



eduresourceza.com



St Mary's School
Waverley
Founded 1888

Physical Sciences Preliminary Examination

Paper II – Chemistry

Monday 16 September 2024

Form V

Marks: 200

Examiner: Mrs C. Adelaar

Time: 3 hours

Moderators: Dr C. Huysamer & Ms M. Blair

Examination number: _____

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 32 pages and a data sheet of 3 pages (i-iii). Please make sure that your question paper is complete.
2. Please **take home** the data sheet at the end of your exam.
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 above.
4. Use the data and formulae whenever necessary.
5. Show your workings 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. Please make use of point form in explanation questions and be as concise as possible.
11. Extra answer space (pages 9, 21 and 31) is included at the end of the exam paper. If you run out of space for an answer, use this space. If you use this extra space, make sure that you indicate this clearly at the question to ensure that your answer is marked in full.

QUESTION 1

MULTIPLE CHOICE

Answer these questions on the multiple-choice answer grid provided below. There is only one correct answer for each of the multiple-choice questions. Make a clear cross (×) in the box corresponding to the letter 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

(10 x 2) [20]

- 1.1 When in the liquid phase, the following three substances share a common intermolecular force. Which intermolecular force is this?

H ₂ O (l)	HCl (l)	CCl ₄ (l)
----------------------	---------	----------------------

- A covalent bonds
- B hydrogen bonds
- C dipole-dipole forces
- D London forces

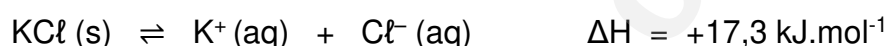
- 1.2 An unknown element X forms a compound X(Cr₂O₇)₂. Which chemical formula represents another compound where X has the same valency?

- A X₃N₄
- B X₂O
- C X₃PO₄
- D X(NO₂)₂

- 1.3 Of the following factors (i – iv) which one/s, if any, will NOT cause a disturbance to a chemical equilibrium?
- i: change in concentration
 - ii: change of temperature
 - iii: change in surface area
 - iv: addition of a catalyst

- A All four factors WILL disturb a chemical equilibrium.
- B Factors i and ii will NOT disturb a chemical equilibrium.
- C Factors iii and iv will NOT disturb a chemical equilibrium.
- D Only factor iv will NOT disturb a chemical equilibrium.

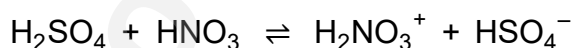
- 1.4 Potassium chloride dissolves and dissociates in water forming a saturated solution according to the following equation.



How can the solubility of potassium chloride be increased?

- A By decreasing the temperature.
- B By increasing the temperature.
- C By adding more solid potassium chloride.
- D By adding some concentrated HCl.

- 1.5 The following reaction occurs between concentrated sulfuric and nitric acid.

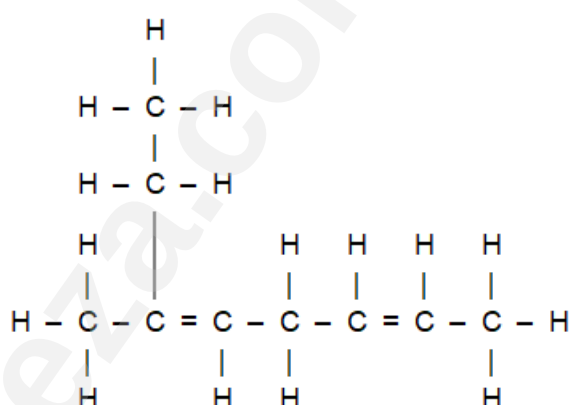


Identify the two species which are acting as Brønsted–Lowry bases.

- A H_2NO_3^+ and HSO_4^-
- B HNO_3 and H_2NO_3^+
- C H_2SO_4 and HSO_4^-
- D HNO_3 and HSO_4^-

- 1.6 10 cm³ of 0,2 mol.dm⁻³ HCl solution is titrated against 0,2 mol.dm⁻³ aqueous ammonia. Which of the following statements is INCORRECT?

- A HCl and ammonia react in a mole ratio of 1:1.
- B A greater volume of ammonia solution than HCl will be required to reach the equivalence point because ammonia is a weak base.
- C The end point of the titration will have a pH of 4,2 – 6,3 because ammonia is a weak base.
- D 0,002 moles of salt are produced in the reaction.

- 1.7 Which one of the following statements about the standard hydrogen electrode is TRUE?
- The electrode operates under standard conditions, specifically an acid concentration of 1 mol.dm^{-3} , a temperature of 0°C and a gas pressure of 1 atm .
 - Oxidation always happens at this electrode.
 - It always reacts spontaneously with the other half cell connected to it.
 - It is connected to the negative terminal of the cell.
- 1.8 What is the IUPAC name for the compound shown below?
- 2-ethylhepta-2,5-diene
 - 2-ethylhept-2,5-diene
 - 6-methylocta-2,5-diene
 - 6-methyloct-2,5-diene
- 
- 1.9 Which one of the following molecular formulae can be **neither** an ester nor an acid?
- CH_2O_2
 - $\text{C}_3\text{H}_8\text{O}$
 - $\text{C}_2\text{H}_2\text{O}_4$
 - $\text{C}_3\text{H}_6\text{O}_2$
- 1.10 How many moles of oxygen gas (O_2) are required for the complete combustion of 1 mole of but-2-ene?
- 16
 - 12
 - 8
 - 6

(10 x 2) [20]

QUESTION 2

2.1 Define *electronegativity*.

(2)

2.2 The compounds SO₂ and MgO are both oxides but with different melting points as shown below.

Compound	Melting point (°C)
SO ₂	-72
MgO	2852

2.2.1 Give the name for SO₂.

(1)

2.2.2 Fully explain the difference in the melting points of SO₂ and MgO. Ensure you refer to the type of lattice for each solid in order to compare them.

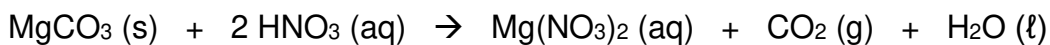
(6)

2.2.3 Ammonia, NH₃, is the same type of solid as SO₂ and yet its melting point is 2 °C.

Account for ammonia's melting point compared to SO₂. Do not repeat information from 2.2.2 above, simply continue the discussion for ammonia.

(2)

The reaction takes place according to the balanced equation below and runs to completion.



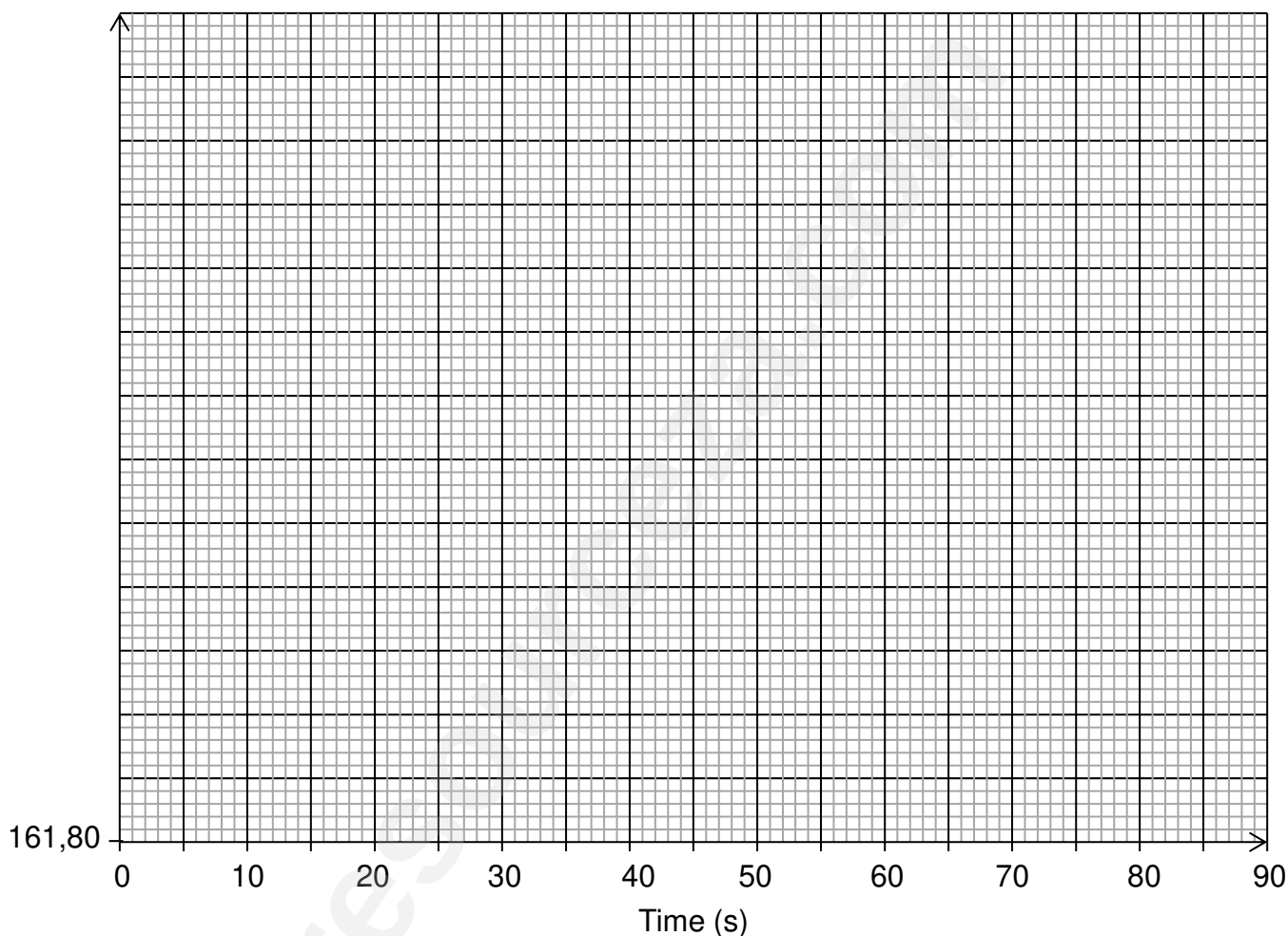
Time (s)	Mass of flask and contents (g)
0	162,38
10	162,19
20	Missing value:
30	162,06
40	162,03
50	162,01
60	162,00
70	162,00
80	162,00



- Assume that V_m for the conditions of this experiment is $24 \text{ dm}^3 \cdot \text{mol}^{-1}$.

(7)

- 3.2 Use the data from the table, including your value from question 3.1, to plot a graph of the progress of this reaction over time. Complete all necessary aspects of the graph as well as a line of best-fit. (6)



- 3.3 Use the graph to determine the average rate of reaction for the first 15 seconds of the reaction.

(3)

- 3.4 Give the two ways in which the overall average reaction rate could be increased in this reaction, other than by using a catalyst or more finely ground powder.

(2)

- 3.5 Based on your answer to 3.4 above, what single condition must be met in order for only the rate of the reaction to be changed, and not the final mass of the flask and its contents?

(1)

- 3.6 In a repeat of the experiment, the magnesium carbonate was replaced with large chips instead of powder. Use collision theory to explain the resulting change in the rate of the reaction.

(4)

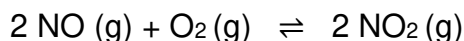
[23]

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

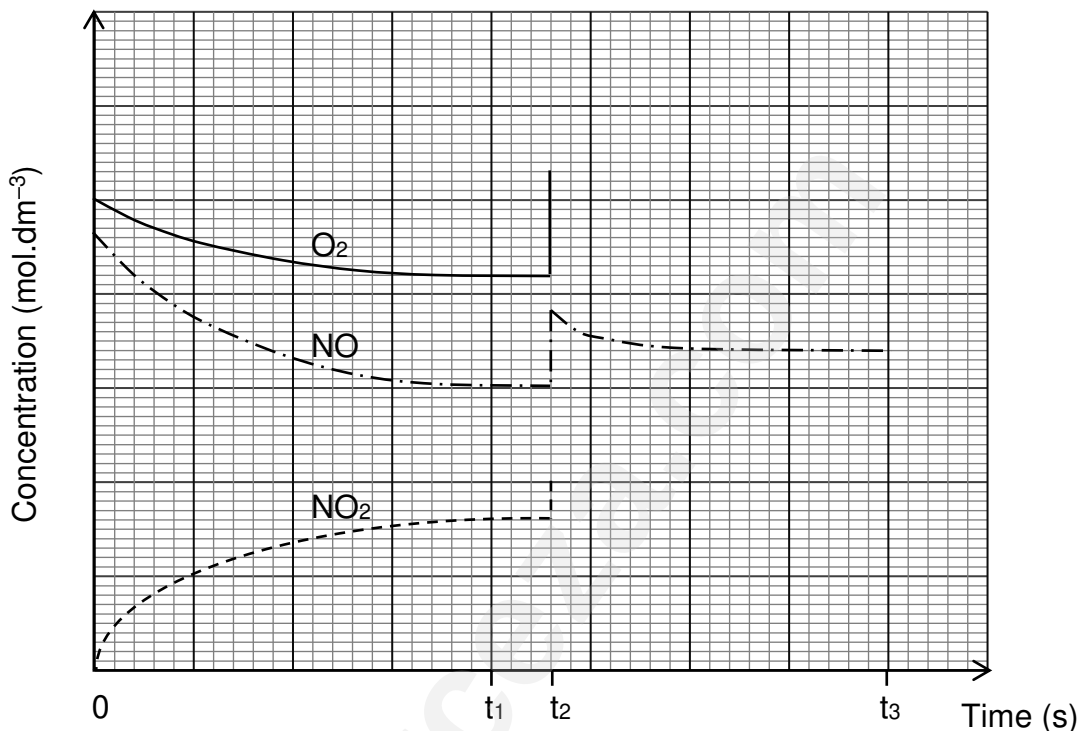
[illegible]

QUESTION 4

- 4.1 The graph below (Graph A) shows the concentration of gases in a sealed 1 dm³ reaction vessel over time. The chemical reaction is as follows:



Graph A:



- 4.1.1 Equilibrium is reached for the first time between t_1 and t_2 on the graph. Why do the horizontal lines indicate that equilibrium has been reached?

(1)

- 4.1.2 At t_2 the disturbance to the equilibrium is an increase in pressure. What is the cause of this disturbance?

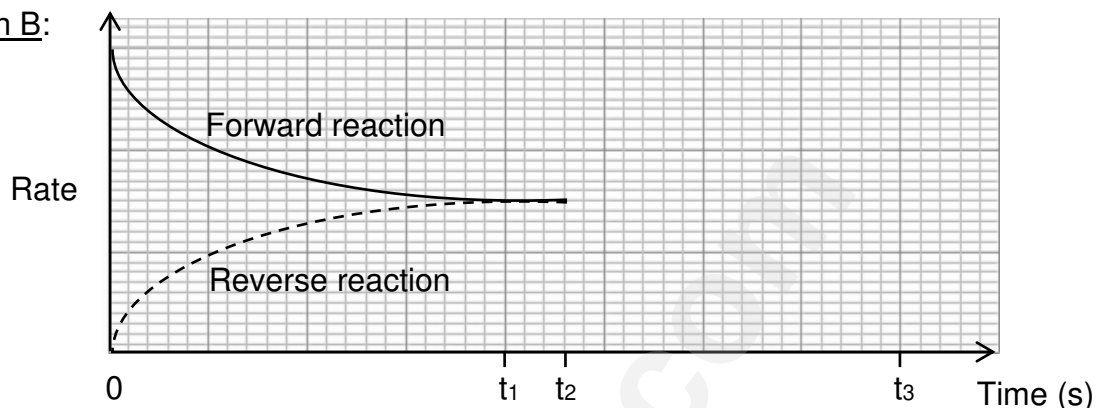
(1)

- 4.1.3 **On the graph above** (Graph A), complete the curves for O_2 and NO_2 between t_2 and t_3 . The graph is drawn to scale and your lines must also be drawn to scale.

(3)

- 4.1.4 The graph below (Graph B) corresponds with the previous graph (Graph A on page 10). On the axes below, sketch the adjustment to the rate of the forward and reverse reactions between t_2 and t_3 . Pay attention to the time at which the new equilibrium is reached.

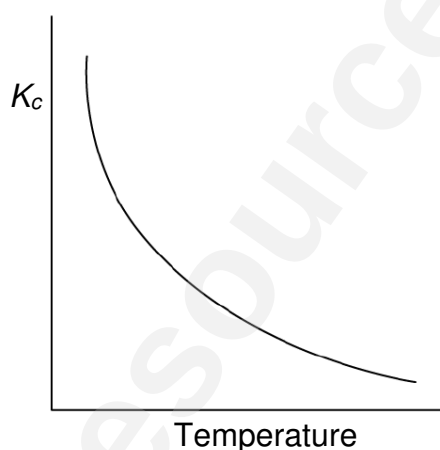
Graph B:



(3)

- 4.1.5 The graph below (Graph C) shows the relationship between temperature and K_c for the chemical equilibrium above.

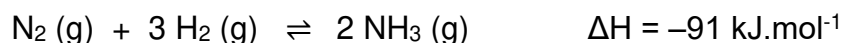
Graph C:



Use the information from the graph above to determine whether the forward reaction is exothermic or endothermic. Justify your answer.

(4)

- 4.2 Ammonia can be manufactured from nitrogen and hydrogen gases in the Haber process. The equilibrium is shown below.



- 4.2.1 Write an expression for K_c for this equilibrium.

(2)

- 4.2.2 A chemist carries out a series of experiments to investigate the conversion of nitrogen and hydrogen into ammonia under different conditions.

The chemist mixes together 10,4 mol N_2 and 22,5 mol H_2 and pressurises the gases so that the total gas volume is 5 dm³.

The mixture is allowed to reach equilibrium at constant temperature and without changing the total gas volume. The equilibrium mixture contains 5,6 mol NH_3 .

Calculate the K_c for this reaction at this temperature.

(7)

When the Haber process is performed industrially, the conditions of pressure and temperature are adjusted so that the yield of the reaction increases.

4.2.3 Explain as simply as possible what is meant by yield in a reaction.

(2)

Although Le Châtelier's principle is used to suggest the best conditions for a reaction, in industrial applications, yield is often sacrificed for rate.

4.2.4 Use Le Châtelier's principle to state whether a higher or lower temperature should be used to produce the maximum yield of ammonia in the industrial reaction. Circle the correct answer below:

Use a HIGHER temperature OR Use a LOWER temperature (1)

4.2.5 For the **industrial** process for manufacturing ammonia, answer the question below by focusing on each point and addressing all 3 in your answer. Use bullet points.

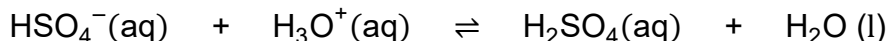
- State a problem that may occur from using this temperature (4.2.4 above), and
- discuss the specific issue that it poses to industry, and
- suggest a way in which chemists can reduce the impact of this problem.

(3)

[27]

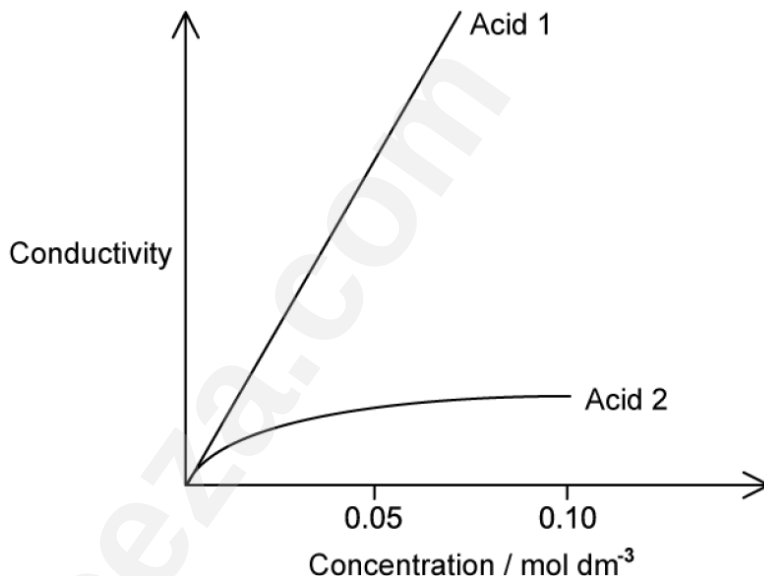
QUESTION 5

- 5.1 Identify the amphoteric substances in the following reaction by circling them. (2)



- 5.2 The variation of conductivity and concentration of a strong and weak monoprotic acid are shown in the graph alongside.

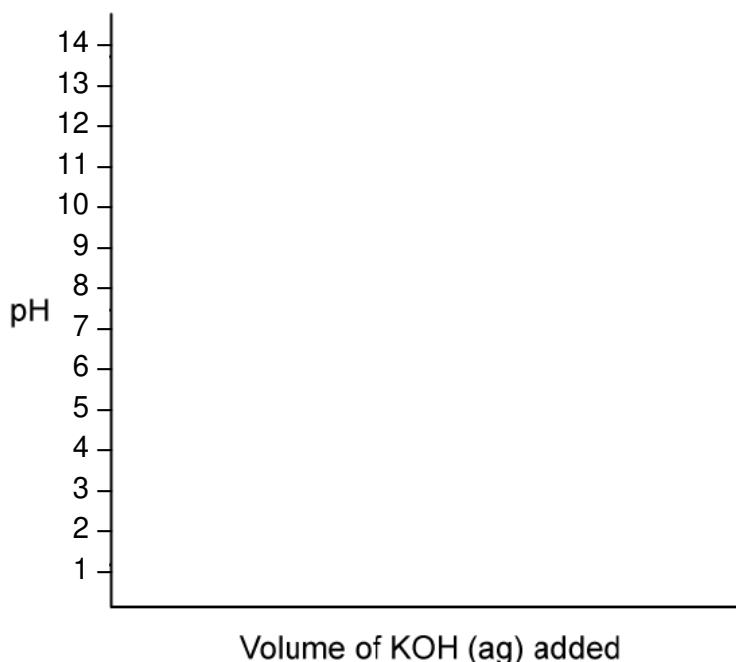
Identify the weak acid (Acid 1 or Acid 2) from the information given and justify your choice.



- 5.3 A pH curve can be drawn from the data recorded from the following titration procedure: (3)

- HCl (aq) and a pH meter are placed into a beaker
- KOH (aq) is added to the beaker from a burette while stirring
- KOH (aq) is added until the pH of the solution remains unchanged

Sketch a curve on the axes provided alongside for the titration described above.
Mark the equivalence point with a dot and the letter E as shown: • E

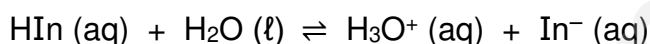


5.4 A titration was performed between solutions of ethanoic acid, CH_3COOH (aq) and sodium hydroxide, NaOH (aq).

5.4.1 Write an equation for the reaction between ethanoic acid and sodium hydroxide. Phase labels are not required.

(2)

Indicators ionise in water according to the following equation. The indicator in its different forms has different colours.



The table below provides information about three different indicators.

Indicator	End-point pH range	Colour of molecular form of indicator	Colour of ionic form of indicator
Bromophenol blue	3.0 - 4.8	Yellow	Blue
4-nitrophenol	5.6 - 7.0	Colourless	Yellow
Cresol purple	7.6 - 9.2	Yellow	Purple

5.4.2 Using the information in the table above, **circle** the name of the indicator which would be suitable for this titration.

(1)

When the indicator is placed into NaOH (aq) it results in a DECREASE in the concentration of hydronium ions in solution.

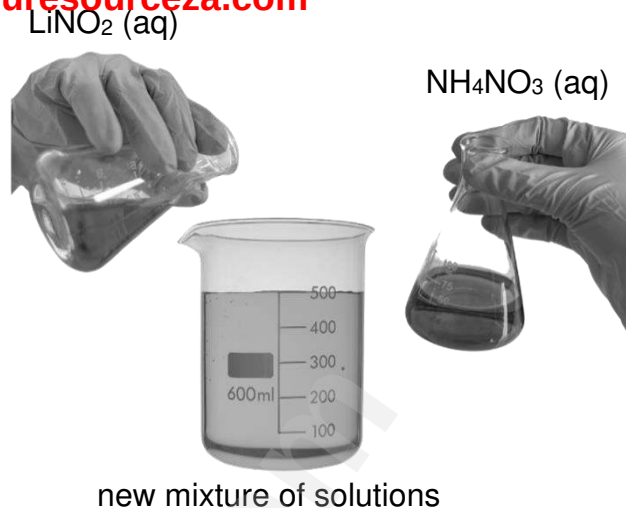
5.4.3 Explain why the concentration of hydronium ions DECREASES.

(2)

5.4.4 Hence, what colour will the solution be if the indicator is placed into NaOH (aq)? Explain your answer in terms of Le Châtelier's principle. Use bullet points in your answer.

(4)

- 5.5 Two salt solutions are mixed together in one beaker. 250 cm³ of each salt, both with a concentration of 0,5 mol.dm⁻³ are placed into the same beaker. The two salts are LiNO₂ (aq) and NH₄NO₃ (aq).
No reaction between these salts occurs.



Consider the following two ions from this new mixture: NO₂⁻ and NO₃⁻.

5.5.1 Name the NO₂⁻ ion.

_____ (1)

5.5.2 Define *hydrolysis* of a salt.

_____ (2)

5.5.3 The NO₃⁻ ion (with 3 oxygen atoms) does NOT undergo hydrolysis. Give a reason for this in terms of the relative strengths of the acid and base in the conjugate pair.

_____ (2)

5.5.4 The NO₂⁻ ion DOES undergo hydrolysis. Name the ion produced from this hydrolysis reaction.

_____ (1)

5.5.5 Of the two positive ions in the mixture, the NH₄⁺ ion DOES undergo hydrolysis. Write the equation showing the hydrolysis reaction of ammonium ions. Phase labels are not required.

_____ (2)

Consider the equilibrium constants provided below for the hydrolysis of NO_2^- and NH_4^+ :

$$K_b \text{ for } \text{NO}_2^- = 2,5 \times 10^{-11}$$

$$K_a \text{ for } \text{NH}_4^+ = 5,5 \times 10^{-10}$$

5.5.6 Predict whether the new mixture of solutions will be NEUTRAL, ACIDIC or ALKALINE.

_____ (1)

5.5.7 Refer to both constants above to explain your answer to 5.5.6 above.

_____ (3)

[29]

QUESTION 6

Potassium permanganate (KMnO_4) acts as a powerful oxidising agent in an acidic medium.

6.1 Define the term *oxidising agent*.

(1)

The permanganate ions in solution are purple in colour, and when reduced, become colourless.

A solution of KMnO_4 (aq) can be standardised through titration using a standard solution of oxalic acid, $(\text{COOH})_2$ (aq), to which dilute sulphuric acid has been added to provide H^+ ions for an acidic medium.

The acid is heated to 60°C during the titration.

Reaction requirements:

purple KMnO_4 (aq)

colourless $(\text{COOH})_2$ (aq)
to which H_2SO_4 (aq) has been added

$(\text{COOH})_2$ (aq) heated to 60°C

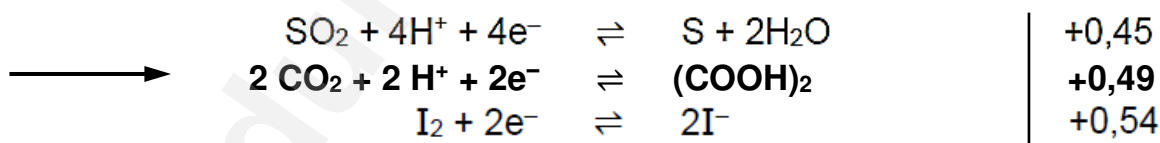
V_{initial}

V_{final}

end point: pale permanent pink colour

The reaction is a spontaneous redox reaction. The moment there is an excess of KMnO_4 present in the conical flask, the solution becomes a pale permanent pink colour. Hence, KMnO_4 is its own indicator in the reaction.

The half reaction involving oxalic acid does not appear on your standard electrode potentials table. Based on its $E^\ominus$ value, the reaction can be inserted, as shown below.



Hence, the oxidation half reaction for oxalic acid is:



6.2 Write the reduction half reaction for this reaction.

(1)

6.3 Write the overall **balanced ionic** equation for this reaction. Spectator ions are not required.

(3)

6.4 By referring to **all** relevant substances in the titration and the hydrochloric acid **anion**, explain why **hydrochloric acid CANNOT be used for acidification** in this reaction, in terms of relative strengths of reducing and oxidising agents. Refer to both the table of standard electrode potentials and the additional reaction for oxalic acid from page 18. Use bullet points.

6.5 If hydrochloric acid were used, what aspect of the validity of the practical titration would be negatively affected?

The solution of oxalic acid is made by dissolving 0,225 g of $(\text{COOH})_2$ crystals in water to make up a solution of exactly 25 cm^3 .

6.6 Calculate the concentration of the oxalic acid solution.

edit

6.7 Use your balanced equation from question 6.3 to determine the concentration of the permanganate ions in the original solution.

(4)

Information for 6.8 and 6.9:

One of the **products** of this reaction, manganese sulphate, acts as a **catalyst** in the reduction of the permanganate ion. The rate of this reaction is further affected by the **initial heating** of the oxalic acid solution to 60 °C.

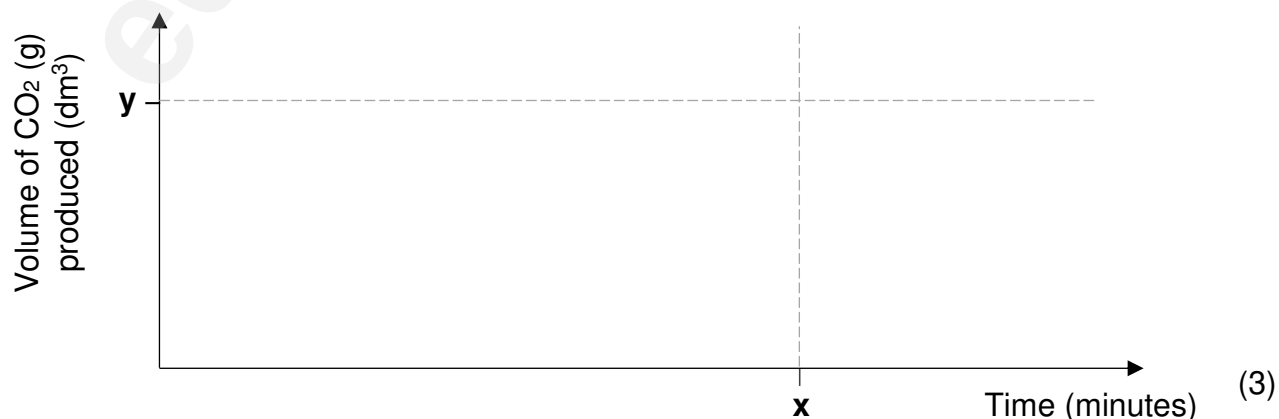
When acidified KMnO_4 (aq) and $(\text{COOH})_2$ (aq) are added to a flask simultaneously, the reaction proceeds to completion and the rate of the reaction can be monitored.

6.8 Define *catalyst*.

(2)

6.9 The reaction was performed once with the temperature of the $(\text{COOH})_2$ (aq) **at 60 °C** and the reaction took **x minutes** to reach completion and produced **y dm³** of carbon dioxide gas as shown in the graph below.

On the axes below, sketch a rate of reaction curve for the reaction when the $(\text{COOH})_2$ (aq) solution was heated to **70 °C**. No heading is required. Pay attention to shape and end time.



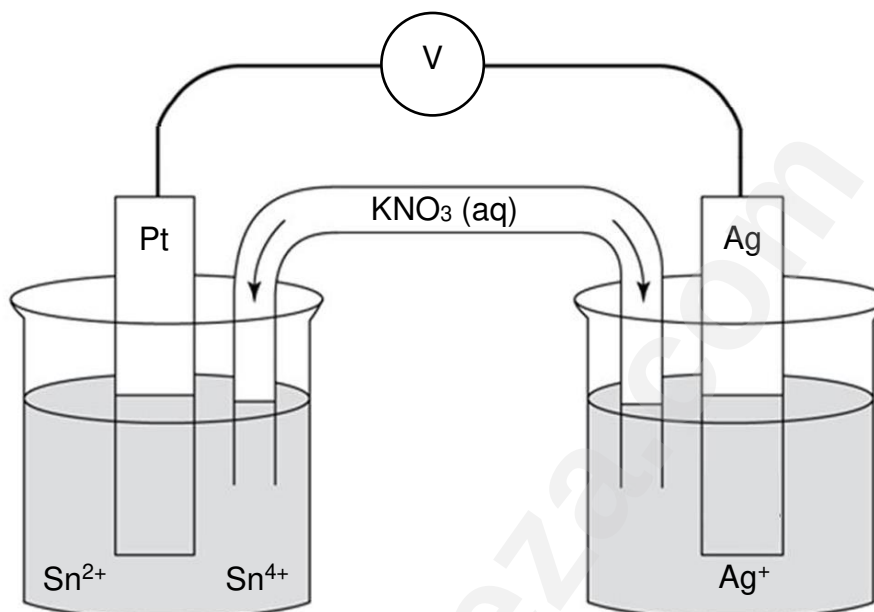
**REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE
ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.**

[illegible]

QUESTION 7

Two metals are connected as shown in a galvanic cell that spontaneously produces a reading on the voltmeter when operating under standard conditions.

Platinum metal is placed in a solution of $\text{Sn}(\text{NO}_3)_2$ and $\text{Sn}(\text{NO}_3)_4$. Silver metal is placed in a solution of AgNO_3 .



7.1 Determine the emf of this cell under standard conditions.

(3)

7.2 Write the cell notation for this cell. Standard conditions are not required, but phase labels must be included.

(3)

7.3 What is the purpose of the structure that contains KNO_3 (aq)?

(2)

7.4 A spatula of $\text{Sn}(\text{NO}_3)_2$ powder is fully dissolved in the electrolyte at the platinum electrode.

7.4.1 Will the reading on the voltmeter INCREASE, DECREASE or STAY THE SAME?

_____ (1)

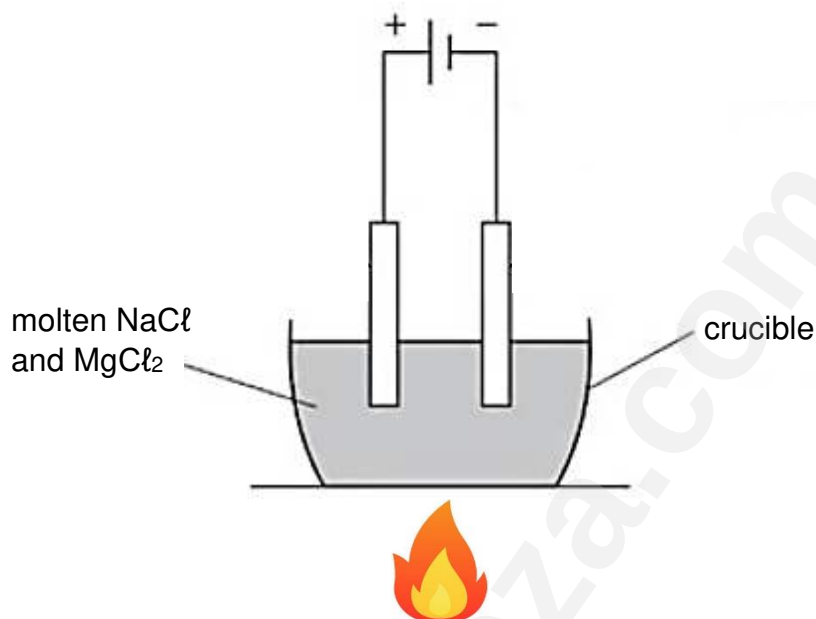
7.4.2 Explain your answer to 7.4.1 above.

_____ (3)

[12]

QUESTION 8

- 8.1 A mixture of solid sodium chloride (NaCl) and magnesium chloride (MgCl_2) is subjected to electrolysis with graphite electrodes. The salt mixture is heated to 810°C in order for both salts to melt.



- 8.1.1 **On the diagram above**, label the cathode and indicate the direction of flow of positive ions in the molten electrolyte. (2)

- 8.1.2 Other than its ability to conduct electricity, give a reason why graphite is a suitable material for the electrodes in this electrolytic cell.

_____ (1)

- 8.1.3 Only one metal is produced through electrolysis of this salt mixture. Explain why this is the case.

_____ (2)

- 8.1.4 For this reaction, determine and write down the:

a) reduction half reaction: _____ (2)

b) oxidation half reaction: _____ (1)

8.2 A DILUTE aqueous solution of sodium chloride (NaCl (aq)) can undergo electrolysis in the laboratory.

8.2.1 Name the oxidising agent in this reaction.

_____ (1)

8.2.2 Identify the molecular product of oxidation in this reaction.

_____ (1)

8.3 A CONCENTRATED solution of sodium chloride (brine) is used industrially for electrolysis in a membrane cell in the chlor-alkali industry.

8.3.1 Which product of this electrolytic process is the alkali referred to in the chlor-alkali industry?

_____ (1)

8.3.2 At which electrode, ANODE or CATHODE, is this product produced?

_____ (1)

8.3.3 Explain how the high purity of the alkali product is ensured in the membrane cell electrolytic process.

_____ (3)

8.3.4 Identify the gaseous products of this electrolytic process.

_____ (1)

8.3.5 Identify one potential danger associated with either or both of the gaseous products of the electrolytic process.

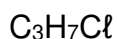
_____ (1)

QUESTION 9

9.1.1 Define a *homologous series*.

(2)

9.1.2 Which of the following molecules is/are from the same homologous series as butane? Circle the correct molecule/s.

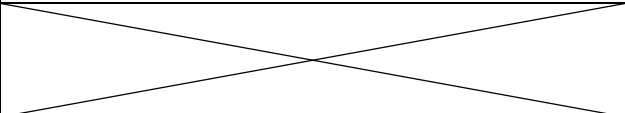
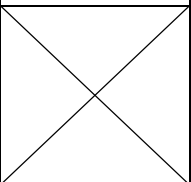
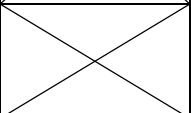


(1)

9.1.3 Define *structural isomers*.

(2)

9.1.4 Complete the following table (cells i – iv) for various types and examples of structural isomers. Each row refers only to one type of isomerism identified in the second column. Cells in the table that are crossed through do not have to be completed. (5)

Molecular formula	Type of isomer shown in examples (last column)	Maximum number of isomers for this molecule	Names of 2 specific examples of isomers with this molecular formula
C_5H_{12}	(i) _____	(ii) _____	
$\text{C}_3\text{H}_7\text{OH}$	Positional		(iii) _____ _____
$\text{C}_7\text{H}_{14}\text{O}_2$	(iv) _____		propyl butanoate methyl hexanoate

- 9.2 Ethanoic acid and fluoroethane have very similar molar masses yet their boiling points are very different as shown alongside.

	Molar mass (g.mol ⁻¹)	Boiling point (°C)
Ethanoic acid	50	117,9
fluoroethane	48	-37,1

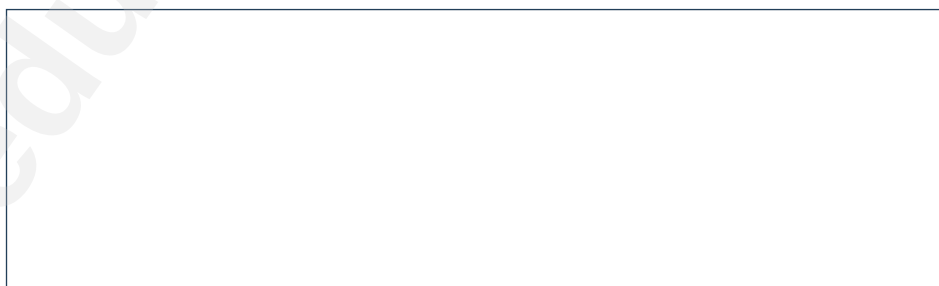
Explain why ethanoic acid has a significantly higher boiling point than fluoroethane. Use bullet points

(4)

- 9.3 The pineapple-like smelling organic compound has the formula: **CH₃CH₂COOCH₂CH₃**
- 9.3.1 Give the IUPAC name for the compound above.

(2)

- 9.3.2 Draw the structural formula of the functional group of this compound.



(2)

- 9.3.3 Give the IUPAC name for the functional isomer of the compound above.

(2)

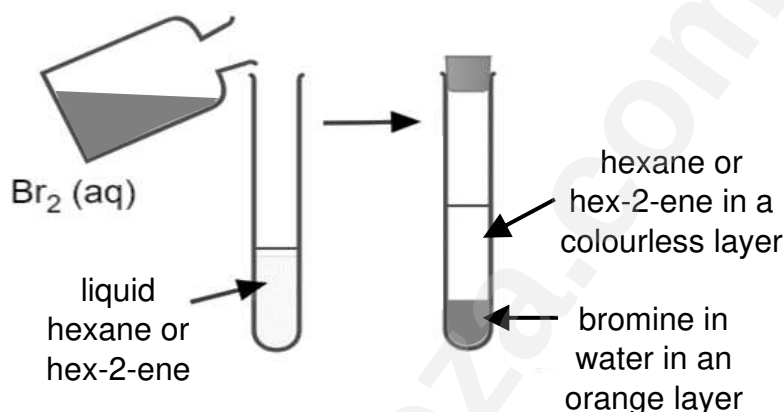
[20]

QUESTION 10

10.1 Hexane, C_6H_{14} (l), and hex-2-ene, C_6H_{12} (l), were used to investigate the reactivity of alkanes and alkenes, first in a darkened room and then in sunlight.

- Hexane and hex-2-ene were poured into two separate test tubes.
- Some orange coloured bromine water (bromine dissolved in water) was added to the contents of each test tube.

(Note: The two liquids in each test tube have different densities and do not mix. The diagram below shows the initial two layers in each test tube.)



- After this, the test tubes were shaken vigorously.

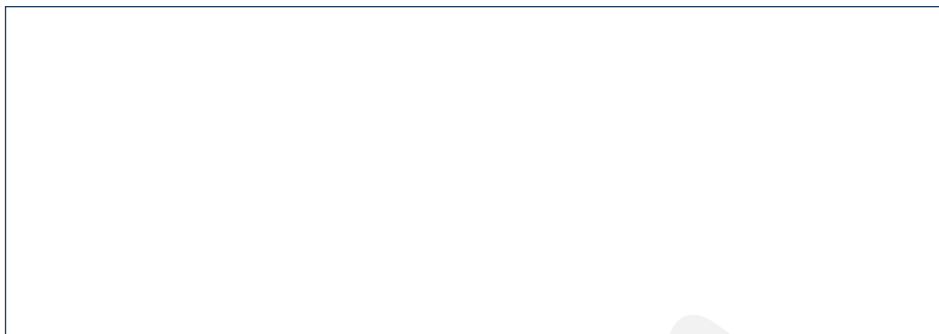
The observations are shown in the table below:

Compound	Action of bromine in the dark	Action of bromine in the sunlight
X	Top layer stays colourless Bottom layer starts orange and becomes colourless within a few seconds	(a)  Top layer stays colourless Bottom layer starts orange and becomes colourless within a few seconds
Y	Top layer becomes dark orange Bottom layer becomes colourless The colour stays in the top layer over time	(c)  (b)  (d)  Top layer starts dark orange and becomes colourless after a long time Bottom layer becomes colourless

10.1.1 Which one of the compounds, **X** or **Y**, from the table of observations above, is hexane?

(1)

- 10.1.2 Draw the structural formula for the organic product of the reaction formed in test tube (a).



(2)

- 10.1.3 Name the GENERAL type of reaction responsible for the observations for compound Y.

(1)

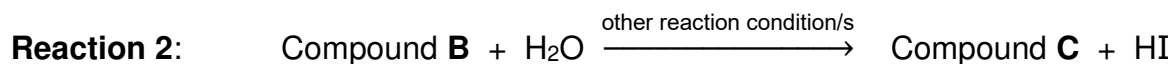
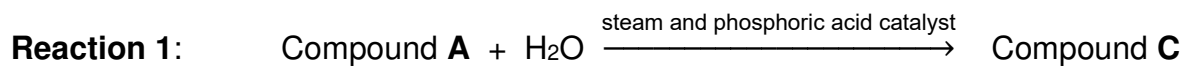
- 10.1.4 Refer to test tube (c). Explain why the colour has moved from the bottom aqueous layer into the top layer. Discuss solubility in your answer.

(3)

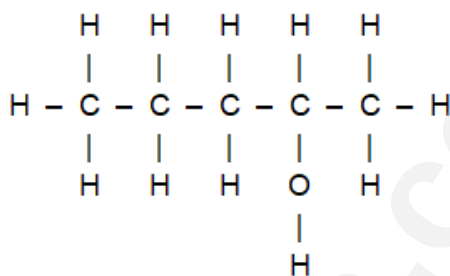
- 10.1.5 This experiment shows the “test for a specific feature of hydrocarbons”. Make a conclusion about the nature of compound X based on the results in terms of this “test”.

(1)

- 10.2 Two different reactions (1 and 2 below) produce the same product (Compound **C**) as shown below.



The structural formula for the product, compound **C** is shown below:



- 10.2.1 Name the functional group present in compound **C** which determines to which homologous series it belongs.

_____ (1)

- 10.2.2 Name the GENERAL type of reaction taking place in Reaction 1.

_____ (1)

- 10.2.3 Give the IUPAC name for compound **A**.

_____ (2)

- 10.2.4 Name the SPECIFIC type of reaction taking place in Reaction 2.

_____ (1)

- 10.2.5 Give the IUPAC name for compound **B**.

_____ (3)

- 10.2.6 Under what condition/s must Reaction 2 take place?

_____ (1)

[17]

TOTAL: 200 MARKS

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

[illegible]

Examination number: _____

Chemistry Preliminary examination 2024

Question	Topic	Possible Marks	Marks obtained	Percentage
1	MCQ	20		
2	Bonding	11		
3	Rates of reactions	23		
4	Equilibrium	27		
5	Acids and bases	29		
6	Electrochemistry: general and rates	24		
7	Galvanic cells	12		
8	Electrolysis	17		
9	Organic	20		
10	Organic reactions	17		
Total		200		

Sources: Acknowledgements and thanks:

Images and Questions adapted from: CIE A Level Chemistry Chemical Equilibria Reversible Reactions & Dynamic Equilibrium and Brønsted–Lowry Theory of Acids & Bases

Images from: <https://www.sciencephoto.com/media/727565/view>

Questions adapted from: <https://testbook.com/chemistry/titration-of-oxalic-acid-with-kmno4#:~:text=Potassium%20permanganate%20is%20standardized%20against,room%20temperature%20is%20given%20below.&text=The%20ionic%20equation%20involved%20in%20the%20process%20is%20given%20below> and <https://www.vedantu.com/chemistry/titration-of-oxalic-acid-with-kmno4>

Images adapted from: <https://acechemistry.co.uk/topic/alkenes-test-for-...>