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PHYSICAL SCIENCES
GRADE 12
PRELIMINARY EXAMINATION PAPER 2
31 JULY 2017

MARKS: 200
SET BY: C VISSER

TIME: 3 HOURS
MODERATED BY: C ORCHISON

INSTRUCTIONS AND INFORMATION

- This test consists of 13 pages and 9 questions. Answer ALL the questions.
- A data sheet has been provided.
- Write your name and teacher's name in the appropriate spaces on the answer book.
- A non-programmable calculator and appropriate mathematical instruments may be used.
- Number the answers correctly according to the numbering system used in the question paper.
- Give brief but concise motivations and discussions where required.
- Use the mark allocation as a guide to the maximum time you should spend on each question.
- Give answers to two decimal places where necessary.

GOOD LUCK!

QUESTION 1: Multiple Choice

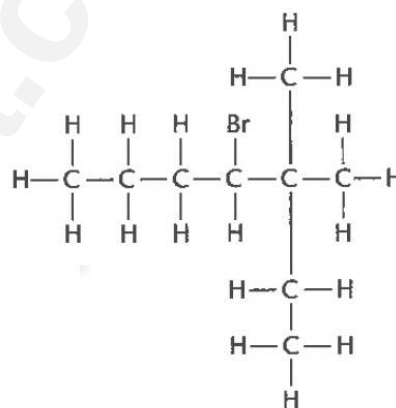
1.1 Which compound is a saturated hydrocarbon?

- A) 2-methylpropane
- B) but-2-ene
- C) 2-methylpent-2-ene
- D) pent-2-yne

1.2 Which formula represents an ester?

- A) $\text{CH}_3\text{COOCH}_3$
- B) CH_3OH
- C) CH_3COOH
- D) $\text{CH}_3\text{CH}_2\text{CH}_3$

1.3 The correct IUPAC name for the compound shown alongside is:

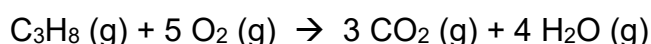


- A) 3-bromo-2-ethyl-2-methylhexane
- B) 4-bromo-5-ethyl-5-methylhexane
- C) 4-bromo-3,3-dimethylheptane
- D) 4-bromo-5,5-dimethylheptane

1.4 For a certain reversible chemical reaction, the activation energy for the forward reaction is 10 kJ and 30 kJ for the reverse reaction. Which of the following correctly describes the reaction type, ΔH and the direction of the reaction?

	REACTION TYPE	ΔH (kJ)	DIRECTION OF REACTION
A)	Exothermic	-20	Forward reaction
B)	Exothermic	+40	Forward reaction
C)	Endothermic	-20	Reverse reaction
D)	Endothermic	+40	Reverse reaction

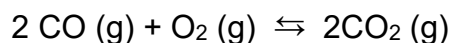
1.5 Consider the reaction:



If the rate of appearance of CO_2 is $0,8 \text{ mol} \cdot \text{s}^{-1}$, the rate of disappearance of O_2 is:

- A) $0,8 \text{ mol} \cdot \text{s}^{-1}$
- B) $0,48 \text{ mol} \cdot \text{s}^{-1}$
- C) $0,27 \text{ mol} \cdot \text{s}^{-1}$
- D) $1,33 \text{ mol} \cdot \text{s}^{-1}$

- 1.6 Consider the following equilibrium:



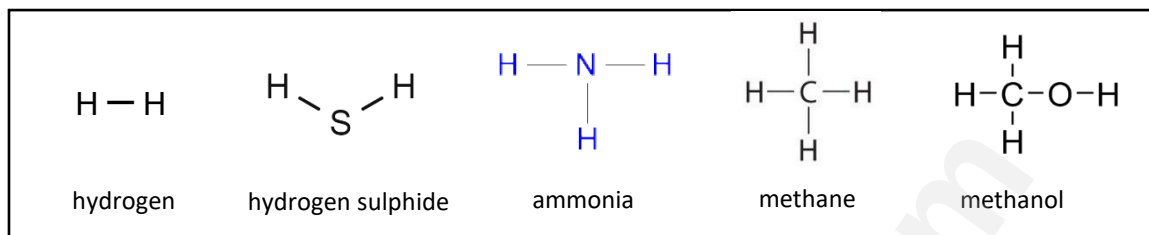
Which of the following factors will not alter the equilibrium position?

- A) A decrease in volume
 - B) A temperature increase
 - C) The addition of a catalyst
 - D) The addition of more oxygen
- 1.7 Which of the following statements concerning dilute hydrochloric acid is/are correct?
- i) It is able to conduct electricity
 - ii) it has a high pH value
 - iii) it turns bromothymol blue yellow
 - iv) it has a high K_a value
- A) i, ii, iv B) i, iii, iv C) ii, iii, iv D) i, iv
- 1.8 When concentrated hydrochloric acid is added to a saturated solution of table salt, a precipitate forms. This illustrates:
- A) that HCl is a proton donor
 - B) hydrolysis
 - C) the common ion effect
 - D) dissociation
- 1.9 Which of the following pairs will react with each other spontaneously?
- A) $\text{Mg}^{2+} \text{(aq)} + \text{Cu (s)}$
 - B) $\text{Cu}^{2+} \text{(aq)} + \text{Ag (s)}$
 - C) $\text{Mg}^{2+} \text{(aq)} + \text{Zn (s)}$
 - D) $\text{Ag}^{2+} \text{(aq)} + \text{Pb (s)}$
- 1.10 A Zn-Cu cell has been operating for some time but the net cell reaction has not reached equilibrium. How will an increase in the $[\text{Cu}^{2+}]$ affect the emf of the cell?
- A) The emf will increase
 - B) The emf will decrease
 - C) The emf will remain the same
 - D) The emf will be zero

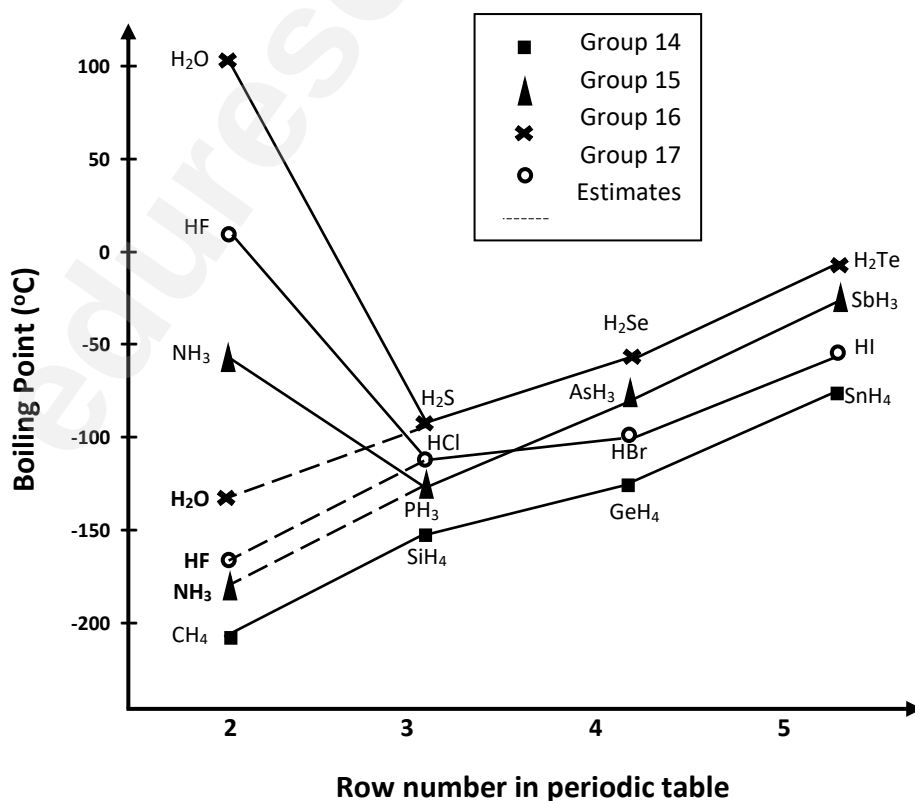
[2x10 = 20]

QUESTION 2

Given the following substances, answer the questions that follow.



- 2.1.1 Name the substance which will have the lowest boiling point? (1)
- 2.1.2 What intermolecular forces can we attribute the low boiling point in question 2.1.1 to? (1)
- 2.2 Classify the specific type of bond between the hydrogen and carbon atoms in methane. (2)
- 2.3 Which substance/s form non-polar molecules? (2)
- 2.4 Explain why methane will not dissolve in water but ammonia will. (3)
- 2.5 The general trends in boiling points for the hydrides of group 14, 15, 16 and 17 hydrides is shown in the graph.



- 2.5.1 Describe the general trend in boiling points for group 14 hydrides. (2)
- 2.5.2 The estimates for first hydride in groups 15, 16 and 17 are different from the actual boiling point. Explain why the boiling points of these compounds are much higher than expected. Make reference to intermolecular forces in your answer. (3)
- 2.6.1 A friend of yours argues that NaCl (boiling point of 1465 °C) and HCl (boiling point of -85 °C) should have the same type of intermolecular forces and hence behave similarly since they are both chlorides bonded with a group 1 element. Explain why your friend is wrong. Make reference to type of substances and intermolecular forces in your answer. (4)
- 2.6.2 NaCl (s) and HCl (g) also react very differently with water. Using balanced chemical equations (including phases), show their reactions with water. (6)

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QUESTION 3

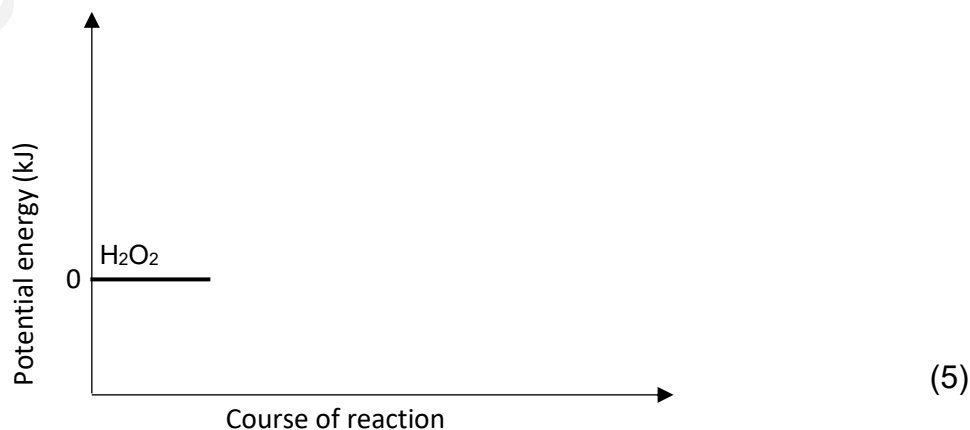
Hydrogen peroxide, H_2O_2 , decomposes to form water and oxygen according to the following balanced chemical equation:



The activation energy for this reaction is 83 kJ and the heat of reaction (ΔH) is -198 kJ.

- 3.1 Define the term **activation energy**. (2)
- 3.2 On the set of axes on your answer sheet, complete the potential energy diagram for this reaction. (Does not have to be drawn to scale)

Remember to include important values and to label the graph.



When powdered manganese dioxide is added to the reaction mixture, the rate of the reaction increases.

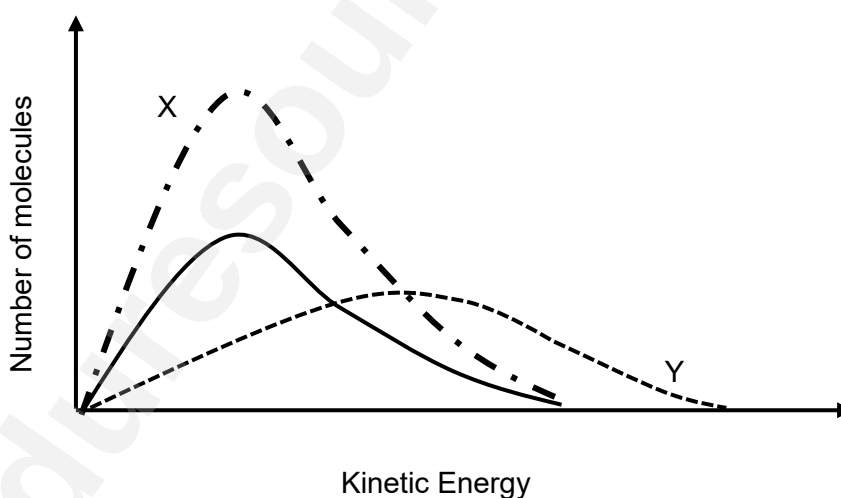
- 3.3 Use the collision theory to explain how the manganese dioxide influences the rate of the decomposition of hydrogen peroxide. (2)
- 3.4 On the graph drawn for question 3.2, use a dotted line to show the path of the reaction when the manganese dioxide is added. (2)

Two men walk into a bar.
One man orders H_2O .
The other says,
"I'll have H_2O , too."

The second man dies.

- 3.5 Three Maxwell-Boltzmann distribution curves for the oxygen gas produced under different conditions are shown in the graph below. Use the solid line as your reference curve.

The curve with the solid line represents 1 mole of oxygen gas at 90 °C.



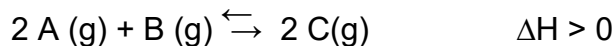
Choose the curve (X or Y) that best represents EACH of the following scenarios:

- 3.5.1 The reaction vessel was heated. (1)
- 3.5.2 More oxygen was produced at a comparative temperature. (1)

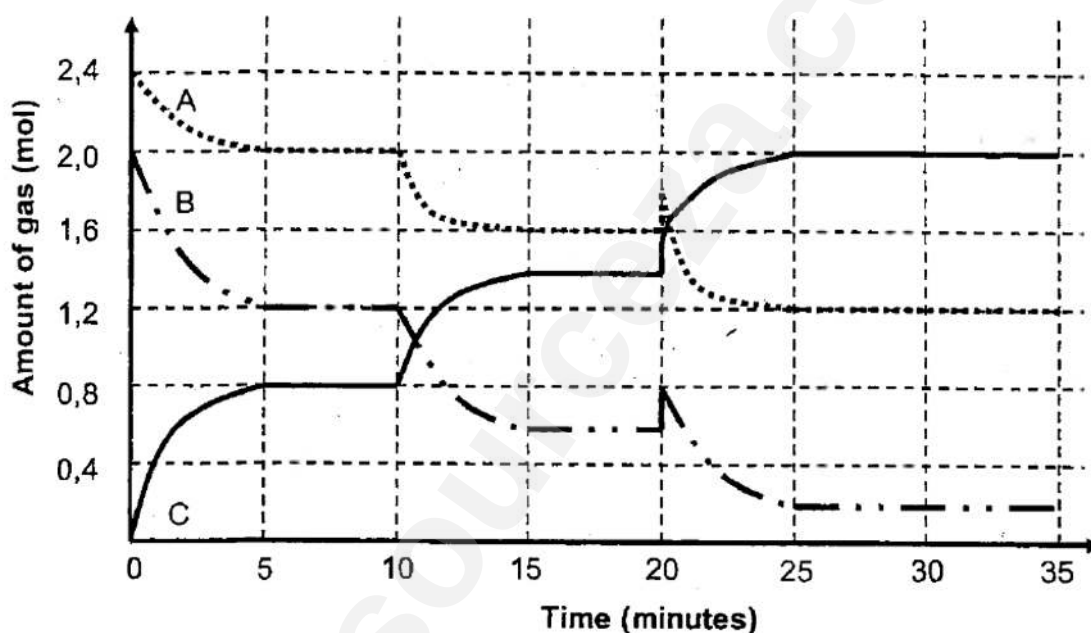
[13]

QUESTION 4

- 4.1 Reactants A (g) and B (g) are sealed in a container and allowed to reach equilibrium at 25°C according to the following equation:

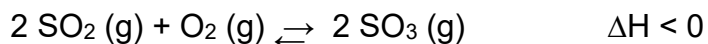


The graph below represents the changes in the amount of each gas over a period of 35 minutes.



- 4.1.1 Explain what is meant by **a closed system**. (2)
- 4.1.2 How long does the reaction take to reach equilibrium for the first time? (1)
- 4.1.3 How does the rate of the forward reaction compare to the rate of the reverse reaction at $t = 3$ minutes? (1)
- 4.1.4 At $t = 10$ minutes, a temperature change was made and a new equilibrium was established. Was the temperature increased or decreased? Use Le Chatelier's Principle to explain your answer. (3)
- 4.1.5 What change was made to the equilibrium mixture at $t = 20$ minutes? (1)
- 4.1.6 How will the value of the K_c calculated at 18 minutes compare to that calculated at 8 minutes? Explain your answer. (3)

- 4.2 The contact process is an industrial process used to make sulphuric acid. The reaction below represents the catalyzed step in the contact process:



The reaction reaches equilibrium at 427°C.

- 4.2.1 Explain how a higher temperature will affect each of the following:

4.2.1.1 The rate of production of $\text{SO}_3 (\text{g})$. (3)

4.2.1.2 The yield of $\text{SO}_3 (\text{g})$. (3)

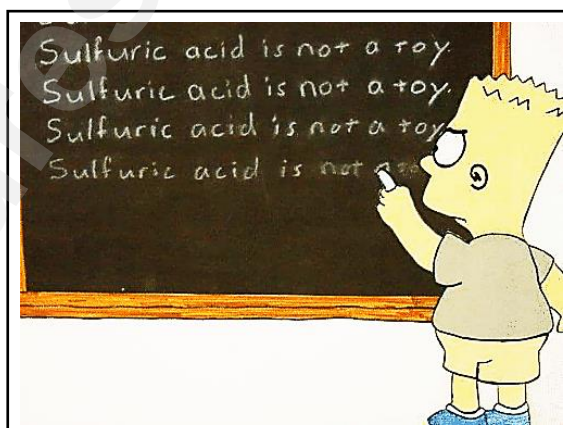
- 4.2.2 The reaction is investigated on a small scale in the laboratory. Initially 4 mol of $\text{SO}_2 (\text{g})$ and an unknown number of moles, x , of $\text{O}_2 (\text{g})$ are sealed in a 2 dm³ flask and allowed to reach equilibrium at a certain temperature.

At equilibrium, it is found that the concentration of $\text{SO}_3 (\text{g})$ present in the flask is 1,5 mol·dm³.

4.2.2.1 Calculate the number of moles of $\text{O}_2 (\text{g})$ initially present in the flask if the equilibrium constant (K_c) at this temperature is 4,5. (8)

4.2.2.2 Hence calculate mass of $\text{O}_2 (\text{g})$ initially present in the flask. (3)

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QUESTION 5

- 5.1 Like all equilibrium constants, the ionic product, K_w , of water changes its value as the temperature changes, as shown in the table below:

TEMPERATURE (°C)	K_w VALUE
25	$1,0 \times 10^{-14}$
65	$2,92 \times 10^{-14}$

- 5.1.1 Give an equation to show the auto-ionisation (autoprotolysis) of water. (Include phases) (4)
- 5.1.2 Water is an **ampholyte**. Explain what this statement means. (2)
- 5.1.3 Is the ionisation of water exothermic or endothermic? Explain your answer. (3)

- 5.2 Ethanoic acid is a common organic acid. The dissociation constant of this acid at room temperature is:

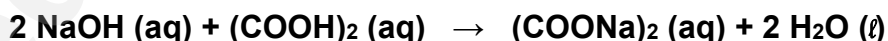
$$K_a = 1,74 \times 10^{-5}$$

- 5.2.1 What is the significance of a low K_a value for ethanoic acid and what does this tell us about the strength of ethanoic acid? (2)
- 5.2.2 What does the K_a indicate about the electrical conductivity of ethanoic acid? Write only STRONG, POOR or NON-CONDUCTOR. (1)

- 5.3 30 g of commercial caustic soda (NaOH) is made up to a solution with a volume of 250 cm^3 .

10 cm^3 of this solution is titrated against a standard solution of oxalic acid and is neutralised by $13,5 \text{ cm}^3$ of acid of concentration $0,5 \text{ mol} \cdot \text{dm}^{-3}$.

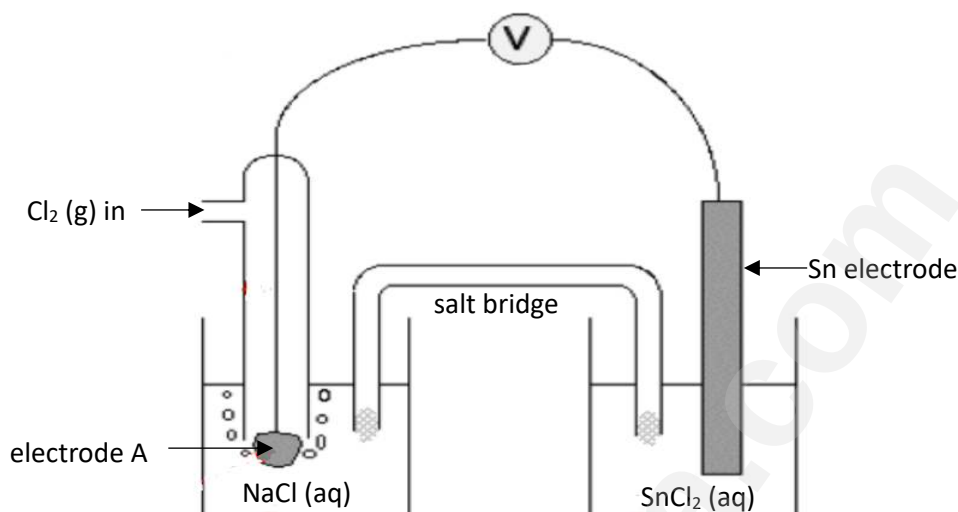
The reaction for the neutralisation is:



- 5.3.1 What would be the purpose of adding an indicator while titrating? (1)
- 5.3.2 Classify oxalic acid as monoprotic, diprotic or triprotic. (1)
- 5.3.3 Will the salt formed be acidic or basic? Explain your answer using hydrolysis. (2)
- 5.3.4 Calculate the concentration of the sodium hydroxide solution. (5)
- 5.3.5 Commercial caustic soda is often impure. Calculate the mass of sodium hydroxide that actually reacted. (5)

QUESTION 6

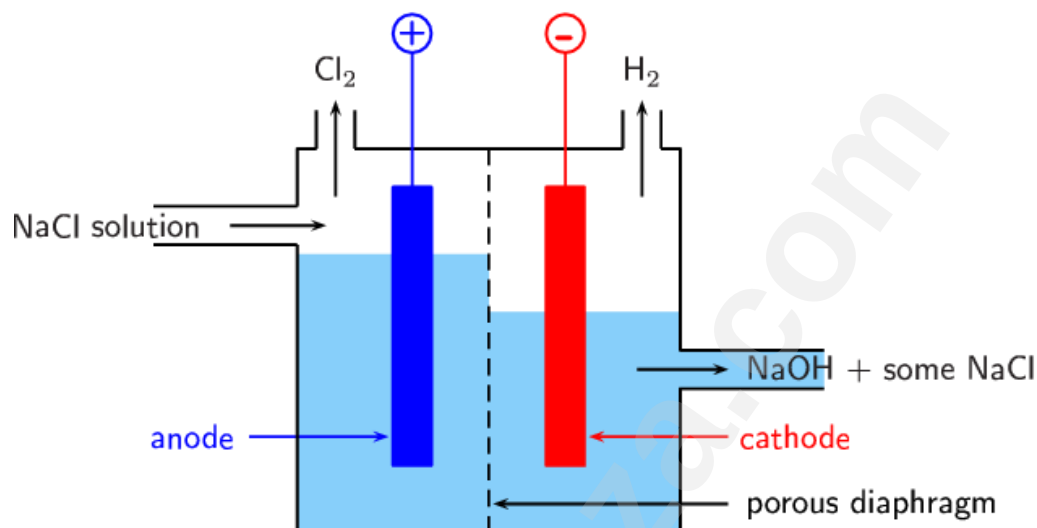
The diagram below represents a galvanic cell.



- 6.1 What is the energy conversion that takes place in this cell? (1)
- 6.2 Name a suitable material that can be used as electrode A. (1)
- 6.3 Is electrode A POSITIVE or NEGATIVE when the cell is working? (1)
- 6.4 Give the formula for a compound that can be used in the salt bridge. (1)
- 6.5 Give two modifications that can be made to the salt bridge to increase the capacity of the cell to deliver current. (2)
- 6.6 In which direction will the electrons flow in the external circuit?
Write only 'from A to Sn' or 'from Sn to A'. (1)
- 6.7 In which direction will the anions in the salt bridge move?
Write only 'towards the Sn half-cell' or 'towards the Cl₂ half-cell.' (1)
- 6.8 Write balanced equations for the:
 - 6.8.1 Oxidation half-reaction (2)
 - 6.8.2 Reduction half-reaction (2)
- 6.9 Write down the cell notation for this cell. (3)
- 6.10 Calculate the initial emf for this cell under standard conditions. (3)
- 6.11 Give two applicable standard conditions for this cell. (2)
- 6.12 If the mass of one of the electrodes has decreased by 11,9 g in 1½ hours, calculate
 - 6.12.1 the mass of the chlorine gas that has reacted. (5)
 - 6.12.2 the current produced in the external circuit in 2 minutes. (6)

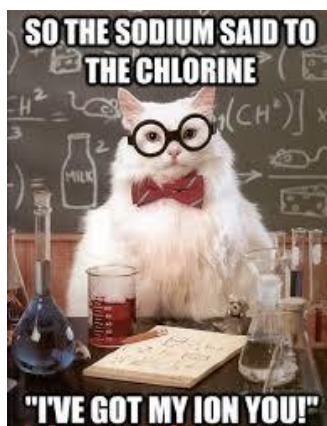
QUESTION 7

The following diagram illustrates the industrial production of chlorine by means of a diaphragm cell.



- 7.1 A DC power source is used. Why can alternating current not be used? (2)
- 7.2 Give the equation for the half-reaction that occurs at the anode. (2)
- 7.3.1 Give a definition for **oxidizing agent**. (2)
- 7.3.2 Name the oxidizing agent in this cell. (1)
- 7.4 Explain why sodium ions (Na^+) do not get reduced at the cathode. (1)
- 7.5 Give the overall reaction as a balanced chemical equation. (3)
- 7.6 Give a difference between the membrane cell and the diaphragm cell. (1)
- 7.7 Give two reasons as to why the diaphragm cell is being phased out of industry and the membrane cell is now being used. (2)

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QUESTION 8

A laboratory technician is supplied with three unlabeled bottles, P, Q and R, containing an alcohol, a carboxylic acid and an alkane of comparable molecular mass. In order to identify each sample, she determines the boiling point of each under the same conditions. The results are shown in the table below.

SAMPLE	BOILING POINT (°C)
P	76
Q	36
R	118

8.1 For this investigation, give the:

8.1.1 Independent variable (1)

8.1.2 Dependent variable (1)

8.2 Give a controlled variable that the laboratory technician considered in order for this to be a fair test? (1)

8.3 Explain, by referring to the intermolecular forces present, which sample is most likely to be an alkane. (3)

8.4.1 Name the functional group for a carboxylic acid. (1)

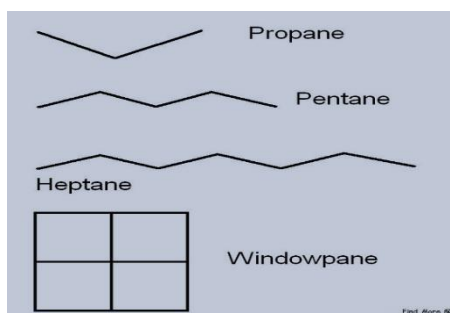
8.4.2 Explain, by referring to the intermolecular forces present, which sample is most likely to be a carboxylic acid (3)

8.5 The alkane is later identified as pentane.

8.5.1 Define the term **Homologous series**. (2)

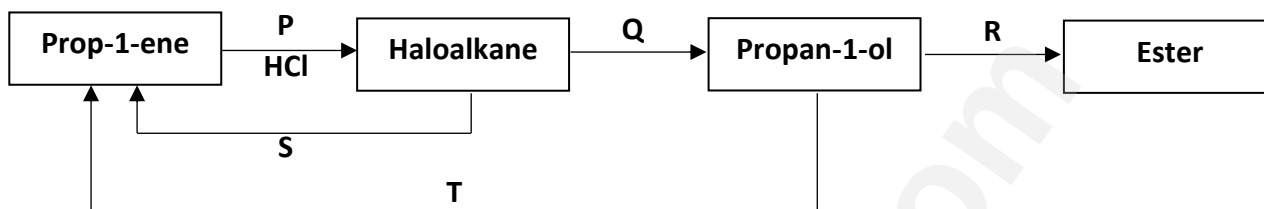
8.5.2 Will the boiling point of butane be HIGHER THAN or LOWER THAN that of pentane? Explain your answer. (4)

[16]



QUESTION 9

Consider the flow diagram below which shows the preparation of an ester using prop-1-ene as a starting reagent. P, Q, R and S represent different organic reactions.



9.1 Prop-1-ene lends itself to many types of reactions due to its state of saturation.

9.1.1 Define the term **saturated hydrocarbon**. (2)

9.1.2 Give the type of addition reaction represented by **P**. (1)

9.1.3 Give the balanced equation for reaction **P** using structural formulae. (3)

9.1.4 Give the IUPAC name of the haloalkane formed in reaction **P**. (2)

9.2 In both reactions **Q** and **S**, a haloalkane is reacted with potassium hydroxide.

9.2.1 In Reaction **S**, prop-1-ene is formed. Give the general formula for an alkene. (1)

9.2.2 What type of reaction is represented by reaction **Q**? (1)

9.2.3 Give the chemical formulae for the non-organic products in reaction **S**. (2)

9.3 In reaction **T**, propan-1-ol undergoes elimination to become prop-1-ene.

9.3.1 To which homologous series does propan-1-ol belong? (1)

9.3.2 Give the type of elimination reaction represented by **T**. (1)

9.3.3 Concentrated sulphuric acid is used as a catalyst in this reaction. What is its other function in this reaction? (1)

9.3.4 Give a balanced chemical equation for this reaction using molecular formulae. (phases are not necessary). (3)

PTO

9.4 In reaction **R**, propan-1-ol reacts with a carboxylic acid to produce an ester.

9.4.1 Name the reaction that takes place. (1)

9.4.2 Give the formula for the catalyst needed. (1)

9.4.3 Draw the structural formula of the 5-carbon ester formed. (2)

9.4.4 Give the IUPAC name of the ester formed. (2)

9.4.5 Give a definition for an **isomer**. (2)

9.4.6 Give the structural formula of a functional isomer of the ester formed. (2)

[28]

