Please paste the barcoded label here	TOTAL MARKS

NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2024

PHYSICAL SCIENCES: PAPER II

EXAMINATION NUMBER													

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 28 pages as well as a DATA SHEET of 3 pages (i–iii). 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 examination number in the space provided on the question paper.**
4. Unless instructed otherwise, you do NOT have to give state symbols (phase indicators) when asked to write a balanced chemical equation.
5. Use the data and formulae whenever necessary.
6. Show all the necessary steps in calculations.
7. Where appropriate, give your answers to two decimal places.
8. It is in your own interest to write legibly and to present your work neatly.
9. TWO blank pages (pages 26 and 27) and extra graph paper (page 28) are included at the end of the examination paper. If you run out of space for an answer, use these pages. Clearly indicate the number of your answer should you use this extra space.

FOR OFFICE USE ONLY: MARKERS TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Total
Mark										
Marker Initial										
Moderated Mark										
Moderator Initial										
Question Total	**20**	**14**	**32**	**25**	**28**	**20**	**21**	**17**	**23**	**200**
Re-mark										
Initial										
Code										

QUESTION 1 MULTIPLE CHOICE

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

A	B	C	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 If a scientific experiment yields precise results, it means that …

A the measuring equipment was correctly calibrated.
B all variables other than the independent variable were fixed.
C similar results will be obtained when the experiment is repeated.
D the average of the repeat results is close to the accepted value.

1.2 In which one of the following compounds will each ion contain the same number of electrons as argon?

A Be_3P_2
B Ca_3P_2
C $A\ell_2S_3$
D Mg_3N_2

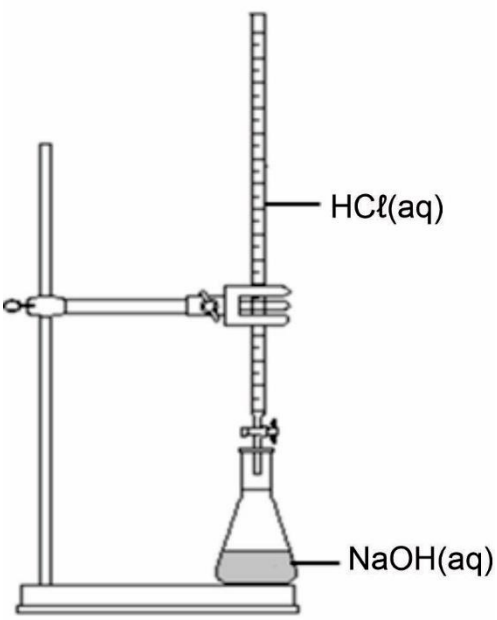
1.3 A standard solution is one with a …

A volume of 22,4 dm^3 at STP.
B concentration of 1 $mol \cdot dm^{-3}$.
C pH of 7 at 25 °C.
D known concentration.

1.4 Which one of the following statements is **always** true for monoprotic acids?

A The lower the concentration of the acid solution, the weaker the acid.
B There will be more H_3O^+ ions in 100 cm^3 of a strong acid solution than in 100 cm^3 of a weak acid solution.
C The pH of a strong acid is lower than the pH of a weak acid.
D One mole of a strong acid will produce more H_3O^+ ions in water than one mole of a weak acid.

1.5 In a titration of HCℓ against standard NaOH as shown below, the burette and the flask are washed with distilled water but not dried before the solutions are added to them.



The concentration of the acid as calculated from the titration is …

A not affected by the wet apparatus.
B affected by both pieces of wet apparatus.
C only affected by the wet flask.
D only affected by the wet burette.

1.6 Adding a catalyst to a reaction in equilibrium will speed up …

A the forward and reverse reactions equally, and increase the yield.
B the forward and reverse reactions equally, and not affect the yield.
C the forward reaction more than the reverse reaction, and increase the yield.
D the forward reaction more than the reverse reaction, and not affect the yield.

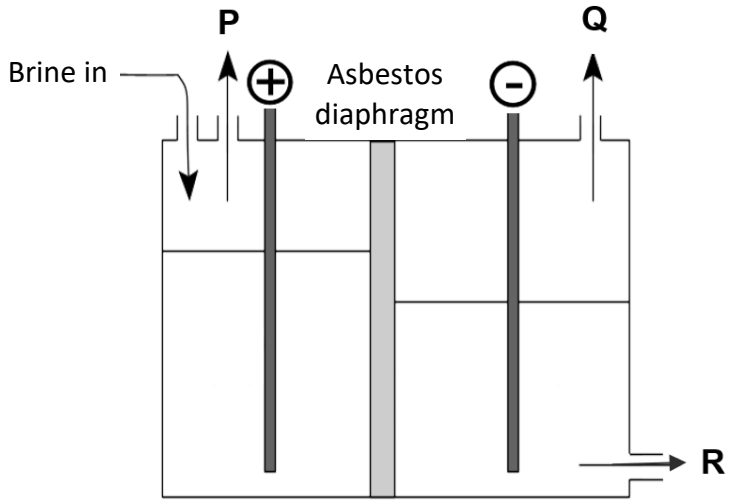
1.7 In a galvanic cell, the flow of electrons is from the …

A cathode to the anode through the salt bridge.
B anode to the cathode through the salt bridge.
C reducing agent to the oxidising agent through the external circuit.
D oxidising agent to the reducing agent through the external circuit.

1.8 The electrorefining of copper makes use of …

A an electrolytic cell with pure copper as the cathode.
B an electrolytic cell with pure copper as the anode.
C a galvanic cell with pure copper as the cathode.
D a galvanic cell with pure copper as the anode.

1.9 A simplified diagram of a diaphragm cell used in the Chlor-Alkali process is given below.



Which one of the following statements is true?

A Chloride ions cannot pass through the diaphragm.
B The sodium ions are spectator ions in this type of cell.
C The raw material can be any concentrated sodium salt solution.
D Product **P** is hydrogen gas.

1.10 Which one of the following compounds is an alkene?

A C_6H_{12}
B C_2H_2
C $C_{10}H_{22}$
D C_4H_8O

[20]

QUESTION 2

Intermolecular forces hold compounds together in the liquid or solid state.

2.1 Explain the formation of London forces between molecules. (3)

2.2 Consider the following substances: CH_3OH, CO, N_2

2.2.1 State the **specific** type of intramolecular bond found in: (2)

CO

N_2

2.2.2 Methanol, CH_3OH, has hydrogen bonding. Using structural formulae, draw a diagram showing the hydrogen bonding in methanol. Clearly label one of the hydrogen bonds. (3)

2.2.3 The boiling points of CO and N_2 can be compared because their molecules are isoelectronic (i.e. they have the same number of electrons).

Which of CO or N_2 will have the higher boiling point? Explain the answer by making reference to the relative strengths of ALL intermolecular forces present. (6)

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QUESTION 3

The decomposition of hydrogen peroxide is an exothermic redox reaction where H_2O_2 acts as both a reducing agent and an oxidising agent.

$$2H_2O_2 \rightarrow 2H_2O + O_2 \qquad \Delta H < 0$$

3.1 Define a *redox reaction*. (2)

3.2 Using the table of standard electrode potentials, write down equations for:

3.2.1 The half reaction for the oxidation of H_2O_2. (1)

3.2.2 The half reaction for the reduction of H_2O_2. (1)

3.3 Circle the correct option between the brackets: (1)

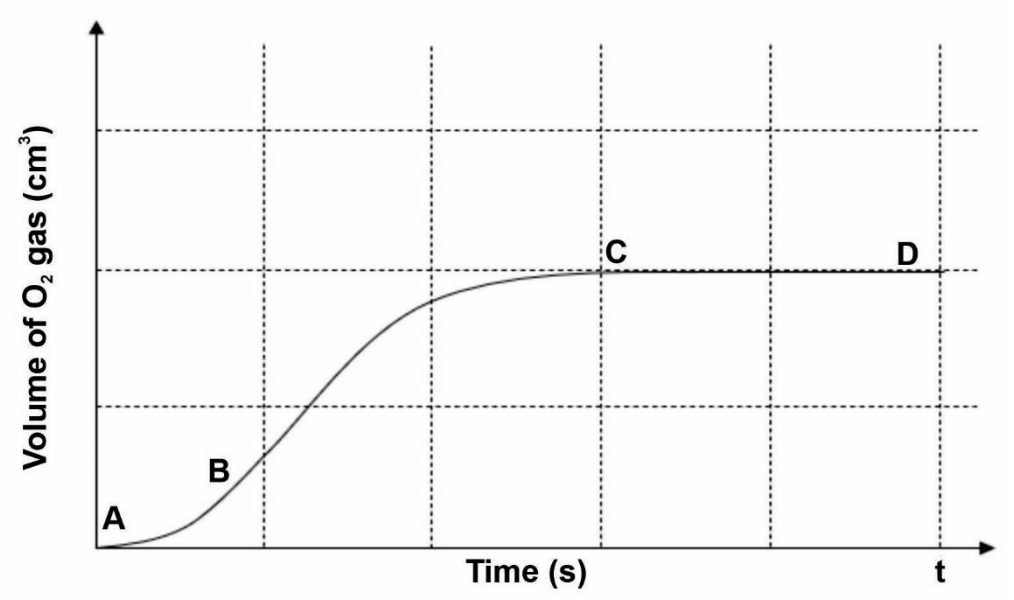
The rate of decomposition of H_2O_2 is (EQUAL TO / HALF / DOUBLE) the rate of formation of the oxygen gas.

3.4 Define *exothermic reactions*. (2)

A 50 cm^3 sample of H_2O_2 of concentration 0,2 $mol \cdot dm^{-3}$ decomposed when the catalyst MnO_2 was added to it. The reaction equation is repeated below:

$$2H_2O_2 \rightarrow 2H_2O + O_2 \qquad \Delta H < 0$$

The O_2 gas produced was collected in a gas syringe. The following graph shows the volume of gas collected against time.



3.5 Define *catalyst*. (2)

3.6 Consider the intervals shown on the graph. Circle the correct option between the brackets and provide a reason. (Do not refer to the shape of the graph in your answers.)

3.6.1 In interval **AB**, the shape of the graph shows that the rate of decomposition of H_2O_2 is …

(INCREASING / DECREASING / CONSTANT / ZERO) (1)

The reason for this rate is … (2)

3.6.2 In interval **CD**, the shape of the graph shows that the rate of decomposition of H_2O_2 is …

(INCREASING / DECREASING / CONSTANT / ZERO) (1)

The reason for this rate is … (2)

3.7 On the axes on page 8, draw the curves that would be obtained when repeating the experiment, keeping all conditions the same, except:

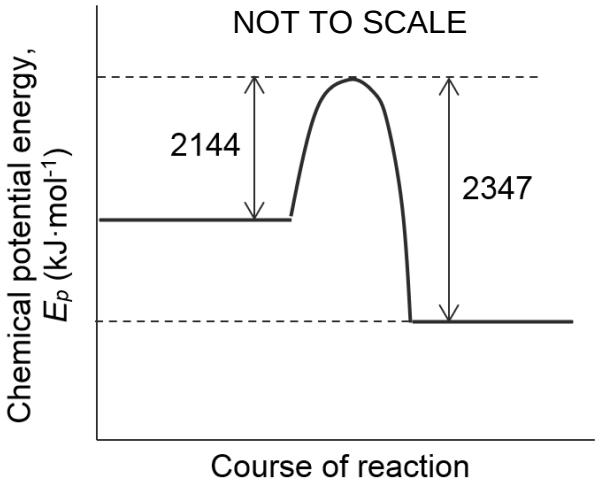
3.7.1 The concentration of the H_2O_2 is changed to 0,3 mol·dm^{-3}.
Label this curve **C2**. (2)

3.7.2 The H_2O_2 is cooled before starting the experiment.
Label this curve **T2**. (2)

NOTE: In both cases the reaction goes to completion before the time t indicated on the x-axis.

3.8 Refer to the collision theory to explain how the increased concentration affects the reaction rate. (5)

3.9 The energy-profile graph for the decomposition of H_2O_2 is shown below.



3.9.1 Define the *activated complex*. (2)

3.9.2 Label the position of the activated complex with an **X**, on the graph. (1)

3.9.3 On the same axes draw the curve that will be obtained for the catalysed reaction. (2)

3.9.4 What does the value of 2 347 kJ·mol^{-1} represent? (1)

3.9.5 Calculate ΔH for the reaction. (2)

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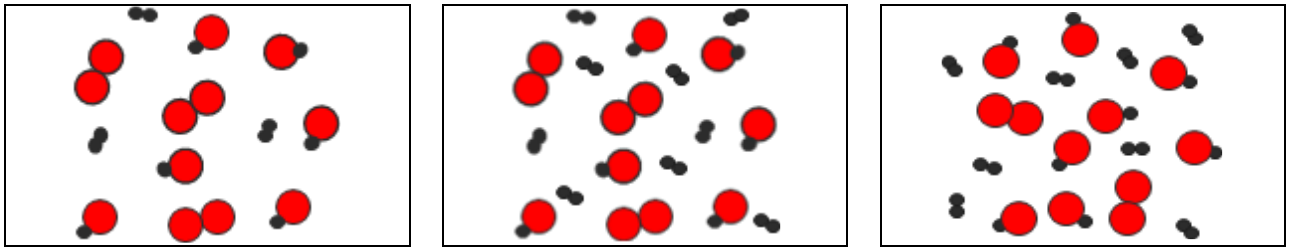
QUESTION 4

The equilibrium reaction between hydrogen gas and iodine gas is investigated at 200 °C. The equation for the reaction is as follows:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The number of moles of each substance present in a sealed 2 dm^3 container at various times is represented below. Each molecule represents a mole of that substance.

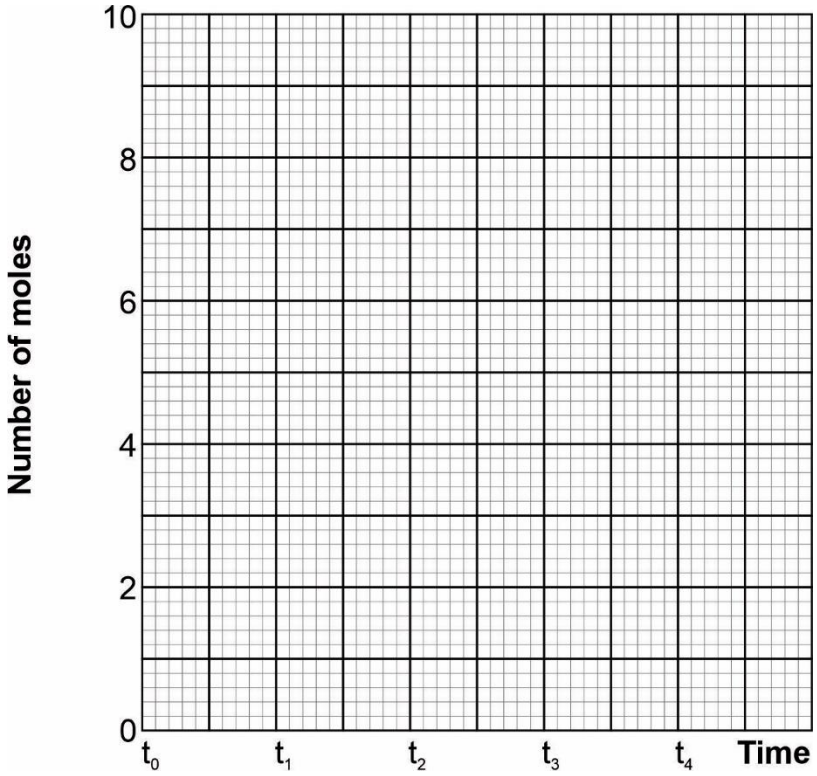
H • I ●



From time t_0 to t_1 At equilibrium: 3 mol H_2 3 mol I_2 6 mol HI	At time t_1 Equilibrium is disturbed.	From time t_2 to t_3 New equilibrium: 8 mol H_2 2 mol I_2 8 mol HI

4.1 Identify the disturbance that occurred at time t_1. (2)

4.2 Plot the number of moles of H_2, I_2 and HI on the axes below, **from t_0 to t_3 only**. Label each of the three lines clearly. A heading is not required. (6)
(An extra copy of the graph paper is provided on page 28, should you need it.)



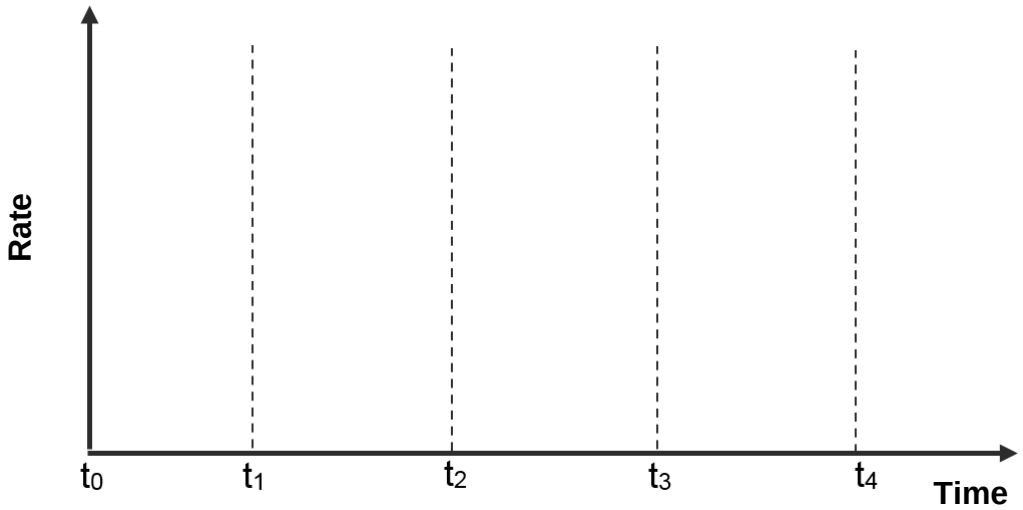
4.3 Explain the change in the number of moles of each substance from time t_1 to time t_2 by applying Le Châtelier's principle. (4)

4.4 Calculate K_c before and after the disturbance at t_1 and hence explain why the disturbance could not have been a temperature change. (6)

4.5 At time t_3, the volume of the container is doubled. Complete the graph **on page 12** (number of moles vs time) from t_3 to t_4 to show any changes that occur as a result of the disturbance at t_3. (2)

4.6 On the axes below, sketch the graphs of rate versus time for the forward and reverse reactions, from t_0 to t_4. (5)

- Use a solid line ——— to represent the rate of the forward reaction.
- Use a dashed line - - - - - - to represent the rate of the reverse reaction.



[25]

QUESTION 5

Consider the reaction equation shown below:

$$6NaOH(aq) + 4S(s) \rightarrow Na_2S_2O_3(aq) + 2Na_2S(aq) + 3H_2O(\ell)$$

5.1 Name the compound $Na_2S_2O_3$. (2)

5.2 The compound NaOH is a base. Circle the correct words between the brackets in the following sentence:

NaOH is a (STRONG / WEAK) base that (COMPLETELY / PARTIALLY) (IONISES / DISSOCIATES) in water. (3)

5.3 NaOH(s) melts at 318 °C. Explain why NaOH(s) has a high melting point. (4)

5.4 The compound Na_2S can be classified as a salt.

5.4.1 Define *salt*. (2)

5.4.2 Na^+ ions do not react with water. However, the S^{2-} ion reacts with water as follows:

$$S^{2-}(aq) + H_2O(\ell) \rightleftharpoons HS^-(aq) + OH^-(aq)$$

Label and draw lines to link the conjugate acid-base pairs in the equation. (2)

$S^{2-}(aq)$	+	$H_2O(\ell)$	$\rightleftharpoons$	$HS^-(aq)$	+	$OH^-(aq)$

5.4.3 Name this type of reaction of an ion (from a salt) with water. (1)

5.4.4 Classify Na_2S as an ACIDIC or a BASIC salt. Give a reason. (2)

5.4.5 Consider the following statement: (1)

'The S^{2-} ion is amphiprotic.'

Circle the correct option between the brackets:

The statement is (TRUE / FALSE).

5.5 2,24 g of S is added to 0,5 dm^3 of a 0,3 $mol \cdot dm^{-3}$ NaOH solution. The reaction equation is rewritten below:

$$6NaOH(aq) + 4S(s) \rightarrow Na_2S_2O_3(aq) + 2Na_2S(aq) + 3H_2O(\ell)$$

5.5.1 Perform suitable calculations to determine the limiting reagent. (6)

5.5.2 Calculate the mass of **$Na_2S_2O_3$** produced if the reaction has a 75% yield. (5)

[28]

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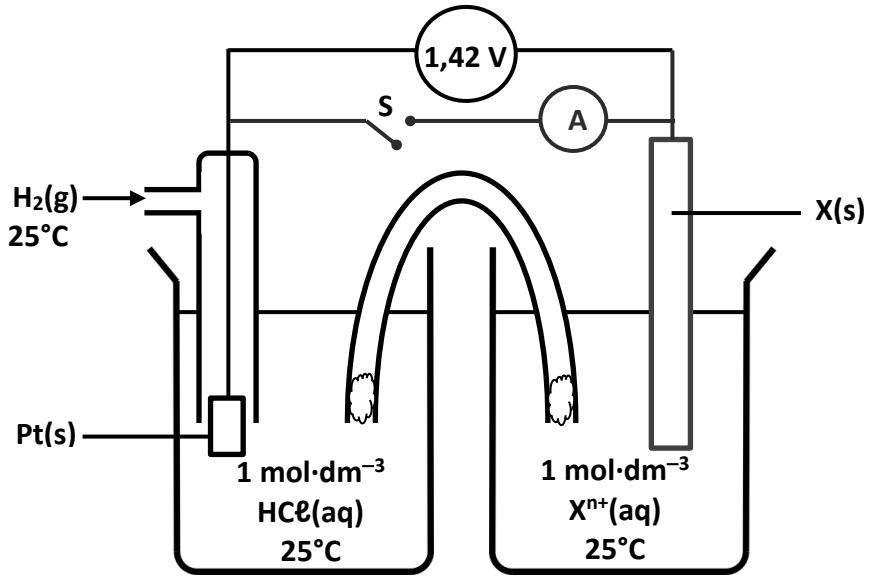
QUESTION 6

A galvanic cell is set up as shown below. A standard hydrogen electrode is connected to metal **X** in a solution of its ions. The voltmeter reads 1,42 V.



6.1 Consider the 1 mol·dm^{-3} HCℓ solution.

6.1.1 Write an equation for the ionisation reaction of HCℓ(aq). (2)

6.1.2 Hence, explain why this solution provides the necessary condition for the electrolyte of the standard hydrogen electrode. (2)

6.2 Musa says that a 0,5 mol·dm^{-3} oxalic acid solution could be used as the electrolyte for the standard hydrogen electrode instead of the HCℓ.

6.2.1 Write down the formula of oxalic acid. (1)

6.2.2 Explain why Musa is incorrect. (2)

6.3 Write down one other standard condition not shown in the diagram of the galvanic cell on page 18. (2)

6.4 When the switch is closed, the pH of the HCℓ(aq) **decreases**.

6.4.1 Circle the correct answer between the brackets: (1)

The standard hydrogen electrode is acting as the (ANODE / CATHODE) of the cell.

6.4.2 Explain the answer with reference to the decreasing pH. (2)

6.5 Identify metal **X** by means of a calculation. Show all your working. (4)

6.6 The smooth Pt electrode is replaced with one that is coated with a layer of powdered Pt. How will this affect …

6.6.1 the emf of the cell? (1)

Circle one of: INCREASE / DECREASE / NO CHANGE

6.6.2 the maximum current that the cell can deliver? (1)

Circle one of: INCREASE / DECREASE / NO CHANGE

6.7 The saturated salt solution in the salt bridge is replaced with a diluted salt solution. How will this affect …

6.7.1 the emf of the cell? (1)

Circle one of: INCREASE / DECREASE / NO CHANGE

6.7.2 the maximum current that the cell can deliver? (1)

Circle one of: INCREASE / DECREASE / NO CHANGE

[20]

QUESTION 7

Aluminium ore is refined to produce aluminium oxide. The aluminium oxide is melted and electrolysed to recover the pure aluminium.

7.1 Name an ore containing aluminium. (1)

7.2 Complete and balance the equation for the dissociation of $A\ell_2O_3$ when molten. (2)

$$A\ell_2O_3 \xrightarrow{heat}$$

7.3 Calculate the total number of ions present in 5 g of $A\ell_2O_3$. Round off only the final answer. (5)

7.4 Complete and balance the equation for the electrolytic decomposition of $A\ell_2O_3$. (3)

$$A\ell_2O_3 \longrightarrow$$

7.5 In the industrial process, cryolite, $Na_3A\ell F_6$, is melted together with the $A\ell_2O_3$.

7.5.1 What is the function of the cryolite? (1)

7.5.2 Explain why the sodium ions in the molten electrolyte are not reduced at the cathode. (2)

7.6 Circle the correct answer between the brackets: (1)

In the industrial process, the graphite (ANODES / CATHODES) need to be replaced regularly.

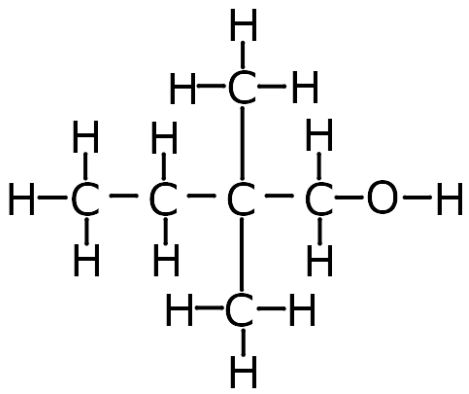
7.7 Calculate the time taken for a current of $1,5 \times 10^5$ A to produce 5×10^4 g of aluminium. (6)

[21]

QUESTION 8

8.1 Consider compound **P**.

Compound **P**



8.1.1 Define *functional group*. (2)

8.1.2 NAME the functional group of compound **P**. (1)

8.1.3 Give the IUPAC name of compound **P**. (3)

8.1.4 Explain why a dehydration reaction does NOT take place when compound **P** is heated with concentrated H_2SO_4. (2)

8.1.5 The compound $CH_3(CH_2)_5OH$ is a structural isomer of compound **P**.

Circle the correct option between the brackets:

$CH_3(CH_2)_5OH$ is a (FUNCTIONAL / CHAIN / POSITIONAL) isomer of compound **P**. (1)

8.1.6 The boiling point of $CH_3(CH_2)_5OH$ is 157 °C while compound **P** has a boiling point of 136,5 °C. Explain the difference. (4)

8.2 Draw the structural formula of: 3–ethyl–2,4–difluoro–5–methyloctane (4)

[17]

QUESTION 9

9.1 Consider the compounds **A** to **J** shown below:

A	$CH_3(CH_2)_3CH(OH)CH_3$	**F**	$CH_2C(CH_3)CH_3$
B	$CH_2CHCH_2CH_3$	**G**	$CH_3CHCHCH_3$
C	$CHC\ell CHC\ell$	**H**	$CH_3(CH_2)_4COOH$
D	CH_3OH	**I**	$HCOO(CH_2)_4CH_3$
E	$CH_3(CH_2)_2CH_3$	**J**	$CH_3CH_2CH_2CHBrCH_2Br$

9.1.1 Write down the letter/s of the compound/s corresponding to the following descriptions. The compounds may be used more than once or not at all. (9)

(a)	Two compounds that belong to the same homologous series but are NOT isomers.	
(b)	Two compounds that are functional isomers.	
(c)	Two compounds that are positional isomers and are NOT chain isomers.	
(d)	A haloalkane.	
(e)	A saturated hydrocarbon.	
(f)	A compound that could be a product of the standard test for unsaturation	

9.1.2 Give the IUPAC names of:

(a) Compound **F**. (2)

(b) Compound **I**. (2)

9.2 For each of the following:

- Complete and balance the equation, using **condensed structural** formulae.
- Give the reaction type.

9.2.1 $CH_3CH_3 + 2C\ell_2 \xrightarrow{ultraviolet\ light}$

_____ (3)

GENERAL reaction type: _____ (1)

9.2.2 $CH_3COOH + CH_3CH_2CH_2OH \xrightarrow{conc.\ H_2SO_4}$

_____ (2)

SPECIFIC reaction type: _____ (1)

9.3 Consider the reaction equation below:

$$C_{13}H_{28} \xrightarrow{catalyst} 3C_3H_6 + \mathbf{X}$$

9.3.1 Write the **molecular** formula of **X**. (1)

_____

9.3.2 State the SPECIFIC reaction type. (2)

_____

[23]

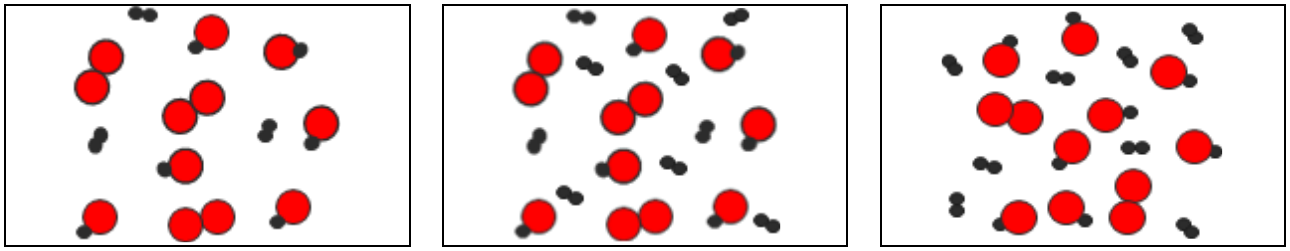
Total: 200 marks

ADDITIONAL SPACE (ALL QUESTIONS)

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

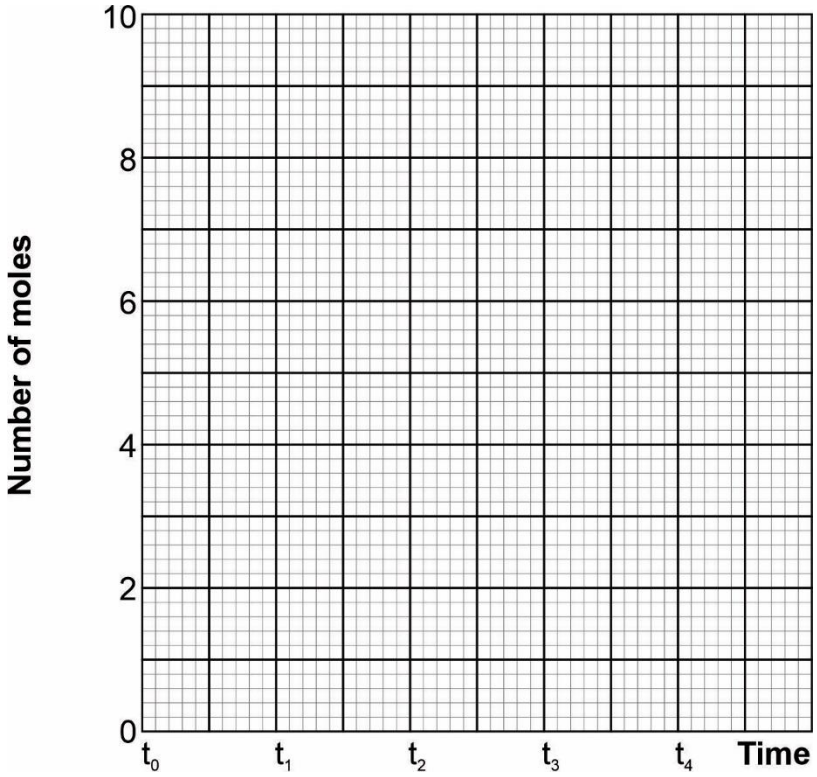
Question 4.2 and 4.5 (Extra graph paper. Only use if necessary.)

H ● I ●



From time t_0 to t_1 At equilibrium: 3 mol H_2 3 mol I_2 6 mol HI	At time t_1 Equilibrium is disturbed.	From time t_2 to t_3 New equilibrium: 8 mol H_2 2 mol I_2 8 mol HI

4.2 Plot the number of moles of H_2, I_2 and HI on the axes below, **from t_0 to t_3 only**. Label each of the three lines clearly. A heading is not required. (6)



4.5 At time t_3, the volume of the container is doubled. Complete the graph (number of moles vs time, repeated above) from t_3 to t_4 to show any changes that occur as a result of the disturbance at t_3. (2)