In the first experiment 50 cm³ of sodium thiosulphate is added to 100 cm³ of dilute hydrochloric acid of 2 mol.dm⁻³ in a flask, which is placed on a cross drawn on a white sheet of paper. The hydrochloric acid is in excess.

The time it takes for the cross to disappear is recorded.

The experiment is then repeated 4 times using different volumes of the sodium thiosulphate solution. The results were recorded in the table below:

Experiment	Volume of Na ₂ S ₂ O ₃ (cm ³)	Volume of H ₂ O (cm ³)	Time (s)	Ave. rate ($\frac{1}{\text{time}}$) (x 10 ⁻² s ⁻¹)
1	50	0	22,7	4,4
2	40	10	28,6	3,5
3	30	20	38,5	2,6
4	20	30	58,8	1,7
5	10	40	111,1	0,9

- 2.1 Define *reaction rate*. (2)
- 2.2 How does the concentration of sodium thiosulphate solution used in experiment **2** compare with that used in experiment **5**? Only write GREATER THAN, SMALLER THAN or THE SAME. (1)
- 2.3 Draw a graph of the **average reaction rate** versus the **volume of sodium thiosulphate** used on the ANSWER SHEET provided. (6)

2.4 Use your graph to answer the following questions:

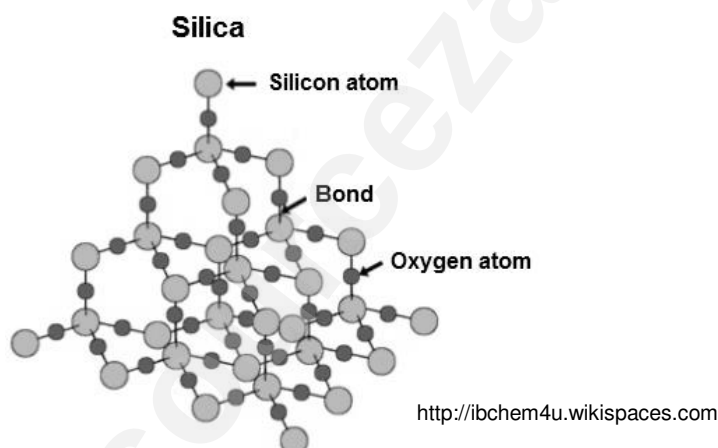
2.4.1 Determine the volume of sodium thiosulphate that needs to react for the cross to disappear in 40 seconds. (**Indicate on your graph how you determined the value.**) (3)

2.4.2 Write a conclusion for this investigation. (2)

2.5 Discuss the effect of an **increase** in concentration of $\text{Na}_2\text{S}_2\text{O}_3$ on the reaction rate by using the collision theory. Use bullet points. (4)

2.6 The mass of sulphur produced in experiment 1 is 1,62 g. Calculate the mass of sodium thiosulphate used in experiment 1. (5)

2.7 The atomic structure of silicon dioxide (silica) at room temperature is given below.



2.7.1 Write down the chemical formula for silicon dioxide. (1)

2.7.2 Define *intramolecular bond*. (2)

2.7.3 The type of bonding found between silicon and oxygen atoms is a covalent bond. Calculate whether this bond would be polar or non-polar. (2)

2.7.4

	Silicon dioxide	Carbon dioxide
Melting Point ($^{\circ}\text{C}$)	1710	-78.5

Why are the melting points of silicon dioxide and carbon dioxide, so different? In your answer consider the **type of forces and bonds present**, in each compound. (4)

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QUESTION 3

- 3.1 40 g of calcium carbonate (CaCO_3) reacts with 500 cm^3 of hydrochloric acid (HCl) of concentration $1,2 \text{ mol.dm}^{-3}$ according to the following balanced equation:

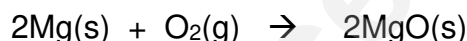


3.1.1 Calculate the moles of each reactant. (4)

3.1.2 Hence, decide which of the two substances will be used up completely? Show your working and write down calcium carbonate or hydrochloric acid. (2)

3.1.3 How many grams of the other substance are in excess. (3)

- 3.2 Magnesium burns in air to form magnesium oxide according to the following balanced equation:

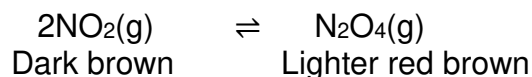


When 336 dm^3 of oxygen gas at STP reacts with an excess of magnesium, 875 g of magnesium oxide is produced. Calculate the % yield for this reaction. (6)

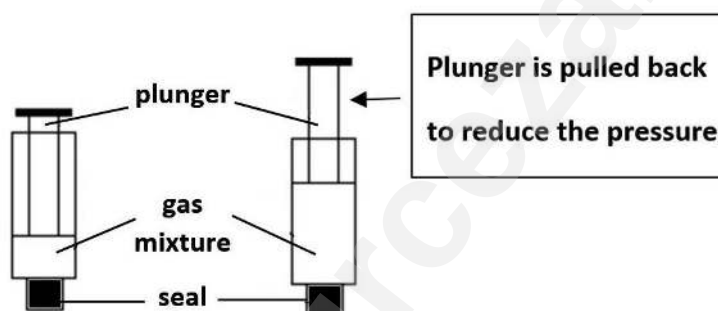
[15]

QUESTION 4

- 4.1 An equilibrium between nitrogen dioxide (NO_2) and dinitrogen tetroxide (N_2O_4) is established in a sealed gas syringe that can be considered to be a closed system. The balanced equation for the system is shown below.



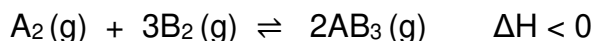
- 4.1.1 What is a *closed system* (in chemical terms)? (2)
- 4.1.2 State *Le Chatelier's Principle*? (2)
- 4.1.3 The pressure on the equilibrium mixture is **decreased** by pulling the plunger backwards and holding it in this new position.



The colour inside the syringe immediately lightens and then slowly darkens a bit.

- (a) Why did the colour initially lighten? (1)
- (b) Use Le Chatelier's principle to fully explain why the mixture darkens again. (4)
- 4.1.4 The plunger is fixed in place and the syringe is warmed in a water bath. The gas mixture becomes darker brown.
- (a) State whether the rate of the forward reaction INCREASED or DECREASED. (1)
- (b) State whether the forward reaction is ENDOTHERMIC or EXOTHERMIC. (1)

4.2 A hypothetical chemical system is represented by the equation below:



6 mol of $\text{A}_2(\text{g})$, 6 mol of $\text{B}_2(\text{g})$ and 1 mol of $\text{AB}_3(\text{g})$ are introduced into a 2 dm^3 flask which is sealed at 22°C . At equilibrium the concentration of AB_3 is found to be $2 \text{ mol}\cdot\text{dm}^{-3}$.

4.2.1 Write down an expression for the equilibrium constant (K_c) for this reaction. (2)

4.2.2 Calculate the concentration of each substance present in the equilibrium mixture at 22°C .

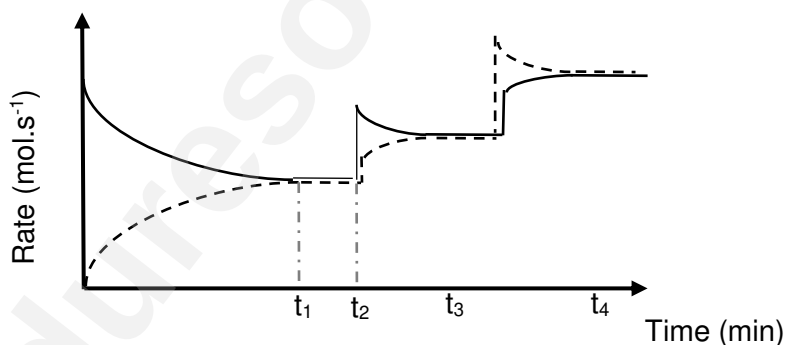
Clearly **list** the equilibrium concentrations of $\text{A}_2(\text{g})$ and $\text{B}_2(\text{g})$ after your working. (5)

4.2.3 Calculate the equilibrium constant for this reaction at 22°C . (2)

The equilibrium mixture is then subjected to the following changes:

- (a) Increasing pressure (at constant temperature).
- (b) Increasing temperature (at constant pressure).

A graph showing these changes is shown below:



4.2.4 Identify what change is shown in the graph at t_2 . (1)

4.2.5 How does the value of the equilibrium expression (K_c) change between:

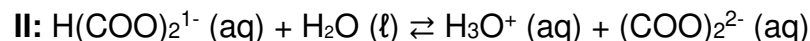
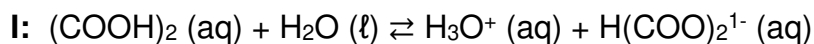
- (a) t_1 and t_3 ? (1)
- (b) t_3 and t_4 ? (1)

Write down only INCREASE, DECREASE or STAYS THE SAME.

[23]

QUESTION 5

Anhydrous oxalic acid is an example of a **diprotic** acid which ionise in two steps as shown in the following equations:



5.1 Write down:

5.1.1 what is meant by the term **diprotic** acid. (2)

5.1.2 the **formulas** of each of the TWO bases in reaction **II**. (2)

5.1.3 the definition of an *amphoteric substance*. (2)

5.1.4 the **formula** of the substance which acts as an amphoteric substance in reaction **I** and **II**. (1)

5.2 Tinotenda makes the following statement:

“Oxalic acid is a weak acid and thus will always form a diluted solution.”

5.2.1 Is a weak acid always a diluted acid? (1)

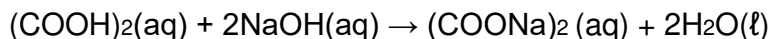
5.2.2 Explain your answer in QUESTION 5.2.1. (2)

5.3 A standard solution of $(\text{COOH})_2$ with a concentration of **0,2 mol.dm⁻³** is prepared by dissolving a certain amount of anhydrous oxalic acid, $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$, in water in a **250 cm³** volumetric flask.

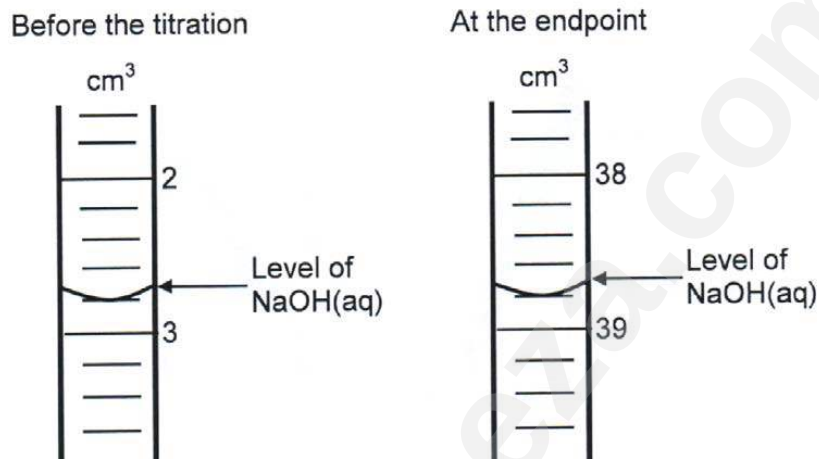
5.3.1 Define *standard solution*. (2)

5.3.2 Calculate the mass of oxalic acid used to prepare the standard solution. (4)

- 5.4 During a titration, 25 cm³ of the standard solution of (COOH)₂ prepared in QUESTION 5.3, is neutralised by a sodium hydroxide solution using a burette. The balanced equation for this reaction is:



The following diagrams indicate the respective burette readings before the titration and at the **end point**.



- 5.4.1 Briefly state what will happen at the *end point* of a titration. (1)
- 5.4.2 Refer to the table of indicators below and state which indicator would be most suitable for this titration.

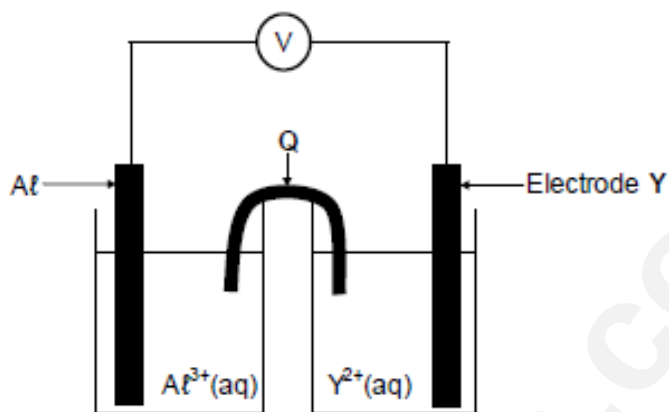
Indicator	Colour change Acid to Base	pH range
Methyl orange	Red to yellow	3,1 – 4,4
Bromothymol blue	Yellow to blue	6,0 – 7,6
Phenolphthalien	Colourless to pink	8,3 – 10, 0

- 5.4.3 Use the burette readings and calculate the concentration of the sodium hydroxide solution. Clearly show your steps. (6)
- 5.4.4 Predict what the pH of the solution will be at the end point. Only write: **LESS THAN 7**, **EQUAL TO 7** or **GREATER THAN 7**. (1)
- 5.4.5 Write a balanced chemical equation to help you fully explain your answer in QUESTION 5.4.4., due to the hydrolysis of (COONa)₂. (4)

[29]

QUESTION 6

In the electrochemical cell shown below an aluminium electrode and another metal electrode, **Y**, are used.



6.1 Write down the:

6.1.1 Name the component **Q**. (1)

6.1.2 Type of electrochemical cell represented above. (1)

It is found that the **mass of the aluminium electrode increases** whilst the cell is functioning.

6.2 How will EACH of the following change while the cell is functioning? Choose from: INCREASES, DECREASES or REMAINS THE SAME.

6.2.1 The concentration of $\text{Al}^{3+}(\text{aq})$. (1)

6.2.2 The concentration of $\text{Y}^{2+}(\text{aq})$. (1)

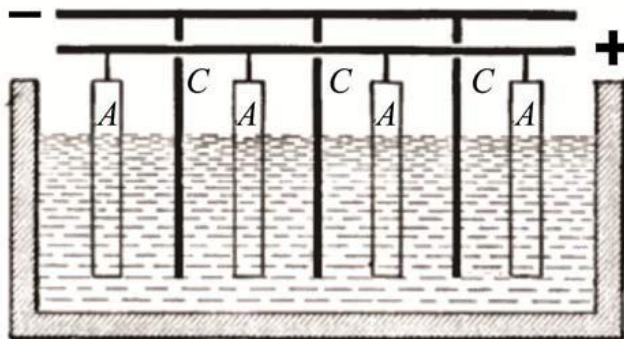
6.3 Write down the:

6.3.1 Half-reaction that takes place at electrode **Y**. (2)

6.3.2 Cell notation of the cell. **INCLUDE** state symbols. (4)

6.4 The initial Emf of this cell measured under standard conditions is 0,7 V. Identify metal **Y** by means of a calculation. (4)

Copper is refined, from impure copper to pure copper by an **electrolytic** process. The apparatus for this process is illustrated below:



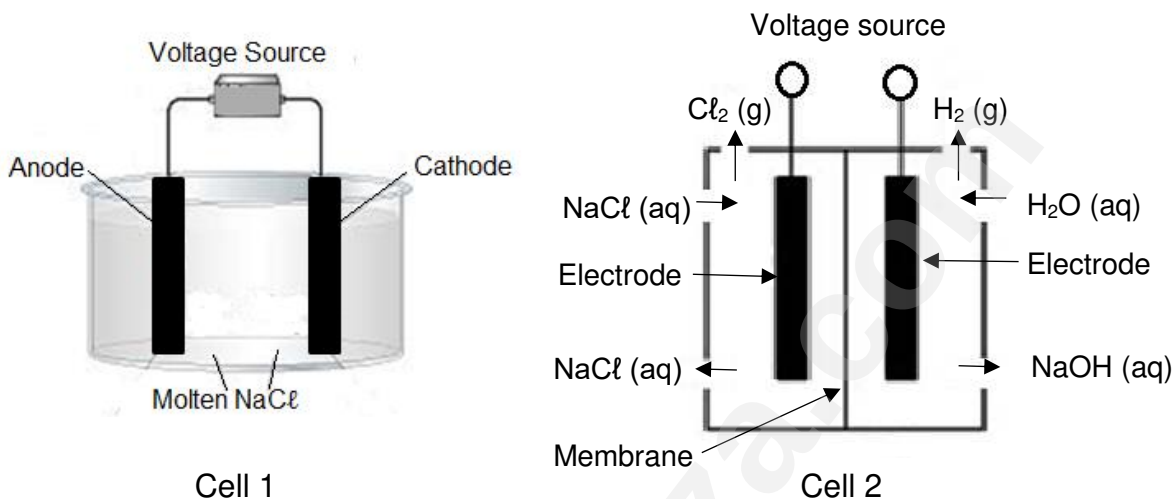
The electrodes marked **A** are the anodes and the electrodes marked **C** are the cathodes.

- 6.5 Describe the **electrolytic** cell in terms of energy conversion taking place in the cell. (1)
- 6.6 Is the impure metal the anode or the cathode? Give the chemical equation for the reaction that takes place at this electrode. (2)
- 6.7 Suggest an electrolyte that is suitable for this reaction to take place. (1)
- 6.8 If more reactive metal ions such as Zn^{2+} or Fe^{2+} go into the solution with copper ions why do they not get discharged at the cathode along with copper ions? (2)
- 6.9 A current of 8 A flows for a time of 20 minutes and deposits 3,2 g of pure copper.
- 6.9.1 Calculate the number of moles of copper deposited. (2)
- 6.9.2 Calculate the number of electrons which flow through the circuit in order to deposit this mass of copper. (Charge required for 1 mol of electrons (Faraday) = 96 500 C.mol⁻¹) (4)

[26]

QUESTION 7

The cells below represent the electrolysis of molten sodium chloride and aqueous sodium chloride (brine solution) respectively:



- 7.1 In Cell 1, state why the sodium chloride must be molten to conduct the electrical current. (2)
- 7.2 State the function of the membrane in **Cell 2**. (1)
- 7.3 State whether the cathode in these cells is positive or negative. (1)
- 7.4 Consider the reactions at the **cathodes** of the cells:
- 7.4.1 Write down the half reaction that occurs in **Cell 1**. (2)
- 7.4.2 Write down the half reaction that occurs in **Cell 2**. (2)
- 7.4.3 Explain why the cathode reactions in these two cells are NOT the same, specifically looking at the inherent reactivity of the ions in **Cell 2**. (4)

[12]

QUESTION 8

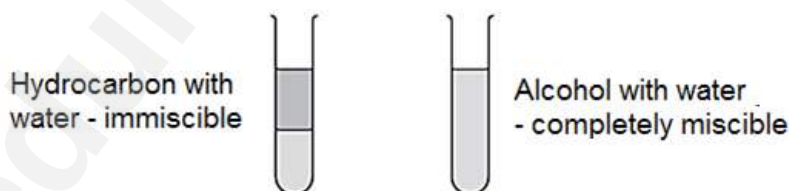
- 8.1 Daniel collected data on the boiling points of the first six members of the alkene homologous series and their corresponding alkanes.

No of C atoms	Alkane	Boiling point (°C)	Alkene	Boiling point (°C)
2	ethane	-88	ethene	-104
3	propane	-42	propene	-48
4	butane	0	1-butene	-6
5	pentane	36	1-pentene	30
6	hexane	69	1-hexene	63

- 8.1.1 Define *functional group*. (2)
- 8.1.2 Describe the functional group of alkenes in words. (2)
- 8.1.3 Explain the chemistry behind the trend in boiling points shown by both homologous series as the **number of carbon atoms in the molecules increases**.
(NOTE: Do not focus on difference in boiling point between alkane and alkene but on increasing carbon atoms.) (4)
- 8.1.4 Make a general statement comparing the boiling points of the alkanes and the alkenes. (2)
- 8.2 Janco conducted two experiments using test tubes:

Experiment 1 – 10 cm³ of a saturated hydrocarbon was mixed with 10 cm³ of water.

Experiment 2 – 10 cm³ of an alcohol was mixed with 10 cm³ of water.

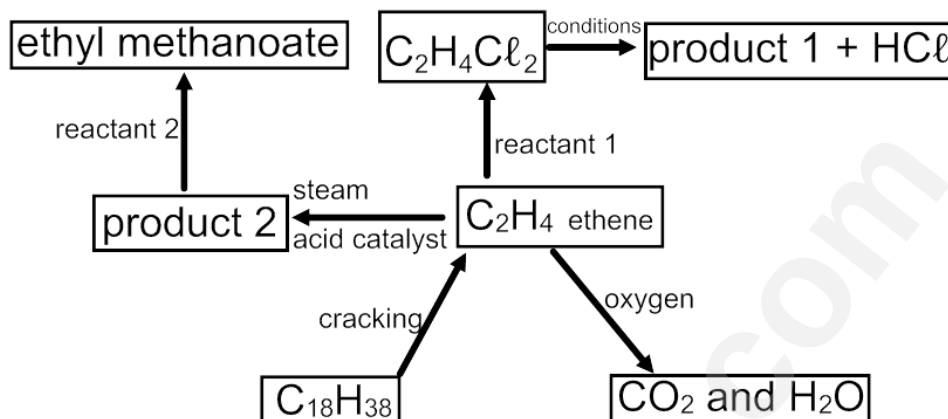


- 8.2.1 Define *saturated hydrocarbon*. (2)
- 8.2.2 Explain, with reference to the relevant intermolecular forces, why the hydrocarbons are immiscible in water. (3)
- 8.2.3 Methane reacts with fluorine in the presence of specific conditions. **State** one of the conditions for this reaction to take place and write the **chemical formulae** of the products that would form. (3)

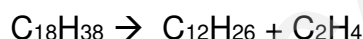
[18]

QUESTION 9

Consider the flow chart showing the reactions involving ethene below:



- 9.1 Ethene is produced in a **thermal cracking** reaction from $C_{18}H_{38}$. The **unbalanced** chemical equation for this reaction is given below:



- 9.1.1 State the reaction conditions for this specific cracking reaction. (3)
- 9.1.2 Is cracking a chemical or physical process? Provide one reason for your answer. (2)
- 9.1.3 Write down the balanced chemical equation for this cracking reaction. (2)
- 9.2 Ethene can react with oxygen to form carbon dioxide and water.
- 9.2.1 Give the **name** of this chemical reaction. (1)
- 9.2.2 Write the balanced chemical equation for the reaction that occurs. (2)
- 9.3 Ethene reacts with reactant 1 to form $C_2H_4Cl_2$.
- 9.3.1 **Name** reactant 1. (1)
- 9.3.2 Provide the IUPAC name **and** the condensed structural formula for $C_2H_4Cl_2$. (4)
- 9.3.3 $C_2H_4Cl_2$ reacts further under specific conditions, hot concentrated KOH in an ethanol solvent and in the absence of water to form product 1 and HCl. Draw the complete structural formula of product 1. (2)

9.4 Ethene reacts to form product 2 which can then be reacted with reactant 2 to form ethyl methanoate.

9.4.1 What **general and specific type** of organic chemical reaction forms product 2 from ethene? (2)

9.4.2 Provide the IUPAC name for reactant 2. (2)

9.4.3 Provide the structural formula **and** the IUPAC name of the **functional isomer** of ethyl methanoate. (4)

[25]

Total: 200 marks