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QUESTION 1**TOTAL: /20**

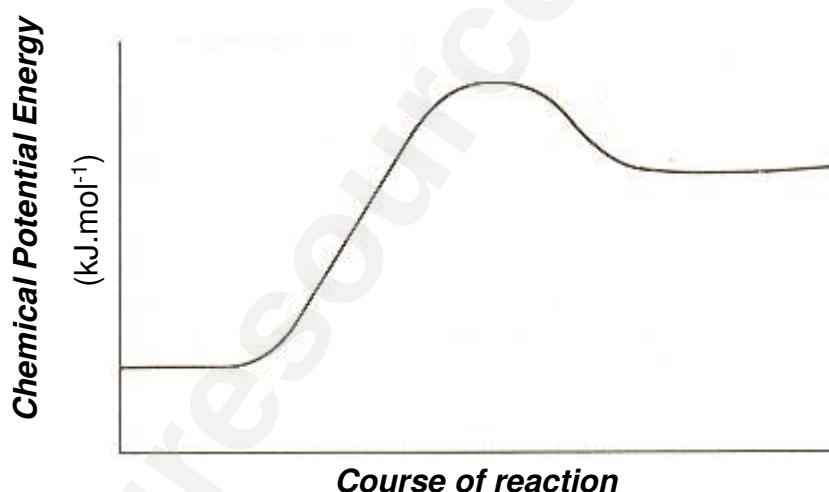
Place an × on the correct answer on your answer sheet.

- 1.1) The number of sodium ions ($\text{Na}^+_{(\text{aq})}$) in 1 dm^3 of sodium carbonate (Na_2CO_3) solution of concentration $0,5 \text{ mol.dm}^{-3}$, is:
- A** $12,04 \times 10^{23}$
 - B** $6,02 \times 10^{23}$
 - C** $3,01 \times 10^{23}$
 - D** $6,02 \times 10^{24}$
- 1.2) 100 cm^3 of nitrogen monoxide gas (NO) combines with precisely 50 cm^3 of oxygen to form precisely 100 cm^3 of a single gaseous compound, all volumes being measured at the same temperature and pressure. Which of the following equations best fits these facts?
- A** $\text{NO}_{(\text{g})} + \text{O}_{2(\text{g})} \rightarrow \text{NO}_{3(\text{g})}$
 - B** $\text{NO}_{(\text{g})} + 2\text{O}_{2(\text{g})} \rightarrow \text{NO}_{5(\text{g})}$
 - C** $2\text{NO}_{(\text{g})} + \text{O}_{2(\text{g})} \rightarrow 2\text{NO}_{2(\text{g})}$
 - D** $2\text{NO}_{(\text{g})} + \text{O}_{2(\text{g})} \rightarrow \text{N}_2\text{O}_{4(\text{g})}$
- 1.3) Which one of the following substances will conduct electricity when solid?
- A** table salt (NaCl)
 - B** diamond
 - C** graphite
 - D** dry ice (CO_2)

1.4) Consider diamond and choose the most correct statement regarding the bonding in diamond:

- A** Diamonds consist of carbon atoms which are ionically bonded in a lattice structure.
- B** Diamonds consist of carbon atoms held together by strong electrostatic forces between the positive cores and the delocalised electrons.
- C** Diamonds consist of carbon atoms which are bonded in planar hexagonal ring structures with delocalised electrons between the planes.
- D** Diamonds consist of carbon atoms where each carbon atom is bonded covalently to four other carbon atoms to form an atomic lattice.

1.5) The following energy profile shows the chemical potential energy changes as a particular reaction proceeds.

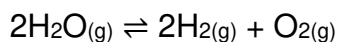


Which of the following correctly answers the following two questions?

- i) Is the reaction exothermic or endothermic?
- ii) Which of the reactants or products has the stronger bonds?

	i	ii
A	Exothermic	Reactants
B	Exothermic	Products
C	Endothermic	Reactants
D	Endothermic	Products

- 1.6) Consider the gas-phase equilibrium system represented by the equation:



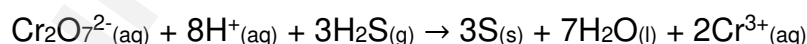
Given that the forward reaction is **endothermic**, which of the following changes will **decrease** the equilibrium amount of H_2O ?

- A** Decreasing the volume of the container (the total pressure increases)
- B** Adding more oxygen
- C** Adding a solid phase catalyst
- D** Increasing the temperature at constant pressure

- 1.7) If 200 ml water was added to a $0,25 \text{ mol} \cdot \text{dm}^{-3}$ solution of ammonia, the amount of OH^- ions would(i)..... and the concentration of OH^- would(ii).....

	i	ii
A	Increase	Increase
B	Decrease	Increase
C	No change	No change
D	Increase	Decrease

- 1.8) When potassium dichromate reacts with hydrogen sulphide in the presence of an acid, the solution changes from orange to cloudy green in colour. This indicates that a redox reaction has taken place. The balanced ionic chemical equation for the reaction is:

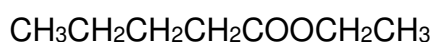


The oxidising and reducing agents in the forward reaction are:

	Oxidising agent	Reducing agent
A	$\text{Cr}_2\text{O}_7^{2-}$	H_2S
B	H_2S	$\text{Cr}_2\text{O}_7^{2-}$
C	H_2S	SO_4^{2-}
D	SO_4^{2-}	H_2S

- 1.9) The emf in a galvanic cell can be increased by:
- A** Using electrodes with larger surface areas.
 - B** Changing the concentration of the ions in each cell by different amounts.
 - C** Replace the salt bridge with a shorter, wider one.
 - D** Using less resistive wire to connect the anode and cathode.

- 1.10) The organic compound below can be called:

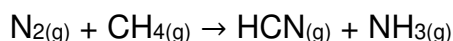


- A** pentyl ethanoate
- B** ethyl pentanoate
- C** butyl ethanoate
- D** ethyl butanoate

(2 × 10 = 20)

QUESTION 2**TOTAL: /20**

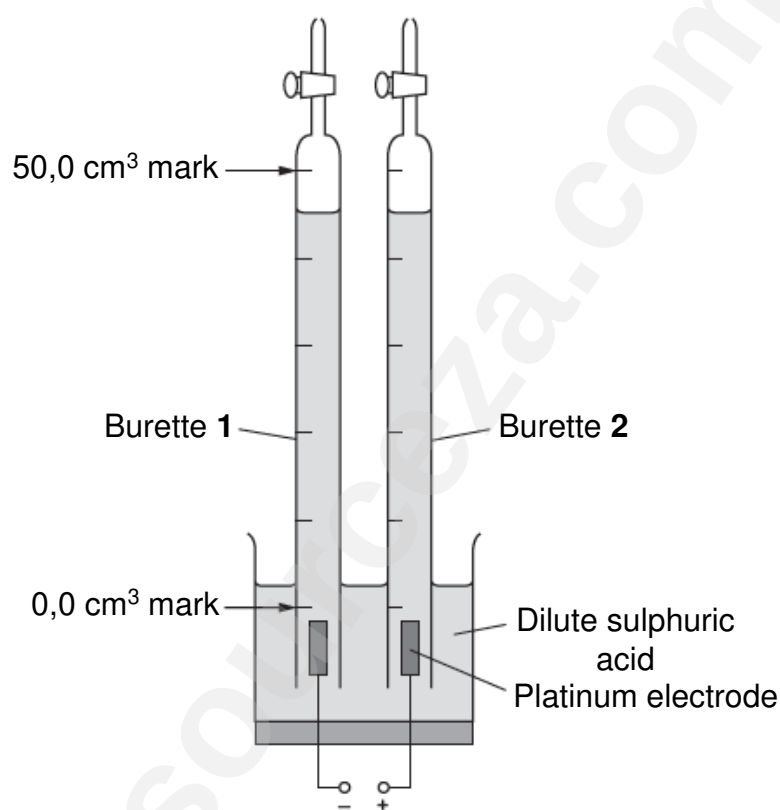
The Cassini Huygens probe in 2004 investigated the surface and atmosphere of Titan, a moon that orbits Saturn that contains a very dense atmosphere of nitrogen and methane gas and liquid lakes of hydrocarbons. The following basic chemistry reaction was proposed in the upper atmosphere of Titan.



- 2.1) Define **electronegativity**. (2)
- 2.2) Comment on the polarity of the bonds in nitrogen and methane. Provide a suitable explanation for your comments. (4)
- 2.3) Define **intermolecular forces**. (2)
- 2.4) As hydrogen cyanide and ammonia reach the surface of Titan they condense. Which molecule will become a liquid first? Provide a detailed explanation of how you reached your conclusion. (5)
- 2.5) The intermolecular forces between nitrogen molecules are London forces (induced dipoles). Express in words how these forces will arise between nitrogen gas molecules. You may use diagrams to aid your explanation. (4)
- 2.6) State whether the following **molecules** are polar or non-polar:
- 2.6.1) CH_4 (1)
- 2.6.2) HCN (1)
- 2.6.3) NH_3 (1)

QUESTION 3**TOTAL: /30**

Dilute sulfuric acid, $\text{H}_2\text{SO}_{4(\text{aq})}$, can be electrolysed using platinum electrodes and a direct current. Hydrogen gas is produced at the cathode and oxygen gas is produced at the anode. The two gases are collected separately in burettes filled with dilute sulfuric acid placed over each electrode.



reaction at electrode in burette 1: $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_{2(\text{g})} + 2\text{OH}^-(\text{aq})$

reaction at electrode in burette 2: $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_{2(\text{g})} + 4\text{H}^+(\text{aq}) + 4\text{e}^-$

The production of hydrogen gas over time can be measured, and the data is used to determine the charge caused by one mole of electrons, known as the Faraday constant, F . The current was kept constant at 0,80 A.

Time (s)	Reading on burette 1 (cm ³)	Volume of H_{2(g)} produced (cm ³)	Charge passed (C)
0	46,20	0	0
50	41,20	5,0	40
150	31,45	15,2	X
250	20,80	25,4	200
350	11,45	34,8	280
450	1,50	44,7	360

- 3.1) Identify the type of electrochemical cell represented in the diagram above and state the energy conversion that occurs in this cell. (2)
- 3.2) Show how one would calculate the charge passed at time, **t = 150s**. (3)
- 3.3) Plot a graph on the grid provided to show the relationship between volume of H_{2(g)} produced (**y-axis**) and charge passed (**x-axis**). Include a suitable line of best fit. (7)
- 3.4) Which burette would be considered the cathode in the above cell? Provide a suitable reason for your answer. (2)
- 3.5) Are your results reliable? Use an aspect of your graph to support your answer. (2)
- 3.6) Calculate the gradient of your line of best fit. Clearly indicate on your graph the points that were used in your calculations. (4)
- 3.7) Using your gradient calculated in **3.6**), that the molar volume at room temperature being 24 000 cm³.mol⁻¹ and that the units for the gradient is cm³.C⁻¹, calculate Faraday's constant. (4)

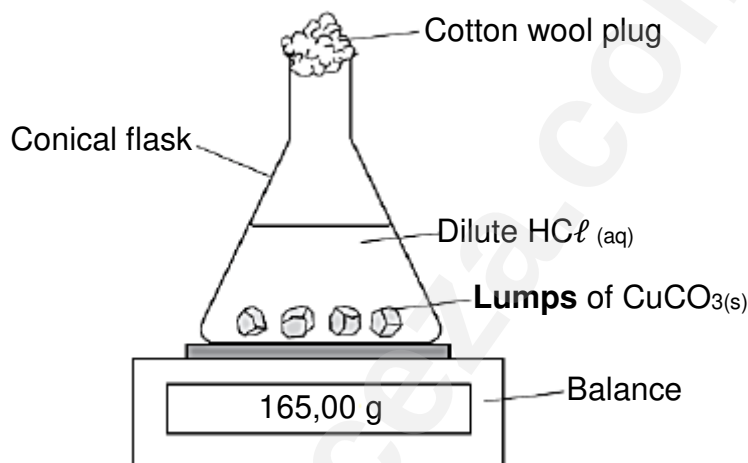
- 3.8) Sketch a new line of best fit on your plotted grid to illustrate the difference if one measured the volume of oxygen collected. (2)
- 3.9) Give one reason why platinum is used as an electrode. (1)
- 3.10) Copper is cheaper than platinum. Using one's knowledge of electrochemistry, explain why copper is not used as the electrodes (3)

QUESTION 4**TOTAL: /35**

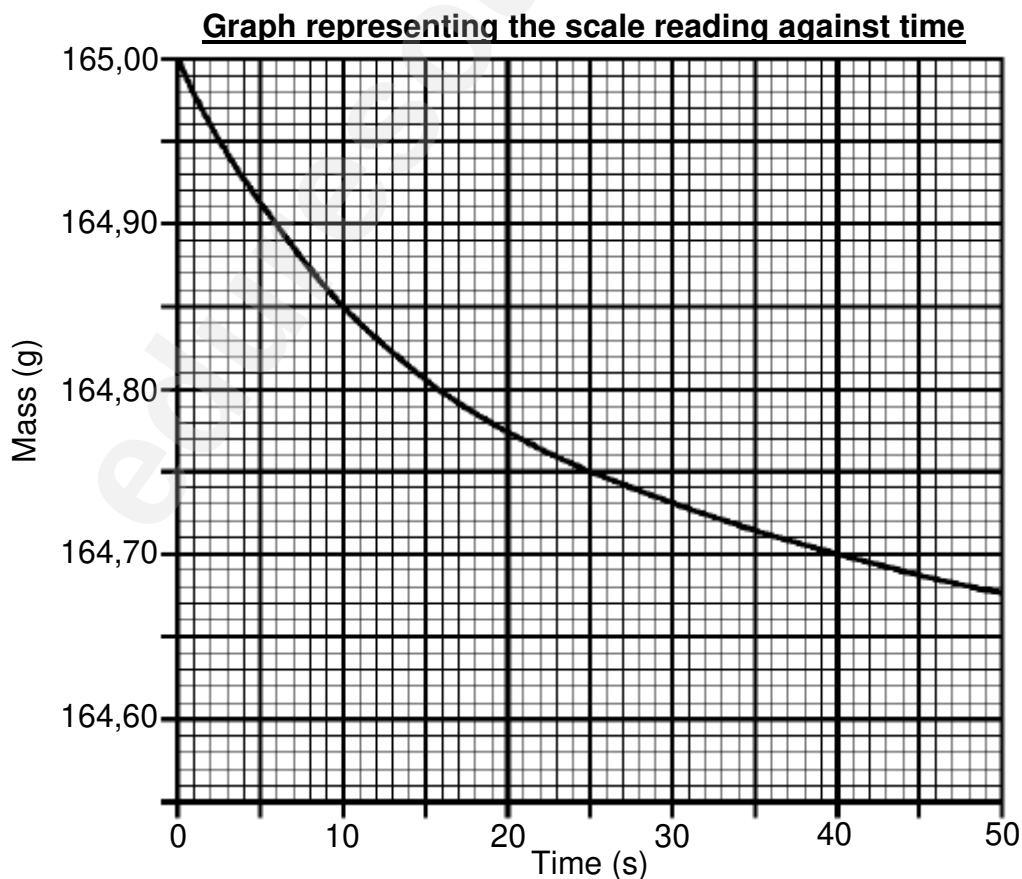
4.1) Copper (II) carbonate reacts with excess dilute hydrochloric acid as shown.



A student used the apparatus shown below to follow the progress of the reaction. The copper (II) chloride solution produced has a **green/blue** colour.

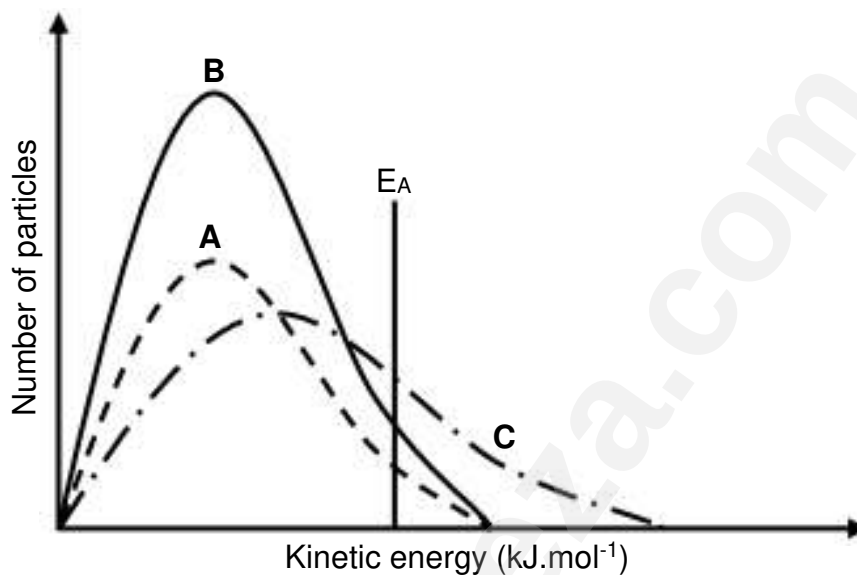


The experiment was carried out using 0,5 g of copper (II) carbonate. The graph below shows the results obtained for the first 50 s of the reaction.



- 4.1.1) Why is a cotton wool plug placed at the mouth of the flask? (2)
- 4.1.2) Define the **rate of the reaction**. (2)
- 4.1.3) Has the reaction gone to completion? Provide a suitable explanation for your answer. (2)
- 4.1.4) This is not the most ideal method to monitor this reaction. Suggest another method and explain how you would measure the rate of the reaction. (2)
- 4.1.5) Calculate the average rate of reaction in mol.s^{-1} between **t = 10 s** and **t = 30 s**. (4)
- 4.1.6) The following graph has been replicated on the answer sheet. On this graph sketch further relative graphs (no values required on the axes) if the following conditions have been changed. Label the graphs **a)** and **b)** accordingly.
- a) 1,00 g of powdered copper (II) carbonate is used instead of the lumps. (2)
 - b) The concentration of the acid is decreased. (2)
- 4.1.7) In another experiment using the same chemicals, 1,5 g of impure copper (II) carbonate is reacted with 75 ml of $0,25 \text{ mol.dm}^{-3}$ of hydrochloric acid to produce 180 cm^3 of carbon dioxide gas at STP.
- a) Calculate the percentage purity of the copper (II) carbonate. (6)
 - b) Define **concentration**. (2)
 - c) Determine the new concentration of the hydrochloric acid after the reaction is completed. (5)

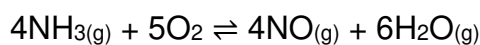
- 4.2) The Maxwell-Boltzmann energy distribution curves for another three experiments have been represented below. Curve **A** is the reaction run at 25 °C and 1 mol.dm⁻³.



- 4.2.1) Suggest a reason for the shape of curve **B** and comment on the rate of the reaction. Use collision theory to explain your answer. (3)
- 4.2.2) Suggest a reason for the shape of curve **C** and comment on the rate of the reaction. Use collision theory to explain your answer. (3)

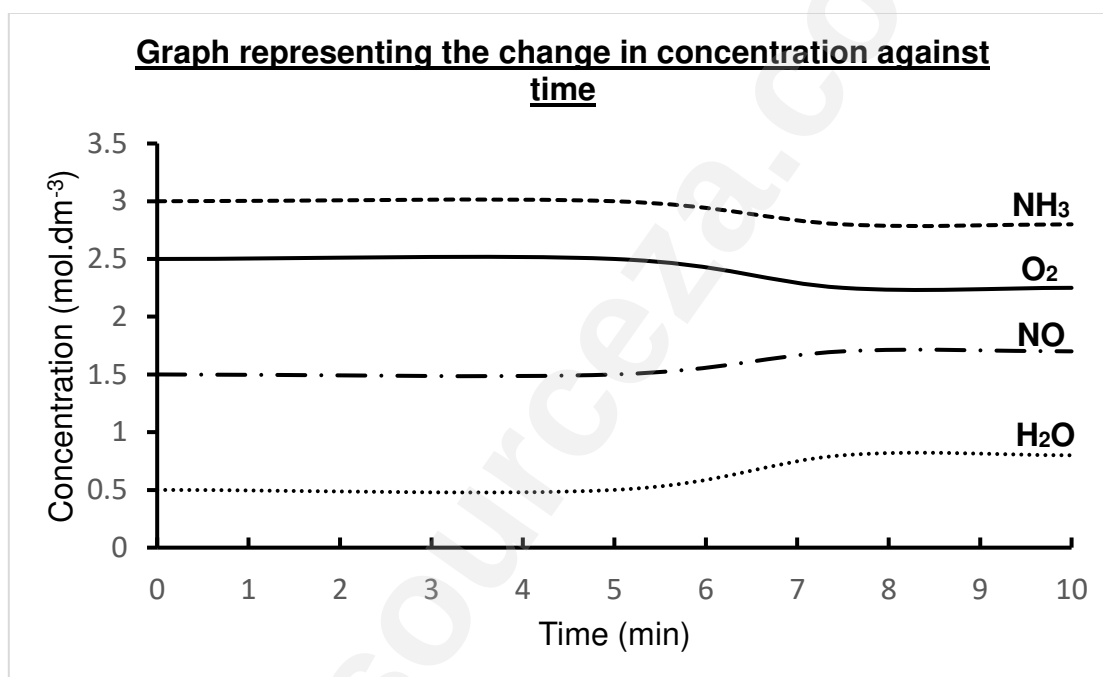
QUESTION 5**TOTAL: /15**

The following chemical reaction is the first step in the Ostwald process.



Refer to the concentration against time graph given below and answer the questions.

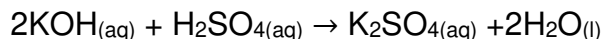
The reaction takes place in a **2 dm³** container. The K_c value between **t = 0** and **t = 5 min** is $1,00 \times 10^{-5}$.



- 5.1) What is meant by **closed system**? (2)
- 5.2) If the equilibrium concentration for nitrogen monoxide (NO) is $1,7 \text{ mol.dm}^{-3}$, calculate the equilibrium constant from **t = 8 min** to **t = 10 min**. (7)
- 5.3) State **Le Chatelier's principle**. (2)
- 5.4) If the stress at **t = 5 min** was a temperature increase, determine if the forward reaction was exothermic or endothermic. Use your answer in 5.2) to support your answer. (3)
- 5.5) If a catalyst was added along with the temperature increase, how would the graph change between **t = 5 min** and **t = 8 min**. (1)

QUESTION 6**TOTAL: /20**

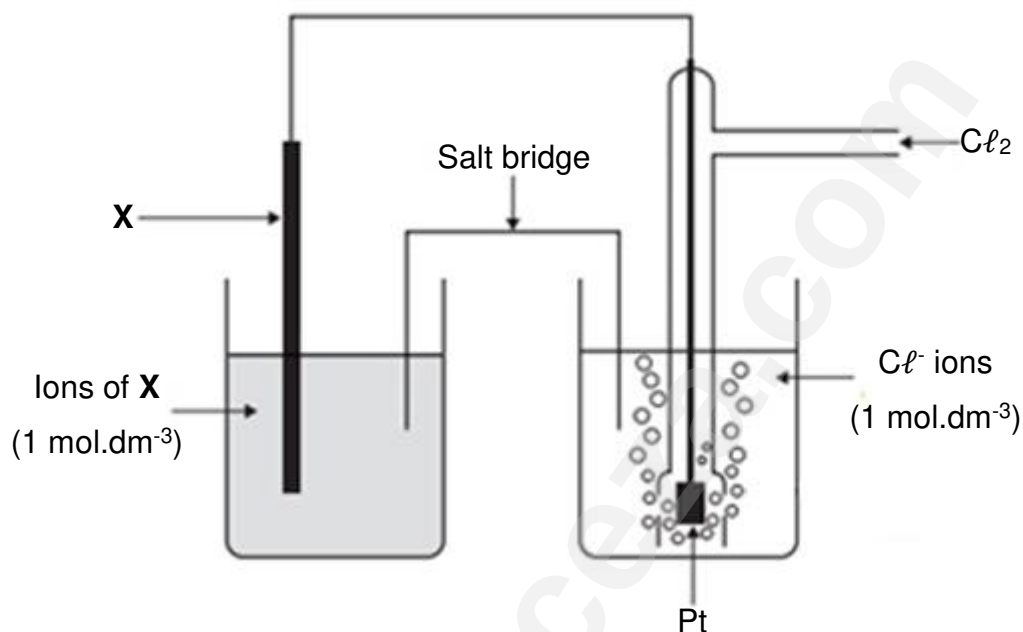
- 6.1) A student carefully titrates a standard solution of $0,025 \text{ mol.dm}^{-3}$ potassium hydroxide with 25 ml of $0,010 \text{ mol.dm}^{-3}$ of sulphuric acid according to the following chemical reaction equation.



- 6.1.1) Provide the **Brønsted-Lowry** definition for a **base**. (2)
- 6.1.2) Sulphuric acid is considered a strong acid. What does this statement mean? (2)
- 6.1.3) Calculate the concentration of the hydroxide ions in the original sulphuric acid solution before the addition of the potassium hydroxide. (4)
- 6.1.4) Define **equivalence point**. (2)
- 6.1.5) Determine the volume of potassium hydroxide that is required to fully neutralize the sulphuric acid. (3)
- 6.2) A student is titrating an acid into a base to determine the concentration of the base. The endpoint of the neutralization reaction is reached but the stopcock on the burette sticks slightly and allows a few more drops of acid to fall into the solution. Explain how will this affect your calculations for the concentration of the base? (2)
- 6.3) A student carefully pipettes 2.5 ml of $0.525 \text{ mol.dm}^{-3}$ NaOH into a test tube. She places the test tube into a small beaker to keep it from spilling and then pipettes 7.5 ml of $0.355 \text{ mol.dm}^{-3}$ HCl into another test tube. When they reach to put this test tube of acid into the beaker along with test tube of base she accidentally knocks the test tubes together hard enough to break them and their respective contents combine in the bottom of the beaker. Is the solution formed from the contents of the two test tubes acidic or basic? Use suitable calculations to back up your answer. (5)

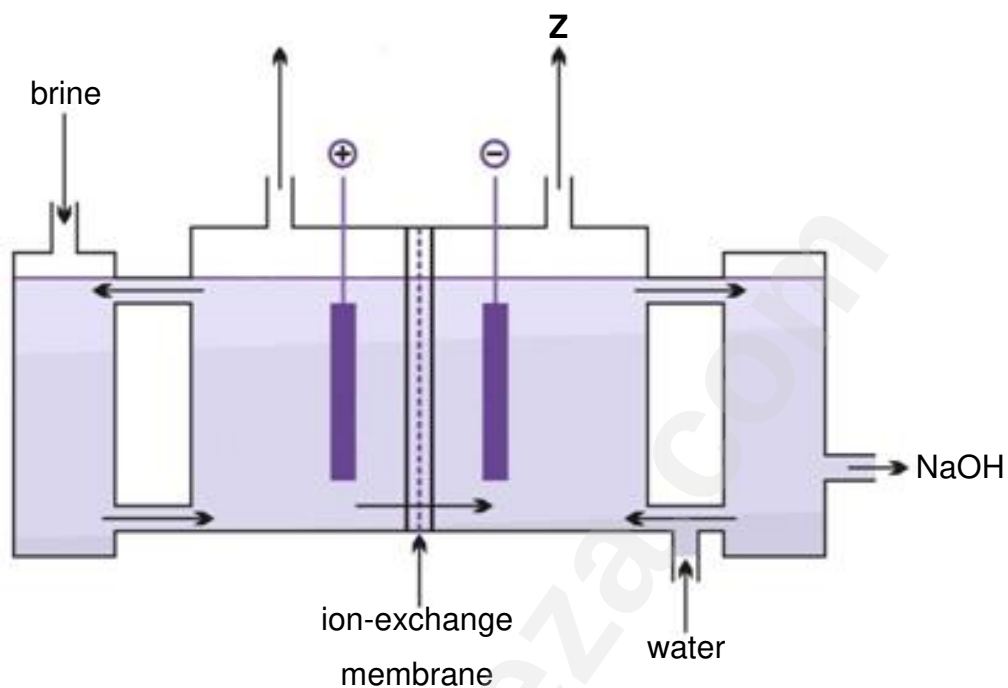
QUESTION 7**TOTAL: /25**

- 7.1) The galvanic cell shown below was set up using a Cl_2/Cl^- cathode half-cell and a half-cell made from an unknown metal electrode and a solution containing the metal ions.



- 7.1.1) State the energy conversion that would occur in this cell. (2)
- 7.1.2) Define the term **cathode**? (2)
- 7.1.3) State the functions of the salt bridge. (2)
- 7.1.4) After discharging 9409 C of electricity it was found that 0.0325 mol of metal **X** was eroded from the electrode made of metal **X**.
- Calculate the number of moles of electrons that flowed in order to deposit 0.0325 mol of **X**. (3)
 - Using your answer in **7.1.4a**), determine the charge on the **X** ion in solution. (2)
 - Give the balanced overall reaction equation for the galvanic cell. (4)

7.2) Refer to the membrane cell below and answer the questions that follow:



7.2.1) What is brine? (2)

7.2.2) Write down the reaction that occurs at the anode. (2)

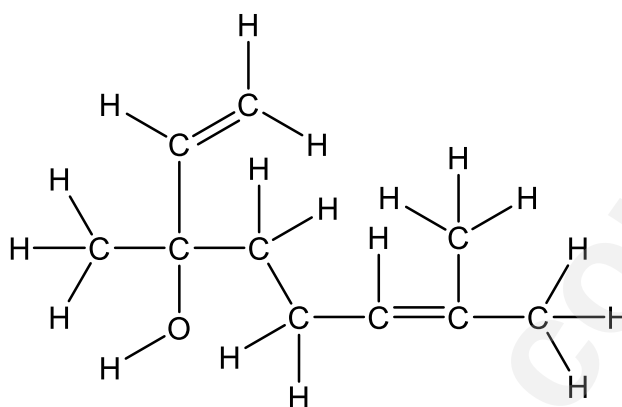
7.2.3) What is the purpose of the ion-selective membrane? (2)

7.2.4) Identify the product, **Z** that is formed at the cathode. (1)

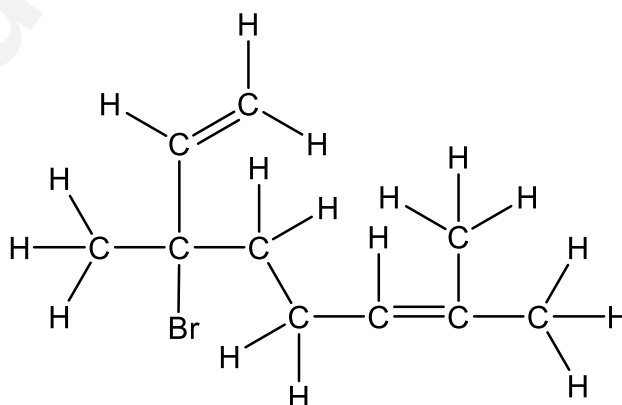
7.2.5) Why is the product in **7.2.4)** produced rather than sodium metal. Refer to the standard electrode potential table to support your answer. (3)

QUESTION 8**TOTAL: /20**

- 8.1) The following compound, known as linalool is an active ingredient in the aroma of lillies.

**linalool**

- 8.1.1) Define **functional group**. (2)
- 8.1.2) **Name** the functional groups in linalool. (2)
- 8.1.3) "*Linalool is a saturated hydrocarbon*". Do you agree with any part of this statement? Explain your answer. (3)
- 8.1.4) Linalool has a boiling point of 199 °C. Explain why the boiling point of linalool is substantially higher than water. (3)
- 8.2) Linalool can be synthesized from the following compound **Y**:

**Y**

8.2.1) Write down the IUPAC name for compound **Y**. (4)

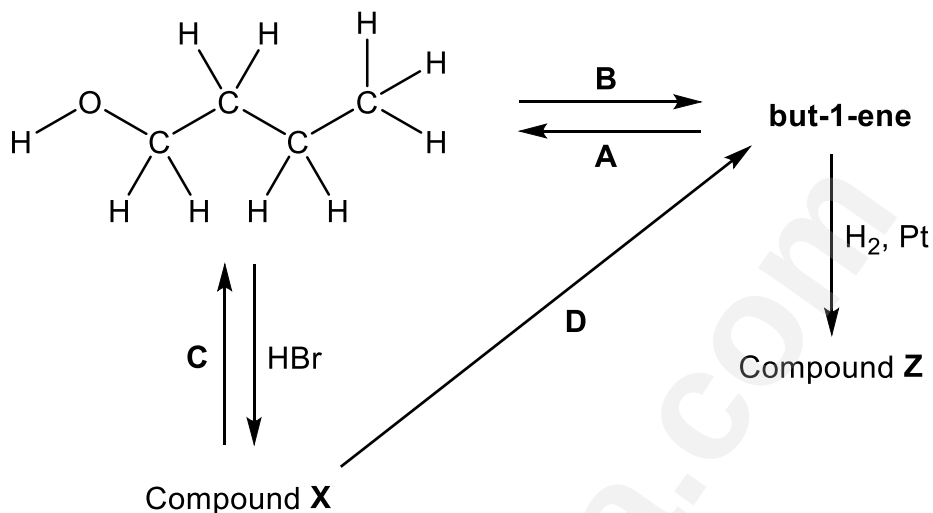
8.2.2) Define **structural isomer**. (2)

8.2.3) Draw a chain isomer consisting of a 6-carbon chain of compound **Y**. (4)

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QUESTION 9**TOTAL: /15**

Refer to the reaction scheme below and answer the questions that follow:

9.1) Refer to reaction **D**.

9.1.1) Identify the type of reaction. (1)

9.1.2) Name the specific type of reaction. (1)

9.1.3) Using structural formula, write out the reaction equation including the reaction conditions. (4)

9.2) Draw the structure of compound **Z**. (3)9.3) Alkene **Y** is converted to compound **Z**. Refer to this reaction.

9.3.1) Identify the type of reaction. (1)

9.3.2) Name the specific type of reaction. (1)

9.3.3) Using molecular formula, write out the reaction equation for the complete combustion of compound **Z**. (4)