

B O A R D O F S T U D I E S
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1998
APPLIED STUDIES
1 UNIT

*Time allowed—Two hours
(Plus 5 minutes reading time)*

DIRECTIONS TO CANDIDATES

- Attempt **THREE** questions.
- Each question is worth 20 marks.
- Board-approved calculators may be used.
- Answer each question in a **SEPARATE** Writing Booklet.

QUESTION 1. Applications of Computer-controlled Systems**Marks**

- (a) Read the extract taken from an article about a high technology building in Singapore. Then answer the questions on the following page. **11**

It's the year 2001: a would-be thief infiltrates the newly opened post office and bank (Posbank) building in Singapore, moving silently in the dark.

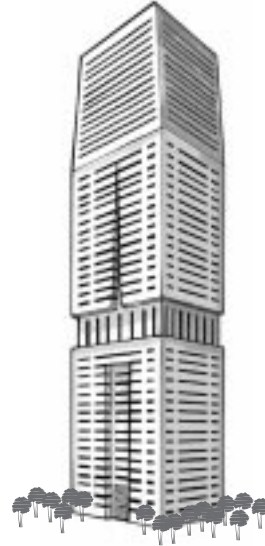
The thief strays into a movement sensor. Suddenly every light on the floor comes on at full power, every door locks automatically and the alarm sounds.

The intruder's image appears on a monitor in the building's ultra-high-tech control centre. Then it's a simple matter for the security staff to use the intercom to order him through the only door on the floor that will still open: a lift that will deliver him to waiting guards.

The Melbourne-based consultants Consultel Australia are designing this futuristic system for Singapore's \$400-million Post Office Savings Bank building.

A control room will be connected to all the building's eyes, ears and moving parts.

A computer system in the control room will be used for controlling airconditioning, lighting, power, escalators, lifts, exit-control systems and the security systems. It sits above all those systems and manages them.



The 'intelligence' of the building will include lights that adjust automatically as people move into and out of areas, localised environmental controls and the ability to rearrange infrastructure—such as what switches control individual lights—from the central control room.

It is claimed that the system will allow huge energy savings to be made.

There will also be a security system for protecting Posbank's offices, its main bank vaults and the building's control room 'brain'.

The 'access control' for the building will be integrated, including closed-circuit TV, movement sensors and alarms. Automated doors will respond to 'smart cards' and to thumb and palm prints, for high security areas.

QUESTION 1. (Continued)

Marks

- (i) Movement sensors used in the building are mentioned in the extract. Name or describe TWO other sensors that would be required in the building.
 - (ii) Name TWO actuators (effectors) mentioned in the extract.
 - (iii) Centralising all the building's control functions allows data to be collected easily. Identify TWO types of data that could be collected.
 - (iv) Select ONE of the types of data you identified in part (iii) above and describe some possible uses for this data.
 - (v) Discuss how this type of automated building might affect the people who work in it.
 - (vi) What are some of the ethical considerations in using thumb prints and palm prints, or employees carrying 'smart cards' for security access?
- (b) Choose ONE of the computer-controlled systems that you have studied. Do NOT use the system described in part (a) above. **9**
- (i) Name the system.
 - (ii) What factors led to the development of the system?
 - (iii) Draw and label a block diagram of the system.
 - (iv) Describe the computer algorithm that controls the system.
 - (v) Describe ONE limitation of the system.

QUESTION 2. Applied Mathematical Skills**Marks**

- (a) Read the following information and answer the questions that follow.

5

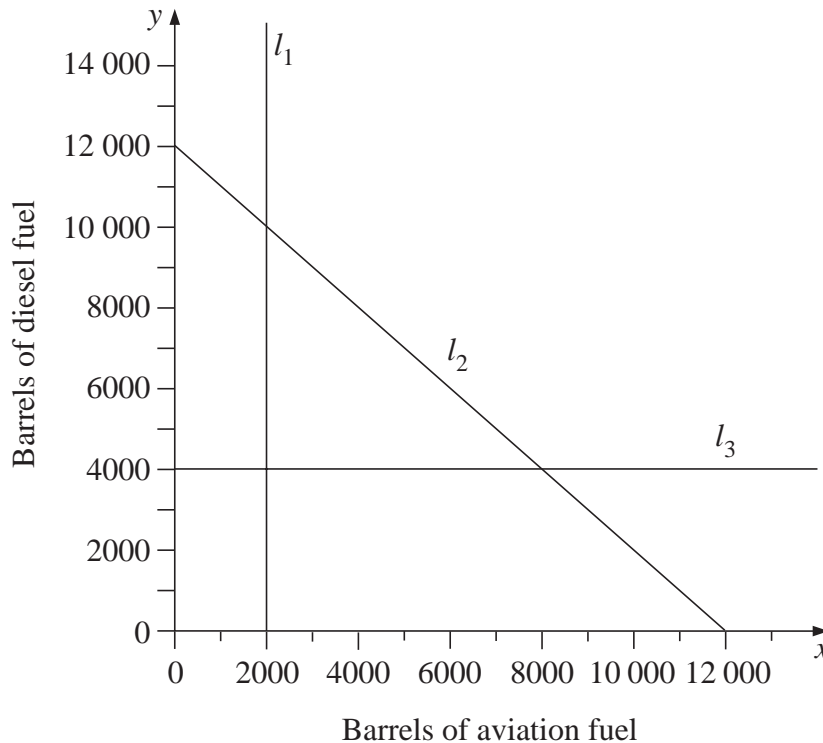
A petroleum company produces aviation fuel and diesel fuel. It makes a profit of \$8 per barrel on aviation fuel and \$6 per barrel on diesel fuel.

The company can produce a maximum of 12 000 barrels of fuel in total per day.

The company has a contract to supply a minimum of 2000 barrels per day of aviation fuel to the regional air terminal.

The company must produce at least 4000 barrels of diesel fuel per day to satisfy a commercial contract with a trucking company.

The graph below can be used to find the profit associated with differing levels of production.



- (i) Which line (l_1 , l_2 , or l_3) represents the boundary of the constraint: ‘The company must produce at least 4000 barrels of diesel fuel per day to satisfy a commercial contract with a trucking company’?
- (ii) What formula would be used to determine the profit earned for differing levels of production, given that x represents barrels of aviation fuel and y represents barrels of diesel fuel?
- (iii) What is the minimum daily profit that the petroleum company could expect to earn if it satisfied all of its constraints?

QUESTION 2. (Continued)

Marks

- (iv) The petroleum company operates under a fourth constraint:

Aviation fuel must be transported 30 kilometres from the production site to the airport. Diesel fuel must be transported 15 kilometres from the production site to the trucking facility. The company has transportation facilities to handle 240 000 barrels-kilometres per day.

Write down the equation of the line that would have to be drawn on the sketch to represent this new constraint.

- (b) Consider the following table. It shows the average consumer price index (CPI) between 1993 and 1997. 5

<i>Year</i>	1993	1994	1995	1996	1997
<i>CPI</i>	100.0	108.3	118.6	126.1	131.4

- (i) Explain how the CPI is calculated.
- (ii) What is the average price change between 1995 and 1997? Give your answer as a percentage, correct to one decimal place.
- (iii) Use the CPI figures to calculate the expected cost of a computer in 1997 if it cost \$3000 in 1995.
- (iv) Explain why using the CPI figures in your calculation in part (iii) may be inappropriate.
- (c) The Logistic law models population growth. In this model the rate of population growth slows as the population becomes large. 3
- (i) Draw a graph that exhibits the main features of the Logistic law.
- (ii) Give an example of a population whose growth is modelled by the Logistic law and state TWO factors that act to limit the growth of this population.

Question 2 continues on page 6

QUESTION 2. (Continued)

Marks

- (d) An art collector purchases a painting worth \$36 000. The painting increases in value at the rate of 8% per annum. Using the formula 3

$$A = P\left(1 + \frac{r}{100}\right)^n$$

determine after how many years the painting will be worth twice the purchase price. Show all working. Give your answer correct to two decimal places.

- (e) Read the following passage carefully. 4

An automotive company manufactures steering wheels. The company manufactures the steering wheels at a rate of twenty-five per minute. The company packages the steering wheels for dispatch at a rate of fifteen per minute. This results in an increasing backlog of steering wheels for dispatch during any production shift.

When a backlog of steering wheels reaches 3000, production ceases and the backlog for dispatch is cleared. Production does not recommence until the backlog has been entirely cleared.

A shift starts at 9.00 am with no backlog.

- (i) How many steering wheels have been produced after one hour?
- (ii) What is the size of the backlog for dispatch after one hour?
- (iii) At what time will production stop because of the backlog for dispatch?
- (iv) At what time will production recommence?

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QUESTION 3. Mathematical Ideas**Marks**

- (a) (i) Distinguish between Copernicus' and Ptolemy's models of planetary motion. **4**
- (ii) Copernicus' theory of planetary motion caused conflict among some scientists and religious leaders. Explain the basis of this conflict.
- (b) Kepler's third law of planetary motion states that the ratio of the squares of the period of revolution of two planets is equal to the ratio of the cubes of their semi-major axes. **3**

This can be written as:

$$\frac{P_A^2}{P_B^2} = \frac{R_A^3}{R_B^3},$$

where P_A and P_B are the periods of revolution of Planet A and Planet B respectively and R_A and R_B are the lengths of the semi-major axes of Planet A and Planet B respectively.

- (i) Define the term *semi-major axis*.
- (ii) Venus is 0.72 Astronomical Units from the Sun and has a period of revolution of 0.61 years. Saturn is 9.54 Astronomical Units from the Sun. How long does it take Saturn to make one revolution? Give your answer correct to one decimal place.
- (c) The orbit of the planet Migid has a semi-major axis of length 1.4 Astronomical Units. The planet has an eccentricity of 0.5. **2**

Draw a sketch of the path of the planet, clearly labelling the lengths of the semi-major and semi-minor axes.

QUESTION 3. (Continued)

Marks

(d) The formula:

5

$$\pi = 4 \times \left(1 - \frac{2}{3 \times 5} - \frac{2}{7 \times 9} - \frac{2}{11 \times 13} - \dots \right),$$

known as the Leibnitz formula, can be used to approximate π .

- (i) What is the sum of the series to the first four terms?
- (ii) Write down the next term of the series.
- (iii) Archimedes (287 BC–212 BC) gave a bounded approximation of π . He stated that

$$3\frac{1}{7} > \pi > 3\frac{10}{71}.$$

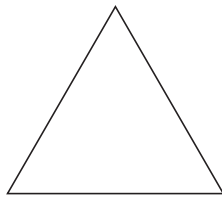
Explain why it is necessary to sum a large number of terms of the Leibnitz formula to fall within the limits of Archimedes' approximation.

(e) (i) What is a *fractal*?

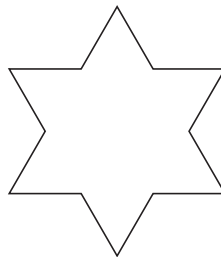
6

- (ii) The first three steps in the construction of a fractal pattern based on equilateral triangles are drawn below.

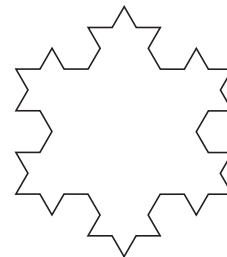
Original shape



Stage 1



Stage 2



1. Describe how each stage of the fractal has been generated.
2. Assuming that the length of the sides of the original triangle is 9 cm, calculate the perimeter of Stage 1 and Stage 2.
3. A fractal can have an infinite length in a finite area.

Using the results calculated in part (2.), discuss the statement above.

QUESTION 4. Science and Medicine**Marks**

- (a) South American Indians chew leaves from a plant to reduce feelings of hunger. **10**
The people who use these leaves do not report any side-effects. A scientist has found that one particular chemical in the leaves is responsible for this reduction in feelings of hunger. A pharmaceutical company wishes to market this chemical as a drug to help obese (overweight) people lose weight.

Some early testing involved using the drug in animal trials. One experiment used 250 young male and female rats over a thirty-day period. Half the rats (control group) were supplied with as much food as they wanted. The other half (experimental group) also had as much food as they wanted, however the food contained some of this chemical.

The table below shows the mean change in weight of the rats over the 30 days.

	<i>Control group</i>	<i>Experimental group</i>
Males	+5%	-35%
Females	+2%	-30%

(‘+’ indicates a weight increase and ‘-’ indicates a weight decrease)

- (i) Explain why the drug would need to undergo extensive testing before it could be marketed.
- (ii) State ONE conclusion that can be drawn from this experiment regarding the effect of the drug on weight loss in rats.
- (iii) Why would males and females have been measured separately?
- (iv) State ONE important question regarding the effect of this drug on weight loss in rats that has not been answered by this experiment.
- (v) Briefly describe the design of an experiment to find the answer to the question you have suggested in part (iv) above.

Assuming that the results of the animal experiments look promising, clinical trials are undertaken.

- (vi) Why would clinical trials be undertaken?
- (vii) What group or groups of people need to be involved in such a trial?
- (viii) Briefly describe how such a trial might be undertaken.

QUESTION 4. (Continued)

Marks

(b) Choose ONE case study from the following conditions:

3

- asthma
- anaemia
- diabetes
- malaria
- smallpox
- tuberculosis.

- (i) Name the condition that you have chosen.
- (ii) Name ONE pharmaceutical that is used to treat or prevent the condition.
- (iii) Explain the scientific basis for the action of the pharmaceutical.
- (iv) State ONE limitation of the pharmaceutical in treatment or prevention of the condition.

(c) The three images below are taken using different diagnostic techniques.

7

X-RAY OF A
DISLOCATED FINGERULTRASOUND SHOWING
THE HEAD OF A FETUSRADIOISOTOPE SCAN
OF A THYROID GLAND

Select ONE of the diagnostic images above, then answer the questions below about that image.

- (i) Which of the diagnostic images above have you chosen?
- (ii) Explain ONE scientific principle that has been used to produce the image you have chosen.
- (iii) Describe ONE advantage of using the technique to produce the image.
- (iv) State ONE precaution that would have been taken to produce the image.
- (v) Discuss the limitations of the image produced with the technique.

QUESTION 5. Scientific Research**Marks**

- (a) You have studied at least two specific examples in the following list of Australian research programs. **8**
- A project associated with CSIRO's Australia telescope
 - Antarctic research projects involving ice-core studies
 - The bush-fly control program
 - The crown of thorns starfish research project
 - Gene mapping and/or transgenic animals
 - Methods of assessing and monitoring corrosion
 - Studies involving health and food additives
 - The Synroc project
 - A sewage treatment project
 - A project to develop alternative energy sources
- (i) Name the TWO projects you have studied and provide a clear statement of the problem(s) being investigated in each case.
- (ii) Choose ONE of the two projects that you named in part (i). Write down its name. Describe how the project was carried out.
- (iii) Explain how the results of the research project named in part (ii) contributed to the knowledge and/or solution of the problem being investigated.
- (b) You have carried out a scientific research project of your own and submitted a report of your findings. **6**
- (i) Write down the aims of the project, together with an hypothesis you have tested.
- (ii) Describe how the research was carried out. Include a discussion of the variables you studied and any controls you may have included.
- (iii) Describe ONE conclusion you have made from your study. Discuss the relevance of your conclusion with regard to other work in this field.

QUESTION 5. (Continued)

Marks

- (c) Tutorial classes are used by many universities to teach problem-solving skills. A university wishes to evaluate computer-aided learning as an alternative method of teaching problem-solving skills. **6**

100 first-year chemistry students are tested on their problem-solving ability (*Test 1*). The students are then randomly split into four groups.

- Group A Receive no tutorial or computer-aided instruction.
- Group B Attend two hours per week of tutorial classes only.
- Group C Attend one hour per week of tutorial classes and one hour per week of computer-aided instruction.
- Group D Spend two hours per week of computer-aided instruction.

After six weeks the students are tested again (*Test 2*).

- (i) Formulate an hypothesis that is tested by this experiment.
- (ii) Which of the four groups could be called the control group for the hypothesis in part (i)?
- (iii) Describe how the results from *Test 1* and *Test 2* can be used to evaluate the relative effectiveness of the teaching methods.
- (iv) Discuss how the experiment could be affected if the students were allowed to select their preferred group.

QUESTION 6. Significant Technological Achievements**Marks**

This question must be answered in terms of significant technological achievements from the following list.

<i>Area</i>	<i>Technological achievement</i>	
Agriculture	Farm implements	<i>or</i> Genetic engineering in farm animals
Electronics	Integrated circuits	<i>or</i> Use of fibre optics
Engineering	Pre-stressed structures and post-stressed structures	<i>or</i> Refrigeration
Food	Milk products	<i>or</i> Grape products
Manufacturing	Robotics in motor-car manufacturing	<i>or</i> Assembly-line production of whitegoods
Materials science	PET	<i>or</i> Solar cells
Textiles	'Superwash' wool	<i>or</i> Shuttleless looms
Transport	Electric trains	<i>or</i> Air-traffic control

- (a) From the above list, select ONE technological achievement you have studied. **8**
- (i) Name the technological achievement.
 - (ii) Discuss the implications of this achievement for industry.
 - (iii) What effects has the application of this achievement had on society in Australia?
 - (iv) Discuss the effects of the achievement on production.
 - (v) Discuss possible strategies that could be used to market this technological achievement.

QUESTION 6. (Continued)

Marks

- (b) From the list on the previous page, select ANOTHER technological achievement you have studied. **8**
- (i) Name the technological achievement.
- (ii) What alternative technology existed prior to the development of the technological achievement named in part (i)? Explain what advantages the new technology has over the old technology.
- (iii) Describe how the technological achievement is used. Use diagrams to illustrate your answer.
- (iv) How did this technological achievement advance scientific and technological understanding?
- (c) Select ONE of the technological achievements you have described in part (a) or part (b). Describe a practical activity that was used to demonstrate its underlying principles. Use diagrams where appropriate. **4**

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QUESTION 7. Statistical Methods**Marks**

- (a) (i) A statistician enters a set of numbers into a computer program. She erroneously enters one number. **7**

Identify the conditions under which this mistaken entry affects:

1. the range;
2. the mode;
3. the median.

- (ii) Explain the purpose of the interquartile range in analysing a data set.

- (b) The table below shows the mean and standard deviation in French and German in a statewide examination. The marks in each examination were normally distributed. **3**

<i>Subject</i>	<i>Mean</i>	<i>Standard deviation</i>
French	50	12
German	61	15

A student who studied both subjects achieved the following scores:

French : 70

German : 81

- (i) Calculate the z -score statistic for each subject.
- (ii) What does the calculated result for part (i) indicate about the student's relative performance between subjects?
- (c) A large study in NSW found that the diameters of ears of wheat were normally distributed with a mean of 40.2 mm and a standard deviation of 2.1 mm. **3**

A farmer measures a sample of 100 randomly selected ears of wheat on the farm and determines that the average diameter of the ears of wheat was 42.1 mm.

Using the z -test, determine if the farmer can reasonably claim to produce crops with larger diameters of ears than the state average.

QUESTION 7. (Continued)

Marks

- (d) Students at an isolated rural high school decide to conduct a study of the voting intentions of people in their community in a possible Republic referendum. The question to be posed is: 'Should Australia become a republic?'. 7

The students form two groups, *A* and *B*. Group *A* decides to use a simple random sample. Group *A* members question people as they enter the local shopping centres on a Wednesday morning. Group *B* uses a stratified sample. Both groups decide to use a total sample of 200.

- (i) Discuss the biases involved in the sampling method employed by Group *A*.
- (ii) Name TWO factors that should be considered in the design of the stratified sample used by Group *B* to minimise bias. Discuss how failure to consider these factors could influence the study.
- (iii) If the Federal Government carried out the referendum using a system of voluntary postal votes, what bias would be expected due to the type of sampling method?

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QUESTION 8. Technology and the Consumer**Marks**

This question must be answered in terms of the consumer products from the following list:

- bicycle helmets
- cameras
- cosmetics
- devices for heating water
- fertilisers
- hand-held, power-driven tools
- household cleansers
- irons
- portable music players
- sewing machines
- types of household insulation.

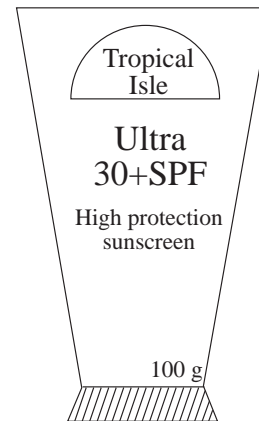
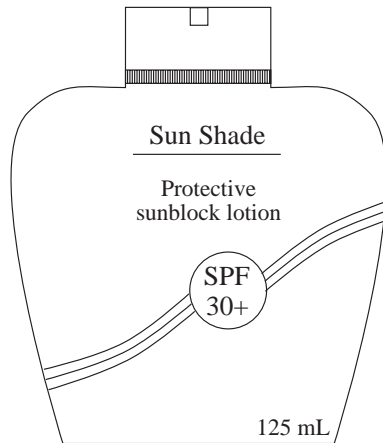
- (a) (i) Name ONE product from the above list. **6**
- (ii) Describe how you evaluated this product against TWO of the following product evaluation criteria:
- guarantees or warranties
 - aesthetic qualities
 - appropriateness for the function intended.
- (iii) 1. Describe ONE detrimental effect this product has had on society.
2. How can the consumer be educated to reduce this effect on society?
- (b) (i) Name ANOTHER product from the above list. **7**
- (ii) Describe the materials used in the manufacture of this product.
- (iii) Why are different brands of this product available?
- (iv) Describe a test you could use to compare the safety aspects of different brands of this product.
- (v) Describe another test you could use to compare different brands of this product to determine the best buy.

QUESTION 8. (Continued)

Marks

- (c) New laws mean that sunscreens can be sold with a protection factor higher than SPF 15. Two products that can be marketed under this new law are presented below.

7



- Strong smelling sunscreen
 - Absorbed by skin easily
 - Skin left with slightly sticky finish
 - Bottle is wide and hard to hold
 - Firm press-up lid
 - \$9.56
 - Two hours water resistant
 - Broad spectrum
 - Suitable for all skin types
- Mildly fragrant
 - Takes a bit of rubbing in
 - Skin left soft and moist
 - Packaging slippery when wet
 - Screw-top lid
 - \$9.16
 - Four hours water resistant
 - Broad spectrum
 - Suitable for all skin types
 - Non-degradable in sun
- (i) Based on the data provided, analyse these two products. On the basis of your analysis, select the better product. Give reasons for your choice.
- (ii) Your company is about to produce a new sunscreen called Lite-n-Shade.
1. What tests would you perform to ensure the product is competitive in the marketplace?
 2. What test results would convince you to manufacture the product?
- (iii) Identify a target market group for these products. Describe a marketing strategy you might use to promote the sale of these products to the target group.

QUESTION 9. Technology of Communication Systems**Marks**

- (a) At Aqua World a simple communication system has been designed for the dolphin show. Three coloured lights (blue, red and yellow) have been placed in the dolphin tank and can be switched on by the trainer standing beside the tank. One of the dolphins, Buttons, has been trained to perform different tasks in response to each light. See the table below. **4**

<i>Light colour</i>	<i>Task</i>
Blue	Retrieve a ball and place it in a container.
Red	Press a sensor plate to light up an 'applause' sign.
Yellow	Jump through a hoop.

- (i) Explain what you would consider to be TWO limitations of the system.
- (ii) Describe improvements that could be made to the current dolphin communication system.

- (b) You have studied one of the communication systems below: **10**

- telephone
- television
- radio
- computer networks.

- (i) Name the communication system you have studied and use this system to answer the following questions.
- (ii) Give a brief historical background on the development of the system.
- (iii) Describe the technological processes involved in the communication system in terms of:
- encoding and decoding
 - the form of transmitted data
 - the communication medium.
- (iv) Apart from its original purpose, describe TWO benefits that the system offers today's society.
- (v) Explain how 'noise' can be minimised in the system.

QUESTION 9. (Continued)

Marks

- (c) A local high school decides to preserve an historical record of communication systems used in 1998. They plan to store documents and equipment in a time capsule for future generations. You have been asked to contribute by answering the following questions, using the communication system you identified in part (b). **6**
- (i) Name ONE piece of specialised equipment necessary to the system that you would place in the time capsule. Give a reason for your choice.
 - (ii) Draw a simple diagram clearly labelling how the specialised equipment you placed in the capsule integrates with the communication system.
 - (iii) Name ONE limitation of the system. Suggest ways in which future generations could correct this limitation.

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QUESTION 10. The Environment**Marks**

- (a) You have undertaken research and prepared an environmental report on an issue of local significance. **8**
- (i) What was the local issue you investigated?
 - (ii) What changes have contributed to the current situation?
 - (iii) Describe the research methods you used to investigate this issue.
 - (iv) Discuss the findings of your research.
 - (v) Describe how the issue relates to ONE global issue.
 - (vi) Discuss any steps that have been or could be taken at a local level to help alleviate the global problem.
- (b) Select ONE of the following global issues: **6**
- greenhouse effect
 - ozone layer depletion
 - use of non-biodegradable materials.
- (i) Describe the underlying scientific basis of this problem.
 - (ii) Describe the environmental and health effects of this problem.
 - (iii) Describe ONE short-term and ONE long-term strategy that could be used to solve this problem.
- (c) Australia is being called the vanishing continent. The thin layer of soil that supports our agriculture is being washed away, blown away or poisoned. **6**
- (i) Name TWO environmental issues that may be responsible for this soil degradation.
 - (ii) Describe how ONE of the issues you have named in part (i) has caused this problem.
 - (iii) Describe what processes could be, or have been, introduced to prevent further soil degradation.

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