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St Mary's School
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Physical Sciences Preliminary Examination

Paper II – Chemistry

Thursday 20 September 2018

Form V

Marks: 200

Examiner: M Blair

Time: 3 hours

Examination number: _____

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages, a yellow answer sheet of 1 page (i) and a green data sheet of 3 pages. Please make sure that your question paper is complete.
2. Remove the data and answer sheets from inside this question paper. **Write your examination number on the answer sheet and question paper.**
3. **Please complete the multiple choice question on your answer sheet:**
There is only one correct answer for each of the multiple choice questions. The letter corresponding to the answer you think is correct should be marked with a cross, thus:

A	B	C	D
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Here, C is the answer

4. Start each question on a new page, but please write on both sides of the paper.
5. Use the data and formulae whenever necessary.
6. Show all of the necessary steps in calculations.
7. Where appropriate, take your answers to 2 decimal places, unless instructed otherwise. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
8. It is in your own interest to write legibly and to present your work neatly. Please ensure that you number your answers as the questions are numbered.
9. When you hand in your exam, place the yellow answer sheet in the **front** of your answer book and your question paper booklet and green data sheets at the **back** of your answer book.

Answer questions 1.1 – 1.10 on the grid provided on your ANSWER SHEET. Place a cross in the appropriate block for each question.

1.1 Which one of the bonds between the atoms below has the highest polarity?

- A H – C
- B H – Cl
- C H – O
- D H – N

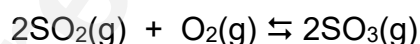
1.2 Which chemical equation represents an endothermic reaction?

- A $\text{NH}_4\text{NO}_3(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{NH}_4^+(\text{aq}) + \text{NO}_3^-(\text{aq}) \quad \Delta H > 0$
- B $2\text{Mg}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{MgO}(\text{s}) \quad \Delta H < 0$
- C $\text{Zn}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{ZnCl}_2(\text{aq}) + \text{H}_2(\text{g}) + \text{heat}$
- D $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g}) \quad \Delta H = -131 \text{ kJ}\cdot\text{mol}^{-1}$

1.3 Which one of the reactions below will produce the salt sodium ethanoate?

- A $\text{HCl}(\text{s}) + \text{CH}_3\text{COOH}(\text{aq}) \rightarrow$
- B $\text{CH}_3\text{COOH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow$
- C $\text{CH}_3\text{COOH}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow$
- D $\text{H}_2\text{CO}_3(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow$

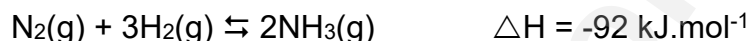
1.4 In an experiment, 0,1 mol of $\text{SO}_2(\text{g})$ and 0,1 mol of $\text{O}_2(\text{g})$ are added to an empty 1 dm³ flask which is then sealed. The resulting reaction reaches equilibrium as shown in the following balanced chemical equation:



Which one of the following is not true at equilibrium?

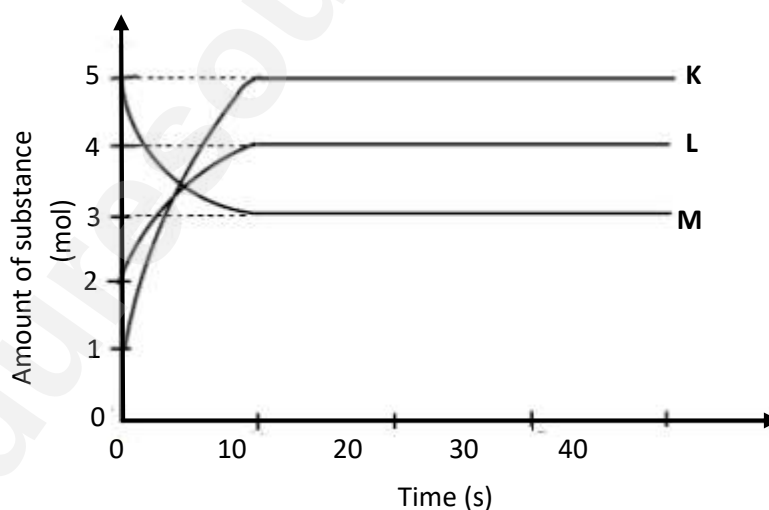
- A $[\text{SO}_2] = [\text{O}_2] = [\text{SO}_3]$
- B $[\text{O}_2] < [\text{SO}_3]$
- C $[\text{SO}_2] = [\text{SO}_3]$
- D $[\text{SO}_2] < [\text{O}_2]$

- 1.5 An electrochemical cell consists of a standard hydrogen electrode and a $\text{Cu}^{2+}(\text{aq})/\text{Cu}(\text{s})$ electrode which uses copper (II) sulphate solution. Which one of the following does not affect the emf of the cell?
- A The volume of the copper (II) sulphate solution.
 - B The temperature.
 - C The pressure of the hydrogen.
 - D The concentration of the copper (II) sulphate solution.
- 1.6 The Haber process which is used to make ammonia from nitrogen and hydrogen at 450°C according to the following balanced equation.



When the temperature of the system at equilibrium is increased;

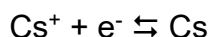
- A K_c decreases
 - B K_c increases
 - C K_c stays the same
 - D K_c first decreases then increases.
- 1.7 The graph below shows the relationship between the amount of substance and time in a chemical reaction involving substances K, L and M.



The chemical reaction represented above could be:

- A $3\text{M} \rightarrow 4\text{K} + 5\text{L}$
- B $5\text{M} \rightarrow 2\text{K} + \text{L}$
- C $\text{M} \rightarrow 2\text{K} + \text{L}$
- D $\text{M} \rightarrow \text{K} + 2\text{L}$

1.8 The half-reactions below take place in an electrochemical cell.



Which one of the statements below is true for this cell when it delivers current?

- A The mass of the Cs electrode increases.
- B Pt^{2+} undergoes oxidation more easily than Cs.
- C Pt^{2+} undergoes reduction more easily than Cs^+ .
- D Electrons will flow from the Pt electrode to the Cs electrode in the external circuit.

1.9 In the cell to produce aluminium from alumina, the carbon anode...

- A gains mass.
- B reacts to form CO_2 .
- C is the site where $\text{Al}^{3+} \rightarrow \text{Al}$.
- D does not conduct electricity.

1.10 What is the organic product formed if propene ($\text{CH}_3\text{CH}=\text{CH}_2$) is reacted with steam and a phosphoric acid catalyst?

- A $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{OH}$
- B $\text{CH}_3\text{CH}_2\text{CH}_3$
- C $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{OH}$
- D $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

2 x 10 = [20 marks]

Consider the list of six substances with their formulae and boiling points in the table below:

NAME OF SUBSTANCE	FORMULA	BOILING POINT (°C)	MELTING POINT (°C)
Water	H ₂ O	100	0
Ethanol	CH ₃ CH ₂ OH	78	-114
Bromine	Br ₂	58,8	-7
Iodine	I ₂	184,3	114
Ammonia	NH ₃	-33,3	-78
Phosphine	PH ₃	-87,7	-133

2.1 Ethanol is soluble in water.

2.1.1 Refer to the relative strength of the intermolecular forces in ethanol and water to explain why ethanol is soluble. (3)

2.1.2 Octan-3-ol however is not soluble in water. Explain why it is not soluble in water. (2)

2.2 Explain why the boiling point of iodine is higher than that of bromine. (2)

2.3 Name the **intra**molecular bond in iodine. Use the specific name. (2)

2.4 Name the type of macromolecule iodine forms. Choose (one) from: Metallic macromolecule; Ionic macromolecule; Molecular macromolecule; Atomic macromolecule. (1)

2.5 Explain why phosphine will evaporate faster than ammonia by referring to the types of intermolecular forces present in each substance. (3)

2.6 Which substances in the table above are liquids at room temperature? (2)

[15]

Question Three

(Start question on a new page)

Antacids help relieve the pain of indigestion which is caused by an increase in the acidity level in the stomach. Fast pain relief relies on a fast neutralisation reaction between the antacid and the hydrochloric acid in the stomach. The active ingredient in the antacid tablet is calcium carbonate which reacts with the hydrochloric acid in the stomach according to the reaction;



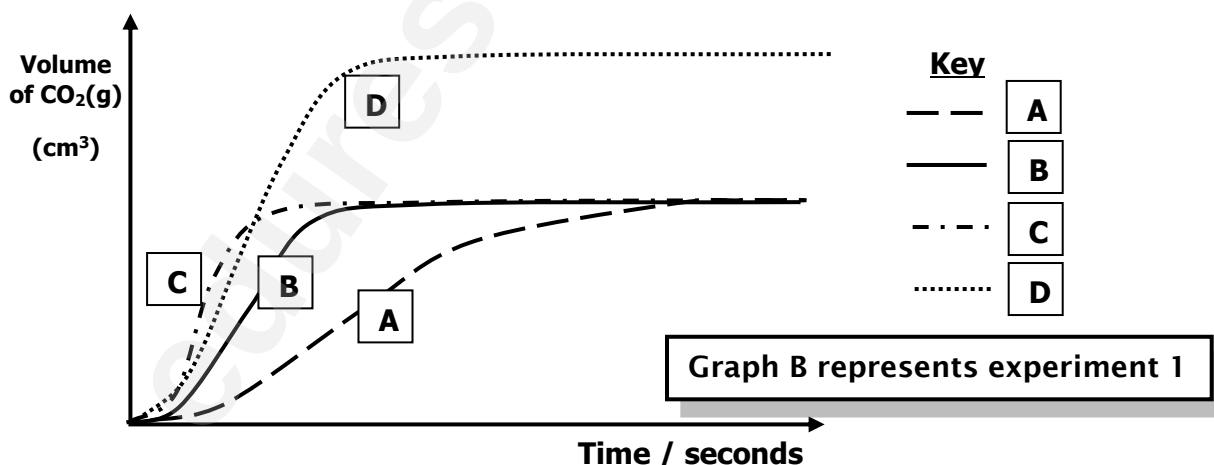
The instructions on the antacid packet recommend that you chew the tablet for fast relief. Petra and Mila are set the task of designing an experiment to investigate the effect of the particle size of the tablet on the reaction rate between hydrochloric acid and antacid tablets. They decide to collect the carbon dioxide gas produced in the reaction over a period of time in order to monitor the reaction rate.

- 3.1 What is their independent variable? (1)
- 3.2 What is their dependent variable? (2)
- 3.3 State two relevant variables that they will need to control (keep fixed). (2)
- 3.4.1 State a suitable hypothesis for their investigation. (2)
- 3.4.2 Briefly give a reason for the hypothesis based on the collision theory. (4)

Petra and Mila carried out further investigations between the reaction of antacid tablets with **excess** hydrochloric acid. The details of their investigations are tabulated below:

Experiment	1	2	3	4
Volume of acid (cm ³)	300	300	300	300
Concentration of acid (mol.dm ⁻³)	0,1	0,1	0,2	0,1
Number of tablets	1	2	1	1
Temperature (°C)	40	40	40	30

The results are recorded on the sketch graph below. Experiment 1 is represented by graph B.



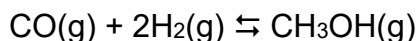
- 3.5 Match the graphs A, C & D to the experiments 2, 3 & 4 and give a reason for each. (6)
- 3.6 Petra and Mila carried out one last experiment in which they used exactly the same conditions as in experiment 1 (graph B) except that they used 400 cm³ of hydrochloric acid instead of 300 cm³. Explain how this would have affected the reaction rate by referring to the gradient of the graph (compared to B, the control) and the highest point of the graph (compared to B, the control). (3)

[20]

Question Four**35 marks**

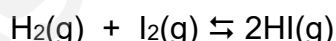
(Start question on a new page)

- 4.1 The reaction below between carbon monoxide and hydrogen can be used industrially to make methanol. The process is carried out at 250°C and between 5000 kPa and 10 000 kPa.



- 4.1.1 Explain why increasing the pressure increases the yield of methanol. (3)
- 4.1.2 Give one disadvantage of industrial processes being carried out at high pressure. (1)
- 4.1.3 The reaction gives a greater equilibrium yield at 100°C than at 250°C. Is the forward reaction in this process exothermic or endothermic? Explain. (3)
- 4.1.4 Explain why the reaction is nevertheless carried out at 250°C. (1)
- 4.1.5 Aluminium oxide is a catalyst in this process. Sketch and label an energy profile diagram of E_p versus progress of the reaction (reaction co-ordinate) to explain how a catalyst works in this reaction in terms of activation energy. (4)
- 4.1.6 If 100 dm³ carbon monoxide and 120 dm³ hydrogen are placed in a container at STP and allowed to react completely, which would be in excess and by how many moles? (6)
- 4.1.7 Calculate the volume of methanol gas that would be produced in 4.1.6 should the reaction run to completion with the quantities given in 4.1.6. (3)

- 4.2 Hydrogen and iodine, both with an initial concentration of 0,01 mol.dm⁻³, were allowed to react in a closed container. At equilibrium, the concentration of hydrogen iodide was 0,003 mol.dm⁻³ in accordance with the following equation:



- 4.2.1 The equilibrium constant would be calculated using which one of the following sets of values (A, B, C or D)? (2)

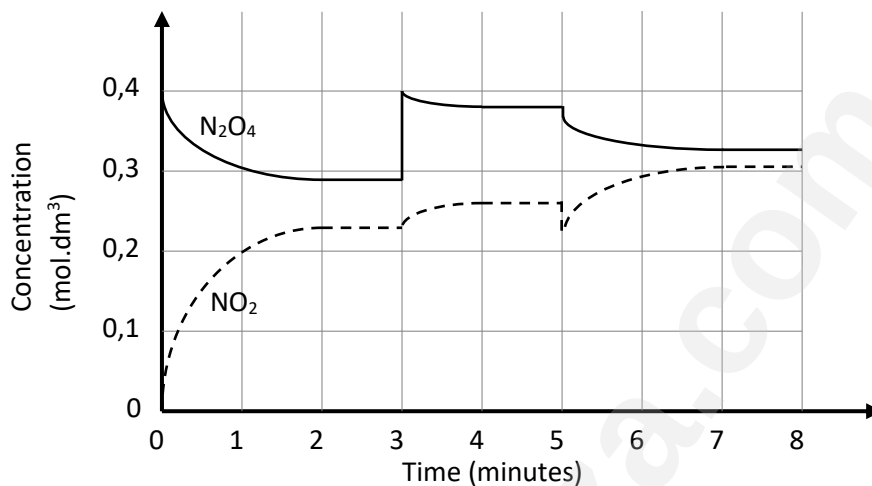
	H ₂ (g) (mol.dm ⁻³)	I ₂ (g) (mol.dm ⁻³)	HI(g) (mol.dm ⁻³)
A	0,007	0,007	0,003
B	0,0015	0,0015	0,003
C	0,004	0,004	0,006
D	0,0085	0,0085	0,003

- 4.2.2 Calculate the equilibrium constant using the values that you chose in 4.2.1. (4)
- 4.2.3 What can you conclude from your answer in 4.2.2? (1)

- 4.3 Consider the following reaction, initially at 298 K, that reached equilibrium after two minutes in a sealed 1 dm³ reaction vessel:



The following graph shows the change in the amount of the substances in the reaction mixture over a time interval of 8 minutes:

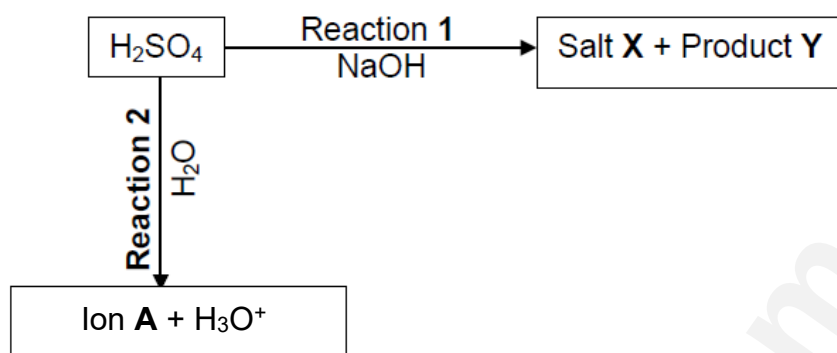


(Source: SJC exam July 2007)

- 4.3.1 What was done to cause the change shown on the graph **at** $t = 3$ minutes? (1)
- 4.3.2 What was physically done **at** $t = 5$ minutes to cause the changes on the graph if the equilibrium constant remained unchanged? How do you know this? (2)
- 4.3.3 Explain the trajectory of the graph lines **between** 5 and 8 minutes. (4)

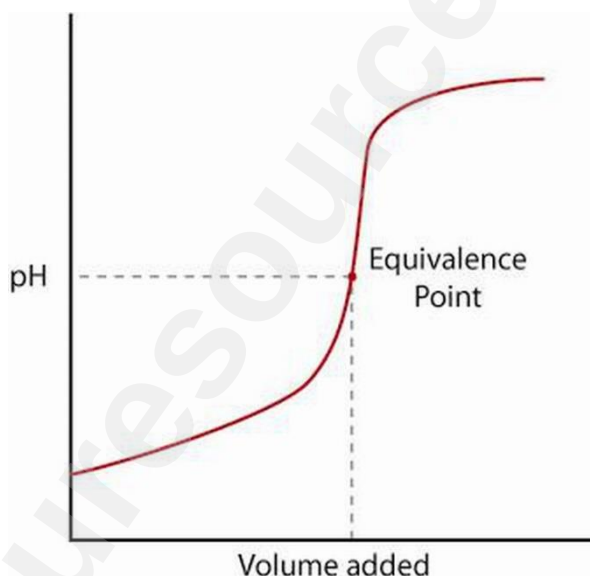
[35]

5.1 Two reactions of sulphuric acid are shown in the flow diagram below.



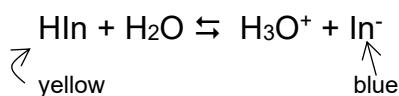
(Source: Edexcel
GCE 2012)

- 5.1.1 Define a *Lowry-Brønsted* base. (2)
- 5.1.2 Write down a balanced equation for Reaction 1. (2)
- 5.1.3 When Reaction 1 is performed as a titration, bromothymol blue is used as an indicator. Use the titration curve below and state whether H_2SO_4 or NaOH has been placed in the conical flask below the burette. Explain your choice. (2)



(Source:
<https://www.thoughtco.com/acids-and-bases-titration-curves-603656>)

- 5.1.4 The indicator in the solution in the conical flask is yellow to start. Use your answer to 5.1.3, the equilibrium equation for an indicator (below) and Le Chatelier's Principle to explain why the indicator in the solution in this titration would change to blue (if the titration went beyond the end point). (3)



- 5.1.5 Relook at the original flow diagram above. Write down the formula of ion A. (2)
- 5.1.6 The sulphuric acid could be measured out using either a pipette or a measuring cylinder. Give one practical advantage of using each piece of apparatus in this context. (2)

- 5.2 A solution of sodium hydroxide is prepared by dissolving 6 g of solid NaOH in water and making up the solution to 500 cm³.

- 5.2.1 Define *concentration*. (2)
- 5.2.2 Calculate the concentration of the NaOH solution. (5)
- 5.2.3 Calculate the H₃O⁺ ion concentration in this NaOH solution. (3)

The NaOH solution reacts completely with 10 g of impure ammonium chloride according to the balanced equation below:



- 5.2.4 Calculate the percentage purity of the NH₄Cl. (4)

- 5.3 The table below shows the equilibrium constants of two acids at a particular temperature.

Name	Formula	K _a
Nitrous acid	HNO ₂	4,5 × 10 ⁻⁴
Hypochlorous acid	HClO	3,5 × 10 ⁻⁸

(Source: Edexcel GCE 2012)

- 5.3.1 Write a balanced chemical equation for the ionisation of nitrous acid in water. Phase labels are not required. (3)
- 5.3.2 Which of these acids would be a better electrical conductor? Explain your answer. (assume the concentration and temperature of both acids is the same). (3)

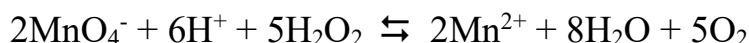
[33]

Question Six

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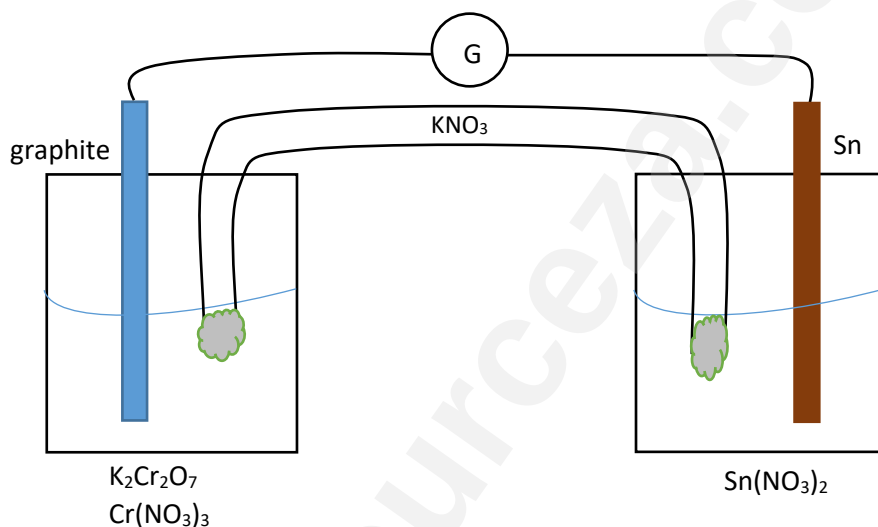
18 marks

- 6.1 If the overall equation for the oxidation of hydrogen peroxide by permanganate ions is



Use the table of reduction potentials to calculate the $E^\ominus_{\text{cell}}$ for the reaction. (3)

- 6.2 The diagram below shows an electrochemical cell. In one compartment of the cell a graphite rod is placed into an acidified solution of $\text{K}_2\text{Cr}_2\text{O}_7$ and $\text{Cr}(\text{NO}_3)_3$. In the other compartment a Sn rod is placed into a solution of $\text{Sn}(\text{NO}_3)_2$ as shown in the diagram below. KNO_3 solution is present in the salt bridge.



- 6.2.1 The cell above is a galvanic (voltaic) cell. State two ways that you can tell this is a galvanic cell. (2)
- 6.2.2 Graphite is not a metal, so why is it used as an electrode? (2)
- 6.2.3 State the NAME of the metal 'Sn'. (1)
- 6.2.4 Which electrode (Sn or graphite) is the anode? (1)
- 6.2.5 Identify the reduction half reaction for this cell above. (2)
- 6.2.6 Identify the oxidation half reaction for this cell above. (1)
- 6.2.7 Write the overall equation for this galvanic cell. (2)
- 6.2.8 Identify a spectator ion in this reaction. (1)
- 6.2.9 Describe and explain the purpose of the movement of the ions in the salt bridge. (3)

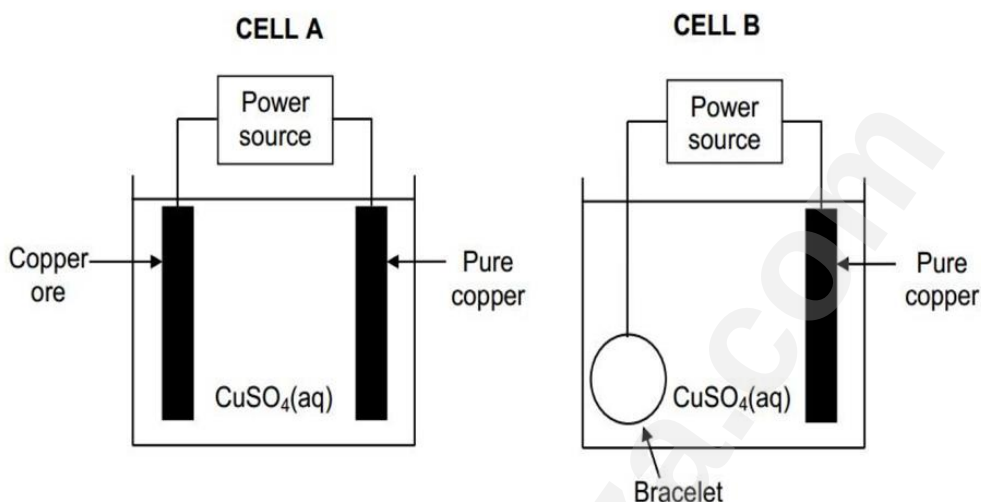
[18]

Question Seven

(Start question on a new page)

11 marks

The simplified diagrams below represent two electrochemical cells A and B. Cell A is used in the purification of copper ore containing silver and platinum impurities. Cell B is used to electroplate a bracelet with a layer of copper.



(Source: DBE Feb 2013)

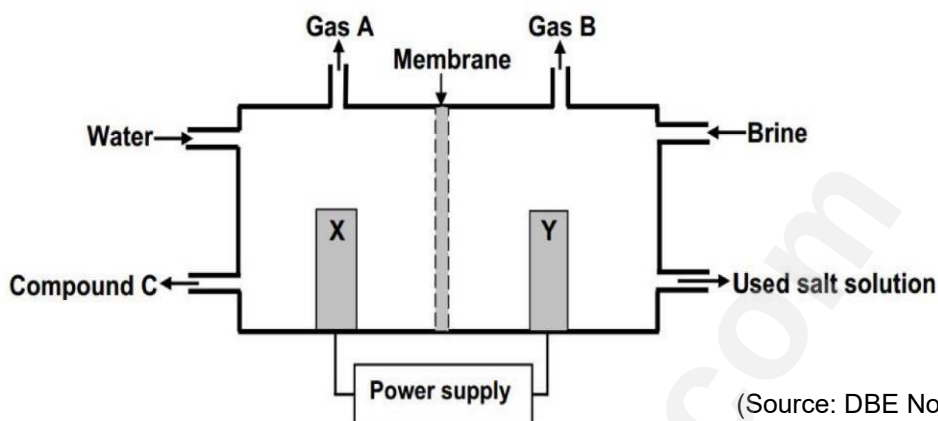
- 7.1 Write down the reaction that would occur at the cathode in these cells. (2)
- 7.2 Pure copper is used as one of the electrodes in each of the cells above. In which cell (A or B) is the pure copper the cathode? (1)
- 7.3 Consider cell B.
- 7.3.1 Would the bracelet be connected to the positive or the negative pole of the power source? (1)
- 7.3.2 Write down the half-reaction that takes place at the bracelet. (1)
- 7.3.3 Initially $\text{CuSO}_4(\text{aq})$ has a blue colour. How will the intensity of the blue colour change whilst the cell is functioning? Write down INCREASES, DECREASES or REMAINS THE SAME and give a reason for your answer. (3)
- 7.4 Consider cell A.
- 7.4.1 The impurities from the copper ore do not react in this cell. Why do they not react? (2)
- 7.4.2 What happens to the impurities from the copper ore? (1)

[11]

Question Eight**18 marks**

(Start question on a new page)

The simplified diagram of a membrane cell used in the chlor-alkali industry is shown below. Gas A, gas B and compound C are the three major products formed during this process. X and Y represent the two electrodes.

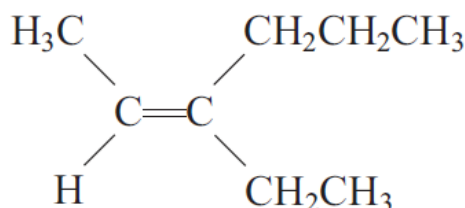


(Source: DBE Nov 2011)

- 8.1 Identify the function of the membrane in this cell. (1)
- 8.2 Which electrode, X or Y, is connected to the positive terminal of the power supply? Briefly explain how you arrived at your answer. (2)
- 8.3 Write down the name or the formula of;
- 8.3.1 Gas A (1)
- 8.3.2 Gas B (1)
- 8.3.3 Compound C (1)
- 8.4 Write down the relevant half reactions and hence derive the balanced overall reaction taking place in this cell. (3)
- 8.5 If 25 mol of NaOH is produced per hour in a membrane cell, calculate the average current that needs to be delivered to the cell per hour. (6)
- 8.6 The chlor-alkali industry is sometimes blamed for contributing to the greenhouse effect. Briefly explain how the above cell contributes to the greenhouse effect. (3)

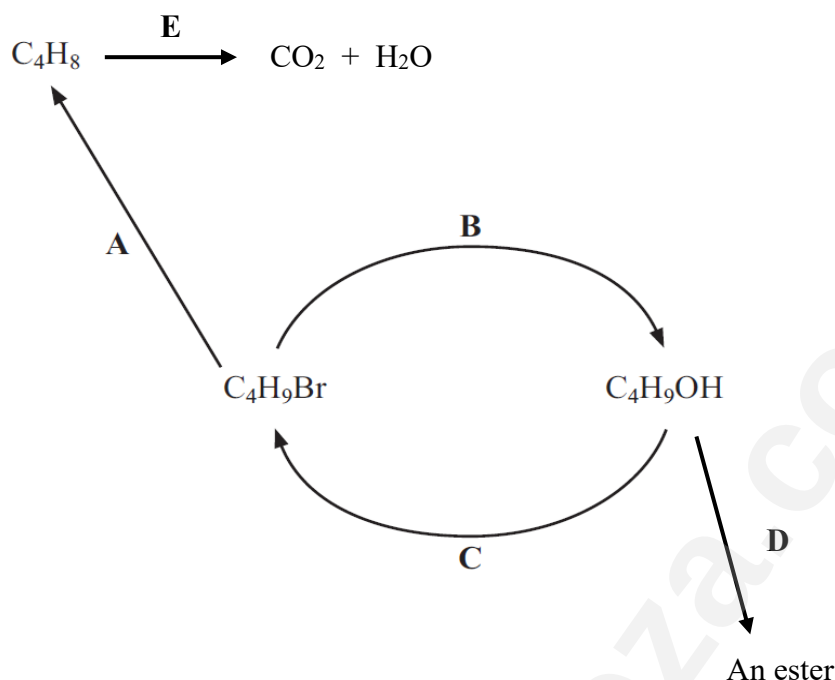
[18]**Question Nine****Organic Chemistry****30 marks**

- 9.1 Define an *unsaturated compound*. (2)
- 9.2 Name the organic compound shown below: (5)



- 9.3 Define the term *isomer*. (2)

- 9.4 How many compounds have the formula C_5H_{12} ? Name one of them. (3)
- 9.5 The following flow diagram shows organic compounds and reactions (A, B, C, D and E) that can occur between them.



- 9.5.1 C_4H_9Br is an integral part of the processes occurring above. Give the name of one of the isomers of C_4H_9Br . (2)
- 9.5.2 Name process A in the diagram above. (1)
- 9.5.3 Name one of the conditions of the process identified in 9.5.2. (1)
- Processes B and C between C_4H_9Br and butan-1-ol above are reversible reactions.
- 9.5.4 What type of organic reaction are reactions B and C? (1)
- 9.5.5 Butan-1-ol is one of the products formed during reaction B. Identify the other product. (1)
- 9.5.6 State the name of a positional isomer of butan-1-ol. (1)

Butan-1-ol is a reactant in reaction D.

- 9.5.7 If the other reactant is ethanoic acid, **name** and **draw** the expanded structural formulae for the ester that is formed in reaction D. (3)
- 9.5.8 Name 2 positional isomers of the ester in 9.5.7. (4)
- 9.5.9 Name the functional isomer of the ester in 9.5.7. (2)

Reaction E is a combustion reaction.

- 9.5.10 Write a balanced chemical equation for reaction E. (2)

[30]

TOTAL = 200 marks