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ST BENEDICT'S

SUBJECT	Prelim paper II	DATE	23 July 2018
GRADE	12	MARKS	200
EXAMINER	Mrs Visentin	MODERATOR	Mr McCoy
NAME		DURATION	180 minutes
CLASS			

**LOW
ORDER**

55%

HIGH ORDER

45%

INSTRUCTIONS

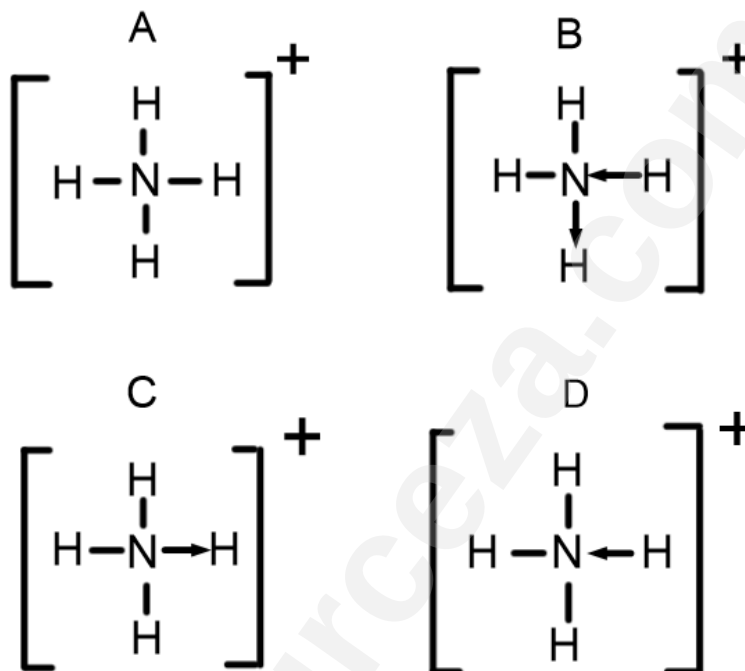
1. This Examination consists of 19 pages and an answer sheet.
2. It is in your own interest to write legibly and to present your work neatly.
3. Answer all questions.
4. Rough work and planning may be done as long as it is clearly indicated as rough work. Rough work will not be marked.
5. An information sheet will be handed out separately.

Question	1	2	3	4	5	6	7	8	9	Total
Marks	20	16	26	24	8	27	25	18	36	200

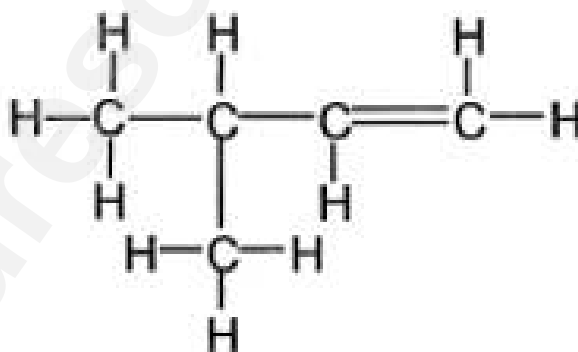
QUESTION 1- MULTIPLE CHOICE**20 MARKS**

Answer these questions on the multiple-choice grid on your answer sheet. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

- 1.1 Which diagram correctly shows the bonding in the ammonium ion, NH_4^+ ? (2)



- 1.2 Consider the organic compound shown below:

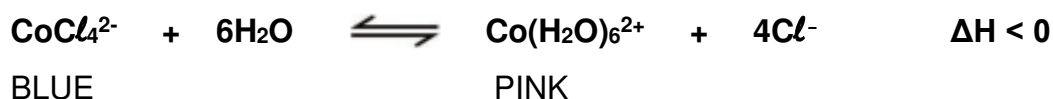


The compound is...

- A saturated and branched.
- B saturated and straight- chained.
- C unsaturated and straight-chained.
- D unsaturated and branched.

(2)

- 1.3 A violet coloured solution is prepared by dissolving cobalt chloride crystals in a mixture of ethanol and water. This violet colour is due to two different coloured cobalt(II) ions existing together in equilibrium in the solution as shown in the balanced chemical equation:



What colour change will be observed when a few drops of concentrated HCl are added to 1 cm³ of the violet solution? (2)

- A The solution turns colourless
B The solution turns blue
C The solution turns pink
D No colour change

- 1.4 1,0 mol.dm⁻³ solutions of H₂SO₄, HCl and CH₃COOH are prepared. When comparing the three solutions, which of the following statements is correct? (2)

- A The CH_3COOH solution has the lowest pH.
- D The H_2SO_4 solution has the lowest $[\text{H}_3\text{O}^+]$.
- C The CH_3COOH has the lowest ionisation constant (K_a).
- D The HCl has the lowest electrical conductivity

- 1.5 H_3AsO_4 reacts with water as follows:



The conjugate base of H_3AsO_4 in this reaction is: (2)

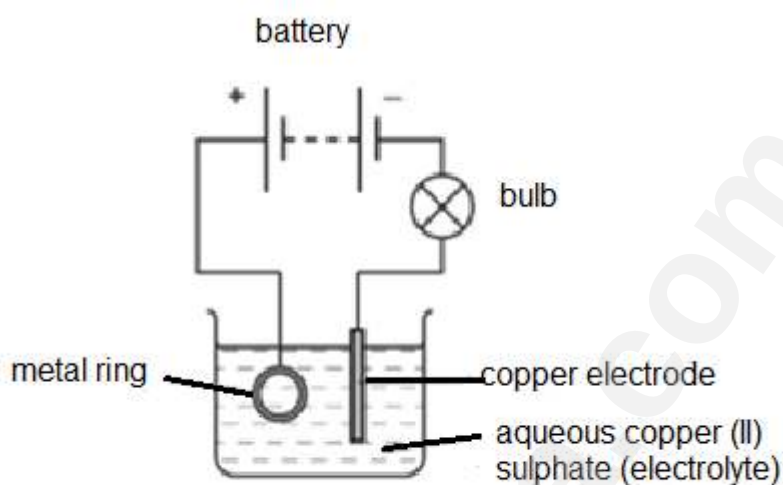
- A H_2AsO_4^-
B H_3O^-
C H_2O
D OH^-

- 1.6 Compare the $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ of H_2O at 25°C before and after adding HCl . Assume equilibrium is re-established each time. (2)

- A both $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ increase.
B both $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ decrease.
C $[\text{H}_3\text{O}^+]$ increases and $[\text{OH}^-]$ decreases.
D $[\text{H}_3\text{O}^+]$ decreases and $[\text{OH}^-]$ increases.

- 1.7 The chemical formula for calcium sulphite is: (2)
- A $\text{Ca}(\text{SO}_3)_2$
 - B CaSO_4
 - C Ca_3SO_2
 - D CaSO_3
- 1.8 Which of the following pairs will react with each other spontaneously? (2)
- A $\text{Mg}^{2+}(\text{aq}) + \text{Cu}(\text{s})$
 - B $\text{Cu}^{2+}(\text{aq}) + \text{Ag}(\text{s})$
 - C $\text{Mg}^{2+}(\text{aq}) + \text{Zn}(\text{s})$
 - D $\text{Ag}^+(\text{aq}) + \text{Pb}(\text{s})$
- 1.9 Which one of the following statements about the extraction of aluminium from alumina is false? (2)
- A Aluminium is formed at the negative electrode through the process of reduction.
 - B Alumina dissolves in molten cryolite reducing the energy cost of running the smelter.
 - C Carbon dioxide is a by-product of the extraction process.
 - D Oxide ions are reduced at the graphite electrodes.

1.10 The diagram shows the apparatus used in an attempt to electroplate a metal ring with copper.



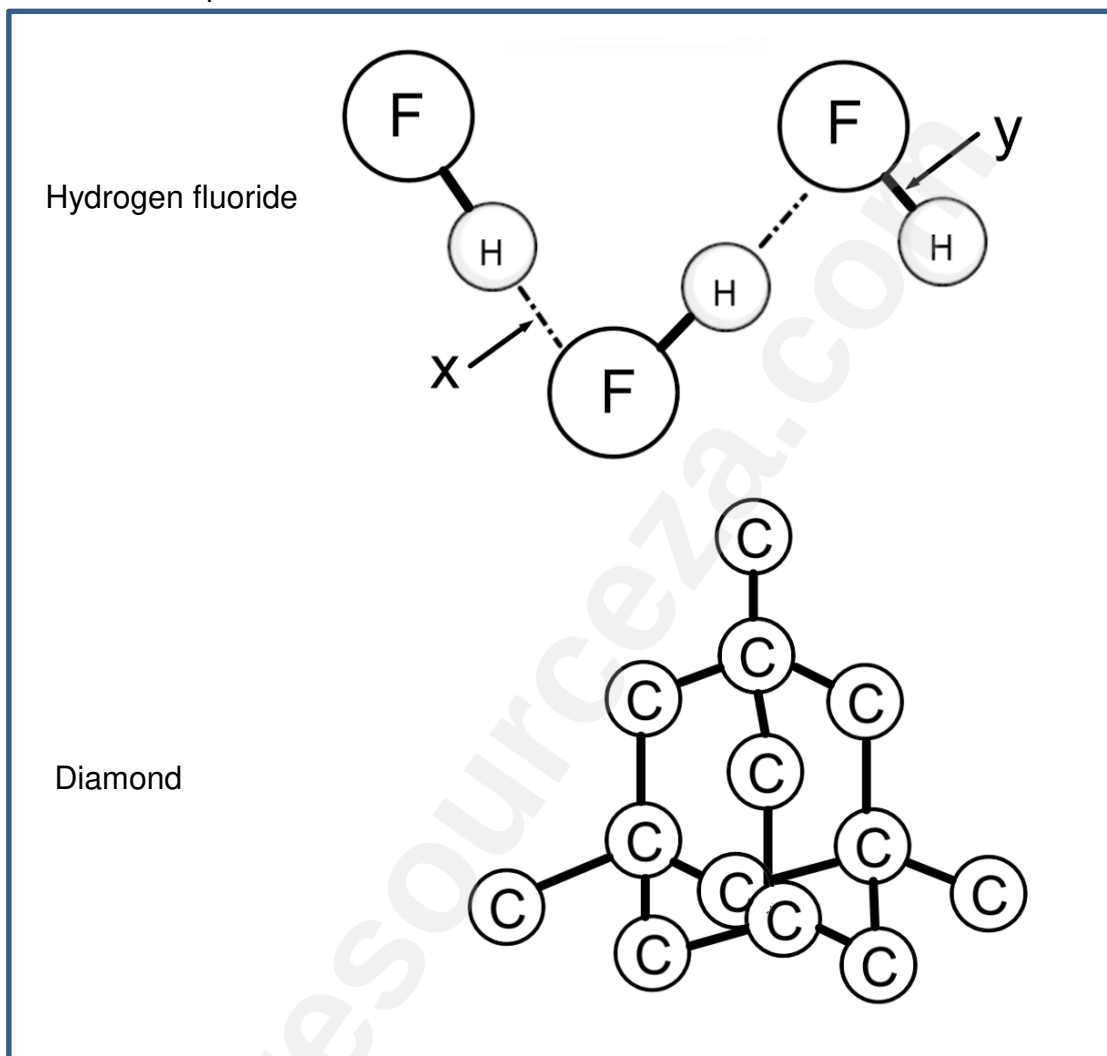
The experiment did not work. Which change is needed to make the experiment work?

(2)

- A Reverse the connection to the battery.
- B Increase the temperature of the electrolyte.
- C Replace the copper electrode with a carbon electrode.
- D Add solid copper sulphate to the electrolyte.

QUESTION 2 - START ON THE TOP OF A NEW PAGE 16 MARKS

- 2.1 Consider the diagram below of molecules of hydrogen fluoride and a unit showing the structure of a diamond lattice. Both substances are in a condensed phase.



- 2.1.1 Define *intramolecular bond*. (2)
- 2.1.2 Explain why the intramolecular bond represented by the letter y in the diagram is polar covalent. A simple calculation is required in your explanation. (2)
- 2.1.3 Name the specific type of force represented by the letter X in the diagram. (1)
- 2.1.4 State two criteria that are met by hydrogen fluoride that enables "X" force to exist. (2)
- 2.1.5 Explain why the boiling point of diamond (4827 °C) is higher than the boiling point of hydrogen fluoride (19,5 °C). (3)

- 2.2 Consider the following substances that are at room temperature and then answer the questions that follow:

aluminium	potassium iodide	hydrogen chloride	methane	ammonia
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Choose substances from the table above. You may use the substance once, more than once or not at all in your answers.

Give the name of ONE substance from the table which:

- 2.2.1 forms dipole - dipole intermolecular forces. (1)
- 2.2.2 consists of positive kernels in a sea of delocalised electrons. (1)
- 2.2.3 does not conduct electricity in the solid phase but does when it is molten. (1)
- 2.2.4 contains polar covalent bonds but its molecules are non-polar. (1)
- 2.2.5 contains molecules that have one lone pair. (1)
- 2.2.6 has predominantly induced temporary dipoles (London forces) between its molecules. (1)
-

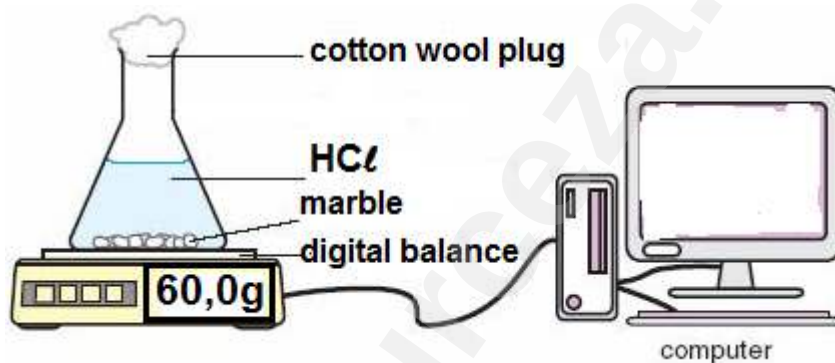
QUESTION 3 - START ON THE TOP OF A NEW PAGE**26 MARKS**

Ryan and Andrea want to investigate the effect of the size of marble chips (calcium carbonate) on the rate of reaction between calcium carbonate and hydrochloric acid at 20 °C.

The chemical equation for the reaction is:



Ryan places a large 20 g marble chip of calcium carbonate into a conical flask and adds 50 cm³ of dilute hydrochloric acid into the flask, sufficient to cover the marble chip completely. He places a cotton wool plug at the mouth of the flask which is placed on top of a digital scale. The decrease in mass of the conical flask and its contents (the system) is recorded digitally over time intervals.



The table shows Ryan's results for the decrease in mass of the system in 30 second intervals.

Time (s)	Mass (g)
0	60,00
30	58,70
60	57,90
90	57,50
120	57,10
150	56,90
180	56,75
210	56,75

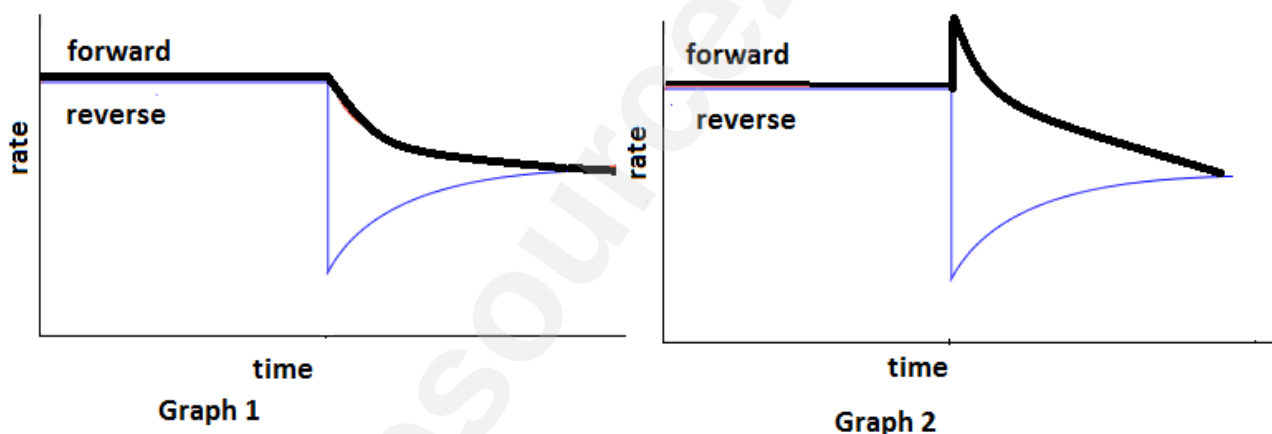
- 3.1 Andrea makes the following statement: “*The reason why the mass of the conical flask is decreasing over time is because the reactants are being used up.*” Explain why Andrea’s statement is incorrect. (2)
- 3.2 Ryan plotted a graph to show the trend in the relationship between the decrease in mass of the system and time. The incomplete graph is provided for you on the ANSWER SHEET. Complete the graph on the ANSWER SHEET by following these instructions:
- 3.2.1 Determine the scale used on the y-axis and fill in the numbers in the empty blocks provided on your ANSWER SHEET. The scale on the y-axis **does not** start with 0. (2)
- 3.2.2 Plot the missing points that are printed in **bold** in the table. (1)
- 3.2.3 Draw a best-fit line (a curve) through the points. (2)
A heading is not required.
- 3.3 Define *rate of reaction*. (2)
- 3.4 The average rate of the reaction between $t = 0 \text{ s}$ and $t = 60 \text{ s}$ is $-0,035 \text{ g} \cdot \text{s}^{-1}$
- 3.4.1 Explain why the value is negative. (2)
- 3.4.2 Calculate the average rate of the reaction between time interval $t = 60 \text{ s}$ and $t = 120 \text{ s}$ (2)
- 3.4.3 Account for the difference in average reaction rates between the time intervals: $t = 0 \text{ s}$ and $t = 60 \text{ s}$ and $t = 60 \text{ s}$ and $t = 120 \text{ s}$ by referring to Collision theory and reaction rate. (3)
- 3.4.4 Provide one suggestion that can be made to the method to improve the means of collecting data for the loss of mass of reactants. (1)
- 3.5 Ryan repeats the experiment with 20 g of powdered calcium carbonate.
- 3.5.1 Suggest one variable other than temperature that Ryan should control to ensure that his results are valid. (1)
- 3.5.2 On the same set of axes on your ANSWER SHEET, draw in the shape of the graph that Ryan should expect to get. Label your graph ‘powered calcium carbonate’. (2)
- 3.6 Calculate the concentration of the hydrochloric acid used in this experiment given that the calcium carbonate was in excess. (6)
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QUESTION 4 - START ON THE TOP OF A NEW PAGE 24 MARKS

Zinc sulphide reacts with oxygen in a closed system to produce zinc oxide and sulphur dioxide. The reaction reaches dynamic equilibrium at a specific temperature and the equation is shown below:



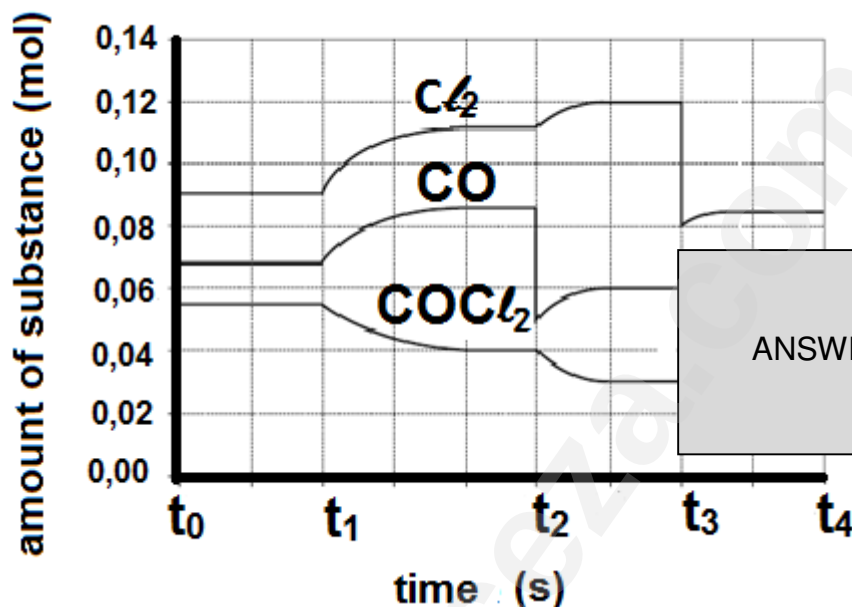
- 4.1 Explain what is meant by a closed system. (2)
- 4.2 What is meant by dynamic chemical equilibrium? (1)
- 4.3 State how each of the following changes to the system will affect the yield of zinc oxide at equilibrium. Choose from: **INCREASE, DECREASE or NO EFFECT.**
- 4.3.1 A decrease in the volume of the container. (1)
- 4.3.2 Adding more ZnS(s) and resealing the reaction vessel. (1)
- 4.4 Which one of the following graphs would be the rate graph if some sulphur dioxide were removed from the equilibrium system? Write down graph 1 or graph 2. (2)



- 4.5 State Le Chatelier's principle. (2)
- 4.6 Using Le Chatelier's principle, explain how an increase in temperature will affect the yield of zinc oxide at equilibrium. (4)
- 4.7 1050 g of ZnS is initially placed in a sealed 10 dm³ container with 20 moles of O₂, and reaches equilibrium. The reaction is kept at a constant temperature. The volume of SO₂ (at STP) produced at equilibrium is 220,5 dm³.
- 4.7.1 Write down a mass action expression for this reaction. (3)
- 4.7.2 Calculate the value of K_c for this reaction at this temperature. (8)

QUESTION 5 - START ON THE TOP OF A NEW PAGE**8 MARKS**

Consider the following reaction that reaches dynamic equilibrium at a constant temperature in a 1 dm³ closed system:



ANSWER BOOKLET

- 5.1 At time t₁ the temperature of the container is increased. Is the forward reaction exothermic or endothermic? (1)
- 5.2 Suggest what change was made to the system at t₂. (1)
- 5.3 Explain, using Le Chatelier's principle, how the change mentioned in question 5.2, affected the concentration of the other gases as indicated in the graph. (3)
- 5.4 At t₃ the pressure of the system decreased (volume of the system increased). Draw the effect of this change on the graph in your ANSWER BOOKLET for CO and for COCl₂. (3)

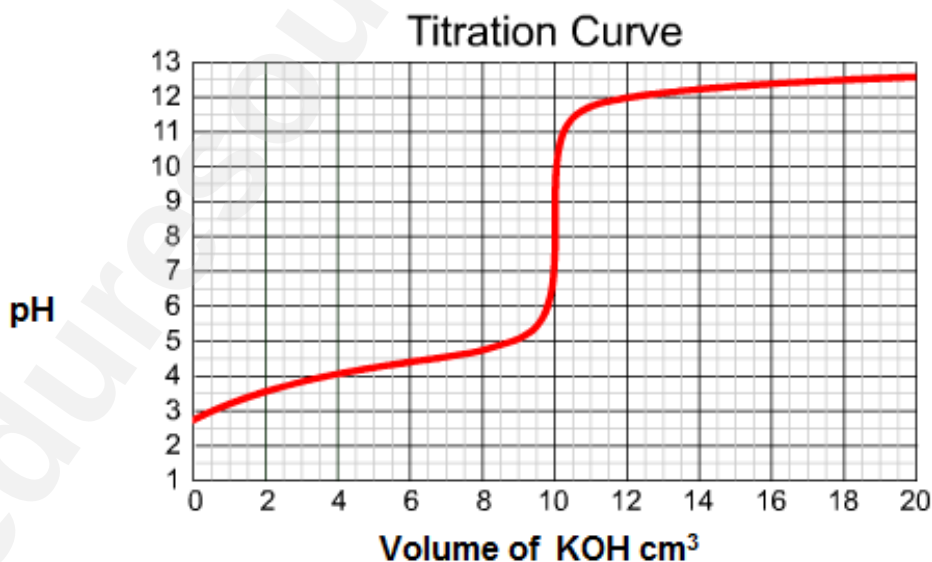
QUESTION 6 - START ON THE TOP OF A NEW PAGE 27 MARKS

Potassium hydroxide is a strong base.

- 6.1 State the difference between a concentrated base and a strong base. (2)
- 6.2 A student is instructed to make a standard solution of potassium hydroxide of concentration $0,3 \text{ mol.dm}^{-3}$ in a 250 cm^3 of water at 20°C .
- 6.2.1 Define *standard solution*. (2)
- 6.2.2 Name the apparatus that is used to make up a volume of exactly 250 cm^3 of solution. (1)
- 6.2.3 Write down a balanced chemical equation to show the dissociation of KOH in water. Include state symbols in your answer. (2)
- 6.2.4 K_w of water at 20°C is $0,681 \times 10^{-14}$. Calculate the concentration of hydronium ions in the potassium hydroxide solution at 20°C . (3)

The standard potassium hydroxide solution prepared in question 6.2 is used to find the concentration of either aqueous **oxalic acid** ($\text{H}_2\text{C}_2\text{O}_4$) or **hydrochloric acid** by means of a titration. The formula for oxalic acid can also be written as $(\text{COOH})_2$.

- 6.2.5 The K_a value at 25°C for HCl is $1,3 \times 10^6$ and for $\text{H}_2\text{C}_2\text{O}_4$ is $6,5 \times 10^{-5}$. Which of these two acids will have a higher concentration of hydronium ions (H_3O^+). Explain. (2)
- 6.2.6 The pH of the reaction between KOH and **one** of the acids was recorded with a pH sensor as the reaction took place. The curve obtained is shown below.



- (a) Define *equivalence (or neutralization point)*. (2)
- (b) Explain why the acid used is oxalic acid and not hydrochloric acid. (2)

- (c) The following table shows two possible salt hydrolysis equations of the aqueous salt $K_2C_2O_4$ that forms when KOH reacts with $H_2C_2O_4$. Choose the correct equation by writing down the correct corresponding, letter A or B.

A	$C_2O_4^{2-} + H_2O \rightleftharpoons H_2C_2O_4 + OH^-$
B	$K^+ + H_2O \rightleftharpoons KOH + H^+$

(1)

- (d) Explain your choice to (c).

(3)

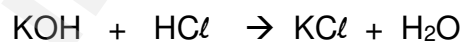
- 6.2.7 The table below lists the indicators that are most commonly used in a school lab.

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

Which indicator would be best suited for the titration of potassium hydroxide solution against the hydrochloric solution. (1)

- 6.3 The student dissolves 3 g of impure potassium hydroxide in water and makes the solution up to 250 cm^3 .

He then takes $25,0\text{ cm}^3$ of this solution and titrates it with dilute hydrochloric acid. He finds that he needs $25,80\text{ cm}^3$ of $0,2\text{ mol.dm}^{-3}$ hydrochloric acid to fully neutralise the potassium hydroxide. They react according to the equation below:

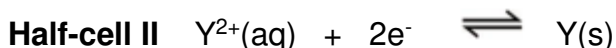
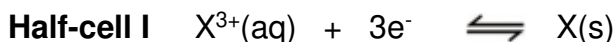


Calculate the moles of KOH in the original solution. (6)

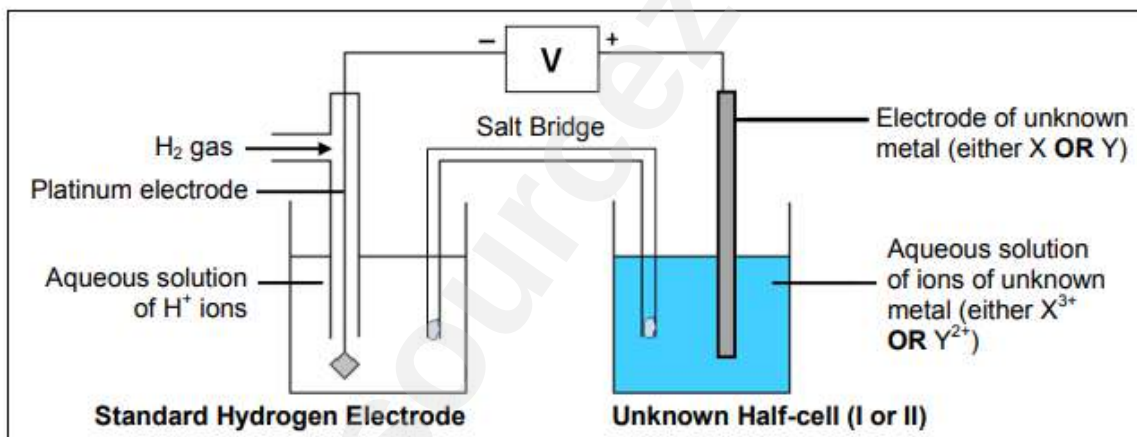
QUESTION 7 - START ON THE TOP OF A NEW PAGE**25 MARKS**

(IEB, sup, March 2018)

James is required to determine the standard electrode potential of two unknown hypothetical half-cells I and II. The half-reaction taking place in each of the half-cells is given below.



James connects each half-cell, under standard conditions, to a standard hydrogen electrode. The two half-cells are connected by a salt bridge which is an aqueous saturated solution of sodium nitrate. He connects the standard hydrogen electrode to the negative terminal of a digital voltmeter as shown in the diagram below. The standard electrode potential (E^0) for each half cell, as given by the reading on the voltmeter, is then recorded.

**Results:**

	Cell	Reading on voltmeter (V)
P	Standard hydrogen electrode + Half-cell I	+0,61
Q	Standard hydrogen electrode + Half-cell II	-2,14

7.1 Define the following terms:

7.1.1 *Anode* (2)

7.1.2 *Reducing agent* (2)

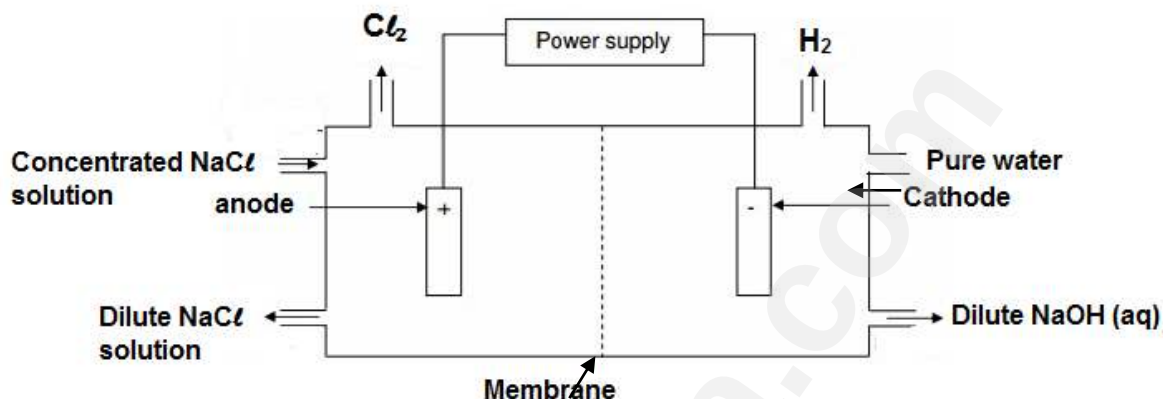
7.2 Give the symbol of the reducing agent of cell P. (1)

7.3 Write down the balanced net ionic chemical equation for the reaction taking place in cell P. (3)

- 7.4 State how each of the following will affect the reading on the voltmeter in cell P. Choose from INCREASES, DECREASES OR REMAINS THE SAME.
- 7.4.1 Increasing the concentration of X^{3+} ions in half cell 1. (1)
- 7.4.2 increasing the concentration of electrolyte in the salt bridge. (1)
- 7.5 State the direction that the sodium ions in the horizontal portion of the salt bridge will flow. Answer to the LEFT or to the RIGHT. (1)
- 7.6 Explain the chemistry (referring to the movement of ions) behind your answer to 7.5. (4)
- 7.7 Which metal, **X** or **Y**, is a stronger reducing agent? (1)
- 7.8 Fully explain the significance of the negative reading on the voltmeter in cell **Q** in comparison to the half-cell potential of the standard hydrogen electrode. (3)
- 7.9 James now connects half-cell I to half-cell II under standard conditions to make cell **R**.
- 7.9.1 Write down the cell notation for cell **R**. You do not need to include standard conditions. (3)
- 7.9.2 Calculate the initial emf of cell **R**. (3)
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QUESTION 8 - START ON THE TOP OF A NEW PAGE 18 MARKS

8.1 The chloralkali industry produces chlorine using three types of electrolytic cells. The simplified diagram below shows a membrane cell.



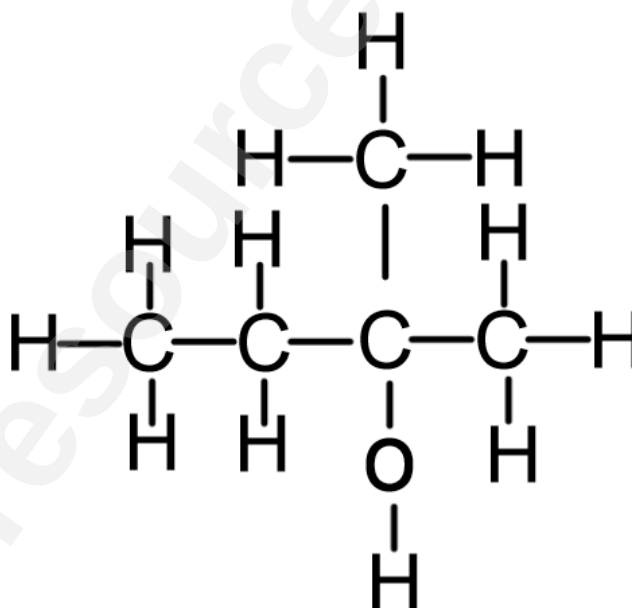
- 8.1.1 Define *oxidation*. (2)
- 8.1.2 Give two reasons why the membrane cell is the preferred cell for the preparation of chlorine gas. (2)
- 8.1.3 Why is it advisable to use inert electrodes in this process? (2)
- 8.1.4 Write down the equation for the half-reaction taking place at the anode. (2)
- 8.1.5 Use the relative strengths of oxidising agents present in the brine solution to explain why sodium metal is not one of the products in this process. (2)
- 8.1.6 When the concentration of NaCl is reduced and replaced by a dilute solution of NaCl , the percentage of oxygen gas in the chlorine gas produced is high. Explain why this should happen. Write down an equation for a suitable half-reaction which supports your answer. (3)
- 8.2 Molten sodium chloride is electrolyzed completely. The sodium and chlorine are recovered separately.
- 8.2.1 Write down the oxidation half reaction. (1)
- 8.2.2 Determine the moles of electrons released in the oxidation if 21,3 g of chlorine is formed. (2)
- 8.2.3 Calculate the total charge transferred during the electrolysis. (2)

QUESTION 9 - START ON THE TOP OF A NEW PAGE 36 MARKS

9.1 The table below compares the boiling points of straight chained, five carbon organic compounds from different homologous series.

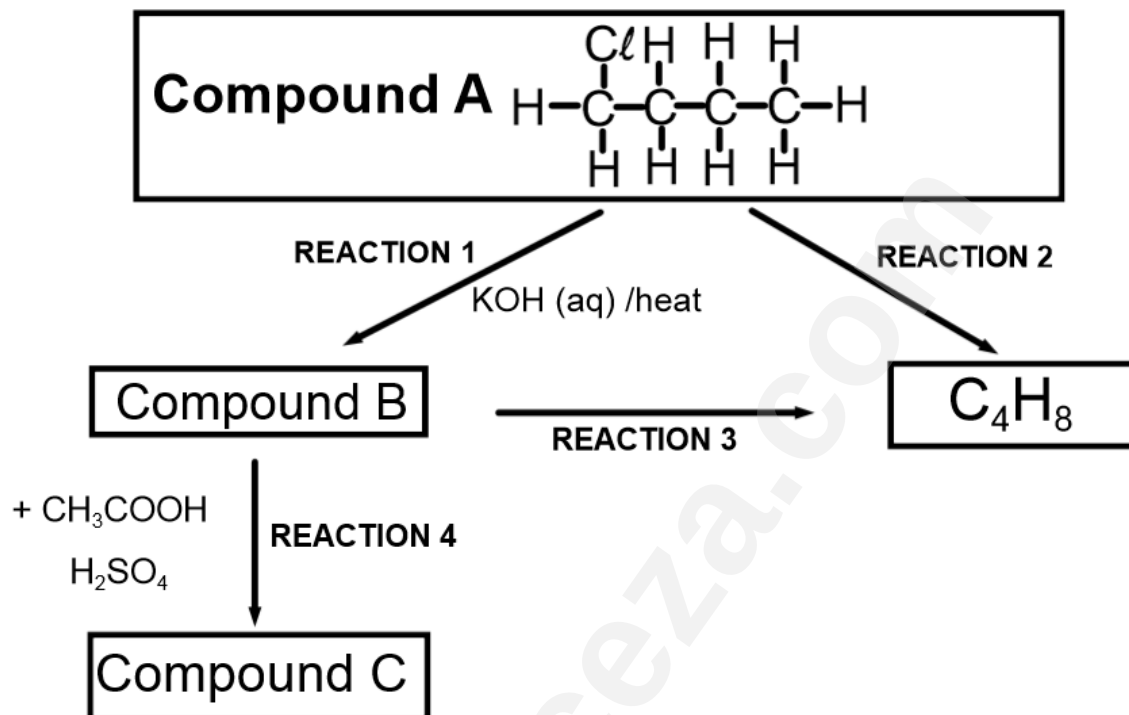
Name of compound	Boiling points (° C)
pentane	36,1
1-pentanol	138,0
pentanoic acid	186,0

- 9.1.1 Although pentane and 1-pentanol are both five carbon structures, 1-pentanol has a significantly higher boiling point than pentane. Compare the intermolecular forces between the molecules of these substance to explain why this occurs. (3)
- 9.1.2 The structural formula of a chain isomer of 1- pentanol is shown below.



- (a) Write down the IUPAC name of the above isomer. (3)
- (b) Would the boiling point of this compound be higher than, lower than or the same as 1-pentanol? Give a reason for your answer. (4)

9.2 Consider the following sequence of organic reactions.



9.2.1 Compound A belongs to a homologous series.

- (a) Define *homologous series*. (2)
- (b) Identify the homologous series that compound A belongs to. (1)

9.2.2 Identify the type of reaction occurring in:

- (a) reaction 1 (1)
- (b) reaction 2. (1)

9.2.3 Draw the structural formula of compound B and circle its functional group. (2)

9.2.4 Compound B reacts with ethanoic acid to produce compound C in the presence of concentrated sulphuric acid according to reaction 4.

- (a) Using a structural formula, draw and name the organic molecule of compound C that forms. (4)
- (b) Provide the name of a functional isomer of compound C. (1)
- (c) Give the chemical formula of the inorganic product that will also be produced in this reaction. (1)
- (d) Give a reason why sulphuric acid is used in this reaction. (1)

9.2.5 Consider C_4H_8 .

- (a) Define *isomer*. (2)
- (b) Give the semi-structural (condensed structure) formula of a **branched** chain isomer of C_4H_8 . (2)

Unlabelled containers of liquid C_4H_8 , C_4H_{10} and $CH_3CH_2CH_2COOH$ have been given to a lab technician to identify. He marks each container X, Y and Z and performs certain tests on the liquids. The results he obtains is shown in the table below.

Test	X	Y	Z
Solubility in water	Completely miscible	immiscible	immiscible
Addition of bromine water	No immediate change	Rapidly discolours	No immediate change
Effect on Litmus paper	Turns blue litmus red	No effect	No effect

- (c) Identify each of compounds X, Y and Z. (3)
- (d) Write down a balanced chemical reaction using structural formula for the reaction between Y and bromine water. (3)
- (e) Write down the balanced chemical equation for the complete combustion of C_4H_8 , using molecular formula. (2)

END OF PAPER