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KINGSWOOD COLLEGE

PHYSICAL SCIENCES

PAPER 2

GRADE 12

September 2020

Examiner: G. Makoni

Moderator: D. Price

Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
 - a question paper with 15 pages, 14 printed, page 14 is blank
 - an answer sheet for question 1 printed on page 13 and for question 3.3 on page 15.
 - A 3 page coloured formula and data sheet is provided separatelyMake sure that your question paper is complete before starting.
2. Write your full name clearly on your answer booklets.
3. There are 9 questions.
4. Answer **all** the questions in the exam booklets provided. Begin each question on a new page and leave at least 1 line between each part of a question
5. Use the data and formulae whenever necessary.
6. Read the questions carefully.
7. Aluminium and chlorine are written as Al and Cl respectively in chemical equations.

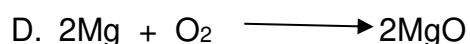
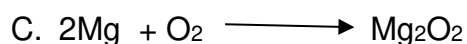
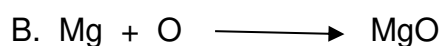
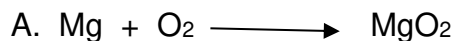
We acknowledge use of papers from various other schools and IEB and we are grateful for the generosity.

DO NOT TURN THIS PAGE OVER UNTIL THE INVIGILATOR TELLS YOU TO

Question 1

For each of the following multiple choice questions choose the letter which corresponds to the best answer and make a cross over the letter (A-D) of your choice on provided answer sheet on page 13.

1.1 Which of the following equations is balanced correctly and is chemically correct?



[2]

1.2 *Concentration* can be defined as

A. The mass in grams of solute per unit volume of solution

B. The amount of solute per unit volume of solution

C. The amount in kilograms of solute per unit volume of solution

D. The number of moles of solute per m^3 of solvent.

[2]

1.3 When considering the molecule of carbon dioxide which statements below are correct?

	Intramolecular Bond	Intermolecular Force
A	Polar covalent bond	Dipole – dipole interactions
B	Non- polar covalent bond	Dipole – dipole interactions
C	Polar covalent bond	Induced dipole – dipole interactions
D	Polar covalent bond	Van der Waals forces

[2]

1.4 Endothermic reactions can be viewed as reactions in which

A. A reaction in which chemical potential energy is converted to thermal energy

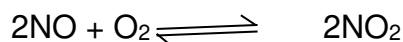
B. A reaction in which temperature decreases to a minimum then rises back to room temperature.

C. A reaction in which energy needed to break existing bonds is less than energy needed to form new bonds.

D. A reaction in which $\Delta H \leq 0$

[2]

1.5 In the reaction:



NO is a colourless gas whereas NO₂ is a brown gas. Which statement about this reaction is **not** true?

- A. The yield of the reaction will increase as the pressure is increased.
- B. The equilibrium mixture will turn colourless at high pressures
- C. More NO₂ is produced when O₂ is added to the mixture
- D. Addition of a catalyst does not affect the position of equilibrium. [2]

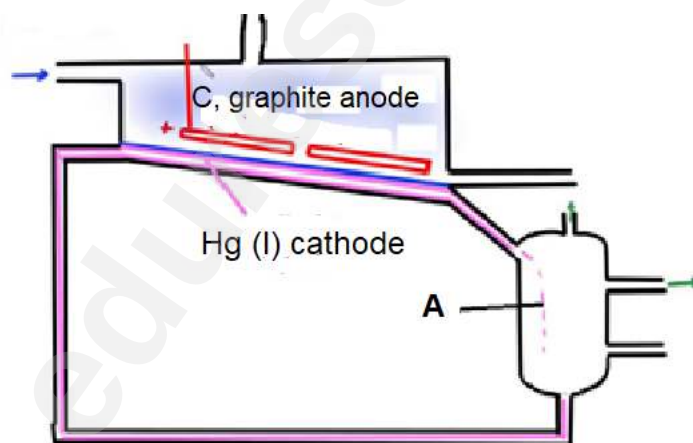
1.6 *Dissociation* can be defined as

- A. The splitting of molecules into ions
- B. The splitting of an ionic compound into ions
- C. The process in which an acid produces hydronium ions in solution
- D. All of the above answers are correct [2]

1.7 The aqueous solution with the highest conductivity is

- A 0,1 mol·dm⁻³ HF
- B 0,2 mol·dm⁻³ HCl
- C 0,3 mol·dm⁻³ NH₄OH
- D 0,2 mol·dm⁻³ H₃PO₄ [2]

1.8 The cell below is a mercury cathode cell used during the chlor-alkali industries:



The reaction occurring in A is

- A. $2\text{Cl}^- \longrightarrow \text{Cl}_2 + 2\text{e}^-$
- B. $2\text{H}_2\text{O} + 2\text{e}^- \longrightarrow \text{H}_2 + 2\text{OH}^-$
- C. $2\text{NaCl} + 2\text{H}_2\text{O} \longrightarrow 2\text{NaOH} + \text{H}_2 + \text{Cl}_2$
- D. $2\text{Na} + 2\text{H}_2\text{O} \longrightarrow 2\text{NaOH} + \text{H}_2$ [2]

- 1.9 Consider the list of metals below. Identify the metal that will be able to reduce $\text{Cd}^{2+}(\text{aq})$ to $\text{Cd}(\text{s})$ but which will not reduce $\text{Mn}^{2+}(\text{aq})$ to $\text{Mn}(\text{s})$.
- A Zinc
 - B Magnesium
 - C Nickel
 - D Silver
- [2]
- 1.10 Hydrohalogenation reactions could involve
- A the substitution of HBr in an alcohol.
 - B the addition of H_2O to an alkene.
 - C the addition of HC/ to an alkene.
 - D the addition of HI to an alcohol
- [2]

20 marks

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.

$\text{SiO}_2(\text{s})$	$\text{NH}_3(\text{g})$	$\text{H}_2\text{O}(\ell)$	$\text{KBr}(\text{s})$	$\text{C}_6\text{H}_{12}(\ell)$
$\text{Kr}(\text{g})$	$\text{Pt}(\text{s})$	$\text{PH}_3(\text{g})$	$\text{NH}_4\text{Cl}(\text{aq})$	$\text{I}_2(\text{s})$

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.)

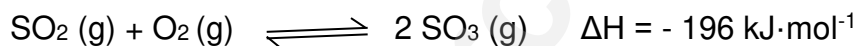
- 2.1.1 A substance that has a giant covalent network structure. [1]
- 2.1.2 A **compound** with pure covalent bonds. [1]
- 2.1.3 A substance that has non-polar molecules, despite the presence of polar covalent bonds within the molecules. [1]
- 2.1.4 A substance that exists as individual atoms, which interact through London forces only. [1]
- 2.1.5 A substance that exists in a giant ionic lattice. [1]
- 2.1.6 A slightly acidic salt. [1]
- 2.1.7 A substance that can conduct electricity in both solid and liquid phases. [1]

- 2.1.8 A 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, I₂ is a solid, whereas H₂O is a liquid. Explain this difference in states [5]
- 2.3 KBr is very soluble in H₂O, but it is insoluble in C₆H₁₂.
- 2.3.1 Define the term *solute*. [2]
- 2.3.2 NAME the **solute** in a solution of KBr in H₂O. [1]
- 2.3.3 Identify **and** illustrate with a sketch diagram that has Couper diagrams the predominant intermolecular force that occurs between the particles of KBr and the particles of H₂O in an aqueous solution of KBr. [5]

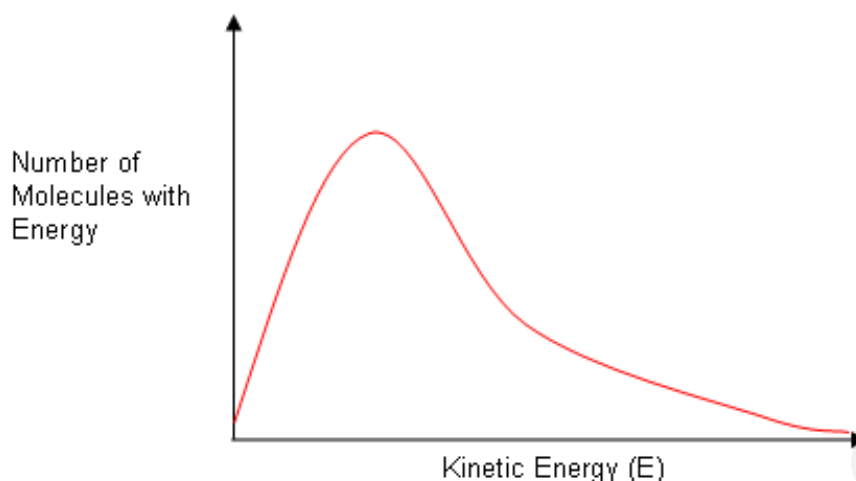
23 marks

Question 3

Consider a reaction that is used in the manufacturing of sulphuric acid.



- 3.1 Define the following terms:
- 3.1.1 *Reaction Rate* [2]
- 3.1.2 *Activated complex* [2]
- 3.2 A pupil incorrectly states that "*a catalyst lowers the activation energy which results in more collisions taking place per second*"
- 3.2.1 Explain how a catalyst lowers the activation energy? [1]
- 3.2.2 Use collision theory to explain why the rate increases when a catalyst is added to the system **and hence** correct the statement from the pupil [5]
- 3.3 Another way of changing the rate of reaction is to decrease the temperature. Sketch on the answer sheet provided on page 15 the new Boltzmann distribution for the sample of gas at a **LOWER** temperature. [3]



- 3.4 Draw a label potential energy profile (reaction profile diagram) for this reaction. Show any values which you may know on the diagram. [5]

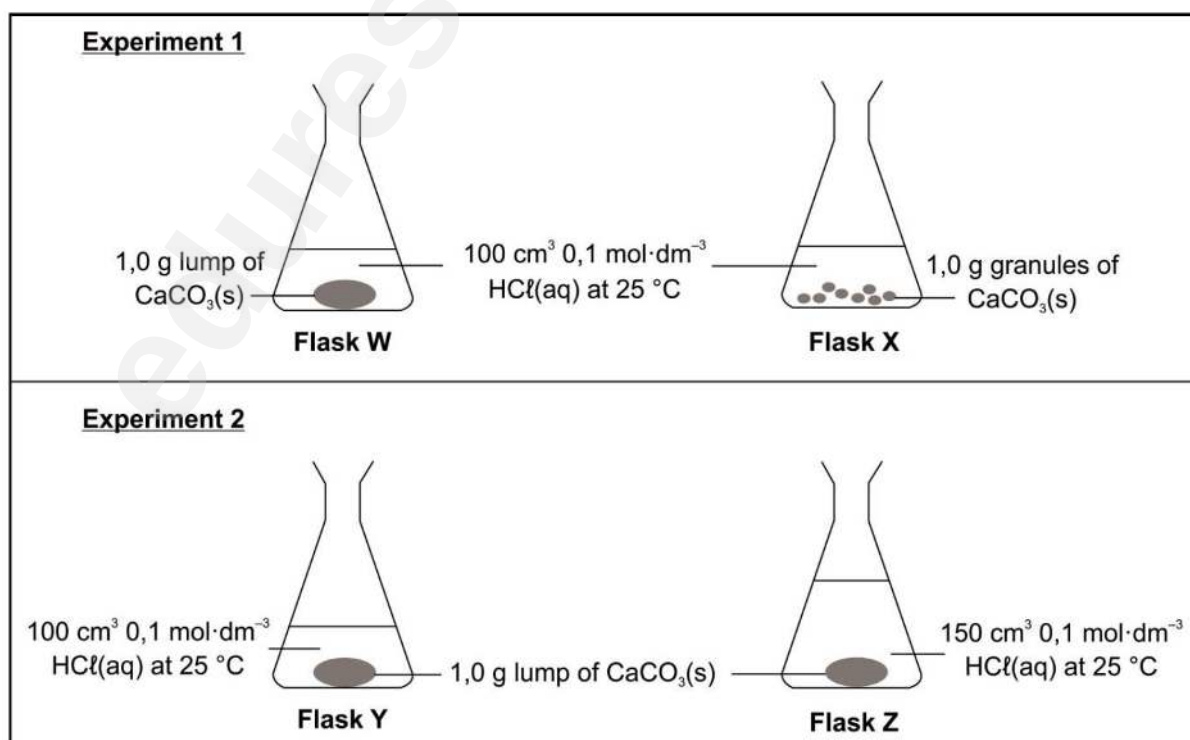
18 marks

Question 4

Two experiments were conducted to investigate the rate of reaction between **EXCESS** calcium carbonate and dilute hydrochloric acid. The balanced chemical equation for the reaction is given below.



The diagrams show the reaction conditions used in each experiment.

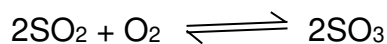


- 4.1 Suggest a suitable method of measuring the rates of the reactions in these experiments. Additional apparatus besides that shown in the diagrams may be used. State what apparatus is required and what reading(s) would need to be taken. [3]
- 4.2 Identify the independent variable in **Experiment 1**. [1]
- 4.3 In **Experiment 1**, in which flask, **W** or **X**, will the reaction rate be faster? Explain fully. [4]
- 4.4 Calculate the volume of CO₂(g) produced at STP in flask **W**. [5]
- 4.5 Consider the reaction conditions given for **Experiment 2**.
- 4.5.1 How will the rate of reaction in flask **Z** compare to that in flask **Y**? Choose from **GREATER THAN Y**, **LESS THAN Y** or **EQUAL TO Y**. [1]
- 4.5.2 It is observed that the total volume of gas produced in flask **Z** is greater than that produced in flask **Y**. Account for this observation. [2]

16 marks

Question 5

- 5.1 Explain what the term “reversible reaction” means. [2]
- 5.2 State *Le Chatelier’s principle*. [2]
- 5.3 Use Le Chatelier’s principle to predict the effect of the following changes on the following reactions:
- 5.3.1 Increasing temperature for the following reaction:
- $$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3. \quad \Delta H = -46\text{kJ}\cdot\text{mol}^{-1} \quad [2]$$
- 5.3.2 Increasing pH for the following reaction that is initially in equilibrium:
- $$\text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O} \rightleftharpoons 2\text{CrO}_4^{2-} + 2\text{H}^+. \quad [3]$$
- 5.3.3 Use the collision theory to explain the changes predicted in 5.3.2. [2]
- 5.3.4 a). Use the information below to sketch a labelled rate versus time graph for the reaction in 5.3.1. Initially there was H₂ and N₂ and no NH₃; equilibrium was achieved at t₁ and at t₂ the temperature of the reaction mixture was decreased. A new equilibrium is achieved at t₃. [3]
- b). How would you expect the K_c value at t₁ to compare with the K_c value at t₃. Explain your answer. [2]
- c). Use your understanding of rates of reaction and Le Chatelier’s principle to explain the shape of your sketch from t₂ to t₃. [3]
- 5.4 The key reaction in the Contact process is:



The reaction is catalysed by V_2O_5 .

At 37 °C, 5 moles of SO_2 and 3 moles of O_2 were mixed in a closed container in the presence of V_2O_5 . The system was allowed to reach equilibrium in a 2.5 dm^3 container. After equilibrium was achieved only 3.4 moles of SO_2 were left in the container.

- 5.4.1 Deduce the concentrations of the equilibrium mixture. [6]
- 5.4.2 Write down an expression of K_c for the reaction. [2]
- 5.4.3 Deduce the value of K_c for this reaction at 37 °C. [2]
- 5.4.4 State the significance of the value of the K_c you obtained in 5.4.3. [1]

30 marks

Question 6

Sulphur dioxide gas, amongst other gases, is released as a pollutant when coal, a fossil fuel, is burned in a power station. This gas is highly soluble and will dissolve easily in atmospheric water to form sulphurous acid (H_2SO_3), a form of acid rain. The acid ionizes in water according to the following equation:



- 6.1 What is the name of the reaction taking place above? [1]
- 6.2 State with a reason the substance acting as the conjugate base [3]
- 6.3 Sulphurous acid is a weak acid.
 - 6.3.1 Define a *weak acid*. [2]
 - 6.3.2 Sulphurous is a dibasic acid, explain with the aid of an equation what you understand from the term dibasic. [4]
- 6.4 Consider a solution of the salt ammonium sulphate $[(\text{NH}_4)_2\text{SO}_4]$
 - 6.4.1 Define a *salt*. [2]
 - 6.4.2 **Name** the acid and base that need to react to produce ammonium sulphate. [2]
 - 6.4.3 Write down the name and chemical formula of the ion which undergoes hydrolysis [2]
 - 6.4.4 With the aid of a hydrolysis equation state whether $(\text{NH}_4)_2\text{SO}_4$ is an acidic, neutral or basic salt. [4]

- 6.5 Matthew finds some sulphuric acid solution in a bottle labelled 'dilute sulphuric acid'. He wants to determine the concentration of the sulphuric acid solution. To do this, he decides to titrate the sulphuric acid against a **standard** potassium hydroxide (KOH) solution of concentration 0.2 mol.dm^{-3} .

6.5.1 Define a *standard solution*? [2]

In the laboratory Izzy makes up a potassium hydroxide solution (KOH) to neutralize the sulphuric acid solution.

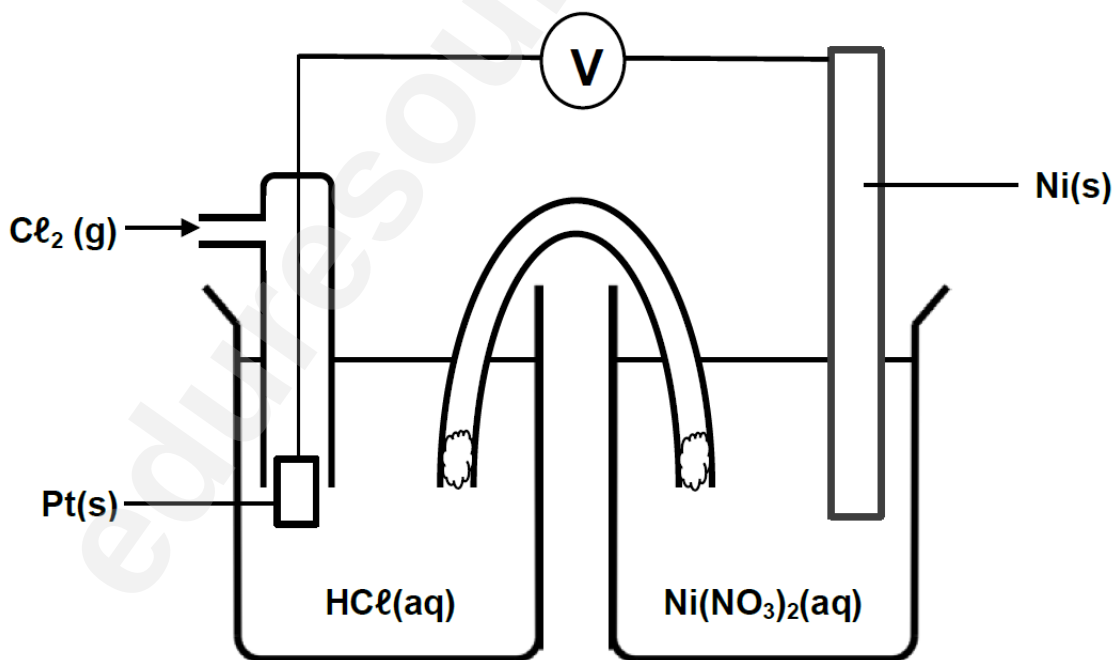
6.5.2 Write a balanced chemical equation for the reaction between H_2SO_4 and KOH. [3]

6.5.3 During the titration he finds that 15 cm^3 of the KOH solution neutralizes 20 cm^3 of the H_2SO_4 solution. Calculate the concentration of the H_2SO_4 solution. (5)

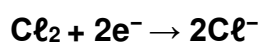
30 marks

Question 7

A galvanic cell is constructed using a standard $\text{Cl}_2|\text{Cl}^-$ half-cell and a standard $\text{Ni}|\text{Ni}^{2+}$ half-cell, as shown in the diagram below. The solution in the nickel half-cell is initially **pale green**.



- 7.1 The reduction half-reaction that occurs in this cell is shown below:



7.1.1 Define *oxidising agent*. [1]

7.1.2 Explain why Cl_2 is reduced instead of Ni^{2+} . [2]

7.2

7.2.1 Define *anode*. [2]

7.2.2 Identify the anode in this cell. [1]

7.3 Identify the positive electrode in this cell. [1]

7.4 Write the cell notation for this cell, **including relevant conditions**. State symbols need not be shown. [5]

7.5 The voltmeter is now replaced with a light bulb so that current flows.

7.5.1 Write down the half-reaction that occurs in the nickel half-cell. [2]

7.5.2 Hence, state TWO changes that will be **observed** in the nickel half-cell after a significant amount of time has passed. [2]

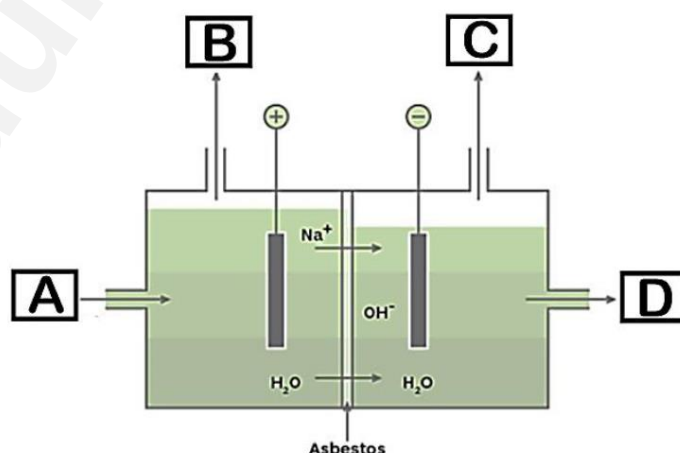
7.5.3 One of the functions of the salt bridge is to maintain electrical neutrality. State ONE other function of the salt bridge. [1]

7.5.4 Use the changes that occur in the **nickel half cell** to explain how the salt bridge maintains electrical neutrality. [2]

7.6 Destiny accidentally drops some concentrated AgNO_3 solution into the chlorine half-cell, causing a white precipitate of AgCl to form. How would this affect the initial cell emf? State only INCREASES, DECREASES or REMAINS THE SAME. [1]

20 marks**Question 8**

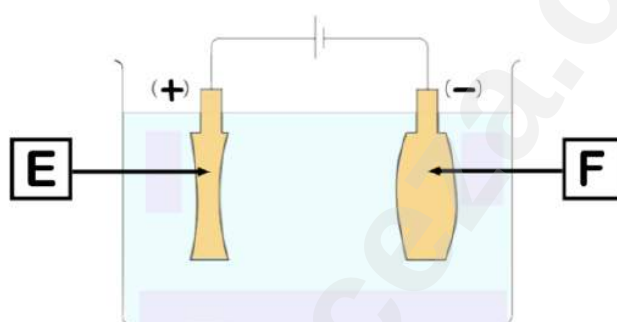
The Kingswood Grade 12s visited a nearby Chlor-alkali factory. Below is schematic diagram of what they found:



8.1 What type of cell did they find at the factory? [1]

- 8.2 Why is the level of solution in the left-hand compartment (half-cell) adjusted to be higher than the level in the right-hand compartment (half-cell)? [2]
- 8.3 Name the substances labelled A, B, and D. [3]
- 8.4 Write the equation for the reaction that takes place at the cathode. [2]
- 8.5 Explain briefly why Na and Cl_2 are not produced on the cathode. [4]
- 8.6 In another type of Chlor-alkali cell, the asbestos is replaced by a cellulose membrane. Explain to the difference this makes to the functioning of the cell. [2]

The Grade 12s also find a copper refinery and see cells set up as shown below:

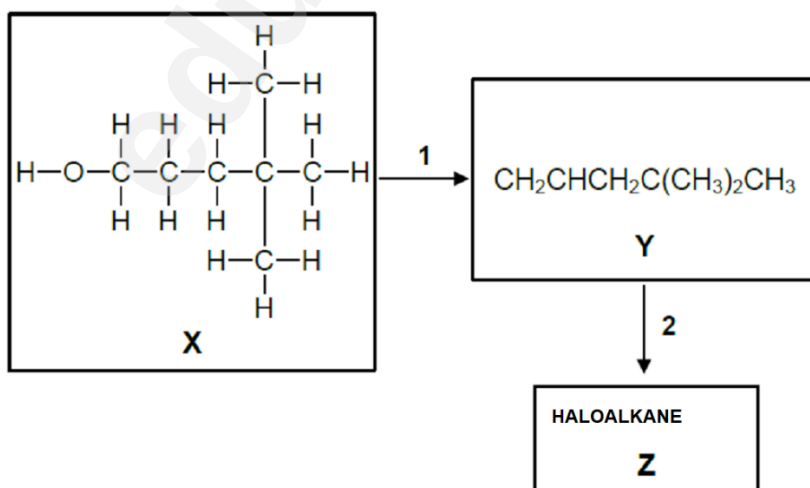


- 8.7 Explain why this is an electrolytic cell. [1]
- 8.8 Label F as either 'pure copper' or 'impure copper'. [1]
- 8.9 Write the equation for the reaction taking place at the anode. [2]

18 marks

Question 9

The following sequence of reactions shows the production of compound Z, a haloalkane, 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: Br₂

9.1

- 9.1.1 Define *functional group*. [2]
- 9.1.2 NAME the functional group of compound X. [1]
- 9.1.3 Write down the IUPAC name of compound X. [3]

9.2

- 9.2.1 Define *homologous series*. [2]
- 9.2.2 Identify the homologous series of compound Y. [1]
- 9.2.3 Draw the full structural formula of compound Y. [3]

9.3

- 9.3.1 NAME the **specific** type of addition reaction represented by reaction 2. [1]
- 9.3.2 Using condensed-structural formulae, write down the chemical equation for reaction 2. [3]

9.4

- 9.4.1 Identify the TYPE of reaction represented by reaction 1. [1]
- 9.4.2 NAME the homologous series of the organic product that would be produced if compound X heated with a carboxylic acid in the presence of concentrated sulfuric acid. [1]

9.5 Using molecular formulae, write a balanced chemical equation for the complete combustion of compound X. [3]

9.6 Write down the condensed-structural formula of an UNBRANCHED, CHAIN isomer of compound Y. [2]

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

- 9.7.1 Identify the TYPE of reaction that occurs. [1]
- 9.7.2 NAME the homologous series of the organic product formed. [1]

25 marks

Name: _____

Answer sheet for question 1

- Put an X over the box which contains the letter which corresponds to the correct answer as shown below.

A	~~B~~	C	D
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- There is only one correct answer for each question.
- Remember to detach this answer sheet and put it in your answer booklet.

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

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Name _____

3.3

