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PRELIMINARY EXAMINATION 29 AUGUST 2019

PHYSICAL SCIENCES – PAPER 2 (CHEMISTRY)

Time: 3 hours
Examiner: Durban-50 Cluster (T. Rodrigues)

200 marks
Moderator: S. Pillay

Name: _____

Exam Number:

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PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This QUESTION PAPER consists of 14 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. **Write your name and exam number on the front page of your QUESTION PAPER and the blue ANSWER BOOK and the yellow ANSWER SHEET.**
3. There are 10 questions. Answer **ALL** questions on the foolscap paper provided in your ANSWER BOOK. Do **NOT** answer any questions on the question paper.

QUESTION 4.6 must be answered on your yellow ANSWER SHEET.

4. Read the questions carefully.
5. Write on **BOTH SIDES** of the paper.
6. **QUESTION 1** consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are to be answered on the answer sheet provided on the **inside cover** of your blue answer book. 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
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Here the answer C has been marked.

7. **START EACH QUESTION ON A NEW PAGE.**
8. Show your working in all calculations.
9. It is in your own interests to write legibly and set your work out neatly.
10. Unless instructed otherwise it is NOT necessary to give state symbols (phase indicators) when asked to write a balanced chemical equation.
11. Where necessary, round off your FINAL answer to **2 decimal places**.

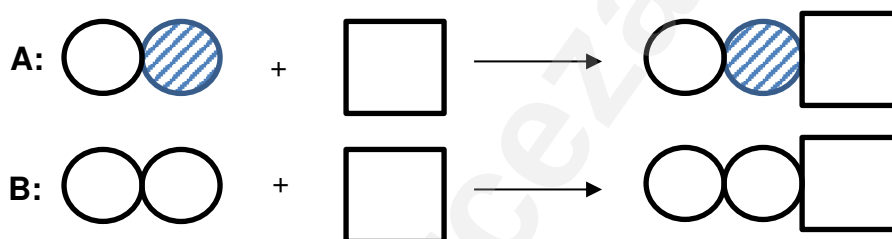
QUESTION 1

Answer these questions on the inside front cover of your Answer Book. Make a cross (X) on the letter of the response which you consider to be the most correct.

- 1.1 A solid **X** does not conduct electricity. **X** melts at 115 °C and still does not conduct electricity in the molten state. Which one of the following is the probably identity of **X**?

A. Diamond
B. Sulfur
C. Sodium
D. Sodium iodide

- 1.2 Consider reactions **A** and **B**, the reacting particles of which are represented by shapes. All other factors that could influence the rate of reaction being the same for **A** and **B**, predict which of the reactions, with a reason, would be faster.



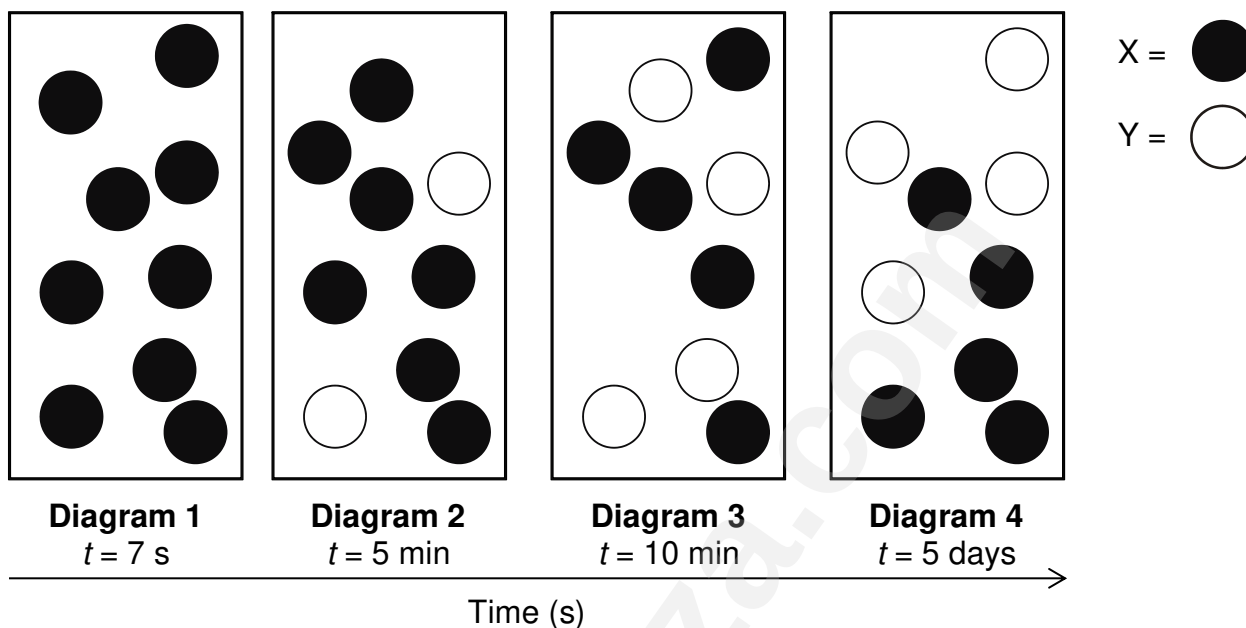
	Reaction	Reason
A.	A	There is a greater chance of a correct orientation.
B.	A	The activation energy is lower.
C.	B	There is a greater chance of a correct orientation.
D.	B	The activation energy is lower.

- 1.3 What will happen to the position of equilibrium and the value of the equilibrium constant when the temperature is increased in the following reaction?



	Position of Equilibrium	Value of Equilibrium Constant
A.	Forms more reactants	Decreases
B.	Forms more reactants	Increases
C.	Forms more products	Decreases
D.	Forms more products	Increases

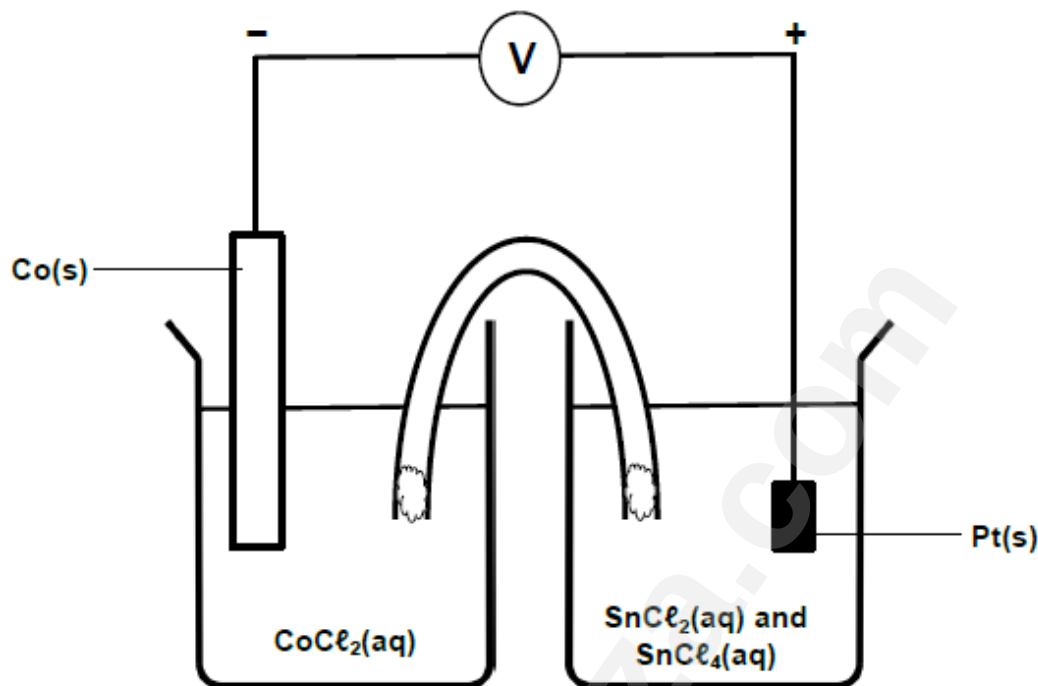
- 1.4 The following sequence of diagrams represents a chemical system as time passes for a gas phase reaction in which reactant **X** is converted to product **Y**.



Which one of the following statements is CORRECT?

- A. At $t = 5 \text{ days}$ the rate of the forward reaction is greater than the rate of the reverse reaction.
- B. At $t = 7 \text{ s}$ the reaction has reached completion.
- C. At $t = 10 \text{ min}$ the system has reached a state of equilibrium.
- D. At $t = 5 \text{ days}$ the rate of the forward reaction is less than the rate of the reverse reaction.
- 1.5 When a dilute solution of ethanoic acid (CH_3COOH) is prepared in water, approximately **99 %** of the acid molecules are found **unionised**. When an amount of concentrated hydrochloric acid (HCl) is added to the solution, it is found that 99,98 % of the ethanoic acid molecules are **unionised**. The difference in the degree of ionisation can best be attributed to:
- A. the common ion effect.
- B. ethanoic acid being a weak acid.
- C. a precipitation reaction taking place.
- D. CH_3COOH and HCl forming a conjugate acid-base pair.
- 1.6 How should a $0,001 \text{ mol}\cdot\text{dm}^{-3}$ solution of hydrobromic acid, HBr , be classified?
- A. CONCENTRATED and STRONG
- B. CONCENTRATED and WEAK
- C. DILUTE and STRONG
- D. DILUTE and WEAK

1.7 A standard galvanic cell is constructed as shown in the diagram below.



Which one of the following correctly represents the cell notation for this cell?

- A. $\text{Co(s)} \mid \text{Co}^{2+}(\text{aq}) \parallel \text{Sn}^{4+}(\text{aq}), \text{Sn}^{2+}(\text{aq}) \mid \text{Pt(s)}$
- B. $\text{Co}^{2+}(\text{aq}) \mid \text{Co(s)} \parallel \text{Pt(s)} \mid \text{Sn}^{4+}(\text{aq}), \text{Sn}^{2+}(\text{aq})$
- C. $\text{Pt(s)} \mid \text{Sn}^{2+}(\text{aq}), \text{Sn}^{4+}(\text{aq}) \parallel \text{Co}^{2+}(\text{aq}) \mid \text{Co(s)}$
- D. $\text{Sn}^{2+}(\text{aq}), \text{Sn}^{4+}(\text{aq}) \mid \text{Pt(s)} \parallel \text{Co(s)} \mid \text{Co}^{2+}(\text{aq})$

1.8 Which of the following are TRUE for the Diaphragm Cell in the Chlor-Alkali Industry?

- i. Depleted brine exits the anode compartment.
- ii. Dilute sodium hydroxide exits the cathode compartment.
- iii. The sodium hydroxide product is not contaminated with sodium chloride.

- A. i only.
- B. ii only.
- C. i and ii.
- D. ii and iii.

- 1.9 In the electrorefining of copper, blister (impure) copper is purified in an electrolytic cell. Which one of the following combinations correctly describes the predominant half-reactions occurring at the anode and the cathode in this cell?

	Anode	Cathode
A.	$\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$	$\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$
B.	$\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$	$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
C.	$\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^-$	$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
D.	$\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$	$2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$

- 1.10 During a hydrogenation reaction:

- A. hydrogen reacts with an alkane to form the next member of the homologous series.
- B. the number of double bonds in an alkene increases.
- C. an alkene is changed into an unsaturated hydrocarbon.
- D. oil is changed into margarine.

[20]

QUESTION 2

In the table below the melting points and boiling points of different substances at **standard pressure** are given. Use this information to answer the following questions.

Substance	Melting Point (°C)	Boiling Point (°C)
He	-272	-269
HBr	-86,9	-66,8
CCl ₄	-23	77
CO ₂	Sublimes at -78,5	
CH ₄	-184	-162
H ₂ O	0	100

- 2.1 In which one of the substances will the weakest intermolecular forces exist in the solid phase? Give a reason for your choice. (2)
- 2.2 Which one of the substances is a liquid at -10 °C? (1)
- 2.3 Define *intramolecular bond*. (2)
- 2.4 NAME the specific type of intramolecular bond in H₂O. (2)
- 2.5 Define *intermolecular force*. (2)
- 2.6 NAME the predominant intermolecular force in CO₂. (1)
- 2.7 NAME the predominant intermolecular force in H₂O. (1)
- 2.8 Classify CH₄ as a POLAR or NONPOLAR **molecule**. (2)
- 2.9 Fully explain the difference in boiling points between HBr and CCl₄. (4)

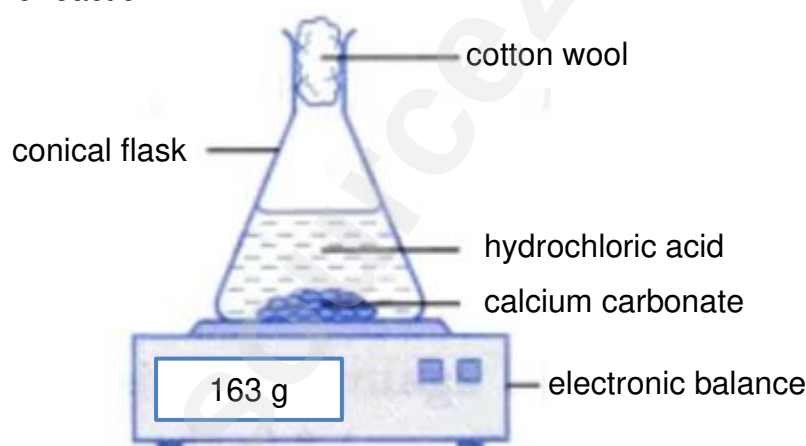
[17]

QUESTION 3

Bronwyn is investigating how the rate of a reaction changes during a reaction. She is using the reaction of calcium carbonate with hydrochloric acid.

- 3.1 Write a balanced chemical equation for the reaction between calcium carbonate and hydrochloric acid. (3)
- 3.2 3.2.1 Define *heat of reaction*. (2)
- 3.2.2 The reaction is exothermic. Describe what this means with reference to the energy changes that occur in the reaction. (2)

Bronwyn sets up her apparatus as shown in the diagram below. A conical flask containing hydrochloric acid solution at room temperature (25 °C) is placed on the mass balance and powdered calcium carbonate is carefully added into the flask. The mass of the reaction vessel is monitored during the reaction.



- 3.3 The mass of the reaction vessel is observed to decrease with time. Give a reason for why this happens. (1)
- 3.4 When Bronwyn initially sets up the experiment, the reaction occurred too fast for her to accurately monitor the change in mass.
- 3.4.1 Describe the *collision theory* model that is used to explain reaction rates. (3)
- 3.4.2 Use the collision theory to explain how using a single lump of calcium carbonate would affect the rate of the reaction, as compared to using a powder. (4)
- 3.4.3 Suggest TWO other changes that could be made to the experiment to slow the reaction rate so that it could be more accurately measured. (2)
- 3.4.4 Describe ONE alternative method that could also be used to measure the rate of this reaction. Make sure to describe what quantities must be measured and what apparatus must be used. (3)

Bronwyn sets up the experiment again, using a flask with 250 cm^3 of a $1,5\text{ mol}\cdot\text{dm}^{-3}$ hydrochloric acid solution into which $13,86\text{ g}$ of pure calcium carbonate is carefully added. The mass of the flask, with its contents, is measured every twenty seconds.

The results of their investigation are tabulated below.

Table showing the change in mass with time

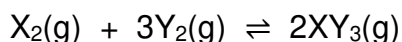
Time (s)	Mass (g)	Loss of mass (g)
0	169,1	0
20	168,3	0,8
40	166,7	2,4
60	164,6	4,5
80	163,8	5,3
100	163,4	X
120	163,1	6,0
140	163,0	6,1
160	163,0	6,1
180	163,0	6,1

- 3.5 Determine the value of **X** from the table. (2)
- 3.6 Calculate the average rate of formation of carbon dioxide gas in units of $\text{g}\cdot\text{min}^{-1}$. (4)
- 3.7 Calculate the volume of carbon dioxide gas that is produced in the reaction, assuming the gas is collected at STP. (5)
- 3.8 Show, by calculation, that the calcium carbonate will be completely consumed in this reaction. (4)

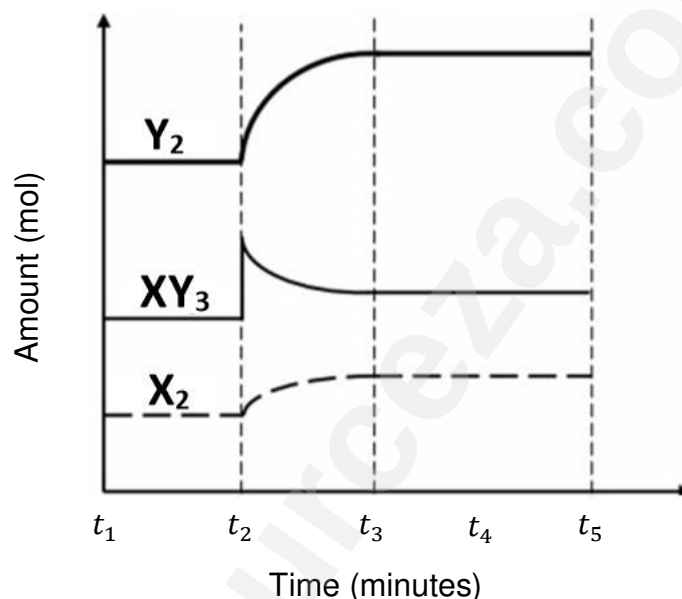
[35]

QUESTION 4

Ali is investigating the production of a chemical, XY_3 , that could be formed from the reaction between X_2 and Y_2 . The following balanced chemical equation represents a reversible reaction that has reached equilibrium at 470°C in a closed container:



Ali measures the number of moles of each of these gases as the reaction proceeds and plots them on the following graph. (The graph is not drawn to scale.)



- 4.1 What is meant by the term *dynamic chemical equilibrium*? (2)
- 4.2 Suggest what change was made at time t_2 to the equilibrium system. (1)
- 4.3 Use Le Châtelier's principle to explain the changes seen in the graph between times t_2 and t_3 . (3)
- 4.4 How would the value of the equilibrium constant at time t_4 compare to the value of the equilibrium constant at time t_1 ? State only LESS THAN, MORE THAN, or THE SAME. (1)
- 4.5 At time t_5 , the temperature is decreased, which causes an increase in the amount of reactants. Explain whether the forward reaction is exothermic or endothermic. (4)
- 4.6 On the axes given in your ANSWER SHEET, draw a graph of reaction rate vs time for the times given in the ANSWER SHEET. Use a solid line for the forward reaction rate and dashed line for the reverse reaction rate. (5)

4.7 Ali now injects 5 mol of X_2 and 5 mol of Y_2 into a 5 dm^3 sealed empty container. Equilibrium is reached at 450°C . Upon analysis of the equilibrium mixture, she finds that the mass of XY_3 is 20,4 g.

4.7.1 Write the expression for the equilibrium constant for this reaction. (2)

4.7.2 Calculate the value of the equilibrium constant at 450°C if the molar mass of XY_3 is $17 \text{ g}\cdot\text{mol}^{-1}$. (7)

[25]

QUESTION 5

Lithium fluoride crystals, LiF(s) , dissolve in water to form lithium and fluoride ions. The fluoride ions react with water.

5.1 Write down the name of the process described by the underlined sentence. (1)

5.2 Is lithium fluoride ACIDIC or BASIC in aqueous solution? (2)

5.3 The ionisation constant, K_b , for each of the following bases in water at 25°C is given in the table below:

Name	Formula	K_b
Ammonia	NH_3	$1,8 \times 10^{-5}$
Hydrogen carbonate ion	HCO_3^-	$2,4 \times 10^{-8}$

5.3.1 Define *base* according to Brønsted and Lowry. (1)

5.3.2 If the concentration for both bases are equal, choose which one of these bases would have a lower pH? Justify your answer. (3)

5.3.3 Write a balanced chemical equation for the reaction of hydrogen carbonate with water. (2)

5.3.4 Write down the formula for the conjugate acid of HCO_3^- . (1)

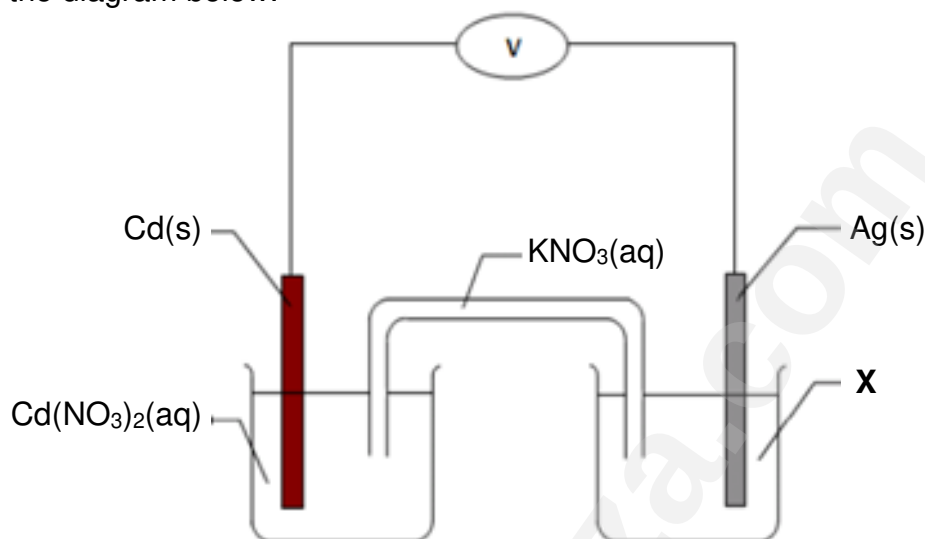
5.3.5 Write down the expression for base dissociation constant, K_b , for NH_3 . (2)

5.4 A solution of barium hydroxide, a strong base, is prepared with concentration $0,38 \text{ mol}\cdot\text{dm}^{-3}$. Calculate the concentration of hydronium ions in this solution. (4)

[16]

QUESTION 6

Heshnya sets up a galvanic cell under standard conditions using cadmium and silver electrodes as shown in the diagram below.

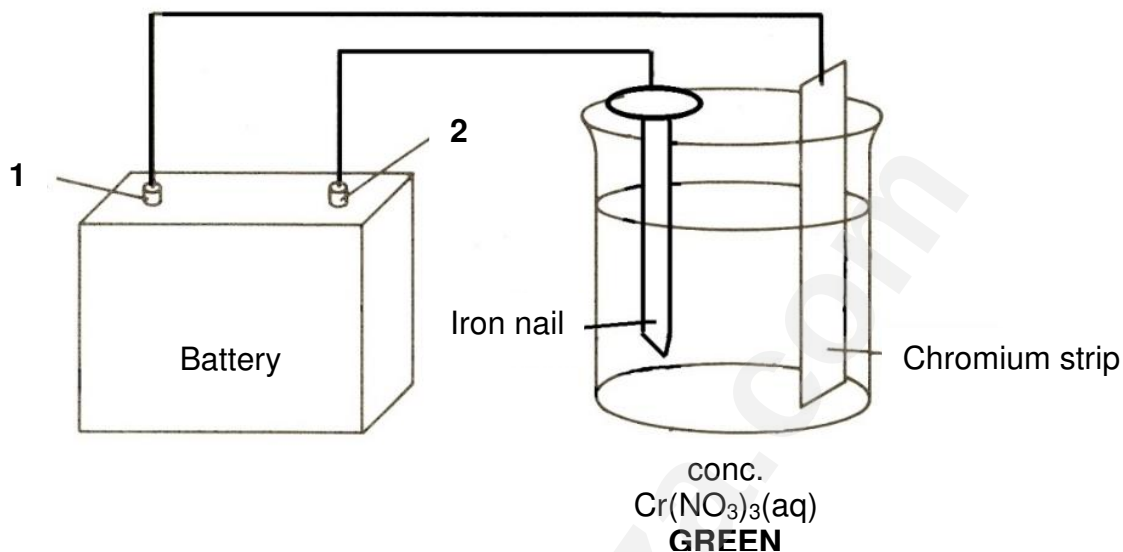


- 6.1 What energy conversion takes place in this cell? (2)
- 6.2 Define *electrolyte*. (2)
- 6.3 Write the formula of the substance used for the electrolyte in the silver half-cell. (1)
- 6.4 Define *oxidising agent*. (1)
- 6.5 Give the symbol of the oxidising agent in this cell. (1)
- 6.6 Write down the reduction half-reaction occurring in this cell. (2)
- 6.7 Define *anode*. (2)
- 6.8 Write the formula of the anode. (1)
- 6.9 State TWO functions of the salt bridge. (2)
- 6.10 Explain how the salt bridge achieves its function by referring to the changing ionic conditions and the migration of ions in the cadmium half-cell. (3)
- 6.11 Calculate the initial reading on the voltmeter. (3)
- 6.12 Heshnya adds some concentrated aqueous KCl solution to the silver half-cell, causing a precipitate to form. How will this affect the initial cell emf? State only INCREASES, DECREASES, or NO EFFECT. (2)
- 6.13 The voltmeter is replaced with a resistor, causing a current to flow. State what Heshnya will observe in the silver half-cell after a significant amount of time. (2)

[24]

QUESTION 7

In the electrolytic cell shown here below, an iron nail is being plated with chromium.

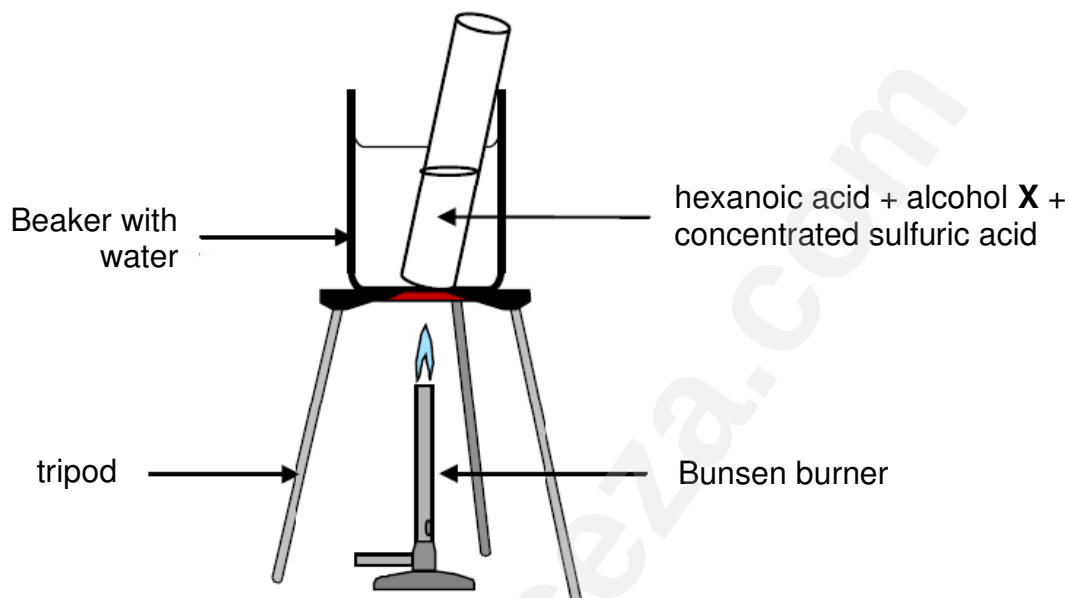


- 7.1 State the identity of the iron nail as the ANODE or CATHODE. (1)
- 7.2 Identify terminal 1 of the battery as POSITIVE or NEGATIVE. (1)
- 7.3 Chromium metal deposits onto the iron nail.
- 7.3.1 Write the equation for the half-reaction that occurs at the iron nail. (2)
- 7.3.2 There are competing half-reactions at the iron nail electrode. Fully explain why chromium is formed **predominantly** at the iron nail. (2)
- 7.3.3 A constant current flows for a time of 10 minutes and deposits 0,95 g of pure chromium on the nail. Determine the current that is used. (6)
- 7.3.4 How can a thicker layer of chromium be plated on the nail? (1)
- 7.3.5 Iron is a reactive metal. Explain briefly why it does not matter that the nail is made of iron. (2)
- 7.4 Write the equation for the half-reaction that occurs at the chromium strip electrode. (2)
- 7.5 Hence, state TWO observations that would be made at the chromium strip? (2)
- 7.6 Give another industrial use of electrolysis other than electroplating. (1)

[20]

QUESTION 8

Hexanoic acid is responsible for the unique odour associated with goats. When it reacts with alcohol **X**, ethyl hexanoate, which is used commercially as a fruit flavour, is formed. Lauren set up the apparatus shown below to prepare ethyl hexanoate in a laboratory.

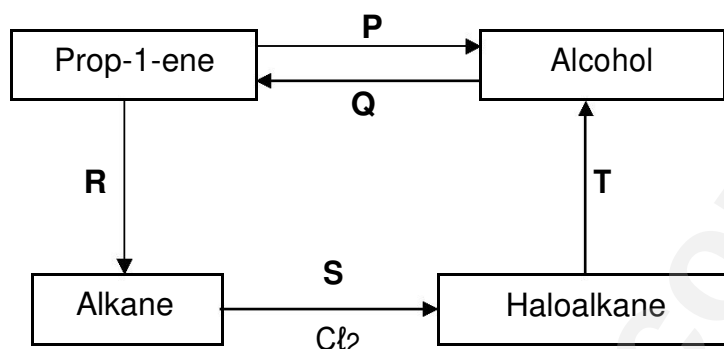


- 8.1 Define *homologous series*. (2)
- 8.2 NAME the homologous series to which ethyl hexanoate belongs. (1)
- 8.3 Define *functional group*. (2)
- 8.4 NAME the functional group of hexanoic acid. (1)
- 8.5 Give the general formula for the homologous series to which alcohol **X** belongs. (1)
- 8.6 Write down the IUPAC name of alcohol **X**. (2)
- 8.7 State TWO purposes of the sulfuric acid. (2)
- 8.8 Use structural formulae to write a balanced chemical equation for the preparation of ethyl hexanoate. (6)
- 8.9 Suggest a possible reason for Lauren heating the test tube in a water bath rather than directly over a flame. (1)
- 8.10 Define *structural isomer*. (2)
- 8.11 Write the IUPAC name of a FUNCTIONAL isomer of ethyl hexanoate. (2)
- 8.12 Using molecular formulae, write a balanced chemical equation for the complete combustion of ethyl hexanoate. (3)

[25]

QUESTION 9

In the flow diagram below prop-1-ene is used as the starting reagent in the preparation of other compounds. **P** to **T** represent organic chemical reactions.



9.1 Name the GENERAL TYPE of reaction represented by:

9.1.1 **P** (1)

9.1.2 **S** (1)

9.1.3 **Q** (1)

9.2 Consider reaction **P**. Write down the:

9.2.1 FORMULA of a suitable catalyst. (1)

9.2.2 structural formula of the alcohol. (2)

9.3 Consider reaction **R**.

9.3.1 Write down the SPECIFIC TYPE of reaction. (1)

9.3.2 Using condensed-structural formulae, write the balanced chemical equation for this reaction, including reaction conditions. (4)

9.4 Consider reaction **T**.

9.4.1 NAME a suitable inorganic reagent needed for reaction **T**. Include TWO conditions this reagent must have. (3)

9.4.2 Draw the condensed-structural formula for the haloalkane used in reaction **T**. (2)

9.4.3 List ALL of the intermolecular forces present in the alcohol product. (2)

[18]

Total: 200 Marks