



NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2012

PHYSICAL SCIENCES: PAPER II

Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages, an Answer Sheet (Graph Paper) of 1 page and a Data Booklet of 4 pages (i – iv) with data and formulae. Please remove the Data Booklet and Answer Sheet from the middle of your paper.
 2. Please check that your question paper is complete.
 3. ALL the questions in this paper must be answered.
 4. **START EACH QUESTION ON A NEW PAGE.**
 5. Read the questions carefully.
 6. Use the data and formulae whenever necessary.
 7. It is in your own interest to write legibly and to set your work out neatly.
 8. Express ALL answers correct to TWO decimal places.
 9. Show all the necessary steps in calculations.
 10. NB Question 4.6 must be answered on the Answer Sheet. Make sure that you hand in this sheet.
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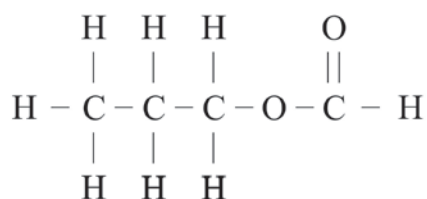
QUESTION 1 MULTIPLE CHOICE QUESTIONS

Answer this question on the flap of your Answer Book.

1.1 A compound that obeys the general formula C_nH_{2n+2} is ...

- A an alkane
- B an alkene
- C an alkyne
- D an unsaturated hydrocarbon

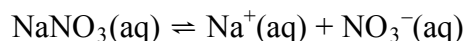
1.2 Consider a molecule of the organic substance propyl methanoate.



Which one of the following is an isomer of propyl methanoate?

- A Ethyl methanoate
 - B Methyl ethanoate
 - C Butanoic acid
 - D Propanoic acid
- 1.3 A test tube contains 4 g of zinc powder covered with 20 cm³ of a 0,01 mol·dm⁻³ hydrochloric acid solution. A second test tube contains 8 g of zinc pellets covered with 25 cm³ of a 0,05 mol·dm⁻³ nitric acid solution. What could possibly cause the reaction in the second test tube to take place at a faster rate?
- A The volume of the acid in the second test tube is greater
 - B The nitric acid has a higher concentration
 - C The zinc pellets have a greater mass
 - D The surface area of the zinc pellets is greater than that of the powder
- 1.4 For a certain chemical reaction that has reached equilibrium, the value of K_c at 200 °C is 1×10^{-5} . What does this value of K_c imply?
- A The reaction rate is very high
 - B The reaction rate is very low
 - C The reaction produces a small amount of products
 - D The reaction produces a large amount of products

1.5 The following reaction has reached chemical equilibrium at 30 °C:



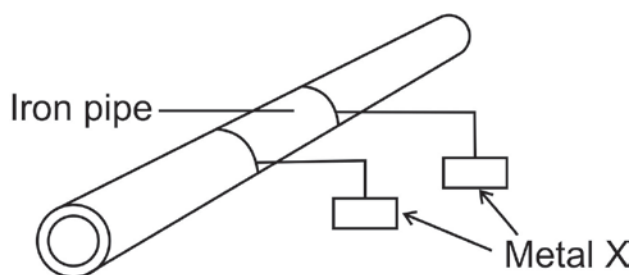
A few drops of concentrated nitric acid are added to the above (saturated) equilibrium mixture without significantly changing the volume or the temperature of the mixture. Which one of the following combinations best describes the possible effect, on the equilibrium and on the product $[\text{Na}^+][\text{NO}_3^-]$, of the addition of nitric acid?

	Equilibrium	$[\text{Na}^+][\text{NO}_3^-]$
A	Reverse reaction favoured	Decreases
B	Reverse reaction favoured	Remains constant
C	Forward reaction favoured	Decreases
D	Reverse reaction favoured	Increases

1.6 In the reaction $\text{Cl}_2 + 2\text{I}^- \rightarrow 2\text{Cl}^- + \text{I}_2$, which one of the following statements is true?

- A Chloride ions are reduced
- B Iodine acts as a reducing agent
- C Chlorine acts as a reducing agent
- D Iodide ions are oxidised

1.7 When a metal pipe made up mainly of iron is buried in wet soil, blocks of an unknown metal X are connected to the pipe as shown in the sketch below.

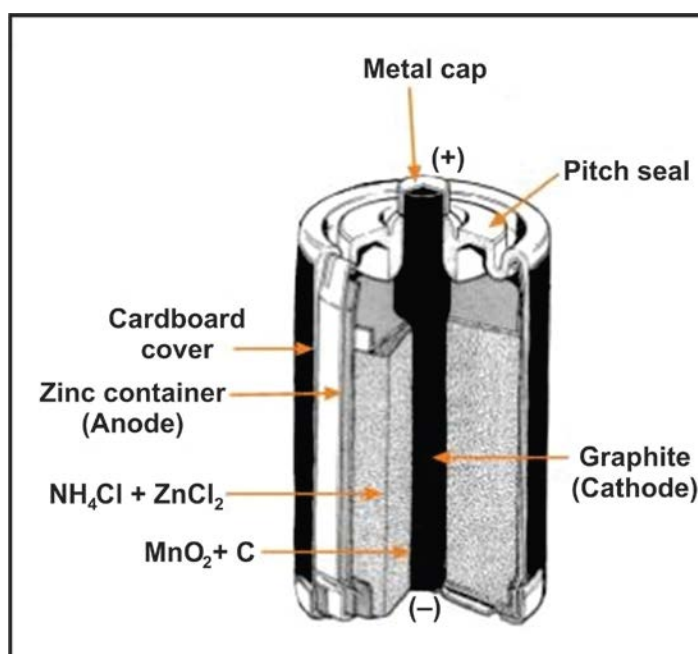


The reason for this is to prevent corrosion (rusting).

Which one of the metals listed below would be the MOST suitable to be used as metal X?

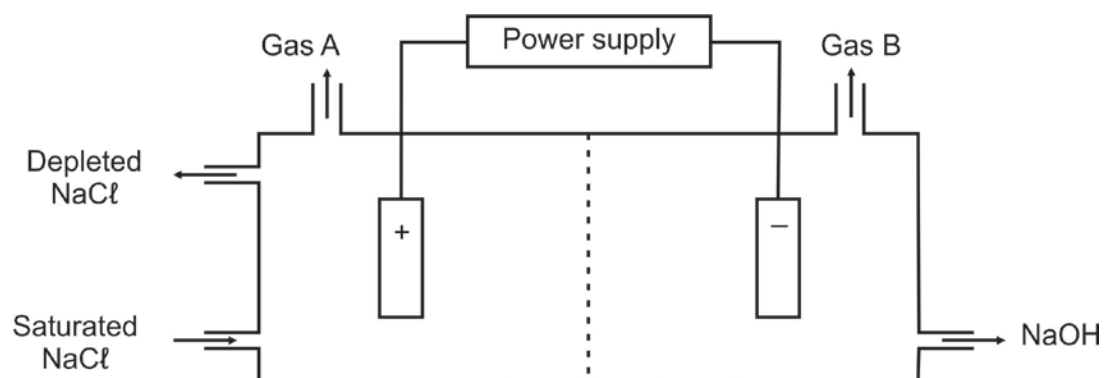
- A Al
- B Ag
- C Cu
- D Mg

- 1.8 Sodium aluminium hexafluoride (Na_3AlF_6), better known as cryolite, is added to aluminium oxide (alumina) in the industrial process for the extraction of aluminium. What is the reason for adding cryolite to the reaction mixture?
- A It prevents the graphite electrodes from corroding due to the large electric current being passed through the electrodes.
- B It helps reduce the melting point of the alumina to reduce the electrical costs of keeping the alumina molten.
- C It acts as a protective layer to protect the iron container from the intense heat required during the extraction process.
- D It acts as a catalyst to help speed up the extraction process.
- 1.9 The common torch battery is an example of a Leclanché cell. In the centre of the cell is a solid carbon electrode surrounded by a paste of powdered graphite and manganese dioxide. The function of the graphite will be to ...



- A increase the surface area of the electrode and lower its internal resistance.
- B replace the carbon in the carbon electrode during continuous use.
- C store electrical energy more efficiently.
- D change it from a secondary to a primary cell.

1.10 The diagram below shows a cell used to prepare chlorine gas and sodium hydroxide.



Which ONE of the following combinations is applicable to the cell while it is functioning?

	Reaction at positive electrode	Gas A	Gas B
A	oxidation	hydrogen	chlorine
B	reduction	chlorine	hydrogen
C	oxidation	chlorine	hydrogen
D	oxidation	chlorine	oxygen

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QUESTION 2 ORGANIC CHEMISTRY

Start this question on a new page.

2.1 What is meant by each of the following terms?

2.1.1 Catenation (2)

2.1.2 Functional group (2)

2.1.3 Polymerisation (2)

2.2 Write IUPAC names for each of the following organic molecules.

2.2.1 $\text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3$ (2)

2.2.2 $\text{CH}_3\text{CH}(\text{F})\text{CH}_2\text{CH}(\text{F})\text{CH}_2\text{CH}_3$ (2)

2.2.3 $\text{C}_3\text{H}_6\text{O}_2$ (2)

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

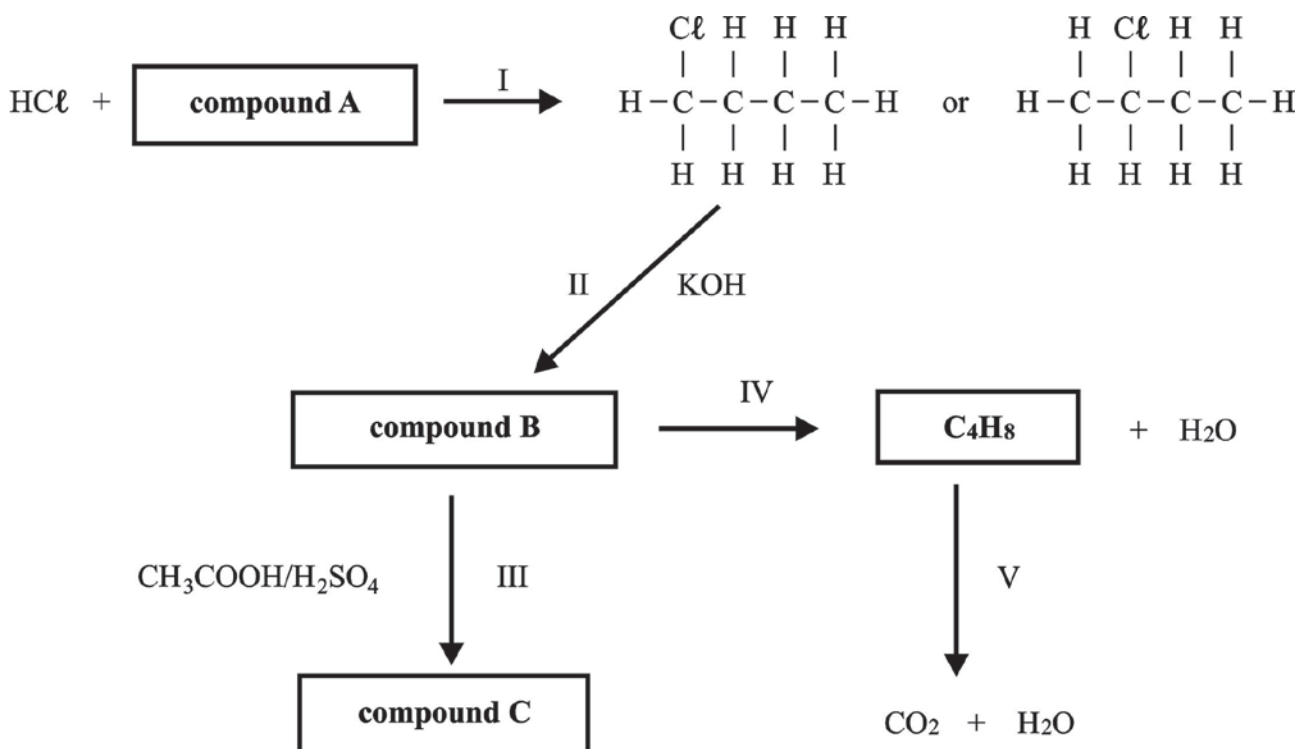
Name of compound	Boiling points ($^{\circ}\text{C}$)
butane	-1
1-butanol	117,7
butanoic acid	163,5

2.3.1 What is meant by the term 'homologous series'? (2)

2.3.2 Although butane and butanol are both four carbon structures, butanol has a significantly higher boiling point than butane. Compare the intermolecular forces between the molecules of each substance to explain why this occurs. (4)

2.3.3 An isomer of butanol, namely methylpropanol (isobutanol) has a boiling point of $107,9^{\circ}\text{C}$. Explain why methylpropanol has a lower boiling point than 1-butanol. (3)

2.4 Consider the following sequence of organic reactions.



2.4.1 Identify the type of reaction represented by the numerals I – IV. (4)

2.4.2 Compound B reacts with ethanoic acid to produce product C in the presence of concentrated sulphuric acid, in a warm water bath according to reaction III.

- Using a structural formula, draw and name the organic molecule of the compound C that forms. (4)
- Name the other product that will also be produced in this reaction. (1)
- Give two reasons why sulphuric acid is used in this reaction. (2)
- Why do you think that a warm water bath was used for heating instead of using a Bunsen burner flame? (2)

2.4.3 Consider reaction IV.

- Name the homologous series to which C_4H_8 belongs. (1)
- Using condensed structural formulae, draw and name all three isomers of C_4H_8 . (7)

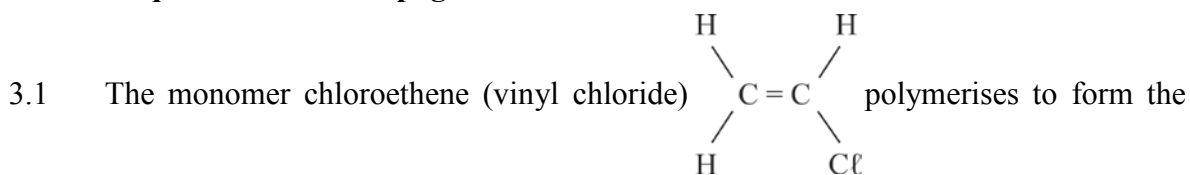
2.4.4 Reaction V is a **combustion reaction**.

- Write down the balanced chemical equation for this reaction. (2)
- 14 g of C_4H_8 reacts with excess oxygen. Determine the mass of CO_2 gas produced at STP. (4)

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QUESTION 3

Start this question on a new page.



polymer polychloroethene by means of an addition polymerisation reaction. Addition polymerisation is a three step process where step 1 is initiated by a free radical represented by the symbol – R•.

- 3.1.1 What is meant by the term 'free radical'? (2)
- 3.1.2 Name the two other steps in the addition polymerisation process. (2)
- 3.1.3 Using the structural formula of chloroethene given, **show** how a monomer of chloroethene reacts with the free radical in the initiation step. (3)
- 3.1.4 Show how chloroethene polymerises into PVC [polyvinyl chloride or polychloroethene] in step 2 of the process (use one repeat unit in your answer). (3)
- 3.1.5 Read the passage below:

Vinyl chloride is a chemical intermediate, not a final product. Due to the hazardous nature of vinyl chloride to human health, there are no end products that use vinyl chloride in its monomer form. Polyvinyl chloride is very stable, storable, and nowhere near as acutely hazardous as the monomer.

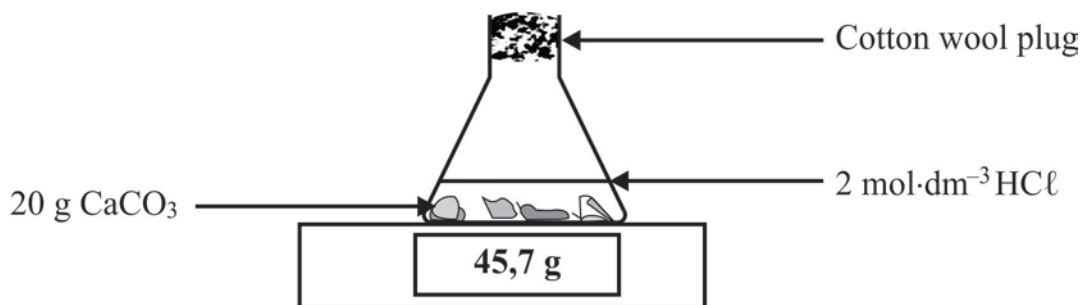
Based on its stability, storability and non-toxicity, suggest TWO possibilities where polyvinyl chloride can be most effectively used in society.

(4)
[14]

QUESTION 4

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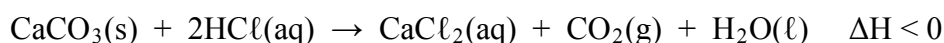
Sheldon and Leonard wish to investigate how the rate of the reaction between a carbonate and an acid at a temperature of 25 °C changes with time. They place 20 g of calcium carbonate into a conical flask and add an **excess amount** of 2 mol·dm⁻³ hydrochloric acid to the flask while at the same time placing a cotton wool plug at the mouth of the flask. The flask is placed on a mass balance to record the total mass at the start of the reaction.



Sheldon now records the mass of the flask and contents as the reaction progresses, at thirty second intervals, to test his hypothesis for the experiment. The results are shown in the table below.

Time (s)	Mass (g)	Loss of mass (g)
0	45,7	
30	44,9	0,8
60	43,3	2,4
90	41,2	4,5
120	40,4	5,3
150	40,0	5,7
180	39,7	6,0
210	39,8	6,1
240	39,8	6,1

The balanced chemical equation for the reaction at 25 °C is:



4.1 What is meant by the term 'hypothesis'? (2)

4.2 Suggest a possible hypothesis for the above experiment. (1)

- 4.3 Sheldon states that the loss of mass represents the independent variable in the investigation while Leonard argues that it has to be the dependent variable.
- 4.3.1 What is the difference between an independent and dependent variable? (4)
- 4.3.2 Whose statement is correct? Give a reason for your answer. (2)
- 4.4 What is the reason for placing the cotton wool plug in the mouth of the flask? (2)
- 4.5 Halfway through the experiment, Leonard tries to take the stopwatch away from Sheldon. Sheldon refuses to give it to him. Is Sheldon correct in denying Leonard the use of the stopwatch? Give a reason for your answer. (2)
- 4.6 **Using the graph paper provided on the Answer Sheet**, plot a graph of loss of mass vs time, and draw the line of best fit. (7)
- 4.7 Using your graph, explain the shape of the graph between the times
- 4.7.1 $t = 0 \text{ s}$ and $t = 90 \text{ s}$ (3)
- 4.7.2 $t = 90 \text{ s}$ and $t = 180 \text{ s}$ (2)
- 4.7.3 $t = 210 \text{ s}$ and $t = 240 \text{ s}$ (2)
- 4.8 Leonard now wishes to investigate how changing the conditions of the experiment will affect the results. He designs three additional experiments and enters his new experimental conditions in the table below.

Experiment no.	Temperature ($^{\circ}\text{C}$)	Mass of CaCO_3 (g)	Concentration of HCl ($\text{mol}\cdot\text{dm}^{-3}$)
2	10	20	2
3	25	20	4
4	25	15	2

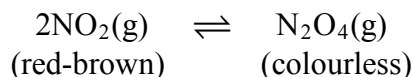
- 4.8.1 What is meant by the term 'control variable'? (2)
- 4.8.2 Name a control variable in experiments 2 and 4, when compared individually to the original experiment. (2)
- 4.8.3 Using the same axes, redraw the basic shape of the graph (not to scale) from Question 4.6 in your Answer Book and label it 'Experiment 1'. On the same set of axes, and labelling them Experiments 2, 3 and 4 respectively, draw in the shapes of the graphs that Leonard would expect to obtain. (6)

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QUESTION 5

Start this question on a new page.

Dinitrogen tetroxide (N_2O_4), a colourless gas, is formed when two molecules of red-brown nitrogen dioxide (NO_2) gas bond together, reaching chemical equilibrium according to the following equation:



Initially 0,5 mol of NO_2 gas was sealed in a 400 cm^3 container. When chemical equilibrium was established at $200 \text{ }^\circ\text{C}$, it was found that 0,2 mol of N_2O_4 had been formed as a result of the NO_2 reacting.

The resulting equilibrium mixture is now a pale red-brown colour.

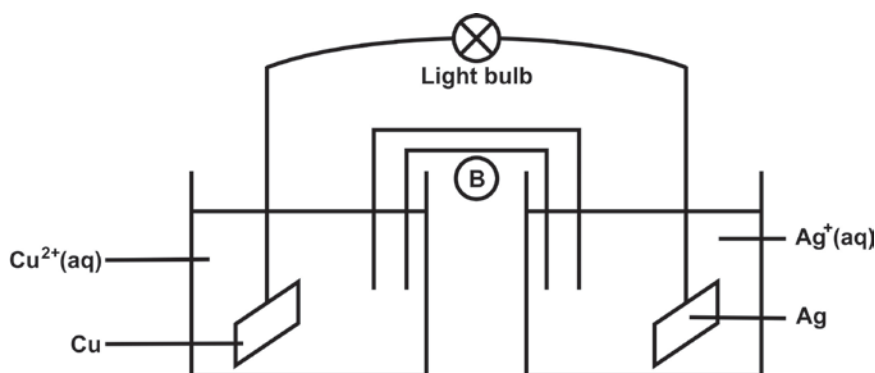
- 5.1 Using the above chemical equation and the information provided, determine:
- 5.1.1 the **amount** of NO_2 used up during the reaction. (2)
 - 5.1.2 the **amount** of NO_2 that remains at equilibrium. (2)
- 5.2 Calculate the **concentrations** of both NO_2 and N_2O_4 at equilibrium. (3)
- 5.3 Calculate the value of the equilibrium constant (K_c) for the reaction at $200 \text{ }^\circ\text{C}$. (3)
- 5.4 The volume of the container is now reduced to 200 cm^3 while the temperature remains constant.
- 5.4.1 What will be **observed** inside the container? (2)
 - 5.4.2 Using Le Chatelier's principle, explain this observation. (4)
- [16]**

QUESTION 6

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- 6.1 Vanitha wishes to set up a silver-copper Galvanic cell under standard conditions. She is provided with a silver spoon and a small piece of flat copper plate. She places the silver spoon in a silver nitrate solution and the piece of copper is placed in a copper sulphate solution. The two half cells are then connected to a small light bulb marked 1,1 V.

A diagram of the cell is given below.



- 6.1.1 What is meant by the following terms?
- Galvanic cell (2)
 - Standard conditions (with reference to this cell) (2)
- 6.1.2 What mass of AgNO_3 must be dissolved to make up a solution of volume 275 cm^3 to achieve the standard condition for this half cell? (4)
- 6.1.3 What will Vanitha observe happening with the light bulb? Use a calculation to support your answer. (3)
- 6.1.4 State TWO reasons for using the apparatus labelled 'B' in the diagram. (2)
- 6.1.5 Write down a balanced chemical equation for the reaction taking place in this cell. (3)
- 6.2 In the motor industry, delicate finishes on luxury cars are often completed by installing chrome plated components. The components are electroplated by using an electrolyte containing Cr^{3+} ions. The anode is made from pure chromium metal and the cathode is the component that requires plating.

For a deposit of 0,01 mol of chromium metal over the component to complete the finish, a current of 0,80 A needs to be passed through a solution containing the chromium ions, Cr^{3+} .

Calculate the total time it will take the 0,01 mol of chromium metal to deposit over the component being electroplated.

($N_A = 6,02 \times 10^{23}$; $F = 96\,500 \text{ C}$)

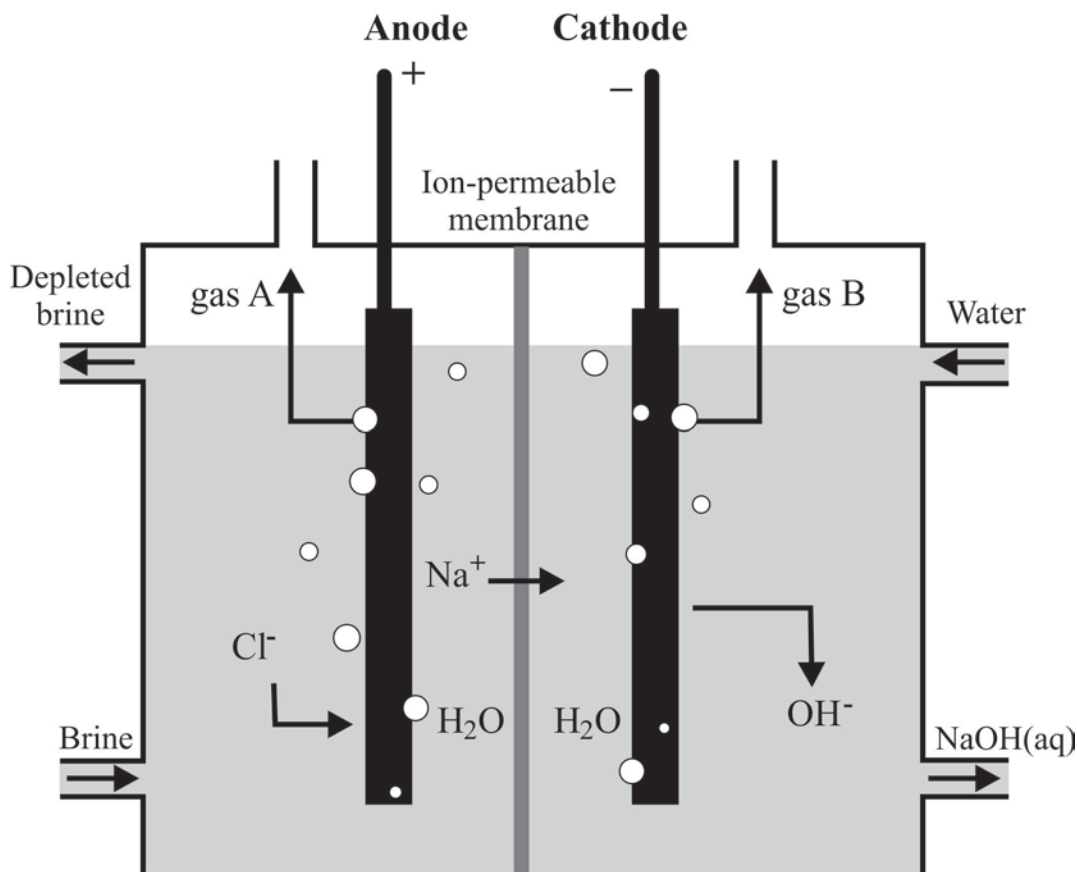
(6)
[22]

QUESTION 7

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The electrolysis of brine is the basis of the chlor-alkali process, a major industrial process producing hydrogen, chlorine and sodium hydroxide.

DIAGRAM OF A MEMBRANE CELL



- 7.1 What is meant by the term 'brine'? (2)
- 7.2 Explain how the ion permeable membrane functions in this cell. (3)
- 7.3 Sodium cations (Na^+) are found in the cathodic compartment of the membrane cell, yet they do not undergo reduction to form sodium metal, instead hydrogen gas is produced. Using half reactions, explain why this occurs. (3)
- 7.4 Chlorine and sodium hydroxide are two of the major products formed in this cell. Give ONE possible use of each of these products in modern society and state how this use would impact on one's daily life. (4)

[12]

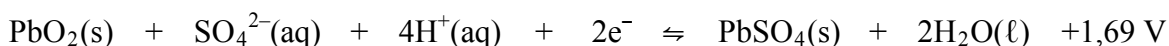
QUESTION 8

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The lead-acid battery is made up of a series of secondary cells which together form the lead-acid car battery.

Each cell has positive and negative plates that are all connected closely together in series. The positive plates are grids of lead with spongy **lead oxide**, **PbO₂**, pressed into the holes. The negative plates are made from pure **lead**. A solution of sulphuric acid acts as the electrolyte. A normal motorcar battery comprises **six individual cells**.

The half reactions are given below with their standard electrode potentials:



- 8.1 Why are the cells in the lead-acid battery described as secondary cells? (2)
- 8.2 Using the half reactions given above, write down an equation to describe the chemical reaction taking place when the cell is being used (i.e. delivering current). (3)
- 8.3 Consider the solution of sulphuric acid being used as the electrolyte. What will happen to the concentration of this electrolyte as this battery is being used? Explain your answer. (3)
- 8.4 When a motor car is moving, an alternator in the engine is able to recharge the battery. Describe two changes that take place inside the battery when this recharging takes place. (2)
- 8.5 What will the total voltage be that the battery will be able to deliver? Show all relevant calculations. (3)
- 8.6 What is the advantage of having the plates fairly close together? (2)
- 8.7 A particular lead-acid battery of emf 12 V is able to deliver 22,5 A of current in 2 hours.
- 8.7.1 What is meant by the term 'cell capacity'? (2)
- 8.7.2 Calculate the total energy stored in the battery when fully charged. (4)
- 8.7.3 If a car door is left open, calculate how long it will take for the battery to discharge completely if a light bulb is able to transfer 21 J of energy every second. Express your answer in hours and minutes. (4)
- 8.8 Not only is there lead present in a car battery, but the grids that contain the lead dioxide are also made of lead. Sadly, many manufacturers simply dispose of old car batteries by throwing them into landfill sites. Describe the negative impact of this method of disposal and what measures could be taken to minimise the effect on the environment. (6)

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Total: 200 marks