Diploma Programme
Programme du diplôme
Programa del Diploma

Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 3

Friday 10 May 2019 (morning)

1 hour 15 minutes

Candidate session number

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[45 marks]**.

Section A	Questions
Answer all questions.	1 – 3

Section B	Questions
Answer all of the questions from one of the options.	
Option A — Neurobiology and behaviour	4 – 8
Option B — Biotechnology and bioinformatics	9 – 13
Option C — Ecology and conservation	14 – 18
Option D — Human physiology	19 – 23

2219–6015

36 pages

Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1. The drawing shows part of a *Thunbergia grandiflora* plant. It has been widely cultivated as an ornamental garden plant.

[Source: from Wight, R., Icones Plantarum Indiae Orientalis, vol. 3 (1846)]

(a) Using the drawing, deduce which plant phylum *T. grandiflora* belongs to, giving **one** visible recognition feature of this phylum. [1]

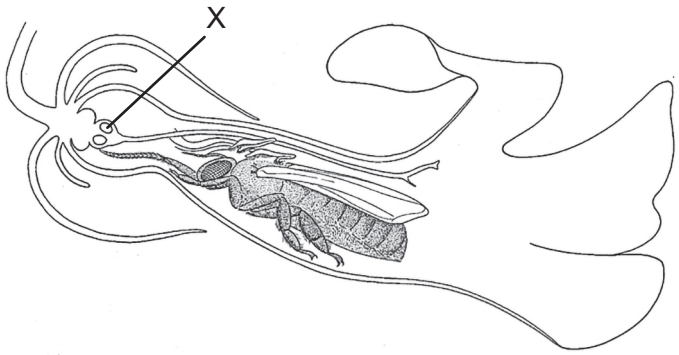
. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) The drawing shows a section through a *T. grandiflora* flower, which contains a honeybee (*Apis mellifera*).



[Source: © D G Mackean (www.biology-resources.com/drawing-plant-flower-tropical-06.html)]

(i) Identify the structure labelled X. [1]

. . . . . .

(ii) Outline the relationship the bee has with the *T. grandiflora* flower. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

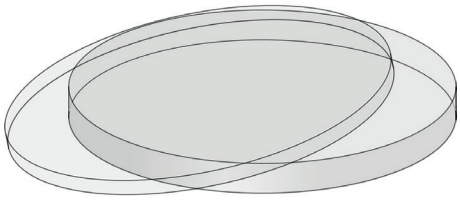
. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) After fertilization, seeds of *T. grandiflora* form in a small pod. If you were provided with Petri dishes, absorbent cotton balls and seeds, suggest how **one** variable affecting germination of these seeds could be investigated. [3]

Petri dish

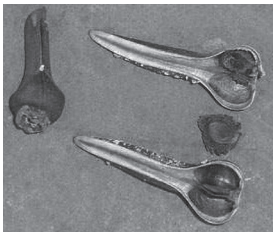


[Source: Openclipart/Pixabay/https://pixabay.com/vectors/petri-dish-glass-science-agar-agar-149008/]

Absorbent cotton balls

[Source: © Nattawut Lakjit/Dreamstime.com]

Seeds



[Source: Agnes Lusweti]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

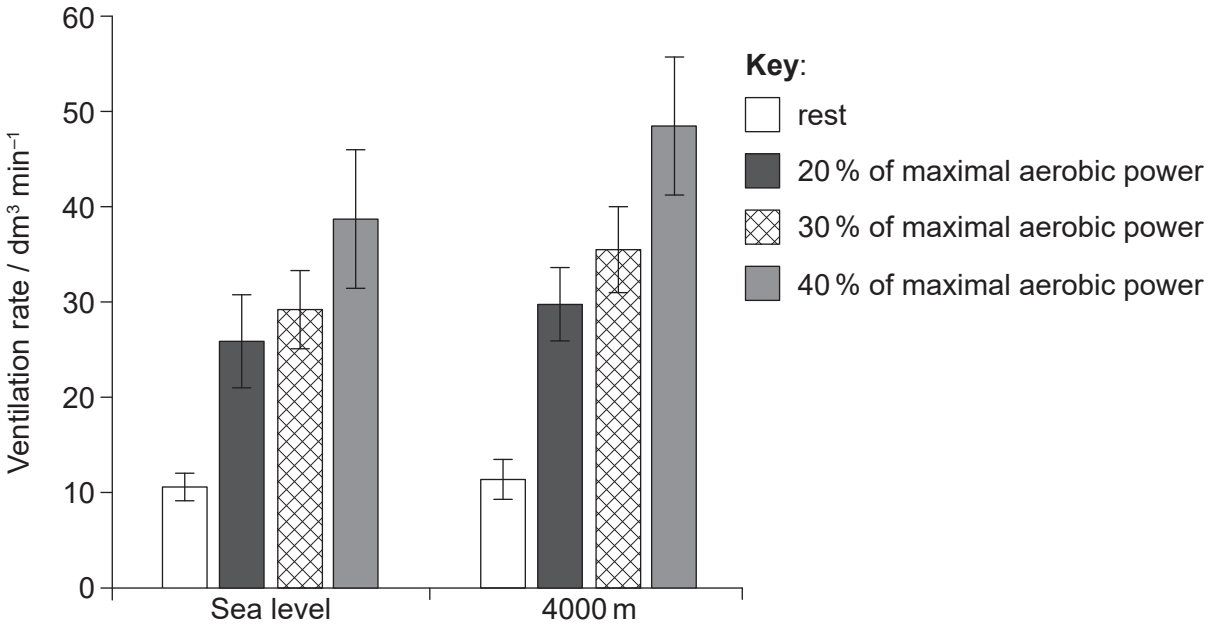
. . . . . .

. . . . . .

. . . . . .

. . . . . .

2. A study was conducted on 25 healthy, non-smoking males to look at the effect of exercise and altitude on ventilation rate. Subjects were first asked to rest in a sitting position for six minutes. They then pedalled for three periods of six minutes at increasing exercise intensity: at 20 %, 30 % and 40 % of their maximal aerobic power. The entire study was conducted either in normal sea level oxygen conditions or in lower oxygen conditions simulating an altitude of 4000 m. The results are shown in the bar chart.



[Source: E Hermand, *et al.*, (2015), Periodic breathing in healthy humans at exercise in hypoxia, *Journal of Applied Physiology*, **118**, pages 115–123. https://doi.org/10.1152/japplphysiol.00832.2014]

(a) State **one** other variable that should have been controlled in this study. [1]

. . . . . .

(b) Compare and contrast the effect of increasing exercise intensity at sea level and at an altitude of 4000 m. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(c) Outline how ventilation rate could have been monitored in this study. [2]

. . . . . .

. . . . . .

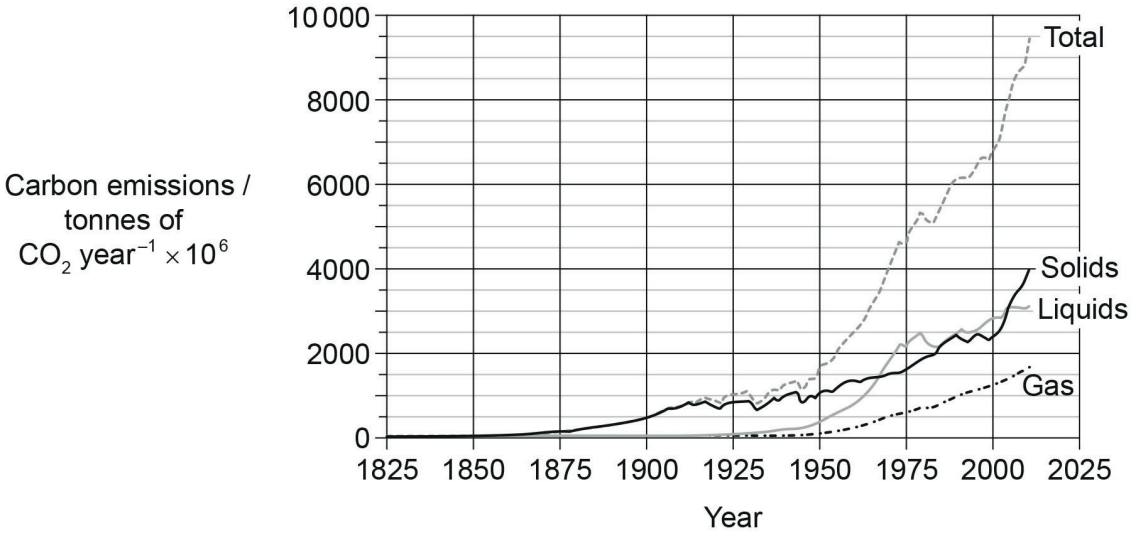
. . . . . .

. . . . . .

. . . . . .

. . . . . .

3. The graph shows global CO_2 contributions from the use of fuels since 1825. Emissions estimates for the years since 1950 are based on energy data from the United Nations while emissions estimates for years prior to 1950 have been constructed using a variety of sources.



[Source: Boden T ; Marland G ; Andres R J (1999): Global, Regional, and National Fossil-Fuel CO2 Emissions (1751 – 2014) (V. 2017). Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory (ORNL), Oak Ridge, TN (United States). doi:10.3334/CDIAC/00001_V2017]

(a) Calculate the percentage increase in the use of liquid fuels from 1950 to 1975. [1]

. . . . . %

(b) Referring to the data, compare and contrast the changes in the use of the different fuels between 1950 and 1975. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

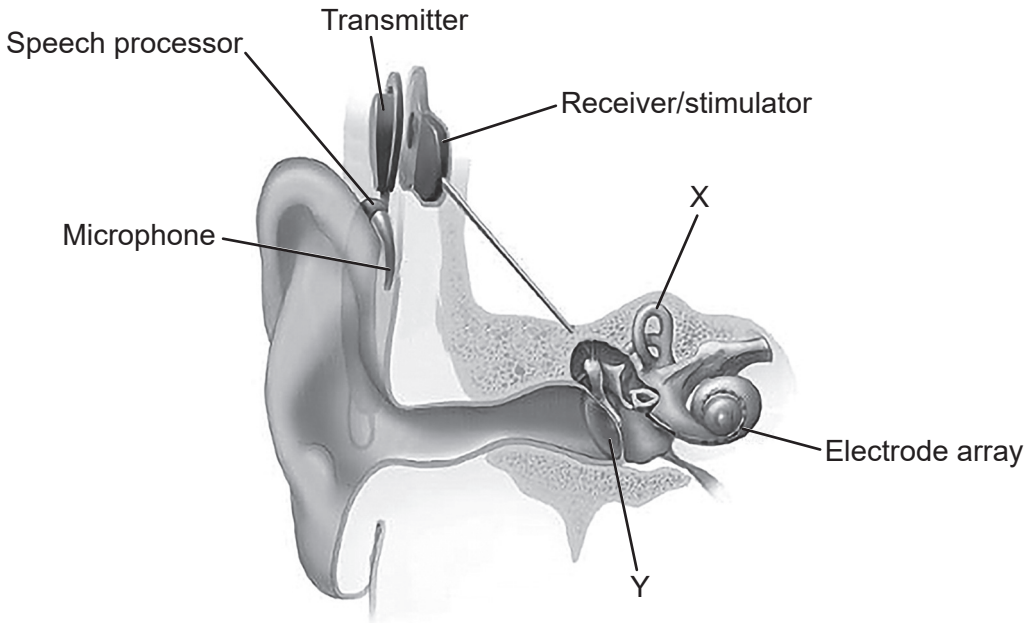
. . . . . .

Section B

Answer **all** of the questions from **one** of the options. Answers must be written within the answer boxes provided.

Option A — Neurobiology and behaviour

4. Hearing loss can range from mild to severe. Cochlear implants have been used in those with profound hearing loss such as children who are born deaf. The image shows a cross section of the ear with a cochlear implant.



[Source: NIDCD (www.nidcd.nih.gov/health/cochlear-implants)]

(a) (i) Identify the parts of the ear labelled X and Y. [2]

X: . . . . . .

Y: . . . . . .

(Option A continues on the following page)

(Option A, question 4 continued)

(ii) Describe the use of cochlear implants in deaf patients. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

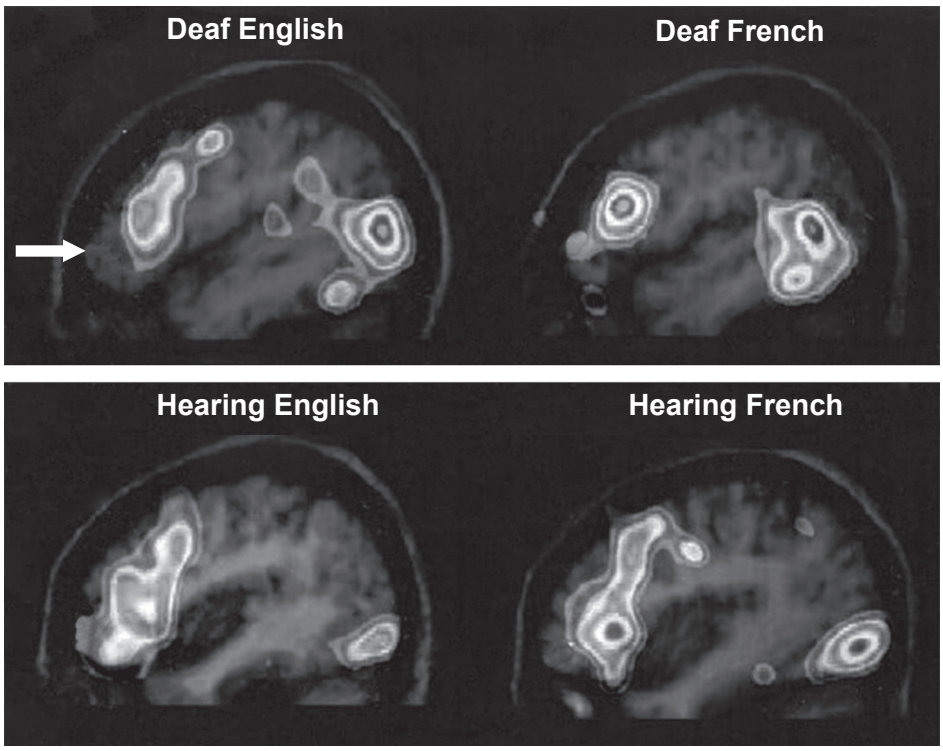
. . . . . .

. . . . . .

(Option A continues on the following page)

(Option A, question 4 continued)

(b) People who are deaf often learn to communicate using sign language. In a study, brain imaging was carried out using functional magnetic resonance imaging (fMRI) of profoundly deaf and hearing people who were processing the same aspects of language. The deaf individuals in the study used either an English sign language or a French sign language.



[Source: Copyright 2000 National Academy of Sciences, U.S.A.]

(i) Identify the area of the brain which is labelled with the white arrow in the fMRI. [1]

. . . . . .

(ii) Compare the general patterns of activation in the brain shown when all of the individuals in the study processed language. [1]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option A continues on the following page)

(Option A, question 4 continued)

(iii) Suggest **one** reason for two different language groups being used in the study. [1]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(iv) Outline how fMRI is used in brain studies. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(v) Suggest what might result if a deaf individual who uses sign language has a lesion in the Broca's area of the brain. [1]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option A continues on the following page)

(Option A continued)

5. (a) Distinguish between learned behaviour and innate behaviour. [2]

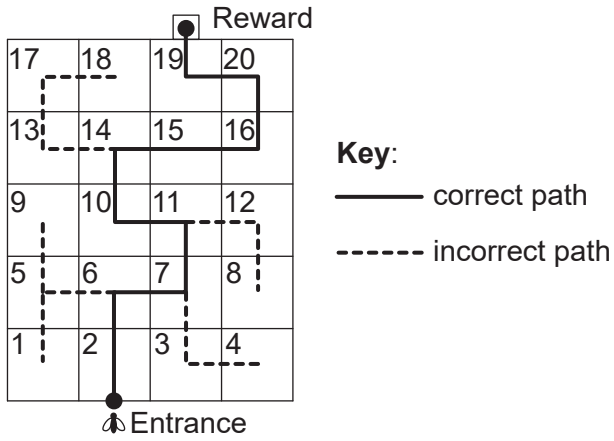
. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) An investigation was carried out to examine whether honeybees (*Apis mellifera*) can learn "rules" to deal with complex tasks and then apply them to new situations. To train bees, they were rewarded each time they followed a cue to make a correct turn at the start of a training maze. They were then allowed to find their way through the entire training maze.

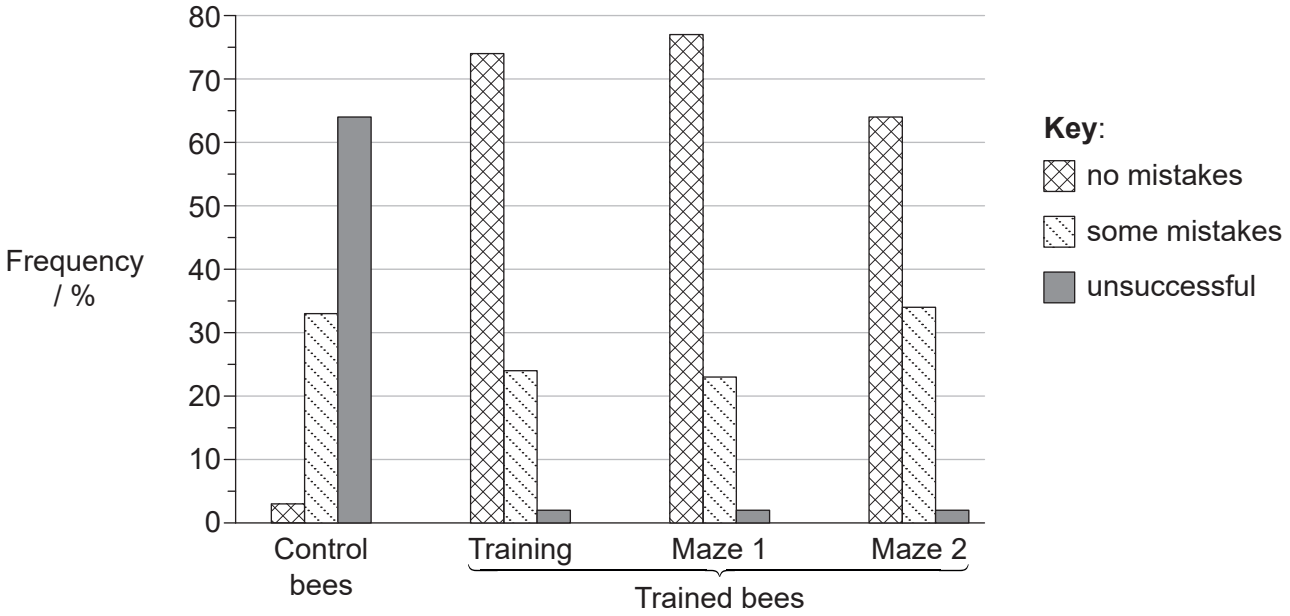


This was followed by attempts to navigate two unfamiliar mazes (maze 1 and maze 2) to see whether the bees could apply the rules to follow a path through different mazes. Untrained control bees were also put into mazes. Only one bee was tested in each maze at a time.

(Option A continues on the following page)

(Option A, question 5 continued)

The bees were classified according to how successful they were in making their way through each maze. The results are shown in the bar chart.



[Source: reprinted from *Neurobiology of Learning and Memory*, **72**, S.W. Zhang *et al*, Honeybee Memory: Navigation by Associative Grouping and Recall of Visual Stimuli, 180–201, Copyright 1999, with permission from Elsevier]

(i) Evaluate how the data supports the hypothesis that honeybees are able to learn to use cues to find the path through new mazes. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

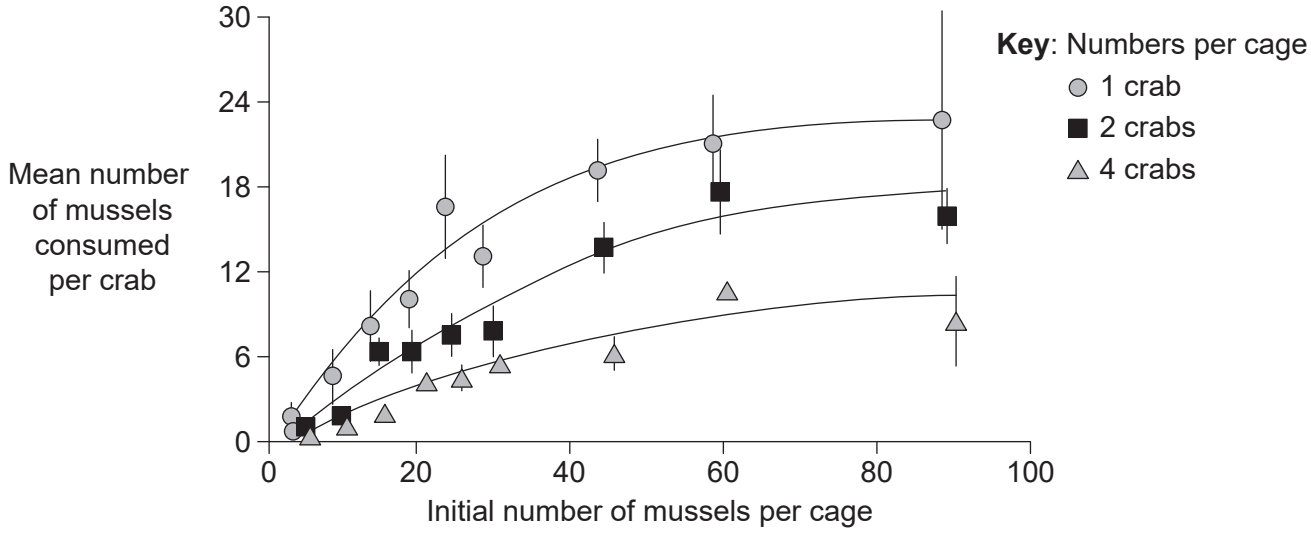
(ii) Suggest an advantage of such behaviour. [1]

. . . . . .
. . . . . .
. . . . . .

(Option A continues on the following page)

(Option A continued)

6. The shore crab (*Carcinus maenas*) forages for food in the intertidal zone on rocky seashores. An experiment was carried out to assess predation at specified levels of food abundance. An area of shore was enclosed in a wire cage. All other food was removed from the encaged area except the mussels provided by the investigators. The number of mussels consumed was measured while the crabs foraged at densities of one, two or four crabs per cage.



[Source: reprinted from B D Griffen and D G Delaney, *Ecology*, **88** (12), pages 3012–3021, copyright 2007, with permission, the Ecological Society of America]

(a) (i) Suggest a reason for the plateau in the graph when only one crab is present in the cage. [1]

. . . . . .

. . . . . .

(ii) Determine whether foraging by crabs is dependent on number of prey (mussels) or number of predators (crabs). [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option A continues on the following page)

(Option A, question 6 continued)

(b) Outline the role of natural selection in animal behaviour. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

7. Outline the process that could result in spina bifida during neural tube development. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option A continues on the following page)

(Option A continued)

8. Discuss the effect of endorphins on the central nervous system (CNS) and in pain relief. [6]

End of Option A

Option B — Biotechnology and bioinformatics

9. Citric acid is produced on an industrial scale and global production is over 1.4 million tons per year with a rising trend in demand.

(a) (i) State **one** industrial use of citric acid. [1]

. . . . . .

(ii) State the scientific name (binomial) of the microorganism usually used in this process. [1]

. . . . . .

(Option B continues on the following page)

(Option B, question 9 continued)

(b) The citrus fruit processing industry generates tons of waste such as orange peel from the extraction of juice. Orange peel has a total sugar content of between 29–44 %. An investigation was carried out into the use of waste orange peel as a raw material for citric acid production. Orange peel was put into a flask together with the microorganisms needed for citric acid production. The flask was kept at 30 °C and the concentration of sugars and citric acid were monitored.

Removed for copyright reasons

(i) Identify a sugar, other than sucrose, that could contribute to the total sugar content of the orange peel. [1]

. . . . . .

(ii) Compare and contrast the trends for citric acid and sucrose concentrations. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B, question 9 continued)

(c) Explain the use of fermenters for large-scale production of metabolites such as citric acid. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

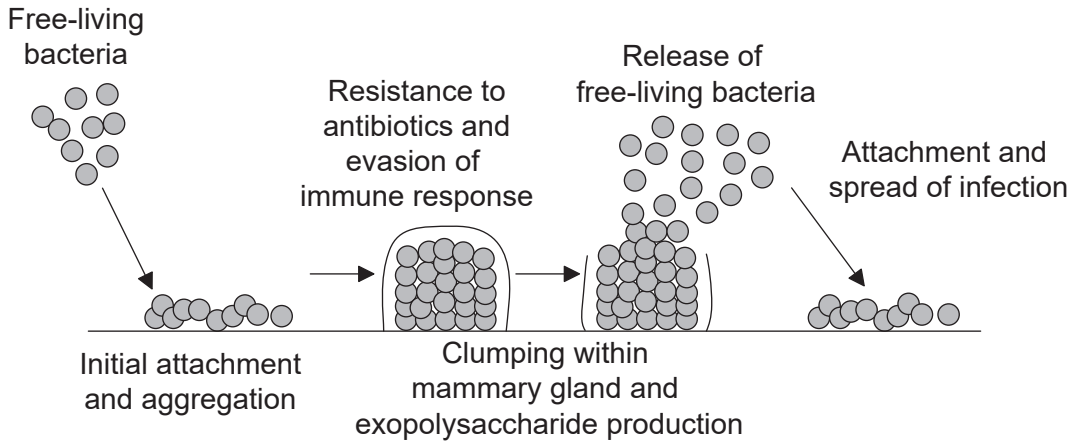
. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B continued)

10. The diagram shows the formation of a biofilm in a mammary gland, producing a mastitis infection.



[Source: © International Baccalaureate Organization 2019]

(a) (i) Outline the process of quorum sensing in bacteria forming a biofilm. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(ii) Suggest **one** reason, other than quorum sensing, for the resistance to antibiotics of a biofilm. [1]

. . . . . .
. . . . . .

(b) Outline **one** example of an environmental problem caused by biofilms. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option B continues on the following page)

(Option B continued)

11. (a) A segment of DNA is shown. Determine a possible open reading frame (ORF) segment in the DNA segment by completing the table. [2]

DNA 5′	A	G	A	T	G	T	C	A	C	T	A	C	A	G	T	C	T	T	C	A	C	T	G	A	A	A	C	C	T
DNA 3′	T	C	T	A	C	A	G	T	G	A	T	G	T	C	A	G	A	A	G	T	G	A	C	T	T	T	G	G	A
ORF																													

(b) In gene research, outline the use of

(i) open reading frames. [1]

. . . . . .

. . . . . .

(ii) gene knockout. [1]

. . . . . .

. . . . . .

(iii) BLASTn. [1]

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B continued)

12. Biopharming is the use of genetically modified plants or animals as a source of pharmaceutical products.

(a) Outline how a **named** vector is used to introduce a new gene into a plant. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) State the role of marker genes. [1]

. . . . . .
. . . . . .

(c) Describe how human antithrombin can be produced by biopharming. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option B continues on the following page)

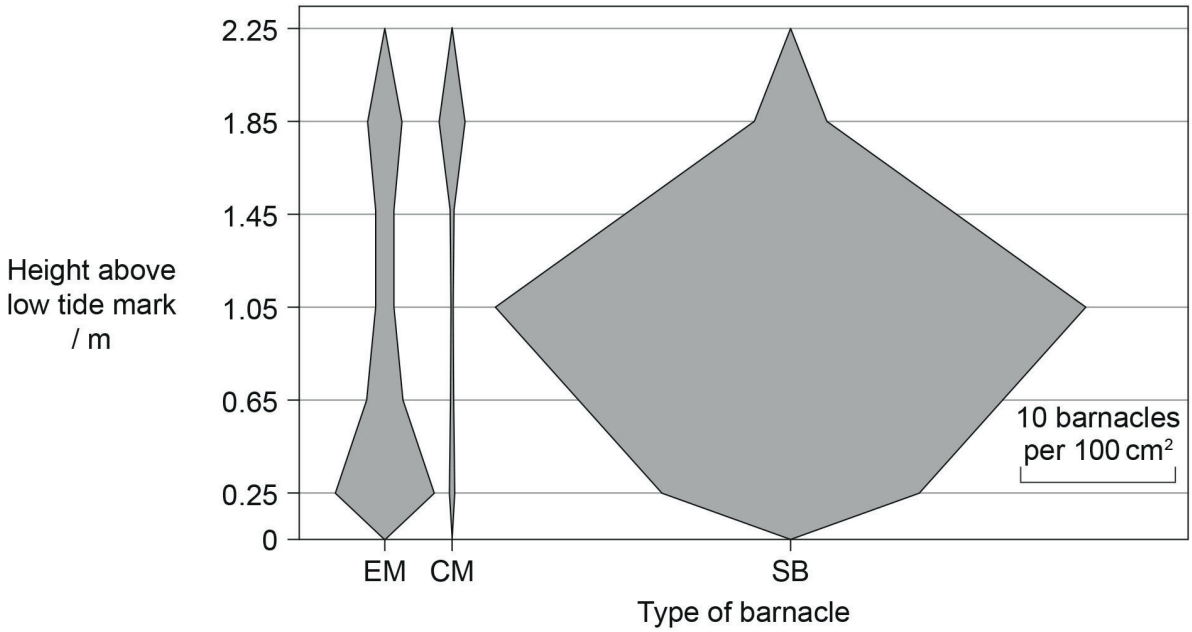
(Option B continued)

13. Discuss the use of microarrays in the diagnosis of disease. [6]

End of Option B

Option C — Ecology and conservation

14. A survey was made of the intertidal zone at Butter Lump Bay, Great Cumbrae, Scotland. The three species of barnacle found were *Elminius modestus* (EM), *Chthamalus montagui* (CM) and *Semibalanus balanoides* (SB). The kite diagram shows the vertical distribution of these three species from the low tide mark at 0 m to 2.25 m above low tide.



[Source: reprinted from *Estuarine Coastal and Shelf Science*, **152**, M C Gallagher, *et al.*, The invasive barnacle species, Austrominius modestus: Its status and competition with indigenous barnacles on the Isle of Cumbrae, Scotland, pages 134–141, 2014 with permission from Elsevier]

(a) Outline how the data could have been obtained. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option C continues on the following page)

(Option C, question 14 continued)

(b) Describe the distribution of *C. montagui* and *S. balanoides* barnacles in Butter Lump Bay. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) *E. modestus* is an invasive barnacle while the others are native species. Analyse the data to show how it supports this statement. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) Barnacles are sensitive to pollution. Outline how it might be possible to use these organisms as indicator species. [2]

. . . . . .

. . . . . .

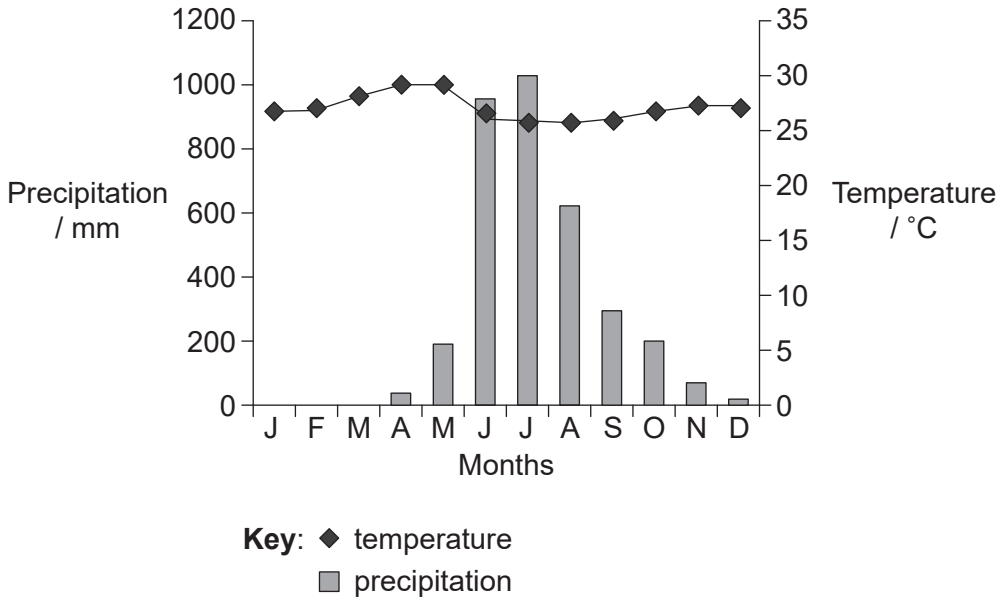
. . . . . .

. . . . . .

(Option C continues on the following page)

(Option C continued)

15. (a) The climograph shows data collected at Mangalore, India. The natural vegetation of the surrounding area is forest and the climate is tropical.



[Source: from: *The Physical Environment: An Introduction to Physical Geography*. Michael Ritter https://earthonlinemedia.com/ebooks/tpe_3e/]

Using the climograph,

(i) calculate the range of temperature. [1]

. . . . . °C

(ii) identify the relationship between maximum temperature and rainfall. [1]

. . . . . .

(iii) outline the pattern of rainfall. [1]

. . . . . .

. . . . . .

(Option C continues on the following page)

(Option C, question 15 continued)

(b) Natural forests in the area around Mangalore contain hardwood trees such as teak, *Tectona grandis*, which are deciduous, shedding their leaves once a year. Suggest, with a reason, when this might happen. [2]

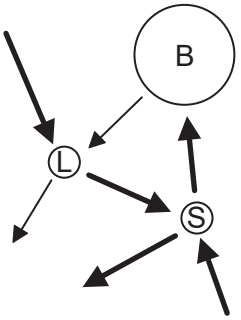
. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) The image shows a Gersmehl diagram of tropical rainforest.



[Source: © International Baccalaureate Organization 2019]

Explain what this diagram indicates about nutrients in this type of ecosystem. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option C continues on the following page)

(Option C continued)

16. (a) Explain the factors that can contribute to the exponential growth phase in a sigmoid population curve. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) Outline the effect of carrying capacity on the growth of a population. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

17. Outline a **named** example of the captive breeding and reintroduction of an endangered animal species. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option C continues on the following page)

(Option C continued)

18. Commercial fertilizers are often applied to agricultural land. Discuss the use of fertilizers on crops and their effect on other ecosystems. [6]

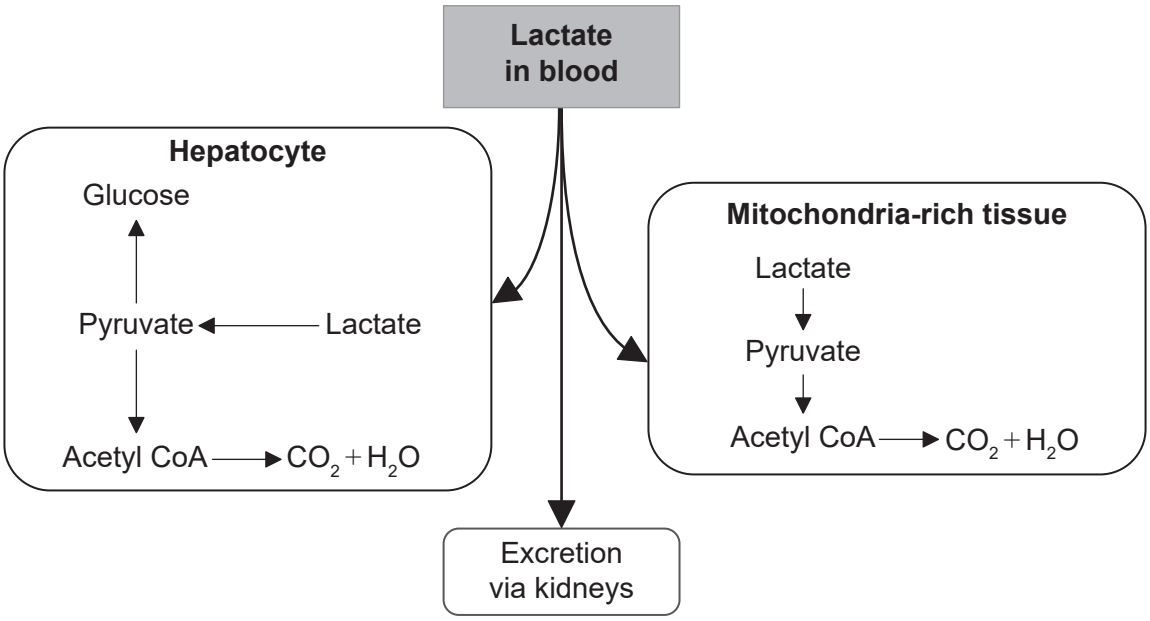
End of Option C

Please **do not** write on this page.

Answers written on this page
will not be marked.

Option D — Human physiology

19. The diagram shows metabolic pathways for lactate in humans.



[Source: © International Baccalaureate Organization 2019]

(a) State the name of the blood vessel through which lactate from muscles reaches the liver. [1]

. . . . . .

(b) Compare and contrast the possible metabolic pathways for lactate in hepatocytes and in mitochondria-rich tissue. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) List **two** functions of hepatocytes other than regulating lactate levels in the blood. [2]

1. . . . . .

2. . . . . .

(Option D continues on the following page)

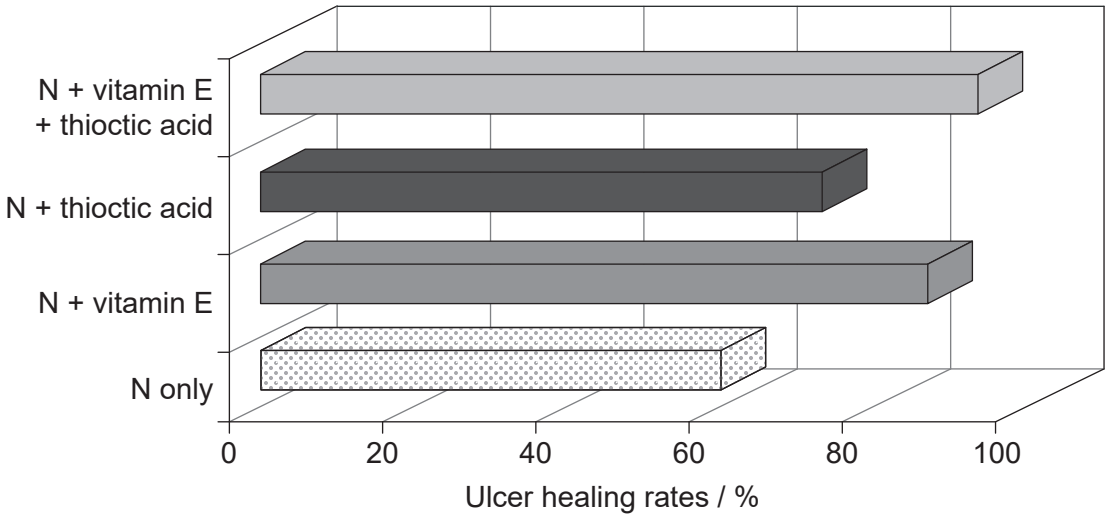
(Option D continued)

20. Most stomach ulcers are caused by a bacterium that lives under the mucus lining of the stomach wall.

(a) State the name of the bacterium that can cause stomach ulcers. [1]

. . . . . .

(b) This organism causes the production of reactive compounds which result in oxidation. This makes the ulcer progress and, consequently, healing is more difficult. A study was carried out to compare the effect of the drug nizatidine (N) alone or combined with the antioxidants vitamin E and thioctic acid.



[Source: Effect of Helicobacter Pylori Eradication Therapy and some Antioxidants on Ulcer Healing Rates in Patients with Helicobacter pylori-associated Duodenal Ulcer, Ahmed M Ali, 2013, http://www.rroij.com/open-access/effect-of-helicobacter-pylori-eradication-therapy-and-some-antioxidants-on-ulcer-healing-rates-in-patients-with-helicobacter-pylor-.php?aid=34774, licensed under a Creative Commons Attribution 4.0 International License]

Compare and contrast the effect of adding antioxidants to nizatidine on the ulcer healing rate. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option D continues on the following page)

(Option D, question 20 continued)

(c) Components of gastric juice have been thought to aggravate the development of ulcers. Outline the role of nerves in the secretion of gastric juices. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

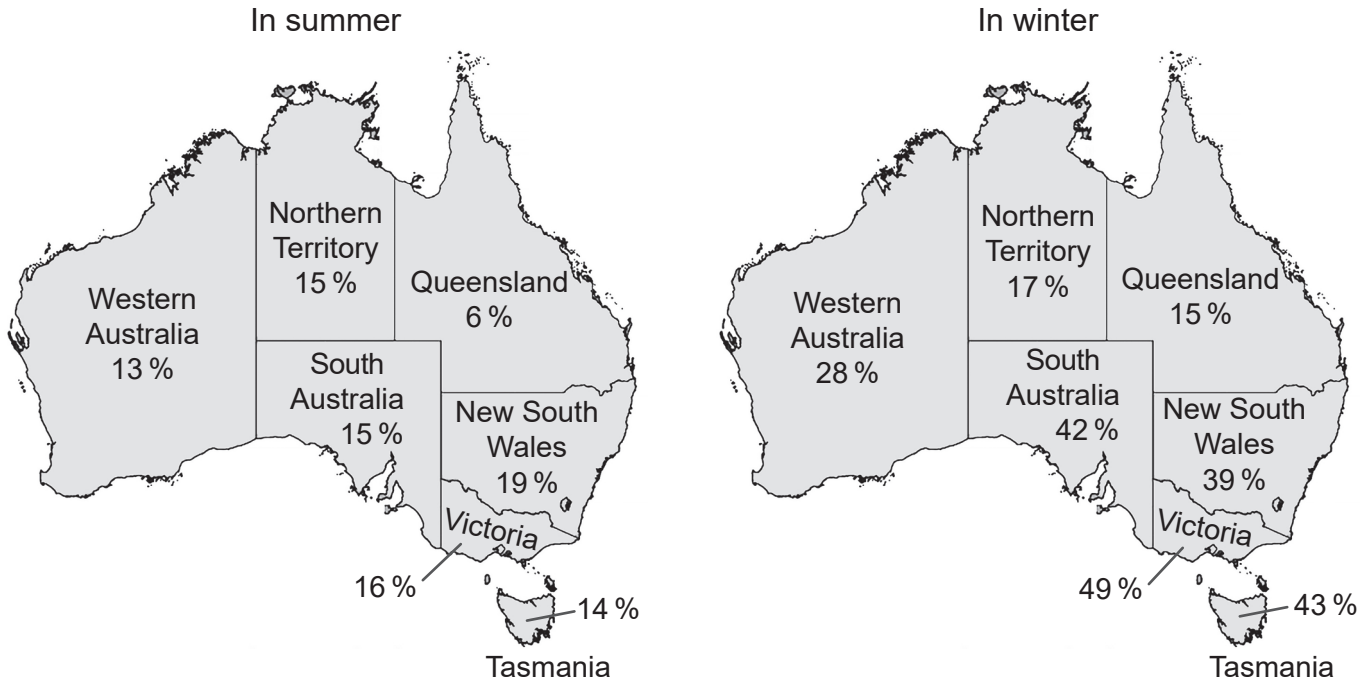
(d) Gastric juice production can be inhibited by the hormone secretin which is a polypeptide. Outline the mechanism by which a peptide hormone carries out its function. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option D continues on the following page)

(Option D continued)

21. Australia is in the Southern Hemisphere so December to February are summer months and June to August are winter months. Data on vitamin D deficiency levels were collected throughout the year for the Australian National Health Measures Survey. This was then used to analyse the seasonal effects of vitamin D deficiency. Vitamin D deficiency levels for those who had their blood samples taken in summer were compared with those who had them taken in winter. The maps show the vitamin D deficiency by state between 2011 and 2012.



[Source: www.abs.gov.au/ausstats/abs@.nsf/Lookup/4364.0.55.006Chapter2002011-12]

(a) (i) Identify which state had the smallest seasonal change in vitamin D levels. [1]

. . . . . .

(ii) Suggest **one** reason why people in Victoria show such a large seasonal change in vitamin D levels. [1]

. . . . . .

. . . . . .

(Option D continues on the following page)

(Option D, question 21 continued)

(b) Outline **one** effect of lack of vitamin D. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(c) Vitamins and minerals are both essential nutrients. Compare and contrast vitamins and dietary minerals. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

22. (a) State **one** function of the atrioventricular node. [1]

. . . . . .
. . . . . .

(b) Describe how the structure of cardiac muscle cells allows them to carry out their function. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option D continues on the following page)

(Option D continued)

23. Discuss the significance of the oxygen dissociation curves for adult hemoglobin and fetal hemoglobin. [6]

End of Option D