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PRELIMINARY EXAMINATION 2021

PHYSICAL SCIENCES PAPER II (CHEMISTRY)

Examiner: L.VISSER

Moderator: D.HUDSON-LAMB

Duration: 3 HOURS

Max. Marks: 200

PLEASE READ THE FOLLOWING INSTRUCTIONS:

1. This question paper consists of 16 pages (including the cover page), an Answer Sheet and a Data Sheet of 3 pages (i–iii).
2. Please check that your question paper is complete.
3. Read the questions carefully.
4. Answer ALL the questions.
5. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the multiple-choice Answer Sheet provided. 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
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Here the answer C has been marked.

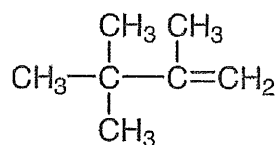
6. **START EACH QUESTION ON A NEW PAGE.**
7. Please ensure that you number your answers as the questions are numbered.
8. Use the data and formulae sheet whenever necessary.
9. You may use an approved, non-programmable and non-graphical calculator, unless otherwise stated.
10. Show all the necessary steps in calculations.
11. Where appropriate, round off your final answers correct to 2 decimal places, unless instructed otherwise.
12. It is in your own interest to write legibly and to present your work neatly.

QUESTION 1 MULTIPLE CHOICE

Answer these questions on the Multiple-Choice Answer Sheet provided. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

- 1.1 The correct chemical formula for calcium permanganate is:
- A CaMnO_4
 - B Ca_2MnO_4
 - C $\text{Ca}(\text{MnO}_4)_2$
 - D $\text{Ca}_2(\text{MnO}_4)_2$
- 1.2 Ammonia (NH_3) and hydrogen chloride (HCl) are both gases at room temperature. Which of the following statements about these gas molecules is correct?
- A They both contain hydrogen bonds between the gas molecules.
 - B Ammonia molecules are polar; hydrogen chloride molecules are non-polar.
 - C They both contain polar covalent bonds.
 - D Ammonia is covalently bonded and hydrogen chloride is ionically bonded
- 1.3 Which one of the following metal containers can be used for the storage of a solution of copper (II) chloride?
- A Ag
 - B Zn
 - C Mg
 - D Fe
- 1.4 Which one of the following SPECIFIC reaction types represents the conversion of ethene to chloroethane?
- A Halogenation
 - B Hydrohalogenation
 - C Dehalogenation
 - D Dehydrohalogenation

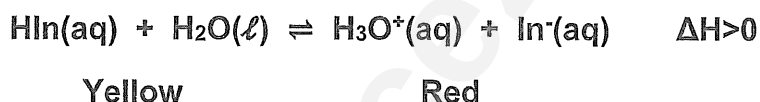
- 1.5 Consider the structure of the organic compound below:



<https://www.tcichemicals.com/AT/en/p/T0671>

The IUPAC name of this compound is:

- A 2,3,3,3 - tetramethylprop - 1- ene
 B 2,3,3 - trimethylbut - 1- ene
 C 2,2,3 - trimethylbut - 3 - ene
 D 1,1,1,2 - tetramethylprop - 2 - ene
- 1.6 An acid-base indicator, represented as HIn(aq) , reaches dynamic chemical equilibrium when it is added to water, as shown in the equation below:



At chemical equilibrium, the colour of the solution is orange.

Which ONE of the following will turn the colour of the solution yellow?

- A The addition of NaOH
 B The addition of H_2O
 C An increase in temperature
 D The addition of HCl

- 1.7 An electrolytic cell is used in industry to extract aluminium from aluminium oxide.

The following statements regarding this electrolytic cell are given:

- I. Oxygen gas is produced at the anode
 II. Aluminium ions are reduced at the positive electrode.
 III. The reaction is endothermic.

Which of the above statements are correct?

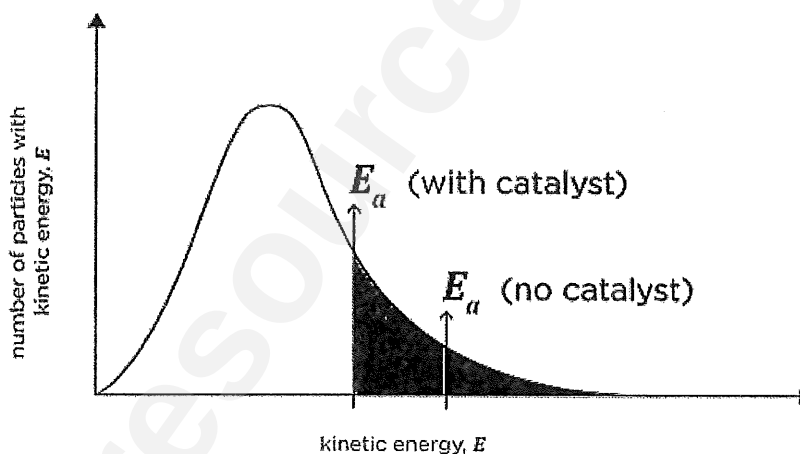
- A I and II only
 B II and III only
 C I and III only
 D I, II and III

1.8 The ionisation constant 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 acids **X** and **Y** 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 aqueous solution than **Y**.
 - D **X** and **Y** are both dilute solutions of acids.
- 1.9 The energy distribution for particles in a fixed mass of gas is shown below. The activation energy for a chemical reaction is shown on the curve, with and without the addition of a catalyst.

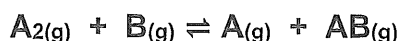


<http://www.a-levelnotes.co.uk/chemistry-aqa-a-level-notes-kinetics.html>

The effect of a catalyst on the minimum amount of energy required to break the intramolecular bonds and the number of effective collisions per unit time is given by:

	Minimum amount of energy required to break bonds	Number of effective collisions per unit time
A	Decreases	Remains the same
B	Increases	Decreases
C	Remains the same	Increases
D	Decreases	Increases

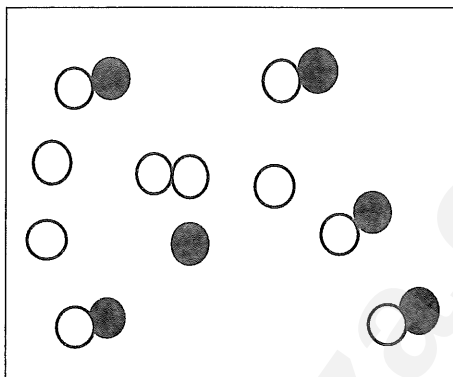
1.10 The following hypothetical reaction is at chemical equilibrium at 300 K.



The diagram below shows the molecules involved in this equilibrium at 300 K.

Key: ○ = atom A and ● = atom B

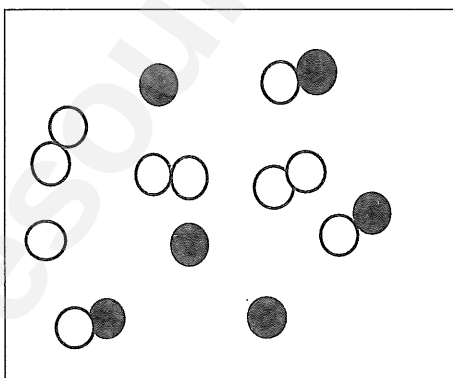
300K:



The temperature is now increased to 500 K.

The diagram below represents the same equilibrium mixture at 500 K.

500K:



Which ONE of the following statements is CORRECT?

- A The forward reaction is exothermic.
- B The concentration of A is higher at the higher temperature.
- C An increase in temperature favours the forward reaction.
- D The yield of AB increases as the temperature increases

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QUESTION TWO

The following reaction is used to produce SF₄ which is involved in the production of CFC's that were used as coolants in refrigerators.



- 2.1 Define *intramolecular bonding*. (2)
- 2.2 Name the specific type of intramolecular bond in SO₂. (2)
- 2.3 What volume of SO₂ will be produced at STP if 1kg of S completely reacts with excess OF₂? (5)

The reactants started with a potential energy of 530kJ·mol⁻¹ and the activation energy for the reaction represented by the above equation is 75 kJ·mol⁻¹.

- 2.4 Define *activation energy*. (2)
- 2.5 Sketch the energy profile for the above reaction in your answer book. The energy profile must include the following labels:
- Energy of the reactants (E_{reactants})
 - Energy of the products (E_{products})
 - Activation energy (E_a)
 - Heat of reaction (ΔH)
 -

The following values should also be indicated on the energy profile:

- Energy of the products
- Energy of the activated complex.

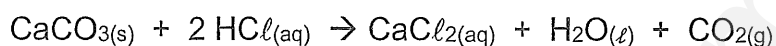
(6)

[17]

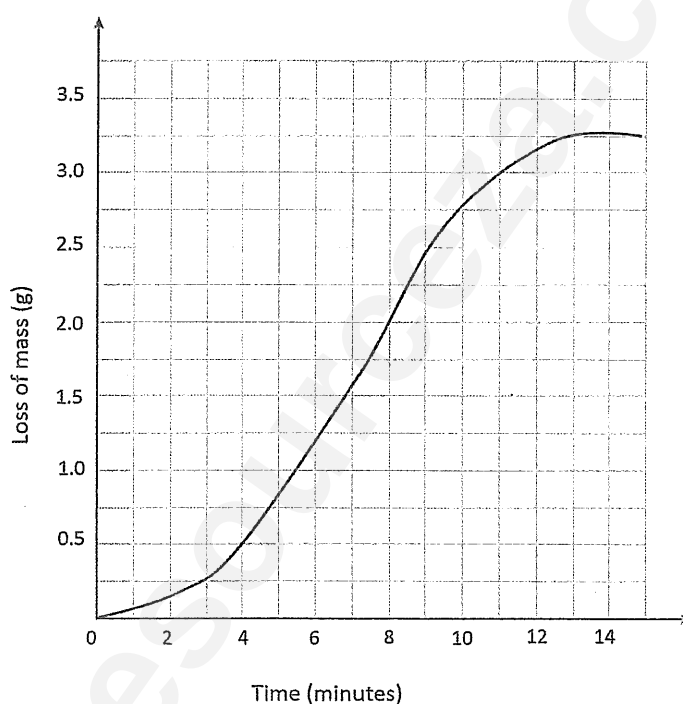
QUESTION THREE

Several large pieces of calcium carbonate with a total mass of 12 g were placed in an open reaction vessel with 200 cm³ of HCl of concentration 3 mol·dm⁻³. The hydrochloric acid completely covered the lumps of calcium carbonate.

The balanced chemical equation for the reaction that occurs in the reaction vessel is shown below:



The mass of the flask was determined at 2-minute intervals and the loss of mass due to the production of carbon dioxide versus time was plotted on the graph given below.



- 3.1 Calculate the number of moles of calcium carbonate in the 12 g sample. (2)
- 3.2 Which reagent was in excess? Show all working. (4)
- 3.3 Compare the rate of the reaction between 0-3 minutes and 3-6 minutes. (1)
- 3.4 Give ONE possible reason for the difference in the rates described in question 3.3. (2)
- 3.5 Compare the rate of the reaction between 4-8 minutes and 10-12 minutes. (1)
- 3.6 Explain the difference in the rates described in question 3.5 in terms of the collision theory. (4)
- 3.7 What is the final mass of carbon dioxide produced? (1)

- 3.8 Determine the percentage yield of carbon dioxide. (5)

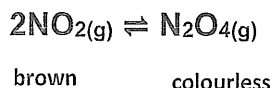
This investigation is repeated using 12 g of powdered CaCO_3 and 200 cm^3 of $3 \text{ mol} \cdot \text{dm}^{-3} \text{ HCl}$.

- 3.9 What effect (if any) will this have on:
- 3.9.1 The gradient of the graph from 4-8 minutes? (1)
- 3.9.2 The final mass of carbon dioxide produced? (1)
- 3.10 Compare and briefly comment on the electrical conductivity of CaCl_2 and CO_2 , two of the products of the reaction. Your answer must include a description of the intramolecular bonding that occurs in both substances. (6)

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QUESTION FOUR

Brown nitrogen dioxide reacts to form colourless dinitrogen tetroxide in a closed system, according to the balanced chemical equation below:



A group of investigators place 36,8 g of nitrogen dioxide in an empty sealed 1000 cm³ container and record the change in the number of moles of nitrogen dioxide over a period of 4 minutes at standard room temperature. Their results are represented in the table below:

Time (min)	Moles of NO ₂ (mol)
0	0,80
1	0,30
2	0,25
3	0,20
4	0,20

- 4.1 Complete the graph of moles of NO₂ versus time on the answer sheet provided. (4)
- 4.2 At what time does the reaction represented above reach dynamic chemical equilibrium? (1)
- 4.3 Explain what is meant by *dynamic chemical equilibrium*. (2)
- 4.4 Explain why the moles of N₂O₄ will be 0,3 mol when dynamic chemical equilibrium is reached. (2)
- 4.5 Sketch the graph of moles of N₂O₄ versus time on the same set of axes used in question 4.1. (3)
- 4.6 Calculate the equilibrium constant for this reaction at room temperature. (3)

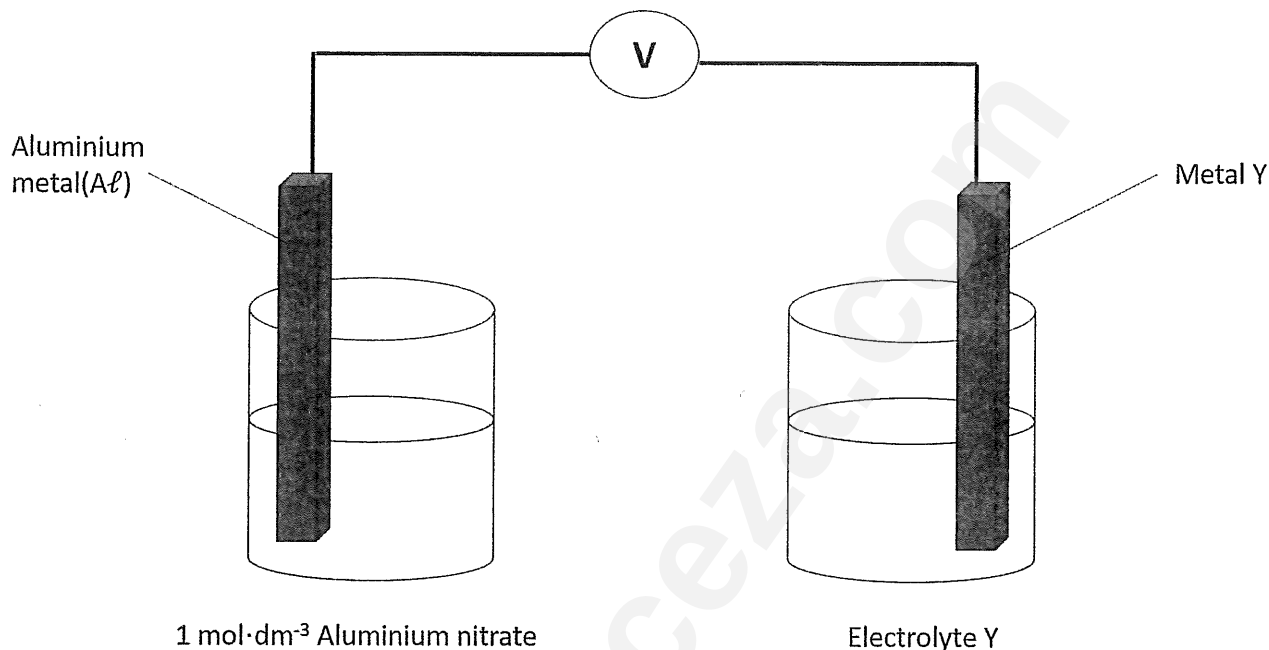
The temperature of the container is increased and the colour of the enclosed gases changes from a light brown to a darker brown.

- 4.7 Is the reaction represented by the equation above an endothermic or exothermic reaction? Explain your answer in terms of Le Chatelier's Principle. (4)
- 4.8 The equilibrium constant for the reaction at the new higher temperature is 5. Determine the concentration of NO₂ at equilibrium at the new higher temperature. Your answer must be correct to 4 decimal places. (5)

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QUESTION FIVE

An electrochemical cell is constructed as shown in the diagram below. A strip of metal (Al) and an unknown metal, Y, are used as electrodes. When the electrochemical cell is operating the mass of the aluminium electrode decreases.



- 5.1 Explain why the electrochemical cell that is shown in the above diagram will NOT operate. (3)

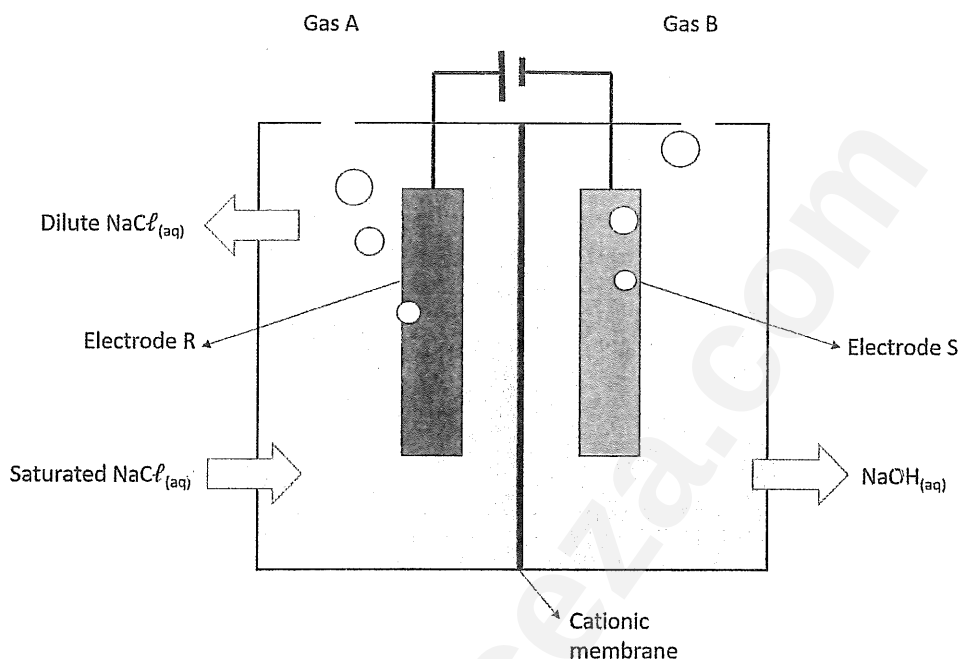
The following questions refer to when the cell IS operating.

- 5.2 Is aluminium the cathode or the anode? Justify your answer. (3)
- 5.3 Define *oxidising agent*. (2)
- 5.4 The standard cell potential is +1,52 V. Prove that metal Y is tin (Sn). (4)
- 5.5 Write a balanced net ionic equation for the overall chemical reaction occurring in this cell. (3)
- 5.6 Write down the cell notation for this cell. Include the standard conditions. Phase indicators are not necessary. (4)
- 5.7 Identify a suitable electrolyte that could be used in metal Y's half-cell. (1)
- 5.8 Explain why the emf of this electrochemical cell decreases to zero over time. Your answer must include a description of the changes in the concentrations of the electrolytes. (3)

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QUESTION SIX

Chlorine is used worldwide to purify contaminated water. The diagram below shows a type of membrane cell used in the chlor-alkali industry to produce chlorine industrially.

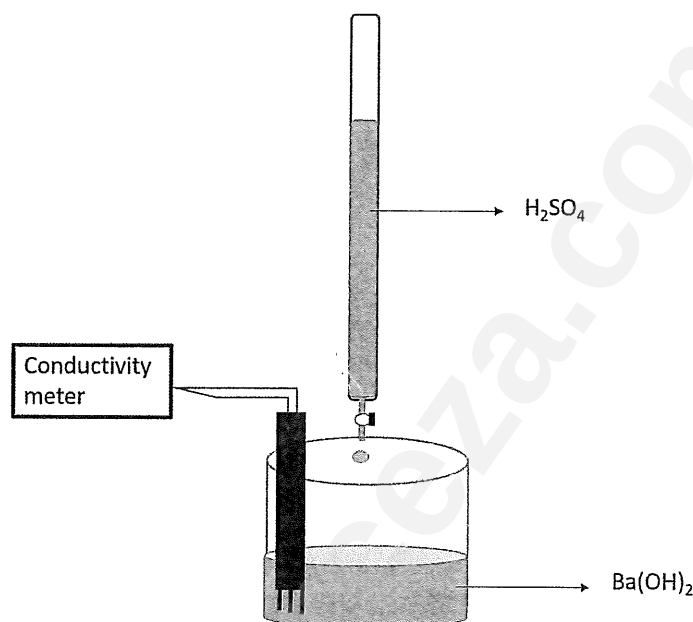


- 6.1 Describe the energy conversion that takes place when this cell is operating. (2)
- 6.2 Identify:
- 6.2.1 Gas A
- 6.2.2 Gas B (2)
- 6.3 Explain the role of the cationic membrane in increasing the purity of the NaOH solution. (2)
- 6.4 According to the Table of Standard Reduction Potentials oxygen gas should be produced from water at the anode of the chlor-alkali cell. What is the main reason that chlorine gas is predominantly produced at the anode? (2)
- 6.5 Write down the half-reaction that takes place at electrode S. (2)
- 6.6 Does the pH of the electrolyte surrounding electrode S *increase/decrease or remain the same* as the reaction progresses? (1)
- 6.7 Explain the answer to question 6.6. (1)
- 6.8 Use values from the Table of Standard Electrode Potentials and a calculation to prove that the net cell reaction is non-spontaneous. (3)
- 6.9 Calculate the average current that needs to be delivered to this cell to produce 17 000 dm³ of chlorine gas at STP, over a period of 24 hours. (6)

[21]

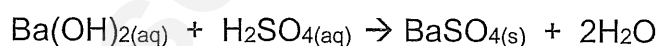
QUESTION SEVEN

250 cm³ of a 0,14 mol·dm⁻³ solution of the **strong base**, Ba(OH)₂, was prepared by a group of students in a laboratory. A burette was filled with a solution of the **diprotic acid**, H₂SO₄ of unknown concentration. 40 cm³ of the Ba(OH)₂ solution was added to a beaker. A conductivity meter was placed in the beaker to determine the conductivity of the solution in the beaker during the titration.

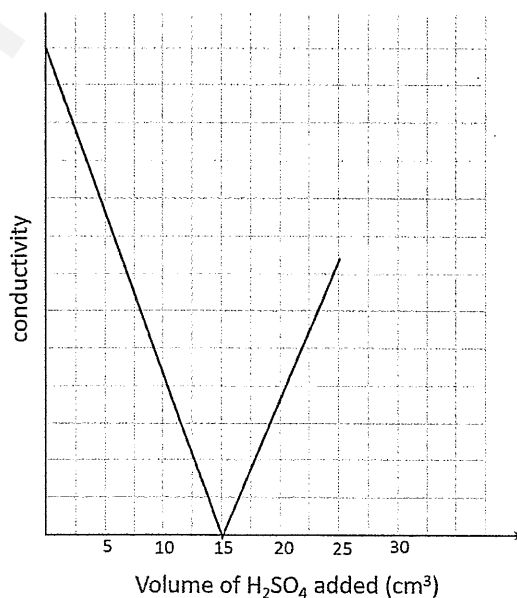


The sulphuric acid was slowly added to the solution in the beaker.

The balanced chemical equation for the reaction between barium hydroxide and sulphuric acid is represented below.



A graph of the conductivity of the solution in the beaker versus the volume of sulphuric acid added is represented below.



- 7.1 Define a *strong base*. (2)
- 7.2 Why is sulphuric acid a **diprotic acid**? Write an equation to support your answer. (3)
- 7.3 Explain the change in the conductivity of the solution in the beaker as the sulphuric acid is added. (4)
- 7.4 Predict the approximate pH of the solution when the volume of sulphuric acid added to the beaker is:
- 7.4.1 15 cm³
- 7.4.2 25 cm³ (2)
- 7.5 Define *neutralisation*. (2)

The students conduct another investigation. This time they add a solution of hydrochloric acid of unknown concentration to 25 cm³ of the barium hydroxide solution of concentration 0.14 mol·dm⁻³. They decide to determine the end point by noting the colour change of a suitable indicator.

Indicator	pH range
Methyl orange	3,1 - 4,4
Bromothymol blue	6,0 - 7,6
Phenolphthalein	8,3 - 10,0

- 7.6 Use information from the table above to briefly explain why the students chose to use bromothymol blue indicator. (2)
- 7.7 Write an equation to show how hydrochloric acid ionises in water and identify the conjugate acid-base pairs. (3)
- 7.8 Write a balanced chemical equation for the reaction between barium hydroxide and hydrochloric acid. (3)
- 7.9 Explain how the students will be able to determine the end point using their chosen indicator. (2)
- 7.10 23,5 cm³ of hydrochloric acid was required to reach the end point in this titration. Determine the concentration of the hydrochloric acid solution. Give your answer to 3 decimal places. (4)

[27]

QUESTION EIGHT

Organic compounds **A-E** and their boiling points are given in the table below:

SYMBOL	ORGANIC COMPOUND	BOILING POINT ($^{\circ}\text{C}$)
A	CH_3OH	66
B	Octanol	195
C	$ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & \\ & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{OH} \\ & & & & & & \\ & \text{H} & & \text{H} & & \text{H} & \end{array} $	97
D	$ \begin{array}{ccccccc} & \text{H} & & \text{O} & & & \\ & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - \text{O} & - & \text{H} \\ & & & & & & \\ & \text{H} & & & & & \end{array} $	118
E	Propane-1,2,3 - triol	290

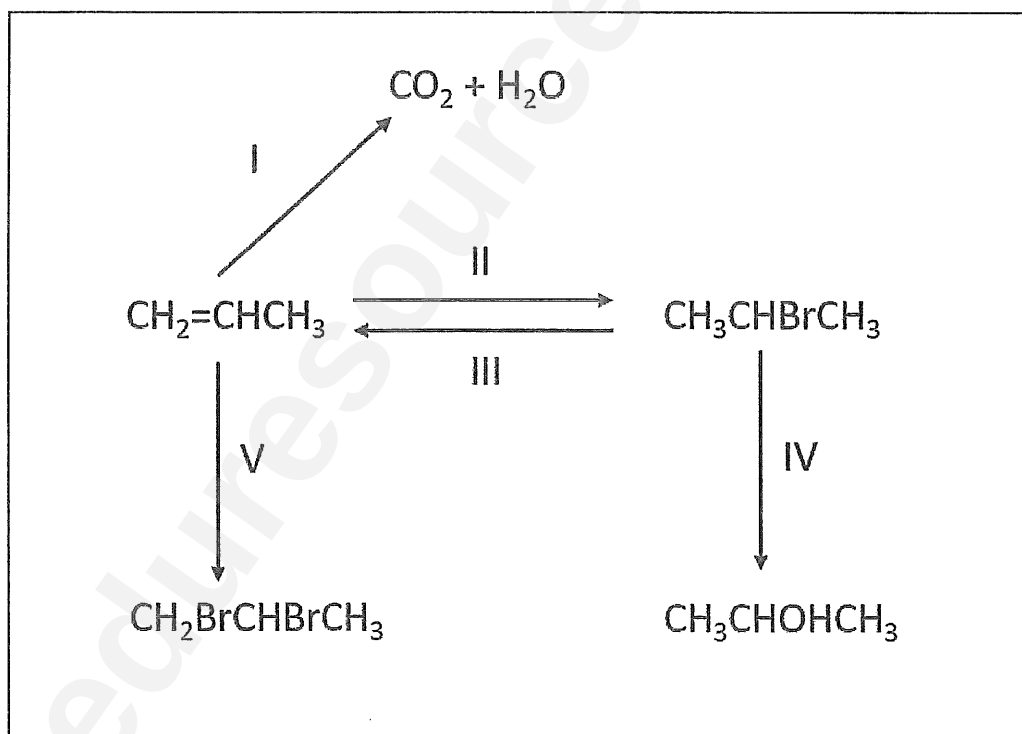
- 8.1 Name the functional group of **A**. (1)
- 8.2 Name the homologous series that compound **D** belongs to. (1)
- 8.3 Define the term *structural isomer*. (2)
- 8.4 Give the IUPAC name of a positional isomer of compound **C**. (2)
- 8.5 Give the condensed structural formula of a functional isomer of compound **D**. (2)
- 8.6 Explain the difference in the boiling points of compounds **B** and **C** in terms of intermolecular forces and energy. (4)

- 8.7 Give one reason for the difference in the boiling points of compounds **C** and **E**. (2)
- 8.8 Write a balanced equation, using structural formulae, for the reaction between compounds **A** and **D**. (3)
- 8.9 Name the organic product produced in the reaction between compounds **A** and **D**. (2)
- 8.10 Write the formula of the catalyst used in the reaction between compounds **A** and **D**. (1)
- 8.11 Explain how the addition of a catalyst affects the rate of the reaction between **A** and **D**. (2)

[22]

QUESTION NINE

Organic reactions I - V are shown below.



- 9.1 Which of the above reactions I - V can be described as:
- 9.1.1 Hydrohalogenation
 - 9.1.2 Combustion
 - 9.1.3 Elimination
 - 9.1.4 Substitution
- (4)
- 9.2 Define the term *unsaturated* compound. (2)

- 9.3 Give the IUPAC name of the unsaturated hydrocarbon represented above. (2)
- 9.4 Reaction **V** involves the use of bromine water as a reagent. Describe what will be observed during reaction **V**. (2)
- 9.5 Write a balanced chemical equation, using molecular formulae, for reaction **I**. (3)
- 9.6 List the reaction conditions necessary for reaction **IV** to occur. (2)
- 9.7 Write the chemical formula of the other reagent used in reaction **II**. (1)
- 9.8 Give the IUPAC name of the product of reaction **V**. (2)

[18]

Grand Total: 200

**EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES
(CHEMISTRY)**

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Magnitude of charge on electron	e	$1,6 \times 10^{-19} \text{ C}$
Mass of an electron	m_e	$9,1 \times 10^{-31} \text{ kg}$
Standard pressure	p^θ	$1,01 \times 10^5 \text{ Pa}$
Molar gas volume at STP	V_m	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature	T^θ	273 K
Avogadro's constant	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$
Faraday's constant	F	$96\,500 \text{ C} \cdot \text{mol}^{-1}$

TABLE 2 CHEMISTRY FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$	$n = \frac{V}{V_m}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14} \text{ at } 298 \text{ K}$	
$Q = It$	$E_{\text{cell}}^\theta = E_{\text{cathode}}^\theta - E_{\text{anode}}^\theta$	
$Q = nF$	$E_{\text{cell}}^\theta = E_{\text{oxidising agent}}^\theta - E_{\text{reducing agent}}^\theta$	

TABLE 3 PERIODIC TABLE

[illegible]

TABLE 4 STANDARD ELECTRODE POTENTIALS

	Half-reaction	E°/volt
	$\text{Li}^+ + \text{e}^- \rightleftharpoons \text{Li}$	-3.05
	$\text{K}^+ + \text{e}^- \rightleftharpoons \text{K}$	-2.93
	$\text{Cs}^+ + \text{e}^- \rightleftharpoons \text{Cs}$	-2.92
	$\text{Ba}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ba}$	-2.90
	$\text{Sr}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sr}$	-2.89
	$\text{Ca}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ca}$	-2.87
	$\text{Na}^+ + \text{e}^- \rightleftharpoons \text{Na}$	-2.71
	$\text{Mg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mg}$	-2.37
	$\text{Al}^{3+} + 3\text{e}^- \rightleftharpoons \text{Al}$	-1.66
	$\text{Mn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mn}$	-1.18
	$2\text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^-$	-0.83
	$\text{Zn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Zn}$	-0.76
	$\text{Cr}^{3+} + 3\text{e}^- \rightleftharpoons \text{Cr}$	-0.74
	$\text{Fe}^{2+} + 2\text{e}^- \rightleftharpoons \text{Fe}$	-0.44
	$\text{Cd}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cd}$	-0.40
	$\text{Co}^{2+} + 2\text{e}^- \rightleftharpoons \text{Co}$	-0.28
	$\text{Ni}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ni}$	-0.25
	$\text{Sn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sn}$	-0.14
	$\text{Pb}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pb}$	-0.13
	$\text{Fe}^{3+} + 3\text{e}^- \rightleftharpoons \text{Fe}$	-0.04
	$2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$	0.00
	$\text{S} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{S}(\text{g})$	+0.14
	$\text{Sn}^{4+} + 2\text{e}^- \rightleftharpoons \text{Sn}^{2+}$	+0.15
	$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+0.17
	$\text{Cu}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cu}$	+0.34
	$2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^- \rightleftharpoons 4\text{OH}^-$	+0.40
	$\text{SO}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{S} + 2\text{H}_2\text{O}$	+0.45
	$\text{I}_2 + 2\text{e}^- \rightleftharpoons 2\text{I}^-$	+0.54
	$\text{O}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{O}_2$	+0.68
	$\text{Fe}^{3+} + \text{e}^- \rightleftharpoons \text{Fe}^{2+}$	+0.77
	$\text{Hg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Hg}$	+0.79
	$\text{NO}_3^- + 2\text{H}^+ + \text{e}^- \rightleftharpoons \text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+0.80
	$\text{Ag}^+ + \text{e}^- \rightleftharpoons \text{Ag}$	+0.80
	$\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+0.96
	$\text{Br}_2 + 2\text{e}^- \rightleftharpoons 2\text{Br}^-$	+1.09
	$\text{Pt}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pt}$	+1.20
	$\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$	+1.21
	$\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$	+1.23
	$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1.33
	$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-$	+1.36
	$\text{Au}^{3+} + 3\text{e}^- \rightleftharpoons \text{Au}$	+1.42
	$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+1.51
	$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$	+1.77
	$\text{F}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{F}^-$	+2.87

Increasing oxidising ability

Increasing reducing ability

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GRADE 12 PRELIMINARY EXAMINATION 2021

PHYSICAL SCIENCES PAPER 2

MULTIPLE CHOICE ANSWER SHEET

EXAM NUMBER: _____

QUESTION 1

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	
					Total mark

EXAM NUMBER: _____

HEADING: _____

