

PHYSICAL SCIENCES: PAPER II

Time: 3 hours

200 marks

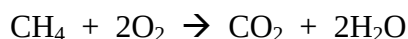
PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 12 pages and a green insert of 4 pages (i – iv) with data and formulae. Please remove the insert from the middle of your paper. A sheet of graph paper is provided for Question 6.7.
 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 as decimals.
 9. Show all the necessary steps in calculations.
-

QUESTION 1 MULTIPLE CHOICE

Choose the most correct answer from the options presented and record the answer on the answer grid provided on the inside cover of your Answer Book.

1.1 Consider the reaction represented by the following equation:



- A The reaction is an addition reaction.
- B The reaction is a dehydration reaction.
- C The reaction is a redox reaction.
- D The reaction is an endothermic reaction.

1.2 The reaction of ethane with chlorine gas can be classified as ...

- A an addition reaction.
- B a substitution reaction.
- C a redox reaction.
- D a dehydration reaction.

1.3 The test for determining whether an organic molecule is unsaturated assumes that ...

- A the unsaturated molecule will react slowly with bromine.
- B bromine will quickly undergo substitution with the organic molecule.
- C there is ultraviolet light activating the molecule.
- D the brown bromine will become colourless as the reaction progresses.

1.4 The alkenes have the general formula:

- A $\text{C}_n \text{H}_{2n+2}$
- B $\text{C}_n \text{H}_{2n-2}$
- C $\text{C}_n \text{H}_{2n+4}$
- D $\text{C}_n \text{H}_{2n}$

1.5 Short chain alcohols are exceptionally soluble in water because ...

- A they have a highly polarised O-H bond.
- B the intermolecular forces are relatively weak between the molecules.
- C they do not contain double bonds.
- D the molecule is not symmetrical.

1.6 The catalysed reaction of ethene with steam at 300 °C and a pressure of 70 atmospheres leads to the formation of ...

- A an ester.
- B an alkane.
- C an aldehyde.
- D an alcohol.

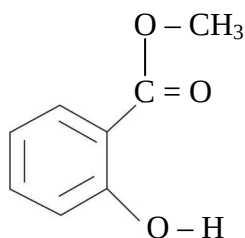
- 1.7 What substance, when added to a di-carboxylic acid in a reaction, allows for the formation of a polyester?
- A Free radical
 - B Water
 - C Alkene
 - D Diol
- 1.8 When considering experimental method, the term 'reliability' is about ...
- A not making any mistakes.
 - B using the apparatus carefully.
 - C getting 3 readings close together.
 - D getting close to an accepted value.
- 1.9 Isomers have ...
- A the same general formula but different molecular formula.
 - B the same structural formula but different molecular formula.
 - C the same empirical formula but different structural formula.
 - D the same molecular formula but different structural formula.
- 1.10 Esters are isomers of ...
- A alcohols.
 - B haloalkanes.
 - C carboxylic acids.
 - D aldehydes.

[20]

QUESTION 2 ORGANIC CHEMISTRY AND POLYMERS

Oil of wintergreen is a commonly used ester. It is the oil that is often used as a warming rub for sore muscles. It is easily made in the laboratory.

Below is a representation for oil of wintergreen.



- 2.1 NAME three functional groups that are present in the molecule above. (6)
- 2.2 NAME the two functional groups that are needed in order to form esters in the laboratory. (4)
- 2.3 Would you expect oil of wintergreen to be water soluble? Explain your reasoning. (4)

In order to make oil of wintergreen, a small amount of sulphuric acid is usually added to the reaction mixture. The sulphuric acid acts as a catalyst for the reaction. The reaction is exothermic.

- 2.4 What is the function of the catalyst? (2)
- 2.5 How does a catalyst achieve its function? (2)
- 2.6 Sketch a potential energy diagram (reaction profile) for the reaction to form oil of wintergreen. Plot potential energy vs reaction co-ordinate for the sketch. (4)
- 2.7 Would you expect sulphuric acid to be present at the completion of the reaction? Explain. (3)

[25]

QUESTION 3

Start on a new page.

Tupperware and a synthetic hockey field share the same type of molecule. It is the remarkable molecule poly (propene). Poly (propene) is also called polypropylene and it is made by the joining of building blocks. Propene is the building block used to make polypropylene.

Chemists employ 3 steps to convert propene to polypropylene. These steps allow the chemist to control the length of the polypropylene chain and also some of the characteristics of the polymer.

Polypropylene is resilient and easily moulded. It can then be extruded as fibres and woven into carpets, and also shaped into bowls and cups. It has the advantage of not being easily degraded when inside, but its use outdoors means that it must have a u.v. stabiliser added.

3.1 Write down the structural formula for the monomer of polypropylene. (4)

The process of making polypropylene relies on three main steps. One of the steps is propagation.

3.2 Name the 2 other steps that are used in the process to convert propene to polypropylene. (4)

3.3 Explain, using words and diagrams, how propagation occurs in the manufacture of polypropylene. (6)

3.4 Is polypropylene a thermoset or a thermoplastic polymer? Explain. (3)

3.5 TABULATE at least 2 advantages and 2 disadvantages of using polypropylene in the kitchen. (5)

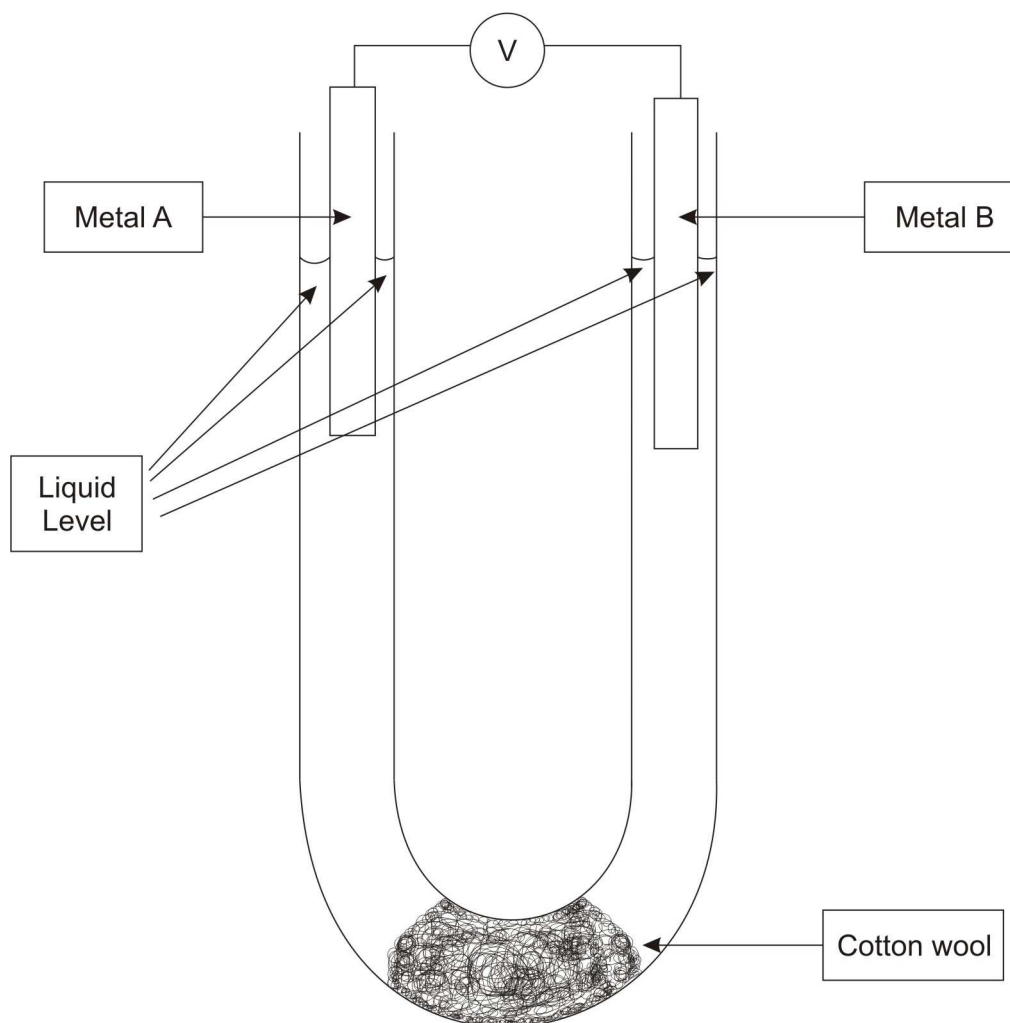
[22]

QUESTION 4 SIMPLE CELL

Start on a new page.

Alice is a hard-working student, who understands how a Galvanic cell works.

She has set up the following practical where she has tried to rank a number of metals based on their ability to act as reducing agents. The cell she has constructed is as follows: (voltmeter terminals are indicated + and -).



Alice connects up different metals and she gets the following results: (The first mentioned metal is set up as metal A, the second metal is set up as metal B).

Chromium (metal A) and silver (metal B) give a reading of 0,3 V

Silver (metal A) and zinc (metal B) give a reading of -0,7 V

Zinc (metal A) and chromium (metal B) give a reading of 0,4 V

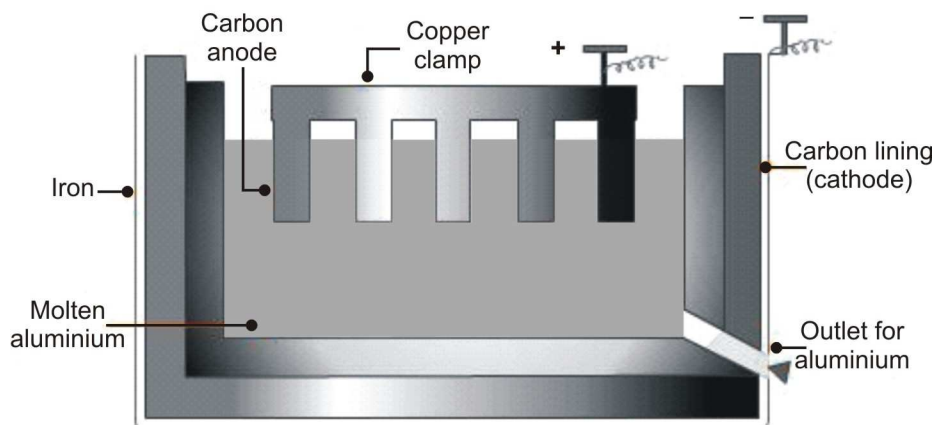
- 4.1 Write down the independent variable for this experiment. (2)
- 4.2 State the property that is being used as the dependent variable. (2)
- 4.3 List 3 variables that need to be controlled for this experiment. (3)

- 4.4 Explain why some variables need to be controlled whilst other variables are allowed to vary in an experiment that works well. (4)
- 4.5 State a suitable hypothesis that Alice might make for this experiment. (3)
- 4.6 Is the solution that metal A is dipped into the same solution that metal B is dipped into? Explain. (4)
- 4.7 Draw up a table with the headings: Anode, Cathode, Voltage, for the data collected. (4)
- 4.8 Write down a suitable conclusion for this experiment. (3)
- 4.9 What purpose/s is the cotton wool serving? (2)
- 4.10 4.10.1 Calculate E_{cell}^{θ} for the combination of silver and zinc using your Table of Standard Reduction Potentials. (3)
- 4.10.2 Explain why the calculated value for the silver and zinc cell is different from the value that Alice determined experimentally. (3)

[33]

QUESTION 5 ALUMINIUM PRODUCTION**Start on a new page.**

The Hall-Heroult process is used to manufacture aluminium from its ore, bauxite. The ore is processed and purified. Alumina (Al_2O_3) is produced from the ore and this is fed into the cell where it undergoes a chemical change to produce aluminium.

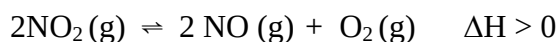


- 5.1 Is this process Galvanic or electrolytic? Explain. (3)
- 5.2 Alumina has a melting point of 2 030 °C.
- 5.2.1 How does the melting point of alumina affect the cost of the aluminium that is produced? (2)
- 5.2.2 What is done to the alumina that reduces its melting point? (2)
- 5.3 Write down the half-reaction that takes place at the cathode. (2)
- 5.4 Explain why graphite is used as the anode. (3)
- 5.5 Define the term 'electrode'. (2)
- 5.6 Why do the carbon anodes need frequent replacement in this process? (3)
- 5.7 Would it be fair to suggest that aluminium is a very reactive metal? Use the Table of Standard Reduction Potentials to explain your answer. (3)
- 5.8 Environmentalists in South Africa have been arguing that the production of aluminium in this country ought to be stopped. Do you agree or disagree? Use your understanding of the aluminium manufacturing process to argue your position. Include positive and negative considerations in your answer. You may answer in point form. (7)

[27]

QUESTION 6 CHEMICAL CHANGE AND EQUILIBRIUM**Start on a new page.**

One of the products that is produced in a motor car's exhaust system is the gas nitrogen(IV) oxide (nitrogen dioxide, NO₂). It is the brown gas that is largely responsible for the smog that hangs over cities in winter. In the combustion chamber of the engine of a car, the following dynamic equilibrium can be established:



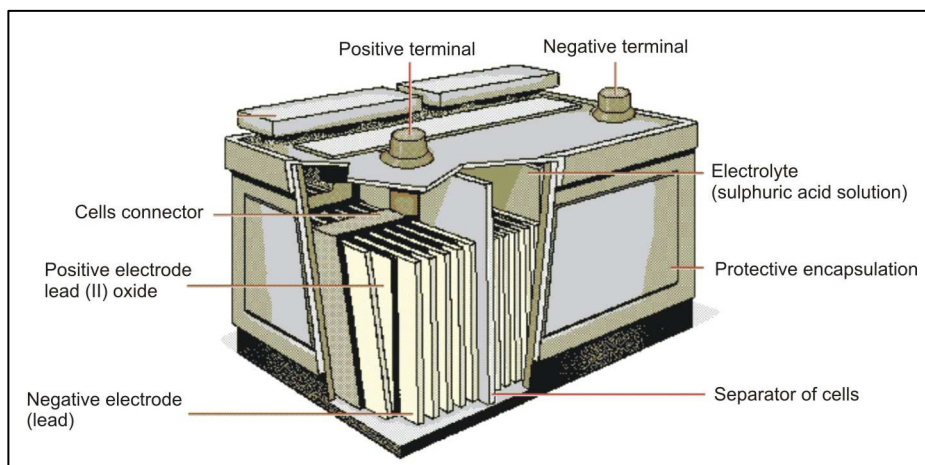
- 6.1 Explain the term 'dynamic equilibrium'. (2)
- 6.2 Write down the equation for the equilibrium constant (K_c) for this reaction. (2)
- 6.3 What are the requirements for an equilibrium to be established? (2)
- 6.4 6.4.1 Is the forward reaction exothermic or endothermic? (1)
- 6.4.2 If the temperature increases, what effect would this have on the equilibrium? Explain. (3)
- 6.5 Use Le Chatelier's principle to explain whether more NO (g) will be formed at equilibrium if the pressure increases. (4)
- 6.6 A motor car company is evaluating the quantities of each gas in the cylinder. The following values have been collected.

Calculate the missing values. Write down the sample number with your answer next to it. (2)

Sample Number	[NO ₂] (mol·dm ⁻³)	[NO] (mol·dm ⁻³)	[O ₂] (mol·dm ⁻³)	[NO] ² ·[O ₂]	[NO ₂] ²
1	4,2	2,3	1,1	6	18
2	7	3,4	1,8	?	49
3	13	4,7	2,2	?	169
4	17	5,4	2,8	81	289
5	22	7,2	2,9	150	484

- 6.7 On the graph paper provided plot a graph of [NO]²·[O₂] vs [NO₂]² for this data. (7)
- 6.8 Determine the most reliable value for K_c from the data provided. Show all your working. (4)
- 6.9 Is it better to work from the graph to calculate K_c directly? Explain your reasoning. (3)

[30]

QUESTION 7 LEAD ACID ACCUMULATOR**Start on a new page.**

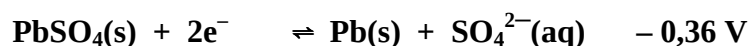
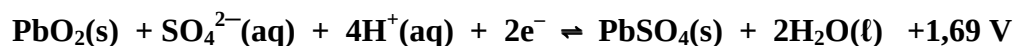
You may need the following information for this question:

$$N_A = 6,022 \times 10^{23} \text{ mol}^{-1}$$

The diagram above shows the inside of a lead-acid battery.

The lead-acid battery is used extensively every day. It is standard on most cars, and has found its way into homes and factories. It is used as the power supply on submarines and even as a back-up supply for alarms and emergency power in some factories.

The following half-reactions apply to the lead-acid battery:



7.1 Explain the term 'electrolyte'. (2)

7.2 Write down the overall cell reaction for the recharging process of the accumulator. (3)

A way of determining whether the battery is charged is to look at the density of the electrolyte.

State of charge (%)	Density ($\text{g}\cdot\text{cm}^{-3}$)
100	1,265
75	1,225
50	1,190
25	1,155
0	1,120

7.3 Explain the chemistry that causes the change in density to vary in proportion to the battery's charge. (3)

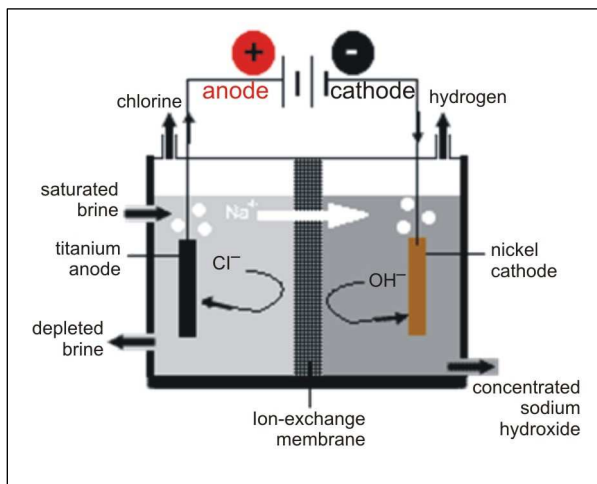
7.4 Calculate the mass of lead that is deposited when a current of 1 A passes through the cell for 10 minutes. (6)

It is estimated that a lead-acid battery lasts on average 2 – 3 years. It is also estimated that there are 7,5 million cars on South African roads.

- 7.5 Lead-acid batteries do not last significantly longer than 2 – 3 years on average. Suggest an appropriate reason why they cannot be discharged and recharged indefinitely. (2)

'Lead-acid batteries are a health hazard and ought to be recycled. Yet, even with recycling programs in place, they still find their way to landfill sites and pollute drinking water and lead to health risks. Cars should shift to lithium-ion batteries instead.'

- 7.6 Do you agree or disagree with the statement? Explain your reasoning. (6)
[22]

QUESTION 8 MEMBRANE CELL**Start on a new page.**

The membrane cell has been steadily replacing the older designs for the manufacture of chlorine. A simplified membrane cell is shown above.

- 8.1 Explain why the mercury cell is being phased out worldwide, even when it is very efficient. (4)
- 8.2 Compare the diaphragm and membrane cells. Explain why the membrane cell is replacing the diaphragm cell as industry expands. Refer to the quality of the product and cost of production in your answer. (4)
- 8.3 What is the difference between the membrane and the diaphragm as used in the cells? (2)
- 8.4 Explain why sodium metal cannot be produced in a membrane cell. (3)
- [13]**

QUESTION 9 RATES OF REACTION**Start on a new page.**

Ethelred is once again unready for his test in the next period. You bump into him as he is reading through his work at the last minute. Seeing you he recognises that you know quite a lot about Chemistry. He asks you to explain a few things that he does not understand.

- 9.1 Why does an increase in pressure speed up a reaction involving a gas? Explain your answer. (3)
- 9.2 Does the rate of a chemical reaction always increase when the temperature increases? Explain your answer, by making use of the collision theory. (5)
- [8]**

Total: 200 marks