NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2008

PHYSICAL SCIENCES: PAPER II

Time: 3 hours 150 marks

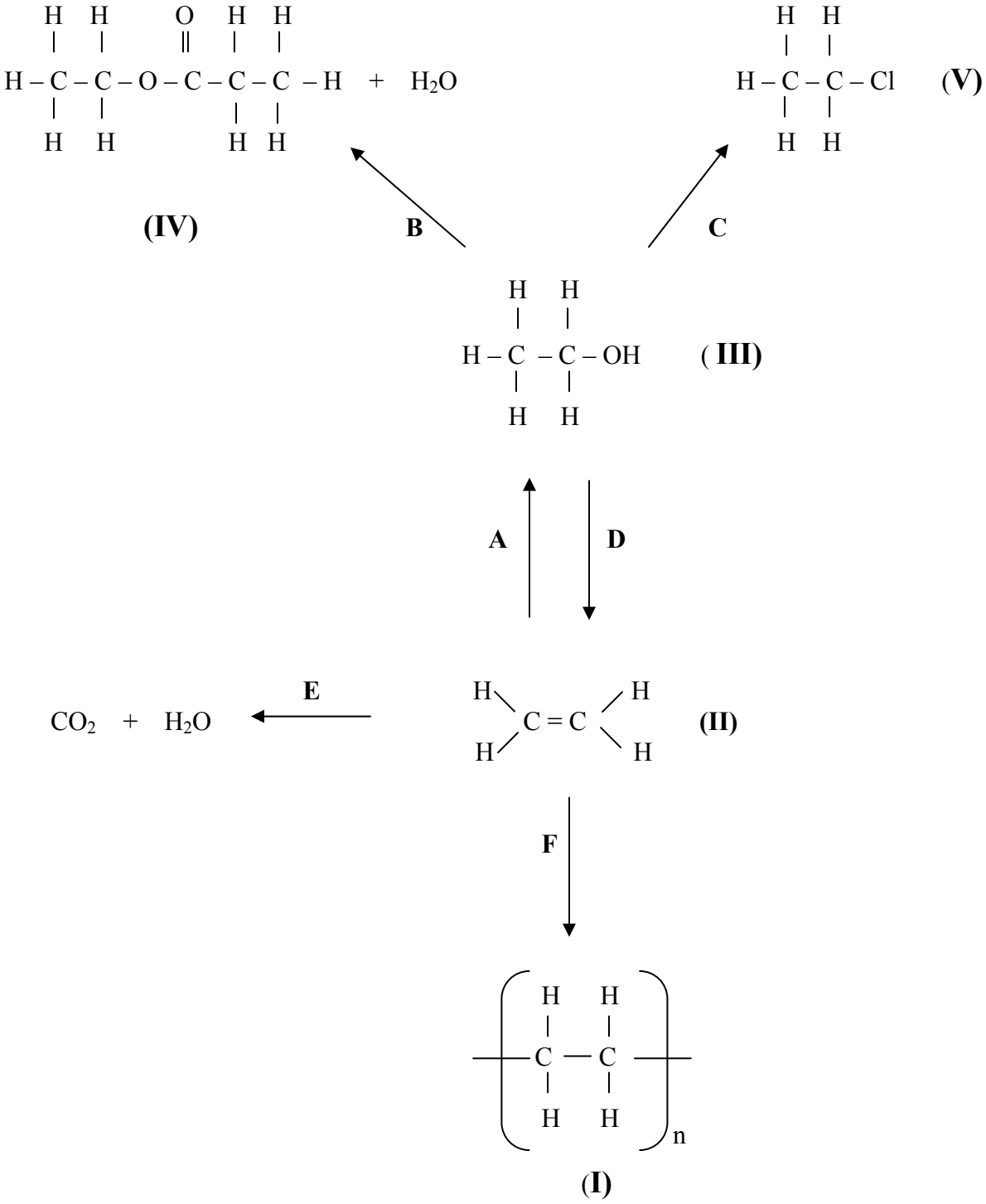
PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of a question paper of 12 pages and a four page green insert with
   - a data and formulae sheet (3 pages); and
   - graph paper for question 2.5.
2. Please check that your question paper is complete.
3. Detach the insert from the middle of your question paper and hand this in with your Answer Book at the end of the examination.
4. ALL the questions in this paper must be answered.
5. Use the data and formulae whenever necessary.
6. Read the questions carefully.
7. It is in your own interest to write legibly and to set your work out neatly.

QUESTION 1

Organic chemistry is the study of carbon and the chemistry of its associated compounds. One of the simplest ways of representing this chemistry is to draw reaction pathways just like the one that appears below.

Consider the following sequence of organic reactions and then answer the questions that follow. Reactions are labelled from **A** to **F** while molecules are labelled from **I** to **V.**



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

1.2 Identify the homologous series to which the following molecules belong:

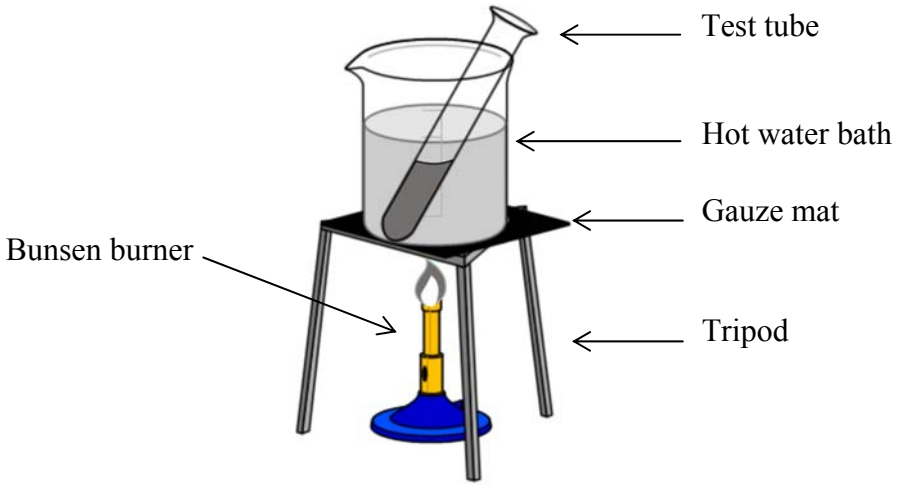
1.2.1 II
1.2.2 III
1.2.3 IV (3)

1.3 Name the types of reaction labelled **A, C, D** and **E** in the reaction sequence provided. (4)

1.4 Consider reaction **B**. To form this molecule labelled IV, a reaction takes place between molecule III and another molecule from a different homologous series.

1.4.1 Name the homologous series to which the other molecule belongs. (1)

To prepare molecule IV in the laboratory, the two reactants are mixed together in a test tube. A few drops of concentrated sulphuric acid are added and the test tube is placed in a hot water bath and then heated as illustrated below.



1.4.2 Why do you think the test tube must be heated in a hot water bath and not over an open Bunsen burner flame? (2)

1.4.3 Sulphuric acid (H_2SO_4) is often considered as a catalyst in this reaction. Explain what is meant by the term catalyst. (2)

1.4.4 Where, in everyday life, would molecules of this newly formed substance most likely be found? (1)

1.5 There are TWO possible **types** of isomers of organic molecules that have the molecular formula $C_4H_8O_2$.

1.5.1 Explain what is meant by the term 'isomer'. (1)

1.5.2 Name the homologous series to which each of these isomers belongs. (2)

1.5.3 Each of these isomers has a distinctly different boiling point. Explaining your answer fully, say which one would have the higher boiling point. (3)

1.6 Reaction **F** illustrates the overall reaction of the **monomer** ethene to form the **polymer**, polyethylene. This type of reaction is known as **addition polymerisation.**

1.6.1 Define the terms **monomer, polymer** and **addition polymerisation** as highlighted above. (3)

There are three steps in the preparation of the polymer chain, namely INITIATION, PROPAGATION and TERMINATION. The reaction is initiated by a free radical which is a molecular fragment with an unpaired electron denoted by the symbol – '$R^{\bullet}$'.

1.6.2 Using molecular structures, show how molecules of ethene will combine during:

(a) the INITIATION; and (2)
(b) the PROPAGATION (2)

steps of the polymerisation that forms polyethelyne.

1.6.3 TERMINATION is the step that terminates the chain. Using molecular structures, show TWO possible methods to terminate the polymer chain of polyethelyne. (4)

1.7 Consider the following article pertaining to the production and use of the plastic polymer polyethylene terephthalate or PET in the South African economy.

THE POPULAR POLYMER …

PET or polyethylene terephthalate, is the material of choice for a growing number of bottlers. In many respects, PET is one of the miracle packaging materials of the last century. Its versatility is astounding. New uses are developed year after year, creating economies or other benefits in countless applications. But increased utility has led to one big challenge: how do we cope with PET's success? PET, or polyethylene terephthalate, is the key point of focus as it is encountered so frequently in the form of soft drink and water bottles, plastic jars, containers, trays and clamshell packages. PET consumption increases steadily year on year. Strong growth can be expected for many years to come. By 2001, per capita consumption in Africa was between one quarter and one fifth the level found in Europe and America, suggesting that huge increases in volumes are on the horizon as African PET consumption reaches 'maturity'.



In the past, much of the growth was attributable to replacement business; i.e. providing PET as a substitute for glass bottles, PVC containers and tin cans. In many instances, PET has almost totally replaced PVC. In future, growth in polymer volumes for PET bottle applications will be largely a matter of organic growth as the advantages of this material are discovered by a wider base of new customers. For example, market trends indicate a move towards the packaging of fruit juices, milk and beer in recyclable PET where the resealability of the PET bottle makes it preferred over metal cans. Unlike many other plastics, tainting of foodstuffs through chemical leaching associated with some other plastic compounds is absent in PET products.
Increased usage of this polymer may create an environmental challenge, but in other respects PET leads to considerable energy and environmental benefits. PET offers numerous economic and logistical advantages. PET bottles are strong and resilient yet have only 7% of the mass of glass bottles. This has benefits to the transport industry and more specifically, can be important in the fight against global warming.

[Extracted from *Mind Action Series*: Grade 12 based on web article from <www.petco.co.za>]

1.7.1 PET is becoming increasingly popular as a plastic compound used in many areas of the economic sector. State THREE advantages that PET offers compared to other materials and explain why you think these advantages are so widely accepted. (6)

1.7.2 The last paragraph of this article states:

'Increased usage of this polymer may create an environmental challenge'

Suggest THREE possible disadvantages that the use of PET would have on, or impact on, the environment. (3)

1.7.3 Critically analyse these advantages and disadvantages and make an informed decision as to how the product will impact positively and negatively on the environment as a whole. (6)

47 marks

QUESTION 2

Tshepiso and Belinda have been set a task to investigate how concentration affects the rate of a chemical reaction. One of the many techniques that may be used to investigate this is a chemical reaction known as the 'Iodine Clock'. The reaction occurs between two solutions, one containing an excess of iodate ions (IO_3^-) called Solution A, and another containing hydrogen sulphite ions (HSO_3^-) in the presence of starch, called Solution B. When Solution B is added to Solution A, a chemical reaction takes place in which iodine (I_2) is released and causes the starch solution to turn a deep blue colour, hence indicating the end of the reaction.

Tshepiso and Belinda wish to vary the concentration of Solution A and measure the time taken for the iodine to turn the starch blue.

2.1 (a) State what is meant by the term 'hypothesis' for an experiment. (2)
(b) Write a suitable hypothesis for this experiment. (2)

2.2 What would be the **independent, dependent** and **control** variables in this experiment? (3)

2.3 Belinda has been provided with a **scrambled sequence** of instructions telling her how to perform the experiment.

A Accurately measure 50 cm^3 of Solution B in a measuring cylinder.
B Dilute each sample of Solution A with distilled water so that the TOTAL VOLUME in each polystyrene cup is 100 cm^3.
C STOP the stopwatch immediately when the deep blue colour is observed.
D Add the sample of Solution B to the sample of Solution A in the polystyrene cup.
E Carefully measure out and pour 50 cm^3 , 40 cm^3 , 30 cm^3 , 20 cm^3 and 10 cm^3 of Solution A separately into the five polystyrene cups.
F You are provided with five identical polystyrene cups.
G START the stopwatch immediately as the two solutions begin to mix.
H Repeat all steps now using a different volume of Solution A. (4)

Using just the letters provided, list the correct sequence of instructions to assist Belinda in planning the experiment.

Tshepiso and Belinda now perform the experiment and write down the results as follows:

Results obtained from the Iodine clock experiment

When we added 50 cm^3 of Solution B to the polystyrene cup containing 50 cm^3 of Solution A and 50 cm^3 of distilled water, we stopped the stopwatch at exactly 12,34 s when the solution turned a dark blue. We repeated this method for the next cup which now contained 40 cm^3 of Solution A and 60 cm^3 of distilled water. This time it took a bit longer for the Solution to turn dark blue and we stopped the stopwatch when it read 15,53 s. Again we repeated this for the remaining three cups which contained various dilutions as explained in the method. We obtained time readings of 20,56 s, 27,03 s and 55,55 s respectively.

Tshepiso now takes the readings of time and calculates **the reciprocal of time (1/t)** for each set of readings.

2.4 Using all the information provided in the 'Results obtained from the Iodine clock experiment' paragraph, draw up a neat table with suitable headings and transfer all the data onto the table to record Tshepiso and Belinda's results. Include in your table all the volume and dilution data for Solutions A and B as well as all Tshepiso's **1/t** calculations. (Approximate Tshepiso's **1/t** results to the third decimal place). (5)

2.5 Tshepiso now wishes to analyse his results by plotting a graph using the data from the **volume of Solution A used** and the **reciprocal of time (1/t)** calculated in the table. Use the graph paper provided to plot this graph. (6)

2.6 How long would it take for the reaction mixture to react if 35 cm^3 of Solution A was used in the experiment? By using a dotted line on your graph, carefully show how you obtain this data and then show all calculations in your Answer Book. (2)

2.7 What conclusion were Tshepiso and Belinda able to draw from this experiment? (2)

2.8 The experiment was conducted in identical polystyrene cups of identical dimensions. Why do you think this was so? (2)

2.9 Using exactly the same apparatus and identical solutions, would you expect the results to be the same if Belinda performed the experiment instead of Tshepiso? Explain your answer. (4)

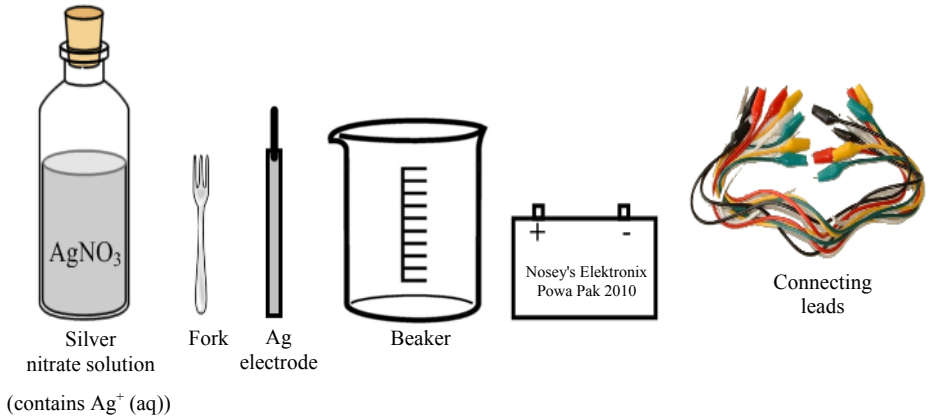
2.10 In your Answer Book, redraw a sketch graph of your original graph and label it **'P'**. On the same set of axes, sketch the graph you would expect to obtain if this entire experiment was performed at a higher temperature. Label this graph **'Q'**. (2)

34 marks

QUESTION 3

3.1 Vanitha has just been given an antique silver fork from her grandmother and she is desperate to restore it back to its original elegance by coating it with a new layer of silver.

She knows that she can use an electrolytic cell to perform this restoration. She asks her Physical Sciences teacher if she can use her school's science laboratory to perform the restoration and requests the following pieces of equipment:



3.1.1 Name the process by which metal objects can be covered with a new metal layer. (1)

3.1.2 Vanitha is supplied with the apparatus above (not drawn to scale). Using the apparatus, draw a neatly **labelled** diagram to show how she would set up the apparatus to perform the experiment. (4)

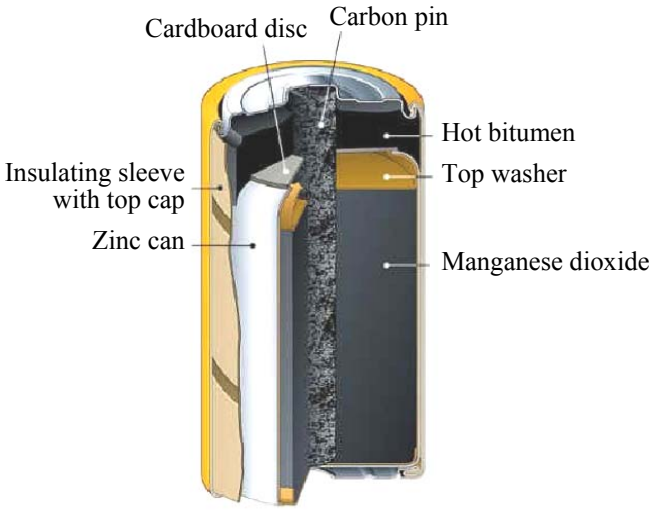
3.1.3

(a) Must the silver fork be the anode or the cathode of the electrolytic cell? Explain your answer. (2)

(b) Give a half reaction equation to support your answer above. (1)

3.1.4 Explain why it is essential that the other electrode be made of silver metal. Provide an equation to support your answer. (4)

3.2 Everyone is familiar with what is commonly known as a 'torch battery'.



It is known scientifically as a Leclanché cell and commonly called a zinc-carbon cell. This is an example of a primary cell which is used in torches, toys and small appliances. There is a casing of zinc around the cell known as the **zinc can** which surrounds a chemical paste containing ammonium chloride and manganese dioxide. This paste is in contact with a central carbon electrode which runs the length of the cell.

The half-reactions that occur are:

	E° (V)
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	$-0,76$
$2NH_4^+(aq) + 2e^- \rightleftharpoons 2NH_3(g) + H_2(g)$ (in contact with central carbon electrode)	$+0,74$

3.2.1 What is the difference between a primary and a secondary cell? Give one example of a secondary cell. (2)

3.2.2 Based on the standard reduction potential (E°) values given, identify, and briefly explain, which reaction will occur at the anode and cathode respectively. (3)

3.2.3 This type of cell is called a dry cell, yet the electrolyte is found as a moist paste. Why would a moist paste and not a dry powder be found in this cell? (2)

3.2.4 Using the Table of Standard Reduction Potentials, calculate the potential difference that each torch cell is able to deliver. (2)

21 marks

QUESTION 4

The Agrochemical Industry provides a vital service by producing artificial fertilisers which are added to the soil to restore nutrients so that more crops can be produced. Fertilisers are available in many forms and can be purchased easily in many different retail stores throughout the country.

4.1 You are provided with a 10 kg bag of fertiliser that carries the following information, **NPK – 3:1:5 (26) SR** as seen on the fertiliser bag below.

4.1.1 **Name** the primary nutrients given by the symbols NPK required by all plants to ensure healthy and sturdy growth. (3)

4.1.2 Using chemical formulae, give an example of the chemical form in which these nutrients are found in artificial fertiliser. (3)

4.2 Fazul and Holly are enthusiastic members of their school Science Club and are busy with a school project that is investigating artificial fertilisers and how these are produced. Their research shows that the reaction between hydrogen and nitrogen to produce ammonia is an example of a chemical reaction that is able to reach dynamic chemical equilibrium within a closed system according to the following chemical equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -46\ kJ \cdot mol^{-1}$$

4.2.1 Give the name of the industrial process that uses this reaction to manufacture ammonia. (1)

4.2.2 In this process, the reactants and products are said to reach dynamic chemical equilibrium. Explain what is meant by the term 'dynamic'. (2)

In his research, Fazul finds that under certain conditions of temperature and pressure, the following amounts of reactant and product were present when equilibrium was reached inside the reaction vessel:

N_2 = 6 000 mol

H_2 = 29 000 mol

NH_3 = 18 000 mol

The volume of the reaction vessel is 10^5 litres.

4.2.3 Using the data provided, calculate **(in mol·dm^{-3})** the concentrations of reactants and products present in the reaction vessel at equilibrium. (3)
(Note: 1 litre = 1 dm^3)

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

4.2.5 Calculate the value of K_c for this reaction. (2)
(Note: K_c, in this case, is unitless, therefore you do not have to put units in your final answer.)

Holly observes that one of the conditions affecting the equilibrium is changed and a **new** equilibrium is established. At the new equilibrium, the concentration of NH_3 is 0,24 mol·dm^{-3}.

4.2.6 By how much, in mol·dm^{-3}, did the concentration of ammonia increase from what it was originally in 4.2.3? (2)

4.2.7 If the value of K_c remains **constant** after the new equilibrium has been reached, what TWO factors could have led to this change? (4)

4.3 A discussion between Fazul and Holly now takes place. Fazul says:

'This reaction is exothermic and therefore it should be performed at low temperatures. This will make the forward reaction more favourable and you will get a higher yield of ammonia.'

Holly disagrees and says:

'*If you want the forward reaction to be more favourable, then you need to make the forward reaction faster and thus you need a higher temperature to get a higher yield. I think you should perform the reaction at a much higher temperature.*'

4.3.1 Who do you think is correct? With reference to **both** arguments, explain why you have made this decision. (5)

Fazul then adds the following to the argument:

'*I think we should also use a catalyst because then we will get more ammonia being produced.*'

Fazul has made a crucial error in his understanding of how catalysts work in chemical reactions.

4.3.2 Carefully analyse this statement by identifying and stating the error he has made with reference to the workings of a catalyst. (2)

4.3.3 Correct the statement he has just made by writing a correct statement. (2)

4.4 After further research, both learners find that good agricultural soil has a high component of soluble fertiliser present. It is naturally present in the soil and all farmers regularly measure the quantity as it is essential for healthy crop growth. However when heavy rains fall, farmers regularly have to use artificial fertilisers on the land.

4.4.1 Using one of your examples from 4.1.2, explain with the aid of a chemical equation, what problem you see possibly occurring in the soil when heavy rains fall. (3)

4.4.2 Do you think that the regular use of artificial fertilisers will solve the problem? Give a reason for your answer. (2)

Organic fertiliser is a natural fertiliser which produces nitrates which are slowly released into the soil over time. This process is assisted by the oxygenated water that is absorbed by the rotting material. This process is very slow yet it is once again becoming a popular method of fertilising crops in the modern day and age, as it was long ago.

4.4.3 Why do you think it is advantageous for a farmer to want to use organic fertilisers instead of synthetic fertilisers in his fields? (2)

There has been much controversy over the use of organic and inorganic fertilisers in recent times. It is important to note that it makes no difference to a tomato plant if the nutrients it is absorbing come from a pile of compost (organic) or from a fertiliser factory (inorganic). A nutrient is a nutrient – no matter what the source of it might be.

<www.CartoonStock.com>

4.4.4 Name two organic fertilisers that are sources of primary nutrients for plants. (2)

4.4.5 With reference to the agricultural environment in South Africa, list TWO possible advantages and TWO possible disadvantages of inorganic fertilisers. (4)

4.4.6 Based on the **disadvantages** of inorganic fertilisers above, suggest how the use of organic fertilisers addresses this issue. (4)

48 marks

Total: 150 marks