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**WOODRIDGE COLLEGE**

28 SEPTEMBER 2023

3 HOURS

PHYSICAL SCIENCES: PAPER 2

EXAMINER: Dr C Logie

TOTAL = 200 marks

MODERATOR: Mr P Maartens

GRADE 12**NAME:** _____.**PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY:**

1. This question paper consists of 28 pages and a data sheet of 3 pages. Please make sure that your question paper is complete.
2. Read the questions carefully.
3. Answer ALL the questions on the question paper and hand it in at the end of the examination. Remember to write your name in the space provided above and to circle your teacher's initials.
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
7. Answers must be expressed in decimal format, not left as proper fractions.
8. Where appropriate, express answers to TWO decimal places.
9. It is in your own interest to write legibly and to present your work neatly.
10. Two blank pages (pages 27 and 28) are included at the end of the exam paper. If you run out of space for an answer, use these pages. If you use this extra space, make sure that you indicate this clearly at the question to ensure that your answer is marked in full.
11. A non-programmable scientific calculator may be used.

FOR OFFICE USE ONLY: MARKER TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	TOTAL
MARK										
Question total	20	32	27	25	26	19	13	20	18	200

Answer these questions on the multiple-choice 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	X	D
---	---	---	---

 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

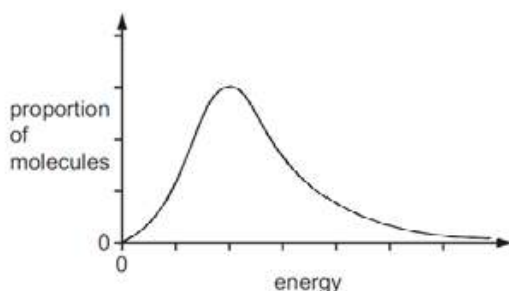
1.1 Which of the following statements is NOT correct?

- A. The strongest type of intermolecular force in ammonia is hydrogen bonding.
- B. The strongest type of intermolecular force in hydrogen chloride is permanent dipole-dipole force.
- C. The strongest intermolecular force in ethanol is permanent dipole-dipole force.
- D. The strongest intermolecular force in water is hydrogen bonding. (2)

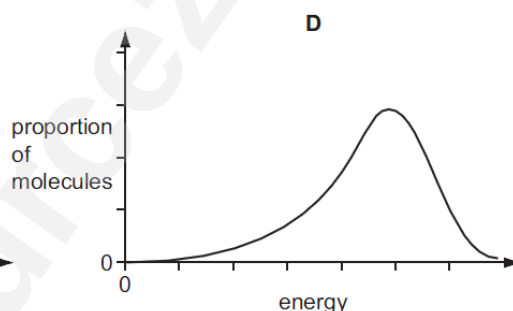
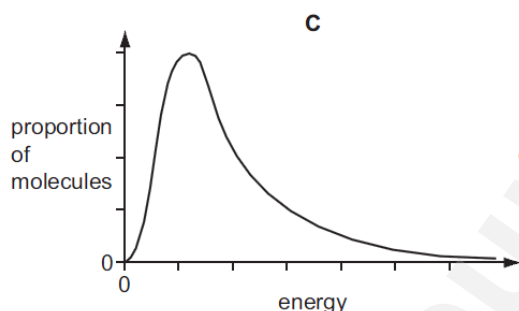
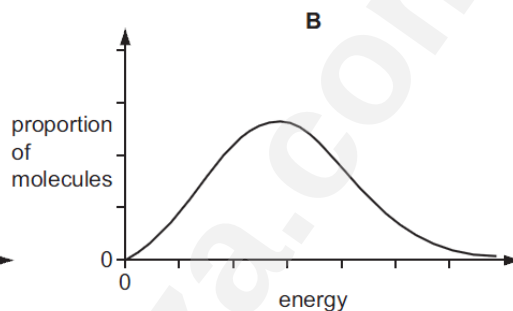
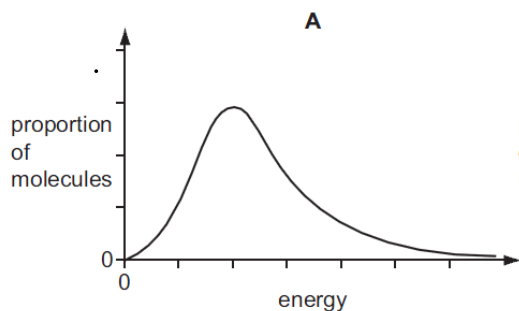
1.2 Which of the following molecules has the highest boiling point?

- A. hexane
- B. propane
- C. 2,3-dimethylbutane
- D. propene (2)

- 1.3 The molecular energy distribution curve represents the variation in energy of the molecules of a gas at room temperature.

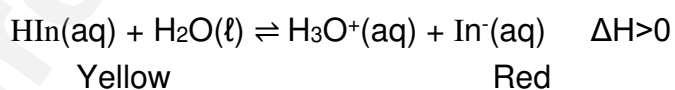


Which curve applies for the same gas at a **lower** temperature?



(2)

- 1.4 An acid-base indicator represented as HIn(aq) , reaches dynamic chemical equilibrium when added to water as shown in the equation below:

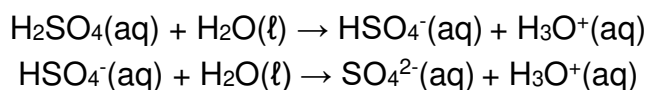


At chemical equilibrium the colour of the solution is orange (a mixture of red and yellow). Which one of the following will turn the colour of the solution yellow?

- A. The addition of NaOH.
B. The addition of H₂O.
C. An increase in the temperature.
D. The addition of HCl.

(2)

1.5 Sulfuric acid ionises in water according to the following equations:



Consider the following statements about the ionisation above:

- (I) $\text{H}_2\text{O}(\ell)$ acts as a base in both reactions.
- (II) $\text{HSO}_4^-(\text{aq})$ acts as an ampholyte.
- (III) $\text{SO}_4^{2-}(\text{aq})$ is the conjugate base of $\text{H}_2\text{SO}_4(\text{aq})$

- A. (I) only
- B. (I) and (II)
- C. (I) and (III)
- D. (I), (II) and (III)

(2)

1.6 The ionisation constants, K_a , for two acids X and Y are given below:

Acid	K_a
X	4×10^{-4}
Y	3×10^{-6}

From the information given about the acids we can deduce that:

- A. X is a weak acid and Y is a strong acid.
- B. X and Y are both strong acids
- C. X will ionise more completely in water than Y.
- D. X and Y are both dilute solutions of acids.

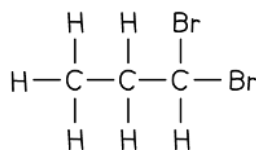
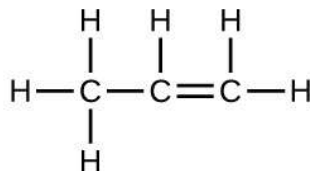
(2)

1.7 In which of the following substances will sulfur act as the best reducing agent?

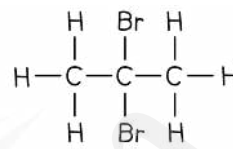
- A. $\text{H}_2\text{SO}_4(\text{aq})$
- B. $\text{H}_2\text{S}(\text{g})$
- C. S
- D. $\text{SO}_2(\text{g})$

(2)

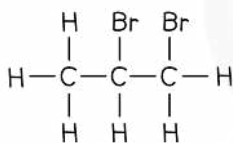
- 1.8 What is the structure of product of the reaction between bromine and the compound shown below?



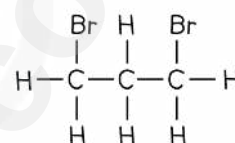
A.



C.



B.



D.

(2)

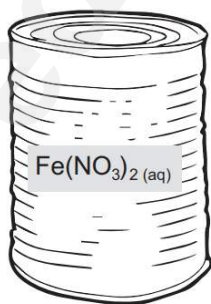
- 1.9 Sodium aluminium hexafluoride, better known as cryolite, is added to aluminium oxide (alumina) in the industrial process for the extraction of aluminium. What is the reason for adding the cryolite to the reaction mixture?

- A. It prevents the graphite electrodes from corroding due to the large electric current being passed through the electrodes.
- B. It helps reduce the melting point of the alumina to reduce the electrical costs of keeping alumina molten.
- C. It acts as a protective layer to protect the iron container from the intense heat required during the extraction process.
- D. It acts as a catalyst to help speed up the extraction process.

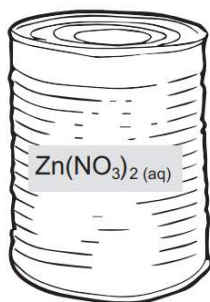
(2)

- 1.10 Four tin (Sn) cans are each filled with a different solution as shown by the labels on the cans in the diagrams below. Each solution has a concentration of $1 \text{ mol} \cdot \text{dm}^{-3}$ at 25°C . Which one of the tin cans will undergo oxidation?

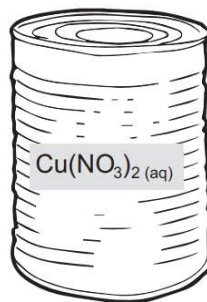
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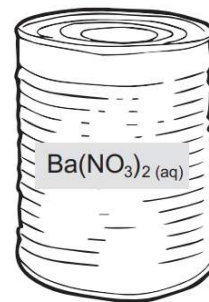
A



B



C



D

[20]

QUESTION 2

- 2.1 From the list given below select only the one chemical substance that best fits the description given. Substances can only be used once and not all need to be used:

CO₂ NaF Pb H₂O CBr₄ SiO₂ Hg I₂

- 2.1.1 A giant molecular crystal held together by covalent bonds.

_____ (2)

- 2.1.2 A non-polar molecule with polar bonds that has van der Waals forces between the molecules in a liquid.

_____ (2)

- 2.1.3 Atoms held together by metallic bonds in the solid state.

_____ (2)

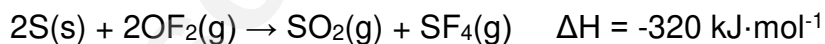
- 2.1.4 A non-polar molecule with non-polar bonds that is found as a solid at room temperature due to weak London forces.

_____ (2)

- 2.1.5 A polar molecule held together in the liquid state by hydrogen bonds.

_____ (2)

- 2.2 The following reaction is used to produce SF₄ which is involved in the production of CFCs that were used as coolants in refrigerators.



- 2.2.1 Define *intramolecular bonding*.

_____ (2)

- 2.2.2 Name the specific type of intramolecular bond in SO₂.

_____ (2)

(5)

2.2.4 Define *activation energy*.

(2)

- Energy of reactants ($E_{\text{reactants}}$)
- Energy of products (E_{products})
- Activation Energy (E_a)
- Heat of Reaction (ΔH)

- Energy of products
- Energy of activated complex

2.3 A catalyst could be used during the manufacture of SF₄.

2.3.1 Define the term *catalyst*.

(2)

2.3.2 How will a catalyst change the energy profile you drew in Question 2.2.5?

(1)

2.3.3 State the effect that a catalyst will have on each of the following. (write ONLY INCREASE, DECREASE OR NO EFFECT)

a. The heat of the reaction

(1)

b. Energy of the products

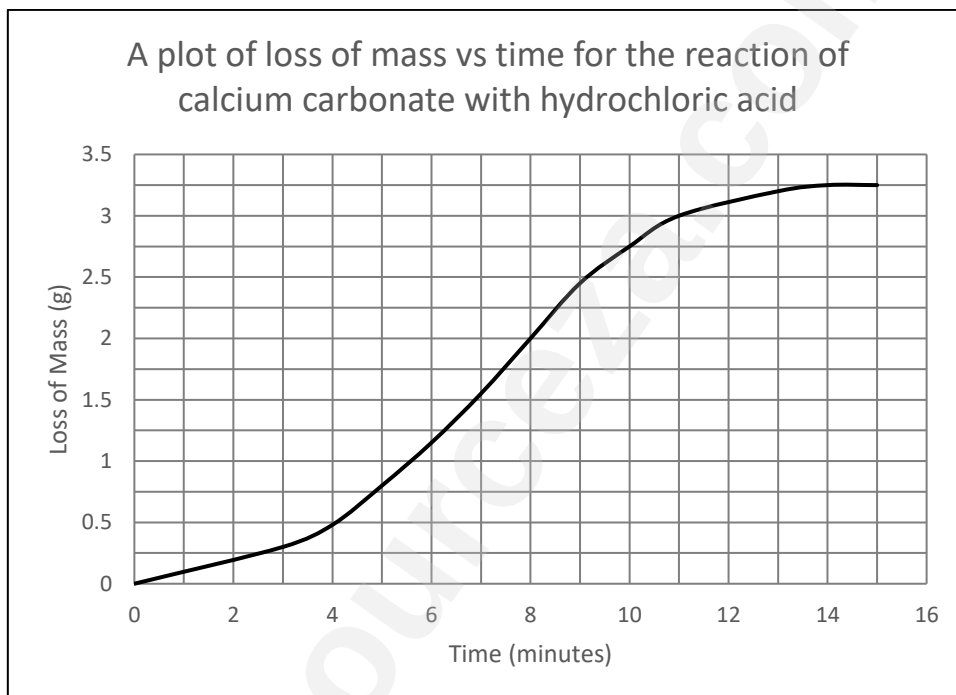
(1)

[32]

QUESTION 3

Several large pieces of calcium carbonate with a total mass of 12 g are placed in an open vessel. Enough hydrochloric acid is added to completely cover the lumps, 200 cm³ with a concentration of 3 mol·dm⁻³, and the mass of the flask determined every two minutes. A graph of the results is shown below.

The balanced chemical equation for the reaction taking place in the flask is:



3.1 What is meant by a closed system?

(2)

3.2 Use your answer in 3.1 to explain why reversible arrows are not used in the equation above.

(2)

3.3 Calculate the number of moles of calcium carbonate in a 12 g sample.

(3)

3.4 Which reagent was excess? Show all working.

(4)

3.5 Compare the rate of reaction between 0 and 3 minutes with the rate between 3 and 6 minutes.

(1)

3.6 Give one possible reason for the difference in rates described in Question 3.5.

(2)

3.7 Compare the rate of reaction between 4 and 8 minutes with the rate between 10 and 12 minutes.

(1)

3.8 Explain the difference in rates described in Question 3.7 in terms of the Collision Theory.

(4)

3.9 What is the final mass of carbon dioxide produced?

(1)

3.10 Determine the percentage yield of carbon dioxide.

(5)

This reaction is now repeated using 12 g of powdered calcium carbonate and 200 cm³ of 3 mol·dm⁻³ hydrochloric acid.

3.11 What effect (if any) will this have on:

3.11.1 the gradient of the graph between 4 and 8 minutes?

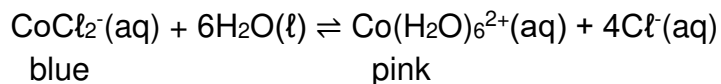
3.11.2 the final mass of carbon dioxide produced?

(2)

[27]

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 to Question 4.1.2 in terms of how the rates of the forward and reverse reactions are affected.

(3)

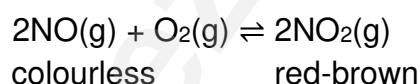
- 4.1.4 From the results of Experiment 2 determine the sign of ΔH for the forward reaction.

(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?

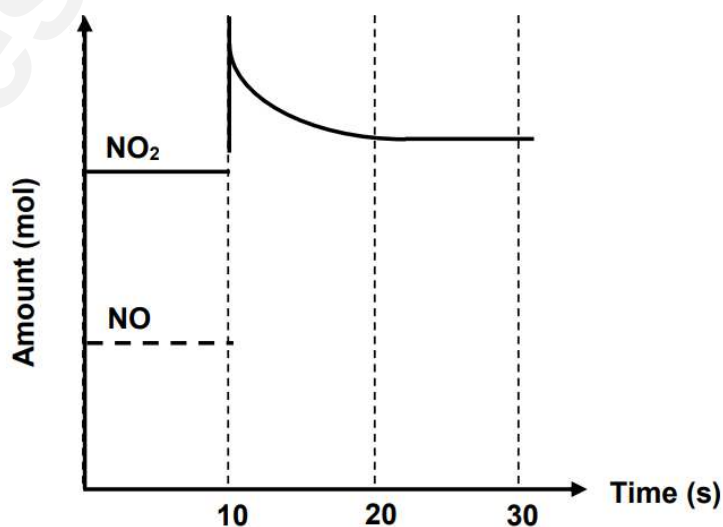
(1)

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

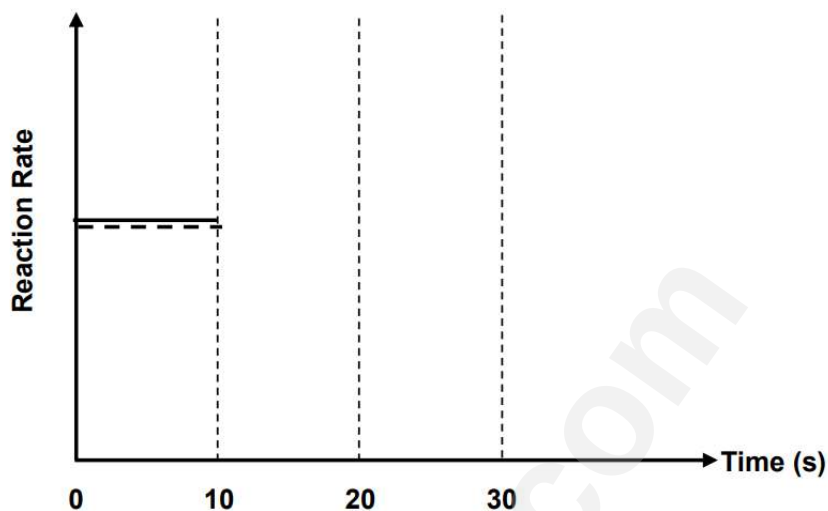
(2)

(5)

a. Complete the amount vs time graph for NO between $t = 10\text{s}$ and 30s . (2)



- b. Complete the reaction rate vs time graphs between $t = 1$ s and 30s.
NOTE: solid line = forward reaction and dashed line = reverse reaction (3)



[25]

QUESTION 5

(Adapted from Trinityhouse Prelim 2022)

5.1 Phosphoric acid (H_3PO_4) is a weak, polyprotic acid.

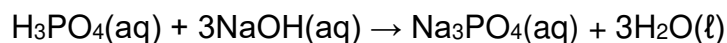
5.1.1 Define the term *weak acid*?

(2)

5.1.2 Give a reason why phosphoric acid is referred to as a polyprotic acid.

(2)

- 5.2 A pupil needs to determine the concentration of a phosphoric acid solution. She decides to titrate the phosphoric acid against a standard sodium hydroxide solution. The balanced chemical equation is given below:



- 5.2.1 Define the term *standard solution*.

(2)

- 5.2.2 Calculate the mass of NaOH needed to make up 500 cm³ of a 0,22 mol·dm⁻³ NaOH solution.

(4)

- 5.2.3 During the titration she found that 15 cm³ of the 0,22 mol·dm⁻³ NaOH solution neutralises 20 cm³ of the phosphoric acid solution. Calculate the concentration of the phosphoric acid

(4)

- 5.2.4 What is meant by “*hydrolysis of a salt*”?

(2)

- 5.2.5 Which one of the indicators listed below should be used in this titration? Briefly explain your answer by referring to the hydrolysis of Na_3PO_4 . Include one or more equations with your answer.

Name of indicator	pH range of indicator
Methyl orange	3,1 – 4,4
Bromothymol blue	6,0 – 7,6
phenolphthalein	8,4 – 10,0

(4)

- 5.3 Solution A is ethanoic acid of concentration $0,05 \text{ mol} \cdot \text{dm}^{-3}$
 Solution B is hydrochloric acid of concentration $0,05 \text{ mol} \cdot \text{dm}^{-3}$
 Solution C is hydrochloric acid of concentration $0,5 \text{ mol} \cdot \text{dm}^{-3}$

Which solution/s (A, B or C?) would you expect to have....

- 5.3.1 the higher pH?

(2)

- 5.3.2 the lowest K_a value?

(2)

- 5.3.3 the greater electrical conductivity?

(2)

[26]

QUESTION 6

The cell notation of a standard galvanic (voltaic) cell containing an unknown metal electrode is shown below:



6.1 Give the energy conversion taking place in this galvanic cell.

_____ (2)

6.2 State **two** standard conditions that are applicable to the $\text{Pb}^{2+}(\text{aq}) \mid \text{Pb(s)}$ half-cell.

_____ (2)

6.3 Name the component of the cell which is represented by $\parallel$.

_____ (1)

6.4 Describe how the component identified in Question 6.3 performs its function in this specific cell.

_____ (2)

6.5 The initial reading on a voltmeter connected across the electrodes of this standard galvanic cell is 1,53 V. Determine the identity of the unknown metal.

_____ (3)

- 6.6 Write down the balanced ionic equation representing the chemical reaction occurring in the galvanic cell. Use the symbol of the unknown metal in the equation, in place of X.

(3)

- 6.7 How will the initial voltmeter reading be affected if the concentration of the electrolyte in the $X(s) | X^{3+}(aq)$ half-cell is increased?

6.7.1 Write down INCREASES, DECREASES or REMAINS THE SAME.

(1)

6.7.2 Briefly explain your choice of answer to Question 6.7.1.

(2)

- 6.8 The surface area of both electrodes is increased equally, allowing them to have the same but larger surface area.

6.8.1 How does this affect the initial reading on the voltmeter? Write down INCREASES, DECREASES or REMAINS THE SAME.

(1)

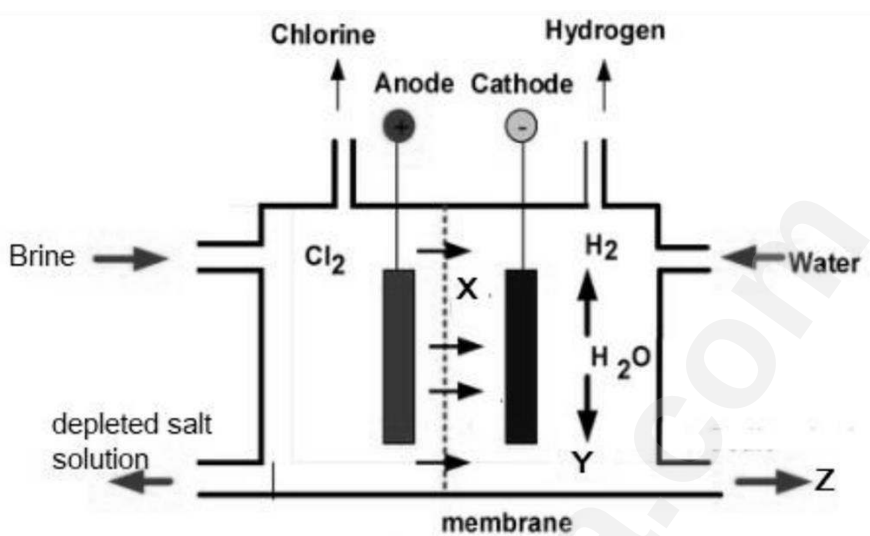
6.8.2 Briefly explain how increasing the surface area of the electrodes affects how this cell operates.

(2)

[19]

QUESTION 7

Chlorine gas is an important chemical for many industrial processes. It is produced on large scale using a membrane cell and brine as a reactant.



7.1 What is a brine solution?

(1)

7.2 Write the formula of the species, X, that passes (to the right) through the membrane.

(1)

7.3 Why do the chlorine and hydrogen gas that are produced during the reaction need to be separated?

(2)

7.4 The diagram shows that H_2O produced hydrogen gas and substance Y. Select the appropriate half-reaction from the Table of Reduction Potentials that illustrates this reaction.

(2)

7.5 Write the formula for the aqueous salt, Z, that is a by-product of the chlorine production.

(1)

- 7.6 Besides environmental and health reasons, why is it more advantageous to use the membrane cell rather than the asbestos diaphragm cell to produce chlorine commercially?

(2)

- 7.7 As the brine becomes depleted it is noted that the chlorine gas becomes contaminated with oxygen gas. Explain fully why this occurs. Select an appropriate equation to substantiate your answer.

(4)

[13]

QUESTION 8

Study the organic molecules that belong to different homologous series labelled A-D.

A	$\text{CH}_2=\underset{\text{CH}_3}{\text{C}}-\text{CH}_2-\text{CH}_2-\text{CH}_3$	B	$\text{CH}_3\text{CH}_2\text{CH}_2\underset{\text{OH}}{\text{CH}}\text{CH}_3$
C	$\text{C}_3\text{H}_7\text{Cl}$	D	Propanoic acid

Use the information in the table to answer the questions that follow:

8.1 Define the term *homologous series*.

(2)

8.2 Write down the letter of the compound that ...

8.2.1 has a carboxyl group.

(1)

8.2.2 is a haloalkane.

(1)

8.3 Write down the...

8.3.1 IUPAC name of compound A.

(2)

8.3.2 structural formula of compound D.

(2)

8.4 Consider organic structure labelled B. Downloaded from eduresourceza.com

8.4.1 Define the term *positional isomer*.

(2)

8.4.2 Write down the condensed structural formula for one positional isomer of compound B.

(2)

8.4.3 Using MOLECULAR formula, write down a BALANCED chemical equation for the reaction of compound B with excess oxygen.

(4)

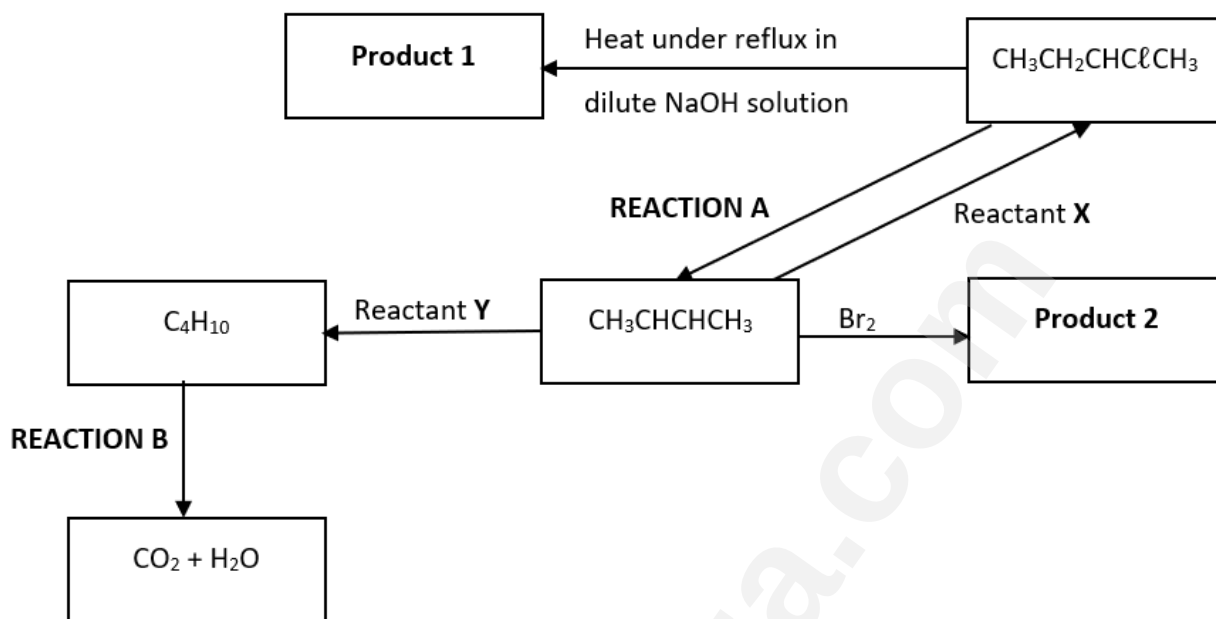
8.5 Compound D gives rise to functional isomers. Draw the structural formula and give the IUPAC name for ONE functional isomer of compound D.



(4)
[20]

QUESTION 9

A flow diagram of compounds and their reactions is shown below.



9.1 Give the general names for reactions A and B:

A:

B:

(4)

9.2 Give the chemical formulae of reactants X and Y.

X:

Y:

(2)

9.3 Give the IUPAC names and STRUCTURAL FORMULAE for products 1 and 2.

Product 1:

Name:

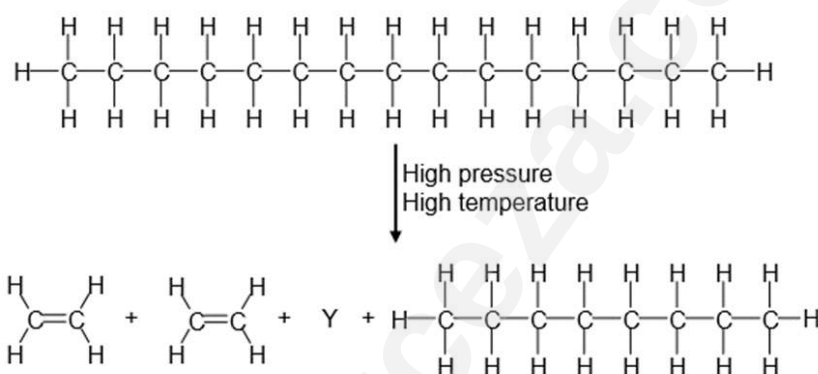
Structural Formula:

(2+2)

 Structural Formula:

(2+2)

- 9.4 Cracking is the process of converting longer chain alkanes into smaller chains. The diagram below shows a possible outcome of cracking $C_{15}H_{32}$.



- 9.4.1 Name the type of cracking that is shown by the diagram above.

(1)

- 9.4.2 Give the IUPAC name and STRUCTURAL FORMULA of product Y.

Name:

 Structural Formula:

(1+2)

[18]

Total = 200 marks

ADDITIONAL SPACE (ALL questions)

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

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