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**ST. MARY'S DSG KLOOF****Physical Sciences****GRADE 12  
TRIALS 2024****Trials Paper 2****Time: 3 hours + 10 min reading  
Marks: 200****Examiners and Moderators: T. Kirsten, K. Bolton and G. Main****Examination number:**

|  |  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|--|

**Read the Following Instructions Carefully:**

1. This paper consists of: A question paper of 28 pages  
A Data sheet
2. Answer **ALL** questions on the paper.
3. It is in your own interest to write legibly and to set your work out neatly.
4. Show all the necessary steps in calculations.
5. Use the data and formulae whenever necessary.
6. All working should be shown and units **MUST** be given with answers. Work to two decimal places or significant figures where appropriate. **Make sure your calculator is in the correct mode.**
7. Two blank pages (27-28) are included at the end of the question paper. If you run out of space for a question, use these extra pages. Clearly indicate the question number of your answer, should you use this extra space.

|                       | Q1        | Q2        | Q3        | Q4        | Q5        | Q6        | Q7        | Q8        | Q9        | TOTAL      |
|-----------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| <b>Mark</b>           |           |           |           |           |           |           |           |           |           |            |
| <b>Question total</b> | <b>20</b> | <b>25</b> | <b>20</b> | <b>29</b> | <b>29</b> | <b>17</b> | <b>21</b> | <b>15</b> | <b>24</b> | <b>200</b> |

**ACKNOWLEDGEMENTS**

St. Mary's Waverley Trials 2020 Paper 2

Beaulieu College Trials 2021 Paper 2

Heronbridge College Trials 2021 Paper 2

IEB November 2018 Paper 2

IEB May 2023 Paper 2

IEB May 2024 Paper 2

(AS): Paper 2 Organic and Physical Chemistry - June 2022

DBE Paper 2 May June KZN 2024

**QUESTION 1      MULTIPLE CHOICE**

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

|          |          |          |          |
|----------|----------|----------|----------|
| <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
|----------|----------|----------|----------|

Here the option C has been marked as an example.

|             |          |          |          |          |
|-------------|----------|----------|----------|----------|
| <b>1.1</b>  | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
| <b>1.2</b>  | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
| <b>1.3</b>  | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
| <b>1.4</b>  | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
| <b>1.5</b>  | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
| <b>1.6</b>  | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
| <b>1.7</b>  | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
| <b>1.8</b>  | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
| <b>1.9</b>  | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
| <b>1.10</b> | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |

**QUESTION 1      MULTIPLE CHOICE**

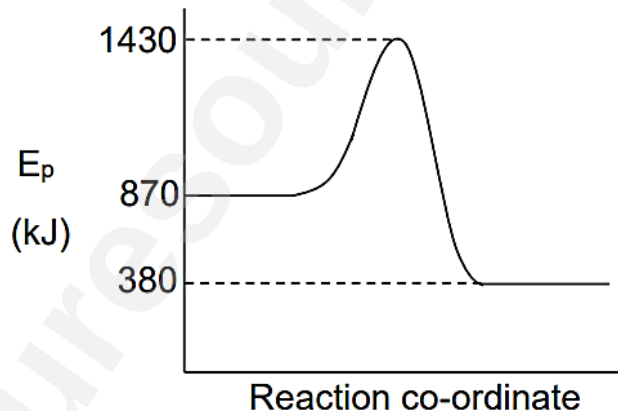
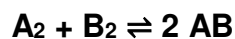
1.1 Which one of the following name and formula combinations is correct?

|   | NAME                  | FORMULA                         |
|---|-----------------------|---------------------------------|
| A | phosphorus trihydride | PH <sub>3</sub>                 |
| B | potassium dichromate  | KCr <sub>2</sub> O <sub>7</sub> |
| C | copper sulphate       | CuSO <sub>4</sub>               |
| D | ammonium nitrite      | NH <sub>4</sub> NO <sub>3</sub> |

1.2 Which one of the following solids does NOT have a giant covalent network structure?

- A Diamond
- B Graphite
- C Silicon dioxide
- D Iodine

1.3 The energy profile for the following reaction is given:



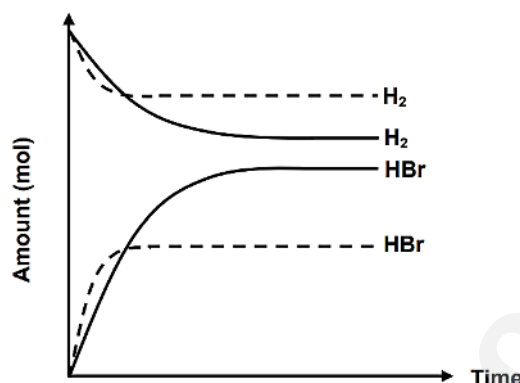
What is the activation energy for the **reverse** reaction?

- A 1430 kJ
- B 715 kJ.mol<sup>-1</sup>
- C 525 kJ.mol<sup>-1</sup>
- D 560 kJ

- 1.4 A container is filled with  $\text{H}_2$  and  $\text{Br}_2$  gases and sealed at a particular temperature. The gases react as shown in the following balanced chemical equation:



The changes in the amounts of  $\text{H}_2$  and  $\text{HBr}$  are shown by the solid lines in the graph below



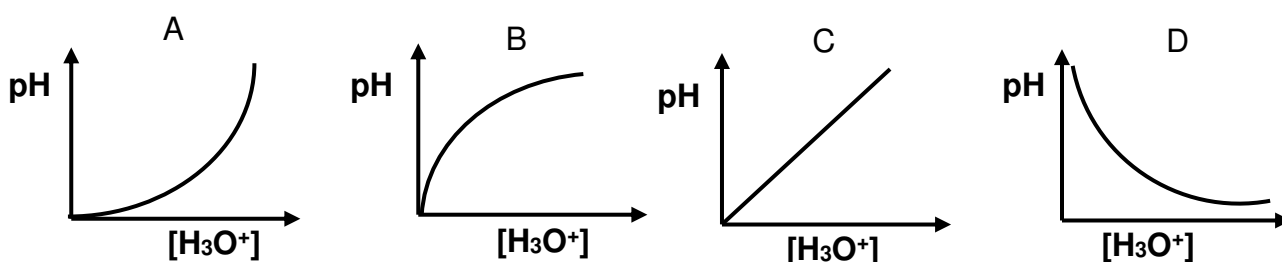
The reaction is then repeated under different conditions. Which one of the following changes to the original conditions would result in the dashed lines (---) shown on the graph?

- A A higher pressure
  - B A higher temperature
  - C A higher concentration of  $\text{Br}_2$
  - D Addition of a suitable catalyst
- 1.5 Consider the reactant **Y** in the following reaction:



The formula of **Y** is:

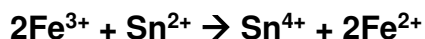
- A  $\text{H}_2\text{SO}_3^-$
  - B  $\text{SO}_3^{2-}$
  - C  $\text{SO}_3^-$
  - D  $\text{H}_2\text{SO}_3$
- 1.6 Which one of the following graphs represents the relationship between pH and the concentration of hydronium ions  $[\text{H}_3\text{O}^+]$  in an aqueous solution?



1.7 Which one of the following redox reactions is non-spontaneous under standard conditions?

- A  $\text{Ni(s)} + \text{Mn}^{2+}(\text{aq}) \rightarrow \text{Ni}^{2+}(\text{aq}) + \text{Mn(s)}$
- B  $\text{Cd}^{2+}(\text{aq}) + \text{Zn(s)} \rightarrow \text{Cd(s)} + \text{Zn}^{2+}(\text{aq})$
- C  $\text{Fe(s)} + \text{Sn}^{2+}(\text{aq}) \rightarrow \text{Fe}^{2+}(\text{aq}) + \text{Sn(s)}$
- D  $\text{Pb}^{2+}(\text{aq}) + \text{Co(s)} \rightarrow \text{Pb(s)} + \text{Co}^{2+}(\text{aq})$

1.8 Which is the oxidising agent in the following reaction?



- A  $\text{Fe}^{2+}$
- B  $\text{Fe}^{3+}$
- C  $\text{Sn}^{2+}$
- D  $\text{Sn}^{4+}$

1.9 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.

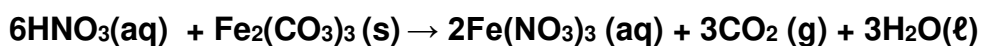
1.10 When hexadecane ( $\text{C}_{16}\text{H}_{34}$ ) is heated to a high temperature, one molecule of hexadecane decomposes to form an alkane containing eight carbon atoms and two different unsaturated compounds. Which equation could represent this reaction?

- A  $\text{C}_{16}\text{H}_{34} \rightarrow \text{C}_8\text{H}_{16} + \text{C}_5\text{H}_{12} + \text{C}_3\text{H}_6$
- B  $\text{C}_{16}\text{H}_{34} \rightarrow \text{C}_8\text{H}_{18} + \text{C}_6\text{H}_{10} + \text{C}_2\text{H}_6$
- C  $\text{C}_{16}\text{H}_{34} \rightarrow \text{C}_8\text{H}_{18} + 2\text{C}_2\text{H}_4 + \text{C}_4\text{H}_8$
- D  $\text{C}_{16}\text{H}_{34} \rightarrow \text{C}_8\text{H}_{18} + \text{C}_6\text{H}_{14} + \text{C}_2\text{H}_2$

[20]

**QUESTION 2      CHEMICAL BONDING**

2.1 Refer to the following balanced equation, for a reaction taking place at STP:



2.1.1 Name the compound  $\text{Fe}_2(\text{CO}_3)_3$ . (3)

2.1.2 Describe an ionic bond. (2)

2.1.3 Which of the compounds in the reaction above are ionically bonded? (2)

2.1.4 Which of the compounds listed in Q2.1.3 above can be used as an electrolyte? (1)

2.1.5 Explain why you rejected one of the compounds listed in Q2.1.3 as an electrolyte. (2)

2.1.6 Calculate the volume of  $\text{CO}_2$  produced when 105,12 g of  $\text{Fe}_2(\text{CO}_3)_3$  reacts with excess  $\text{HCl}$  at STP. (5)

2.2 Molecules of  $\text{HCl}$  and  $\text{F}_2$  both have the same number of electrons.

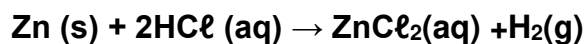
2.2.1 Define *electronegativity*. (2)

2.2.2 State the type of intramolecular bond present in each of  $\text{HCl}$  and  $\text{F}_2$ . Explain the difference in these types of bonds with reference to electronegativity numbers. (4)

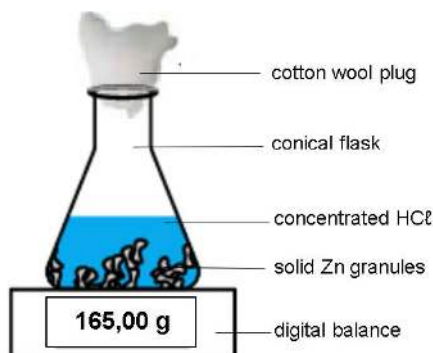
2.2.3 Which of  $\text{HCl}$  or  $\text{F}_2$  will have the higher boiling point? Explain your answer by making reference to the relative strengths of the predominant intermolecular forces present. (4)

**QUESTION 3 RATES OF REACTION**

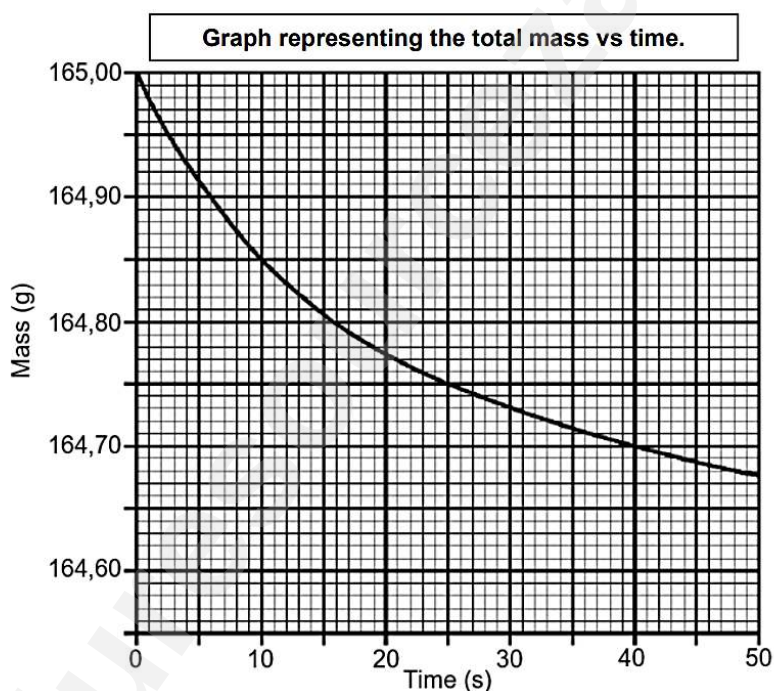
Two Grade 12 students set about investigating the rate of the reaction between 2 g of solid zinc granules and dilute hydrochloric acid, in excess, according to the following reaction:



To determine the rate of the reaction, Andiswa used the apparatus shown below:



The graph below shows her results for the first 50 seconds:



3.1 Anya suggests to Andiswa that the reaction has gone to completion after 50 s.

3.1.1 Define the *rate of the reaction*. (2)

3.1.2 Is Anya correct? \_\_\_\_\_ (1)

3.1.3 Refer to the graph to explain your answer for 3.1.2. (2)

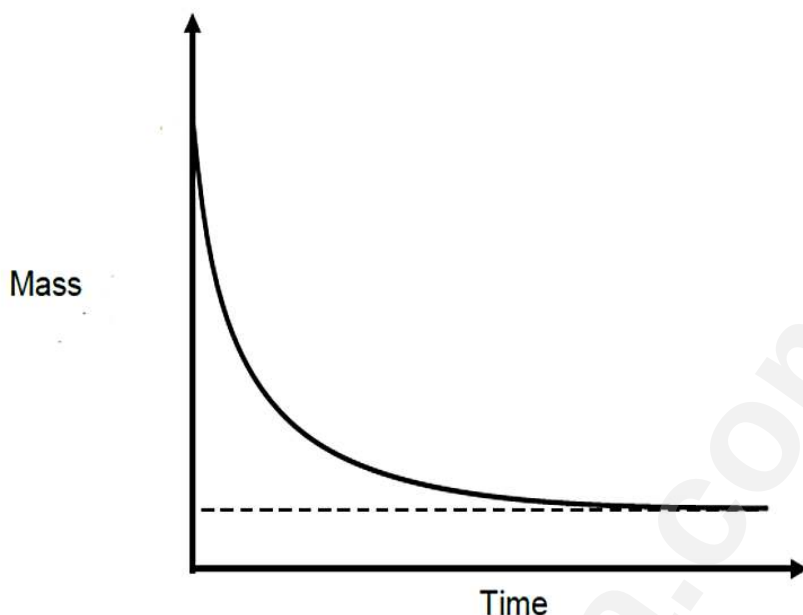
3.2.1 Calculate the average rate of the reaction in  $\text{g.s}^{-1}$ : (4)

a) During the first 10 s.

b) Between 20 s and 40 s.

3.2.2 Use collision theory to explain the difference in your answers between (a) and (b) in Q3.2.1 above. (5)

A sketch graph for the reaction is shown below:

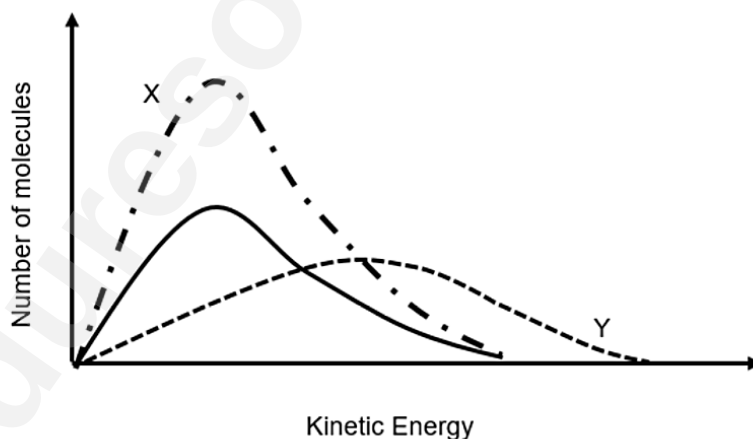


3.3 On the sketch graph axes above, draw two more curves for the following reaction conditions. Label the lines clearly as A and B.

A: 2 g of zinc powder is used. (2)

B: Dilute hydrochloric acid with half the concentration of the original is used. (2)

3.4 The Maxwell-Boltzmann distribution for the original reaction done by Andiswa is shown below using the solid line.



Which of the other two lines indicates the reaction taking place at a higher temperature?  
Write only X or Y. (2)

**QUESTION 4      CHEMICAL EQUILIBRIUM**

The following equation represents the Contact process, a key reaction in the preparation of sulphuric acid:



The reaction is controlled in such a way that the temperature inside the container remains between 400°C and 550°C, and is not allowed to drop below 380°C.

- 4.1 Name the compound  $\text{SO}_3$ . (2)
- 4.2 The reaction is carried out in a closed system. Define a *closed system*. (2)
- 4.3 Explain the industrial reasoning behind keeping the temperature of this reaction in the range 400°C to 550°C, and not allowing it to drop below 380°C. (3)
- 4.4 For the reaction  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H < 0$  the following information is obtained from the analysis of the equilibrium mixture at 400°C:

|                                       |                       |
|---------------------------------------|-----------------------|
| Volume of container                   | = 200 dm <sup>3</sup> |
| Initial quantity of $\text{SO}_2$     | = 50 mol              |
| Equilibrium quantity of $\text{SO}_3$ | = 22 mol              |
| $K_c$ at 400°C                        | = 7,328               |

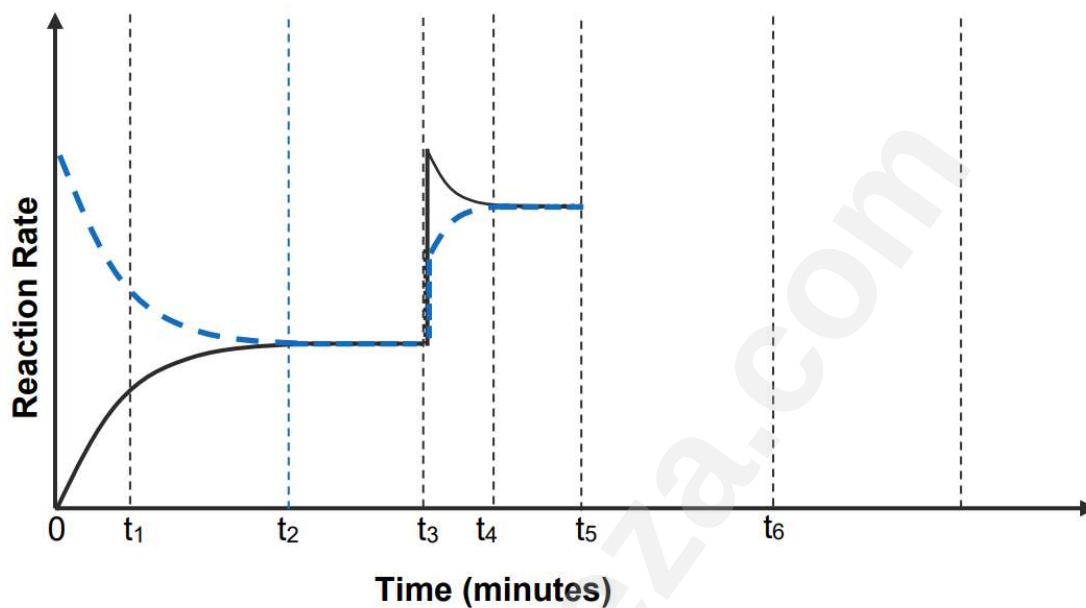
- 4.4.1 Write an expression for  $K_c$  for this reaction. (2)

- 4.4.2 Calculate the concentration of  $O_2$  in the system at equilibrium (answer to 3 decimal places). (6)

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- 4.5 The graph below represents the changes in the system when  $\text{SO}_2$  was allowed to react with excess  $\text{O}_2$ .  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H < 0$

Consider the following graph:



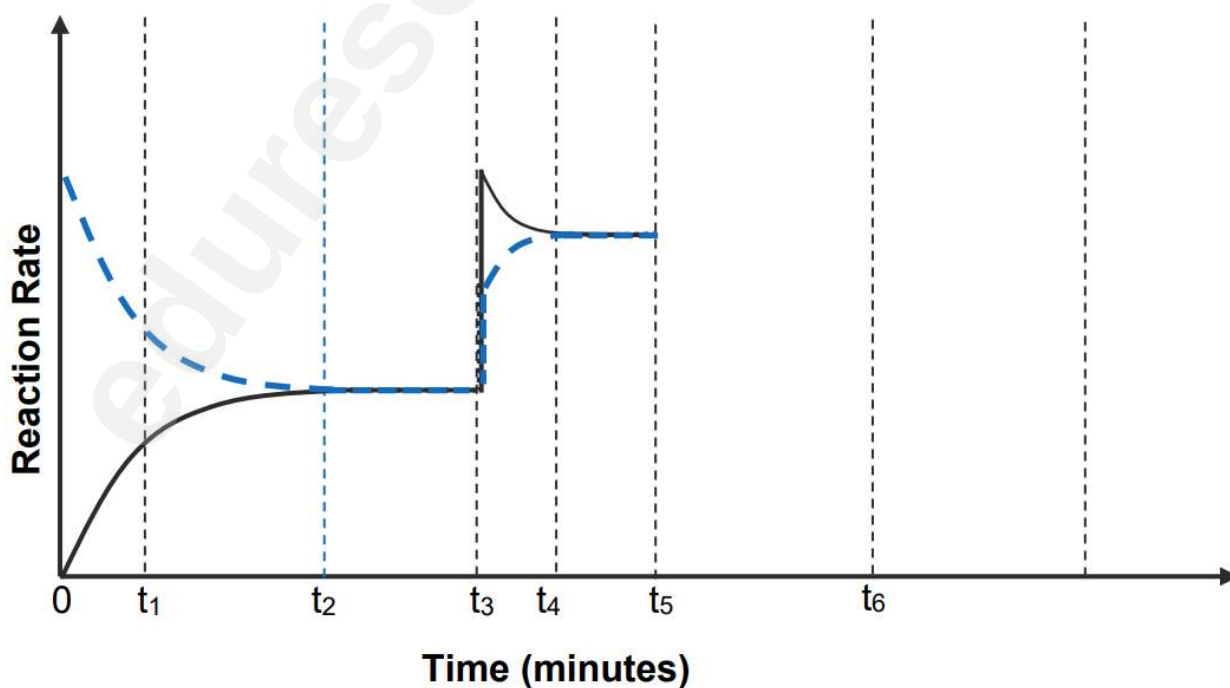
- 4.5.1 Write down the equation for the black solid line. (1)
- 4.5.2 Which has a higher initial reaction rate, the forward or reverse reaction? (1)
- 4.5.3 At which time/s does the reaction reach dynamic chemical equilibrium? (2)
- 4.5.4 Circle the correct word(s) between brackets in the statement below: (1)  
Between  $t_2$  and  $t_3$ , the concentrations of  $\text{SO}_2$  and  $\text{O}_2$  are:  
(EQUAL TO EACH OTHER / CONSTANT / CHANGING).

4.5.5 The system was subjected to a stress at time  $t_3$ .

- a) Identify this stress, and explain your answer with reference to the graph and Le Chatelier's principle. (5)

- b) State the effect, if any, on the  $K_c$  value due to the stress you explained in a) above. Write only INCREASES, DECREASES or NO EFFECT. (1)

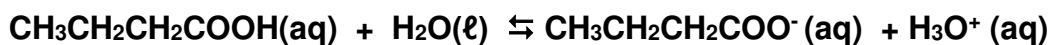
4.5.6 At  $t_5$ , the volume of the container was increased at constant temperature, resulting in a decrease in the pressure. Complete the rate vs time graph on the axes below from  $t_5$  until after equilibrium is re-established at  $t_6$ . (3)



## QUESTION 5

## ACIDS AND BASES

5.1 The reaction for the ionisation of butanoic acid is shown below.



5.1.1 LABEL, in the boxes above, the conjugate acid-base pairs using the notation **A<sub>1</sub> B<sub>1</sub> A<sub>2</sub> B<sub>2</sub>**. (2)

5.1.2 Define *amphoteric substance*. (2)

5.1.3 Give the formula of one amphoteric substance shown in the ionisation reaction. (1)

5.1.4 Write an expression for the equilibrium constant,  $K_a$ , for the ionisation of butanoic acid. (2)

5.1.5 Calculate the concentration of  $\text{H}_3\text{O}^+$  ions in a  $0,1 \text{ mol}\cdot\text{dm}^{-3}$  solution of butanoic acid at  $25^\circ\text{C}$ .  $K_a = 1,5 \times 10^{-5}$  (4)

- 5.2 Sodium hydroxide (NaOH) is a versatile base used extensively in the production of cleaning products. A pupil prepares 600 cm<sup>3</sup> of a standard solution of sodium hydroxide of concentration 0,75 mol.dm<sup>-3</sup>.



- 5.2.1 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)
- 5.2.2 Calculate the mass of sodium hydroxide in the pupil's solution. (4)
- 5.2.3 The pupil titrates her solution of sodium hydroxide (0,75 mol.dm<sup>-3</sup>) with phosphoric acid to determine the concentration of the phosphoric acid. The equation below represents the reaction that takes place.
- $$3\text{NaOH}(\text{aq}) + \text{H}_3\text{PO}_4(\text{aq}) \leftrightarrow \text{Na}_3\text{PO}_4(\text{aq}) + 3\text{H}_2\text{O}(\ell)$$
- She requires 27,5 cm<sup>3</sup> of the phosphoric acid to neutralise 20 cm<sup>3</sup> of sodium hydroxide.
- a) Define *neutralisation* (or *equivalence point*). (2)

- b) Calculate the concentration of the phosphoric acid that was neutralised. (4)

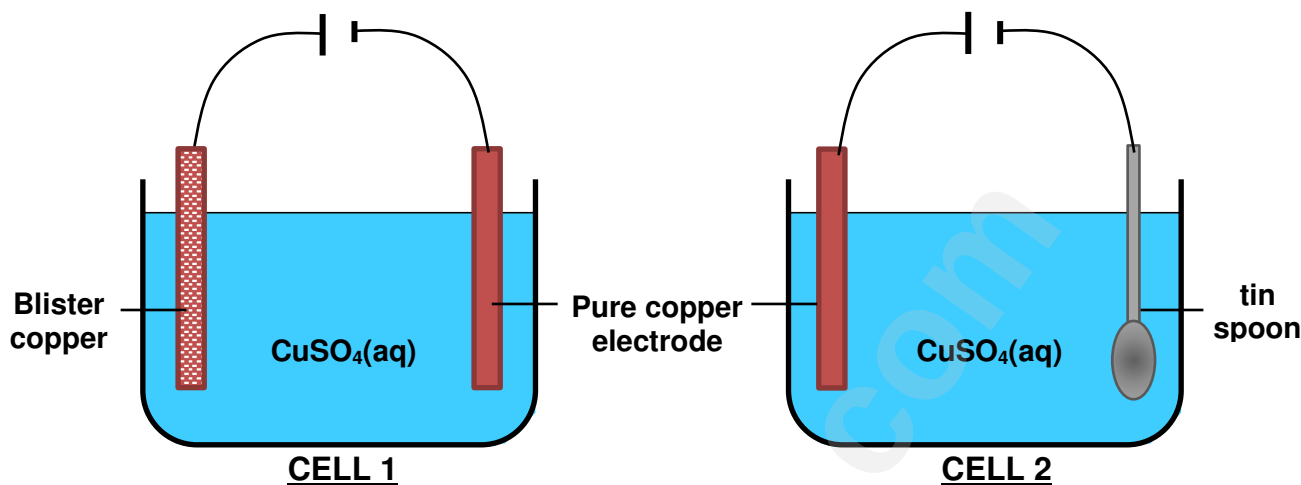
5.2.4 The pupil has the following indicators available to use in her titration:

| Indicator Name   | pH range  |
|------------------|-----------|
| Methyl orange    | 2,1 – 4,4 |
| Bromothymol blue | 6,0 – 7,8 |
| Phenolphthalein  | 8,3 - 10  |

- a) Name the indicator she should use for her titration. (1)
- b) Write an equation for the hydrolysis of the  $\text{PO}_4^{3-}$  ion. Hence, explain the choice of indicator given in Question 5.2.4 a). (4)

**QUESTION 6 ELECTROCHEMISTRY**

Consider the diagrams of two electrolytic cells below.



- CELL 1 is used in the electrorefining of blister copper (impure copper).
- CELL 2 is used to electroplate a tin spoon.

6.1 What energy conversion occurs in these cells? (2)

6.2 In which cell (1 or 2) is the pure copper electrode the anode? (1)

6.3 In addition to copper metal, the blister copper electrode in CELL 1 contains impurities of nickel and silver. Circle the correct options between the brackets in the statement below.

( Ni / Ag ) forms a sludge at the bottom of the cell since it is a (STRONGER / WEAKER) (OXIDISING / REDUCING) agent than Cu. (3)

6.4 In both cells copper is deposited at the cathode.

6.4.1 Define *cathode*. (2)

6.4.2 Write the equation for the cathode half-reaction. (2)

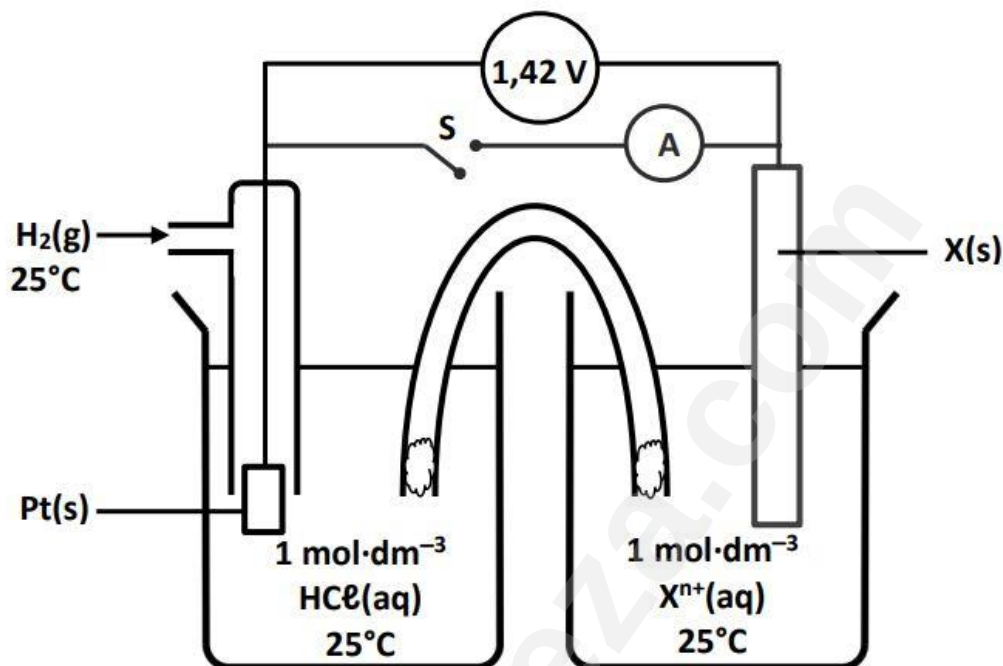
6.4.3 Give a reason why  $\text{SO}_4^{2-}$  ions are not reduced at the cathode. (2)

- 6.5 A current of 2,5 A is passed through CELL 2. Calculate the time taken to deposit 4 g of copper on the spoon. (5)

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**QUESTION 7 ELECTROCHEMISTRY**

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.



7.1 Consider the 1 mol·dm<sup>-3</sup> HCl solution.

7.1.1 Write an equation for the ionisation reaction of HCl(aq). (3)

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

7.2 A pupil says that a 0,5 mol·dm<sup>-3</sup> oxalic acid solution could be used as the electrolyte for the standard hydrogen electrode instead of the HCl.

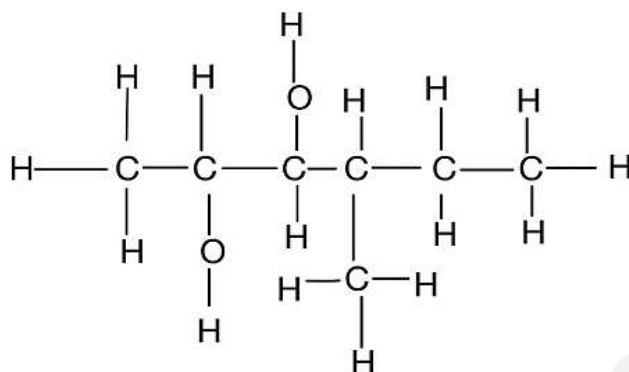
7.2.1 Write down the formula of oxalic acid. (1)

7.2.2 Explain why the pupil is incorrect. (2)

- 7.3 Write down one other standard condition not shown in the diagram of the galvanic cell. (2)
- 7.4 When the switch is closed, the pH of the  $\text{HCl(aq)}$  **DECREASES**.
- 7.4.1 Circle the correct answer between the brackets: (1)
- The standard hydrogen electrode is acting as the ( ANODE / CATHODE ) of the cell.
- 7.4.2 Explain the answer with reference to the decreasing pH. (2)
- 7.5 Identify metal X by means of a calculation. Show all your working. (4)
- 7.6 The smooth Pt electrode is replaced with one that is coated with a layer of powdered Pt. How will this affect ...
- 7.6.1 the emf of the cell? (1)
- Circle one of: INCREASE / DECREASE / NO CHANGE
- 7.6.2 the maximum current that the cell can deliver? (1)
- Circle one of: INCREASE / DECREASE / NO CHANGE
- 7.7 The saturated salt solution in the salt bridge is replaced with a diluted salt solution. How will this affect ...
- 7.7.1 the emf of the cell? (1)
- Circle one of: INCREASE / DECREASE / NO CHANGE
- 7.7.2 the maximum current that the cell can deliver? (1)
- Circle one of: INCREASE / DECREASE / NO CHANGE

**QUESTION 8 ORGANIC CHEMISTRY**

8.1 Consider compound **Q** below.



8.1.1 Define the term *homologous series*. (2)

8.1.2 **NAME** the homologous series of compound **Q**. (1)

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

8.1.4 Using MOLECULAR FORMULA write a balanced equation for the complete combustion of compound **Q**. (5)

8.2

Draw the structural formula of: 1,4-dichloro-4-ethylhept-2-ene.

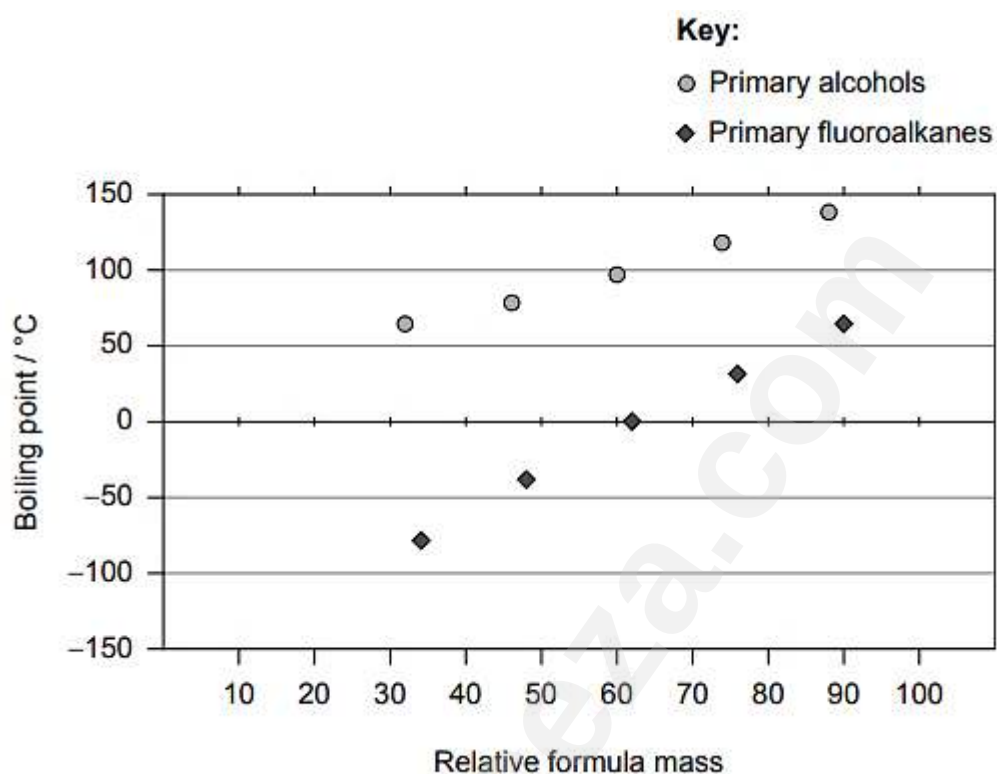
(4)



[15]

**QUESTION 9 ORGANIC CHEMISTRY**

9.1 The graph shows the boiling points of the first five straight-chain alcohols and fluoroalkanes.



9.1.1 Explain the general trend in the boiling points shown for the alcohols. (2)

9.1.2 Explain why the alcohols have higher boiling points than fluoroalkanes of similar relative formula mass. (4)

9.1.3 Predict, giving a reason, how the boiling points of branched fluoroalkanes compare to their straight-chain isomers. (4)

9.2 Consider the compounds A to H shown below: (It might help for you to draw a rough sketch of the structural formula of each molecule)

|          |                                                                                           |          |                                                                       |
|----------|-------------------------------------------------------------------------------------------|----------|-----------------------------------------------------------------------|
| <b>A</b> | $\text{CH}_3\text{C}(\text{CH}_3)\text{FCH}_2\text{CH}(\text{CH}_3)\text{CH}_3$           | <b>E</b> | $\text{CH}_3\text{CH}_2\text{CHC}(\text{CH}_3)\text{CH}_2\text{CH}_3$ |
| <b>B</b> | $\text{CH}_3(\text{CH}_2)_4\text{CHCH}_2$                                                 | <b>F</b> | $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$                        |
| <b>C</b> | $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_3$ | <b>G</b> | $\text{HCOOCH}_2\text{CH}_2\text{CH}_3$                               |
| <b>D</b> | $\text{CH}_3\text{CHCHCH}(\text{CH}_3)\text{CH}_2\text{CH}_3$                             | <b>H</b> | $\text{CH}_3\text{CHCFCH}_2\text{CH}_3$                               |

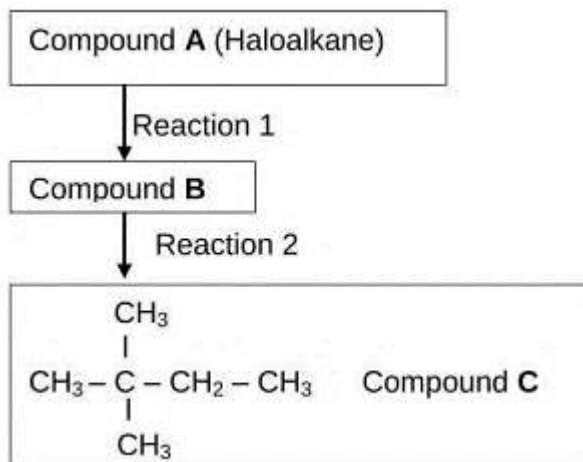
9.2.1 Write down the letter/s of the compound/s corresponding to the following descriptions. The compounds may be used more than once or not at all. (8)

|     |                                                                                                      |  |
|-----|------------------------------------------------------------------------------------------------------|--|
| (a) | Two compounds that belong to a different homologous series and are FUNCTIONAL isomers of each other. |  |
| (b) | Two compounds that are POSITIONAL isomers of each other.                                             |  |
| (c) | An unsaturated hydrocarbon.                                                                          |  |
| (d) | A haloalkane.                                                                                        |  |
| (e) | A compound that is the product of the reaction of an alcohol with a carboxylic acid.                 |  |

9.2.2 Give the IUPAC name of compound **G**. (2)

- 9.3 Compound **A**, a six carbon haloalkane, is used in a two-step reaction to prepare compound **C**.

Reaction 2 is an ADDITION reaction.



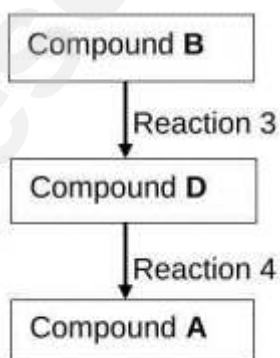
Write down the:

- 9.3.1 NAME or FORMULA of the inorganic reactant for Reaction 2. (1)

- 9.3.2 The GENERAL type of reaction represented by Reaction 1. (1)

Compound **B** is now used in a two-step reaction to produce compound **A**.

Reaction 4 is a SUBSTITUTION reaction.



Write down the:

- 9.3.3 NAME or FORMULA of the catalyst used in Reaction 3. (1)

- 9.3.4 The SPECIFIC type of reaction represented by Reaction 4. (1)

**EXTRA SPACE**

[illegible]

**EXTRA SPACE**

[illegible]