NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY 2014

PHYSICAL SCIENCES: PAPER II

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 16 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. Read the questions carefully.

4. ALL the questions in this paper must be answered.

5. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the Answer Sheet 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.

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

7. Use the data and formulae whenever necessary.

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

9. Express ALL answers correct to TWO decimal places.

10. Show all the necessary steps in calculations.

11. **Question 5.3.2 must be answered on the Answer Sheet.** Make sure that you hand in the Answer Sheet.

12. Please hand in this question paper.

QUESTION 1

In each of the following questions 4 possible answers are provided. Write down only the number of the question and the letter of the corresponding answer, on the Answer Sheet on the inside front cover of your Answer Book.

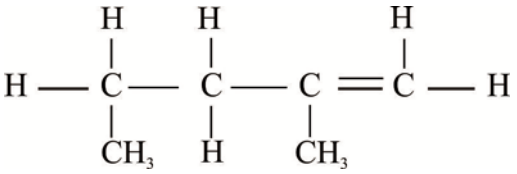
1.1 Compound X is mixed with bromine water. The brown colour of the bromine disappears almost immediately. Which one of the following represents compound X?

A C_2H_4
B C_3H_8
C CH_3OH
D C_2H_6

1.2 Which one of the following can neither be an ester nor a carboxylic acid?

A CH_2O_4
B $C_3H_6O_2$
C CH_2O_2
D $C_2H_4O_2$

1.3 What is the IUPAC name of the following compound?



A 2,4-dimethylbut-1-ene
B 1,3-dimethylbut-1-ene
C 4-methylpent-4-ene
D 2-methylpent-1-ene

1.4 In a series of experiments 0,05 g samples of magnesium were added separately to 100 cm^3 volumes of hydrochloric acid. The table below summarises the experimental conditions:

Experiment	Mg(s)	HCℓ (aq) ($mol \cdot dm^{-3}$)	Temperature of acid (°C)
i	ribbon	0,1	25
ii	ribbon	0,5	25
iii	powder	0,1	70
iv	powder	0,5	25
v	powder	0,1	20

In which two experiments would the magnesium be expected to take the shortest time to completely react with the excess hydrochloric acid?

A i and ii
B iii and iv
C iii and v
D ii and iv

1.5 The rate of the reaction between zinc granules and dilute sulphuric acid can be increased by adding a solution of copper sulphate. The reason for this is that the …

A zinc displaces the copper from the copper sulphate.
B sulphuric acid reacts more vigorously with the copper.
C concentration of the sulphate ions increases.
D copper ions act as a catalyst.

1.6 One of the stages in the industrial preparation of iron from its ore is represented by the equation below:

$$Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(\ell) + 3CO_2(g)$$

The following changes are made to the system:

(i) Fe_2O_3 is added
(ii) CO_2 is removed
(iii) CO is removed

Which of the above changes will favour the forward reaction?

A (i), (ii) and (iii)
B (i) and (ii) only
C (ii) only
D (iii) only

1.7 Consider the following reactions of a metal M.

(i) M reacts with a solution of silver nitrate causing a deposit of metallic silver to form.
(ii) M does not react with a solution of zinc sulphate.

The correct order to list the metals M, Ag and Zn in order of decreasing strength as reducing agents is:

A M, Ag, Zn
B Zn, M, Ag
C Ag, M, Zn
D Ag, Zn, M

1.8 The most common filling for tooth cavities is 'dental amalgam' – a solid solution of tin and silver in mercury. If you bite on a piece of aluminium foil that is in contact with a dental filling in your mouth, you may feel a painful sensation because …

A the aluminium foil is hard.
B a temporary galvanic cell has been set up while the aluminium and the filling are in contact.
C electrons are being transferred to the aluminium.
D a temporary electrolytic cell has been set up while the aluminium and the filling are in contact.

1.9 Consider the asbestos diaphragm found in the diaphragm cell used in the chlor-alkali process. Which of the following statements below is NOT true?

A It is only permeable to Na^+ ions.
B It is environmentally dangerous.
C It is permeable to water.
D It prevents the mixing of the gases produced at the electrodes.

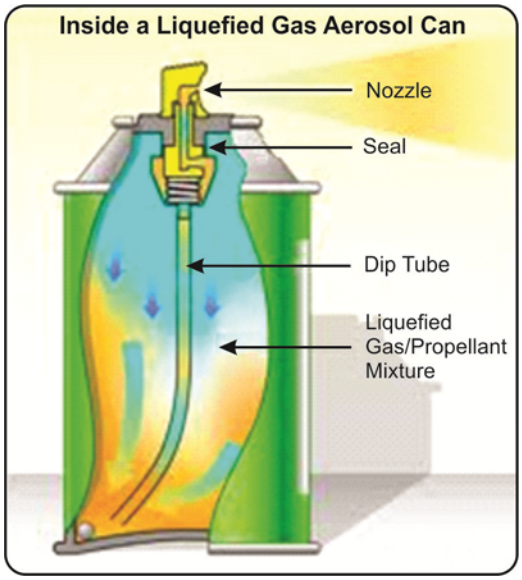
1.10 A commercial dry cell used in a torch is an example of a/an … cell.

A primary
B secondary
C electrolytic
D hydrogen

[20]

QUESTION 2

Propane and butane are used as propellants in spray cans in place of chloroflourocarbons (CFCs).



2.1 Name the homologous series to which propane and butane belong and give the general formula of this series. (2)

2.2 The substance of molecular formula C_4H_{10} exists as two different structural isomers.

2.2.1 What is meant by the term 'isomers of a compound'? (2)

2.2.2 Draw a structural formula for each isomer of C_4H_{10}. (2)

2.2.3 Give the IUPAC name for each isomer in Question 2.2.2. (2)

2.2.4 Which of the 2 isomers has a higher boiling point? Explain your answer. (3)

2.3 Write a balanced equation for the complete combustion of butane. (3)

Newer alternatives to CFCs are hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) such as CH_2FCH_3. These compounds are decomposed by OH^- ions before they reach the stratosphere and therefore do not take part in the reactions resulting in the depletion of the ozone layer.

2.4 Draw the structural formula for CH_2FCH_3 and give the IUPAC name for this compound. (2)

2.5 Give TWO possible reasons for phasing out CFCs. (2)

[18]

QUESTION 3

3.1 Consider the following organic compounds represented by the letters A to D:

A **CH_3COCH_3**
B **CH_3CH_2COOH**
C **CH_3CH_2CHO**
D **$CH_3CH_2CH_2OH$**

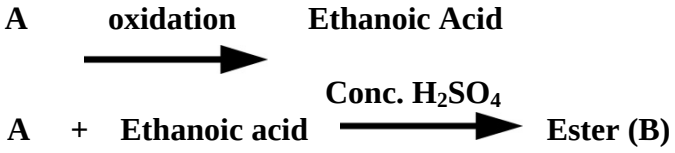
3.1.1 **Name** the functional group of compound A. (2)

3.1.2 Which of the above compounds is a structural isomer of compound A? (2)

3.1.3 Draw the structural formula of compound B. (2)

3.1.4 Give the **molecular formula** of the compound that reacts with H_2O to form compound D in an addition reaction. (2)

3.2 Many common fruits contain organic compounds which have very pleasant odours. These organic compounds are known as esters. Part of the flow diagram of a chemical process that leads to the formation of an ester is shown below:



Ethanoic acid is obtained through the oxidation of compound A.

3.2.1 Write the IUPAC name of compound A. (2)

3.2.2 Give the structural formula of the ester (B) that is formed during the process shown above. (3)

3.2.3 Give two functions of concentrated sulphuric acid in the formation of the ester. (2)

3.2.4 As a safety precaution, esters are prepared by heating the reaction mixture in a test tube in a water bath. Why is such a safety precaution necessary? (2)

[17]

QUESTION 4

4.1 Ethane is a hydrocarbon that undergoes an elimination reaction at 800 °C.

4.1.1 State what is meant by the term 'hydrocarbon'. (2)

4.1.2 Write a balanced chemical equation for this reaction. (2)

4.2 Teflon is an addition polymer of 1,1,2,2-tetrafluoroethene used to make non-stick surfaces for frying pans.

4.2.1 Explain in your own words what is meant by the term 'addition polymerisation'. (2)

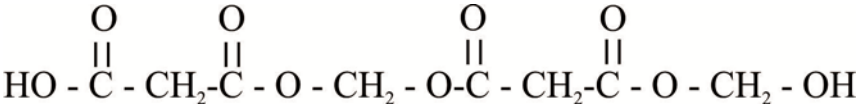
4.2.2 Draw the structural formula for the monomer that is used to make Teflon. (2)

4.2.3 Using structural formulae, show how the reaction that produces Teflon is initiated by means of a free radical ($R^{\bullet}$). (2)

4.2.4 Using structural formulae, show the propagation step in the formation of Teflon. (3)

4.2.5 Many thermoplastic materials are addition polymers, e.g. polyethene and polypropene. What is the significant advantage of thermoplastic materials over thermoset materials? (2)

4.3 Consider the following polymer:



4.3.1 Of what **type** of polymer is the above compound an example? (1)

4.3.2 Give the name of the inorganic product that is formed during this type of polymerisation. (1)

4.3.3 Draw the structural formulae of each of the two monomers from which the polymer shown is made. (4)

[21]

QUESTION 5

Antacids are used to relieve indigestion (the condition when the stomach produces too much acid resulting in an uncomfortable and painful feeling). A certain antacid tablet dissolves in water and reacts with the acid in the stomach to release carbon dioxide gas.

A group of learners want to investigate the effect of temperature on the rate of dissolution of this antacid tablet in water. For this investigation:

5.1 State an investigative question. (2)

5.2 State a hypothesis. (2)

5.3 The active ingredient in most antacid tablets is calcium carbonate which reacts with the hydrochloric acid in the stomach according to the following balanced equation:

$$CaCO_3(s) + 2\,HC\ell(aq) \longrightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g) \qquad \Delta H < 0$$

The learners set up an experiment that collected the carbon dioxide gas released during the reaction and measured the volume of gas collected every half minute. The results of the experiment are shown below.

Time (minutes)	Volume of gas (cm^3)
0	0
0,5	5
1	18
1,5	24
2	28
2,5	31
3	33
3,5	34
4	35
4,5	35,5
5	36
5,5	36

5.3.1 State two variables that the learners will need to control in this experiment. (2)

5.3.2 Plot a graph of volume of gas produced versus time on the graph paper provided. (5)

5.3.3 At what time did the reaction reach completion? (1)

5.3.4 How does the rate of reaction change with time from 0 to 3 minutes? Use the collision theory to explain your answer. (4)

5.3.5 If the mass of calcium carbonate in one antacid tablet is 700 mg, calculate the volume of 0,1 $mol \cdot dm^{-3}$ hydrochloric acid that would be neutralised by one tablet. (4)

[20]

QUESTION 6

Sulphuric acid is made by the Contact process. One of the steps in this process involves the reaction between sulphur dioxide and oxygen in a closed container and the reaction is allowed to reach dynamic chemical equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -192 \text{ kJ}$$

6.1 What is meant by the term 'dynamic chemical equilibrium'? (2)

6.2 If the temperature at which the reaction takes place is increased, state the effect (write down only INCREASE, DECREASE OR STAYS THE SAME) that this change will have on the:

6.2.1 rate of the forward reaction. (1)

6.2.2 amount of SO_3 produced in this reaction. (1)

6.2.3 value of the equilibrium constant. (1)

6.3 Optimum conditions for this process are: a temperature of 430 °C, a pressure of 2 atmospheres, and a vanadium pentoxide (V_2O_5) catalyst.

6.3.1 Considering your answer in Question 6.2.2 above, explain in terms of reaction rate why this reaction must still occur at the relatively high temperature of 430 °C. (3)

6.3.2 How does the pressure of 2 atmospheres influence the yield of sulphur trioxide? Answer INCREASES, DECREASES or STAYS THE SAME. Explain your answer using Le Chatelier's principle. (3)

6.3.3 When equilibrium was reached at 430 °C it was found that the following amounts of reactants and products were present:

SO_2: 0,2 mol
O_2: 0,4 mol
SO_3: 0,2 mol

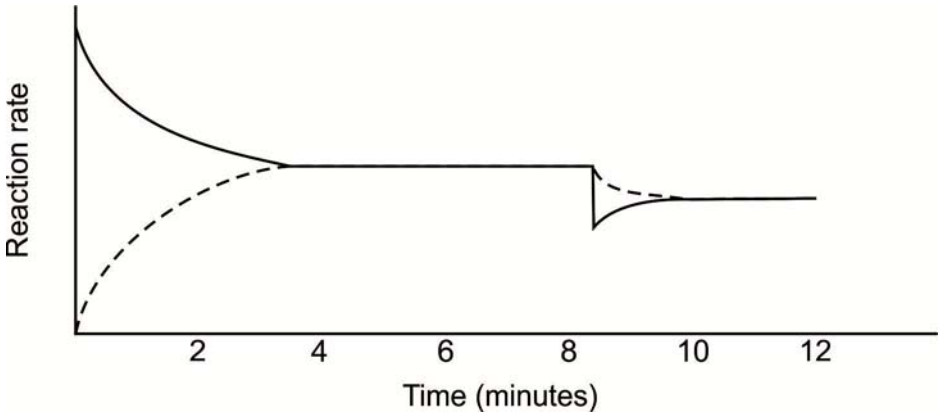
The reaction took place in a container of volume 2 dm^3. Calculate the equilibrium constant at this temperature. (5)

6.3.4 State how the answer to Question 6.3.3 would be affected if the catalyst V_2O_5 was not used. (2)

6.4 A certain amount of the gas SO_3 is sealed in a container. The following equilibrium is reached at a temperature T.

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$$

After 8 minutes, the temperature is decreased. The graph shows the changes in the reaction rate for a period of 12 minutes.



6.4.1 Write down the chemical equation for the reaction represented by the broken/dashed line. (2)

6.4.2 Is the reaction represented by the dashed line endothermic or exothermic? By referring to the graph, give an explanation for your answer. (3)

6.4.3 What is represented by the portion of the graph between 10 minutes and 12 minutes? (1)

[24]

QUESTION 7

A learner finds a piece of unknown metal X in the lab and sets out to identify it, using a standard electrochemical cell. She collects the equipment shown below. She guesses what the metal might be, and uses an aqueous nitrate solution of its ions in one beaker.

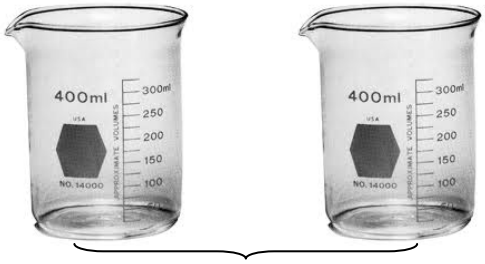
Ni rod

metal X

salt bridge

cotton wool

Voltmeter



beakers

electric leads

7.1 State the standard conditions which would apply to this cell. (2)

7.2 After setting up the experiment, she noticed the initial voltmeter reading to be 1,05 V. After some time she observed that the mass of the nickel electrode had decreased. Calculate the standard electrode potential of metal X. (3)

7.3 Identify metal X. (1)

7.4 Write a half reaction to justify your answer in Question 7.3. (2)

7.5 Identify the reducing agent in the overall cell reaction taking place in this cell. (2)

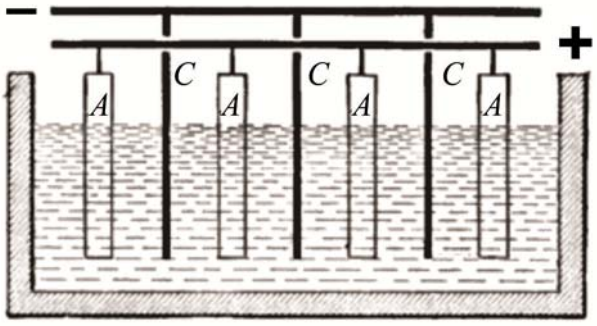
7.6 State TWO functions of the salt bridge in this electrochemical cell. (2)

7.7 What will happen to the emf of the cell if equilibrium is reached? (1)

[13]

QUESTION 8

Copper is refined by an **electrolytic** process. The apparatus for this process is illustrated below:



The electrodes marked A are the anodes and the electrodes marked C are the cathodes.

8.1 State what is meant by the term electrolysis. (2)

8.2 Is the impure metal the anode or the cathode? Give the chemical equation for the reaction that takes place at this electrode. (2)

8.3 Suggest an electrolyte that is suitable for this reaction to take place. (1)

8.4 Why is it necessary for copper to be purified? (2)

8.5 Why is this process carried out at low voltages of 0,2 V to 0,4 V? (2)

8.6 A current of 8 A flows for a time of 20 minutes and deposits 3,2 g of pure copper.

8.6.1 Calculate the number of moles of copper deposited. (2)

8.6.2 Calculate the number of electrons which flow through the circuit in order to deposit this mass of copper. (4)

(Charge required for 1 mol of electrons (Faraday) = 96 500 $C \cdot mol^{-1}$)

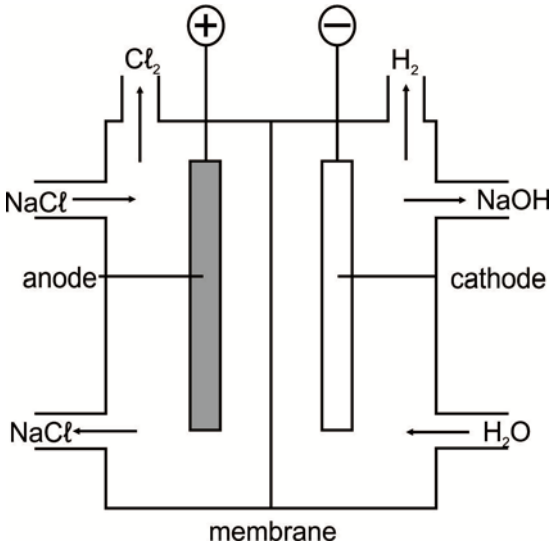
8.7 8.7.1 Name two other industrial applications of electrolysis (other than electro-refining). (2)

8.7.2 Corrugated iron sheets are galvanised and are used extensively for building in South Africa. They consist of a layer of zinc covering the iron. Refer to the table of standard reduction potentials to explain why this is done. (3)

[20]

QUESTION 9

Approximately 30 million tonnes of chlorine are used throughout the world annually. Chlorine is produced industrially by the electrolysis of brine (a concentrated solution of NaCℓ). The diagram below represents a membrane cell used in the production of chlorine gas.



9.1 Give the balanced chemical equation for the half reaction that takes place at the cathode. (2)

9.2 Use values from the Table of Standard Electrode Potentials to prove that the overall reaction is not spontaneous. (4)

9.3 Give the symbol for the chemical species that passes through the membrane while the cell is operating. (1)

9.4 Why is it wise to use unreactive electrodes in this process? (1)

9.5 Explain why this electrolytic process cannot be carried out in one large container without a membrane. (1)

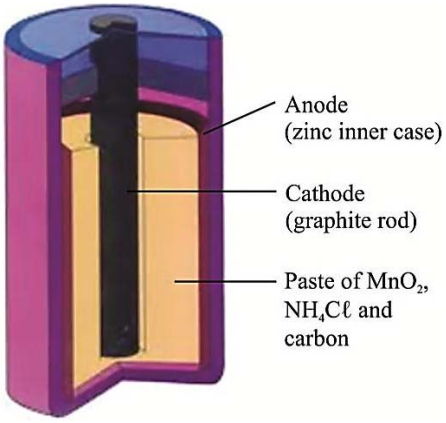
9.6 The membrane of this cell is made from a polymer similar to Teflon. What is the function of the membrane and how does it help to make the cell more efficient? (3)

9.7 Why is an 'Emergency Preparedness and Response Plan' required for chemical plants in which the chloralkali process is carried out? (2)

[14]

QUESTION 10

10.1 The most common 'battery' that is bought in shops is the zinc-carbon dry cell. It is also known as the Leclanché cell after its inventor, George Leclanché. Below is a representation of the cell:



These cells normally provide an emf of 1,5 V each. The half-reactions that take place in the cell can be represented as:

Anode : $Zn \longrightarrow Zn^{2+} + 2e^-$

Cathode : $2MnO_2 + 2NH_4^+ + 2e^- \longrightarrow Mn_2O_3 + 2NH_3 + H_2O$

10.1.1 What energy conversion takes place in this cell? (2)

10.1.2 What is meant by the term 'cell capacity'? (2)

10.1.3 How much energy (in joules) is stored in such a cell that has the following specifications?

Cell capacity = 1 500 Ah and Voltage = 1,5 V (4)

10.1.4 Why does the temperature at which a cell is stored influence its capacity? (3)

10.1.5 Dry cells are generally discarded when 'flat'. Why is the carbon rod the most useful part of the cell, even when the cell is 'flat'? (2)

10.1.6 Explain why a large 'D' size zinc-carbon cell will power a toy motor for longer than a small 'AA' cell, even though both cells have a voltage of 1,5 V. (2)

10.2 Consider the lead-acid battery which is used extensively in motor cars throughout the world as a source of electrical energy.

It is made up of a series of **six** individual cells. Each cell contains a positive plate made from lead oxide, PbO_2, in close proximity to a negative plate made from pure lead. Electrolyte is added to each cell.

The half reactions that occur are given below with their standard electrode potentials.

$$PbSO_4(s) + 2e^- \rightleftharpoons Pb(s) + SO_4^{2-}(aq) \qquad E^\theta = -0,36\ V$$

$$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightleftharpoons PbSO_4(s) + 2H_2O(\ell) \qquad E^\theta = +1,69\ V$$

One of the safety concerns related to the lead-acid battery is the danger associated with the recharging of a flat battery. Water in the battery can be electrolysed to produce hydrogen and oxygen gas during recharging.

10.2.1 The cells in the lead-acid battery are described as secondary cells. Explain why this is so. (2)

10.2.2 Name the electrolyte that is used in this battery. (1)

10.2.3 Using the half reactions above, write an equation to describe the overall chemical reaction taking place when the battery is **recharging**. (3)

10.2.4 Explain what will happen to the concentration of the electrolyte during recharging of the battery. (3)

10.2.5 Using the standard electrode potentials provided, calculate the total emf of the battery. (3)

10.2.6 State one advantage of having the positive and negative plates placed close together. (2)

10.2.7 Use the Table of Standard Electrode Potentials and write down the half-reaction which explains the formation of oxygen gas. (2)

10.2.8 What is likely to happen if the two terminals of a lead-acid battery are accidentally short-circuited? Explain your answer. (2)

[33]

Total: 200 marks