NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION – MARCH 2017

PHYSICAL SCIENCES: PAPER II

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of 15 pages, a yellow Answer Sheet of 1 page and a green Data Sheet of 3 pages (i–iii).

2. Please make sure that your question paper is complete.

3. Remove the Data Sheet and Answer Sheet from the middle of this question paper.
   Write your examination number on the yellow Answer Sheet.

4. Read the questions carefully.

5. ALL of the questions in this paper must be answered.

6. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions must be answered on the answer grid provided on the inside cover of your Answer Book. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	**B**	**C**	**D**

   Here the answer C has been marked.

7. **START EACH QUESTION ON A NEW PAGE.**

8. Please ensure that you number your answers as the questions are numbered.

9. Use the data and formulae whenever necessary.

10. You may use an approved, non-programmable and non-graphical calculator, unless otherwise stated.

11. Show the necessary steps in calculations.

12. Where appropriate take your answers to 2 decimal places.

13 It is in your own interest to write legibly and to set your work out neatly.

QUESTION 1 MULTIPLE CHOICE

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

1.1 Which one of the following is the correct chemical formula for lithium sulphite?

A $LiSO_4$
B Li_2SO_3
C Li_2SO_4
D $Li(SO_3)_2$

1.2 Which one of the following best describes the particles and the electrons involved in the process of ionic bonding?

	Particles	**Electrons**
A	Non-metal ions only	Transferred
B	Metal ions and non-metal ions	Shared
C	Non-metal ions only	Shared
D	Metal ions and non-metal ions	Transferred

1.3 Dipole-dipole forces are found between molecules of:

A PH_3
B H_2
C CH_4
D $HC\ell$

1.4 Which one of the following gives the correct number of atoms in 10 g of $NH_3(g)$?

A $\frac{10}{10} \times 6{,}02 \times 10^{23} \times 4$
B $\frac{10}{17} \times 4$
C $\frac{10}{17} \times 6{,}02 \times 10^{23} \times 4$
D $\frac{10}{17} \times 6{,}02 \times 10^{23}$

1.5 Which one of the following salts, when dissolved in water, will produce a basic solution?

A Sodium nitrate
B Lithium carbonate
C Potassium chloride
D Ammonium chloride

1.6 Consider the oxidation of ammonia as represented by the following balanced chemical equation:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H<0$$

How are the yield of products and the rate of the forward reaction affected by an increase in temperature?

	Yield of products	**Rate of forward reaction**
A	Decrease	Increase
B	Increase	Increase
C	Decrease	Decrease
D	Increase	Decrease

1.7 Which one of the following acid solutions, each of concentration 1 mol·dm^{-3}, has the lowest electrical conductivity?

A $H_2SO_4(aq)$
B $CH_3COOH(aq)$
C $HNO_3(aq)$
D $HC\ell(aq)$

1.8 Which one of the following solutions will oxidise Zn but will not oxidise Sn under standard conditions?

A $Fe^{2+}(aq)$
B $Fe^{3+}(aq)$
C $Mg^{2+}(aq)$
D $Cu^{2+}(aq)$

1.9 The balanced chemical equation below represents a redox reaction taking place between aluminium and iodine.

$$2A\ell + 3I_2 \rightarrow 2A\ell^{3+} + 6I^-$$

The reducing agent in this reaction is:

A $A\ell^{3+}$
B I^-
C $A\ell$
D I_2

1.10 What is an atom or group of atoms that forms the centre of chemical activity in an organic compound called?

A Isomer
B Homologous series
C Reactivity core
D Functional group

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QUESTION 2 CHEMICAL BONDING AND QUANTITATIVE CHEMISTRY

2.1 Use only substances from the list below when answering Questions 2.1.1 to 2.1.7. The phase indicators (state symbols) represent the physical state of each of the substances at room temperature.

NaCℓ(s) **N_2(g)** **Fe(s)** **NH_3(g)** **diamond(s)** **Ne(g)**

Select one substance from the list that has:
(Only write down the question number and the formula of the substance next to it. Substances may be used more than once.)

2.1.1 Induced dipole (London) forces between its atoms. (1)

2.1.2 Induced dipole (London) forces between its molecules. (1)

2.1.3 A giant covalent network structure. (1)

2.1.4 Hydrogen bonding. (1)

2.1.5 Ionic bonds. (1)

2.1.6 Polar covalent bonds. (1)

2.1.7 Pure covalent bonds. (1)

2.2 Write down the chemical formula of:

2.2.1 The permanganate ion. (1)

2.2.2 Magnesium chlorate. (2)

2.3 Hydrogen sulphide (H_2S) and water (H_2O) are two hydrides of Group 16. H_2S is a gas at room temperature whereas H_2O is a liquid.

Explain this difference by referring to the relevant intermolecular forces. (4)

2.4 Thembi prepares 200,00 cm^3 of a standard aqueous solution of magnesium nitrate ($Mg(NO_3)_2$ (aq)) of concentration 0,15 $mol \cdot dm^{-3}$.

2.4.1 Identify the solvent used in Thembi's aqueous solution of magnesium nitrate. (1)

2.4.2 Name the type of Van der Waal's force of attraction between the solute and the solvent. (2)

2.4.3 Write down a balanced chemical equation for the dissociation of $Mg(NO_3)_2$ in water. Phase indicators (state symbols) **must** be shown. (4)

2.4.4 Calculate the number of moles of nitrate ions (NO_3^-) in the solution. (3)

Thembi now dissolves solid sodium nitrate ($NaNO_3$) in 200,00 cm^3 of 0,15 $mol \cdot dm^{-3}$ magnesium nitrate solution. The total concentration of nitrate ions (NO_3^-) in the new solution is 0,50 $mol \cdot dm^{-3}$. (Assume that there is no change in the volume of the solution.)

2.4.5 Calculate the mass of sodium nitrate dissolved. (5)

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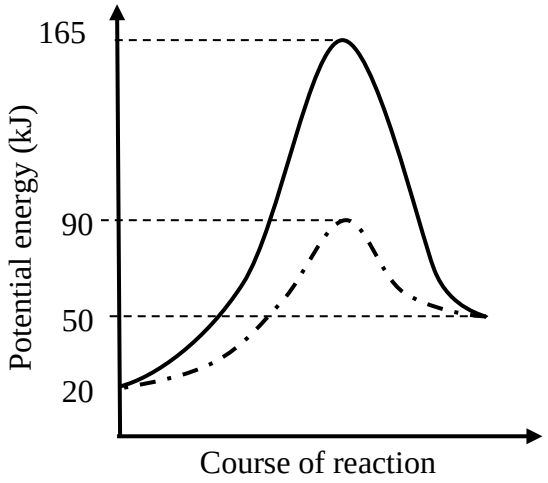
QUESTION 3 ENERGY CHANGE AND REACTION RATES

3.1 Consider the hypothetical reaction represented by the following, balanced chemical equation:

$$\mathbf{A_2(g) + 2B_2(g) \rightleftharpoons 2AB_2(g)}$$

The potential energy profile graph for the above reaction is given below. The dash-dot line (– · –) shows the effect of a catalyst on this reaction.



3.1.1 Define the following terms:

(a) *Heat of reaction.* (2)

(b) *Activated complex.* (2)

3.1.2 Is the forward reaction exothermic or endothermic? (1)

3.1.3 Write down the numerical value (measured in kJ) for the:

(a) Energy of the reactants in the forward uncatalysed reaction. (1)

(b) Energy of the activated complex in the forward uncatalysed reaction. (1)

(c) Heat of reaction (ΔH) for the reverse uncatalysed reaction. (2)

(d) Activation energy for the forward catalysed reaction. (2)

3.2 A series of experiments are conducted to investigate the effect of different factors on the rates of a chemical reaction between sulphuric acid and zinc. The balanced chemical equation for the reaction is:

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

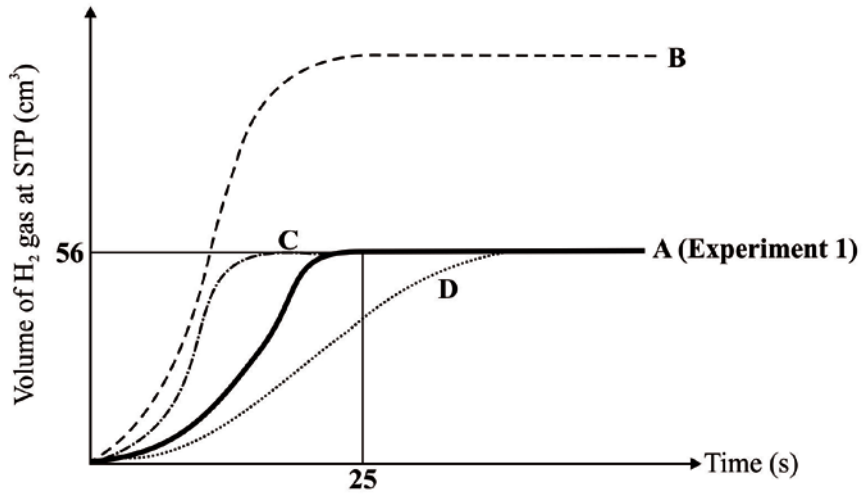
FOUR different experiments are conducted using the conditions given in the table below.

Experiment	Temperature (°C)	Concentration of H_2SO_4 ($mol \cdot dm^{-3}$)	State of zinc
1	25	0,05	Powder
2	25	0,05	Granules
3	35	0,05	Powder
4	25	0,10	Powder

In each of the four experiments the same volume of sulphuric acid and the same mass of zinc is used. The **zinc is always in excess** and is fully covered by the sulphuric acid.

The rate of reaction for each experiment is monitored by measuring the volume of hydrogen gas produced at STP against time. The results of the four experiments are shown in the graph below.

Graph A corresponds to EXPERIMENT 1.



3.2.1 Explain why graph **A** levels out after t = 25 s. (2)

3.2.2 State which of the graphs **B**, **C** or **D** corresponds to:

(a) Experiment 2. (1)
(b) Experiment 3. (1)
(c) Experiment 4. (1)

3.2.3 With reference to reaction rate and the collision theory, explain the differences between graph **A** (Experiment 1) and graph **B**. (4)

3.2.4 Use information from graph A to calculate the average rate of the reaction in Experiment 1 over the first 25 s. Give your answer in units of moles of H_2 gas per second ($mol \cdot s^{-1}$). Give your answer to 4 decimal places. (4)

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QUESTION 4 CHEMICAL EQUILIBRIUM

4.1 Carbon monoxide and hydrogen react in a sealed container to produce methanol. The reaction reaches dynamic chemical equilibrium as shown by the balanced chemical equation below.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H < 0$$

4.1.1 State Le Chatelier's principle. (3)

4.1.2 What is meant by the term *yield*? (2)

4.1.3 What volume change must be made to the reaction container so that a high yield of methanol is obtained? Explain by referring to Le Chatelier's principle. (5)

4.2 In an experiment, 9 mol of gas **P** is introduced into a container at a certain temperature. The container is then sealed and gas **P** decomposes to produce gas **Q** and gas **R**. The reaction taking place reaches dynamic chemical equilibrium for the first time after a period of 25 s.

The number of moles of each gas present with time over 35 s is given in the table below.

Time (s)	**Number of moles of gas (mol)**		
	Gas P	**Gas Q**	**Gas R**
0	9,00	0	0
5	7,40	2,40	0,80
10	6,30	4,05	1,35
15	5,60	5,10	1,70
20	5,20	5,70	1,90
25	5,00	6,00	2,00
30	5,00	6,00	2,00
35	5,00	6,00	2,00

4.2.1 (a) State what is meant by dynamic chemical equilibrium. (1)

(b) How can one tell from the data that the system has reached dynamic chemical equilibrium after a time period of 25 s? (1)

The **incomplete** graph on your ANSWER SHEET shows the number of moles of gas **P** and gas **R** over the period 0 to 35 s. Certain information has been omitted from the graph.

4.2.2 Complete the graph by providing the information requested below.

(a) Write down a suitable heading for the graph on the lines provided above the graph on your ANSWER SHEET. (1)

(b) Write down a suitable label for the *x*-axis in the empty block provided on your ANSWER SHEET. (2)

(c) Determine the scale used on the *y*-axis and fill in the numbers in the empty blocks provided on your ANSWER SHEET. (1)

(d) Draw a best fit line graph, on the same set of axes, to represent the number of moles of gas **Q** over the period 0 to 35 s. Use of a SHARP, DARK PENCIL is recommended. (3)

4.2.3 Copy the equation given below for the decomposition of gas **P** and use the data and the graph to deduce the missing coefficients required to balance the chemical equation.

$$\underline{?}\ \mathbf{P} \rightleftharpoons \underline{?}\ \mathbf{Q} + \underline{?}\ \mathbf{R}$$

(3)

4.2.4 Write an expression for the equilibrium constant (K_c) for this reaction. (2)

4.2.5 The volume of the container is 5 dm^3. Calculate the value of the equilibrium constant (K_c) at the temperature of the experiment. (5)

4.2.6 What information does the value of the equilibrium constant (K_c) give about the expected yield of products in this reaction? (1)

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QUESTION 5 ACIDS AND BASES

5.1 Dylan has a concentrated solution of the strong acid $HNO_3(aq)$. He gradually adds the acid to a large volume of water while continually stirring the solution.

5.1.1 Give the Bronsted-Lowry definition for *an acid.* (1)

5.1.2 Define the term *strong acid.* (2)

5.1.3 Dylan incorrectly tells his friend that he has made the acid weaker by mixing it with water. Explain why Dylan is incorrect. (3)

5.1.4 Write down a balanced chemical equation to show what happens when HNO_3 is added to water. Phase indicators (state symbols) need not be shown. (3)

5.1.5 Dylan adds $HNO_3(aq)$ to magnesium oxide powder. Write down a balanced chemical equation for the reaction that takes place. Phase indicators (state symbols) need not be shown. (3)

5.1.6 NAME the salt formed in the reaction of HNO_3 with magnesium oxide. (2)

5.2 Dylan wants to determine the mass of sodium carbonate in an impure sample. He initially reacts the impure sample with 500 cm^3 of 0,2 $mol \cdot dm^{-3}$ hydrochloric acid. **The hydrochloric acid is in excess**. The balanced chemical equation for the reaction between sodium carbonate and hydrochloric acid is given below.

$$\mathbf{Na_2CO_3(s) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + H_2O(\ell) + CO_2(g)}$$

The impurities do not react with the hydrochloric acid.

The **excess** hydrochloric acid in the above solution is now neutralised in a titration using 40 cm^3 of 0,3 $mol \cdot dm^{-3}$ sodium hydroxide solution. The balanced chemical equation for the reaction between sodium hydroxide and hydrochloric acid is given below.

$$\mathbf{NaOH(aq) + HC\ell(aq) \rightarrow NaC\ell(aq) + H_2O(\ell)}$$

Calculate the mass of Na_2CO_3 in the original sample. (8)

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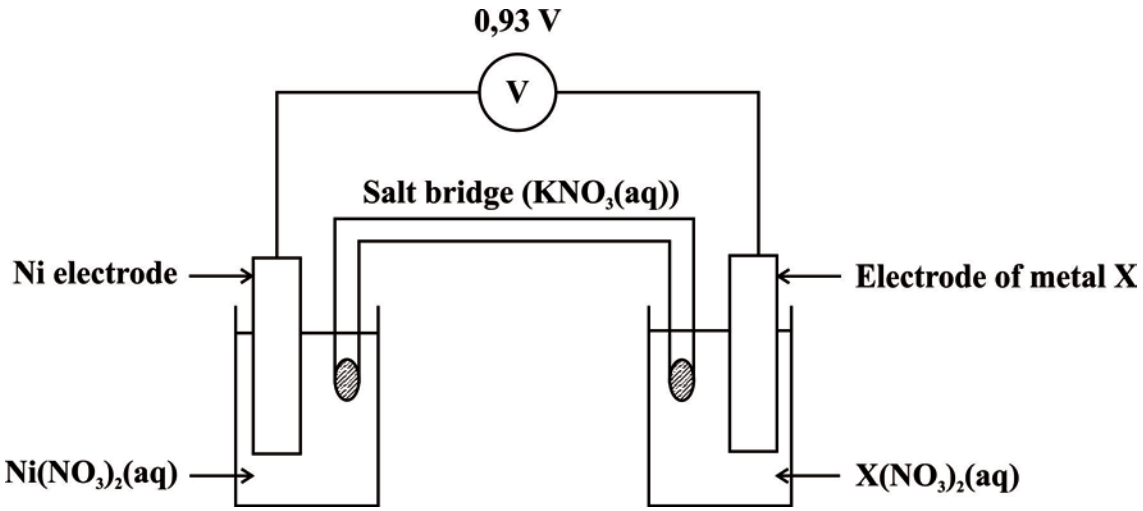
QUESTION 6 GALVANIC CELLS

A galvanic cell is set up under standard conditions using nickel (Ni) and an unknown metal X as electrodes, as shown in the diagram below.

The reading on the voltmeter while the cell is operating under standard conditions is 0,93 V. After the cell has been operating for a period of time, it is observed that **the mass of the nickel electrode has increased**.



6.1 Define the term *anode.* (2)

6.2 Which metal (nickel or metal X) is the cathode of this galvanic cell? Give a reason for your answer. (2)

6.3 Write down a chemical equation to show the half-reaction taking place at the nickel electrode. (2)

6.4 Calculate the standard electrode potential (E°) of metal X and hence determine the identity of metal X. (4)

6.5 Write down the cell notation for this galvanic cell. Standard conditions do not need to be shown. (3)

6.6 The salt bridge used contains a concentrated solution of potassium nitrate. The salt bridge maintains electrical neutrality in the half-cells.

6.6.1 Why is it important that the solution of potassium nitrate is concentrated? (2)

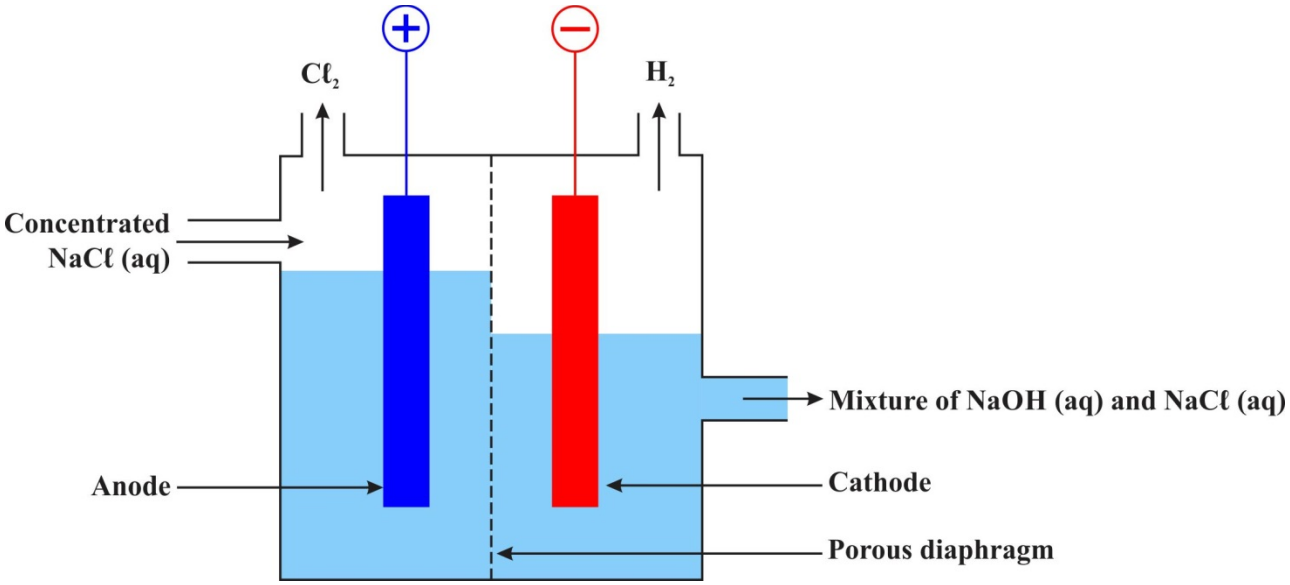
6.6.2 Explain what the expression 'maintain electrical neutrality' means. (1)

6.6.3 Explain why K^+ ions are more suitable cations than Fe^{3+} ions for the salt bridge. (Refer to the table of Standard Electrode Potentials.) (4)

[20]

QUESTION 7 ELECTROLYTIC CELLS

The diaphragm cell (shown in the diagram below) is used in industry for the production of chlorine from the electrolysis of an aqueous solution of saturated sodium chloride.



[Source: <www.everythingmaths.co.za>]

7.1 Describe the energy conversion taking place in this cell. (1)

7.2 Name the substance from which the diaphragm is made. (1)

7.3 Write down a chemical equation to represent:

7.3.1 The anode half-reaction. (2)

7.3.2 The cathode half-reaction. (2)

7.3.3 The net cell reaction. (The equation must be balanced.) (2)

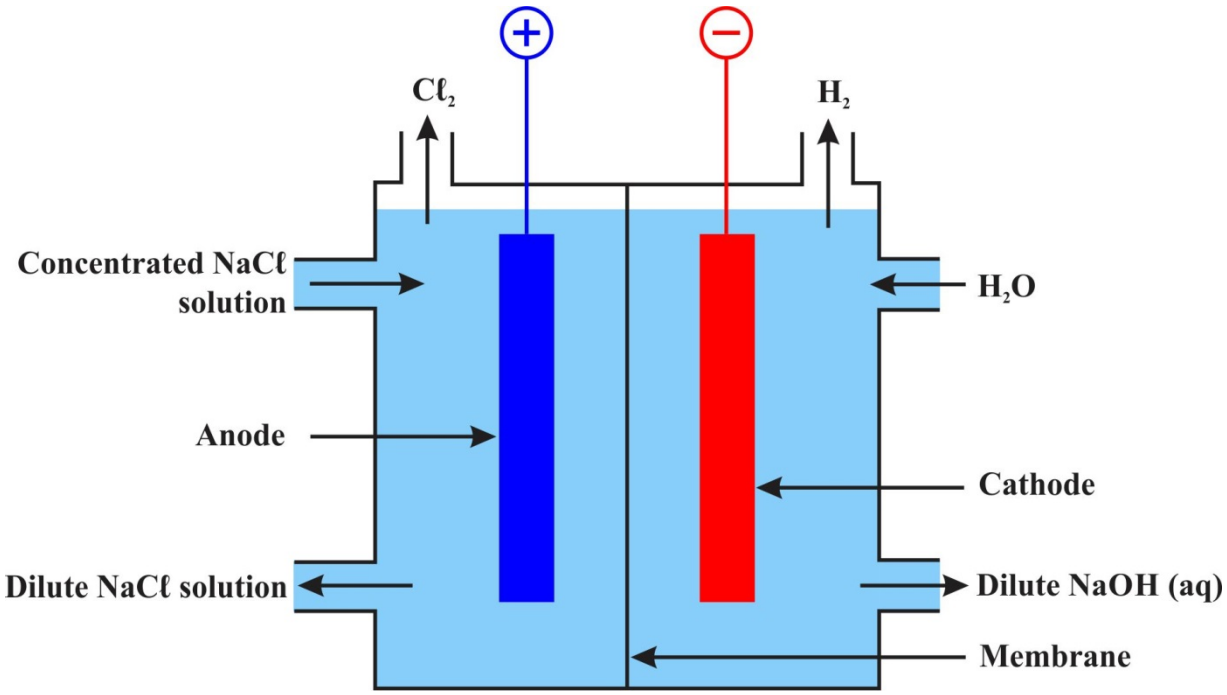
7.4 State one use for each of the following products of this process:

7.4.1 Chlorine (1)

7.4.2 Hydrogen (1)

7.5 Give the chemical symbol of the reducing agent in this process. (2)

7.6 In many countries the diaphragm cell has been replaced by the membrane cell as shown in the diagram below.



[Source: <www.everythingmaths.co.za>]

7.6.1 The sodium hydroxide produced in the diaphragm cell also contains sodium chloride. This, however, is not the case with the sodium hydroxide produced in the membrane cell. Account for this difference. (3)

7.6.2 State TWO advantages, other than the higher purity of the NaOH solution produced, that the membrane cell has over the diaphragm cell. (2)

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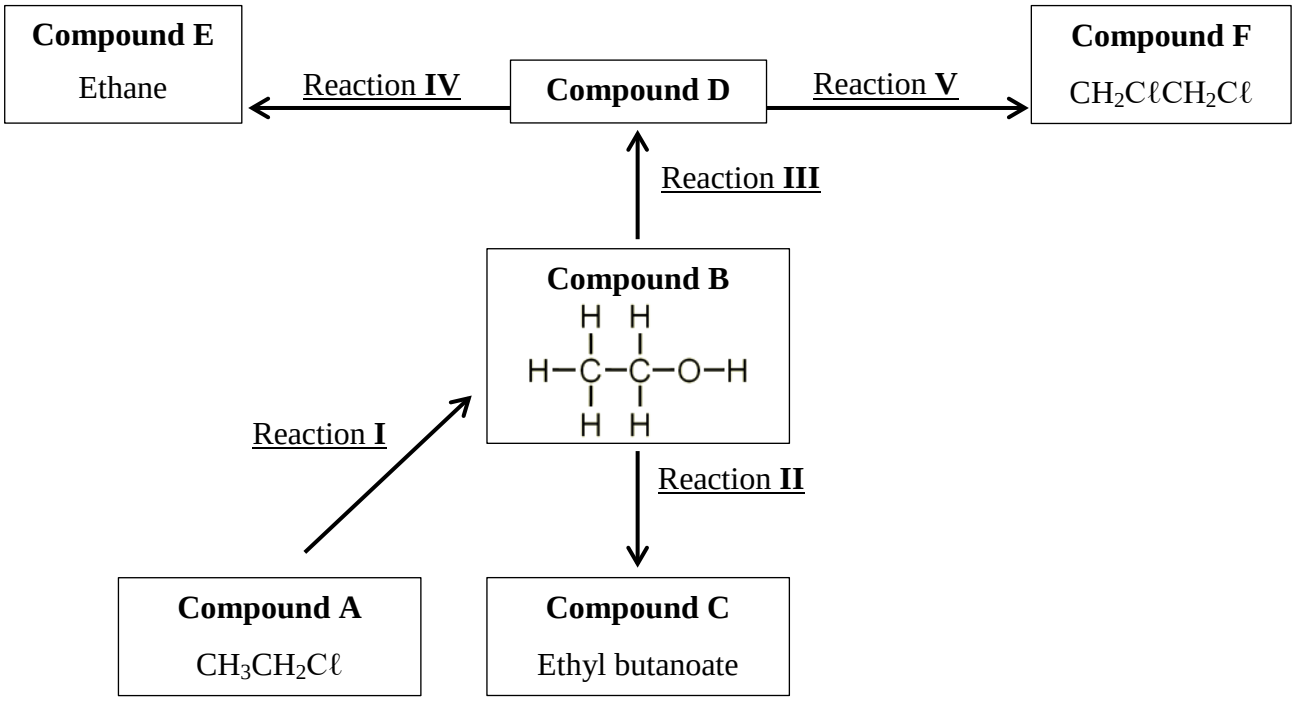
QUESTION 8 ORGANIC CHEMISTRY

Letters **A** to **F** in the diagram below represent six organic compounds. The reactions are numbered **I** to **V**.



The conditions for reactions **I** to **V** are tabulated below.

Reaction	Conditions
I	Heat with NaOH(aq)
II	Heat gently with organic compound **X** and a few drops of concentrated H_2SO_4
III	Heat with excess concentrated H_2SO_4
IV	Heat to 150 °C with H_2 and a Ni catalyst
V	React with $C\ell_2$

8.1 Write down the letter (**A** to **F**) of the compound that is a/an:

8.1.1 Saturated hydrocarbon. (1)

8.1.2 Alcohol. (1)

8.1.3 Ester. (1)

8.2 Write down the IUPAC name of compound:

8.2.1 **D**. (2)

8.2.2 **F**. (2)

8.3 Name the homologous series to which compound **A** belongs. (1)

8.4 Write down the general formula of the homologous series to which compound **E** belongs. (1)

8.5 Give the chemical formula of the inorganic product that has not been shown in reaction:

8.5.1 **I** (1)

8.5.2 **II** (1)

8.6 Write down a balanced chemical equation, using molecular formulae, for the complete combustion of compound **B**. (3)

8.7 What is the function of concentrated H_2SO_4 in reaction **III**? (2)

8.8 Reactions **II** and **III** involve heating compound **B**, which is flammable. Suggest a safe way of heating flammable liquids. (2)

8.9 Name the type of reaction taking place in reaction:

8.9.1 **I** (1)

8.9.2 **V** (1)

8.10 Consider reaction **II** and write down:

8.10.1 The structural formula of organic compound **X** that reacts with compound **B** to form compound **C**. (2)

8.10.2 The molecular formula of compound **C**. (2)

8.10.3 The IUPAC name of a **functional isomer** of compound **C**. (2)

8.10.4 The IUPAC name **and** structural formula of a **positional isomer** of compound **C**. (4)

8.11 Compound **B** is soluble in water whereas compound **E** is insoluble in water. Explain this difference by referring to the relevant types and strengths of the intermolecular forces. (4)

8.12 Compound **E** (ethane) has a boiling point of –89 °C whereas butane has a boiling point of –1 °C. Explain this difference in boiling point by referring to the relevant intermolecular forces and the factors influencing their strength. (4)

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Total: 200 marks