1.18 Human Defences, Vaccination and Drug Development: Test Pack

AQA 8464 · Calculator allowed · about 35 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Pathogens can cause disease in humans.

(a) Give the definition of the term 'pathogen'. **(1)**

(b) Name two types of pathogen. **(2)**

(Total for Question 1 is 3 marks)

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2 Describe two physical or chemical barriers in the human body that help prevent pathogens entering.

(a) Describe one physical barrier and how it stops pathogens. **(1)**

(b) Describe one chemical barrier and how it helps prevent infection. **(1)**

(Total for Question 2 is 2 marks)

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3 Antibodies bind specifically to antigens.

(a) Explain what is meant by the specificity of an antibody. **(1)**

(b) Give one consequence of antibody specificity for vaccine design. **(1)**

(Total for Question 3 is 2 marks)

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4 Vaccination can protect individuals and populations.

(a) Explain how vaccination leads to immunity in an individual. Give the immunological steps. **(3)**

(Total for Question 4 is 3 marks)

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5 Error analysis: A published small study claimed that a new nasal vaccine reduced infection by 50% compared to control. The study had 20 participants in each group. In the vaccine group 6 people were infected; in the control group 12 were infected. A student comments that the study is unreliable. Explain two reasons based on the data and study design that support the student's comment.

(a) Give one reason based on sample size or variability. Refer to the numbers given. **(2)**

(b) Give another reason related to study design or missing information that weakens the claim. **(2)**

(Total for Question 5 is 4 marks)

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6 A community study recorded cases in a recent outbreak. 1 200 people received Vaccine X and 30 of these still developed the disease. In the unvaccinated group of 600 people, 60 developed the disease. Calculate the vaccine efficacy as a percentage using the formula: efficacy = (attack rate unvaccinated - attack rate vaccinated) / attack rate unvaccinated x 100.

(a) Show your working and give the vaccine efficacy to 3 significant figures. **(3)**

(Total for Question 6 is 3 marks)

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7 A pharmaceutical company is developing a new antiviral. In early trials they measure the concentration of drug in the blood of volunteers at intervals. At time 0 the concentration is 12 mg per litre. After 2 hours it is 9.6 mg per litre. Assume first-order elimination and that concentration halves after a fixed time. Use the approximation that for small time intervals the percentage decrease is consistent.

(a) Calculate the percentage decrease in concentration over the 2 hours. Give your answer to 3 significant figures. **(2)**

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(b) Using the 20.0% decrease every 2 hours as an approximation, estimate the concentration after a further 4 hours (total 6 hours). Show working and give answer to 3 significant figures. **(2)**

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(Total for Question 7 is 4 marks)

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8 Data analysis: A trial compared two dosing schedules of a vaccine: single dose and two doses given 4 weeks apart. The table shows the mean antibody titre (arbitrary units) measured 6 weeks after first dose. Single dose group mean = 30 units (n = 50, standard deviation 12). Two-dose group mean = 85 units (n = 48, standard deviation 18).

(a) State two pieces of evidence from the data that suggest the two-dose schedule produces a stronger immune response. **(2)**

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(b) Suggest one further statistical or experimental piece of information that would help determine whether the difference is statistically significant. **(2)**

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(Total for Question 8 is 4 marks)

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Mark scheme · 1.18 Human Defences, Vaccination and Drug Development: Test Pack

Question 1

(a) an organism or agent that causes disease in another organism, oe **B1**

(a) Answer: An organism or agent that causes disease in another organism.

(b) first correct type: bacteria, virus, fungus, protozoan, or parasite **B1**

(b) second correct type: bacteria, virus, fungus, protozoan, or parasite (different to first) **B1**

(b) Answer: Any two of: bacteria; virus; fungus; protozoan; parasite.

Question 2

(a) description of a physical barrier with its protective action, e.g. skin forms a continuous barrier that prevents entry of microbes **B1**

(a) Answer: Skin forms a continuous barrier that prevents microbes entering the body.

(b) description of a chemical barrier with its protective action, e.g. hydrochloric acid in the stomach kills many ingested microbes **B1**

(b) Answer: Hydrochloric acid in the stomach kills many microbes in swallowed food, preventing infection.

Question 3

(a) antibody has a binding site that fits a particular antigen shape; binds only to that antigen or very similar ones **B1**

(a) Answer: An antibody has a binding site complementary to a particular antigen shape so it binds only to that antigen or very similar ones.

(b) vaccine must present the correct antigen(s) to induce protective antibodies; e.g. change in antigen may reduce vaccine effectiveness **B1**

(b) Answer: Vaccines must present the correct antigen so produced antibodies match the pathogen; antigen changes can reduce vaccine effectiveness.

Question 4

(a) vaccine introduces antigen or weakened/killed pathogen so immune system recognises it **M1**

(a) activates B cells to produce specific antibodies against the antigen **A1**

(a) memory B cells and T cells are produced so a faster response occurs on later infection, cao **A1**

(a) Answer: Vaccine introduces antigen so the immune system recognises it; B cells produce specific antibodies; memory B and T cells form so a faster stronger response occurs on later exposure.

Question 5

(a) identifies small sample size (n = 20 per group) and notes this increases random variation **M1**

(a) concludes that with only 20 per group the observed difference (6 vs 12) may be due to chance and is not reliably generalisable, oe **A1**

(a) Answer: The groups are very small (20 each) so random variation is large; the observed difference (6 infected vs 12) could be due to chance and may not be generalisable.

(b) lack of information about randomisation, blinding or participant characteristics **B1**

(b) or absence of statistical significance testing or confidence intervals to show the result is not due to chance **B1**

(b) Answer: There is no information on randomisation, blinding or participant characteristics and no statistical test or confidence intervals; these omissions mean bias or confounding could explain the apparent 50% reduction.

Question 6

(a) calculates attack rates: vaccinated 30/1200 = 0.025 and unvaccinated 60/600 = 0.10 **M1**

(a) substitutes into formula: (0.10 - 0.025) / 0.10 **M1**

(a) 75.0% cao **A1**

(a) Answer: 75.0%

Question 7

(a) calculates percentage decrease: (12 - 9.6) / 12 x 100 **M1**

(a) 20.0% cao **A1**

(a) Answer: 20.0%

(b) applies successive decreases: after 2h 9.6, after 4h 9.6 x 0.80 = 7.68, after 6h 7.68 x 0.80 **M1**

(b) 6.14 mg per litre cao **A1**

(b) Answer: 6.14 mg per litre

Question 8

(a) mean antibody titre is higher for two-dose group (85 vs 30) **B1**

(a) both groups have reasonably large sample sizes (n = 48 and n = 50), so the difference is likely to be meaningful, oe **B1**

(a) Answer: Two-dose group has a much higher mean titre (85 vs 30); both groups have similar sample sizes (n = 48 and 50) so the difference is likely to be meaningful.

(b) provide a p value from an appropriate test (t test) or provide confidence intervals for the means **B1**

(b) or show raw data distribution or do a statistical test to compare means (e.g. t test) oe **B1**

(b) Answer: Provide a p value from a t test or confidence intervals for the means, or show the raw data distribution to assess overlap.

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