NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION – MARCH 2019

PHYSICAL SCIENCES: PAPER II

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of 16 pages, a yellow Answer Sheet of 2 pages (i–ii) and a green Data Sheet of 3 pages (i–iii). Please make sure that your question paper is complete.

2. Remove the Data Sheet and Answer Sheet from the middle of this question paper. **Write your examination number on the yellow Answer Sheet.**

3. Read the questions carefully.

4. ALL of the questions in this paper must be answered.

5. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions must be answered on the answer sheet provided on the inside cover of your 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**

Here the answer C has been marked.

6. **START EACH QUESTION ON A NEW PAGE.**

7. Please ensure that you number your answers as the questions are numbered.

8. Unless instructed otherwise it is NOT necessary to give state symbols (phase indicators) when asked to write a balanced chemical equation.

9. Use the data and formulae whenever necessary.

10. Show all of the necessary steps in calculations.

11. Where appropriate take your answers to 2 decimal places.

12. It is in your own interest to write legibly and to present your work 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 that you consider to be most correct.

1.1 The rate of appearance of **A** in the hypothetical reaction below is x mol·dm^{-3}·s^{-1}. What is the rate of appearance of **B** in mol·dm^{-3}·s^{-1}?

$$\mathbf{3C(aq) \rightarrow 2A(aq) + 2B(aq)}$$

A $\frac{2x}{3}$

B x

C $\frac{3x}{2}$

D $2x$

1.2 A closed system is one in which:

A there is no change in temperature.
B there is an exchange of matter with the environment.
C matter is not exchanged with the environment.
D a stress is continually applied.

1.3 A system is at chemical equilibrium. Which of the following will change as the temperature of the equilibrium mixture is changed?

I K_c
II Total mass of reactants and products
III Rate of forward reaction

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

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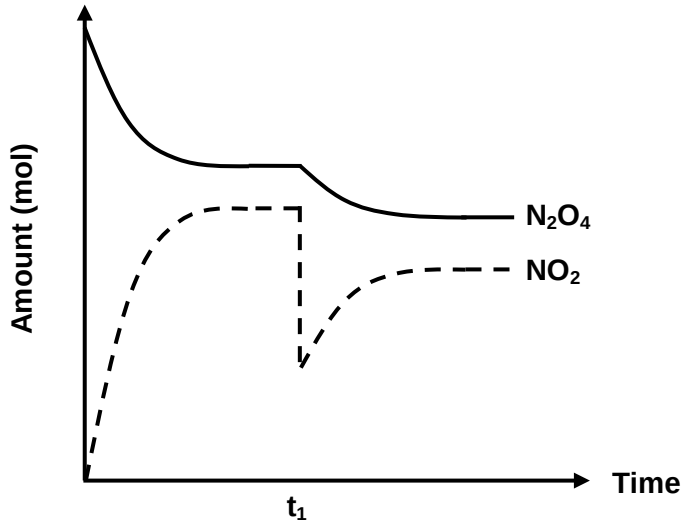
1.4 Consider the balanced chemical equation below and the graph of amount vs time that follows.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H > 0$$



Which one of the following stresses occurred at time t_1?

A NO_2 was removed
B N_2O_4 was removed
C The temperature was decreased
D The pressure was increased

1.5 Which one of the following represents the expression for the acid ionisation constant (K_a) for nitrous acid, HNO_2?

A $$K_a = \frac{\left[NO_2^-\right]\left[H_3O^+\right]}{\left[HNO_2\right]\left[H_2O\right]}$$

B $$K_a = \frac{\left[NO_2^-\right]\left[H_3O^+\right]}{\left[HNO_2\right]}$$

C $$K_a = \frac{\left[HNO_2\right]\left[H_2O\right]}{\left[NO_2^-\right]\left[H_3O^+\right]}$$

D $$K_a = \frac{\left[HNO_2\right]}{\left[NO_2^-\right]\left[H_3O^+\right]}$$

1.6 Which one of the following cells is used to manufacture chlorine gas in industry?

A Membrane cell
B Hall-Héroult cell
C Electrorefining cell
D Electroplating cell

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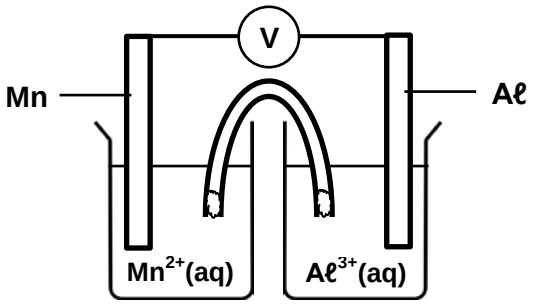
1.7 A galvanic cell is set up as shown below, with ONE of the electrolyte solutions having a non-standard concentration. All other conditions are standard. The initial cell emf is found to be 0,55 V.



Which one of the following shows the correct **anode** for this cell and the non-standard **concentration** used in the corresponding electrolyte?

	Anode	**Concentration of electrolyte**
A	Aℓ	Less than 1 mol·dm^{-3} $Aℓ^{3+}$(aq)
B	Aℓ	More than 1 mol·dm^{-3} $Aℓ^{3+}$(aq)
C	Mn	Less than 1 mol·dm^{-3} Mn^{2+} (aq)
D	Mn	More than 1 mol·dm^{-3} Mn^{2+}(aq)

1.8 Which one of the following molecular formulae represents an alkene?

A $C_{15}H_{32}$
B $C_{15}H_{28}$
C $C_{21}H_{44}$
D $C_{18}H_{36}$

1.9 Which one of the following reactions will NOT take place with an alkene?

A Hydrohalogenation
B Combustion
C Hydrogenation
D Dehydration

1.10 Which one of the following organic compounds has the LOWEST viscosity?

A heptane
B heptan−1−ol
C 2,2−dimethylpentane
D heptanoic acid

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QUESTION 2

2.1 Use only substances from the list below when answering Questions 2.1.1 to 2.1.8. The phase indicators (state symbols) represent the physical state of each of the substances at room temperature.

$SiO_2(s)$	**$NH_3(g)$**	**$H_2O(\ell)$**	**KBr(s)**	**$C_6H_{12}(\ell)$**
Kr(g)	**Pt(s)**	**$PH_3(g)$**	**$NH_4C\ell(aq)$**	**$I_2(s)$**

From the list select ONE: (Only write down the question number and the formula of the substance next to it. Substances may be used more than once or not at all.)

2.1.1 Substance that has a giant covalent network structure. (1)

2.1.2 **Compound** with pure covalent bonds. (1)

2.1.3 Substance that has non-polar molecules, despite the presence of polar covalent bonds within the molecules. (1)

2.1.4 Substance that exists as individual atoms, which interact through London forces only. (1)

2.1.5 Substance that exists in a giant ionic lattice. (1)

2.1.6 Slightly acidic salt. (1)

2.1.7 Substance that can conduct electricity in both solid and liquid phases. (1)

2.1.8 Substance that can undergo oxidation to form oxygen gas. (1)

2.2 2.2.1 Define *intermolecular force*. (2)

2.2.2 At room temperature, I_2 is a solid, whereas H_2O is a liquid. Explain this difference in phase, with reference to the intermolecular forces present in each substance. (5)

2.3 KBr is very soluble in H_2O, but it is insoluble in C_6H_{12}.

2.3.1 Define the term *solute*. (2)

2.3.2 NAME the **solute** in a solution of KBr in H_2O. (1)

2.3.3 Identify the predominant intermolecular force that occurs between the particles of KBr and the particles of H_2O in an aqueous solution of KBr. (2)

2.3.4 In order for KBr to dissolve in C_6H_{12}, the solvent particles must surround the solute particles and be able to dissociate the solute particles. Explain briefly why C_6H_{12} is unable to do this, and hence why KBr(s) is insoluble in C_6H_{12}. (2)

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QUESTION 3

Mbali investigates the rate of the reaction between solid lithium metal and dilute hydrochloric acid. The lithium remains a single lump of solid **until completely consumed** (lithium is the limiting reagent). The reaction is represented by the balanced chemical equation below:

$$2Li(s) + 2HC\ell(aq) \rightarrow 2LiC\ell(aq) + H_2(g) \quad \Delta H < 0$$

Mbali uses a pH meter to monitor the increase in pH of the solution over time. From these pH values, Mbali calculates the concentration of HCℓ at each time, arriving at the following table of results:

Time (s)	pH	[HCℓ] ($\times 10^{-4}$ mol·dm^{-3})
0	2,456	35
0,5	2,509	31
1,0	2,638	23
1,5	2,854	14
2,0	3,097	8
2,5	3,301	5
3,0	3,523	3
4,0	3,824	1,5
5,0	4,301	0,5
6,0	4,301	0,5

3.1 Explain briefly why the pH increases over time. (2)

3.2 The reaction rate initially **increases** (in the first second) and then **decreases** thereafter.

3.2.1 Define *heat of reaction (ΔH)*. (2)

3.2.2 Hence, describe briefly why the reaction rate would increase during the first second. (2)

3.2.3 With reference to the solid lithium, use the collision theory to explain why the reaction rate decreases after the first second. (3)

3.3 A graph showing the relationship between the concentration of HCℓ and time has been partially plotted on the axes provided on your ANSWER SHEET. Complete this graph by supplying ALL of the missing information and draw a best fit curve through the data. (5)

3.4 Use your graph to predict the concentration of H_3O^+ at 3,5 s. (2)

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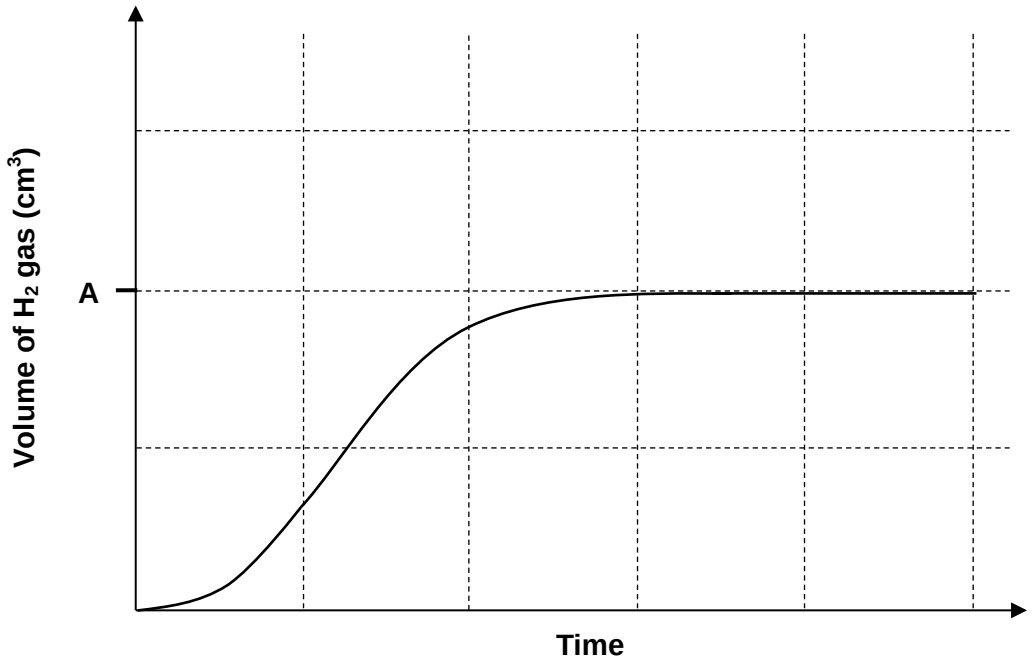
3.5 Mbali now finds a gas syringe and collects the hydrogen gas produced over time in three new experiments. She changes various conditions in each experiment, as shown in the table below.

Experiment	**Temperature (°C)**	**Initial concentration of acid ($mol \cdot dm^{-3}$)**	**Mass of lithium (g)**
1	10	0,1	1,8
2	10	0,2	1,8
3	5	0,1	0,9

Note that in each experiment:

- The same volume of acid is used.
- A single lump of lithium is used.
- The lithium is completely covered by the acid.
- The lithium is always the limiting reagent.

Mbali plots the volume of H_2 gas produced over time and produces the following graph for **Experiment 1**:



3.5.1 Determine the volume, **A**, of H_2 produced in **Experiment 1** using units of cm^3. For this calculation assume the H_2 is collected at STP. (5)

3.5.2 The graph above is provided on your ANSWER SHEET. On these axes, draw the graph that results for **Experiment 2**. (2)

3.5.3 The graph above is provided on your ANSWER SHEET. On these axes, draw the graph that results for **Experiment 3**. (2)

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QUESTION 4

Ozone gas decomposes to oxygen gas according to the following balanced chemical equation:

$$2O_3(g) \rightleftharpoons 3O_2(g)$$

4.1 State *Le Châtelier's principle*. (2)

4.2 Use Le Châtelier's principle to explain how an increase in pressure would affect the equilibrium amount of ozone. (4)

4.3 An increase in temperature results in a decrease in the amount of oxygen.

4.3.1 Which reaction has been favoured by this increase in temperature? State only **FORWARD** or **REVERSE**. (1)

4.3.2 Classify the forward reaction as **ENDOTHERMIC** or **EXOTHERMIC**. (2)

4.3.3 Hence, state what will happen to the value of the equilibrium constant. State only **INCREASE**, **DECREASE**, or **REMAIN THE SAME**. (2)

4.4 Fully explain how the addition of a suitable catalyst will affect the equilibrium amount of oxygen. (3)

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Ozone can be involved in many interesting reactions. One such reaction is the reversible reaction with nitrogen oxide (NO), as shown below:

$$\mathbf{O_3(g) + NO(g) \rightleftharpoons O_2(g) + NO_2(g)} \qquad \mathbf{\Delta H < 0}$$
BROWN

Note that O_3, NO, and O_2 are all **colourless** gases, whereas NO_2 is a **brown** gas.

4.5 A mixture of the following composition was **initially** prepared in a 2 dm^3 sealed container:

$[O_3] = 0{,}6\ mol{\cdot}dm^{-3}$ **$[NO] = 0{,}9\ mol{\cdot}dm^{-3}$**
$[O_2] = 0{,}73\ mol{\cdot}dm^{-3}$ **$[NO_2] = 0{,}55\ mol{\cdot}dm^{-3}$**

The mixture was then heated to 1 500 K. Once equilibrium was established, the concentration of NO was found to be 0,36 $mol{\cdot}dm^{-3}$. The expression used to calculate the equilibrium constant is given below:

$$K_c = \frac{[O_2][NO_2]}{[O_3][NO]}$$

Use this equation and the information given to calculate the value of the equilibrium constant at 1 500 K. (5)

4.6 For each of the following, state only **INCREASE**, **DECREASE**, or **NO EFFECT**.

4.6.1 How will the addition of more NO gas affect the **yield of NO_2** when equilibrium is re-established? (2)

4.6.2 How will a decrease in pressure affect the **number of moles of O_3** when equilibrium is re-established? (2)

4.6.3 How will an increase in temperature **initially** affect the **rate of the forward reaction**? (2)

4.6.4 How will the addition of O_2 (at constant volume) affect the **intensity of the brown colour** of the equilibrium mixture? (2)
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QUESTION 5

Ella makes up 250 cm^3 of an aqueous strontium hydroxide, $Sr(OH)_2$, solution of concentration 0,1 $mol \cdot dm^{-3}$ at 25 °C. At this concentration, $Sr(OH)_2$ can be considered a strong base.

5.1 5.1.1 Define a *base* in terms of the Lowry-Brønsted model. (1)

5.1.2 Define a *strong base*. (2)

5.1.3 Determine the mass of strontium hydroxide needed to make up the solution. (4)

5.1.4 What is the concentration of hydroxide ions in the solution? (2)

5.1.5 Hence, calculate the concentration of hydronium ions in the solution. (3)

5.2 The 0,1 $mol \cdot dm^{-3}$ strontium hydroxide solution is used to determine the concentration of a phosphoric acid (H_3PO_4) solution. Ella uses the following equipment:

- Burette
- Pipette
- Erlenmeyer (conical) flask
- Phenolphthalein indicator
- White tile

10 cm^3 of phosphoric acid of concentration 0,17 $mol \cdot dm^{-3}$ is pipetted into the Erlenmeyer flask, and a few drops of phenolphthalein indicator are added. The strontium hydroxide solution (concentration 0,1 $mol \cdot dm^{-3}$) is added until the neutralisation point is reached.

5.2.1 The white tile is placed under the Erlenmeyer flask during the titration. Give a reason why the white tile would be used in this way. (1)

5.2.2 Write the formula for strontium phosphate, the salt produced in this reaction. (2)

5.2.3 Write a **balanced** chemical equation for the neutralisation reaction between strontium hydroxide and phosphoric acid. (3)

5.2.4 Calculate the amount (in moles) of phosphoric acid added to the Erlenmeyer flask. Round off your answer to **4 decimal places**. (3)

5.2.5 Define *neutralisation or equivalence point*. (2)

5.2.6 Determine the volume of strontium hydroxide solution that will be added using the burette in order to reach the neutralisation point. Give your answer in **scientific notation**. (3)

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5.3 Phenolphthalein indicator can be represented using the general formula HIn. It ionises in water according to the following reaction equation:

$$\underset{\text{COLOURLESS}}{HIn(aq)} + H_2O(\ell) \rightleftharpoons \underset{\text{PINK}}{In^-(aq)} + H_3O^+(aq)$$

The protonated form of phenolphthalein is **colourless** and the de-protonated (ionised) form is **pink**.

5.3.1 Classify phenolphthalein as either an **ACID** or a **BASE**. (1)

5.3.2 Is phenolphthalein **WEAK** or **STRONG**? (1)

5.3.3 What colour would phenolphthalein be in an acidic solution? (1)

5.3.4 With reference to Le Châtelier's principle, explain why phenolphthalein would be this colour in acid. (4)

[33]

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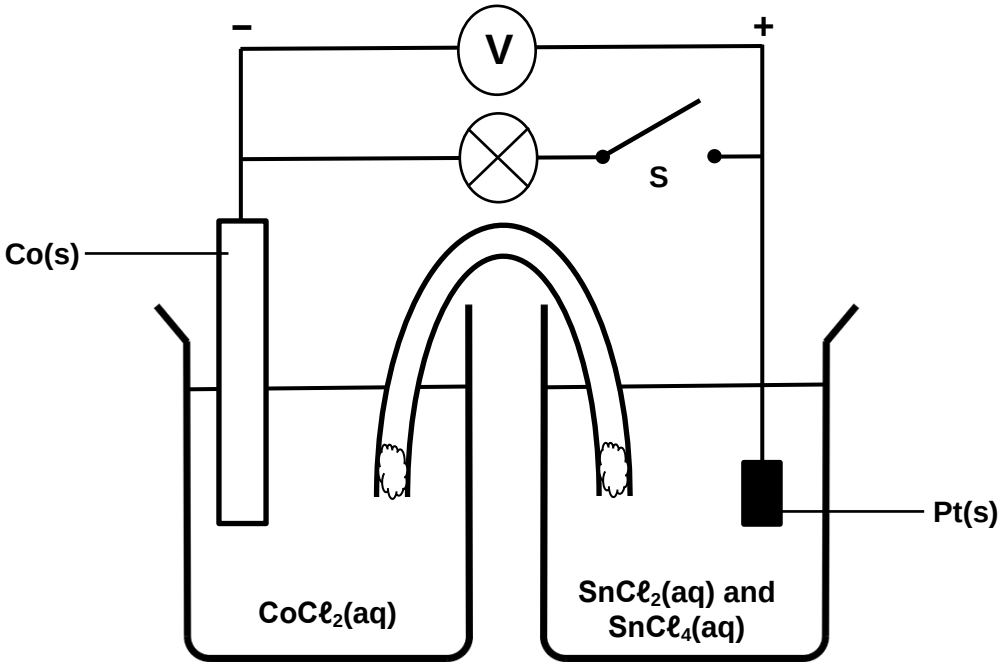
QUESTION 6

A galvanic cell is set up under standard conditions using a cobalt (negative) electrode and an inert platinum (positive) electrode, as shown below. The cobalt electrode is immersed into a solution of **pink** cobalt(II) chloride, $CoC\ell_2(aq)$, and the platinum electrode is immersed into a solution of a mixture of tin(II) chloride, $SnC\ell_2(aq)$, and tin(IV) chloride, $SnC\ell_4(aq)$. A very high resistance voltmeter **V** and low resistance bulb are connected in parallel together with a switch **S**, as shown.



6.1 Identify the cathode. (2)

6.2 Calculate the initial reading on the voltmeter under standard conditions. (3)

6.3 State TWO functions of the salt bridge. (2)

6.4 Write down the cell notation for this cell, including phases. Standard conditions need not be shown. (3)

6.5 Switch S is now closed for a certain period of time, causing the bulb to draw a current. The average current drawn is 4,43 A, resulting in the change in mass of the cobalt electrode to be 8,85 g.

6.5.1 Write down the oxidation half-reaction that occurs. (2)

6.5.2 How would the mass of the cobalt electrode change? State only **INCREASE** or **DECREASE**. (1)

6.5.3 Calculate the change in moles of the cobalt electrode. (2)

6.5.4 The change in mass of the cobalt electrode is due to the transfer of 28 950 C of charge through the circuit. Determine how long it would take for this change in mass to occur. (3)

6.5.5 Suggest ONE change that could be made to the construction of this cell that would increase the maximum current that it can provide. (1)

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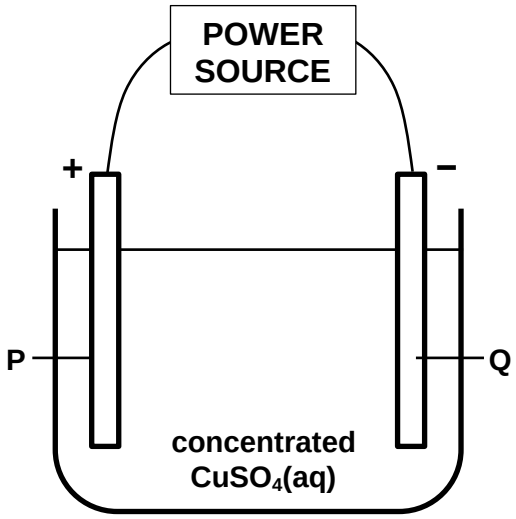
QUESTION 7

The conductivity of copper is drastically affected by the presence of impurities, so it is important to produce very pure copper when used as a conductor.

Impure (blister) copper is purified industrially in an electrorefining process, using a cell as shown in the simple diagram below. The blister copper is electrode **P**.



7.1 Identify the TYPE of cell illustrated above. (1)

7.2 Define *anode*. (1)

7.3 Identify the anode in this cell. Write down only **P** or **Q**. (1)

7.4 Electrode **Q** can be made from graphite. Suggest why graphite is NOT used. (2)

7.5 Identify the material that electrode **Q** should be made from. (1)

7.6 Sulfuric acid is often added to the electrolyte solution. Suggest ONE reason for this addition of sulfuric acid. (1)

7.7 Write down the reduction half-reaction that occurs in this cell. (2)

7.8 A 33 kg blister copper electrode is completely consumed. It is found that only 32,55 kg of pure copper is deposited onto the cathode.

7.8.1 Zinc (Zn) is one of the impurities found in the blister copper electrode. Explain fully why the presence of zinc does not influence the quality of the copper refined. (3)

7.8.2 Gold (Au) is one of the impurities found in the blister copper electrode. Briefly describe what happens to the gold in this electrode. (2)

7.8.3 Calculate the percentage of the blister copper electrode that is pure copper. (3)

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7.9 On a small scale, pure copper metal may alternatively be produced from copper(II) sulfate through the use of a metal such as zinc, as shown in the chemical equation below:

$$\mathbf{CuSO_4(aq) + Zn(s) \rightarrow Cu(s) + ZnSO_4(aq)}$$

7.9.1 Write down the SYMBOL of the reducing agent in this reaction. (1)

7.9.2 Write down the SYMBOL of a metal other than Zn that would also be able to reduce Cu^{2+} to Cu metal. (1)

7.9.3 Explain the answer from Question 7.9.2, with reference to the reducing ability of the metals. (2)

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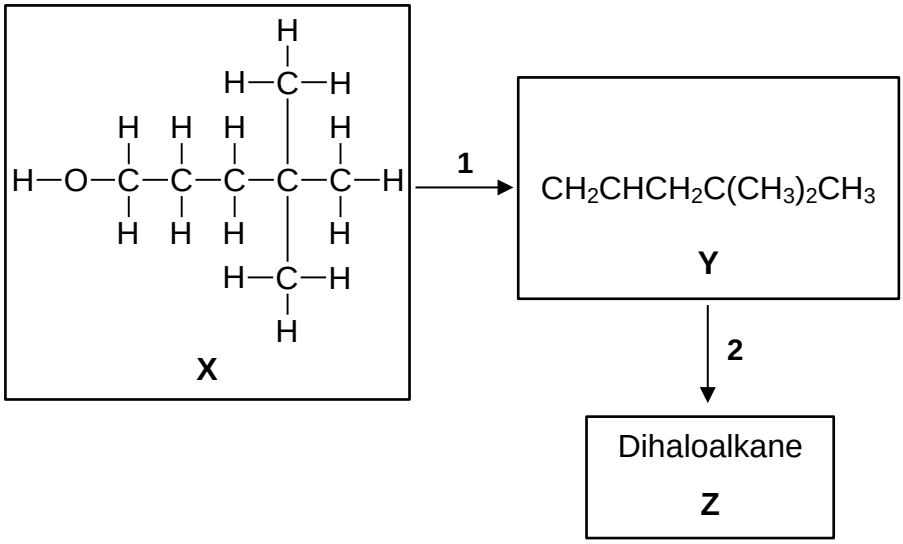
QUESTION 8 ORGANIC CHEMISTRY

The following sequence of reactions shows the production of compound **Z**, a DIHALOALKANE, from compound **X** (a branched alcohol) using organic reactions **1** and **2**.



The following conditions were used for each reaction:
- Reaction **1**: hot, concentrated sulfuric acid
- Reaction **2**: Br_2

8.1 8.1.1 Define *functional group*. (2)

8.1.2 NAME the functional group of compound **X**. (1)

8.1.3 Write down the IUPAC name of compound **X**. (4)

8.2 8.2.1 Define *homologous series*. (2)

8.2.2 Identify the homologous series of compound **Y**. (1)

8.2.3 Draw the structural formula of compound **Y**. (2)

8.3 8.3.1 NAME the specific type of addition reaction represented by reaction **2**. (1)

8.3.2 Using condensed-structural formulae, write down the chemical equation for reaction **2**. (3)

8.4 8.4.1 Identify the TYPE of reaction represented by reaction **1**. (1)

8.4.2 NAME the homologous series of the organic product that would be produced if compound **X** were now treated with a carboxylic acid in the presence of hot, concentrated sulfuric acid. (2)

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8.5 Compound **Z** may also be formed from an alkane. Using structural formulae for organic compounds, write a balanced chemical equation for this reaction. (4)

8.6 Using molecular formulae, write a balanced chemical equation for the complete combustion of compound **X**. (4)

8.7 Draw the condensed-structural formula of an UNBRANCHED, CHAIN isomer of compound **Y**. (2)

8.8 Compound **Y** is now treated with hydrogen gas in the presence of a hot nickel catalyst.

8.8.1 Identify the TYPE of reaction that occurs. (1)

8.8.2 NAME the homologous series of the organic product formed. (2)

8.8.3 What is the purpose of the nickel catalyst? (1)

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Total: 200 marks

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