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ST. MARY'S DSG KLOOF

Physical Sciences

GRADE 12
TRIALS 2022

Trials Paper 2

Time: 3 hours + 10 min reading
Marks: 200

Examiners and Moderators: T. Kirsten, K. Bolton and G. Main

Examination number:

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Read the Following Instructions Carefully:

1. This paper consists of:
A question paper of 29 pages
A Data sheet
2. Read the questions carefully.
3. Answer **ALL** questions on the paper.
4. It is in your own interest to write legibly and to set your work out neatly.
5. Show all the necessary steps in calculations.
6. Use the data and formulae whenever necessary.
7. All working should be shown and units **MUST** be given with answers. Work to two decimal places or significant figures where appropriate. **Make sure your calculator is in the correct mode.**
8. Two blank pages (28-29) are included at the end of the question paper. If you run out of space for a question, use these extra pages. Clearly indicate the question number of your answer, should you use this extra space.

ACKNOWLEDGEMENTS:AQA A Levels Chemistry (www.savemyexams.co.uk)

St. Anne's Trials Paper 2 2017

St. Anne's Trials Paper 2 2018

Epworth Trials Paper 2 2019

Kearsney June Paper 2 2022

IEB Supplementary Examination Paper 2 May 2019

IGSCE CHEMISTRY Paper 2 October/November 2003

IB Chemistry P2 May 2009

IB Chemistry P2 November 2016

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Mark									
Question total	20	16	26	25	33	14	23	29	14

QUESTION 1 MULTIPLE CHOICE

Answer the multiple-choice questions on the answer grid below. Make a clear cross (X) in the box corresponding to the letter that you consider to be correct. Every question has only one correct answer.

A	B	~~C~~	D
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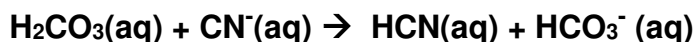
Here the option C has been marked as an example.

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 1 MULTIPLE CHOICE- Answer the multiple-choice questions on the answer grid

- 1.1 The net energy change during a chemical reaction is known as the:
- A bond energy
 - B activation energy
 - C activated complex
 - D heat of reaction
- 1.2 Which of these substances has permanent dipole-dipole attractions between molecules?
- A CCl_4
 - B $\text{C}_2\text{H}_4\text{O}_2$
 - C $\text{C}_4\text{H}_8\text{F}_2$
 - D CO_2
- 1.3 Which one of the following molecules would have the highest boiling point?
- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
 - B $\text{CH}_2\text{CHCH}_2\text{CH}_3$
 - C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
 - D $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
- 1.4 Three substances, X, Y and Z_2 are mixed. The reaction which occurs takes place in two steps as follows:
1. $\text{X} + \text{Z}_2 \rightarrow \text{XZ}_2$ 2. $\text{Y} + \text{XZ}_2 \rightarrow \text{X} + \text{YZ}_2$
- Which one of the substances acts as a catalyst?
- A X
 - B Y
 - C XZ_2
 - D Z_2
- 1.5 A few pieces of granulated zinc are placed in a beaker containing 40 cm^3 of $0,1 \text{ mol} \cdot \text{dm}^{-3}$ hydrochloric acid at 25°C . Which one of the following factors will NOT increase the initial rate of this reaction?
- A Increasing the temperature of the acid solution to 50°C
 - B Breaking up the granulated zinc into smaller pieces
 - C Using 80 cm^3 of $0,1 \text{ mol} \cdot \text{dm}^{-3}$ hydrochloric acid at 25°C
 - D Using 40 cm^3 of $0,2 \text{ mol} \cdot \text{dm}^{-3}$ hydrochloric acid at 25°C

1.6 Consider the following reaction:



Which line in the table correctly describes $\text{H}_2\text{CO}_3(\text{aq})$ and $\text{HCN}(\text{aq})$ in the above reaction?

	$\text{H}_2\text{CO}_3(\text{aq})$	$\text{HCN}(\text{aq})$
A	Base	Conjugate base
B	Base	Conjugate acid
C	Acid	Conjugate base
D	Acid	Conjugate acid

1.7 Which one of the following reactions CANNOT occur spontaneously under standard conditions?

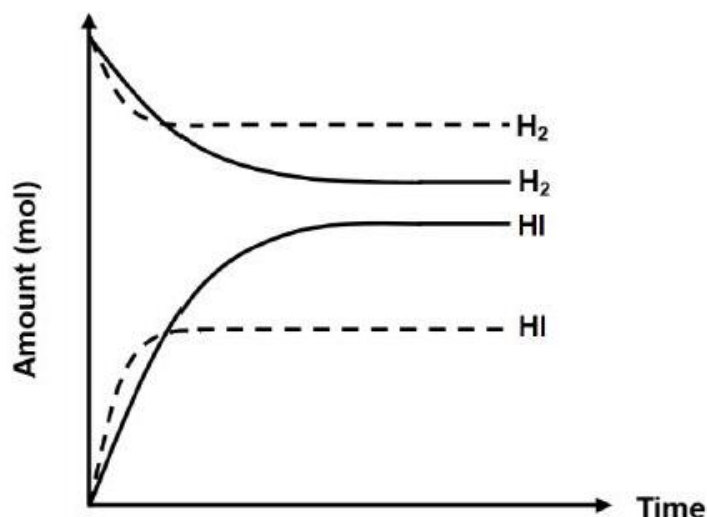
- A $2\text{Fe}^{+3}(\text{aq}) + \text{Zn}(\text{s}) \rightarrow \text{Zn}^{+2}(\text{aq}) + 2\text{Fe}^{+2}(\text{aq})$
 B $\text{Fe}(\text{s}) + 2\text{Fe}^{+3}(\text{aq}) \rightarrow 3\text{Fe}^{+2}(\text{aq})$
 C $\text{Cd}(\text{s}) + 2\text{Cu}^{+2}(\text{aq}) \rightarrow \text{Cd}^{+2}(\text{aq}) + 2\text{Cu}^+(\text{aq})$
 D $2\text{Ag}(\text{s}) + \text{CuCl}_2(\text{aq}) \rightarrow 2\text{AgCl}(\text{s}) + \text{Cu}(\text{s})$

1.8 A container is filled with H_2 and I_2 gases and sealed at a particular temperature. The gases react as shown in the following balanced chemical equation:



The changes in the amounts of H_2 and HI are shown by the solid lines in the graph alongside.

The reaction is then **REPEATED** under different conditions. Which one of the following changes to the original conditions would result in the dashed lines (---) shown on the graph?



- A Addition of a suitable catalyst
 B A higher temperature
 C A higher pressure
 D A higher concentration of I_2

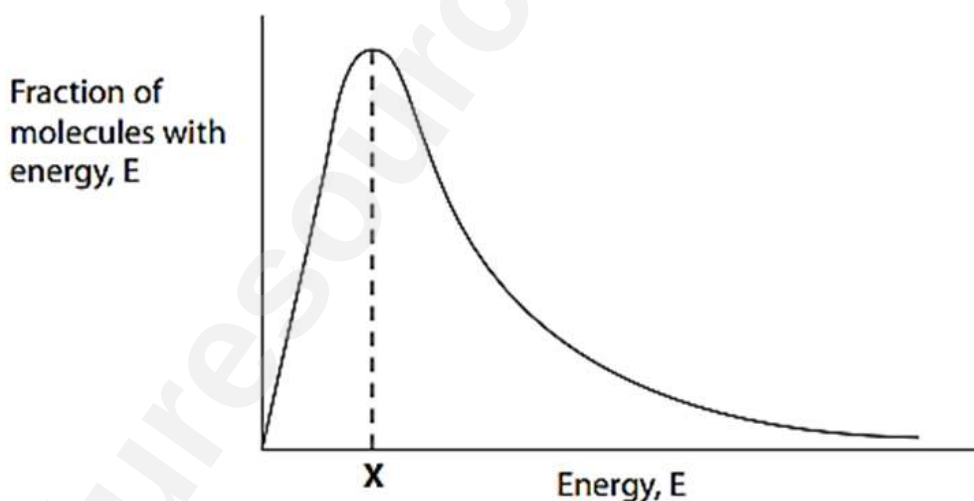
1.9 An electrochemical cell is set up between lead (Pb) and magnesium (Mg). Consider the following statements regarding the cell:

- I. Magnesium will form the anode of this cell.
- II. Lead is the oxidising agent of this cell
- III. When the cell is in operation electrons will flow through the salt bridge from magnesium to lead.
- IV. The mass of the magnesium electrode will decrease.

Which of the statements is/are correct?

- A I and II only
- B III and IV only
- C I and IV only
- D I, III and IV

1.10 The energy marked **X** in the Maxwell-Boltzmann distribution below shows the most common energy of the molecules.



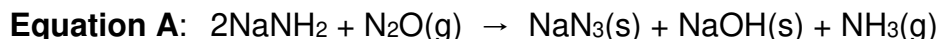
How will this distribution change as the temperature is decreased without changing the total number of molecules?

- A shift left and peak higher
- B shift right and peak lower
- C shift right and peak higher
- D shift left and peak lower

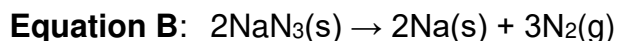
10 x 2 = [20]

QUESTION 2

Sodium azide (NaN_3) is found in the airbags of cars. It is made by reacting dinitrogen monoxide gas (N_2O) with sodium amide (NaNH_2) as shown in equation A:



In a car airbag, sodium azide decomposes to form sodium metal and nitrogen gas, as shown in equation B



With reference to **Equation A**:

2.1 Name the following products: (2)

i) NaOH _____

ii) NH_3 _____

2.2 Define a *polar covalent bond*. (2)

2.3 List TWO species in equation A which have polar covalent intramolecular bonds. (2)

2.4 Sodium azide has a high melting point ($275\text{ }^\circ\text{C}$). Predict the type of bonding in a crystal of sodium azide. (2)

2.5 N_2O has a boiling point of $-88,5\text{ }^\circ\text{C}$ and NH_3 has a boiling point of $-33\text{ }^\circ\text{C}$. With reference to the specific types of intermolecular forces present, explain why the boiling point of NH_3 is significantly higher than N_2O . (4)

With reference to **Equation B**:

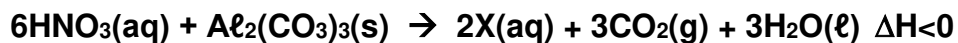
2.6 Name and describe, with the aid of a diagram, the bonding in sodium metal. (3)

2.7 Name the intermolecular force between molecules of N_2 gas. (1)

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QUESTION 3

250 cm³ of 0,3 mol.dm⁻³ nitric acid is added to 7,605 g of powdered Al₂(CO₃)₃. They react at room temperature to form a salt, **X**, as shown in the balanced chemical equation.



3.1 Name the compound Al₂(CO₃)₃. (2)

3.2 Write down the chemical formula of the salt **X**. (2)

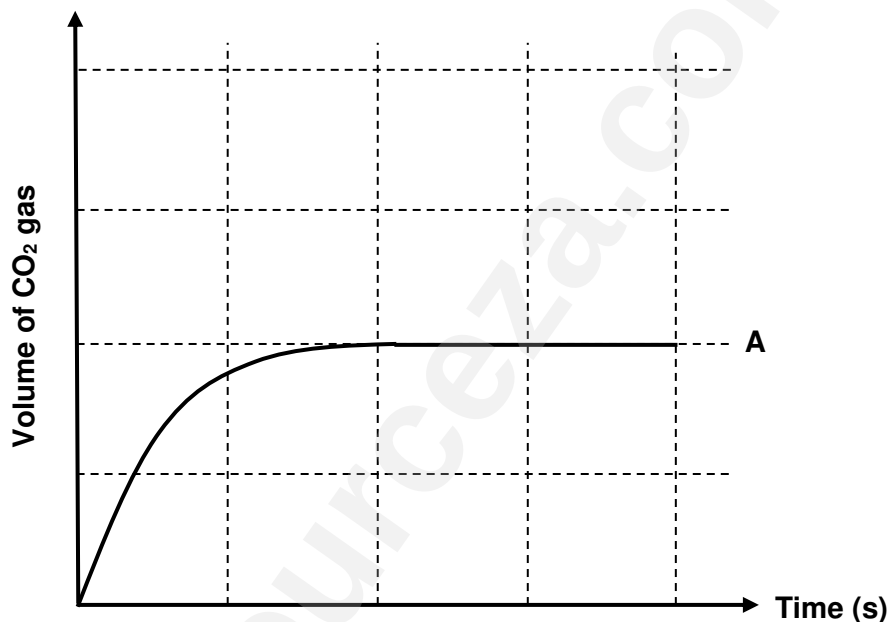
3.3 Calculate the number of moles in 250 cm³ of 0,3 mol.dm⁻³ of HNO₃. (3)

3.4 **Nitric acid is the limiting reagent.** Calculate the number of moles of Al₂(CO₃)₃ that are in excess. (5)

3.5 Calculate the volume of CO₂ gas produced in this reaction, at STP, if the yield is 76,5%. (4)

- 3.6 Define *reaction rate*. (2)

- 3.7 The rate of this reaction is monitored by measuring the volume of CO_2 gas produced at set time intervals. The results for the conditions given in question 3 are shown in the sketch graph labelled **A** below.



On the same set of axes shown for experiment **A** draw the graph for each of the following experiments:

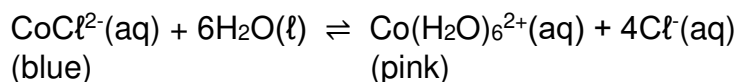
- 3.7.1 Using $0,5 \text{ mol.dm}^{-3} \text{ HNO}_3$. All other conditions remain unchanged. LABEL **B**. (2)
- 3.7.2 Using the same mass of a **single large piece of** $\text{Al}_2(\text{CO}_3)_3$. All other conditions remain unchanged. LABEL **C**. (2)
- 3.8 Use the collision theory to explain how decreasing the temperature would decrease the rate of this reaction. (4)

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QUESTION 4

4.1 A small quantity of cobalt chloride powder is dissolved in ethanol resulting in a blue solution.

When a few drops of water are carefully added to the blue solution the colour changes to light pink. The following equilibrium has been established:



To investigate some of the factors which affect this equilibrium, the following experiments are performed.

- **Experiment 1:** A small quantity of concentrated HCl is added to the solution.
- **Experiment 2:** The beaker with the solution is cooled by immersing it in ice water where the colour of the solution becomes more pink.
- **Experiment 3:** A small quantity of silver nitrate is added to the solution.

4.1.1 Explain what is meant by the term dynamic chemical equilibrium. (2)

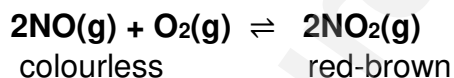
4.1.2 What was observed after experiment 1 was performed? (1)

4.1.3 Explain your answer in 4.1.2 in terms of how the rates of the forward and reverse reactions are affected. (3)

- 4.1.4 From the results of experiment 2 determine the sign of ΔH for the forward reaction. (2)

- 4.1.5 Explain in terms of Le Chatelier's principle how and why the equilibrium was affected in experiment 3. (4)

- 4.2 The colourless gas nitrogen monoxide is reacted with oxygen in a closed container to form the red-brown gas, nitrogen dioxide. At equilibrium the mixture of gases is a pale red-brown colour.



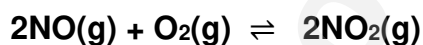
When the above equilibrium mixture is heated the red-brown colour becomes much darker.

- 4.2.1 Which reaction, FORWARD or REVERSE, was favoured when the equilibrium mixture was heated? (1)

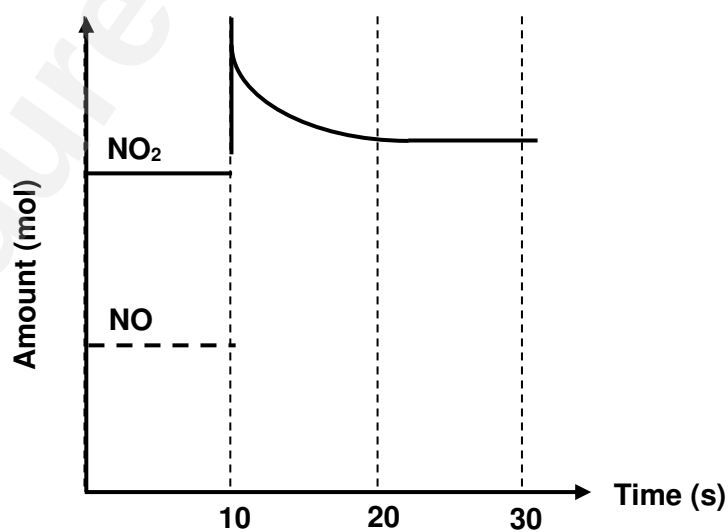
- 4.2.2 Write down the equilibrium constant expression, K_c , for this equilibrium reaction. (2)

- 4.2.3 Initially 3,375 mol of NO and 2,063 mol of O₂ are inserted in a flask of volume 0,75 dm³. At equilibrium the concentration of NO₂ is 1,5 mol.dm⁻³ at 45 °C. Calculate the value of the equilibrium constant at this temperature. (5)

- 4.2.4 This reaction is in equilibrium in a closed flask at a fixed temperature and pressure. At t = 10 s more NO₂ was added to the flask which was then resealed.

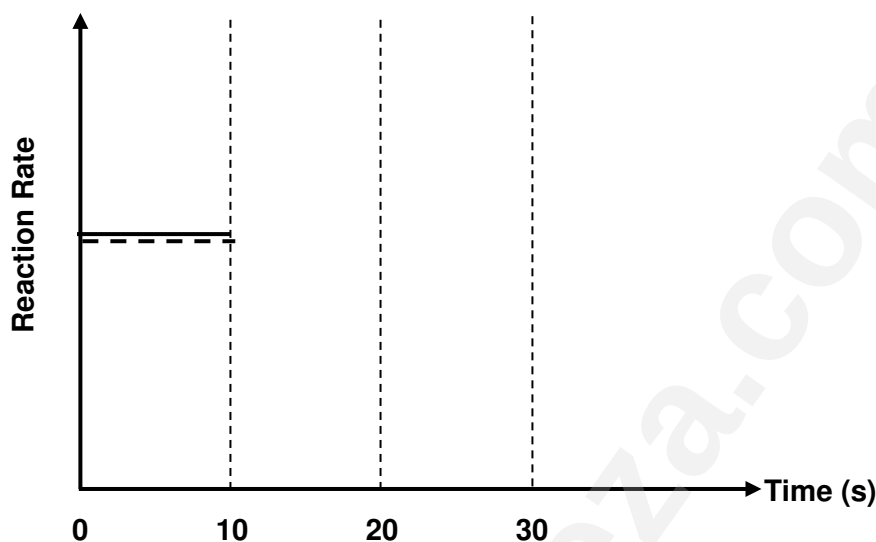


- (i) Complete the amount vs time graph for NO between t = 10 s and 30 s. (2)



- (ii) Complete the reaction rate vs time graphs between $t = 10$ s and 30 s. (3)

NOTE: Solid line = forward reaction
Dashed line = reverse reaction



[25]

QUESTION 5

- 5.1 In aqueous solution, hydrogen sulfide (H_2S) acts as an acid. Saturated aqueous hydrogen sulfide has a K_a value of $8,9 \times 10^{-8}$ at 25°C .

5.1.1 Define the term *acid*. (2)

5.1.2 Explain whether hydrogen sulfide is a strong or weak acid. (3)

5.1.3 Write the ionisation equation for hydrogen sulfide in aqueous solution. (3)

5.1.4 Write the expression for the equilibrium constant, K_a . (2)

5.1.5 Calculate the hydronium ion concentration in saturated aqueous hydrogen sulfide at 25°C if the hydroxide ion concentration is $1,06 \times 10^{-10} \text{ mol}\cdot\text{dm}^{-3}$. (3)

5.1.6 Calculate the concentration of the saturated aqueous hydrogen sulfide solution. (3)

5.2 The pH values of solutions of three organic acids of the same concentration were measured.

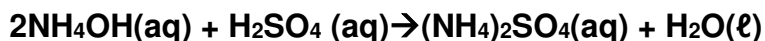
ACID	pH
X	5
Y	2
Z	3

5.2.1 Identify which solution is the *least* acidic. Explain your answer. (3)

5.2.2 Arrange the solutions of the 3 acids in decreasing order of electrical conductivity, starting with the greatest conductivity. (2)

- 5.3 An experiment was carried out to determine the concentration of aqueous ammonia by titrating it with a $0,150 \text{ mol.dm}^{-3}$ sulfuric acid solution. It was found that 25 cm^3 of the aqueous ammonia required $20,1 \text{ cm}^3$ of the sulfuric acid solution for neutralisation.

The balanced equation for the reaction is below:



- 5.3.1 Calculate the concentration of the aqueous ammonia (NH_4OH). (4)

- 5.3.2 Several acid-base indicators are listed in the table below. Identify **one** indicator that could be used for this experiment. (1)

Indicator	Colour in lower pH	Colour in higher pH	pH range
Methyl orange	Red	Yellow	3,1–4,4
Bromothymol blue	Yellow	Blue	6,0–7,6
Phenolphthalein	Colourless	Pink	8,3–10

- 5.3.3 Define *hydrolysis of a salt*. (2)

5.3.4 Using a suitable equation, explain whether the salt formed in this reaction is weakly acidic or weakly basic. (5)

[33]

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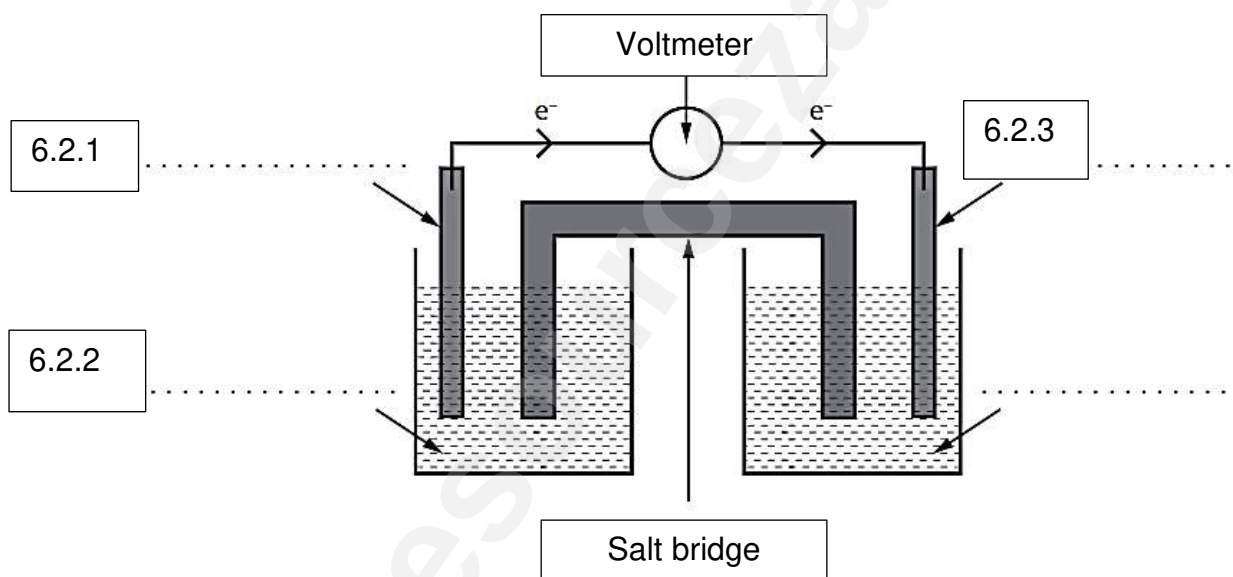
QUESTION 6

A student decides to build a galvanic cell consisting of:

- an aluminium electrode, Al(s)
- a tin electrode, Sn(s)
- a solution of aluminium nitrate, $\text{Al(NO}_3)_3(\text{aq})$
- a solution of tin(II) nitrate, $\text{Sn(NO}_3)_2(\text{aq})$

6.1 Define *oxidation*. (2)

6.2 Label the parts numbered 6.2.1- 6.2.3 in the diagram below. Use labels from the bulleted list above. Electron flow is represented on the diagram. (3)



6.2.1 _____

6.2.2 _____

6.2.3 _____

6.3 Write down the cell notation for this galvanic cell. Standard conditions and phase indicators are not required. (3)

6.4 Calculate the initial emf of this galvanic cell. (2)

6.5 What are the TWO functions of the salt bridge? (2)

6.6 What is the effect of increasing the concentration of the solution in the salt bridge on:
(State only INCREASES, DECREASES, or NO EFFECT.) (2)

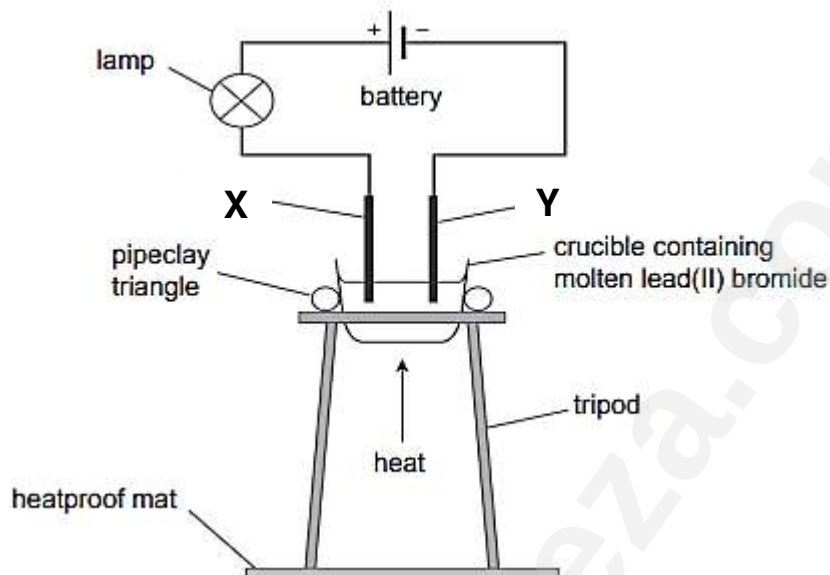
6.6.1 the maximum current the cell can provide?

6.6.2 the initial emf of the cell?

[14]

QUESTION 7

- 7.1 Molten lead (II) bromide undergoes electrolysis. The apparatus below is used to carry out the electrolysis of molten lead (II) bromide.



- 7.1.1 State the energy conversion in this process. (2)

- 7.1.2 Define *cathode*. (2)

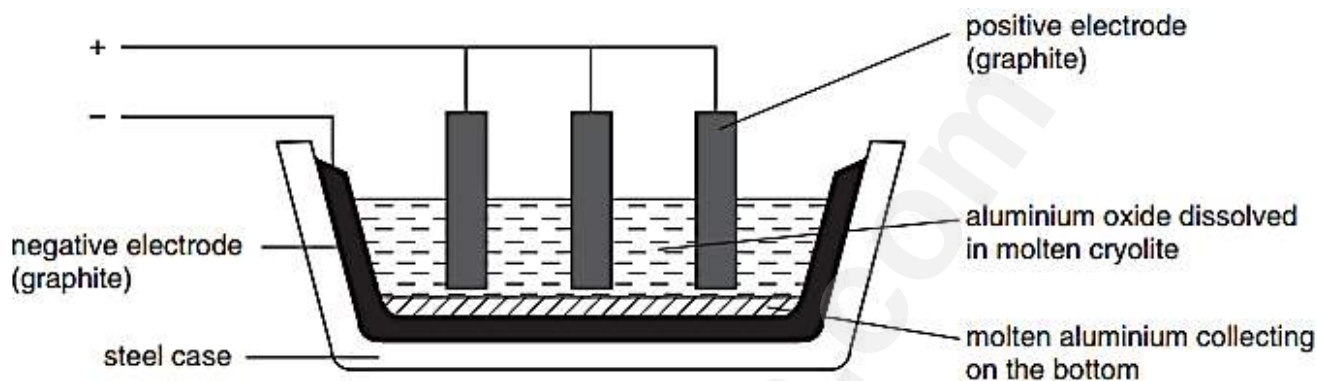
- 7.1.3 Which electrode is the cathode? State only X or Y. (1)

- 7.1.4 Write the half-reaction equation occurring at the cathode. (2)

The same process is repeated but using aqueous lead (II) bromide.

- 7.1.5 State what is observed at the anode. Fully explain why this substance is produced. Refer to the strengths of the relative agents. (3)

- 7.2 Aluminium is extracted from its ore, bauxite. The bauxite is purified to give aluminium oxide. Electrolysis is then used to extract the aluminium from aluminium oxide dissolved in cryolite. The melting point of pure aluminium oxide is 2070°C . The melting point of the mixture of aluminium oxide and cryolite is about 1000°C .



- 7.2.1 What is the name for the purified aluminium oxide? (1)

- 7.2.2 What property of graphite makes it suitable for use as electrodes? (1)

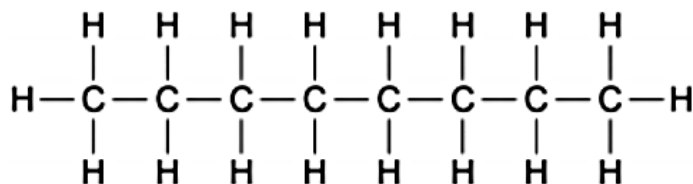
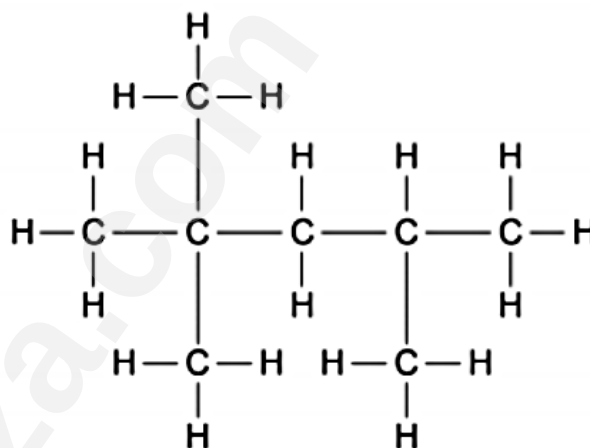
- 7.2.3 The melting point of steel is about 1500°C . Suggest TWO reasons why molten aluminium oxide is not used by itself in this electrolysis. (3)

- 7.3 During the electrolysis, hot oxygen is formed at the positive electrodes. Use suitable equations to explain why the positive electrodes must be replaced frequently. (3)

- 7.4 Calculate the time in seconds required to produce 100 kg of pure aluminium if a current of 150 kA was used. (5)

QUESTION 8

- 8.1 Octane and isooctane are found in petrol. They are structural isomers with the molecular formula C_8H_{18} . The structural formulae and boiling points of octane and isooctane are shown below.

Octane**Boiling point: 125 °C****Isooctane****Boiling point: 99 °C**

- 8.1.1 Give the IUPAC name for isooctane. (3)

- 8.1.2 Define the term *structural isomer*. (2)

- 8.1.3 What type of structural isomer is isooctane? (1)

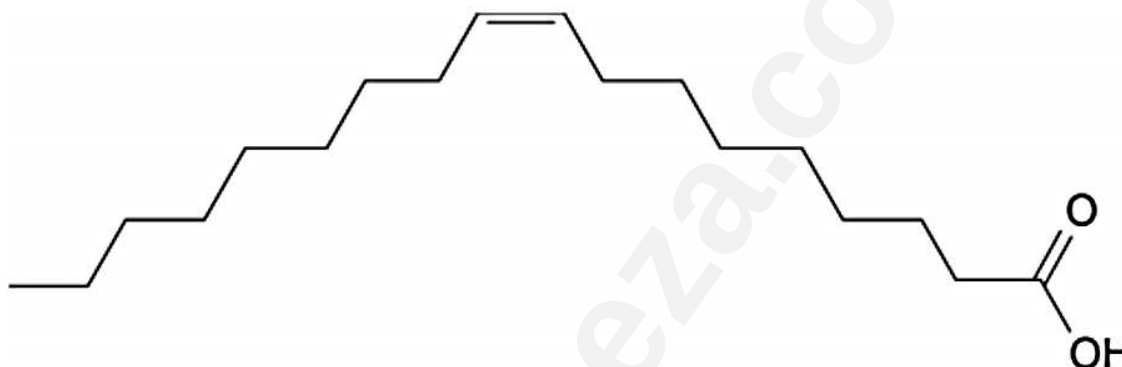
- 8.1.4 Explain the difference in the boiling points of the two compounds. (4)

Octane can be broken up into smaller, more useful molecules using high temperatures and pressures.

8.1.5 What SPECIFIC name is given to this process? (2)

Isooctane can be made from oleic acid ($C_{18}H_{34}O_2$), a straight-chain organic compound obtained from plant oils. The skeletal structure* of oleic acid is shown below.

*In organic chemistry the skeletal structure of a compound shows just the carbon backbone and functional groups.



8.1.6 Name the functional group in oleic acid. (1)

8.1.7 Define an *unsaturated compound*. (2)

8.1.8 Identify a reagent that could be used in a chemical test to show that oleic acid is unsaturated. State what would be observed in this test. (2)

8.2 Propan-2-ol and a metal halide can be made by adding aqueous KOH to 2-fluoropropane and heating under reflux.

8.2.1 Name this SPECIFIC type of reaction. (1)

8.2.2 Write an equation for this reaction using condensed structural formulae. (4)

8.3 Butan-1-ol is mixed with methanoic acid and a small amount of concentrated H_2SO_4 and heated gently in a water bath.

8.3.1 State the SPECIFIC type of reaction which occurs. (1)

8.3.2 Draw the structural formula of the organic product of the reaction. (2)

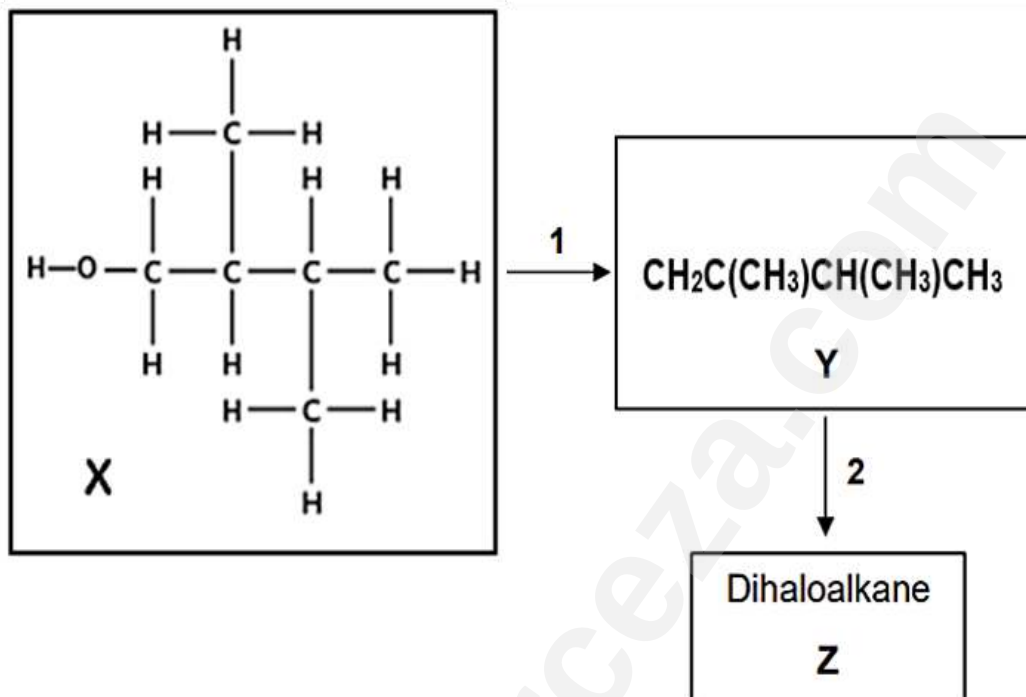
8.3.3 Give the IUPAC name for the organic product you have drawn in Q8.3.2. (2)

8.3.4 Name the functional isomer of the organic product you have named in Q 8.3.3. (2)

[29]

QUESTION 9

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

9.1 Identify the homologous series of compound Y. (1)

9.2 Give the IUPAC name of compound Y. (3)

9.3 Identify the GENERAL type of reaction represented by reaction 1. (1)

9.4 Name the SPECIFIC type of addition reaction represented by reaction 2. (1)

9.5 Draw the structural formula of compound **Z**. (2)

9.6 Compound **Y** can undergo other reactions (apart from reaction 2) depending on reaction conditions. If compound **Y** is treated with hydrogen gas in the presence of a hot nickel catalyst:

9.6.1 Identify the SPECIFIC type of reaction that occurs. (1)

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

9.6.3 Name the homologous series of the product formed. (1)

9.7 Compound **X** can be burnt in the presence of oxygen and undergoes a combustion reaction. Complete and balance the following reaction for the combustion of compound **X**.



[14]

REMEMBER TO CLEARLY INIDICATE AT THE QUESTION THAT YOU USED THE ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.

[illegible]

