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**PHYSICAL SCIENCES PAPER 2
TRIAL EXAMINATION 2021**

Time: 3 Hours + 10 min reading time

Examiner: K. Storm

Total: 200

Moderator: I Evans

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of 16 pages, an ANSWER SHEET of 3 pages, and a Data Sheet. Please make sure that your question paper is complete.
2. Write your name on the question paper and answer book.
3. Read the questions carefully. All the questions must be answered.
4. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions must be answered on the GRID provided on the inside cover of your Answer Book. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	B	C	D
---	---	---	---

Here the answer C has been marked.

5. **START EACH QUESTION ON A NEW PAGE.**
6. Please ensure that your answers are numbered as the questions are numbered on this exam paper.
7. Unless instructed otherwise it is NOT necessary to give state symbols (phase indicators) when asked to write a balanced chemical equation.
8. Use the data and formulae whenever necessary.
9. Show all the necessary steps in calculations.
10. Where appropriate take your answers to 2 decimal places.
11. It is in your own interest to write legibly and to present your work neatly.

QUESTION 1

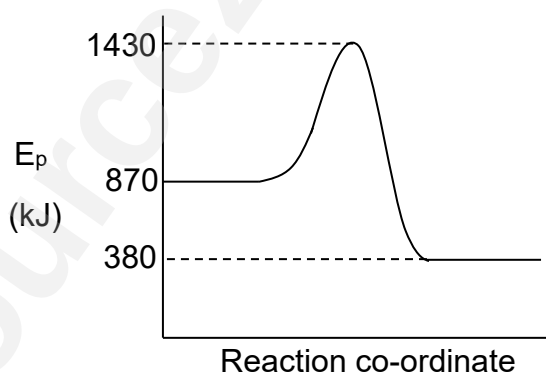
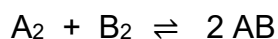
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MULTIPLE CHOICE

Answer questions 1.1 – 1.10 on the grid provided on the inside cover of your ANSWER BOOK.
There is only one correct answer for each of the multiple choice questions. Place a cross over the letter that represents the most correct answer.

1.1 In which one of the following pairs of compounds would you expect the chemical bonding in both compounds to be ionic?

- A NaCl; SO₂
- B MgF₂; K₂O
- C H₂S; Al₂S₃
- D CsCl; F₂

1.2 The energy profile for the following reaction is given:



What is the activation energy for the reverse reaction?

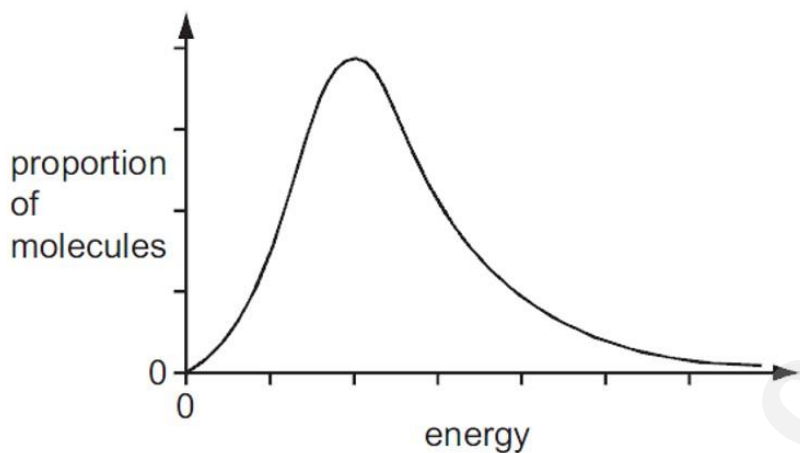
- A 1430 kJ
- B 715 kJ.mol⁻¹
- C 560 kJ
- D 525 kJ.mol⁻¹

1.3 Which one of the following substances will have a very weak conjugate base?

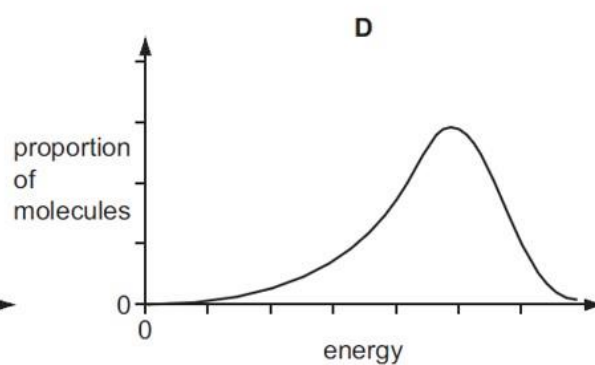
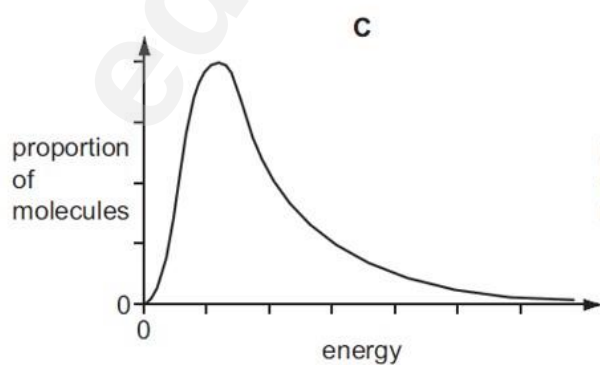
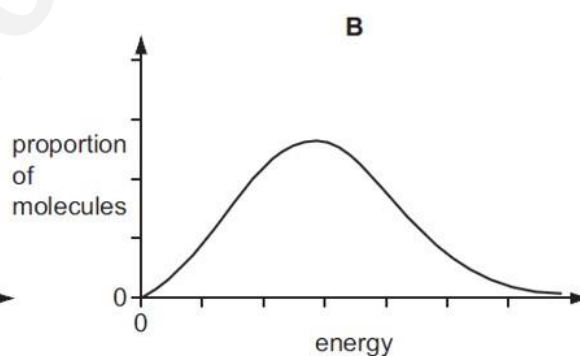
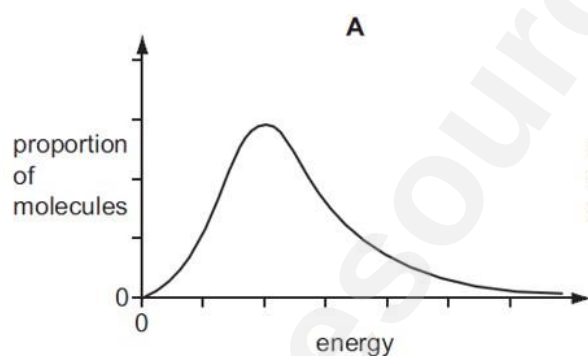
- A H₂O
- B KOH
- C HSO₄⁻
- D HCO₃⁻

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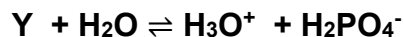
- 1.4 The molecular energy distribution curve represents the variation in energy of the molecules of a gas at room temperature.



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

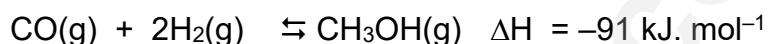


- 1.5 Consider the reactant Y in the following reaction:



The formula of Y is:

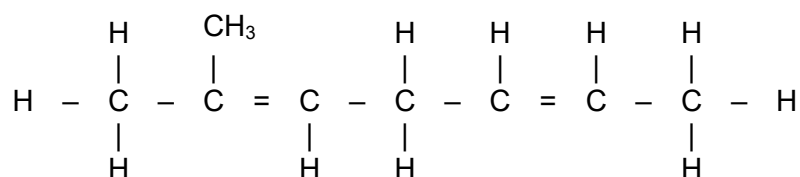
- A PO_4^{3-}
 - B $H_2PO_4^-$
 - C HPO_4^{2-}
 - D H_3PO_4
- 1.6 Methanol is synthesised from carbon monoxide and hydrogen according to the equation below.



Which one of the following changes would **not** affect the value of the equilibrium constant and would **not** increase the yield of methanol?

- A. increase in temperature
 - B. decrease in temperature
 - C. increase in pressure
 - D. decrease in pressure
- 1.7 When the standard hydrogen electrode is connected to a $Zn|Zn^{2+}$ half-cell, which one of the following statements is CORRECT?
- A Zn is the oxidising agent.
 - B H^+ is the oxidising agent.
 - C H_2 is oxidised.
 - D Zn^{2+} is reduced.
- 1.8 Which one of the following statements about the recovery of aluminium from bauxite is FALSE?
- A Cryolite reduces the running costs of the cell.
 - B Carbon dioxide is produced during the process.
 - C The aluminium produced in the cell is molten.
 - D The graphite cathode is corroded during operation.

1.9 What is the IUPAC name for the organic compound shown below?



- A 2-methylhept-2,5-diene
- B 2-methylhepta-2,5-diene
- C 2-methylheptan-2,5-diene
- D 6-methylhepta-2,5-diene

1.10 Which pair of substances correctly matches the reactant and product of an addition reaction?

	<i>Reactant</i>	<i>Product</i>
A.	$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{OH}$	$\text{CH}_3 - \text{CH}_2 - \text{CH} = \text{CH}_2$
B.	$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \underset{\text{OH}}{\text{CH}} - \text{CH}_3$	$\text{CH}_3 - \text{CH}_2 - \text{CH} = \text{CH} - \text{CH}_3$
C.	$\text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3$	$\text{CH}_3 - \text{CH}_2 - \underset{\text{Cl}}{\text{CH}} - \text{CH}_2 - \text{CH}_3$
D.	$\text{CH}_3 - \underset{\text{OH}}{\overset{\text{O}}{\text{C}}}$	$\text{CH}_3 - \underset{\text{O} - \text{CH}_3}{\overset{\text{O}}{\text{C}}}$

(10 x 2) [20]

QUESTION 2

- 2.1 2.1.1 Write down the name of the compound LiMnO_4 . (1)
- 2.1.2 Write down the formula for potassium hydrogen carbonate. (1)
- 2.1.3 Define *electronegativity*. (2)

- 2.2 You are provided with a list of substances below. The state labels of each substance is at room temperature. Answer the questions below.

Ni(s) CS₂(g) C(s) NH₃(g) NaNO₃(s) SiO₂ (s) He(g)

For each question below, select only **one** substance from the list above that:
(A substance may be used more than once)

- 2.2.1 is an inert, monatomic substance. (1)
- 2.2.2 has a high melting point due to strong electrostatic forces between the cations and anions. (1)
- 2.2.3 has 3 polar covalent bonds and one lone pair of electrons. (1)
- 2.2.4 has delocalised valence electrons. (1)
- 2.2.5 has non-polar covalent bonds and has an extremely high melting point due to the giant lattice structure. (1)
- 2.2.6 has hydrogen bonding intermolecular forces. (1)
- 2.2.7 can conduct electricity when molten. (1)
- 2.2.8 is a weak base. (1)
- 2.3 Iodine is a solid at room temperature.
- 2.3.1 Define an *intermolecular force*. (2)
- 2.3.2 Identify the specific type of **intramolecular** bond that holds atoms of iodine (I_2) together. (2)
- 2.3.3 Identify the specific type of **intermolecular force** that holds molecules of iodine together. (1)
- 2.3.4 Give one reason why iodine crystals do not conduct electricity. (1)

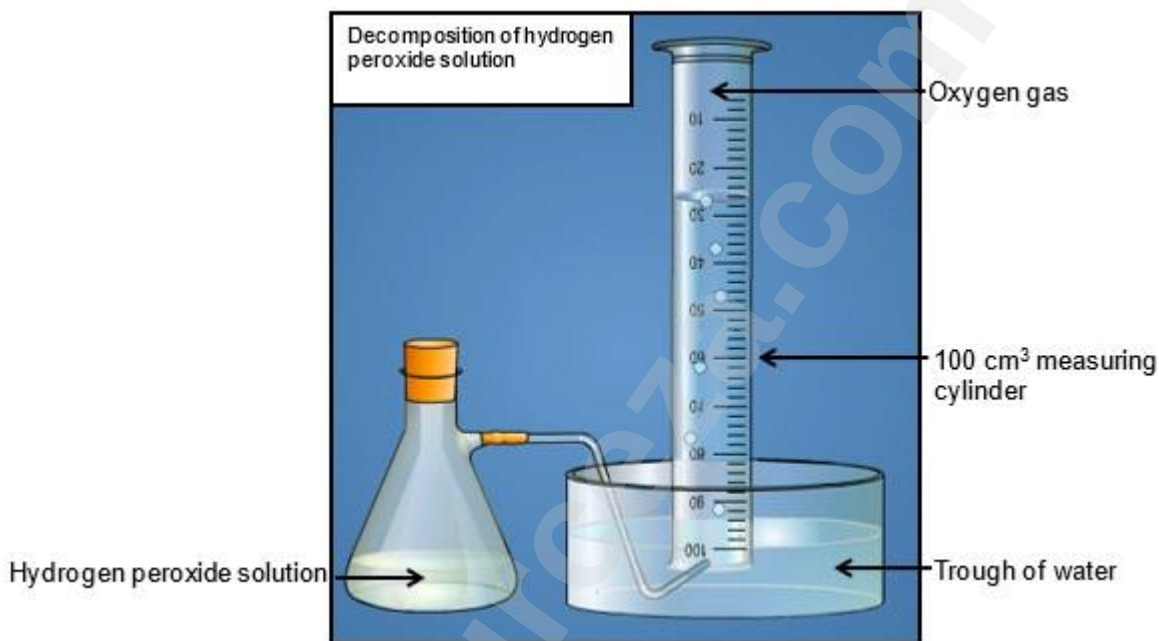
[18]

QUESTION 3

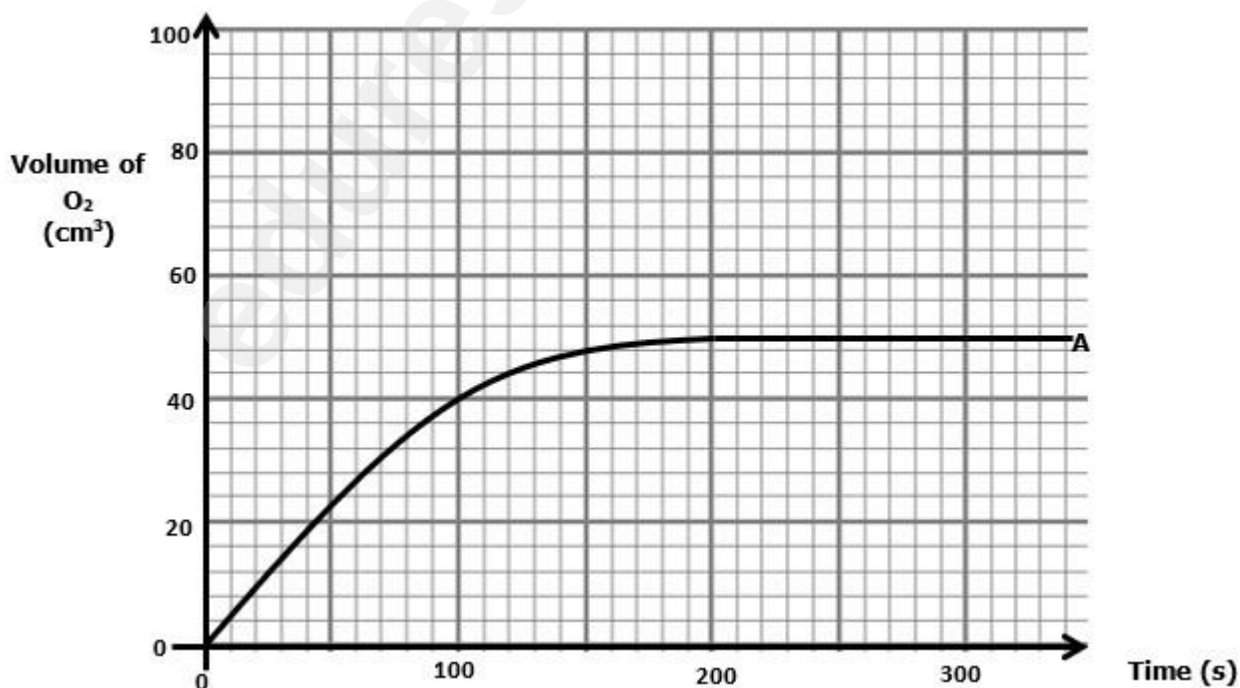
Hydrogen peroxide (H_2O_2) solution spontaneously decomposes to release oxygen gas.



Dylan conducts experiments to investigate the factors influencing the rate of this decomposition. He sets up his apparatus as shown in the diagram below. Every 5 seconds he records the volume of oxygen that has collected by the downward displacement of water in the measuring cylinder.



The graph below (**curve A**) shows how the volume of oxygen produced varies with time when **40 cm³ of a 0,1 mol.dm⁻³** solution of hydrogen peroxide, H_2O_2 , decomposes at 60 °C.

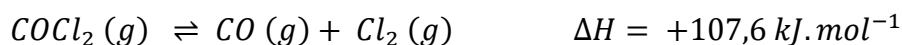


- 3.1 Use the graph to calculate the **average reaction rate** (in $\text{cm}^3 \cdot \text{s}^{-1}$) for the following time intervals:
- 3.1.1 0 to 100 s (2)
- 3.1.2 100 s to 200 s (2)
- 3.2 Does the reaction rate *increase, decrease or remain constant* with time? (1)
- 3.3 Use the collision theory to explain why the reaction rate changes in the manner given in your answer to Question 3.2. (4)
- 3.4 Calculate the maximum volume of oxygen gas that could be produced from the complete decomposition of 40 cm^3 of a $0,1 \text{ mol} \cdot \text{dm}^{-3}$ solution of hydrogen peroxide **at STP**. Give your final answer in cm^3 . (6)
- 3.5 Suggest a reason why the maximum volume of oxygen produced in the experiment as shown in the graph is greater than your answer calculated in Question 3.4. (2)
- 3.6 Using the new conditions given below, sketch curves, on the axes given on the ANSWER SHEET, to illustrate how the volume of oxygen produced would change with time if the experiment was repeated at 60°C .
- Note: Marks will be awarded for the accuracy of the finishing points of your curves as well as for the steepness of their gradients relative to the original curve A.
- 3.6.1 40 cm^3 of a $0,2 \text{ mol} \cdot \text{dm}^{-3} \text{ H}_2\text{O}_2$ solution.
Draw this graph with a dark solid pencil line (—) and label it **curve B**. (2)
- 3.6.2 80 cm^3 of a $0,05 \text{ mol} \cdot \text{dm}^{-3} \text{ H}_2\text{O}_2$ solution.
Draw this graph with a dark dashed pencil line (- - -) and label it **curve C**. (2)
- 3.6.3 20 cm^3 of a $0,1 \text{ mol} \cdot \text{dm}^{-3} \text{ H}_2\text{O}_2$ solution with a catalyst.
Draw this graph with a dash-dot pencil line (- · - ·) and label it **curve D**. (2)
- 3.7 Manganese (IV) oxide, can be used to catalyse this reaction.
- 3.7.1 Write down the chemical formula for manganese (IV) oxide. (1)
- 3.7.2 Define the term '*catalyst*'. (2)
- 3.7.3 How will the addition of the catalyst affect:
- (a) the **rate** and
- (b) the **yield**?
- In each case, state INCREASE, DECREASE or NO EFFECT. (2)

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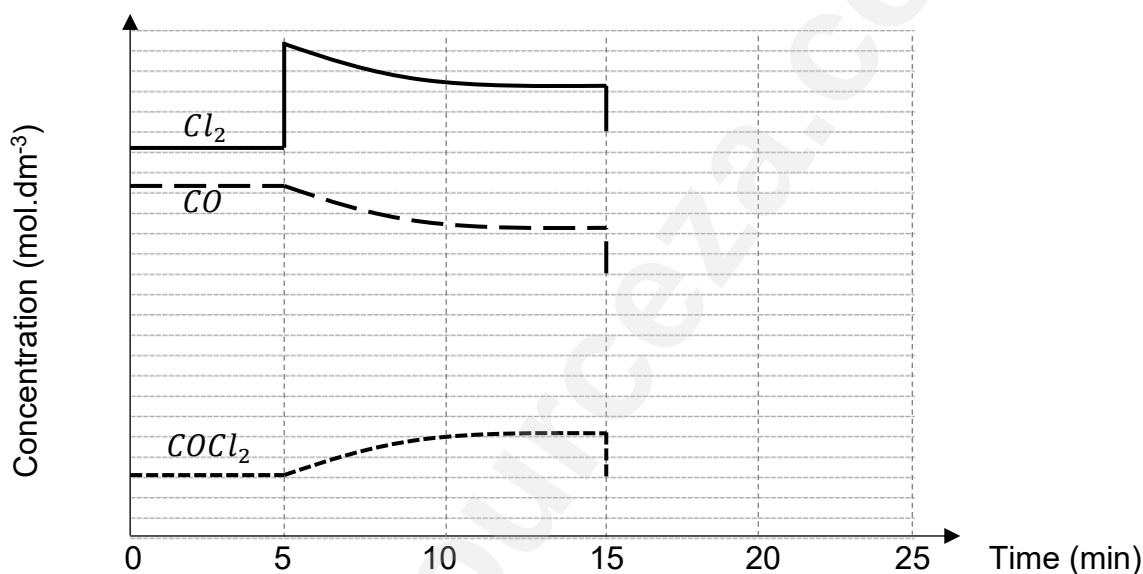
QUESTION 4

Phosgene gas, COCl_2 , exists in equilibrium with carbon monoxide and chlorine gas in a container with a variable volume. The equilibrium is represented by the following balanced equation:



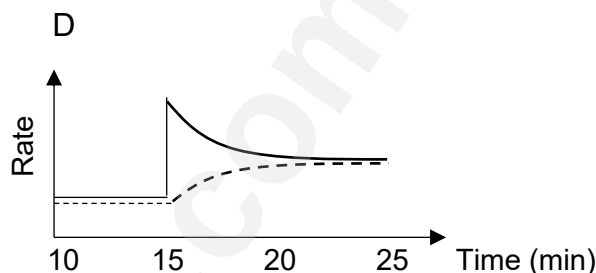
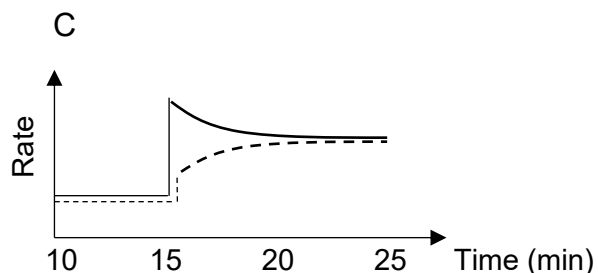
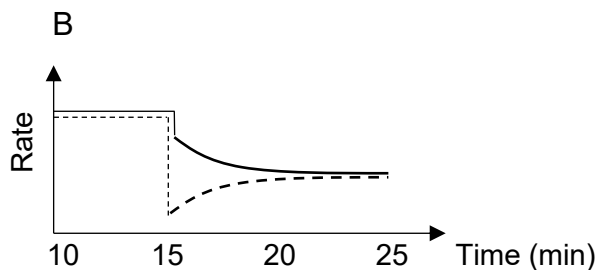
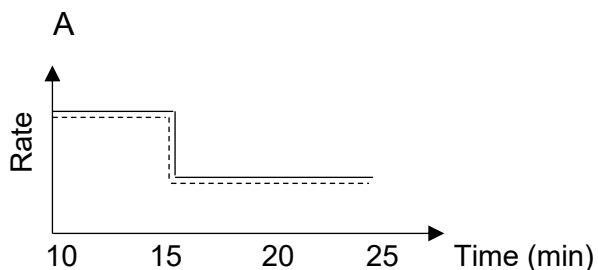
The K_c value for this reaction at 395°C is $1,2 \times 10^3$.

The graph below shows the substances already at equilibrium at $t = 0$ minutes.



- 4.1 Identify the stress that occurred at 5 minutes. (1)
- 4.2 Use Le Châtelier's Principle to explain the changes that occurred between 5 and 10 minutes on the graph. (3)
- 4.3 Define *concentration*. (2)
- 4.4 Identify the disturbance to the equilibrium that occurred at 15 minutes and explain how this would have been brought about. (2)
- 4.5 On the ANSWER SHEET, complete the graph given in order to show the changes to the concentration of each substance allowing for the equilibrium to be re-established at 20 minutes. (4)

- 4.6 Which one of the following rate versus time graphs is the most correct for the period between 10 and 25 minutes? Write down only the letter that represents the correct answer.



(2)

- 4.7 At 25 minutes a further stress acted on the system and once equilibrium had been re-established, the new equilibrium concentrations were as follows:

$$[COCl_2] = 0,009 \text{ mol. dm}^{-3}$$

$$[CO] = 0,40 \text{ mol. dm}^{-3}$$

$$[Cl_2] = 0,52 \text{ mol. dm}^{-3}$$

- 4.7.1 Calculate the K_c for the reaction at the new equilibrium. (4)

- 4.7.2 Use your answer from 4.7.1 above to identify the exact nature of the stress that acted on the system at 25 minutes. Explain your answer fully. (5)

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QUESTION 5

- 5.1 Define *weak base*. (2)
- 5.2 An ammonia solution ($\text{NH}_3(\text{aq})$) has a K_b value at 25°C of $1,8 \times 10^{-5}$.
- $$\text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$$
- 5.2.1 Write an expression for K_b for ammonia (aq). (2)
- 5.2.2 Is an ammonia solution considered to be a good or poor electrical conductor? (1)
- 5.2.3 Use the K_b value to explain your answer. (2)
- 5.3 An ammonium salt (NH_4NO_3) is dissolved in water. Explain, using a suitable equation, whether the solution formed is **acidic, basic or neutral**. (4)

[11]

QUESTION 6

A student carries out an acid-base titration. There is a trial run and then a further three titrations which are represented in the diagram that follows. This is a record of the initial and final burette readings for the three **further** titrations.

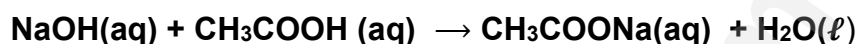
Titration 1		Titration 2		Titration 3	
Initial reading	Final reading	Initial reading	Final reading	Initial reading	Final reading
					

- 6.1 Complete the table of the student's readings on your ANSWER SHEET. (3)
- 6.2 Are these results precise? Justify your answer with reference to the burette readings. (2)

- 6.3 Commercial sodium hydroxide (NaOH) is sold as caustic soda and is impure.
30,0 g of impure NaOH is dissolved and made up to a solution with a volume of 250 cm³.

10,0 cm³ of this solution is titrated against a standard solution of ethanoic acid and is neutralised by 13,5 cm³ of acid with a concentration of 0,5 mol·dm⁻³.

The reaction for the neutralisation is:



- 6.3.1. Define *neutralisation*. (2)
- 6.3.2 Calculate the concentration of the sodium hydroxide solution that **reacted**. (5)
Calculate to four decimal places.
- 6.3.3 Determine the hydronium ion concentration of the original sodium hydroxide solution at 25°C. Assume that there are no other contaminants that affect hydronium ions. (3)

You are given a table of data of several indicators.

Indicator	pH range	Lower pH colour	Higher pH colour
Pentamethoxy red	1.2-3.2	Violet	colourless
Naphthyl red	3.7-5.0	Red	Yellow
4-nitrphenol	5.6-7.0	Colourless	Yellow
Cresol purple	7.6-9.2	yellow	Purple

- 6.4 Write down the name of a suitable indicator for this titration and explain your choice. (3)

[18]

QUESTION 7

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

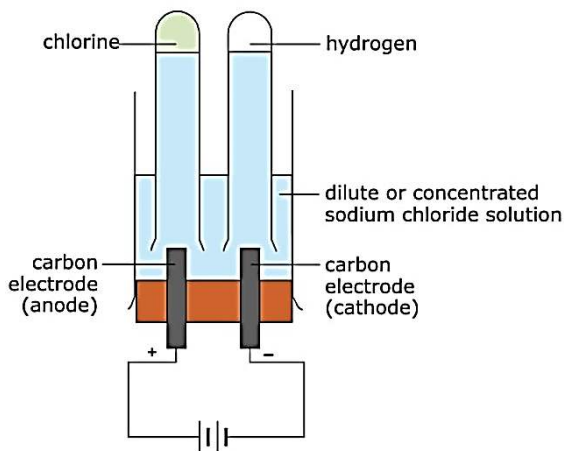


- 7.1 Give the energy conversion taking place in this galvanic cell. (2)
- 7.2 Name the component of the cell represented by the double lines ($\parallel$) in the above cell notation. (1)
- 7.3 State the TWO standard conditions that are applicable to the $\text{Pb}^{2+}(\text{aq}) \mid \text{Pb(s)}$ half-cell. (2)
- 7.4 Identify the **oxidising agent** in the above cell. (1)
- 7.5 The initial reading on a voltmeter connected across the electrodes of the above cell is **1,53 V** . Identify metal X by calculating the standard electrode potential of the unknown metal X and then referring to the RedoxTable. (4)
- 7.6 Write down the balanced equation for the net ionic (overall) reaction taking place in this cell. (Use the correct symbol for element X according to 7.5.) (3)
- 7.7 How will the initial voltmeter reading be affected if the concentration of the electrolyte in the $\text{X(s)} \mid \text{X}^{3+}(\text{aq})$ half-cell is increased? Write down INCREASES, DECREASES or REMAINS THE SAME and give a brief explanation for your answer, with reference to Le Chatelier's principle. (3)
- 7.8 Write down the value of the reading on the voltmeter when the cell reaction has reached equilibrium. (1)

[17]

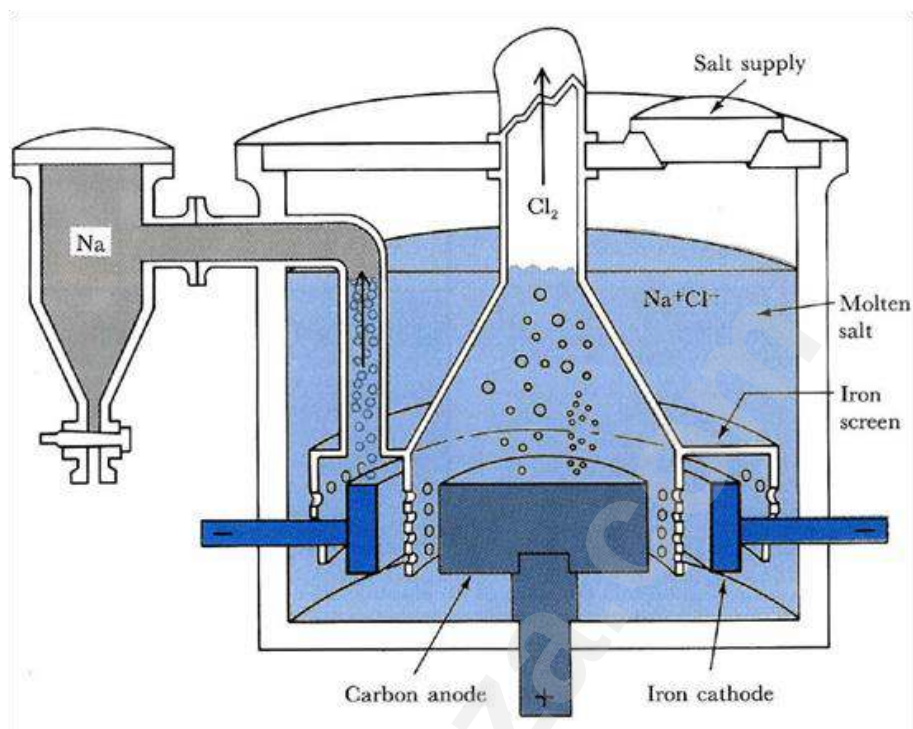
QUESTION 8

- 8.1 Sodium chloride can be easily dissolved in water. The diagram below shows the apparatus used to electrolyse aqueous sodium chloride (brine). Two gases, hydrogen and chlorine, are formed as products.



- 8.1.1 Write down the half-reaction that takes place at the positive electrode. (2)
- 8.1.2 Give one reason why carbon is used for the electrodes? (1)
- 8.1.3 Explain why a brine solution is a suitable electrolyte.
Refer to the type of bonding that takes place in brine. (2)
- 8.1.4 Use the relative strengths of the oxidising agents present to explain why sodium metal is NOT produced at the cathode in the cell above. (2)
- 8.2 A **constant** current of 4 000 A is passed through a chlor-alkali cell for 2,5 minutes. Calculate the volume of chlorine gas produced, at STP, at the anode during this period of time. (9)

8.3 The diagram below shows the apparatus used to electrolyse molten NaCl.



The effect of current on the mass of sodium produced was measured. The current was passed through the molten NaCl for 10 minutes each time. The results are tabulated below.

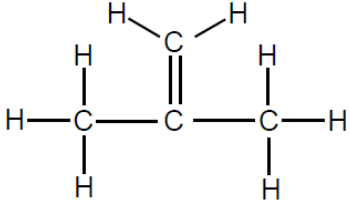
Current	Mass of Na
1,0 A	0,14 g
4,0 A	0,57 g
6,8 A	1,00 g
12,0 A	1,72 g
13,6 A	1,94 g

- 8.3.1 Explain why it is not economical to use molten NaCl. (2)
- 8.3.2 State one error in the format of the table. (1)
- 8.3.3 Plot a graph of the data on the graph paper provided ensuring that the correct variables appear on each axis. (6)
- 8.3.4 Use your graph to predict the mass of sodium that would be produced if a current of 2,5 A was used. (2)
- 8.3.5 What is the relationship between the current and the mass of sodium deposited, as shown by your graph? (2)

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QUESTION 9

The letters **A** to **D** in the table below represent four organic compounds.

A	Ethyl propanoate	B	pentan-1-ol
C		D	2,2-dimethylbutane

9.1 Answer the following questions with respect to Compound **A**.

- 9.1.1 Name the homologous series to which this compound belongs. (1)
- 9.1.2 Name of the type of reaction of which this compound is the product. (1)
- 9.1.3 Give the reaction conditions for the reaction that will lead to the formation of this compound. (2)
- 9.1.4 Write the balanced chemical equation for the formation of this compound using structural formulae. (4)
- 9.1.5 Give the IUPAC NAME of a functional isomer of Compound **A** with no substituents (side chains). (2)

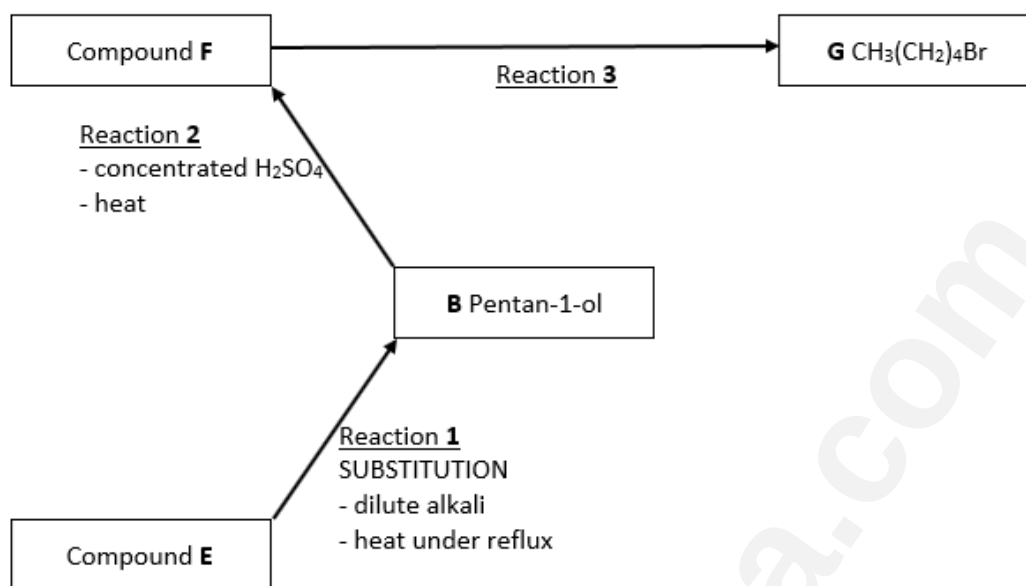
9.2 Study compound **C**.

- 9.2.1 Write down the IUPAC name of this compound. (2)
- 9.2.2 Is this compound SATURATED or UNSATURATED? Give a reason for the answer. (2)
- 9.2.3 Write a balanced chemical equation, using molecular formulae, for the combustion of Compound **C**. (5)

9.3 Rank the boiling points of compounds **A**, **B** and **D** from lowest to highest. Explain your order by referring to the relative strengths of intermolecular forces. (5)

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9.4 Some of the reactions of Compound **B** are represented in the flow diagram below.



9.4.1 Define the term *functional* group. (2)

9.4.2 Name the functional group present in Compound **B**. (1)

9.4.3 Give the condensed structural formula of Compound **B**. (2)

9.4.4 Give the IUPAC name for Compound **E**. (2)

9.4.5 Give the structural formula for Compound **F**. (2)

9.4.6 What type of reaction is Reaction **2**? (1)

9.4.7 Name the type of reaction and give the necessary reactant for Reaction **3**. (2)

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