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WOODRIDGE COLLEGE

15 SEPTEMBER 2021

3 HOURS

PHYSICAL SCIENCES: PAPER 2

EXAMINER: Dr C Logie

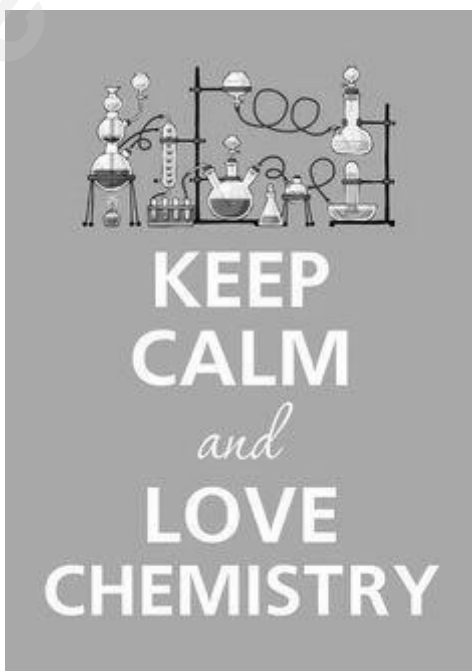
TOTAL = 200 marks

MODERATOR: Mr P Maartens

GRADE 12

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY:

1. This question paper consists of 16 pages with 9 questions, a 2 page answer sheet (pages 17-18) and a data sheet of three pages. Please check that your question paper is complete.
 2. Detach the answer sheet and attach it to the rest of your answers.
 3. Answer ALL the questions.
 4. Number your answers exactly as they appear in the question paper.
 5. It is in your own interest to write legibly and to present your work neatly.
 6. Show all the formulas and equations you use.
 7. Show all calculations and round off answers to 2 decimal places.
 8. All answers should have the correct units.
 9. A non-programmable scientific calculator may be used.
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QUESTION 1 – Multiple Choice

Answer these questions on the ANSWER SHEET provided. Make a cross(X) on the letter of the response which you consider to be the most correct.

- 1.1 Sodium chloride is a liquid at 900°C . How are the particles arranged and how do the particles move in sodium chloride at 900°C ? (2)

	arrangement of particles	motion of particles
A.	regular	vibrate about a fixed point
B.	regular	move randomly
C.	random	vibrate about a fixed point
D.	random	move randomly

- 1.2 Based on the equilibrium constants given, in which of these equilibrium reactions are the products most favoured over the reactants?

- A. $K_{\text{C}} = 0,002$
B. $K_{\text{C}} = 0,0$
C. $K_{\text{C}} = 3,5$
D. $K_{\text{C}} = 6,0 \times 10^{-4}$ (2)

- 1.3 All of the following salts are BASIC in water with the exception of ...

- A. sodium nitrate (NaNO_3)
B. sodium acetate ($\text{CH}_3\text{CO}_2\text{Na}$)
C. sodium phosphate (Na_3PO_4)
D. sodium carbonate (Na_2CO_3) (2)

- 1.4 Which ONE of the following weak acids, each of concentration $0,1 \text{ mol} \cdot \text{dm}^{-3}$, has the lowest pH? (2)

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

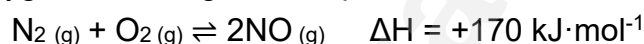
1.5 A strong base is defined as one which

- A. neutralises a strong acid.
 - B. dissociates completely in an aqueous solution.
 - C. ionises completely in an aqueous solution.
 - D. has a pH between 8 and 10
- (2)

1.6 An iron nail is to be electroplated with silver. Which entries in the table are correct? (2)

	Anode	Cathode	Electrolyte
A.	Silver metal	Iron nail	Dilute nitric acid
B.	Iron nail	Silver metal	Aqueous silver nitrate
C.	Iron nail	Silver metal	Dilute nitric acid
D.	Silver metal	Iron nail	Aqueous silver nitrate

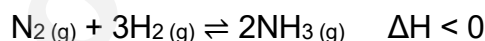
1.7 Nitrogen reacts with oxygen according to the equation:



At equilibrium, which statement is true?

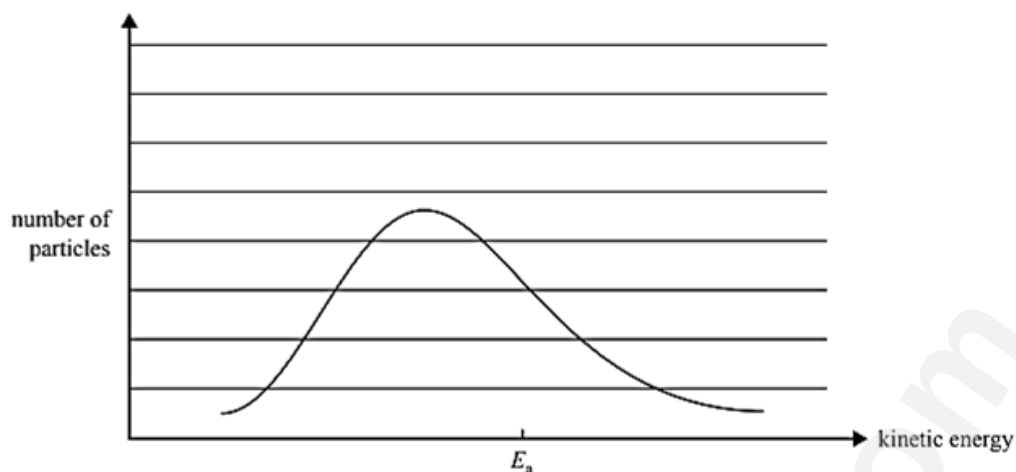
- A. The forward and reverse reactions are taking place at the same rate.
 - B. The forward reaction releases heat energy.
 - C. The reverse reaction is endothermic.
 - D. The equilibrium shifts to the left when the temperature is increased.
- (2)

1.8 Which of the statements is true for the given reaction?



- A. A catalyst increases the number of collisions between the reactants.
 - B. The rate of the forward reaction increases when the temperature increases.
 - C. A catalyst reduces the activation energy of the forward and backward reactions by the same proportion.
 - D. The activation energy of the forward reaction is greater than the activation energy of the reverse reaction.
- (2)

- 1.9 The diagram below represents the Maxwell-Boltzmann distribution of an uncatalysed reaction.



The effect of adding a catalyst could be:

1. the curve flattens to reflect the lower activation energy barrier
2. the curve shifts to the right
3. the Activation Energy (E_a) shifts to the left.

Which of the statements above are correct?

- A. 1 only
B. 1 and 2
C. 2 and 3
D. 3 only

(2)

- 1.10 In a blast furnace, iron is extracted when iron (III) oxide reacts with carbon monoxide according to the following equation: $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$

Which substance is oxidised and which is reduced?

(2)

	oxidised	reduced
A.	CO	Fe_2O_3
B.	CO_2	Fe
C.	Fe	CO
D.	Fe_2O_3	CO_2

[20]

QUESTION 2 – Chemical Bonding

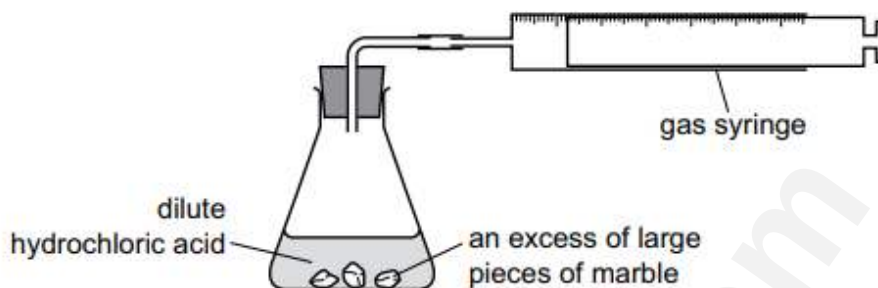
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(Adapted from St Mary's DSG July 2020)

- 2.1 Define the term *ionic bond*. (2)
- 2.2 Give the **formula** of a substance that has an ionic bond. (1)
- 2.3 Name the specific type of **intramolecular** bonds found in:
- 2.3.1 Hydrogen fluoride (2)
- 2.3.2 Fluorine (2)
- 2.4 Name the specific type of **intermolecular** forces found between molecules of:
- 2.4.1 Hydrogen fluoride (2)
- 2.4.2 Fluorine (2)
- 2.5 Explain why the boiling point of hydrogen fluoride (19,5 °C) is higher than the boiling point of fluorine (-188 °C). (2)
- 2.6 Silicon dioxide has a very high melting point of 1610 °C. With reference to the structure and relevant bonds, explain why silicon dioxide has such a high melting point. (4)

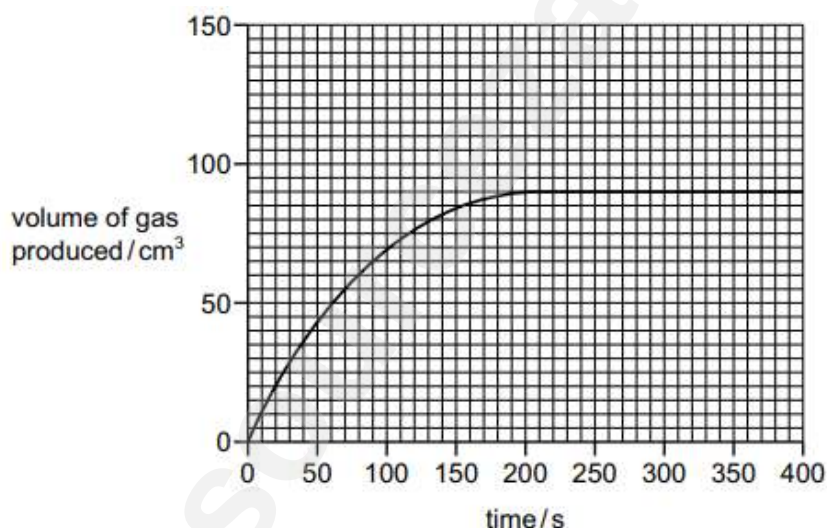
[17]

- 3.1 A pupil investigates the progress of the reaction between dilute hydrochloric acid, HCl , and an excess of large pieces of marble, CaCO_3 , using the apparatus shown below.



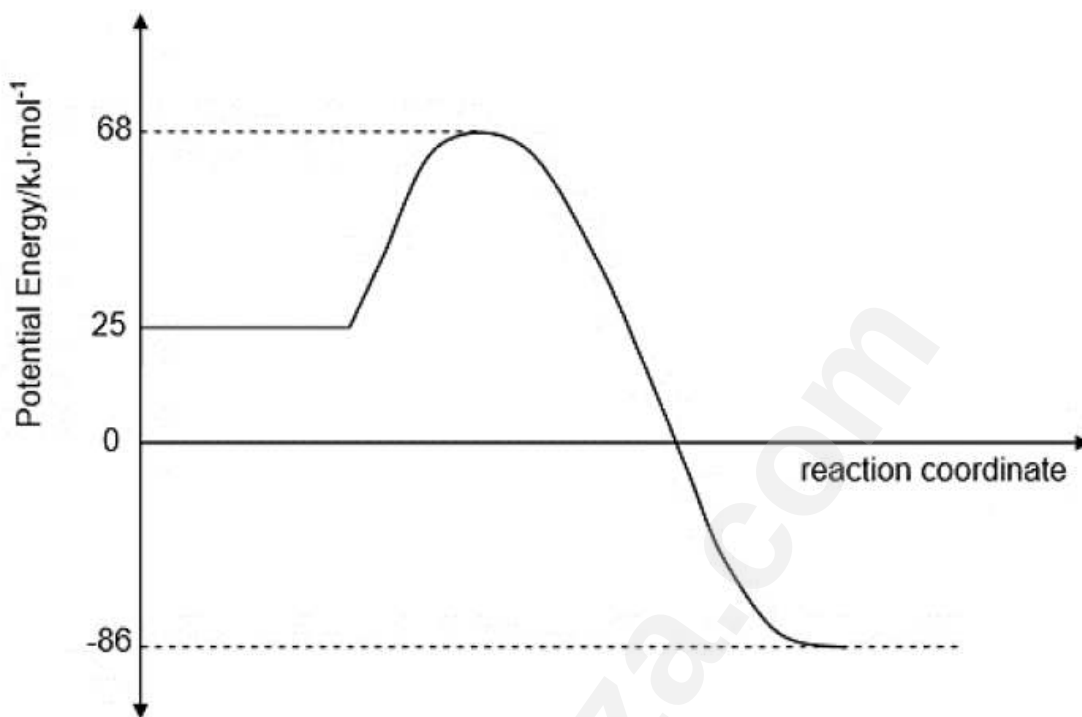
A graph of the volume of gas produced against time is shown below and reproduced on the answer sheet.

A plot of the volume of gas collected vs time for the reaction of CaCO_3 with HCl



- 3.1.1 State how the shape of the graph shows that the rate of reaction decreases as the reaction progresses. (1)
- 3.1.2 Suggest why the rate of reaction decreases as the reaction progresses. (1)
- 3.1.3 At what time does the reaction finish? (1)
- 3.1.4 The experiment is repeated using the same mass of smaller pieces of marble. All other conditions are kept the same. Add a line on the graph on the Answer Sheet to show the progress of the reaction using the smaller pieces of marble. (2)
- 3.1.5 The original experiment is repeated at a higher temperature. All other conditions are kept the same. The resulting increase in rate of reaction can be explained in terms of activation energy and Collision Theory.
- 3.1.5.1 Define the term *activation energy*. (2)
- 3.1.5.2 Use the Collision Theory to explain why the rate of a reaction increases when temperature increases. (4)

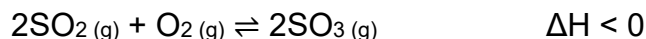
- 3.2 The graph below shows the change in potential energy during the reaction between zinc and sulfuric acid.



- 3.2.1 Is the reaction exothermic or endothermic? (1)
3.2.2 Define the term *heat of reaction*. (2)
3.2.3 Use the graph to calculate:
3.2.3.1 the activation energy for this reaction. (2)
3.2.3.2 the heat of reaction (ΔH) for this reaction. (2)

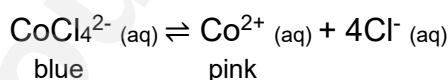
[18]

- 4.1 Sulfur trioxide, SO_3 , is made by the reaction of sulfur dioxide, SO_2 , and oxygen, O_2 , in the presence of a catalyst, according to the equation below.

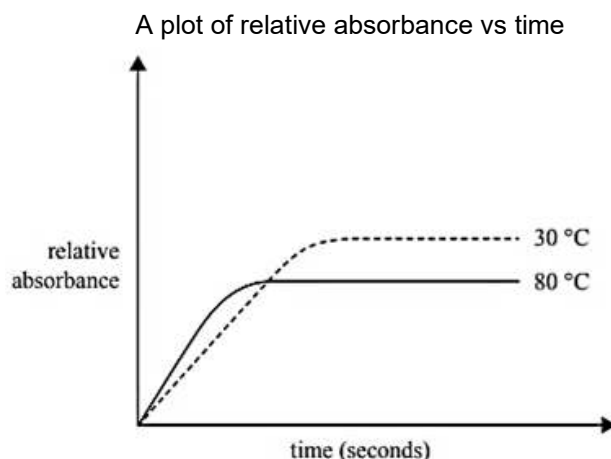


In a closed system in the presence of the catalyst, the reaction quickly achieves equilibrium at 1000 K.

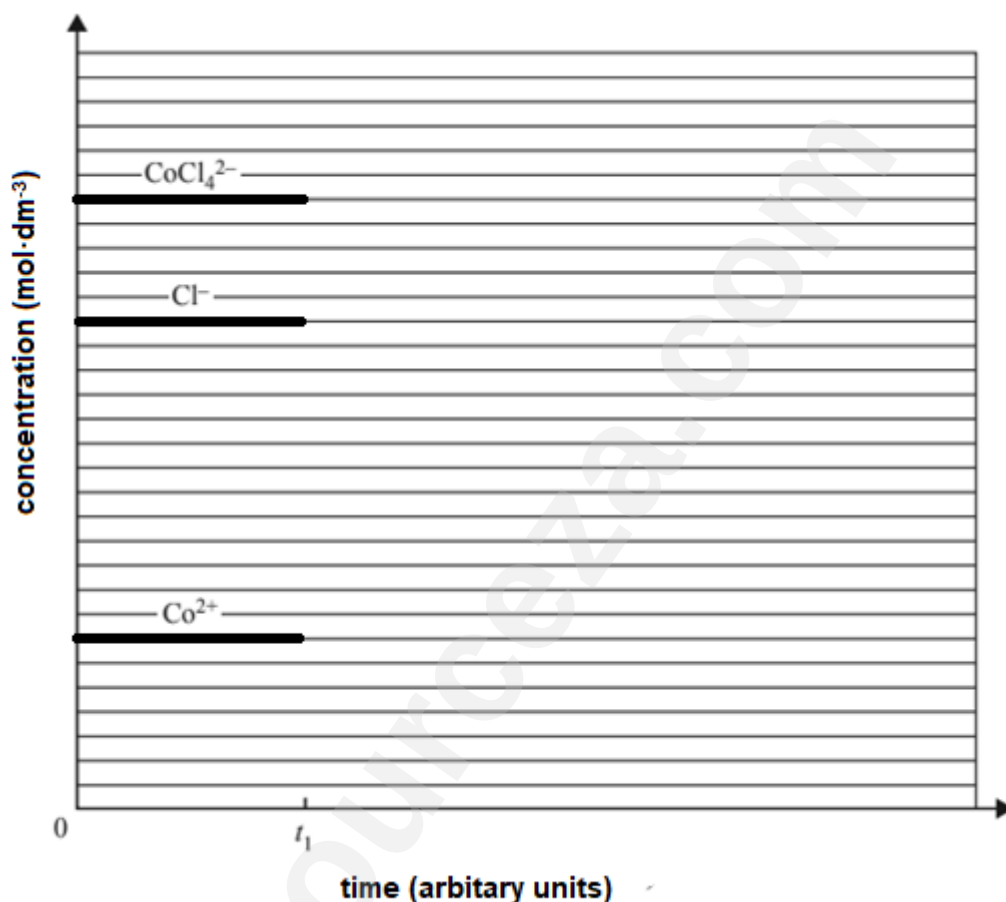
- 4.1.1 Define a *closed system*. (2)
- 4.1.2 State *Le Chatelier's Principle*. (2)
- 4.1.3 Write the K_c expression for this reaction. (2)
- 4.1.4 A mixture of 2,00 mol of $\text{SO}_2(\text{g})$ and 2,00 mol of $\text{O}_2(\text{g})$ was placed in a $4,0 \text{ dm}^3$ evacuated, sealed vessel and kept at 1000 K until equilibrium was reached. At equilibrium, the vessel was found to contain 1,66 mol of $\text{SO}_3(\text{g})$. Calculate the equilibrium constant, K_c , at 1000 K. (7)
- 4.1.5 A manufacturer of SO_3 investigates changes to the reaction conditions used in Question 4.1.4 in order to increase the percentage yield of the product in a closed system, where the volume may be changed, if required. What changes would the manufacturer make to the temperature and volume of the system in order to increase the percentage yield of SO_3 ? Justify your answer. (4)
- 4.2 The cobalt (II) tetrachloride ion, CoCl_4^{2-} , dissociates into the cobalt (II) ion, Co^{2+} , and chloride ions, Cl^- , according to the following equation:



Samples of equal volume of the equilibrium mixture were heated to two temperatures, 30°C and 80°C . The intensity of the pink colour of the Co^{2+} in each sample was recorded every 30 seconds by measuring the absorbance of the solution. The higher the intensity of the pink colour, the higher the absorbance. The results of the experiment are shown in the graph below.



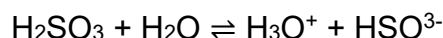
- 4.2.1 State whether the forward reaction is exothermic or endothermic. Using information from the graph, justify your answer. (4)
- 4.2.2 Five drops of silver nitrate, AgNO_3 , solution are added to the equilibrium mixture at time t_1 . The silver nitrate reacts with the chloride ions to form a precipitate of silver chloride, AgCl . A concentration-time sketch graph for this reaction is shown below for the times between zero and t_1 .



On a copy of the graph on the Answer Sheet, continue the graph to show the changes that occur to the system from t_1 until equilibrium is re-established.

(3)
[24]

- 5.1 Sulfur dioxide gas, amongst other gases, is released as a pollutant when coal is burned in a power station. This gas is highly soluble and dissolves easily in atmospheric water to form sulfurous acid (H_2SO_3), a form of acid rain. The acid ionizes in water according to the following equation:

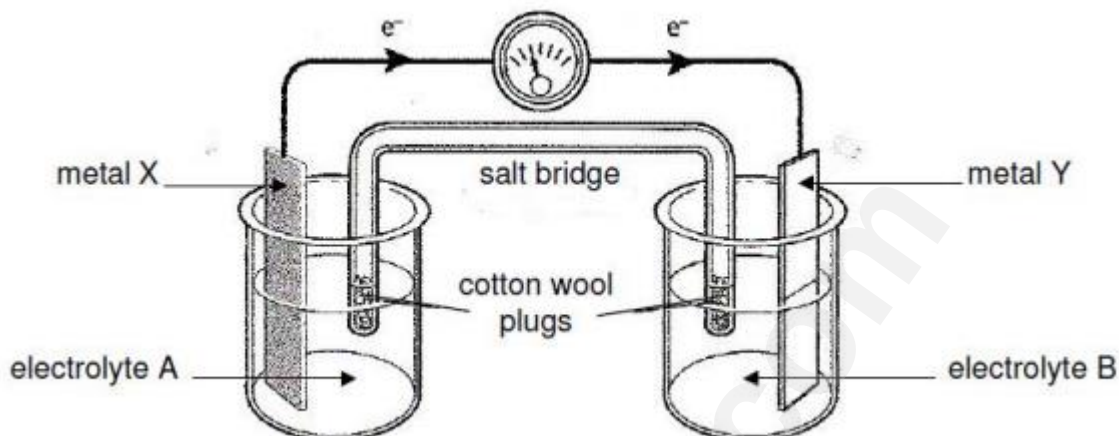


- 5.1.1 What is the name of the reaction taking place above? (1)
- 5.1.2 Identify the conjugate base in the reaction above. (1)
- 5.1.3 Sulfurous acid is a *weak, polyprotic* acid. Define the terms
- 5.1.3.1 *weak acid* (2)
- 5.1.3.2 *polyprotic acid* (2)
- 5.2 Consider a solution of the salt ammonium sulfate, $(\text{NH}_4)_2\text{SO}_4$.
- 5.2.1 Define a *salt*. (2)
- 5.2.2 **Name** the acid and base that need to react to produce ammonium sulfate. (2)
- 5.2.3 Write down the name and chemical formula of the ion that undergoes hydrolysis. (2)
- 5.2.4 With the aid of a hydrolysis equation state whether $(\text{NH}_4)_2\text{SO}_4$ is an acidic, neutral or basic salt. (4)
- 5.3 In the laboratory there is a bottle labelled 'dilute sulfuric acid'. To determine the concentration of the sulfuric acid solution it is titrated against a standard potassium hydroxide (KOH) solution of concentration $0,2 \text{ mol} \cdot \text{dm}^{-3}$.
- 5.3.1 Define the term *standard* solution. (2)
- 5.3.2 What mass of potassium hydroxide is required to make 500 cm^3 of the potassium hydroxide solution? (4)
- 5.3.3 Write a balanced chemical equation for the reaction between H_2SO_4 and KOH. (3)
- 5.3.4 Using the table below, which indicator should be used for the above titration? Give a reason for your choice. (2)

Indicator	More acidic colour	More basic colour	pH range of colour change
Bromothymol blue	Yellow	Blue	6.0 – 7.7
Phenolphthalein	Colourless	Pink	8.3 – 10.0
Methyl orange	Red	Yellow	3.2 – 4.4

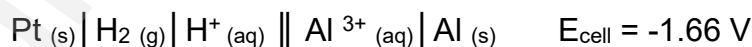
- 5.3.5 It is found that 15 cm^3 of the KOH solution neutralizes 20 cm^3 of the H_2SO_4 solution. Calculate the concentration of the H_2SO_4 solution. (5)
- [32]**

- 6.1 The diagram below shows an electrochemical cell set up under standard conditions using aluminium (Al) and nickel (Ni) electrodes. $\text{AlCl}_3(\text{aq})$ and $\text{NiCl}_2(\text{aq})$ are used as electrolytes, and a solution of sodium nitrate (NaNO_3) is used in the salt bridge.



Answer each of the following questions on this electrochemical cell:

- 6.1.1 Define the term *electrolyte*. (2)
- 6.1.2 Identify:
- 6.1.2.1 Metal X (1)
- 6.1.2.2 Electrolyte B (1)
- 6.1.3 What is the initial concentration of electrolyte B under standard conditions? (1)
- 6.1.4 Write down the half reaction that occurs at the cathode. (2)
- 6.1.5 Write down the **formula** of the ions that move from the salt bridge towards the half-cell that contains metal Y. (1)
- 6.1.6 Calculate the emf of the cell. (3)
- 6.2 The cell notation for another galvanic cell which runs under standard conditions is shown below:



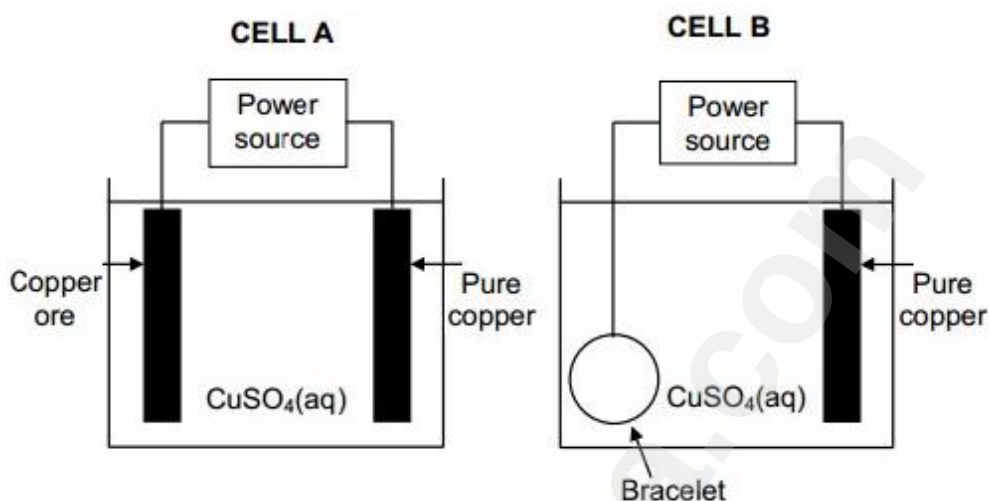
- 6.2.1 Write down the anode half reaction in this cell. (2)
- 6.2.2 Write down the net ionic equation for this cell. (3)
- 6.2.3 If a higher concentration of electrolyte, AlCl_3 , is added to the Al half-cell at the start of the reaction, what will happen to the reading on the voltmeter? Write only INCREASE, DECREASE or REMAINS THE SAME. (1)
- 6.2.4 Explain your answer to Question 6.2.3 (3)

[20]

QUESTION 7 – Electrolytic Cells

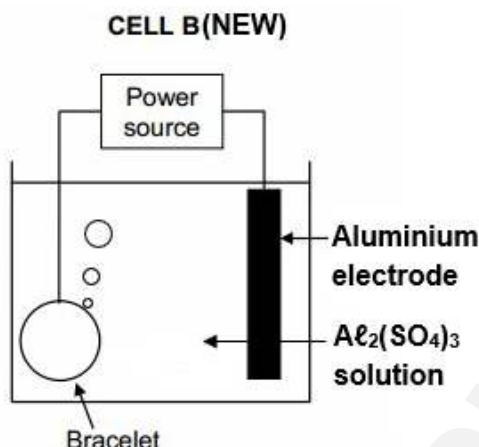
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The simplified diagrams below represent two electrochemical cells, A and B, used in industry. Cell A is used in the purification of copper ore containing silver, gold and platinum impurities. Cell B is used to coat a bracelet with a layer of copper.



- 7.1 Pure copper is used as one of the electrodes in each of the cells above. In which cell (A or B) is the pure copper...
- 7.1.1 the cathode? (1)
- 7.1.2 the anode? (1)
- 7.2 Consider Cell B. Initially the $\text{CuSO}_4(\text{aq})$ has a blue colour. How will the intensity of the blue colour change whilst the cell is functioning? Write down INCREASES, DECREASES or REMAINS THE SAME and then give a reason for your answer. (4)
- 7.3 Write down the half-reaction that takes place at the pure copper electrode in Cell B. (2)
- 7.4 At the bottom of Cell A there is a deposit of metals that form including gold. Explain why this happens? (3)
- 7.5 Calculate the mass of copper in grams that will be deposited on the bracelet if a current of 1,5 A passes through the solution for 15 minutes. (7)

- 7.6 In an attempt to coat the bracelet with aluminium metal instead of copper, the technician uses a solution of aluminium sulfate in the electrolytic cell, as shown below.



When the technician connects the battery though, she notices that there is no shiny plating of aluminium metal appearing on the bracelet. Instead, there is a stream of colourless bubbles forming.

- 7.6.1 Over time, what will be observed at the aluminium electrode? (1)
- 7.6.2 Give the name of the gas being produced at the bracelet. (1)
- 7.6.3 Explain why this gas is produced at the bracelet and not Al(s) as the technician hoped. Refer to the relevant reaction occurring at this electrode in your answer. (3)
- [23]**

QUESTION 8 – Organic Chemistry

- 8.1 The table shows the first four members of a particular homologous series.

Organic Compound	Molecular Formula	Molecular Mass
Methanol	CH_4O	32
Ethanol	$\text{C}_2\text{H}_6\text{O}$	46
Propan-1-ol	$\text{C}_3\text{H}_8\text{O}$	60
Butan-1-ol	$\text{C}_4\text{H}_{10}\text{O}$	?

- 8.1.1 Define the term *homologous series*. (2)
- 8.1.2 Name the **homologous series** to which these compounds belong. (1)
- 8.1.3 Calculate the molecular mass of butan-1-ol. (2)
- 8.1.4 Ethanol can be manufactured from either ethene or glucose.
- 8.1.4.1 Write a balanced equation, using **structural formulae**, for the production of ethanol from ethene. (3)
- 8.1.4.2 Name the **specific type** of reaction in Question 8.1.4.1. (1)
- 8.1.4.3 Give the conditions required for the reaction in Question 8.1.4.1. (1)

8.1.4.4 The fermentation of glucose can be represented by the following equation: $C_6H_{12}O_6 \rightarrow 2C_2H_6O + 2CO_2$
Calculate the maximum mass of ethanol that could be manufactured from 50 kg of glucose. (5)

8.1.5 Ethanol is used as a reactant in the production of ethyl butanoate. In the laboratory a water bath is used as a safety precaution in the production of ethyl butanoate.

8.1.5.1 Use structural formulae to write the chemical equation showing the production of ethyl butanoate. Include all reactants, catalyst/s and products in the chemical equation. (5)

8.1.5.2 A water bath is used because ethanol burns easily. Using molecular formulae, write a balanced equation for the combustion of ethanol. (4)

8.2 The letters A to F in the table below represent six organic compounds.

A	$CH_3CHCHCH_3$	B	$CH_3CH_2CH_2CH_2CH_3$
C	CH_3CH_2F	D	$CH_3CH(CH_3)CH_2CH_3$
E	$ \begin{array}{c} O \\ \\ CH_3CH_2-O-C-CH_2CH_3 \end{array} $	F	$CH_3CH_2CH_2CH_2OH$

8.2.1 Write down the letter(s) that represent(s) each of the following:
(A compound may be used more than once.)

8.2.1.1 An unsaturated compound. (1)

8.2.1.2 Two compounds which are chain isomers of one another. (1)

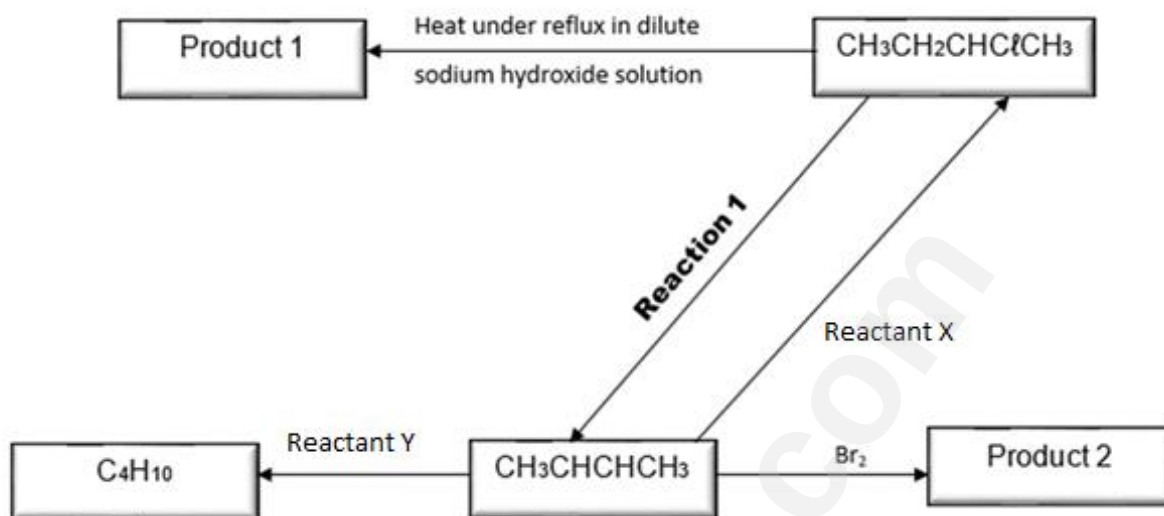
8.2.1.3 A compound containing a carbonyl group. (1)

8.2.1.4 A haloalkane. (1)

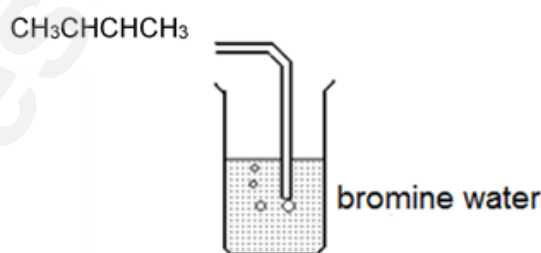
8.2.2 Give the IUPAC name of compound D (2)

[30]

Refer to the flow diagram below and answer the questions that follow:

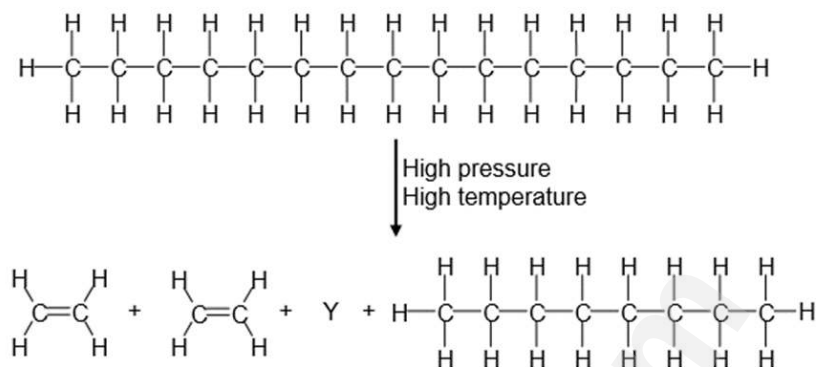


- 9.1 Give the **general** name for Reaction 1. (1)
- 9.2 Draw the structural formula for Product 1. (2)
- 9.3 Give the reaction conditions for Reaction 1. (2)
- 9.4 Give the chemical formula of:
 - 9.4.1 Reactant X. (1)
 - 9.4.2 Reactant Y. (1)
- 9.5 CH₃CHCHCH₃ is reacted with bromine (Br₂) in order to form Product 2. The gas is bubbled through red-brown bromine water as shown in the diagram below.



- 9.5.1 What colour change will be observed in the beaker as the reaction proceeds? (1)
- 9.5.2 What **specific** type of organic reaction is this? (1)
- 9.5.3 Draw the structural formula of Product 2. (2)
- 9.5.4 Give the IUPAC name of Product 2. (2)

- 9.6 Petrol requires the use of alkanes in the range from C_6 to C_{10} . Cracking is the process that is used to convert longer chains into shorter chains.



The diagram below illustrates one of the possible cracking reactions of $C_{15}H_{32}$.

- 9.6.1 What type of cracking is taking place in the above reaction? (1)
- 9.6.2 Write down the molecular formula and IUPAC name for the hydrocarbon represented by Y. (2)

[16]

Total = 200 marks

Name: _____

Question 1 (Multiple Choice):

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

Question 3.1.4:A plot of the volume of gas collected vs time for the reaction of CaCO_3 with HCl 