



eduresourceza.com



Brescia House School

Physical Science Paper II

Grade 12
July 2022

Examiner: Mrs. S Crossman
Moderator: Mrs. K Trenor & Mrs. A Bruns

Total: 200 marks
Time: 3 hours

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of 32 pages and a **data sheet** of two pages. Ensure that your 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.
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 are included at the end of the paper. If you run out of space for an answer, use the page.
11. **IF YOU USE THIS SPACE TO COMPLETE A QUESTION, PLEASE MAKE A NOTE IN THE QUESTION TO DIRECT THE EXAMINER'S ATTENTION. WRITE DOWN THE CORRECT QUESTION NUMBER.**

NAME: _____

Examination Number: 22101402 _ _ _ _

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	TOTAL
Mark										
	/20	/20	/33	/23	/25	/14	/25	/25	/15	/200
Moderated										

QUESTION 1

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.

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

[20 marks]

- 1.1 A 5,62 g sample of anhydrous sodium sulfate, Na_2SO_4 , is dissolved in water and the solution is made up to 250 cm^3 in a volumetric flask.

What is the concentration, in $\text{mol}\cdot\text{dm}^{-3}$, of the hydrated sodium sulfate solution?

- A 0,00016
 B 0,0016
 C 0,016
 D 0,16 (2)

- 1.2 Which of the following statements is **NOT** correct?

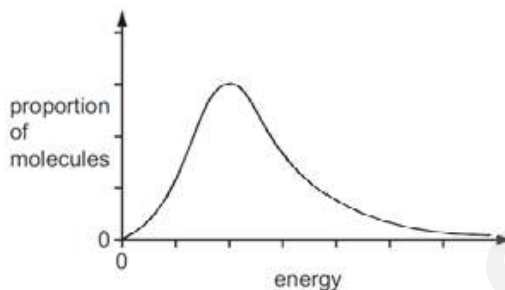
- A The strongest type of intermolecular force in ammonia is hydrogen bonding.
 B The strongest type of intermolecular force in hydrogen chloride is permanent dipole-dipole force.
 C The strongest intermolecular force in ethanol is permanent dipole-dipole force.
 D The strongest intermolecular force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

- 1.3 Which of the following factors can affect the value of the activation energy of a reaction?

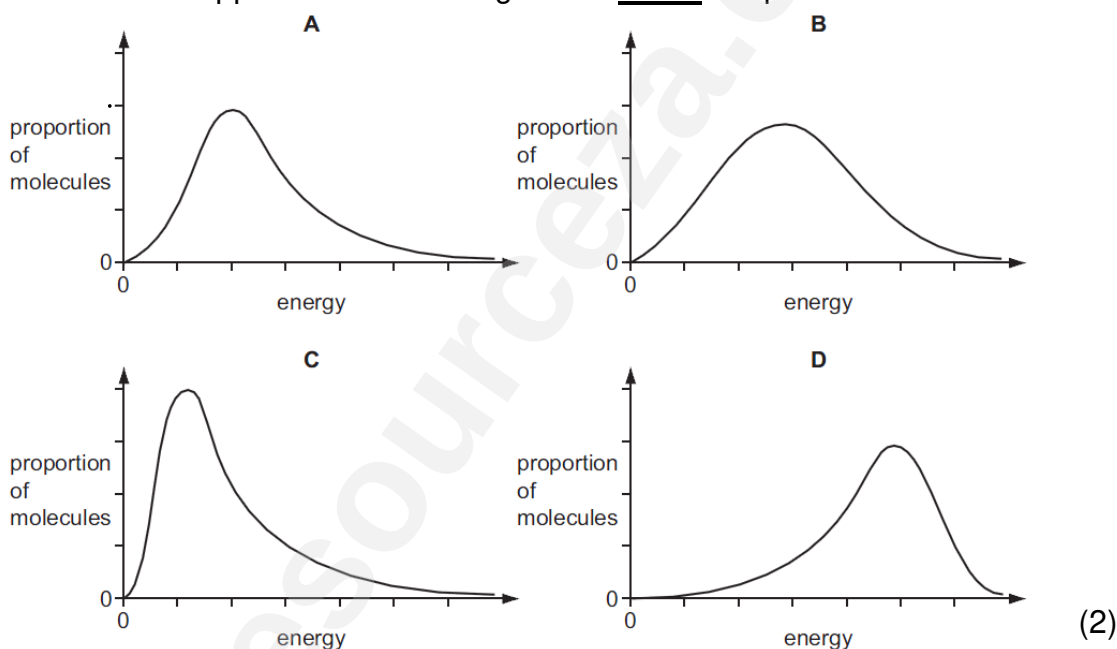
	Presence of a catalyst	Changes in temperature	Changes in the concentration of the reactants
A	x	x	✓
B	✓	x	✓
C	✓	✓	x
D	✓	x	x

(2)

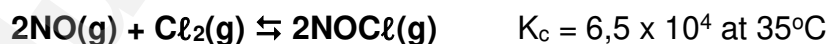
- 1.4 The molecular energy distribution curve represents the variation in energy of the molecules of a gas at room temperature.



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



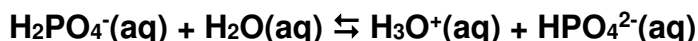
- 1.5 Consider the following reversible reaction:



Which one of the following statements correctly describes the relative concentrations of reactant and products in the system when equilibrium is established in a closed system at 35°C ?

- A The concentrations of reactants and products are equal.
- B There is a greater concentration of products than reactants.
- C The reactant concentration is greater than that of the products.
- D The concentrations of NO and NOCl are double the concentration of Cl_2 .

- 1.6 Identify a conjugate acid-base pair in the reaction represented by the following equation:

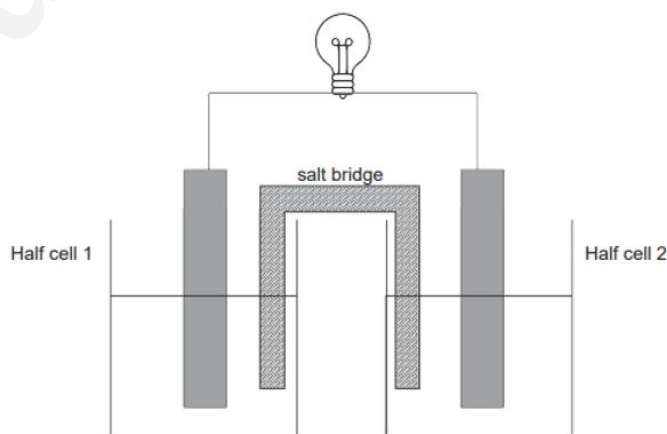


- A $\text{H}_2\text{PO}_4^-(\text{aq})$ and $\text{HPO}_4^{2-}(\text{aq})$
- B $\text{HPO}_4^{2-}(\text{aq})$ and $\text{H}_3\text{O}^+(\text{aq})$
- C $\text{H}_2\text{O}(\text{aq})$ and $\text{HPO}_4^{2-}(\text{aq})$
- D $\text{H}_2\text{PO}_4^-(\text{aq})$ and $\text{H}_2\text{O}(\text{aq})$ (2)

- 1.7 Which of the following statements is/are true for redox reactions?

- I) Redox reactions involve the transfer of electrons from one species to another.
 - II) Oxidation is the gain of electrons; reduction is the loss of electrons.
 - III) Oxidation and reduction take place simultaneously.
 - IV) Complete combustion is a redox reaction, but incomplete combustion is not.
- A I only
 - B I and III only
 - C I, II and III only
 - D I, III and IV only (2)

- 1.8 The diagram alongside shows an electrochemical cell that contains a light bulb.



Which of the following is TRUE?

The salt bridge

- A provides the ions that are oxidised or reduced at the electrodes.
- B maintains the overall electrical neutrality and pH neutrality of the cell by facilitating transfer of electrons and ions from one half cell to another.
- C provides ions and facilitates ion movement between the half cells to complete the electrical circuit.
- D provides the H_3O^+ and OH^- ions needed to maintain pH neutrality of each cell, preventing a build up of electrical charge in the electrolytes. (2)

1.9 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)

1.10 Bromine water is added to a sample of pent-1-ene. Assume that bromine water is the limiting reagent.

Which of the following statements identifies the type of reaction that occurs and the colour of the solution in the flask after the reaction is complete?

	Type of reaction	Solution colour after complete reaction
A	Addition	Colourless
B	Addition	Brown
C	Substitution	Brown
D	Substitution	Colourless

(2)

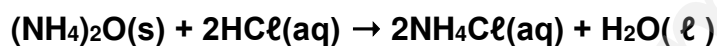
[20 marks]

QUESTION 2

To determine the percentage purity of an impure sample of ammonium oxide, $(\text{NH}_4)_2\text{O}$, a learner follows Steps A and B outlined below:

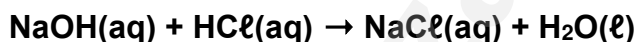
STEP A:

5 g of impure ammonium oxide is dissolved in 100 cm^3 of hydrochloric acid (HCl) of concentration $2 \text{ mol}\cdot\text{dm}^{-3}$. The acid (HCl) is added IN EXCESS.

**STEP B:**

The excess (leftover) HCl is titrated with sodium hydroxide solution (NaOH), to determine how much of the acid was in excess and DID NOT react with the $(\text{NH}_4)_2\text{O}$.

40 cm^3 of $0,6 \text{ mol}\cdot\text{dm}^{-3}$ sodium hydroxide solution neutralises the excess hydrochloric acid.



- 2.1 Calculate the number of moles of hydrochloric acid initially added to the ammonium oxide in STEP A. (3)

- 2.2 Calculate the number of moles of excess hydrochloric acid neutralised by the NaOH in STEP B. Answer to 3 decimal places. (3)

2.3 Use your answers to 2.1 and 2.2 to calculate how many moles of HCl reacted with the $(\text{NH}_4)_2\text{O}$ in STEP A. Answer to 3 decimal places. (2)

2.4 Hence calculate the percentage purity of the original $(\text{NH}_4)_2\text{O}$ sample. Assume that none of the impurities in the $(\text{NH}_4)_2\text{O}$ reacted with the acid. (5)

[13 marks]

QUESTION 3

3.1 The table below gives information about the boiling points of various substances which contain a halogen atom.

Substance	F ₂	Br ₂	HF	HBr	HCl	CH ₃ F	CH ₃ Br
Boiling point (°C)	-188	59	20	-66	-85	-78	4

3.1.1 Explain why bromine requires more energy to boil than fluorine does. (4)

3.1.2 Explain why the boiling points of hydrogen bromide (HBr), hydrogen chloride (HCl), and hydrogen fluoride (HF) differ. (5)

- 3.1.3 The boiling points of fluoromethane (CH_3F) and bromomethane (CH_3Br) differ by approximately 80°C .

Name the strongest type of intermolecular forces in these two substances. (2)

- 3.2 The melting point of potassium sulfate (K_2SO_4) is 197°C , and that of calcium sulfate is $1\,460^\circ\text{C}$.

- 3.2.1 Name the intramolecular bond in potassium sulfate. (2)

- 3.2.2 Explain the vast difference in melting points of these two substances. (3)

- 3.2.3 Write the balanced equation for potassium sulfate dissociating in water. (2)

- 3.2.4 Predict which substance is more soluble in water at room temperature: calcium sulfate or potassium sulfate. (2)

3.3 Hexane and 2,2-dimethylbutane are isomers.

3.3.1 Draw the structural formulae for each of these substances. (3)

Hexane

2,2-dimethylbutane

3.3.2 Which of hexane and 2,2-dimethylbutane has the stronger intermolecular forces? (1)

3.3.3 Explain your answer to 3.3.2. (3)

[27 marks]

QUESTION 4

- 4.1 40 cm of magnesium ribbon is rubbed gently with fine sandpaper until all the black residue is removed from its surface, and the ribbon shines. Four 10 cm lengths of magnesium ribbon are cut.

Magnesium reacts with hydrochloric acid as shown in the following equation:



- 4.1.1 Explain what is meant by *the rate of a reaction*. (2)

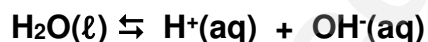
- 4.1.2 Is this reaction exothermic or is it endothermic? (1)

- 4.1.3 Why was it necessary to rub the magnesium ribbon with sandpaper to make it shine? (1)

- 4.1.4 With reference to the collision theory of reactions, describe how an increase in temperature increases the rate of this reaction. (4)

- 4.1.5 Suggest **two** other methods to increase the rate of this reaction, besides increasing the temperature or adding a suitable catalyst. (2)

- 4.2 **Pure water can self-ionise**, as shown by the following equation:



The reaction equilibrium and the pH of water are both affected by changes in temperature. The data in the following table show how changing the temperature affects the pH of pure water.

Temperature (°C)	pH of pure water
0	7,12
10	7,06
20	7,02
25	7,00
30	6,99
40	6,98

- 4.2.1 State *Le Chatelier's Principle*. (2)

- 4.2.2 Show how the tabulated data and Le Chatelier's Principle can be used to deduce whether the self-ionisation of water is exothermic or endothermic. Calculations are not required. (4)

- 4.2.3 Calculate the concentration of $\text{H}^+(\text{aq})$ ions in pure water at 100°C given that $K_w = 5,25 \times 10^{-15}$ at 100°C . (2)

- 4.2.4 The pH of pure water at 100°C is 6,14. Is pure water acidic at 100°C ? Briefly justify your answer. (2)

[20 marks]

QUESTION 5

- 5.1 Ammonia is manufactured by the Haber process. The reaction is shown by the equation that follows:

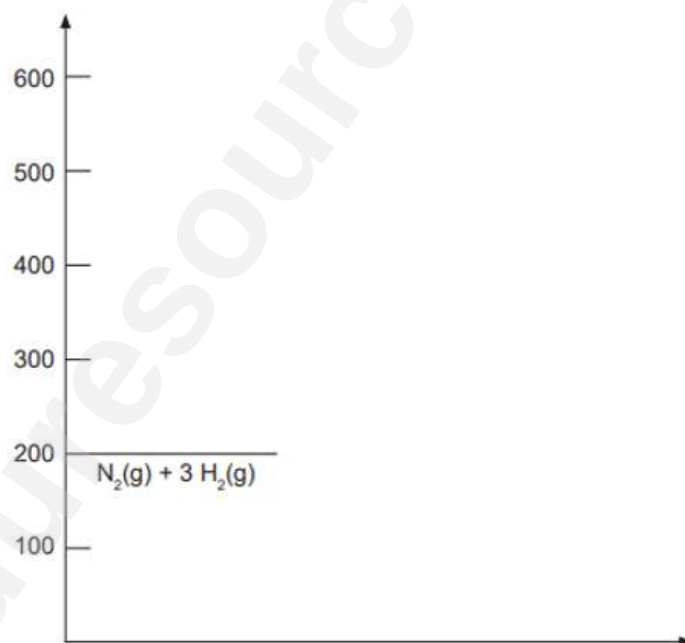


At 400°C, the equilibrium constant of this reaction is equal to $1,60 \times 10^{-2}$.
The activation energy of the forward reaction is $4,00 \times 10^2 \text{ kJ} \cdot \text{mol}^{-1}$.

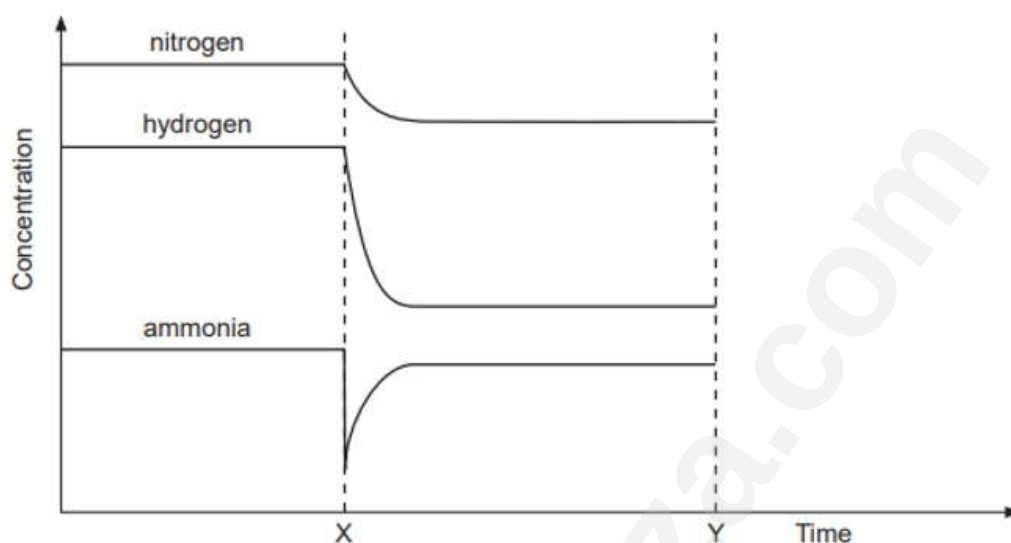
- 5.1.1 Use the following axes to sketch an energy profile diagram for the Haber process. Label the:

- axes
- products
- activation energy
- heat of the reaction

(4)



- 5.1.2 Some hydrogen, nitrogen and ammonia were sealed in a reaction vessel and their concentrations were monitored for a period, as shown in the following graph:



- a) A change was made in the reaction system at time $t = X$. Identify this change and **use the collision theory** to explain the shapes of the curves in the region X – Y. (5)

- b) The temperature of the reaction system was increased at time $t = Y$. Show on the graph how this affected the concentrations of hydrogen, nitrogen and ammonia as the system returned to equilibrium. (3)

5.2 The Contact Process is used to produce sulfuric acid. In this process sulfur dioxide is converted to sulfur trioxide as shown below by the equation for the equilibrium reaction:



This process is carried out at 450°C and at a pressure of 150 kPa in the presence of the catalyst, vanadium pentoxide (V_2O_5).

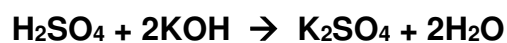
- 5.2.1 Briefly describe the function(s) of the catalyst, **and** its effect on the rate of the reactions. (3)

- 5.2.2 Comment on the choice of the reaction conditions (temperature and pressure), given that the aim is to produce the greatest yield in the shortest time, taking economic constraints into consideration. (5)

[20 marks]

QUESTION 6

- 6.1 In a titration, a 20 cm³ potassium hydroxide solution was neutralized by 15 cm³ of dilute sulfuric acid with a concentration of 0,1 mol·dm⁻³.



- 6.1.1 Which indicator will be most suitable for this titration? (2)

Choose from:

Indicator	PH range
phenolphthalein	8.2 - 10
methyl orange	3.1 - 4.4
bromothymol blue	6 - 7.6

- 6.1.2 Explain your choice of indicator in 6.1.1. (2)

- 6.1.3 Calculate the concentration of the potassium hydroxide solution. (5)

6.2 Butanoic acid undergoes the following hydrolysis reaction:



6.2.1 Define *hydrolysis*. (2)

6.2.2 Name the H_3O^+ ion. (2)

6.2.3 The butanoic acid concentration at 25°C was determined as $0,26 \text{ mol}\cdot\text{dm}^{-3}$.
The value of K_a at 25°C is $1,5 \times 10^{-5}$. Calculate the concentration of H_3O^+ ions. (4)

6.2.4 What is the effect on the value of K_a for this acid, if the temperature is raised to 60°C ? Explain your answer. (4)

- 6.3 1,23 g of powdered sodium carbonate is reacted with 25 cm³ nitric acid with a concentration of 0,58 mol·dm⁻³. The balanced reaction equation is shown below:



- 6.3.1 Determine, by calculation, which reactant is the limiting reagent in this reaction. (5)

- 6.3.2 Determine the maximum volume of carbon dioxide which can be released at S.T.P. during this reaction. (4)

6.3.3 The % yield of this reaction is 76%.

- a) Calculate the volume of carbon dioxide released during this reaction. (2)

- b) Give **two** reasons during the experimental process which could account for the less than 100% yield of carbon dioxide. (2)

[34 marks]

QUESTION 7

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



- 7.1.1 Give the energy conversion taking place in this galvanic cell. (2)

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

- 7.1.3 Name the component of the cell which is represented by $\parallel$. (2)

- 7.1.4 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)

- 7.1.5 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)

7.1.6 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?

a) Write down INCREASES, DECREASES or REMAINS THE SAME. (1)

b) Briefly explain your choice of answer to part (a). (2)

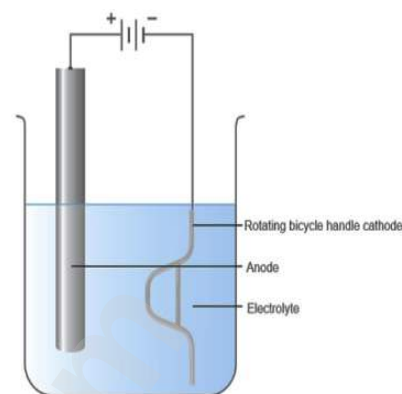
7.1.7 The surface area of both electrodes is increased equally, allowing them to have the same but larger surface area.

a) How does this affect the initial reading on the voltmeter? (1)

b) Briefly explain how increasing the surface area of the electrodes affects how this cell operates. (2)

- 7.2 Chromium plating is used to protect steel from corrosion and to improve the appearance of items, such as bath taps and bicycle handlebars. The diagram below shows a bicycle handlebar being plated with chromium.

0,02 mol of chromium are required to plate the bicycle handle. A current of 0,75 A is maintained during the process.



- 7.2.1 Why must the bicycle handle rotate during this process? (2)

- 7.2.2 **Name** a substance which can be used as the electrolyte in this process. (1)

- 7.2.3 a) Define *the anode* of this cell. (2)

- b) **Name** the material used for the anode of this cell. (2)

- 7.2.4 Write down the half reaction that occurs at the bicycle handle. (2)

- 7.2.5 How many moles of electrons are required to deposit 0,02 moles of chromium? (2)

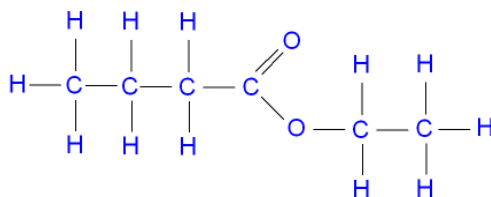
7.2.6 Calculate the time needed to deposit this amount of charge. (4)

7.2.7 This process uses a large amount of electricity. With reference to the charges on the ions, explain this statement. (2)

[35 marks]

QUESTION 8

The structure below shows an organic compound **X** that is used to give a pineapple flavour in sweets.



8.1 Write down the IUPAC name for the organic compound **X** above. (2)

8.2 Define the term: *homologous series*. (2)

8.3 Name the homologous series to which compound **X** belongs. (2)

8.4 Name the carboxylic acid used to make compound **X**. (1)

8.5 Write a balanced equation showing the preparation of compound **X**. Use STRUCTURAL FORMULAE in the equation. (3)

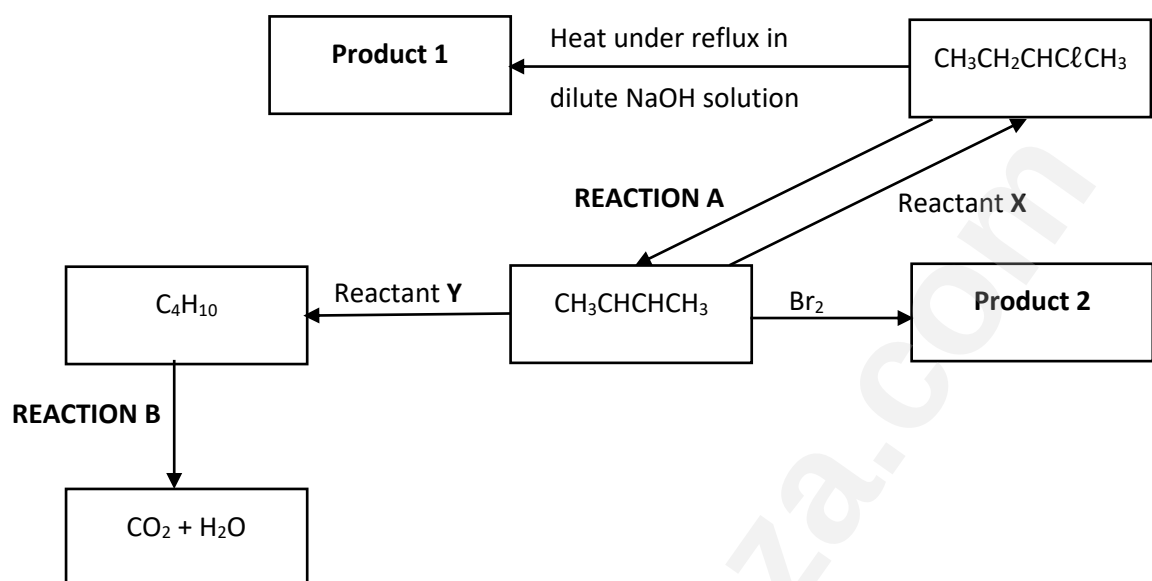
- 8.6 Write down the CONDENSED STRUCTURAL FORMULA of the functional isomer of compound **X**. (2)

- 8.7 Write down the name of one positional isomer of compound **X**. (2)

[14 marks]

QUESTION 9

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



9.1 Give the names of reactions **A** and **B**:

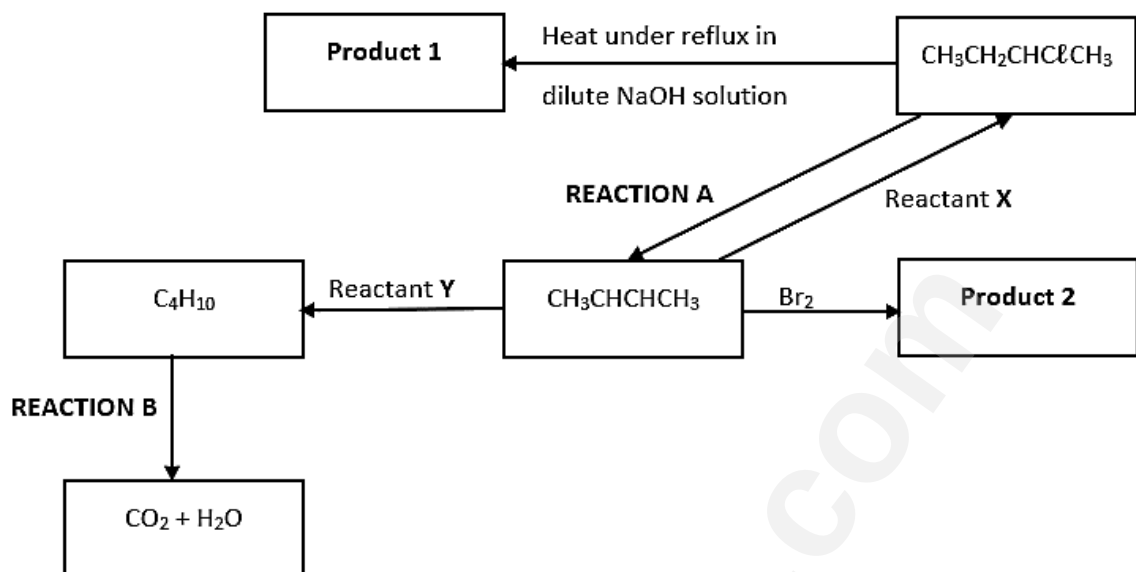
9.1.1 Reaction **A**: _____ (2)

9.1.2 Reaction **B**: _____ (2)

9.2 Give the chemical formulae of reactants **X** and **Y**.

9.2.1 Reactant **X**: _____ (1)

9.2.2 Reactant **Y**: _____ (1)



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

a) **Product 1**

_____ (1)

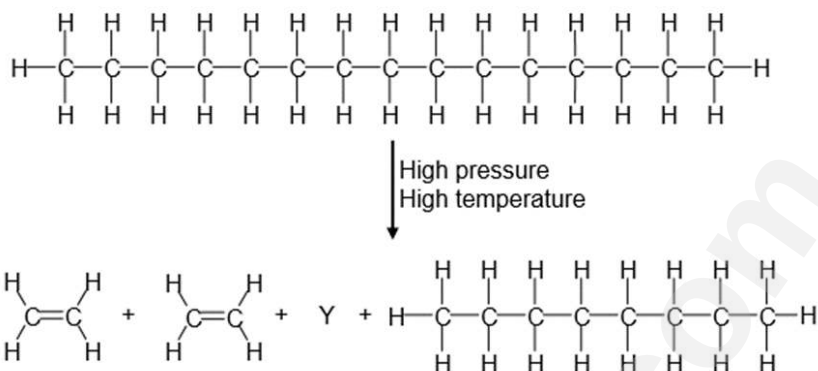
Structural formula: _____ (2)

b) **Product 2**

_____ (1)

Structural formula: _____ (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.

_____ (2)

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

_____ (1)

Structural formula: _____ (2)

[17 marks]