HIGHER

B3H Infection and Response: Higher Tier Practice

AQA 8461 · Calculator allowed · about 100 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Give two different types of pathogen and an example of a disease caused by each.

(a) Name one type of pathogen and an example disease it causes. **(1)**

(b) Name a different type of pathogen and an example disease it causes. **(1)**

(Total for Question 1 is 2 marks)

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2 Describe two physical barriers the human body uses to prevent pathogens entering, and explain how each barrier works.

(a) Describe one physical barrier and explain its action. **(1)**

(b) Describe a second physical barrier and explain its action. **(1)**

(Total for Question 2 is 2 marks)

3 Explain how phagocytes and lymphocytes work together to defend the body against a bacterial infection.

(a) Explain the role of phagocytes in the early response to bacteria. **(1)**

(b) Explain the role of lymphocytes in the specific immune response. **(1)**

(c) Explain how the actions of phagocytes and lymphocytes together clear the infection and provide immunity. **(1)**

(Total for Question 3 is 3 marks)

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4 Vaccination can protect populations from infectious disease.

(a) Explain how vaccines produce immunity in an individual. **(2)**

(b) State one reason why some people cannot be vaccinated and how the community is still protected. **(1)**

(Total for Question 4 is 3 marks)

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5 Explain why antibiotics are ineffective against viruses.

(a) Explain the biological reason antibiotics do not work on viruses. **(2)**

(Total for Question 5 is 2 marks)

6 A bacterial culture starts with 2.00×10^3 bacteria and doubles every 30 minutes. Calculate the number of bacteria after 3.0 hours. Give your answer in standard form.

(a) Show the substitution into the equation $N = N0 \times 2^{t/30}$ where t is minutes, then calculate the final number. **(1)**

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(b) Give the final answer in standard form with units 'bacteria'. **(1)**

(Total for Question 6 is 2 marks)

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7 If each infected person infects an average of 1.8 other people, how many new cases are expected next generation from 50 currently infected people? Give your answer as an integer.

(a) Calculate the expected new cases. **(1)**

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(Total for Question 7 is 1 mark)

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8 Describe the roles of antibodies and memory cells in the adaptive immune response after infection or vaccination.

(a) Describe the role of antibodies. **(1)**

(b) Describe the role of memory cells. **(1)**

(c) Explain how antibodies and memory cells together give effective protection on re-infection. **(1)**

(Total for Question 8 is 3 marks)

9 A student tests three antiseptic solutions A, B and C against a bacterial lawn. The diameters of zones of inhibition (mm) from three repeats are:

A: 12, 14, 13

B: 8, 9, 10

C: 15, 14, 16

Calculate the mean zone for each antiseptic, state which is most effective, and suggest one improvement to the method to make the comparison fairer.

(a) Calculate the mean diameter for A, B and C. Show one calculation. **(2)**

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(b) State which antiseptic is most effective and justify using your means. **(1)**

(c) Suggest one improvement to the method to make the comparison fairer. **(1)**

(Total for Question 9 is 4 marks)

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10 Explain how harmless bacteria that live on human skin can help prevent pathogenic infections.

(a) Explain the protective role of normal skin flora. **(2)**

(Total for Question 10 is 2 marks)

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11 An antibody solution has concentration 8.00 mg L^{-1}. It is diluted 1:4 and then a 1:5 dilution is made from that. Calculate the final antibody concentration in mg L^{-1}.

(a) Show the substitution and calculation for the two successive dilutions. **(1)**

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(b) Give the final concentration to three significant figures with units. **(1)**

(Total for Question 11 is 2 marks)

12 Explain how antibiotic resistance can spread through a bacterial population. Your answer should include natural selection and gene transfer.

(a) Explain selection and increase in resistant bacteria. **(1)**

(b) Explain how resistance genes can spread between bacteria. **(1)**

(c) Give one human action that increases the selection for resistance and explain briefly. **(1)**

(Total for Question 12 is 3 marks)

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13 A public health team records the weekly incidence of a viral infection in a town of 12 000 people. Incidence per week per 1000 people was:
Week 1: 6.0
Week 5: 1.5
Between week 1 and week 5 a vaccination campaign reached 60% of the population. Calculate the percentage decrease in incidence per 1000 people from week 1 to week 5 and discuss one reason why the decrease might not be entirely due to vaccination.

(a) Calculate the percentage decrease in incidence per 1000 people between week 1 and week 5. Show working. **(2)**

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(b) Give one plausible reason why the incidence fell that is not vaccination and explain briefly. **(1)**

(Total for Question 13 is 3 marks)

14 Compare the polymerase chain reaction (PCR) technique with an ELISA test for detecting infection. Give one advantage of PCR and one advantage of ELISA.

(a) Briefly state how PCR detects infection and one advantage of PCR. **(2)**

(b) Briefly state how ELISA detects infection and give one advantage of ELISA over PCR. **(1)**

(Total for Question 14 is 3 marks)

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15 Calculate the herd immunity threshold percentage for a disease with R0 = 3.5. Then calculate how many people in a town of 25 000 must be immune to reach this threshold. Show your working and give the final number as an integer.

(a) Substitute into the formula herd immunity threshold = 1 - 1/R0 and calculate the percentage. **(1)**

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(b) Give the herd immunity threshold as a percentage to three significant figures. **(1)**

(c) Calculate the number of people (integer) in a town of 25 000 who must be immune to reach this threshold. Show working. **(1)**

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(Total for Question 15 is 3 marks)

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16 Evaluate the advantages and disadvantages of using a combined vaccine that protects against multiple diseases in a single injection compared with giving separate single-disease vaccines. Consider effectiveness, logistics, side effects and public health impact in your answer.

(Total for Question 16 is 6 marks)

Mark scheme · B3H Infection and Response: Higher Tier Practice

Question 1

- (a) **B1** one correct type of pathogen with a matching disease, e.g. bacterium - tuberculosis; virus - influenza; fungus - athlete foot; protozoan - malaria, oe
- **(a) Answer: Any one correct pair, for example: bacterium - tuberculosis.**
- (b) **B1** a second correct type and matching disease different from part a, oe
- **(b) Answer: Any different correct pair, for example: virus - influenza.**

Question 2

- (a) **B1** one correct barrier with brief explanation, e.g. skin - acts as a continuous physical barrier stopping pathogens entering
- **(a) Answer: Skin acts as a continuous physical barrier that prevents pathogens entering the body.**
- (b) **B1** one other correct barrier with brief explanation, e.g. mucus and cilia in the trachea trap and move microbes out of the airways
- **(b) Answer: Mucus and cilia in the airways trap and move microbes out of the respiratory system.**

Question 3

- (a) **M1** phagocyte engulfs bacteria by phagocytosis or surrounds and digests bacteria, oe
- **(a) Answer: Phagocytes engulf and digest invading bacteria by phagocytosis.**
- (b) **M1** lymphocytes (B cells) recognise antigens and produce specific antibodies against the pathogen, oe
- **(b) Answer: Lymphocytes recognise antigens and B cells produce specific antibodies to target the bacteria.**
- (c) **M1** combined idea: phagocytes remove many pathogens and lymphocyte antibodies neutralise and mark pathogens for destruction, and memory cells are produced giving long term immunity, oe
- **(c) Answer: Phagocytes remove pathogens and lymphocyte-produced antibodies neutralise and mark pathogens for destruction; memory cells remain to give future immunity.**

Question 4

- (a) **M1** vaccine introduces harmless form of antigen so lymphocytes produce specific antibodies
- (a) **A1** memory cells are produced which provide long term immunity cao
- **(a) Answer: A vaccine introduces harmless antigen so lymphocytes produce specific antibodies and form memory cells that give long term immunity.**
- (b) **B1** one correct reason and effect, e.g. people with weakened immune systems cannot be vaccinated, but herd immunity reduces spread protecting them, oe
- **(b) Answer: Some people with weak immune systems cannot be vaccinated, but herd immunity reduces disease spread and helps protect them.**

Question 5

- (a) **M1** antibiotics target bacterial structures or processes (cell wall synthesis, protein synthesis) not present in viruses
- (a) **A1** viruses replicate inside host cells using host machinery so antibiotics are ineffective cao
- **(a) Answer: Antibiotics target bacterial structures or processes not present in viruses, and viruses replicate inside host cells using host machinery so antibiotics are ineffective.**

Question 6

- (a) **M1** substitutes: $N = 2.00 \times 10^3 \times 2^{180/30}$ or $N = 2.00 \times 10^3 \times 2^6$
- (b) **A1** 1.28×10^5 bacteria cao
- **(b) Answer: 1.28×10^5 bacteria**

Question 7

- (a) **B1** 90 new cases (50 x 1.8 = 90) cao
- **(a) Answer: 90**

Question 8

- (a) **B1** antibodies bind to specific antigens, neutralise pathogens or mark them for destruction by other immune cells, oe
- **(a) Answer: Antibodies bind specific antigens to neutralise pathogens or mark them for destruction.**
- (b) **B1** memory cells remain after first exposure and allow a faster, larger immune response on re-exposure to the same pathogen, oe
- **(b) Answer: Memory cells remain and cause a faster, larger immune response on re-exposure to the same pathogen.**
- (c) **M1** combined explanation: memory cells trigger rapid production of specific antibodies on re-exposure, preventing disease development, oe
- **(c) Answer: Memory cells trigger rapid production of specific antibodies on re-exposure, preventing disease development.**

Question 9

- (a) **M1** shows correct method for a mean for one antiseptic, e.g. A mean = (12+14+13)/3 = 13
- (a) **A1** gives all three correct means: A = 13 mm, B = 9 mm, C = 15 mm cao
- **(a) Answer: Means: A = 13 mm, B = 9 mm, C = 15 mm**
- (b) **B1** C is most effective because it has the largest mean zone of inhibition (15 mm) compared with A and B, oe
- **(b) Answer: C is most effective because it has the largest mean zone of inhibition, 15 mm.**
- (c) **B1** one valid improvement, e.g. use the same volume and concentration of each antiseptic, ensure plates are incubated at the same temperature and time, or use more repeats, oe
- **(c) Answer: Use the same volume and concentration of each antiseptic and incubate all plates at the same temperature for the same time.**

Question 10

- (a) **M1** normal bacteria occupy niches and resources so reduce space and nutrients for pathogens
- (a) **A1** some produce harmful substances or change pH to inhibit pathogen growth, oe
- **(a) Answer: Normal skin bacteria occupy space and resources preventing pathogen colonisation, and some release substances or alter pH that inhibit pathogen growth.**

Question 11

- (a) **M1** correct method: concentration = 8.00 / 4 / 5 or 8.00 x (1/4) x (1/5)
- (b) **A1** 0.400 mg L^{-1} cao
- **(b) Answer: 0.400 mg L^{-1}**

Question 12

- (a) **M1** antibiotic kills susceptible bacteria leaving resistant ones to survive and reproduce
- **(a) Answer: Antibiotics kill susceptible bacteria so resistant bacteria survive and reproduce, increasing their proportion.**
- (b) **M1** resistance genes can be transferred via plasmids by conjugation or by other horizontal gene transfer mechanisms, oe
- **(b) Answer: Resistance genes can spread via plasmids transferred between bacteria by conjugation or other horizontal gene transfer.**
- (c) **M1** one correct human action and explanation, e.g. overuse or incomplete courses of antibiotics increases selection pressure allowing resistant strains to dominate, oe
- **(c) Answer: Overuse of antibiotics or patients not completing courses increases selection pressure so resistant strains are more likely to survive and spread.**

Question 13

- (a) **M1** shows correct method: percentage decrease = (6.0 - 1.5)/6.0 x 100 or equivalent
- (a) **A1** 75% decrease cao
- **(a) Answer: 75% decrease**
- (b) **B1** one plausible alternative with brief explanation, e.g. seasonal change reduced transmission; increased social distancing or school closures reduced contacts; natural depletion of susceptibles, oe
- **(b) Answer: Seasonal factors or increased social distancing could have reduced transmission, so the fall may not be solely due to vaccination.**

Question 14

- (a) **M1** PCR amplifies specific DNA sequences of a pathogen allowing detection of very small amounts
- (a) **A1** advantage: very sensitive and can detect low levels of pathogen genetic material, oe
- **(a) Answer: PCR amplifies pathogen DNA so even tiny amounts can be detected. Advantage: high sensitivity allows early detection.**
- (b) **B1** ELISA detects antigens or antibodies using enzyme-linked antibodies and a colour change; advantage: quicker, cheaper and suitable for high throughput screening, oe
- **(b) Answer: ELISA uses enzyme-linked antibodies to detect antigens or antibodies by a colour change; advantage: quicker and cheaper for mass screening.**

Question 15

- (a) **M1** shows substitution: 1 - 1/3.5
- (b) **A1** 71.4% cao
- **(b) Answer: 71.4%**
- (c) **A1** 17857 or 17858 depending on rounding policy but candidate must give integer consistent with 71.4% (correct computed value 0.7142857 x 25000 = 17857.1425 so 17858 rounded up acceptable) cao
- **(c) Answer: 17858 people**

Question 16

- **Level 3** (5-6): Detailed evaluation: clear balanced judgement supported by multiple reasons and evidence relating to effectiveness, logistics, side effects and public health impact.
- **Level 2** (3-4): Some balanced points with limited justification. Addresses at least two relevant factors with some development.
- **Level 1** (1-2): Limited statements or simple points about one or two factors, little or no development.
- **Indicative content:**
  - Combined vaccines reduce number of injections so increase uptake and compliance, improving herd immunity and public health coverage.
  - Fewer clinic visits reduce logistics costs and demand on healthcare staff, and simplify immunisation schedules.
  - Combined vaccines may reduce the risk of missing one component, but mixing antigens might slightly reduce immune response to one component in some cases; manufacturers design combinations to avoid interference.
  - Risk of side effects: combined vaccine may have cumulative adverse reactions; however clinical trials usually show acceptable safety profiles. Single vaccines allow identification of which component caused a reaction.
  - Cold chain and manufacturing complexity: combined vaccines can be more complex to produce and may require careful storage; single vaccines can be distributed independently if supply issues occur.
  - Final judgement should weigh likely gains in vaccination coverage and public health benefit against slightly increased complexity in production and potential for compounded side effects; for most programmes combined vaccines are advantageous but context and evidence should guide decision.