Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

18 May 2023

Zone A morning | **Zone B** morning | **Zone C** morning

Candidate session number

2 hours 15 minutes

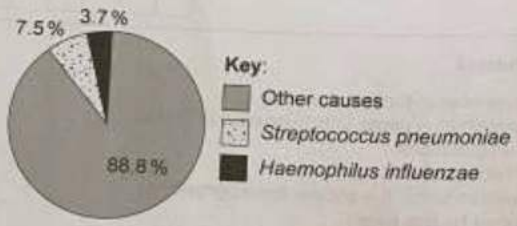
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[72 marks]**.

Section A

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

1. According to the UN Inter-agency Group for Child Mortality Estimation, in the year 2000 there were 9.82 million deaths of children under the age of 5. Many of these deaths were caused by infectious diseases. The pie chart shows estimates for the percentages of deaths that were attributable to two of the most frequent pathogens, *Streptococcus pneumoniae* and *Haemophilus influenzae*.



[Source: adapted from UN Inter-agency Group for Child Mortality Estimation, 2021. *Under-five mortality rate – Total*. [graph online] Available at: https://childmortality.org/data/World [Accessed 14 February 2022].]

(a) Calculate the number of deaths in children under the age of 5 that were attributed to *S. pneumoniae* in the year 2000. [1]

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(b) The deaths due to these two pathogens only included children who were **not** infected with HIV. Suggest a reason for excluding HIV-infected children from the statistics. [1]

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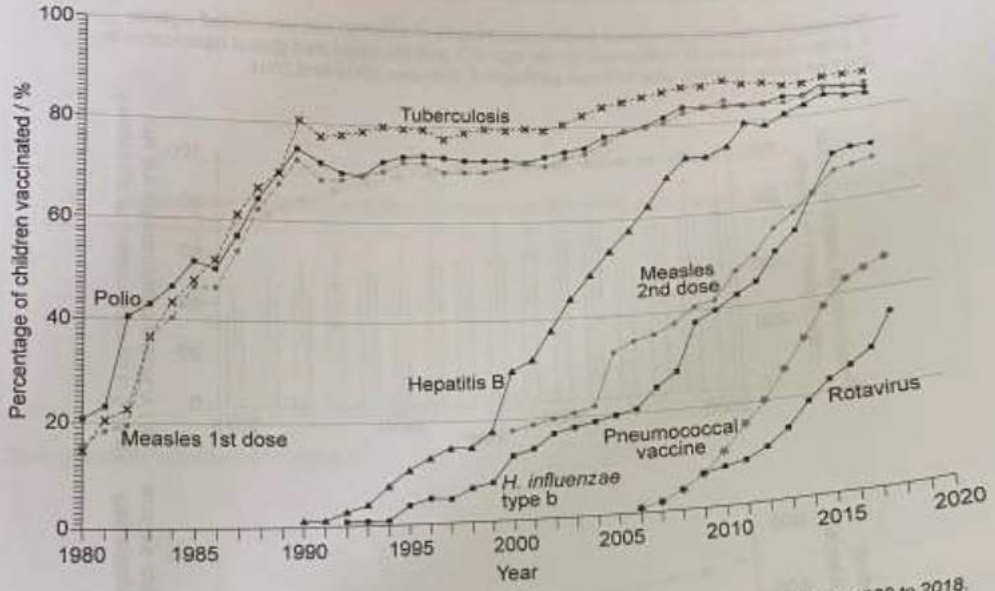
(Question 1 continued)

Vaccination programmes have led to decreases in child mortality. The graph shows global trends between 1980 and 2018 in the vaccination of children against seven different pathogens in the first year of their lives.



[Source: adapted from World Health Organization and UNICEF, 2019. *Global vaccination coverage, world, 1980 to 2018.* [graph online] Available at: https://ourworldindata.org/grapher/global-vaccination-coverage?time=earliest..2018&country=~OWID_WRL [Accessed 8 October 2021].]

(c) (i) Using the graph, identify the percentage who had received the tuberculosis vaccine in 2012. [1]

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(ii) Calculate the difference in time between 40% of children receiving the hepatitis B vaccine and 40% receiving the pneumococcal vaccine. [1]

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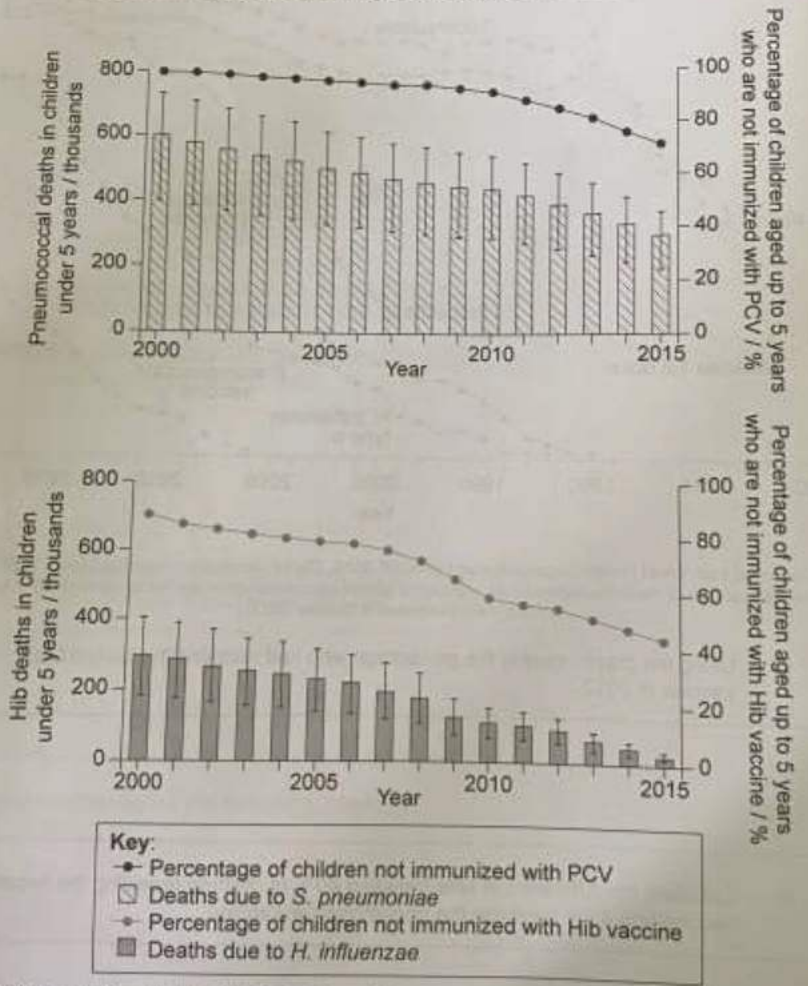
(Question 1 continued)

Children are immunized against diseases caused by *Streptococcus pneumoniae* with pneumococcal conjugate vaccine (PCV) and against diseases caused by *Haemophilus influenzae* with Haemophilus influenzae type b (Hib) vaccine.

The graphs show the estimated global percentages of children **not** vaccinated against *S. pneumoniae* and *H. influenzae* by the age of 5 and the estimated global death rates in children under 5 years, due to these pathogens, between 2000 and 2015.



[Source: adapted from Wahl *et al.*, 2018, Burden of *Streptococcus pneumoniae* and *Haemophilus influenzae* type b disease in children in the era of conjugate vaccines: global, regional, and national estimates for 2000–15. *The Lancet Global Health* 6 (7), E744-757.]

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(Question 1 continued)

(d) Outline the conclusions that can be drawn from the graph showing data for PCV and *S. pneumoniae*. [2]

(e) Suggest reasons for the difference between the data for *S. pneumoniae* and *H. influenzae*. [2]

(This question continues on page 7)

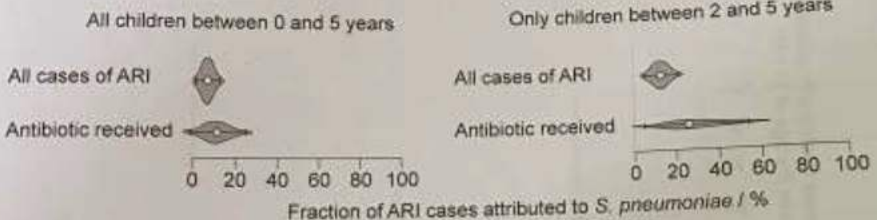
(Question 1 continued)

Acute respiratory infection (ARI) is a frequent reason for antibiotic use among children in low-income and middle-income countries (LMICs). *S. pneumoniae* is the predominant, but not the only, cause of ARI in children.

In a large-scale study, data were collected in 18 LMICs from 65 815 children under the age of 5. The data were analysed to estimate the fraction of ARI cases among the children that could be attributed to *S. pneumoniae* as shown in the graphs.

The upper estimate in the graphs is for all cases, whether or not they were treated with antibiotics. The lower estimate is for the subset of cases that required antibiotic treatment.

The range of estimates is shown by violin plots, with a point for the median estimate and lines for 95% confidence intervals.



[Source: adapted from Lewnard, J.A., Lo, N.C., Arinaminpathy, N. *et al.*, 2020. Childhood vaccines and antibiotic use in low- and middle-income countries. *Nature* 581, pp.94–99.]

(f) Using the data in the violin plots, deduce the age range at which children are most likely to develop ARI due to *S. pneumoniae*. [2]

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(g) Suggest reasons for the difference between the fraction attributed to *S. pneumoniae* in all cases of ARI and in cases where antibiotics were used to treat the infection. [2]

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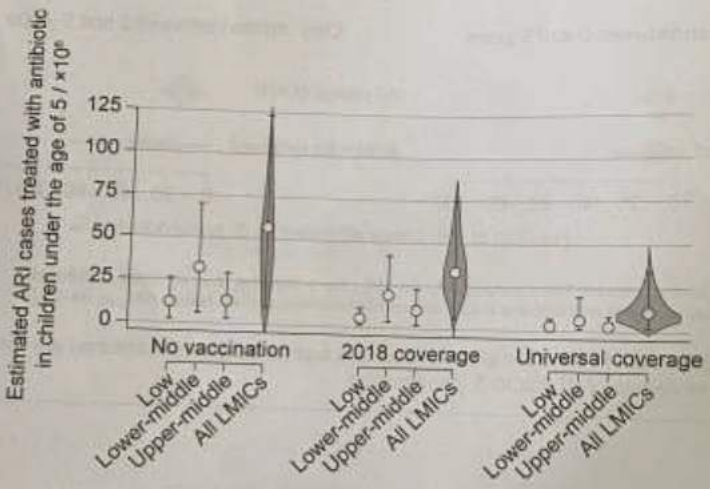
(Question 1 continued)

Estimates were made of the extent of antibiotic use in low-income and middle-income countries. Graphs were constructed to show global estimates for the numbers of cases in LMICs per year of ARI treated with antibiotic in children under the age of 5. The estimates for LMICs were divided according to income: low income, lower-middle income and upper-middle income.

The graph shows estimates for three levels of vaccination for *S. pneumoniae* with PCV:

- no vaccination
- 2018 coverage: the vaccine coverage that there was in 2018
- universal coverage: predictions assuming that in the future all children in all LMICs receive the vaccination.



[Source: adapted from Lewnard, J.A., Lo, N.C., Arinaminpathy, N. *et al.*, 2020. Childhood vaccines and antibiotic use in low- and middle-income countries. Nature 581, pp.94–99.]

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(Question 1 continued)

(h) When there is no vaccination, the estimated number of cases for lower-middle income countries is larger than in either low income or upper-middle income countries. Suggest **one** reason for this. [1]

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(i) Using the data, predict the effect of universal PCV vaccination in LMICs. [1]

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(j) Outline likely health benefits of universal PCV vaccination of children, other than reducing the incidence of ARI. [2]

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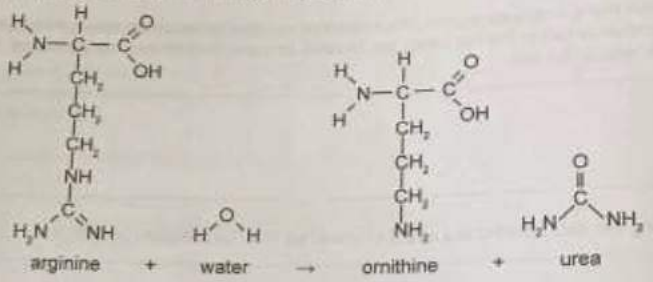
2. The reaction that produces urea in liver cells is shown.



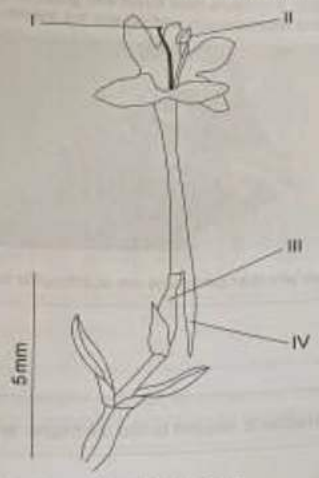
(a) Arginine and ornithine are in the same group of biochemicals. Identify this group. [1]

(b) This reaction forms part of a metabolic cycle. Outline one feature of a metabolic cycle that distinguishes it from a chain. [1]

(c) Predict what effect arginase has on the activation energy of this reaction. [1]

(d) The concentration of urea in blood plasma is typically about 30 mg per 100 ml. In urine it can be as high as 1800 mg per 100 ml. Explain how this increase in concentration is achieved. [3]

3. The drawing shows a flower of red valerian, *Centranthus ruber*.



(a) State the name and function of structures I and II. [2]

Structure I name and function: .....

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Structure II name and function: .....

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(b) Structure III is the ovary. Outline the processes that occur in the ovary. [2]

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(c) Structure IV contains a gland that secretes a sugary liquid. Suggest a benefit to the plant of secreting this liquid. [1]

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4. The Chinese pangolin (*Manis pentadactyla*) is a critically endangered species that has declined in numbers by 80 % since 2000. It inhabits both forest and grassland, where it uses long, powerful claws to open ant and termite nests and ingests the insects using a long, sticky tongue.

(a) (i) State with a reason whether pangolins are autotrophic or heterotrophic. [1]

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(ii) Explain what information is needed to find the trophic level of pangolins. [2]

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(b) Pangolins are unique among mammals in having evolved scales, which are a recognition feature of reptiles. Explain which features you expect pangolins to have, which would show that they are mammals, not reptiles. [2]

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(c) The Chinese pangolin, *Manis pentadactyla*, has a diploid chromosome number of 40.

(i) State how many chromosomes there would be in gametes of this species. [1]

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(Question 4 continued)

(ii) Sex is determined in the same way in pangolins as in humans. State how many autosomes there are in somatic cells of *M. pentadactyla*. [1]

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5. The table shows thermal properties of water and methane.

Property	Freezing point / °C	Boiling point / °C	Heat capacity / $Jg^{-1}°C^{-1}$	Heat of vaporization / Jg^{-1}
Water (H_2O)	0	100	4.2	3357
Methane (CH_4)	-182	-160	2.2	760

(a) Water molecules are polar and methane molecules are non-polar. Explain how this difference affects the thermal properties of these substances. [2]

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(b) Using the data in the table, deduce the reasons for methane being a gas on Earth. [2]

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(c) Water is used as a coolant in sweat. Using the data in the table, explain the reasons for methane not being as suitable as water for use as a coolant. [2]

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Section B

Answer **two** questions. Up to one additional mark is available for the construction of your answers for each question. Answers must be written within the answer boxes provided.

6. Many biological processes are cyclical. Examples of cycles can be found at the level of the cell, the organism and the ecosystem.

   (a) Explain how changes to the cell cycle can result in tumour formation. [4]

   (b) Outline the role of the right atrium in the cardiac cycle. [4]

   (c) Describe processes in the carbon cycle that produce or use carbon dioxide. [7]

7. Proteins are an extraordinarily diverse group of carbon compounds that have a wide range of roles in cells.

   (a) Describe the structure of proteins, including features that are common to all proteins and features that vary. [7]

   (b) Explain the roles of proteins in the movement of substances across membranes. [5]

   (c) Outline how proteins can be separated by gel electrophoresis. [3]

8. Biologists base their theories about the natural world on evidence, which can come from observations or from controlled experiments.

   (a) Explain how observation of the fossil record provides evidence for evolution. [4]

   (b) Outline how experiments into inheritance can be performed using *Drosophila* (fruit flies) and what has been discovered by carrying out such experiments. [4]

   (c) Describe the methods used in cladistics and how evidence gained from this research can be utilized. [7]