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**HILTON COLLEGE
GRADE 12 TRIAL EXAMINATIONS
SEPTEMBER 2024**

**TOTAL
MARKS**

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PHYSICAL SCIENCES: PAPER II

EXAMINATION NUMBER

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**Examiner: Mr MJ van Wyk
Moderator: Mrs K McNeil & Mr K Mgozeli**

**Time: 3 hours
200 Marks**

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 30 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.**
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, express answers to two decimal places.
8. It is in your interest to write legibly and to present your work neatly.
9. Two blank pages (pages 29 and 30) and an extra graph and answer boxes (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.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Total
Mark										
Marker's initial										
Moderated Mark										
Moderator's initial										
Question Total	20	25	25	25	24	21	20	19	21	200

QUESTION 1 MULTIPLE CHOICE QUESTIONS

Answer the multiple-choice questions on the 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 the average of the repeat results is close to the accepted value.
- D similar results will be obtained when the experiment is repeated.

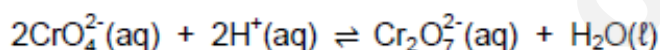
1.2 A closed system is one in which:

- A matter is not exchanged with the environment.
- B there is an exchange of matter with the environment.
- C there is no change in temperature.
- D a stress is continually applied.

1.3 According to the Lowry-Brønsted theory, a conjugate base is formed when a/an ...

- A proton is added to the acid.
- B electron is added to the acid.
- C proton is removed from the acid.
- D electron is removed from the acid.

1.4 Consider the following reaction that reaches equilibrium in a beaker:



A few drops of concentrated $\text{NaOH}_{(\text{aq})}$ are now added to the beaker.

Which ONE of the following combinations correctly identifies the DISTURBANCE ON THE SYSTEM and the SYSTEM'S RESPONSE to the disturbance?

	DISTURBANCE ON THE SYSTEM	SYSTEM'S RESPONSE
A	$[\text{H}^+]$ decreases	Forward reaction favoured
B	$[\text{H}^+]$ decreases	Reverse reaction favoured
C	$[\text{CrO}_4^{2-}]$ decreases	Reverse reaction favoured
D	$[\text{CrO}_4^{2-}]$ increases	Forward reaction favoured

1.5 Which one of the following represents the expression for the acid ionisation constant (K_a) for nitrous acid, HNO_2 ?

A $K_a = \frac{[\text{NO}_2^-][\text{H}_3\text{O}^+]}{[\text{HNO}_2][\text{H}_2\text{O}]}$

B $K_a = \frac{[\text{NO}_2^-][\text{H}_3\text{O}^+]}{[\text{HNO}_2]}$

C $K_a = \frac{[\text{HNO}_2][\text{H}_2\text{O}]}{[\text{NO}_2^-][\text{H}_3\text{O}^+]}$

D $K_a = \frac{[\text{HNO}_2]}{[\text{NO}_2^-][\text{H}_3\text{O}^+]}$

1.6 Consider the statements below regarding an alkaline substance.

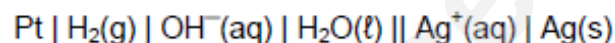
An alkaline substance:

- (i) Reacts with an acid to form a neutral solution
- (ii) Turns red litmus blue
- (iii) Forms a salt when it reacts with an acid

Which of the statements above are ALWAYS TRUE?

- A (i), (ii) and (iii)
- B (i) and (ii) only
- C (i) and (iii) only
- D (ii) and (iii) only

1.7 Consider the cell notation for a galvanic cell.



Which ONE of the following equations represents the half-reaction taking place at the POSITIVE electrode?

- A $\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$
- B $\text{Ag}(\text{s}) \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$
- C $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$
- D $\text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + 2\text{e}^-$

1.8 Which one of the following statements is TRUE regarding the cathode in the electrorefining of copper?

- A It is made of impure copper.
- B Zinc metal deposits onto the cathode.
- C It is the electrode where reduction occurs.
- D It is the positive electrode.

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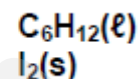
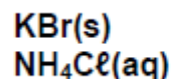
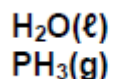
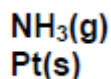
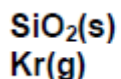
- 1.9 For which ONE of the following molecular formulae are CHAIN isomers possible?
- A C_4H_{10}
 - B C_3H_8
 - C $\text{C}_2\text{H}_6\text{O}$
 - D $\text{C}_3\text{H}_8\text{O}$
- 1.10 Which one of the following reactions will NOT take place with an alkene?
- A Hydrohalogenation
 - B Combustion
 - C Hydrogenation
 - D Dehydration

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QUESTION 2

- 2.1 Use only substances from the list below when answering QUESTIONS 2.1.1 to 2.1.8. The phase indicators (state symbols) represent the physical state of each of the substances at **room temperature**.



From the list select ONE substance's formula to best fit the description at room temperature (Substances may be used more than once or not at all.):

- 2.1.1 Substance that has a giant covalent network structure. (1)

- 2.1.2 **Compound** with pure covalent bonds. (1)

- 2.1.3 Substance that has non-polar molecules, despite the presence of polar covalent bonds within the molecules. (1)

- 2.1.4 Substance that exists as individual atoms, which interact through dispersion forces only. (1)

- 2.1.5 Substance that exists in a giant ionic lattice. (1)

- 2.1.6 Slightly acidic salt. (1)

- 2.1.7 Substance that can conduct electricity in both solid and liquid phases. (1)

- 2.1.8 Substance that can undergo oxidation to form oxygen gas. (1)

2.2. 2.2.1 What is an intermolecular force?

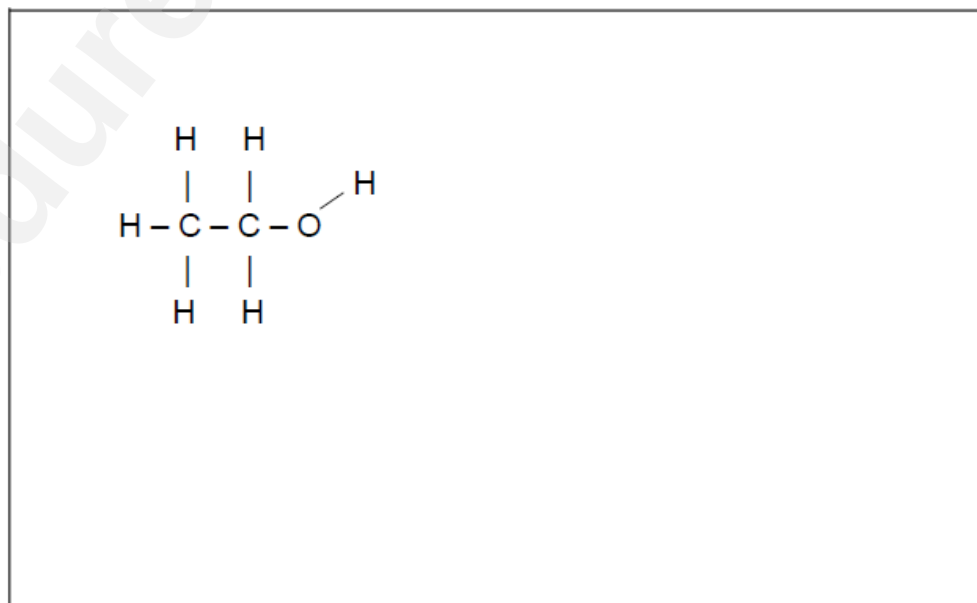
(2)

2.2.2 At room temperature I_2 is a solid and sublimates at a temperature of $184,4\text{ }^{\circ}\text{C}$. This is due to the presence of London forces between the molecules. Explain the origin of London forces between these molecules.

(3)

2.2.3 Ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, has hydrogen bonding forces between its molecules. Using structural formulae and your knowledge of hydrogen bonding forces, complete the diagram showing the hydrogen bonding forces between ethanol molecules. Clearly label one of the hydrogen bonds.

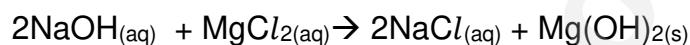
(3)



2.3 Define *molar mass*.

(2)

2.4 When 30 cm³ of a 0,8 mol.dm⁻³ sodium hydroxide solution is added to 25 cm³ of a 0,5 mol.dm⁻³ magnesium chloride solution, a white precipitate of magnesium hydroxide is formed according to the following balanced equation:



2.4.1 Identify the limiting reagent. Show all your working clearly. Do not round answers.

(4)

2.4.2 Calculate the mass of the precipitate formed.

(3)

[25]

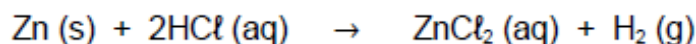
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QUESTION 3

A group of students uses the reaction of EXCESS hydrochloric acid with zinc to investigate factors which influence reaction rate. The balanced equation for the reaction is:



They used the same volume of hydrochloric acid and 1,2 g of zinc in each of the experiments. The reaction conditions and temperature readings before and after completion of the reaction in each experiment are summarized in the table below.

Experiment	REACTION CONDITIONS				Time (s)
	Concentration of HCl (mol.dm ⁻³)	Temperature		State of division of the 1,2 g of Zn	
		Before	After		
1	0,5	20	34	granules	22
2	0,5	20	35	powder	10
3	0,8	20	36	powder	6
4	0,5	35	50	granules	8
5	0,5	20	34	granules	11

3.1 From the information provided circle the correct word between brackets and provide evidence for your choice:

3.1.1 The reaction between hydrochloric acid and zinc is (EXOTHERMIC / ENDOTHERMIC). (1)

3.1.2 Evidence: (1)

3.2 The students compare the results for Experiment 1 and 3. Is this a fair comparison?

3.2.1 Circle one of: YES / NO (1)

3.2.2 Provide a reason for your answer: (1)

- 3.3 The results of Experiment 1 and 2 are compared in the investigation.
Write down the:

3.3.1 Independent variable: _____ (1)

3.3.2 Dependent variable: _____ (1)

- 3.4 Consider Experiments 1 and 5.

3.4.1 How does the rate of the reaction in Experiment 5 compare to that in Experiment 1?

Circle one of: FASTER THAN / SLOWER THAN / EQUAL TO (1)

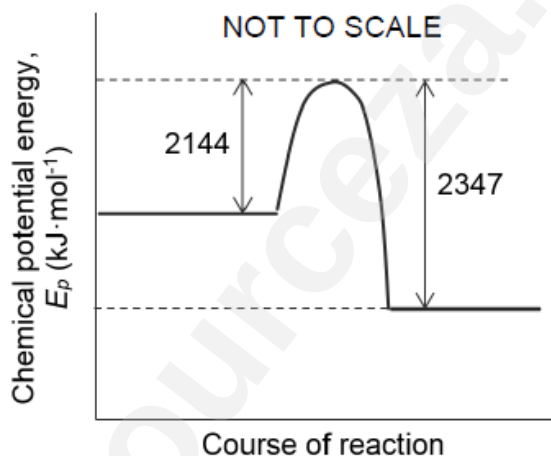
3.4.2 Write down the factor responsible for the difference in the rate of reaction. (1)

- 3.5 Fully explain, by referring to the collision theory, how the change in Experiment 4 affects the reaction rate compared to Experiment 1. (4)

- 3.6 Define the term *reaction rate*. (2)

- 3.7 Using the information in the table calculate the rate at which the hydrochloric acid reacts in Experiment 4 in mol.s^{-1} . (5)

- 3.8 The potential energy-profile graph for the reaction is shown below.



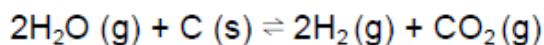
- 3.8.1 Label the position of the activated complex with an **X**, on the graph. (1)
- 3.8.2 On the same axes draw the curve that will be obtained for adding a catalyst. (2)
- 3.8.3 What does the value of 2 144 kJ.mol^{-1} represent? (1)

- 3.8.4 Calculate ΔH for the reaction. (2)

[25]

QUESTION 4

Steam, $\text{H}_2\text{O}_{(\text{g})}$, reacts with hot carbon, $\text{C}_{(\text{s})}$, at $1000\text{ }^\circ\text{C}$ according to the following balanced equation:



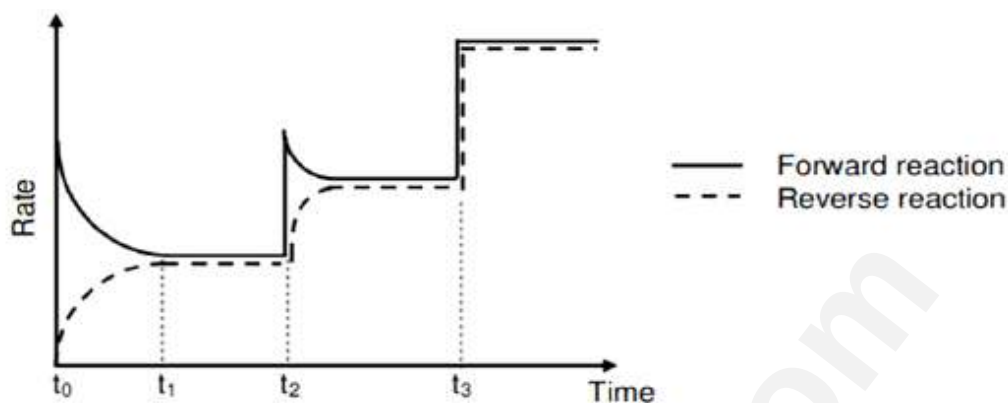
Initially, 36 g of steam and a certain amount of carbon were placed in a 2 dm^3 sealed container and allowed to react in the closed system. At equilibrium it was found that the amount of carbon changed by 0,225 mol.

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

4.2 Calculate the equilibrium constant, K_c , for the reaction at $1\ 000\text{ }^\circ\text{C}$. (6)

4.3 Explain the significance of your value you calculated in QUESTION 4.2 for the equilibrium constant, K_c , when compared to a K_c value of 1. (2)

4.4 The graph shows how the rates of the forward and reverse reactions change with time.



4.4.1 What is meant by when a system is in *dynamic chemical equilibrium*? (3)

4.4.2 Give a reason why the rate of the forward reaction decreases between t_0 and t_1 . (1)

4.4.3 State what is happening between t_1 and t_2 . (1)

4.4.4 Consider the equilibrium mixture at t_3 .

i. What change was made to the equilibrium mixture at t_3 ? (1)

ii. Circle the correct word between the brackets:

The change made to the equilibrium mixture at t_3 have/had (DISTURBED / NO EFFECT ON) the **equilibrium position** of the mixture. (1)

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At time t_2 , the temperature of the system was increased.

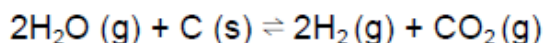
4.4.5 State *Le Châtelier's principle*. (2)

4.4.6 Circle the correct word between the brackets:

The forward reaction is (EXOTHERMIC / ENDOTHERMIC). (1)

4.4.7 Refer to *Le Châtelier's principle* to explain your answer in QUESTION 4.4.6. (3)

4.4.8 How will an increase in pressure affect the yield of H_2 gas when equilibrium is re-established?



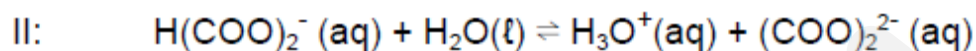
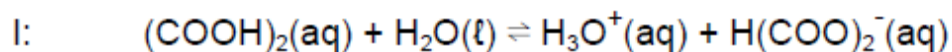
Circle one of: INCREASE / DECREASE / REMAINS THE SAME (2)

[25]

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QUESTION 5

Anhydrous oxalic acid, $(\text{COOH})_2$, is an example of an acid that can donate two protons and thus ionises in two steps as represented by the equations below:



5.1 Write down:

5.1.1 ONE word for the underlined phrase in the above sentence. (1)

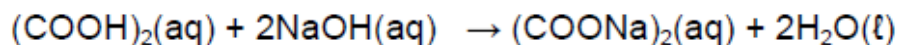
5.1.2 The FORMULA of the conjugate base in reaction II. (1)

5.1.3 The FORMULA of the single substance that is amphoteric in **BOTH** reactions. (2)

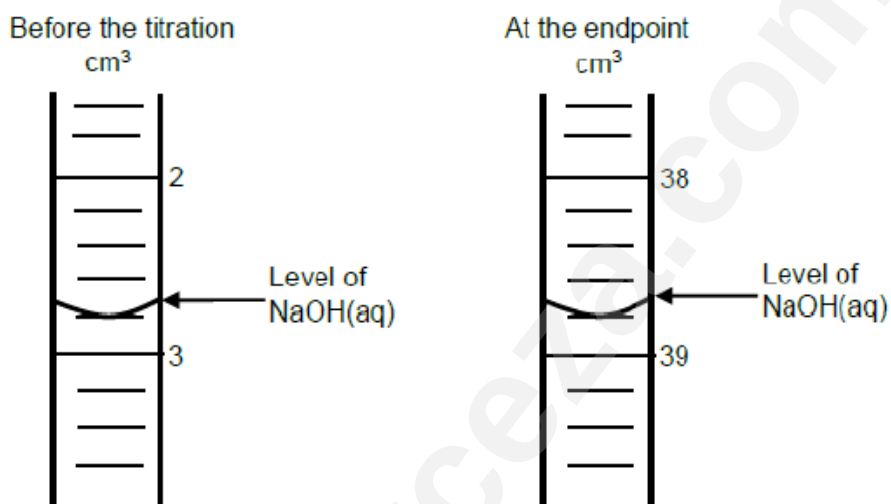
5.2 A standard solution of anhydrous oxalic acid, $(\text{COOH})_2$, of concentration $0,20 \text{ mol} \cdot \text{dm}^{-3}$ is prepared by dissolving a certain amount of $(\text{COOH})_2$ in water in a 250 cm^3 volumetric flask. Calculate the mass of the $(\text{COOH})_2$ needed to prepare the standard solution. (3)

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- 5.3 During a titration, 25 cm³ of the standard solution of (COOH)₂ prepared in QUESTION 5.2 is neutralised by a sodium hydroxide, NaOH, solution from a burette. The balanced equation for the reaction is:



The diagram below show the burette readings before the titration commenced and the endpoint, respectively.



5.3.1 Use the burette readings and the information provided to calculate:

- i. The volume of sodium hydroxide titrated. (1)

- ii. The concentration of the sodium hydroxide solution. (4)

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5.3.2 The following indicators are available for the titration:

(1)

INDICATOR	pH RANGE
A	3,1 - 4,4
B	6,0 - 7,6
C	8,3 - 10,0

Circle ONE of the above indicators which would be most suitable in this titration.

5.3.3 Making use of suitable equations, explain your choice in QUESTION 5.3.2.

(5)

5.4 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)

5.5 NaOH_(s) melts at 318 °C. Explain why NaOH_(s) has a high melting point.

(3)

[24]

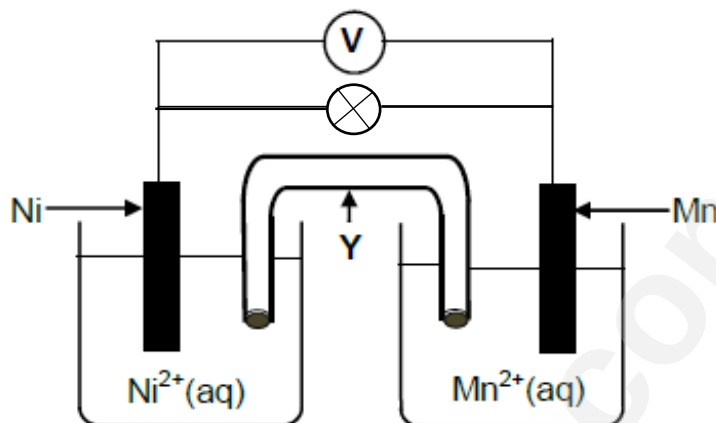
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QUESTION 6

A standard electrochemical cell is set up as shown below.



6.1 Write down TWO functions of component **Y**. (2)

6.2 In which direction will electrons flow in the external circuit?

Circle one of: Ni to Mn / Mn to Ni (1)

6.3 Calculate the initial emf of this cell. (3)

6.4 State what would happen to the voltage reading when the cell has run to completion **AND** provide a reason for this. (2)

6.5 Write down the balanced equation for the net cell reaction taking place. (3)

- 6.6 Both of the electrochemical cell's compartments contain electrolytes.

Define an *electrolyte*.

(2)

- 6.7 The concentration of $\text{Ni}^{2+}_{(\text{aq})}$ is now increased. Circle the correct answer between the brackets:

(1)

The reading on the voltmeter will (INCREASE / DECREASE / REMAIN THE SAME).

- 6.8 Use Le Châtelier's principle to explain the effect of the changing concentration of $\text{Ni}^{2+}_{(\text{aq})}$ on the voltage produced as predicted in QUESTION 6.7.

(3)

- 6.9 The surface area of the electrodes is increased. What would the effect be on:

6.9.1 the maximum current delivered by the cell?

Circle one of: INCREASE / DECREASE / REMAINS THE SAME

(1)

Provide a reason for your answer:

(2)

6.9.2 the EMF that can be delivered by the cell?

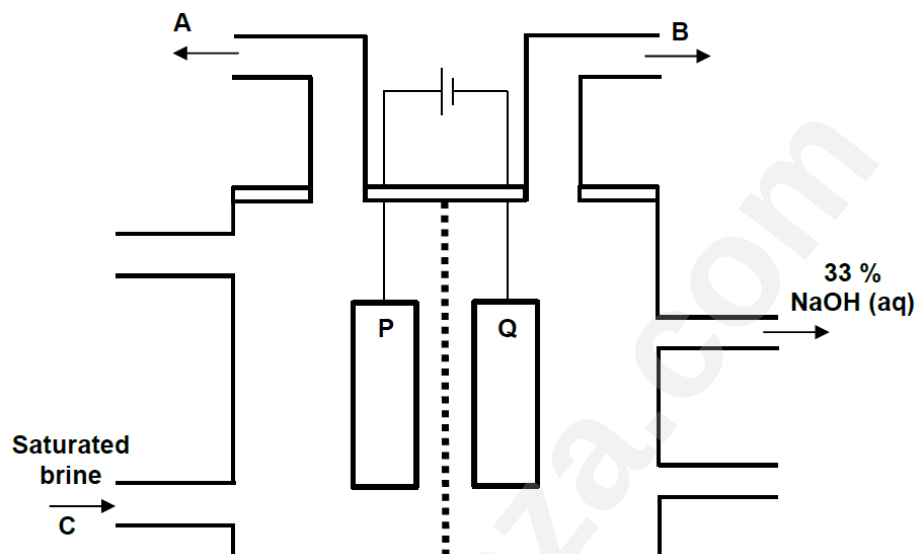
Circle one of: INCREASE / DECREASE / REMAINS THE SAME

(1)

[21]

QUESTION 7

The diagram below shows a representation of a membrane cell used in the Chlor-Alkali Industry. Electrode **P** is made from a substance which is inert.



7.1 Which electrode is the cathode? Choose one of: **P** / **Q** (1)

7.2 Circle the correct answer between brackets: (2)

The membrane cell is an example of an electrolytic cell. This uses (CHEMICAL / ELECTRICAL) energy to cause a (NON-SPONTANEOUS / SPONTANEOUS) redox reaction to occur.

7.3 Chlorine gas is produced at electrode **P** and collected at **A**.

7.3.1 Write down the equation for the half-reaction that produces the chlorine gas. (2)

7.3.2 Write down the overall reaction taking place in the membrane cell. (3)

7.3.3 What is *brine*? (2)

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7.3.4 At **C**, brine enters the cell. FULLY explain why chlorine is produced **predominantly** at electrode **P**. In your answer, you should refer to the following:

- the inherent reactivities of the reacting species (with reference to the standard electrode potentials).
- the concentration of the ions present. (3)

7.3.5 With what substance will the chlorine gas be contaminated? (1)

7.4 7.4.1 Write the **formula** of the product collected at **B**. (1)

7.4.2 Write the **name** of the substance which electrode **P** is made from. (1)

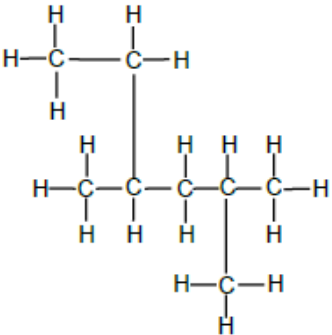
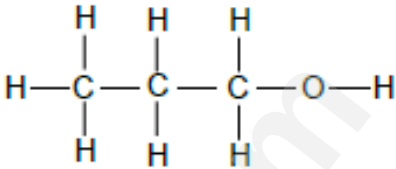
7.5 With reference to intermolecular forces, compare the boiling points of chlorine and hydrogen and FULLY explain the difference. (4)

[20]

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QUESTION 8

Study the table below and answer the questions that follow.

A		B	
C	$C_4H_8O_2$	D	$CH_3(CH_2)_4CHCH_2$

8.1 Define the term *unsaturated* compound. (2)

8.2 Write down the:

8.2.1 Letter that represents an UNSATURATED compound. (1)

8.2.2 IUPAC name of compound **A**. (3)

8.2.3 IUPAC name of the POSITIONAL isomer of compound **B**. (2)

8.2.4 IUPAC name of compound **D**. (2)

8.2.5 Balanced equation, using MOLECULAR FORMULAE, for the complete combustion of compound **A**. (3)

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- 8.3 The formula of compound **C**, $C_4H_8O_2$, represents two compounds that are functional isomers of each other.

8.3.1 Describe what is meant by functional isomers. (2)

8.3.2 Draw the STRUCTURAL FORMULAE of each of these two FUNCTIONAL isomers. (4)

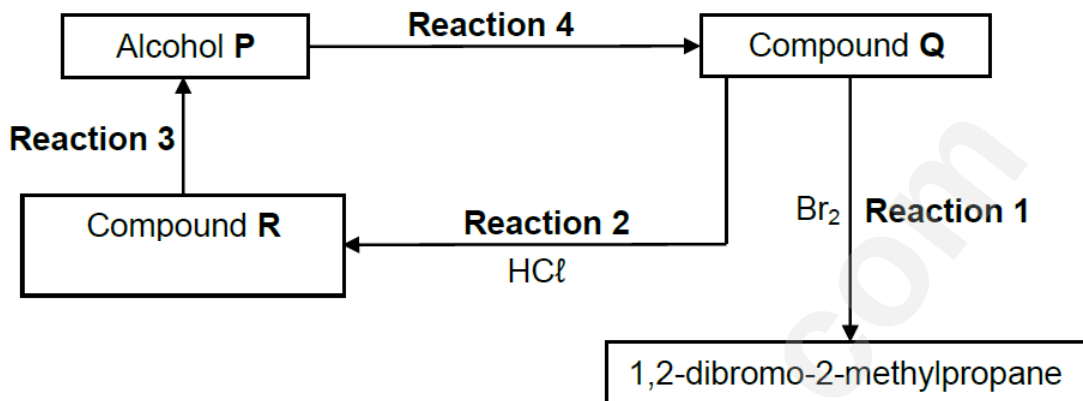


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QUESTION 9

- 9.1 The flow diagram below shows different organic reactions.
P, **Q** and **R** are organic compounds.



Reaction 1 is an addition reaction.

Write down:

- 9.1.1 The SPECIFIC type of addition reaction. (1)

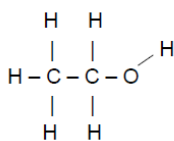
- 9.1.2 ONE observable change which occurs in the container during the reaction. (2)

- 9.1.3 The STRUCTURAL formula of compound **Q**. (2)

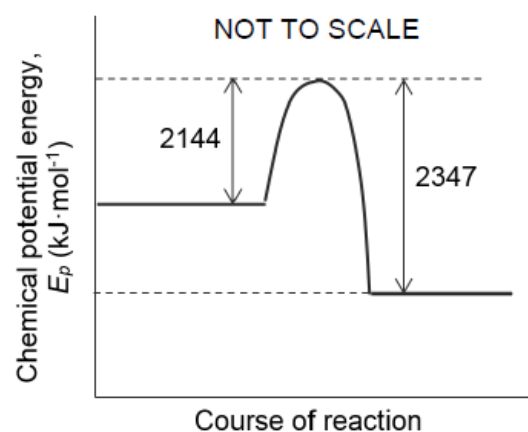
Consider **reaction 2** which is a Hydrohalogenation reaction.

- 9.1.4 The reaction condition for this reaction is that “no water may be present”. Explain why water cannot be present for this specific reaction. (2)

QUESTION 2.3.3



QUESTION 3.8



QUESTION 8.3.2



QUESTION 9.1.3



ADDITIONAL SPACE (ALL QUESTIONS)

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